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Tabel of Content

EDITORIAL

Introduction

About

Indexing

ARTICLES

Dissemination of Social Accounting Information: A Bibliometric Review
Margarida Rodrigues, Maria do Céu Alves, Cidália Oliveira,Vera, Vale,José Vale, Rui Silva

Idiosyncrasies of Money: 21st Century Evolution of Money
Daniel Ogachi,Paul Mugambi,Lydia Bares, Zoltan Zeman

Generalized Trust and Economic Growth: The Nexus in MENA Countries
Rania S. Miniesy, Mariam AbdelKarim

Banks' Performance and Economic Growth in India: A Panel Cointegration Analysis
Md. Shabbir Alam,Mustafa Raza Rabbani,Mohammad Rumzi Tausif, Joji Abey

A Markov-Switching Model of Inflation in Bolivia
Antonio N. Bojanic

COVID-19 Pandemic and Lockdown Fine Optimality
Spyros Niavis,Dimitris Kallioras,George Vlontzos, Marie-Noelle Duquenne

Liquidity Spill-Overs in Sovereign Bond Market: An Intra-Day Study of Trade Shocks in Calm and Stressful Market Conditions
Linas Jurksas,Deimante Teresiene,Rasa Kanapickiene

Movement of Inflation and New Keynesian Phillips Curve in ASEAN
Adhitya Wardhono,M. Abd. Nasir,Ciplis Gema Qori'ah, Yulia Indrawati

Regional Heterogeneity of Preferences and Intergovernmental Transfers
Raúl Alberto Ponce Rodríguez, Benito Alan Ponce Rodríguez

Digital Leadership in the Economies of the G20 Countries: A Secondary Research
Afriyadi Cahyadi, Róbert Magda

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Article

Dissemination of Social Accounting Information: A Bibliometric Review

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Abstract: The discussion in recent decades about sustainable development issues has given rise to a new accounting dimension: social accounting. Currently, this issue remains an emerging theme. Although there are some studies and literature reviews, none include disclosure of social accounting information or the analysis of research paradigms. This article reviews the research on social accounting disclosure and tries to answer the following research questions: What research streams have been followed? Which theories and research paradigms have been used? The search for articles to be included in the literature review was performed through the Web of Science. The 126 articles obtained were later analyzed using Bibliometrix software. Results expose the growing interest in this theme and identify three distinct research lines (three clusters): Cluster 1—Social accounting disclosures, Cluster 2—Legitimacy vs. disclosure of social accounting, and Cluster 3—Motivations for disclosure of social accounting. The main contribute of this article resides, on the one hand, in the fact that no literature review articles have been found that include the theme of the disclosure of information on social accounting and, on the other hand, the treatment of data has been done with innovative software, an R package for bibliometric and co-citation analysis called Bibliometrix. As well as mapping the literature, another theoretical contribution of this study was identifying the main research approaches used in the studies. Within the paradigmatic plurality of social accounting research, the results suggest that social accounting research can also be critically addressed when addressing the sustainability challenges posed by climate change or carbon emissions, among many other aspects. This study is, to our knowledge, the first bibliometric review done about social accounting information disclosure.

Keywords: social accounting; voluntary disclosure; social and environmental accounting; social reporting

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1. Introduction

The last decades have seen a continuous debate globally, notably at the United Nations on social and environmental issues (UNWCED 1987; UN 2015, 2016). Furthermore, more specifically, on the fact that companies are more committed to social responsibility and include the impacts of their activities on these issues in their operational management and global strategy. This means that, in addition to generating profit, they are expected to create

value and contribute to the global value chain. In this context, the role of accounting in promoting sustainable development has gained in relevance (Bebbington and Unermen 2018). In conceptual terms, social accounting is covered in Social and Environmental Accounting (SEA). The SEA is implicitly linked to companies' contribution to present and future sustainability on a global level. Thus, social issues, among others, have begun to be included in the sustainable development agenda, which has led most companies to adopt the integration and dissemination of sustainability practices in their strategy, based on the triple bottom line (economic, social, and environmental dimension). In this context, many companies have integrated environmental and social management policies into their management accounting systems and have increased their disclosure practices (Larrinaga-González and Bebbington 2001). This propensity/trend towards implementing new specific fields of management accounting and its dissemination to all interested parties has sparked greater interest from social science researchers since the early 1970s (Bebbington and Gray 2001). In the 1990s, interest in social accounting reemerged, with significant concern in the public sector (government) and the private sector (business) with the global social impacts and the environment, such as human rights, ethics, conduct, and values and quality of life. In this context, several proposals have emerged for social accounting to be integrated into companies and other organizations' accounting and management systems. In addition, the attitude of companies towards the disclosure of this type of non-financial information may be related to the organizational culture and type of activity, as well as to existing legislation, since the disclosure of social sustainability reports represents a means of managing and meeting the expectations of stakeholders in general (Rodrigues and Mendes 2018). So, current trends indicate that companies are choosing a new way to communicate social and environmental issues (Bebbington and Gray 2001; Larrinaga et al. 2002). Given this scenario, the Social Accounting disseminated by Ramanathan (1976) stands out, which postulates the disclosure of relevant information on the company's objectives, its economic and financial performance, policies, and social contributions and advocates this through reports that observe the relationship between the cost and benefit of disclosure, prioritizing the mitigation of asymmetry of information between users (Niyama and Silva 2014).

The theoretical framework of this theme is essentially focused on three theories: the theory of legitimacy, the theory of stakeholders (stakeholders' theory) and institutional theory, all of which are widely used in social accounting research, namely, to explain what drives organizations to disclose social and environmental information (Deegan 2014).

Stakeholder theory has been one of the most widely used social accounting theories (Gray 2010). There are two strands to this theory, a normative strand that prescribes how companies/organizations should interact with their stakeholders and a managerial strand that seeks to explain how companies/organizations interact effectively with their stakeholders (Deegan 2014). In the first strand, it is considered that organizations must be accountable to their stakeholders. In the second, the organization must first define who the most important stakeholders are, control the resources, and then make efforts to provide them with the necessary information. In other words, organizations tend not to care about the least essential stakeholders (Deegan 2014). Like the stakeholder theory, the theory of legitimacy considers the organization part of a comprehensive social system (Deegan 2019).

However, while the theory of legitimacy is concerned with the expectations of society at large, it sees a social pact between the organization and the society in which it operates (Deegan 2002). Stakeholder theory focuses on stakeholder groups. Thus, according to the legitimacy theory, companies/organizations survive if the society in which they operate realizes that they contribute to society's global value creation chain (Gray et al. 1996). This theory is based on the concept of organizational legitimacy. This means that legitimacy is a general assumption that an entity's actions/attitudes can be appropriated to society by building a system of norms, values, and boundaries according to the system of that society (Suchman 1995). Therefore, the theory of legitimacy allows explaining and understanding why companies adopt the practice of disclosing their social information, either in social reports or as part of their annual financial reports. Society is an interested party in compa-

nies' sustainable behavior and, as such, exerts pressure for them to adopt good practices to obtain external and internal legitimacy and, thus, continue to develop their activities successfully. The theory of legitimacy has similarities with institutional theory. Some authors (Deegan 2014) even claim that institutional theory provides additional insight into how organizations understand and respond to changes brought about by social and institutional pressures and expectations. Stakeholder and legitimacy theories suggest that organizations carefully and deliberately plan to disseminate information to meet more powerful stakeholders or the wider community's expectations. Institutional theory, in turn, suggests that, in the absence of a clear justification for doing so, firms disseminate information because their peers do so or because it has become a common practice in the contexts in which they operate, thus introducing a process of homogenization of practices through institutional isomorphism (DiMaggio and Powell 1983). Thus, the institutional theory makes it possible to understand why the dissemination of information happens and how it happens (Higgins and Larrinaga 2014). It also makes it possible to relate organizational practices to the values of the society in which the organization operates and the need to maintain organizational legitimacy. Thus, according to Deegan (2014), institutional theory complements the explanations given by the theories of related parts and legitimacy, allowing the explanation of some asymmetry of information that was still occurring in the elaboration of social reports.

As for the topicality and timeliness of this work, they stem from several reasons. Firstly, the research carried out on this theme showed that, although three articles reviewed the literature, none of them included the dissemination of social information in the themes addressed. Secondly, it was found that most of the literature on the theme under study is scattered and, consequently, in need of systematization. Finally, given the role that social accounting plays in the current business environment, namely, in the international context, its study becomes relevant also in academic terms. This scarcity of studies on disseminating social accounting is the driving force in the first stage of theoretical development on a topic since literature reviews aim to provide in-depth research on a specific field (Mentzer and Kahn 1995; Seuring and Müller 2008).

Accounting research has been fertile in bibliometric analyses, for example Merigó and Yang (2017) proceeded to systematize the state of the art in accounting, in which it identified research that addressed social accounting in its various aspects. Another study mapped the literature on social responsibility in the mining industry (Rodrigues and Mendes 2018); Erkens et al. (2015) thoroughly analyzed non-financial information; Kulevicz et al. (2020) studied how sustainability reports address socio-environmental and business issues; Sikacz (2017) systematized the publications on corporate social responsibility (CSR) reporting.

However, previous studies on the dissemination of social accounting have not included the epistemological paradigms that guide them, so the objectives of this article are to map the literature on social accounting and its dissemination, use the bibliometric method, and identify the main theoretical currents and the research paradigms used and frame them in the taxonomy of Hopper and Powell (1985). In accordance with Hopper and Powell's taxonomy (Hopper and Powell 1985) which, based on the epistemological and ontological assumptions of the researcher, points to three distinct research paradigms in management accounting, which are: positivist research (mainstream), interpretative research and critical research.

Following this brief introduction, the literature review, methodology, results and conclusions are presented.

2. Literature Review

Accounting can be used to communicate a company's performance to all stakeholders (Riahi-Belkaoui 2004). This information can be reported through formal and/or informal accounting mechanisms, whether formal reports (financial reports) or informal/voluntary reports (sustainability reports) (Buhr and Reiter 2006). Accounting is only one and, in this context, it is difficult to draw a line between financial accounting, social accounting, and

environmental accounting (Cooper et al. 2005). However, with social and environmental impacts becoming more evident, the role played by sustainability has become hardcore in several contexts. In this sense, sustainability research has emerged significantly in academia, so Bebbington and Larrinaga-González (2014) have explored the possibilities of building a sustainability-driven accounting system, suggesting two lines of research: sustainability and total cost accounting, and sustainable consumption/production. Historically, Bebbington and Gray (2001) noted that social accounting became an emerging research topic from the 1970s, reflecting its importance for economic growth (Jones 2003). In addition, social and environmental issues and their performance, have begun to be taken into account in corporate management strategies (Gray 2002). However, during the 1980s and 1990s, interest in social and environmental reporting increased (Adams 2002). It has been found that internal factors, such as ethics and transparency, influence the type of information disclosed in companies. In this period, some regulation on these issues has emerged that has institutionally obliged companies to report information on their social and environmental policies (Adams 2002).

These regulations are intended to establish some standardization in corporate reports, so Bebbington et al. (2012) carried out a comparative study between two countries (Spain and the United Kingdom), with different regulations, which concluded that the legitimacy provided by-laws is crucial for the construction of standardization, and also provided a more subtle set of considerations for understanding the role of regulation in these reports. In this area, the literature has focused on some specific themes, such as social and environmental accounting (e.g., Herbohn 2005; Larrinaga-González et al. 2001), the impacts of legislation (e.g., Deegan and Blomquist 2006; Larrinaga et al. 2002), the dissemination of social and environmental information (e.g., Patten 2005), and the relationship between the dissemination of such information and performance (e.g., Adams 2004). For Moser and Martin (2012), many companies are trying to project an image of commitment to social accounting by voluntarily including additional information in their annual financial reports and demonstrating that they create value for all stakeholders and not just the shareholder. This issue arises mainly in large economic groups. The transfer of social accounting practices between countries voluntarily, with differentiated regulations, implies financial investment, an alignment of values, with added advantages for host countries (Bansal 2005). The advantages inherent in this situation are visible in the strengthening of the transparency, reputation and legitimacy of these economic groups in the global business environment (Bansal 2005) and improving the relationship with all stakeholders.

In this context, organizations must communicate information according to stakeholders and show that their information systems, particularly their accounting systems, are appropriate for providing final outputs on social accounting (de Lima Voss et al. 2017). The dimensions included in social accounting (SEA) reflect that businesses contribute to a country's wealth and economic growth and its social and environmental sustainability (Dahlsrud 2008). Thus, for Jennifer Ho and Taylor (2007), there is an awareness that large economic groups of the imperative need to report on these issues and their social performance, whether through voluntary or mandatory disclosure. Social accounting issues can thus be seen from two perspectives. The first relates to the fulfilment of the subsequent responsibilities and obligations of companies.

In contrast, the second relates to the management of the interests of the various stakeholders and represents a means of obtaining internal and external legitimacy (Murray et al. 2006). On the other hand, social accounting has more impact. It is better evidenced in companies carrying out activities with adverse effects on society in general and the environment (Liu and Anbumozhi 2009), as they have greater public exposure (Reverte 2009). However, other factors influence social reporting. Some authors (Lu and Abeysekera 2014; Van de Burgwal and Vieira 2014; Huang and Kung 2010) have shown that the size of the company, its financial profitability, the influence of stakeholders, external controls (audits), influence the implementation of a social accounting information system.

In short, social accounting is a broad term, including concepts such as corporate social responsibility (CSR), social responsibility accounting (CRA), SEA, reporting and its disclosure, as well as its auditing (Gray et al. 2009). This means that companies tend to promote strategies that incorporate social accounting (SEA) in conjunction with CSR as part of their objectives (Brown and Fraser 2006). However, in terms of practical actions in the surrounding environment and society, these tend to be barely visible (Sikka 2010). This argument does not prevent social accounting from fostering dialogue and commitment with all stakeholders, and there must be a common language and plurality of issues to be discussed (Bebbington et al. 2007; O'Dwyer 2005). Recently, some authors (Adedeji et al. 2018) have argued that it is crucial to determine the influence of corporate governance on companies' sustainability through the initiatives they implement and their association with performance. This means that social accounting is gaining importance for companies. However, most of the evidence gathered in the articles reviewed by Patten and Shin (2019) suggests that sustainability disclosure remains incomplete, biased, and driven by legitimacy concerns. These authors argue that better regulation is needed, including implementing the disclosure of entities' social and environmental information.

Finally, Table 1 shows the studies considered essential/gurus when researching social accounting.

The most studied themes in the 1970s to 1990s are theorization/conceptualization around social accounting, the disclosure of its information and the motivations for doing so. These themes show a cause–effect relationship between them, which means that firstly, it is necessary to define the concepts inherent to social accounting, understood as a new area of accounting. Next, it is necessary to understand how important it is for companies to obtain legitimacy before all stakeholders, which has a positive effect on its disclosure (voluntary or otherwise) and on the motivation of managers/companies to include it in their social performance reports. Nevertheless, these remain of exponential interest to academics, as it is intended to demonstrate in the following sections.

Table 1. Important previous research.

Author(s)	Type of Study	Objective	Conclusions
Reviews and concepts in social accounting research			
Gray (2002)	Theoretical	Review of the literature over the last 25 years on social accounting, in particular articles published in the journal Accounting Organizations & Society.	Social accounting, as a promising area of accounting research, should make more use of its theoretical wealth, and more articles should be published on the commitment it involves.
Rubenstein (1992)	Theoretical	Build the bridge between green accounting and traditional accounting.	Given the existence of natural resources that are crucial for global economic growth, it is pertinent to create accounting that allows the recording of their degradation in the financial statements of the companies that exploit them. This means that accounting will reflect a new social contract between all stakeholders, which goes beyond traditional accounting.
Bebbington and Gray (2001)	Empirical	Through Social Cost Calculation (SCC) they aim to measure the additional costs that companies incur to be sustainable throughout their lifetime in accounting terms.	Although it is a specific case study, they concluded that this was useful in understanding where the implementation of the SCC failed so that it can be avoided in future implementations.
Cooper and Sherer (1984)	Theoretical	Presentation of an alternative scheme for carrying out research in corporate accounting.	Accounting research in the economic, social and environmental dimensions should use an alternative approach (normative, descriptive and critical), particularly in the last two dimensions that are of interest to all stakeholders and not only the shareholder.

Table 1. *Cont.*

Author(s)	Type of Study	Objective	Conclusions
Gray (1992)	Theoretical	Bridging the gap in the literature on natural environment research.	Previous research has provided little informative detail on a new accounting that responds to the interests of social and environmental issues. They highlight some contributions to the creation of such accounting, as it is profoundly difficult to begin to rebuild the world on the basis of financial/accounting practices.
Gray et al. (1997)	Empirical	Understanding of the theoretical and practical issues of social accounting, taking stakeholders into consideration.	The social accounting agenda remains open and is a dynamic process that requires commitments. Thus, it is crucial that the academic community continues to research it and that the necessary theoretical and practical changes are promoted.
Gray (2010)	Theoretical	Understanding of what the concept of sustainability can mean for accounting and finance.	They have compiled the speculation around how to move towards sustainable accounting, which is a challenge.
Hines (1991)	Theoretical	Address the functional gap in the FASB, (Financial Accounting Standards Board) conceptual framework based on anthropology, between accounting and economic reality.	They aimed to facilitate demythologising between reason and objectivity as a means of facilitating critical, constructive and social research in the field of accounting.
Neu et al. (1998)	Empirical	Study of the role of environmental reporting in the mining industry.	The reports show social and environmental information, but it is very aggregated and it is not possible to see the actions taken by the companies.
Legitimacy vs. disclosure of social accounting			
Patten (1992)	Empirical	To examine, based on legitimacy theory, the effects of oil companies' spillages, i.e. their inclusion in their annual reports.	There has been a significant increase in these disclosures, which has a positive relationship with company size and capital holders. This means that when the legitimacy of the company is called into question, they include more social and environmental information in their annual reports.
Dowling and Pfeffer (1975)	Empirical	To provide a conceptual framework for the analysis of organizational legitimacy and the process of obtaining it.	They concluded that legitimacy provides a means to analyze the behaviors that organizations engage in as they vary according to their environment and their own values.
Wiseman (1982)	Empirical	Assessing the quality and accuracy of the disclosure of environmental information included in companies' annual reports.	It concluded that the disclosure of this information is incomplete and does not report on environmental performance.
Motivations for disclosing social accounting			
Hirshleifer (1971)	Empirical	Analysis of the economic information that individuals possess, but incomplete, i.e. they only have information about market opportunities.	He concluded that it is crucial to have public and private information about the market and its environment.
Verrecchia (1983)	Empirical	Presentation of a case, where the information to be disclosed is risky. associado, pelo que deve ser discricionária.	It shows how the existence of costs to be disclosed in excess of stakeholder expectations provides a motivation to withhold such unfavorable information.

3. Methods

This article's research methodology consists of a bibliometric review (analysis of co-citations) using the R software. Bibliometrix (Aria and Cuccurullo 2017). It is a study based on co-citation networks and content analysis (by reading all articles). This type of approach has as its unit of analysis the scientific articles (in this case, the research focused only on scientific articles) and consists of a grouping of documents with a common goal and hardcore (Grácio 2016). This type of analysis provides the identification, evaluation, and analysis of content in specific areas and systematization of concepts, theories, and practices (Rowley and Slack 2004). Content analysis is a research tool aimed at analyzing and systematizing data for replication, with the selection of the data to be analyzed being crucial (Krippendorff 1980) and data collection in this study, followed the common research procedures, through the ISI Web of Science (WoS) search engine to ensure their reliability, since this engine ensures real-time data availability (Krippendorff 2004, 2012). This means that it is a compilation of scientific documents and their contributions, as it brings critical added value and provides a synthesis of the literature on the topic under study and the identification of relevant gaps and clues for future research purposes. Its main objective is to contribute to the advancement of scientific knowledge on this topic by identifying patterns of subtopics, authors, scientific journals, citations, co-citations, keywords, among others (Prasad and Tata 2005; Treinta et al. 2014); and conceptual contents (Seuring and Müller 2008).

This analysis also followed the methodological procedures defined by Tranfield et al. (2003): planning; development; and presentation of results. In this context, the bibliometric analysis of a specific area of research implies adopting a methodical and structured research strategy for the selection of the documents to be included in the respective literature systematization. Thus, it is crucial to define the criteria and keywords to be used in the process of enquiry and specification of documents (Bandara et al. 2011), and therefore the delimitation of the literature search process is fundamental to obtain an appropriate link between the main topic and subtopics and then proceed to their descriptive analysis (Quesado and Silva 2021; Treinta et al. 2014).

Table 2 presents the criteria used in the October 2020 survey.

Table 2. List of Items and Search Criteria.

Items	Criteria
Time horizon:	No chronological filter
Online databases:	ISI (WoS)
Keywords:	Social and CSR accounting and disclosure
Serialization by search category:	Management or Corporate Finance or Economics or Environmental Studies or Environmental Sciences
Serialization by type of document:	Articles
Software used:	R. Bibliometrix
Documents analyzed:	126

After obtaining the final version of the scientific articles database, the analysis developed through the following steps:

1. Export to BIBText of all the bibliographical data in order to prepare the descriptive analysis of the 126 scientific articles identified on the subject (Table 1), in terms of the type of document, number of citations, distribution by year of publication, authors, countries, research areas, and titles of sources.
2. The bibliometric analysis was performed using the R Bibliometrix software (Aria and Cuccurullo 2017). A set of tools was used to process all data on serial publications for analysis (126 documents). From this processing several outputs can be extracted (e.g., on authors, number of publications, networks, couplings) (Ekundayo and Okoh 2018),

which result from procedures for standardizing similarity of publications (Aria and Cuccurullo 2017). The R Bibliometrix software is a package for bibliometric analysis written in R. According to Derviş (2019), R is open-source software, which means that it operates in an integrated environment that consists of open libraries, open algorithm and open graphic software. This tool's other strengths are potent and effective statistical algorithms, access to high-quality numerical routines, and integrated data visualization tools (Aria and Cuccurullo 2017). The R Bibliometrix software can be used to analyze and map bibliographic data simultaneously (Derviş 2019). Compared with other open-access programs such as VOSviewer, Bibliometrix focuses on not only data visualization but also the accuracy and statistical robustness of results (Derviş 2019).

3. Enrichment of the bibliometric analysis, through the integration of a content analysis of the 126 selected documents, aiming to systematize the topics/subjects of research most studied by the scientific community and that originated the clusters (Spens and Kovács 2006; Seuring and Gold 2012). However, this analysis of content is somewhat subjective, given its qualitative character. However, this does not impugn the validity of its inferences and their rigor (Becker et al. 2012), so a structured and systematic approach has been adopted to overcome this limitation, as recommended by Tranfield et al. (2003) and Seuring and Gold (2012).
4. Definition of the research paradigms used in published studies, based on the criteria defined by several authors (Orlikowski and Baroudi 1991; Chen and Hirschheim 2004; Dwivedi and Kuljis 2008), namely whether the article uses primary data (empirical study or not); the nature of the empirical study developed (quantitative and qualitative); and the methods used.

4. Analysis and Discussion of Results

4.1. Characterization of the Data Collected

Before going into the analysis of the data collected, a general characterization of the data collected is presented in Table 3.

Over 15 years, 287 authors have published 126 documents on the dissemination of social accounting information. There is a high level of collaboration in work done. In other words, collaboration among authors appears as a critical factor, and consequently, only eleven authors have published articles individually. The articles analyzed were cited by about 22 authors and have collected more than 3 citations per year.

Table 3. Characteristics of the Data Collected.

Description	Results
TIMESPAN	
Sources (Journals, Books, etc.)	2006 to 2020
Average citations per documents	3.03
Average citations per year per doc	21.88
References	3.767
DOCUMENT TYPES	6.260
Article	
Article and Review	126
DOCUMENT CONTENTS	
Keywords Plus (ID)	338
Author's Keywords (DE)	412

Table 3. *Cont.*

Description	Results
AUTHORS	
Authors	287
Author Appearances	306
Authors of single-authored documents	11
Authors of multi-authored documents	276
AUTHORS COLLABORATION	
Single-authored documents	12
Documents per Author	0.397
Authors per Document	2.52
Co-Authors per Documents	2.68
Collaboration Index	2.71

4.2. Evolution and Characterization of Scientific Production

Concerning the temporal evolution of the articles published on the subject under study, Figure 1 shows researchers' growing interest. Thus, there has been a substantial growth from 2015 onwards, with the most productive year for the publication of research articles on social accounting and its dissemination being the year 2018, with 27 publications, and it is now the year 2020, with 27 publications. This means that the subject continues to arouse growing interest in the scientific community.

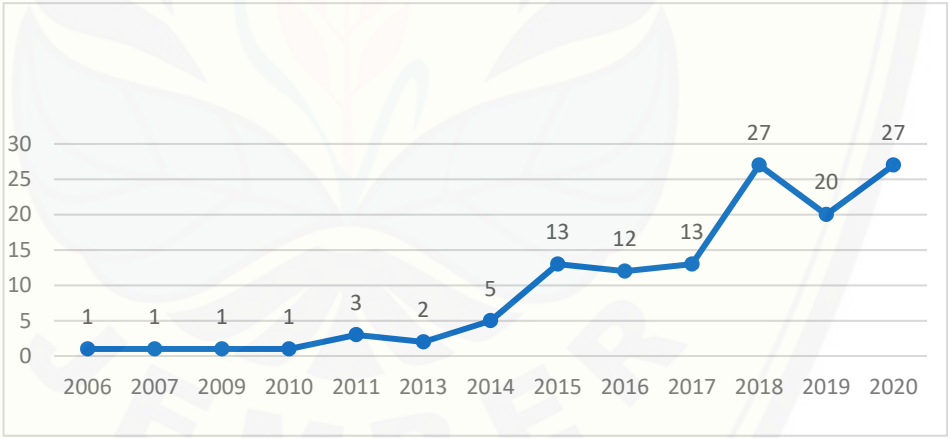

Figure 1. Evolution of the Number of Publications on Social Accounting Disclosures, by Year.

The growth of publications in recent years indicates that this issue has begun to arouse interest and draw attention to social responsibility and the importance of it being disseminated and reported to all stakeholders so that they are endowed with credibility legitimacy both internally and externally. Of course, this legitimacy does not relate to accounting as such, but to the parties involved in its disclosure. It should also be noted that these publications are essentially empirical studies, identifying only two literature review articles, one published in 2015 and one in 2016, and two theoretical articles. The theoretical paper of 2016 shows a recently criticized analysis of the impacts of corporate social responsibility on sustainable human development (Anstätt and Volkert 2016). One of 2015 studies the evolution of social responsibility reporting standards (Tschopp and Huefner 2015). As for empiricists, their main characteristic lies in analyzing published social responsibility reports, in their various items.

To find out which countries publish more articles on the subject under analysis, Figure 2 shows the relevance of each country in the total of articles analyzed, considering the country of the first author, following the information taken from the ISI WoS.

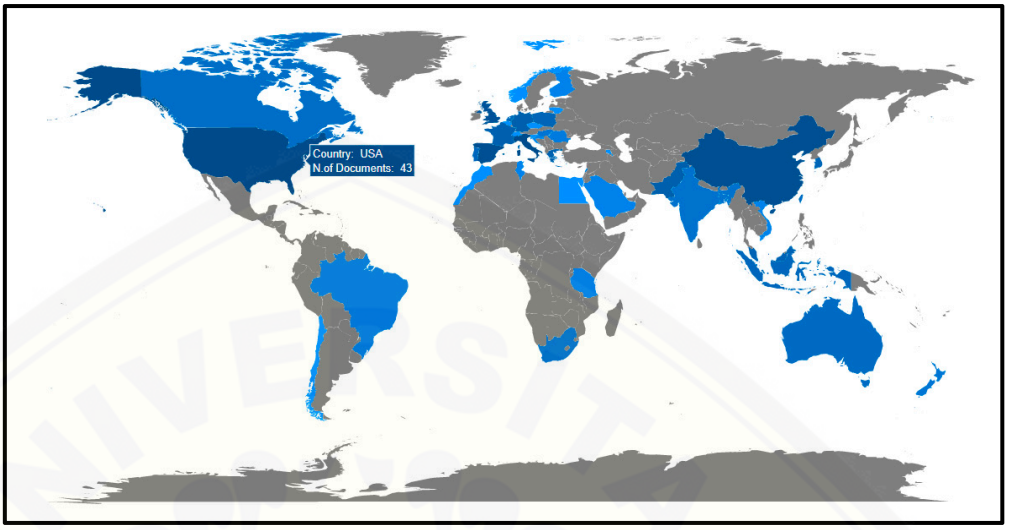

Figure 2. Publications by Country (Country of the first author).

Figure 2 shows the scientific production of the United States of America with 43 publications, Italy (40), China (31), Spain (8), and the United Kingdom (4). In China's case, the interest comes from the importance that the extractive industry has assumed in the economic activity of this country. Here, the negative impacts (e.g., a significant number of accidents in recent years) have triggered the academic world's interest in studying social accounting and its dissemination in this country.

According to the procedures described (first step), the frequency of publications per journal is shown below (Table 4).

Table 4. Journals with the highest number of articles and Web of Science Impact Factor.

Journal	Number of Publications	%	Impact Factor
Sustainability	14	11.11%	2.576
Journal of Business Ethics	12	9.52%	1.165
Corporate Social Responsibility and Environmental Management	10	7.94%	0.97
Sustainability Accounting Management and Policy Journal	10	7.94%	0.67
Social Responsibility Journal	7	5.56%	0.43
Journal of Cleaner Production	5	3.97%	1.615
Journal of Global Responsibility	4	3.17%	0.26
Management Decision	4	3.17%	0.86
Other (<4 publication each)	60	47.6%	
Total	126	100%	

The magazine with the largest number of publications is *Sustainability* magazine. As can be seen in Table 4, it is the journal with the highest impact factor (2.576). The 14 articles published in this journal total 119 citations, with the most frequently cited article (30 citations) by Matuszak and Różańska (2017) being published in this journal. This article addresses the new non-financial reporting requirements implemented through Polish

accounting legislation (PAA) in 2017, after the transposition of an EU directive. This study portrays the analysis carried out in the reports of 150 listed companies after implementing this legislation.

It is also noted in Table 4 that we have four journals: *Sustainability*, *Journal of Business Ethics*, *Corporate Social Responsibility and Environmental Management*, and *Sustainability Accounting Management and Policy Journal*, which concentrate 36.5% (46 articles) of the publications. This does not prevent some dispersion in the publication of this type of work, since there is also a significant group of journals (60) less than three publications. This group of 60 includes the *Accounting Review* journal, with an impact factor of 5.45 and the article by Soana (2011) reflected in the Table 5.

Table 5. Most Cited Articles in the Web Database of Science.

Authors	Journal	Year	Number of Citations	Annual Average Citations
Reverte	*Journal of Business Ethics*	2009	387	32.25
López, Garcia, & Rodriguez	*Journal of Business Ethics*	2007	255	18.214
Kim, Li, & Li	*Journal of Business Ethics*	2006	206	29.429
Soana	*Journal of Business Ethics*	2011	110	11
Vuontisjarvi	*Journal of Banking & Finance*	2014	108	7.2
Mallin, Farag, & Ow-Yong	*Journal of Business Ethics*	2016	85	12.143
Nollet, Filis, & Mitrokostas	*Economic Modelling*	2016	71	14.2
Chauvey, Giordano-Spring, & Cho	*Journal of Business Ethics*	2015	69	11.5
Martinez-Ferrero, Garcia-Sanchez	*Corporate Social Responsibility and Environmental Management*	2015	65	10.833
Garcia-Sanchez & Cuadrado-Ballesteros	*Long Range Planning*	2010	61	12.2
Harjoto & Jo	*Journal of Business Ethics*	2015	61	10.167
Skouloudis, Evangelinos, & Kourmousis	*Journal of Cleaner Production*	2010	59	5.364
Galant & Cadez	*Economic Research-Ekonomska Istrazivanja*	2017	48	12
Giannarakis, Konteos, & Sariannidis	*Management decision*	2014	46	6.571
Tschopp & Huefner	*Journal of Business Ethics*	2015	39	6.5
Tschopp & Nastanski	*Journal of Business Ethics*	2014	37	5.286
Mio & Venturelli	*Corporate Social Responsibility and Environmental Management*	2013	36	4.5
Reverte	*Review of Managerial Science*	2016	32	6.4
Matuszak & Rozanska	*Sustainability*	2017	30	7.5
Perez-Lopez, Moreno-Romero, & Barkemeyer	*Business Strategy and the Environment*	2015	28	4.667

The following graph (Figure 3) shows each journal's growth over the years, with *Sustainability, Journal of Business Ethics,* and *Accounting, Auditing and Accountability Journal*, especially from 2014 onwards.

Furthermore, the authors with the most significant number of publications were sought in the 126 articles analyzed. The author Antonis Skouloudis stands out, with three articles published on the topic under analysis. Two of the articles were published in the *Journal of Cleaner Production* and one article in the magazine *Corporate Social Responsibility and Environmental Management* (Khan et al. 2019; Skouloudis et al. 2010; Skouloudis et al. 2014). In Skouloudis et al. (2010), the non-financial report prepared following the GRI-Global Reporting Initiative, Greece, was studied. The results of this study show that improvements

and more outstanding commitment from stakeholders are still needed. In Khan et al. (2019), corporate social responsibility was addressed from a very particular perspective: people with disabilities. The authors of this study concluded that there is still room for improvement in actions that create the quality of life for these people. In Skouloudis et al. (2014) it was found that, in Greece, the dialogue of large companies with their stakeholders in terms of social responsibility is still very superficial and that only a minority group of companies values this dialogue.

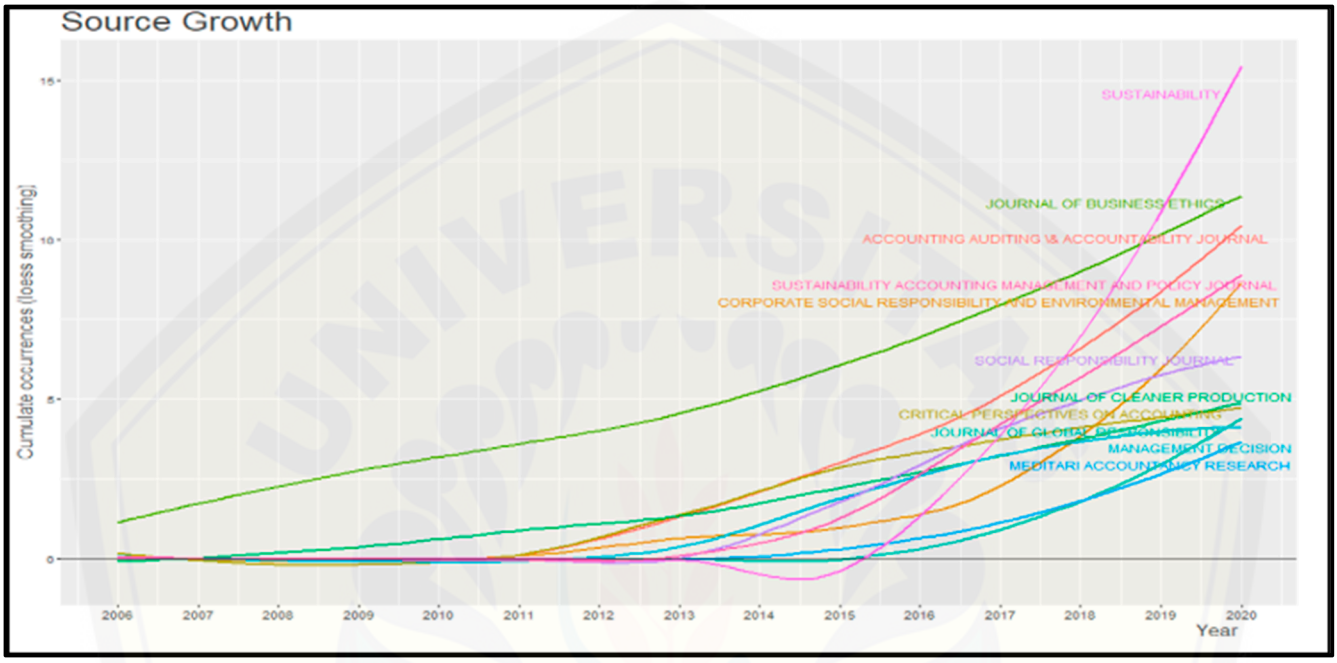

Figure 3. Evolution of Publications, by Year and Journal.

To find out the most relevant works according to the number of citations received by each article, the number of citations and the annual average of citations of the articles were analyzed (Table 5). Although the analysis focused on the 126 articles analyzed, only the 20 most cited articles by other authors are presented here. The Journal of Business Ethics is highlighted here with 8 of the 20 articles in this list. On the other hand, the three papers with the highest number of citations and the highest annual average were also published in this journal (see Table 4). As can be read on the page of the journal itself, the prominence of this journal stems from the fact that social responsibility, social accounting and their disclosure have a significant relationship with the ethical and ontological principles that should guide this particular area of management research.

4.3. Bibliometric Analysis

Moving on to stage 2, network analysis is increasingly used for the operationalization of bibliometric studies and metric studies (Jalal 2019). In this context, the Bibliometrix R software allows a network analysis, through algorithmic connections between the various attributes of the database, and an additional analysis-co-citation or coupling networks (Aria and Cuccurullo 2017). These networks are examined to capture the significant properties of the research subject under analysis and, in particular, to determine the influence of bibliometric units, such as authors and keywords (Aria and Cuccurullo 2017). The data collected were downloaded in Bibtex format from Clarivate Analytics' Web of Science (WoS) database. Subsequently, R Studio software version 1.2.5042 was used to eliminate duplications and to create a unified database. This process resulted in the 126 documents that we have analyzed in this work.

From an analysis of keywords, it was possible to see that specific themes tend to appear related to each other, forming clusters, i.e. densely grouped sets of terms in publications on this theme. We used a factorial analysis to create a map/conceptual structure from a multiple correspondence analysis (MCA). We can see how different concepts are correlated in the analyzed studies (Figure 4). This technique searches for possible keywords in the data records and applies multiple matching analysis (MCA) to the identified keywords. However, irrelevant keywords may occasionally appear.

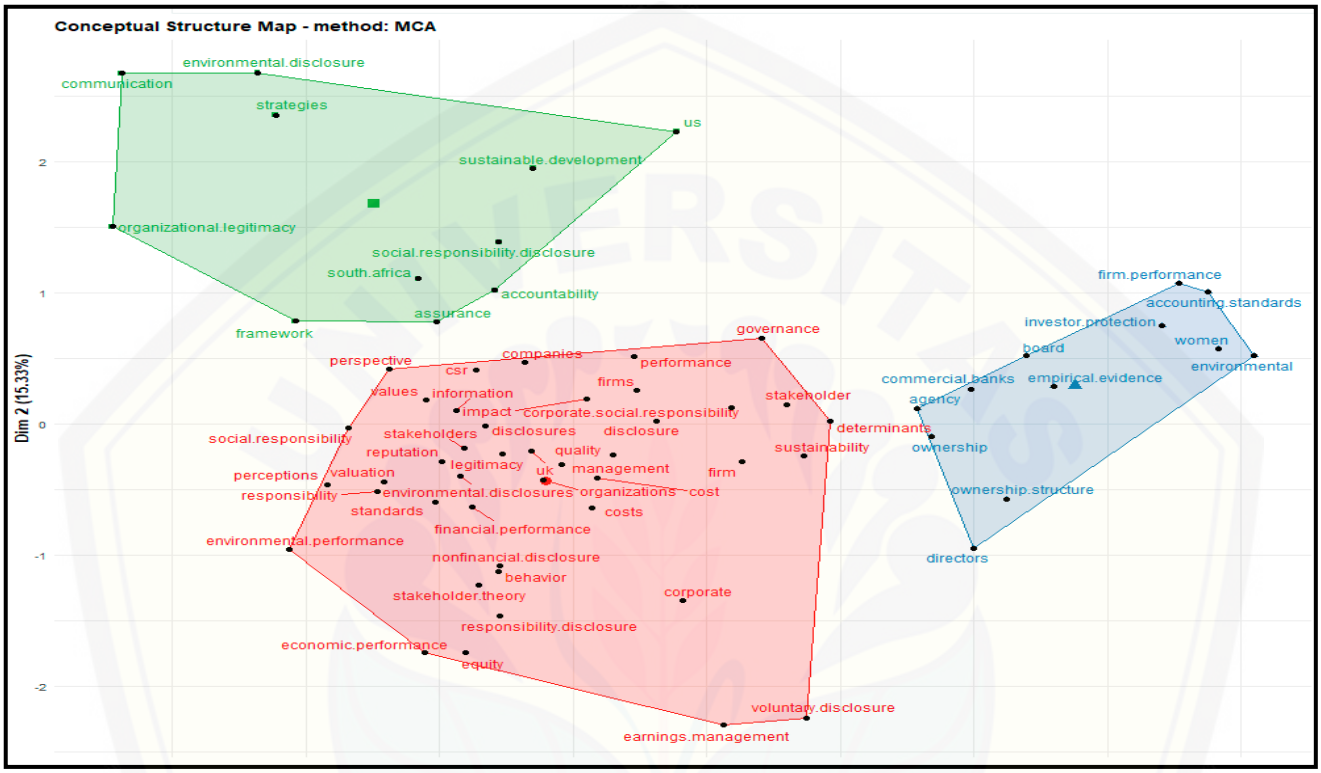

Figure 4. Conceptual Structure Based on the Correlation between Words (n = 126 documents).

This technique identifies research trends in social accounting and its dissemination, and there are three distinct clusters (three colors). Thus, from the analysis of the keywords, it is possible to create or identify a potential conceptual structure on the subject, as shown in Figure 4.

It can be seen that the largest cluster (red) addresses issues related to stakeholder theory and some issues of legitimacy and environmental reporting, voluntary or not, for stakeholders. The issues of financial and non-financial reporting, the linkage of voluntary reporting to the manipulation of results or the study of voluntary reporting determinants are addressed here. The relationship between economic performance and environmental performance is also analyzed here.

The second (green) cluster explores issues associated with disseminating information on social responsibility and the importance of communication in social and environmental reporting. The characteristics of communication on organizational legitimacy are also analyzed.

Finally, in the third cluster, themes associated with disseminating social and environmental information more focused on the company, the characteristics of the management team, the ownership structure, and the protection of shareholders emerge.

Complementary to this figure is a network of co-quotes between authors (Figure 5) that allows identifying the most relevant works and authors cited by more authors, highlighting, among others, the article by Gray et al. (1995) and the classical works by Freeman (1984), Waddock and Graves (1997), and Deegan (2002).

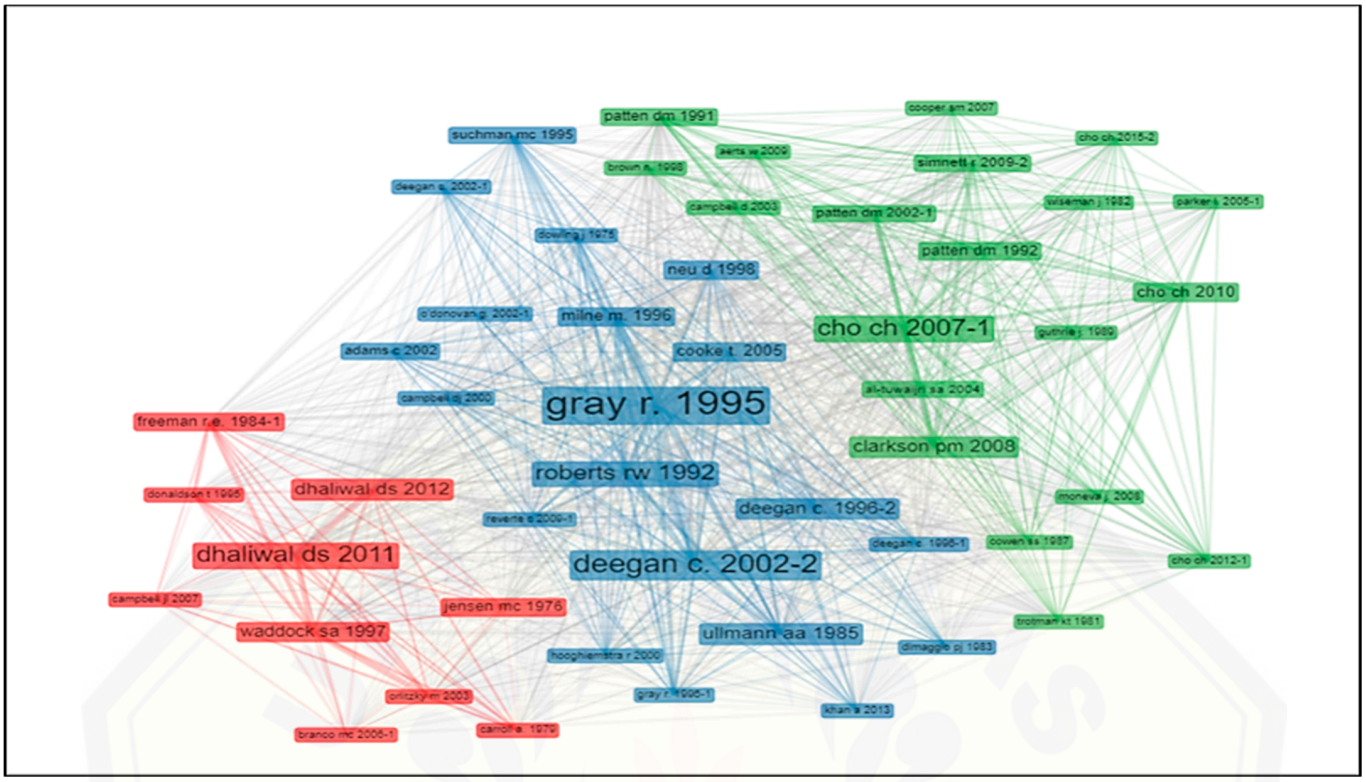

Figure 5. Bidding Network (n = 126 documents).

Three major groups or clusters of authors are also evident here. The first with work related to the issues of legitimacy and disclosure of information on social accounting (blue), the second with work related to the issues of disclosure of information on social accounting (green), and the third focusing on the motivations leading to the disclosure of information on social accounting.

In order to visualize the existing network of scientific collaboration between academics/authors, most studied topics, and journals/journals where the outputs are published, a graph of three fields or Sankey's Diagram (Figure 6) was used, which allows the visualization of the prominent authors, topics (keywords) and international journals where the publications were made. The representation of the network in graphic format facilitates the visualization of the interactions between the three fields analyzed. In this graph, the larger the size of the colored rectangles, the greater the frequency/importance of a given magazine, keyword, or author in the collaboration network. In addition, the links (the lines connecting institutions, keywords, and authors) vary in thickness depending on the number of links. In this context, the graph shows that themes such as "performance", "corporate social responsibility", "governance", and "environmental disclosures" are the ones that generate the most significant collaboration between academics from different institutions. Among the essential authors/papers are Gray et al. (1995); Deegan (2002); Roberts (1992); Cho and Patten (2007); Dhaliwal et al. (2011); Waddock and Graves (1997). Concerning journals, Sustainability, the Journal of Business Ethics and the Journal of Cleaner Production stand out. In terms of topics, performance studies, legitimacy, corporate social responsibility, and environmental reporting are highlighted.

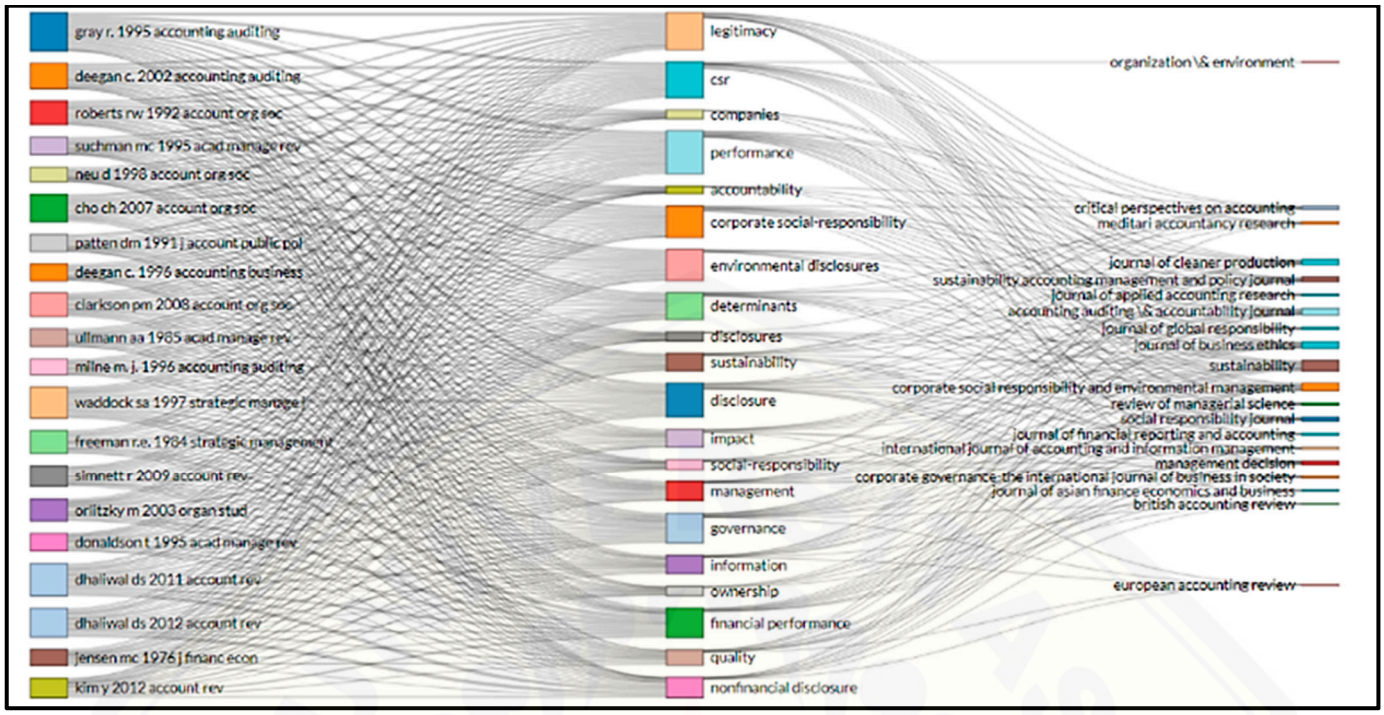

Figure 6. Collaborative network between authors (**left**), topics (**center**) and subsequent publication in a journal (**right**).

4.4. Analysis of the Most Relevant Work

The content of the most relevant work highlighted in each of the clusters identified above was then analyzed. In this context, it is also important to understand the relevance of social accounting in the legitimization of companies' actions and to understand which factors positively affect disclosure (voluntary or not) and on the motivation of managers/companies to include information in their social performance reports. It was also found that the disclosure of information on social accounting is crucial for companies to gain credibility with all stakeholders.

It should be noted that the studies covered in this review have a diversified theoretical framework that includes the theory of legitimacy, stakeholder theory, and institutional theory. This is justified because social accounting is a new area of research that provides intangible benefits to organizations, even if there is some asymmetry of information, which is reflected positively in their financial results and creates value for shareholders and other stakeholders.

Linking the work identified in Figure 5 with the analysis of the main articles developed in Table 6, it can be seen that in the first group we find work framed in the theory of legitimacy (Gray et al. 1995), namely, in the way the search for legitimacy explains the voluntary disclosure of information by companies (Deegan 2002). Here we also find work based on stakeholder theory, namely to explain how stakeholders' power conditions the dissemination of information and CSR practices (Roberts 1992). In the second group, we find work framed in stakeholder theory (Freeman 1984) and focused on the issues of disclosure of information to stakeholders and the impact this voluntary disclosure has on the value of the company (Dhaliwal et al. 2011) and financial analysts' forecasts (Dhaliwal et al. 2012). The third group includes studies that sought to study why companies disclose social accounting information (Cho and Patten 2007) and research the use of language and tone to mask poor performance (Cho et al. 2015).

A further reading of the above table compared to Table 1 shows that the topics highlighted in the latter remain a fertile theme as evidenced in clusters 1 to 3.

Table 6. Analysis of content per cluster (based on the work shown in Figure 5).

Author(s)	Type of Study	Objective	Conclusions
Cluster 1: Legitimacy vs. social accounting disclosure (blue)			
Gray et al. (1995)	Empirical	Interpretation and understanding of the CSR in the UK and its dissemination, in the light of various theoretical frameworks, such as the theory of legitimacy and stakeholder theory.	The conclusion is limited to the geographical context of the study. However, they call for homogenization of practices, both at the level of action and dissemination.
Deegan (2002)	Theoretical	Introduction to a particular volume of the Accounting, Auditing & Accountability Journal on social and environmental reporting, its role in legitimacy, and its dissemination motivations.	It concludes that the theory of legitimacy is widely used to explain the motivations for disseminating this type of information; these motivations are significantly related to the legitimacy that they intend to obtain/maintain for the activity performed.
Roberts (1992)	Empirical	Explanation of corporate social responsibility practices, based on stakeholder theory.	It concludes that this theory explains the need for these practices. The measurement of stakeholder power, strategic stance, and economic performance affect the amount of information disclosed about them.
Cluster 2: Disclosure of social accounting information (red)			
Dhaliwal et al. (2011)	Empirical	Analysis of the impact of voluntary environmental disclosure on business value	They concluded that when a company starts voluntarily disclosing CSR, there is a reduction in the cost of equity. However, they perform well on social responsibility vis-à-vis non-initiated companies. Thus, a potential reduction in equity cost can be a motivating factor for companies to publish social reports autonomously.
Dhaliwal et al. (2012)	Empirical	Study on the relationship between financial and non-financial disclosure and the accuracy of analysts' profit forecasts.	They argued that the disclosure of non-financial information is linked to better environmental information and the fact that it complements the disclosure of financial information, which mitigates the negative effect of the financial opaqueness of the accuracy of the forecasts.
Waddock and Graves (1997)	Empirical	Study of empirical links between social and financial performance.	They argued that this link is visible because the existence of financial leeway for the availability of resources for the CSR is positively associated with the financial result.
Orlitzky et al. (2003)	Empirical	Presentation of a meta-analysis of primary quantitative studies on social and financial performance.	They showed that social performance is positively correlated with financial performance. This relationship tends to be two-way, that reputation is an important mediating factor for disclosure to stakeholders.
Cluster 3: Motivations/Reasons for the disclosure of social accounting (green)			
Cho and Patten (2007)	Empirical	Seeking to analyze the motivations that lead companies to disclose information, these authors will investigate whether social and environmental reporting is a tool for legitimacy.	They conclude that companies use the disclosure of environmental information in financial reporting as a tool for legitimization.
Cho et al. (2010)	Empirical	Analyze whether discriminatory language and verbal tone are reflected in the dissemination of company information.	They conclude that less compliant companies use language and verbal tone to influence the message. To hide their poor performance, these companies use more optimistic language in environmental reporting and seek to disguise the internal reasons for their poor performance through complex and dubious language.
Simnett et al. (2009)	Empirical	Analysis of sustainability reports and factors associated with their preparation	They explained that there is a strong link between the production and dissemination of these reports and the achievement of credibility, notably through an external audit.

4.5. Research Paradigms

For the classification of research paradigms used in published studies, the taxonomy of Hopper and Powell (1985) was used, which points to the existence of three distinct research paradigms in management accounting research: the mainstream, the interpretative paradigm and the critical paradigm. To operationalize this classification, the criteria defined by several authors (Orlikowski and Baroudi 1991; Chen and Hirschheim 2004; Dwivedi and Kuljis 2008) were used, namely, whether the article resorted to primary data (empirical study or not); the nature of the empirical study developed (quantitative and qualitative), and the methods used.

Positivist research represents the most classical and predominant line of research orientation in management accounting (Modell et al. 2007). Its theoretical premises were built on neoclassical economic theory and organizational theory (Wickramasinghe and Alawattage 2007). This way of investigating views society objectively, views individual behavior as deterministic, the researcher here draws on positivist methodology to develop research (Chua 1986; Hopper and Powell 1985; Modell et al. 2007; Ryan et al. 2002) and favors quantitative data and generalization of findings (Ryan et al. 2002; Chua 1986). Therefore, researchers who adopt this type of research assume that management accounting functions independently and disconnected from human consciousness and organizational imperatives. For these researchers, management accounting practices are based on the requirement that there are linear relationships of cause and effect and that organizational practices are universal and independent of the surrounding context, i.e., they function similarly anywhere in the world (Simões and Rodrigues 2012). In this line of thought, the function of management accounting is to ensure that all organizational processes are executed according to plan and, thus, to ensure that resources are used effectively in dynamic and competitive contexts, argued Simões and Rodrigues (2012).

This means that positivist research emphasizes the relationships between things, which stems from the fact that positivism is not interested in the causes of phenomena, but rather how the relationships between facts are produced, studying them without interest in their practical consequences, i.e., the purpose of the researcher is to portray reality, not to judge it (Theóphilo and de Iudícibus 2001). On the other hand, in recent years, some interpretative research works have emerged, which, according to Silva and Silva (2013), attempts to understand the social nature of accounting practices. Its aim is not to generalize or predict future events based on present studies, but to understand daily events, social structures, the meanings that people attribute to it, including the behavior of individuals in a certain context. These ideas are shared by Ryan et al. (2002) who considered that this type of interpretation takes into account the relationship between daily actions and the dimensions of the overall structure, more specifically, in management accounting one seeks to understand how systems interact with their context; that is, researchers follow a holistic orientation.

As opposed to the positive paradigm, the interpretative perspective is based on the premise that social practices, which includes management accounting, are not a natural phenomenon, but a socially constructed phenomenon (Covaleski et al. 1996; Ryan et al. 2002), in which reality is understood as a result of a social construction process and the parties involved can change the social rules and practices that direct their behaviors (Simões and Rodrigues 2012). Additionally, Wickramasinghe and Alawattage (2007) argued that this perspective postulates that accounting practices are the result of the meanings and perceptions shared by the actors involved in the organizations. In other words, the interpretive perspective aims to understand and discover the meanings and beliefs underlying the actions of these actors, in which subjectivism is always implicit (Lourenço and Sauerbronn 2016).

In general, interpretive research uses qualitative methods, using an interactive process involving a field study, which is interpreted in its context from the perspective of the various actors. In this type of research, the researcher is not concerned with obtaining ultimate truths, but rather reports that reflect the various interpretations, since reality is considered to be a construction of its various participants (Silva and Silva 2013).

Despite seeming, in the light of positivist theories, an inadmissible procedure, in interpretative research there is an involvement of the researcher himself in the object of investigation in which the interpretation obtained results much from his experience as a researcher (Silva and Silva 2013). The results of this type of research usually present an account of concrete situations, enabling various interpretations that are tested through case studies (Yin 2015).

Therefore, in epistemological and ontological terms, it can be seen that research in management accounting presents several theoretical approaches and research methods (Luft and Shields 2003). In historical terms, in research in this area, positivist research (more quantitative) has predominated over interpretative research (more qualitative) (Major 2008). In this context, it was found that there is a superiority of the empiricist philosophy, objective in the methodology adopted, mostly by researchers in the USA (Ryan et al. 2002). In Asia, the Pacific, and Europe, on the other hand, interpretative or alternative research has gained ground (Oliveira et al. 2009). This means that in Europe research in this area is accepted as multiparadigmatic, while Americans give preference to the positivist paradigm (Lukka 2010). However, the differences between the paradigms did not prevent a strong growth of publications on management accounting (Luft and Shields 2003). An example of this growth, in particular of qualitative research compared to quantitative research is the work of Parker (2012), who pointed out that the focus on qualitative research has been a contribution to the understanding and critique of management and accounting systems. This argument had already been corroborated by Lukka and Kasanen (1995) who concluded that in-depth case studies allow the complexity of the processes analyzed to be understood and provide a critical understanding of the phenomena of organizations.

As already mentioned, in the USA the positivist paradigm predominates, thus research in management accounting gave way to research in the area of financial accounting (Lukka 2010). This conclusion is clairvoyant in the analysis of the top five US accounting journals, whose published articles are predominantly in financial accounting and framed within the positivist research paradigm (Merchant 2010).

In short, the positivist research in management accounting aims to develop tools and techniques that provide the efficient and effective management of organizations and is in line with the contingency theory, the agency theory, the transaction costs theory, among others, while the interpretive research aims to describe, interpret and theorize what is observed in organizations (Baxter and Chua 2003). It is also noted that the case study method can be used in any of these types of research-positivist or interpretive-(Bloomberg and Volpe 2012).

Finally, there is the critical research which advocates that the objectives of organizations are a result of negotiations; that the units of analysis of the phenomena are social interactions and subordination; that reality is characterized by actions of power, domination, and resistance; that accounting is a process of domination (Wickramasinghe and Alawattage 2007). Finally, this paradigm contributes to management accounting with the creation of a subjective language (Wickramasinghe and Alawattage 2007), which allows the highlighting of issues of social nature in the use of tools and techniques of that accounting (Baxter and Chua 2003).

In the clusters identified, and according to the terminology of Hopper and Powell (1985), it can be concluded that in cluster 1 research work using a more interpretative approach (e.g., Gray et al. 1995) arises, given the ontological positioning of researchers and the theoretical and methodological approaches used (qualitative research work). On the other hand, in clusters 2 and 3, the traditional positive research stream predominates (e.g., Cho and Patten 2007; Cho et al. 2015), with essentially quantitative work. It should also be noted that the *Accounting, Auditing and Accountability Journal* and *Accounting, Organization and Society* publish articles on this topic which fit into the three research paradigms. This plurality in terms of the research paradigms of the articles is related to the fact that in the United Kingdom there is a tendency to accept papers that follow approaches other than the traditional one (positive approach) and even some criticism of the predominant

positivism in the US (Lukka 2010; Merchant 2010). Some authors even argue that this change in epistemological and ontological assumptions has been visible in recent years in management accounting research (e.g., Ryan et al. 2002), and has not prevented increased research in this area (Luft and Shields 2003).

In short, it can be seen that any of the three research paradigms identified by Hopper and Powell (1985) can be used in social accounting research without calling into question the robustness and quality of the studies undertaken, be they theoretical or practical. On the other hand, this plurality shows the variety in the epistemological, ontological, and methodological assumptions of researchers and studies. The interpretative paradigm involves greater subjectivity, since when it comes to responding to the how and why, the researcher's involvement is unquestionable; however, this condition does not call into question the validity, reliability, quality and contribution of such research to the evolution of scientific knowledge.

5. Concluding Remarks

In the study developed, bibliometric techniques helped us map the literature and understand the evolution of research on the dissemination of information on social accounting. This research work allows us to conclude that social accounting is an attractive research area since the year 1970 due to the discussion about sustainable development issues and research contributions to sustainability, with effects in the present and the future.

To provide answers to the objectives initially defined, it is concluded that at the level of social accounting great emphasis has been given to its dissemination, which is evidenced by the results obtained in cluster 2 of the published articles. Cluster 1, on the other hand, makes it possible to argue that the theory of legitimacy is one of the most widely used frameworks in studies on social accounting.

However, Cluster 3, in association with Cluster 1, reveals that dissemination is still a controversial issue in information content. Thus, it can be seen that social accounting still has some limitations in its implementation and interconnection with "traditional" accounting. On the other hand, being its disclosure understood as a voluntary practice for companies/economic groups to obtain/maintain their external and internal legitimacy before all interested parties, there is still some heterogeneity in the information disclosed.

Considering that the search for institutional legitimacy is directly related to institutional theory, the latter is appropriate for work that focuses on a specific company's structure or the adoption of information dissemination practices by similar organizations (mimetic isomorphism). Thus, it can be seen that in work in this area. At the same time, legitimacy theory and institutional theory are used to study specific organizations, and stakeholder theory allows the analysis of interactions between groups of stakeholders or between organizations.

There are, however, pressures for actors in the international context to implement accounting practices that are socially and ethically responsible, in addition to accounting practices that can only be considered in the environmental approach. These practices should be embedded in traditional accounting systems and information should be disclosed in social reports to promote transparency, credibility and enable sustainable performance, thus demonstrating a proactive attitude in this area.

In parallel with the analysis of these theoretical implications, a descriptive mapping of the literature on this subject (figures, charts, and tables) was carried out, systematizing the information and helping future research on the subject, with an indication of the topics that have most aroused the interest of the academic world.

In addition to this, a summary of the paradigmatic plurality revealed by research in social accounting in recent years has been presented. It is noted that positivist research is no longer predominant, giving way to interpretative research and critical research. Mathews (1997) argues that the traditional paradigm no longer meets the needs of research, and many of the studies undertaken no longer fit the assumptions of the traditional model. In interpretative research, the researcher seeks to study a social phenomenon in a particular

context and may become involved in the phenomenon, and tries to interpret the results in the light of the theories that support it. In critical research, the researcher seeks to understand the social world better and promote the necessary social change. He or she seeks to emancipate the individual, freeing him or her from excessively influential discourses that may restrict his or her ability to reflect (Gendron 2018). For example, Kamla et al. (2012) studied the social accounting perceptions of Syrian accounting professionals and concluded that the sociopolitical and socio-economic context had slowed social accounting development in Syria. This means that, like traditional accounting, social accounting research has shifted from theoretical questions, processes, and norms to focus on social phenomena.

In short, in addition to the mapping of literature in elite journals, another theoretical contribution was the identification of the paradigms and research approaches underlying this theme. Thus, it was concluded that social accounting is a multifaceted area that allows research methodologies, and the paradigms used, to be varied and, as such, allow for a greater theoretical and practical deepening of the analyzed themes. Some critical research, associated with social and environmental responsibility, stands out here on which there is still a strong debate. This means that the study of social accounting can also be approached critically, when trying to respond to the challenges of sustainability imposed by climate change or, carbon emissions, among many other aspects.

It is also important to note some academic and management implications. Academically, this study suggests that this theme is still emerging and current since the dissemination of social accounting still needs to be improved, namely, the inclusion of more information on actions in the local community and the implementation of measures that minimize the negative impacts of some of the strategies followed. Further, the motivation for disclosure should not be used as a tool to entice stakeholders for the sake of convenience, but because they actually want to be socially responsible. This means, in management terms, that this disclosure should not be driven by mere compliance with the law, on the contrary, it should be with a view to generating internal and external added value. A further implication for theory and practice is that it has been shown that in any type of research on in social accounting research, any of the research paradigms can be used without jeopardizing the robustness and quality of the studies carried out, whether theoretical or practical. On the other hand, this plurality shows the variety in the epistemological, ontological and methodological assumptions of researchers and studies. The interpretive paradigm involves greater subjectivity, because when the intention is to answer the how and why, the researcher's involvement is unquestionable; however, this does not jeopardize the validity, reliability, quality, and contribution of these studies to the development of scientific knowledge.

Like any research work, this study has some limitations, notably, because it has been limited to the Web of Science database. However, this is one of the most widely recognized in the scientific and academic community. Regarding this limitation, it should be added that the same research was carried out in the Scopus database, and it was found that articles not common to both databases did not influence the final result significantly. Similarly, the analysis of paradigms confined only to articles included in clusters represents a limitation.

Finally, and as topics for future research, it is suggested to study the regulations on the type of information to be included in disseminating social reports and its standardization concerning the Global Reporting Index (GRI) standards. It would also be important to search in other relevant academic databases for articles related to the topic under analysis and add them to the final base to be analyzed in Rstudio, and thus enrich the knowledge of this topic, which suggests another future track. Furthermore, broadening the search terms used in this study is another future clue, since the topic of social accounting can be developed at various levels, for instance to include "sustainability reports", "non-financial information", and other similar ones.

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Idiosyncrasies of Money: 21st Century Evolution of Money

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Abstract: This paper examines the question of what kind of money will govern the 21st century by examining the developments which characterise this landscape. On the basis of a review of the available literature and evidence, it is clear that certain technological innovations, such as the movement towards electronic money, will undoubtedly change how we operate. However, the conclusion in this paper is less sanguine regarding the prospects of a global currency, regional monetary unions, or states' exit from or central banks' control of money. This paper also sees poor prospects for cryptocurrencies at the moment, given their focus on the decentralisation and politicisation of money, because money requires a backstopping force, making it inherently political. Finally, this paper considers how regulators may seek to ensure that money in its digital form is not taken advantage of and applied in malevolent activities. The study used correlation to establish the level of association among variables. A multiple regression analysis was used to draw an econometric model explaining the relationship between the independent and dependent variables. The following variables were used as independent variables: monetary aggregate (M1), harmonised index of consumer prices (HICP), Euro Interbank Offered Rate (EURIBOR), US dollar/euro, and the USD value of Bitcoin. Multiple regression predicted that when inflation rises, the money supply will decrease. M1 includes cash in circulation, current deposits, and other than demand deposits. The study concludes that price increases encourage people to keep their money in longer-term deposits, including in cryptocurrency. Additionally, an increase in EURIBOR and US dollar/euro reduces the supply of money. Otherwise, an increase in the price of bitcoin in the economy would increase the overall money supply.

Keywords: currency; central banks; cryptocurrencies; digital money; money evolution

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1. Introduction

Money performs various economic functions in society: as a store of value, as a unit of account, and as a medium of exchange (Carstens 2019). Money is really what money does (Hicks 1979). People are usually willing to accept whatever "thing" is described as money purely on the basis of trust that others will also accept this "thing" in exchange for goods and services. Remove this trust, which is a function of future expectations, and the coins, notes and other things that are referred to as money become worthless. In this sense, money can adequately be described as a social convention or a social contrivance. It is little wonder, then, that the thing that has represented money over the centuries worldwide has mutated according to circumstances. For instance, there have been times during which money was represented by cowrie shells, cigarettes, stones, gold, coins, and notes, and now, money is increasingly being represented in electronic formats (Carstens 2019). This all feeds back to the point that money is a social convention and that the thing that symbolises

it is not as important as the trust and belief that accompanies such representations of money. Indeed, there has been a movement towards the abstraction of money in the form of digital cash and other electronic forms of money in recent years.

Nevertheless, how are people to be assured that other people will, both now and in the future, accept coins, notes or other representations as money and exchange them for valuable goods and services? The state has always been important in providing the much-needed backstop for currency. In virtually all jurisdictions, the state, acting through central banks, can issue new money and regulate all other financial institutions that create intermediate money. However, partly as a result of the 2008 global financial crisis and partly due to technological evolution, a movement has also arisen that seeks to decentralise money by removing the state from the issuance of money, with the aim of better managing financial crises. Consequently, cryptocurrencies have evolved, whose key feature is the decentralisation of money, with a fixed supply of money replacing the current centralised fiat money. There has also been debate with respect to the need for digital currencies issued by the central bank to replace the state's notes and coins.

Globalisation has also led to the increasing convergence of governance institutions, including through the formation of regional blocs and regional economic organisations that have economic integration as one of their central objectives. The European Economic Community, comprising most of the countries in continental Europe, heavily informed the European Union, with many members adopting a single common currency, the euro. As globalisation intensifies, making the world a global village, is there the potential for a global currency to arise? If this were to happen, coupled with the arguments in favour of the decentralisation of money that continue to reverberate, who would have the ultimate control over money? The state, which has traditionally had the royal prerogative of issuing and controlling money, may give way to private actors, or else the state may exert even more control over money. Moreover, given the increasing complexity of this subject and the various forms that money is bound to take, there is the potential for money to be used to further criminal activities.

For centuries, money has been at the heart of human relationships; the loss of confidence in the value of one's beliefs can lead to both financial and political bankruptcy and even armed conflict. Within the last few years, financial technology has captured the world's attention by providing non-traditional payment options. Most academics agree that so-called "cryptocurrencies" lack all of the attributes of money. While they believe the concept to be highly transformational, they also believe that distributed ledger technology could remove the intermediary in payment services. This would undermine the power of central banks and state influence over the money supply. Indeed, decentralised digital currencies were created with the intent of circumventing central banking regulations. At present, less than one-half of all monetary transactions in Sweden are carried out in cash, as opposed to the 13 per cent of current operations noted by the governor of the Swedish central bank. In the age of banknotes and coins, people would be out of work if they were not paid in cash.

Digital platforms are reshaping relationships between customers, workers and employers as the silicon chip reach permeates almost everything we do—from buying groceries online to finding a partner on a dating website. As computing power improves dramatically and more and more people worldwide participate in the digital economy, we should think carefully about devising policies that will allow us to fully exploit the digital revolution's benefits while minimising job dislocation. This digital transformation results from what economists who study scientific progress and technical change call a general-purpose technology, one with the power to continually transform itself, progressively branching out and boosting productivity across all sectors and industries. Such transformations are rare. Only three previous technologies earned this distinction: the steam engine, the electricity generator, and the printing press. These changes bring enormous long-term benefits.

Financial stability is a requirement of modern market economies. Events have demonstrated that financial institutions cannot be considered reliable over the past decade if

the value of money is not constant. There is a large body of evidence that demonstrates that prosperity is threatened when money is fluctuating. Stopping its loss of value has become the primary, if not the sole, central banks' focus. Money's necessity—and the critical role of governments and central banks in its provision—will be discussed from many different angles. After more than a thousand years of circulation, the number of "monies" began to drop dramatically in the final millennium. It is superficial because many national currencies were not as valuable as "money". Some "units of value" do not need to be defined in terms of a monetary unit.

The term "monetary policy" can describe central banks' actions only for the few currencies that serve as money standards. Policies like these determine the long-term quality of money. In a market economy, the quality of money is linked to the resources used alongside money in money-type functions. In highly volatile markets, people hold onto their money, use it less, make more frequent cash purchases, require more cash managers, and employ financial advisers who charge a great deal. For small investors, the money of lower quality means that more time, effort, and money, and thus resources, are invested in collecting prices and making comparisons. Thus, those resources could have supported "socially beneficial policies" that maintained a sound money supply. The frequently mentioned but little understood "cost of inflation" is the loss of production over time as money deteriorates (Jordan 2005).

2. Money of the 21st Century and Beyond

For about three millennia, money has been part of human civilisation and relationships, enabling the exchange of valuable goods and services by acting as a medium of exchange. Before the invention of money, most of the exchange of goods and services used to occur through barter trade. In bartering, one person would bring particular goods to the marketplace and, in turn, obtain another kind of goods that they did not have from another person or trader. In essence, goods and services could only be exchanged for others as there was nothing else that could compensate one for their goods, nor was there any money to acquire that they desired. Most of the goods employed in the barter trade included cattle, sheep, vegetables and grain. The need for currency or money arose owing to difficulties of ascertaining value to attach to particular goods and services.

Coinage, the practice of minting small pieces of metal with distinctive marks, which appeared in the second half of the 7th century BC, had a transformative effect on ancient economies and societies. Controversies persist concerning ancient coinage's original function, particularly states and markets' role in their emergence. Information-theoretic measures to a corpus of 6859 different coins from the Ancient Mediterranean world, dated between c. 625 and c. 31 BCE, show that symbols minted on coins have become increasingly informative about a coin's value. This trend was specific to value-relevant information, as distinct from information on issuing states. Coin designs also provided more information about higher denominations than about lower denominations. Before the numerical or written value marks were widely used for coinage, these iconic symbols were carrying financial information (Pavlek et al. 2019).

King Alyattes created the first known and documented currency in Lydia, which now forms part of modern-day Turkey, around 600 BC (Burn-Callander 2019). On the other hand, the first coin ever minted featured a roaring lion on its face. The history of paper money dates back to the twelfth and thirteenth centuries, a chapter by Marco Polo in Cathay's book (Tullock 1957). Around 1661 AD, banknotes were printed in Sweden, with the first credit card in the world appearing in 1946. We now speak of cryptocurrencies such as bitcoins, credit cards, and other electronic money forms in this century.

Swedish households have begun to rely more on electronic means of payment, such as bank cards and Swish, while cash use is declining. In terms of electronic payment methods, debit cards are still widely used, but Swish makes a more considerable impact. The survey results show that 80% of respondents used a debit card to make their most recent purchase. The corresponding figure for 2016 was 64%. Six out of ten respondents reported that

they used the mobile payment service Swish in the past month, and the same number of respondents reported using cash. While cash usage is declining, few people encounter problems with shops refusing to accept cash payments. The way payment is made also differs based on the population, where younger people prefer electronic payments to a greater extent. Overall, the use of cash in rural areas is about the same as it was in the last survey, but in rural areas, the usage of cash is slightly more significant than it is for the country as a whole (Sveriges Riksbank 2018a).

As cryptocurrencies' development continues, their popularity and spread of trading rapidly increase. The high volatility of these assets is encouraging in that it allows users to study and anticipate the price of these assets in an ever-changing market environment (Batrancea et al. 2020a, 2020b). Mikhaylov (2020), who discovered EOS cryptocurrency, stated that it was the most effective and promising digital currency. It is simple to use and offers the lowest cost in commissions compared to the other analysed cryptocurrencies, and enables third-party applications in the system. However, it has been established that cryptocurrencies exhibit the highest market volatility level, negatively affecting transactions. Bitcoin has been associated with higher volatilities and forecasting problems using data from the largest crypto exchange—Binance (Xie 2019). Studies have established that the most capitalised cryptocurrencies include Bitcoin, Ethereum, Litecoin and Ripple (Bohte and Rossini 2019).

Since Bitcoin, Ether, and over 2000 cryptocurrencies have collectively reached a market capitalisation of over USD 300 billion, a better understanding of their statistical and financial properties is still in demand. Today, numerous economic theories cannot fully explain their characteristics or describe their statistical and econometric attributes, such as their extreme variability and heteroskedasticity. Findings on the relationship between Bitcoin and Ether prices using a Non-Homogeneous Pólya Gamma Hidden Markov (NHPG) model surpass those obtained from conventional financial data. In this instance, results show that all price series are heteroskedastic, which means frequent shifts between the two states of the underlying Markov process. It is somewhat surprising that the Bitcoin and Ether prices, which appear to be correlated, behave differently. Long-term Bitcoin data studies show a significant covariate change over time. Consequently, cryptocurrencies are unlike any other financial asset, and their understanding necessitates novel tools and approaches (Koki et al. 2019).

This paper considers these issues to survey the future of the money landscape and seek to explore future money. It argues that money institutions are likely to continue to face technological changes and evolve accordingly to conform to the increasing complexities and opportunities. In particular, it argues that electronic cash instead of physical cash will rule the 21st century, but not overwhelmingly. However, this paper argues that the emergence of virtual currencies or cryptocurrencies that seek to decentralise money will barely be successful because of the state's resistance and because such currencies do not fulfil the economic functions of money. It is anticipated that increasing globalisation may result in more regional organisations, and there may be a movement towards a global currency that may not materialise in this century. In the final analysis, this paper concludes that the state will still have significant control over money, whatever its form, and proposes some measures to ensure that money is only employed towards fulfilling legal, economic functions.

3. Methodology

The methodology followed consists of a literary review of the pronouncements of different documents, publications and financial reports regarding the future of money and digital and virtual currencies. This study analyses the different payment options and money related events including cryptocurrency, digital transactions, internet-based transactions and e-commerce transactions. A search was carried out in the databases of countries' financial platforms to analyse different data sets. Panel data were used in the study for the period between 2010 and 2020. An econometric model was conducted to

establish trends in money evolution and use. The study used correlation and multiple regression to establish relationships. The variables used in the study included the monetary aggregate (M1), harmonised index of consumer prices (HICP), Euro Interbank Offered Rate (EURIBOR), US dollar/euro and the US dollar value of Bitcoin.

4. Results

4.1. The Future of Cash

Due to technological innovation and digitalisation, there has been a noticeable trend in recent years towards more money abstraction. In particular, the understanding of "cash being king" has gradually given way to other electronic forms of cash, particularly in Europe and the West. For instance, Nordic countries such as Sweden lead the pack in moving into a cashless society, with cash dropping by 50 per cent. This results from more people choosing to rely on mobile phone applications and debit cards that allow real-time payments. In Sweden, up to half of the banks do not deal in cash, with seven out of ten consumers expressing optimism that they can do without cash, while half of the merchants are expected to no longer deal in cash by the year 2025 (Arvidsson et al. 2018). Concerning payment in stores and supermarkets, only 13 per cent of transactions are conducted in cash (Sveriges Riksbank 2018b). What is more, mobile money, whereby money is transferred through a cell phone, has had tremendous success in countries such as Kenya, where up to EUR 25 billion is transacted annually (Munda 2018).

According to Figure 1, the world is also experiencing a phenomenal growth of contactless payment systems, even as mobile technology becomes more complex and ubiquitous. This has meant that the usage of cash has experienced a significant downturn. For instance, in the United Kingdom (UK), only 34 per cent of all payments were in cash in 2017 (Shaw 2018). Part of this change has been fuelled by the increasingly expensive nature of the infrastructure that underlies and supports cash usage in payment transactions. To illustrate, the setting up of various physical bank branches in various parts and the associated bank charges have eaten into financial institutions' profit margins, thereby making them less competitive.

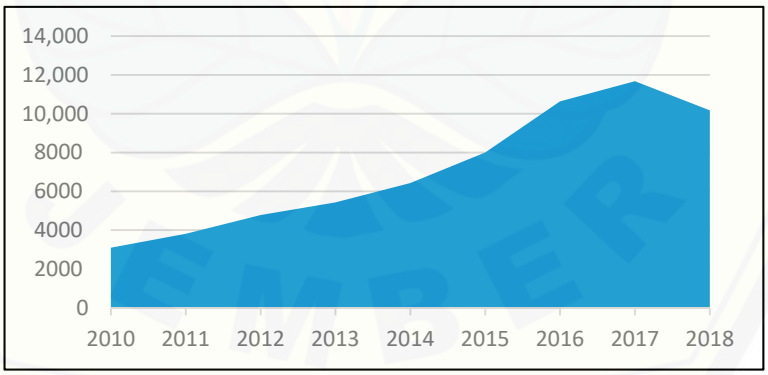
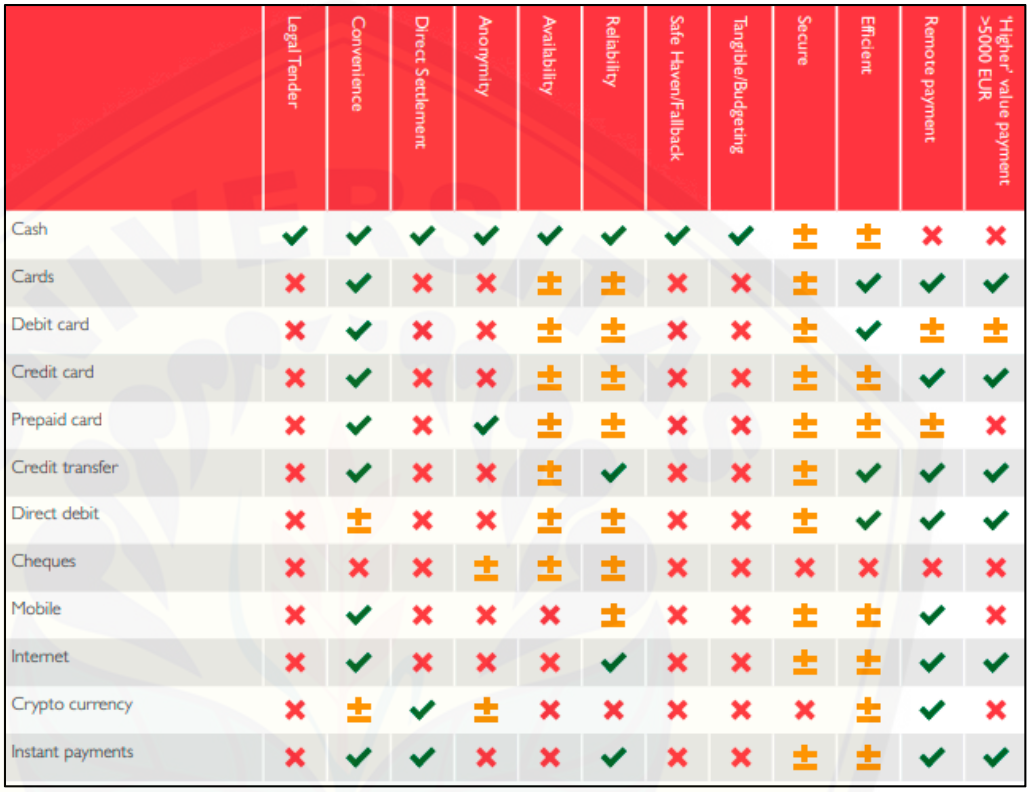


Figure 1. Electronic money—total reported by electronic money institutions in the euro area (2010–2018). Source: authors' elaboration based on data of the European Central Bank.

Developments have also arisen concerning currencies with the development of crypto assets. These cryptocurrencies were mainly a backlash due to the global financial crisis of 2008/2009, which instilled a measure of scepticism among actors. They thus sought a mechanism to delink money from the state and, in turn, to decentralise it. As noted by He, among others, the creation of currencies such as Bitcoin was an endeavour to challenge the state-sponsored currency paradigm and the role of the traditional dominant financial institutions and regulators, including the Central Banks (He et al. 2017). To some extent, cryptocurrencies move towards the "denationalisation of money", an idea propagated earlier by economist Friedrick Hayek (Hayek 1976).

Some benefits accrue to a cashless society compared to the one we are primarily familiar with that mainly uses physical cash in the form of notes or coins (Figure 2). Firstly, the anonymity and untraceable nature of physical cash make it more susceptible to being used in furtherance or commission of illegal and illicit activities, such as tax evasion, bribery, corruption, terrorist financing and counterfeiting (Young 2013). A study by Amiram et al. (2020) established contradictory findings to a study by Young and reported that blockchain-based cryptocurrencies were used to finance terrorist attacks.



	Legal Tender	Convenience	Direct Settlement	Anonymity	Availability	Reliability	Safe Haven/Fallback	Tangible/Budgeting	Secure	Efficient	Remote payment	'Higher' value payment >5000 EUR
Cash	✓	✓	✓	✓	✓	✓	✓	✓	±	±	✗	✗
Cards	✗	✓	✗	✗	±	±	✗	✗	±	✓	✓	✓
Debit card	✗	✓	✗	✗	±	±	✗	✗	±	✓	±	±
Credit card	✗	✓	✗	✗	±	±	✗	✗	±	±	✓	✓
Prepaid card	✗	✓	✗	✓	±	±	✗	✗	±	±	±	✗
Credit transfer	✗	✓	✗	✗	±	✓	✗	✗	±	✓	✓	✓
Direct debit	✗	±	✗	✗	±	±	✗	✗	±	✓	✓	✓
Cheques	✗	✗	✗	±	±	±	✗	✗	✗	✗	✗	✗
Mobile	✗	✓	✗	✗	✗	±	✗	✗	±	±	✓	✗
Internet	✗	✓	✗	✗	✗	✓	✗	✗	±	±	✓	✓
Crypto currency	✗	±	✓	±	✗	✗	✗	✗	✗	±	✓	✗
Instant payments	✗	✓	✓	✗	✗	✓	✗	✗	±	±	✓	✓

Figure 2. Scoring of payment instruments on crucial attributes of payments. Source: Group 4 Securicor (G4S) and Payments Advisory Group analysis, 2018.

On the other hand, contactless payments or electronic cash leave an audit trail for the mere reason that the payer and the receiver are easily identifiable by checking the electronic payment system. Additionally, one can quickly tell the source of one's money used in a transaction. Secondly, a cashless society may be more secure than one manned by physical cash. This is because one is less likely to be confronted by robbers or suffer physical violence if they have no physical cash compared to if they do. Various technologies applied in electronic payments, including retina scanning and face and voice recognition that verify and validate transactions, are potentially more secure. This may be added to end encryption that sometimes accompanies payment systems that make it less likely to decode, thus boosting such electronic platforms' safety and security. Thirdly, an economy that relies on digital cash is better able to conduct its monetary policy through the central bank as people are not usually able to hoard cash when central banks lower interest rates in a bid to stimulate a depressed economy, thus going around the zero lower bound theory of interest rates (Singh 2014). Finally, electronic money may have the positive effect of reducing bank runs given that depositors may not be able to withdraw the physical cash from the banks and keep it at home. At best, depositors would only move the electronic money from one financial institution to another, but not remove such money from the financial system. The most often-mentioned reason for the change in perception was the fact that electronic payments have been made more convenient during the pandemic, e.g.,

by increasing the threshold for the contactless cardholder having to enter his/her personal identification number (PIN) for payment authorisation into the card terminal (Figure 3).

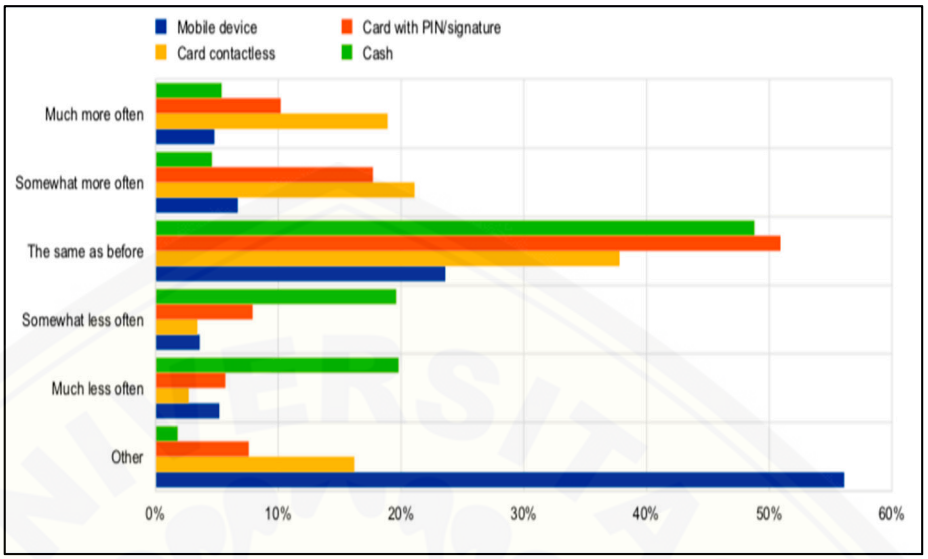


Figure 3. Use of payment methods during the pandemic—source: European Central Bank, 2020.

Given the potential benefits of electronic money and the technological innovation that continues to make this more of a reality by the day, one would imagine that electronic money will soon sound the death knell for physical cash around the globe in the 21st century. We argue that while a significant proportion of countries and peoples, particularly in Europe and North America, are likely to cease using physical cash for electronic money for the vast majority of times, physical cash will still have a place. The place and role of physical cash will be more of a reality particularly in developing economies and for particular transactions and periods even in developed economies, owing to various reasons. Firstly, the potential benefit of electronic money, which comprises traceability, is a drawback in terms of persons who wish to protect their privacy details and avoid surveillance, and even more for those who want to participate in illegal activities (Kahn 2018). Money launderers prefer keeping their identity private and anonymous, and given the power they wield, particularly in narco-states and other countries, they are likely to use the political clout they enjoy to resist a full phasing out of physical cash. Secondly, the nature of technology itself is that it sometimes fails and may experience outages and other breakdown forms. A crash of the technological systems can have a far-reaching and almost catastrophic effect on the commerce world, with payments and transactions failing to go through when the payment system in the form of electronic money fails to work. Thirdly, and related to the second issue, is the potential for cybercrimes by technology gurus, including identity theft, data breaches, and fraudulent transactions. Fourthly, the phasing out of physical cash may have a pernicious effect on the vast majority of people, particularly in developing nations, who barely have bank accounts by further marginalising them and excluding them from the financial system. This would certainly work against the current initiatives towards financial inclusion.

Even over and above the positive attributes of physical cash described above, there are also psychological barriers that may stand in the way of eliminating cash and thus may serve to prevent its full disappearance. Human beings as social beings have a particular tendency to want to associate, feel and connect with things they consider to be of value. Human beings' relationship with money in its physical form of notes and coins goes beyond rationality. For instance, people attach more value to physical notes and coins than electronic money that they cannot easily see or touch, with people considering the money that has since converted to electronic money as less valuable (Uhlmann and Zhu 2013).

This irrationality that is associated with human beings, quite removed from the economic theory of rationality touted as representing the economic man (homo economicus), is also demonstrated in studies that show that people frown less upon white-collar crime as opposed to a robbery which takes away physical cash or other valuable physical items (Holtfreter et al. 2008). In the end, then, we argue that physical cash will not disappear entirely but will still play a significant role, particularly in some societies more than others. This notwithstanding, a sizeable chunk of physical cash will give way to electronic money in the 21st century.

4.2. Dominance of Sovereign Currencies

The emergence of virtual or cryptocurrencies, as discussed above, then puts to the test the continued dominance of sovereign currencies. By sovereign currencies, we mean money issued by states through the central banks. Originally intended to replace sovereign currencies and therefore signal their end, cryptocurrencies may not dominate the world of currencies, at least in this century. This is the likely apparent scenario, at least from the available evidence and assessment of the likely scenarios. A review of some evidence and literature is apt at this point to illustrate this very point. There is still a high demand for cash in most countries (Bech et al. 2018). According to a study, the total market capitalisation for virtual currencies in the United States by November 2018 was around USD 121 billion, while the broad money or sovereign currency was hovering at around USD 17 trillion (Dabrowski and Janikowski 2018).

In contextualising if sovereign currencies will be replaced by private money or virtual currencies, it is critical to examine private money's historical evolution since they are not a new phenomenon. Minimum, virtual currencies are another form of private money that flourished between the 18th century and the start of the 20th century in the UK and the US. Despite the championing of private money by free-market economists in earlier centuries, private money competed poorly against sovereign currencies. This was mainly a function of two factors: network externalities and sovereign currencies' ability to deal with the twin economic problems of information asymmetry and adverse selection. Network externalities in this context refer to the broad acceptability of the sovereign currency by other economic actors and agents capable of performing the various economics functions of money. Historically, this was not possible with other private currencies that mainly operated in opposition to each other.

What is more, the mere existence of many private currencies tended towards higher transaction costs for the various economic actors, thus disincentivising their use. Sovereign currencies were able to deal with this problem, albeit not wholly given the use of foreign currencies, and thus availed a single domestic market for goods and services. Information asymmetry was another economic problem that worked to the disadvantage of private money instead of sovereign currencies. Information asymmetry, which refers to the phenomenon where a financial provider possesses superior information regarding another's creditworthiness or the quality of a particular asset, is a typical feature of all financial intermediation processes. Information asymmetry may lead to excessive risk-taking by financial institutions to the detriment of customers, thereby causing a misallocation of capital and possible financial instability. This argument is one of the justifications for financial regulation.

Within the above context, we need to examine the virtual or cryptocurrencies to decide whether they will replace sovereign currencies as we know them today in the 21st century. First, the virtual currencies in existence, such as Bitcoin, only partially address some economic problems. For instance, the information asymmetry problem is dealt with by the predetermined algorithm employed in their creation and functioning. Their fixed supply also guards against the risk of over-issuance but obviously at the risk of limiting monetary policy targeting. The rise of these virtual currencies is still limited, as most currencies cannot overcome economic problems. One of the reasons for this is that demand for the dollar and the euro is still high since they are considered significant currencies (Jobst and Stix 2017).

Some governments are also unwilling to accept virtual currencies as legal tenders, yet money depends mainly on the state's stability and acceptance. Finally, the competitive nature of the market for virtual currencies will continue to counter the dominance of any virtual currency, preventing it from overcoming the network's externalities.

The upshot of the immediately preceding paragraph is that sovereign currencies will continue to dominate, particularly in significant currency areas including in Europe and North America, as virtual currencies which appear to pose a threat to their dominance suffer various problems. Unless technological innovation can surmount many of these problems going into the future, it is hard to see virtual currencies replacing sovereign currencies. At best, and in exceptional events such as those featuring hyperinflation, civil wars or financial crisis, virtual currencies may offer a good alternative or a means of currency substitution for respective economies (Dabrowski and Janikowski 2018).

4.3. Regional Monetary Unions versus Competition between Currencies

In recent years, there has been a renewed regionalisation of international trade and the creation of preferential trade agreements. In this section, we consider the case of whether we shall also witness the regionalisation of international monetary systems as has been witnessed in Europe with the adoption of a common currency, the euro. Some countries have yielded up their national currencies and instead adopted a common regional currency or a multicurrency monetary union (Jankovics 2004). Eleven member countries in Europe signed the Maastricht Treaty in January 1999, paving the way for forming the European Union. They created a single currency, the euro and a single institution representing the central bank, the European Central Bank (ECB), which is mandated to formulate and implement a single monetary policy for the entire region (Szemeredi 2018).

At the bottom, forming a regional monetary union essentially involves creating a single multinational currency, substituting each nation's currency (Szemeredi 2018). Further, each nation's central bank's monetary policy function is usually transferred to another supranational institution. It is a heavily political and logistical challenge that must have the political will and support of the particular countries' political leadership. The economic rationale for having regional monetary unions is to enhance intra-regional trade, conducive to collective welfare. While the European Union has done relatively well as a regional monetary union, several countries in Central and Eastern Europe, such as Hungary and the Czech Republic, remain out of it (Palankai 2015). In addition, other regional monetary unions such as the Austro-Hungarian union, the Latin and the Scandinavian unions remain defunct, perhaps speaking to the challenges of maintaining such unions, particularly given the political nature of such arrangements (North 2012).

In Africa, monetary unions are contemplated but face various challenges and resistance among some member countries. We argue that this resistance and unwillingness to surrender a country's financial control is an attempt by the respective countries to flex their sovereignty muscle, given that the issuance and control of money is a sovereignty issue (Egedy 2012). We do not see this changing soon because we argue that we are unlikely to see many regional monetary unions in the foreseeable future. There is still insufficient political support for monetary unions in North America with the tension between Canada, the United States and Mexico, and South America with the rise of nationalism in Brazil and Venezuela. Despite the continued growth of intra-regional trade, differences in economic policies and the lack of political support will likely work against regional monetary unions' adoption.

In turn, we might see more competition for currencies between national borders that then peters out, leaving two or three significant currencies with a single dominant currency. Alongside increased intra-regional trade will be competition among various national currencies, though the dominant currencies such as the dollar, the euro and the sterling pound will continue to dominate. This is because a multiplicity of currencies works against dealing with network externalities (Toth 2018). As international trade intensifies, countries interact in the trade markets and then in the currency market. Each country issues

its currency typically, with each country's citizens receiving a domestic currency transfer. The nature of trade entails the exchange of goods and services for a portfolio of currencies. Since sellers accept what buyers hold in the market, the market complementarities lead to various international currencies. In a world with high information costs, an equilibrium featuring two national currencies may arise endogenously, a situation that could hardly be obtained in any other environment. Further, network externalities may lead to coordination failures, thus leading to a single national currency's dominance and the existence of a few substantial or significant currencies.

4.4. Central Banks and Control over Money

Much of the discussion and innovations relating to digital cash and virtual currencies have had one of their single most objectives—eliminating central banks or the state from controlling money. In its place is the private sector or actors, including private commercial banks or technology gurus. In this section, we examine who will have control over money and whether central banks will continue to exert their influence over money in the future, especially as they move further towards the digitalisation of money. Granted, and as already canvassed in this paper, the digitalisation of money can shift and alter the financial system's traditional structures by redefining banks' role, including the central bank. However, it is unlikely to erode or even further supplant the central banks' role and control over money. Even if we were to be generous at best and argue that cash will be abolished in the future, a contention we have partially dismissed, it still does not follow that central banks' control over power will be no more, in no small part because this is a political decision.

Take the example of Sweden, one of the countries where electronic or digital money has proliferated, and cryptocurrencies have also been rising in recent years. Even there, the Swedish central bank is loath to cede this control and power over money, as evident in its decision to allow non-banks to have deposits with it. This concept of non-banks holding deposits with the Swedish central bank is known as e-krona (Riskbank 2017). Such a move is in line with the institution of money's traditional stranglehold by the state from long ago when money issuance was a royal prerogative. In this context, we argue that central banks' power to control money is more likely than not secured by the state's political institutions. In our view, this concept of having non-banks hold deposits with the central bank is most attractive as an investment given the safety afforded by central banks. Firms and households with a significant amount of deposits would prefer this mode of saving or deposit keeping as they also escape the risk of a bail-in if commercial banks fail. In times of crisis or economic uncertainty, most customers would choose to have deposit accounts with the central bank and a few of them at commercial banks. Further, there would be a movement of money from commercial banks to central banks.

Further, cryptocurrencies lack any intrinsic value in themselves as money, thereby making them unconvertible. While cash in the form of notes and coins may also not be possessed of any intrinsic value, their recognition as legal tender insulates them from an implosion of the value of money that lacks intrinsic value.

Central Bank Digital Currency (CBDC) can alter the financial sector, especially the banking sector, fundamentally. A Deep Neural Network (DNN) model for the CBDC introduction and how it may affect commercial banks' deposits has been used to estimate the likelihood of bank runs as a function of system characteristics and CBDCs' intrinsic features. The overall success rate of CBDC and the impact on the banking sector depend on its design. CBDC must be interest-free if the amount of CBDC is capped by account or if commercial banks must guarantee convertibility from banks' deposits. Additionally, a CBDC must also help strengthen the financial system's overall sustainability, which is why a CBDC design that supports financial inclusion is essential. Euro area system data are used to calibrate the model at the beginning. It is concluded that an increase in the financial system risk perception would result in a significant transfer of wealth from bank deposits to CBDC; the latter is not affected by its interest rate (Sanchez-Roger and Puyol-Antón 2021).

Then, the economy is in trouble; monetary policies and adjustments depend on the policy makers' conceptions of money and its functions. There is sufficient consensus among scholars that money is an institution created within the economic system and is in line with other institutions that regulate economic activity. While it is clear that institutions have very different views on what they are and how they work, these views of the working of institutions mean significant differences in monetary enforcement, responsiveness, and stability. Gómez (2019) addresses empirical considerations about money's role in institutional frameworks in discussing institutions' rules and practices. An empirical case study grounds his analysis of Argentina's and the plurality of its currencies in the economy. The study says that while rules guide Argentina's currency, the US dollar was established based on supply and demand principles. As an alternative to traditional and short-term strategy, the big community currency exchanges started during the financial crisis between 1998 and 2002 combined rules and practice. Each of them shows multiple levels of both strength and softness, and fragility.

4.5. Private Actors and Money Control

As already hinted, the emergence of cryptocurrencies is geared towards both decentralising and "depoliticising" money. As one of the first calls for money denationalisation, this ambition is not new, which Friedrich Hayek advanced. Riding on the public fame that he had secured after winning the 1974 Nobel Memorial Prize in Economic Sciences and the inflation of the 1970s, Hayek called for the depoliticisation of money and the delinking of money from politics. Hayek envisioned the emergence of private money or currencies by eliminating government monopoly over money and instead vouching for the private issuance of money. To Hayek, no government could certainly be trusted with this monopoly over money as it is wont to abuse it, attributing the inflation of this period to abuse by governments and the "exclusion of . . . money from itself being regulated by the market process" (Hayek 1976). While Hayek's vision of private currencies was not obtained in the ensuing decades, his ideas partly carried the day as the fiat currencies devised were operated by semi-depoliticised technocrats in independent central banks. States relinquished most of their political responsibilities but still nominally retained their control over currencies (Eich and Tooze 2015). What ensued was unprecedented growth in the size of private credit money in the form of new financial instruments, a depoliticised economic relation and enforced fiscal discipline.

Fast forward to the 2008–2009 global financial crisis that began in the United States and later spread to Europe, and the relative lull and unquestioning of the erstwhile economic system was put to the test. As central banks and governments scrambled to rescue the financial system from a cataclysmic collapse by bailing out the financial institutions using taxpayers' money, it quickly became clear that the then-prevailing understanding of money as apolitical and neutral was only an illusion. By acting as a backstop to the financial system in socialising losses, the state succeeded in saving the financial system. It was also apparent from this financial crisis that private credit money had in large part replaced the currency, seriously denting any erstwhile presumption that money could be accountable to politics. Central banks found it difficult to exert full control over the financial system due to its complexity, sheer scale and financial innovation, leading to the emergence of complex financial instruments that represented money. It only became clear to them that the last decades had led to a "deterritorialisation of money" due to economic globalisation and the international integration of financial markets that constrain individual states' competencies in handling monetary and financial affairs (Zimmermann 2013). The Eurozone, in particular, had to deal with this harsh reality during the Eurozone crisis as the respective countries realised that they did not have the tools of monetary policy required to deal with the situation as they had surrendered them to the European Central Bank following regional integration. Central banks can create new money at the click of a button through measures such as quantity. The ease of dealing with the economic recession amazed many and eroded the myth of apolitical money.

The recognition that money is political and central banks were political institutions as learnt in the aftermath of the financial crisis paved the way for a return to the 1970s Hayekian quest for the complete denationalisation of money and private money removed from the state. It is perhaps worth noting at this juncture that while Hayek castigated central bankers as being the ones to blame for enabling governments to retain their monopoly over money, some central bankers of libertarian leanings still mulled and were impressed by Hayek's ideas of denationalised money. For instance, it is reported that former central banker of the United States, Alan Greenspan, saw technological innovation as having the potential to bring about private money and digital cash (Popper 2015). The vision of Hayek appeared a possibility on 1 November 2008, just a few weeks following the collapse of an investment bank, Lehman Brothers, with the publication of a paper on an online messaging board by an anonymous individual under the pseudonym Satoshi Nakamoto proposing an electronic cryptocurrency known as bitcoin (Nakamoto 2008). The bitcoin was seen as a currency beyond human control by going a step further than Hayek in removing money from the state and commercial banks. At the heart of the supposed problem that bitcoin sought to deal with is the element of trust by enabling the conduct of electronic transactions without relying on human trust (Nakamoto 2008). However, a closer interrogation of bitcoins' operation indicates that they are also guilty of the very centralisation and politicisation they denigrate and seek to replace. In particular, the bitcoin mining algorithm tends to favour the large bitcoin miners representing a largely oligopolistic structure, implying that neither the creation nor the confirmation of bitcoin payments is decentralised—they are highly concentrated among large conglomerates who are often anonymous.

With its underlying blockchain technology, the claim that bitcoin seeks to address the age-old problem of trust in human relations, while accurate, also requires a significant amount of trust. This is especially so when one considers that extant cryptocurrencies rely mainly on other communities of crypto adopters' trust. The adoption of bitcoin in the first place was essentially a representation of trust among human beings who were the founders. This leads us to the inevitable conclusion that blockchain and cryptocurrency payments require trust just as much as money is political. Put differently, while bitcoins and other cryptocurrencies seek to project an external image of being decentralised, apolitical and non-reliant on human trust, nothing can be further from the truth. They still rely on central authorities cleverly embedded within the algorithm and usually confused for network and market power. Rather than radically breaking away from politics, cryptos operate well within the politics of money. Indeed, bitcoins and cryptos' attempt to deny politics and central authority is politics in itself and further validates our argument that money is inescapably political.

Table 1 shows the top ten cryptocurrencies by market capitalisation in 2021. Bitcoin was created by Satoshi Nakamoto in 2009 with the aim that it be used to make purchases only through the internet. On 7 January 2021, the price of 1 Bitcoin reached USD 40,000 for the first time. Ethereum is the most actively used blockchain and the second-largest cryptocurrency by market capitalisation, after Bitcoin.

Table 1. Top 10 cryptocurrencies by market capitalisation (20 January 2021).

Rank	Name	Price	Market Capitalisation
1	Bitcoin	USD 35,032.64	USD 652,251,769,635
2	Ethereum	USD 1340.45	USD 152,924,932,110
3	Tether	USD 1.00	USD 24,757,509,926
4	Polkadot	USD 17.76	USD 16,274,356,276
5	XRP	USD 0.2914	USD 13,234,496,586
6	Cardano	USD 0.3693	USD 11,579,225,544
7	Litecoin	USD 147.13	USD 9,768,509,098
8	Bitcoin Cash	USD 495.04	USD 9,188,190,040
9	Chainlink	USD 21.41	USD 8,524,020,491
10	Binance Coin	USD 42.14	USD 6,518,385,750

Source: Own elaboration based on CoinMarketCap.

The market capitalisation of all the cryptocurrencies from 2016 to 2021 is presented in Figure 4. The market capitalisation of cryptocurrencies was very high during the year 2018. The prices later decreased tremendously after that for a year. The market capitalisation remained constant between 2019 and 2020. This year, the prices have skyrocketed during the first quarter.

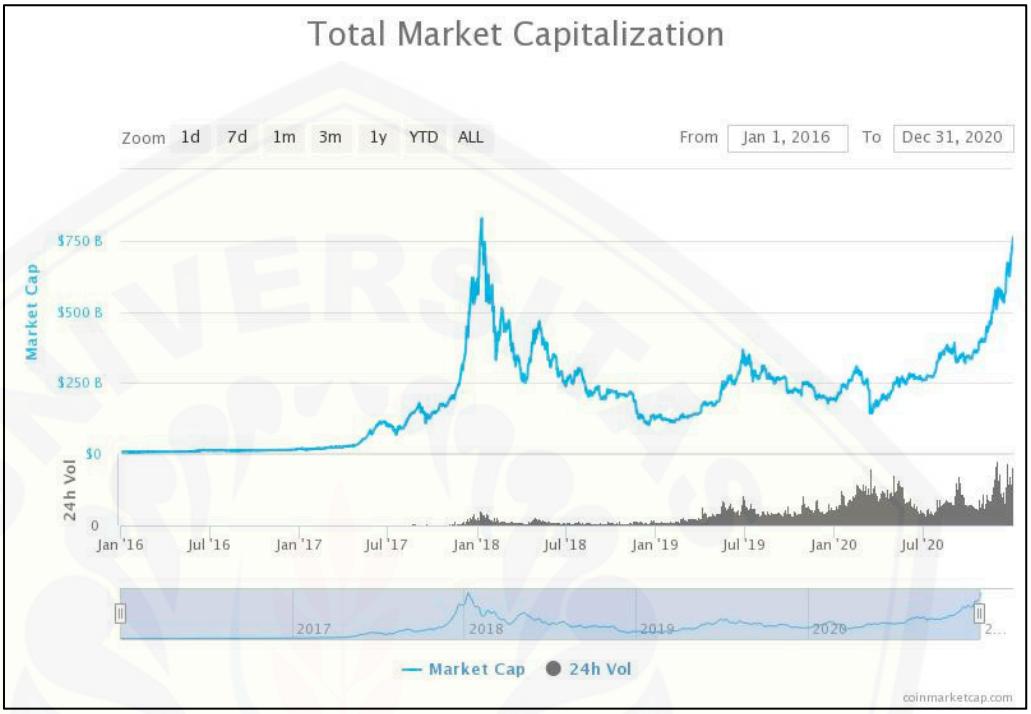


Figure 4. Market Capitalisation. Source: Coinmarketcap, 2021.

Suppose we are to accede to the argument developed in the previous paragraph that money is inherently political and cryptocurrencies, with all of their inventions and assertions to the contrary, are also centralised and political. In that case, it then follows that there is a need to "depoliticise" money. Indeed, the conclusion drawn from these realisations is that rather than seek to depoliticise money, which is a near-impossible feat, we should focus our attention on ensuring that we shape this fictional institution of money according to our political values. Furthermore, this may best be carried out when states or governments still retain some control over the money in whatever form it takes. As such, we argue that despite the increasing influence of private actors, private banks and cryptocurrencies, the state through central banks will continue to exert control over money given the inherently political nature of money. This is evident in the willingness of central banks such as the Bank of England and the Bank of Canada to consider issuing digital currencies and cryptocurrencies of their own to compete with those by private actors (Broadbent 2016).

4.6. Econometric Analysis

In this study, we developed a multiple linear regression model for the Euro area with the following variables (values are selected for each month from 31 January 2011 to 31 December 2020). Table 2 provides the description of the dependent and independent variables. Table 3 reveals the descriptive statistics.

Table 2. Explanatory variables considered in the regression models.

Variable	Description	Unit	Source
M1	Monetary aggregate M1 vis-a-vis euro area non-MFI excl. central gov. reported by MFI and central gov. and post office giro Inst. in the euro area (index)	Percentage change	European Central Bank (Balance Sheet Items)
HICP	The harmonised index of consumer prices—Overall index	Percentage change	European Central Bank (Indices of Consumer Prices)
EURIBOR	Euro Interbank Offered Rate (Euribor) 3-month—Historical close, an average of observations through period	Per cent per annum	European Central Bank (Financial market data)
US/EURO	US dollar/euro	US dollar	European Central Bank (Exchange Rates)
BITCOIN	USD value of Bitcoin	US dollar	Official Data Foundation/Alioth LLC

Table 3. Descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
M1	120	7.525	3.067	1.200	15.600
HICP	120	1.215	0.954	−0.600	3.000
EURIBOR	120	0.068	0.557	−0.538	1.598
US/EURO	120	1.212	0.110	1.054	1.444
BITCOIN	120	3039.263	4177.530	0.300	18,795.200

Table 4 shows the Pearson's correlations coefficient of the variables. There are negative associations between HICP, EURIBOR and EURO. BITCOIN has a positive correlation of 0.491.

Table 4. Pearson's correlation coefficient of variables.

	M1	HICP	EURIBOR	USD/EURO	BITCOIN
M1	1.000				
HICP	−0.761	1.000			
EURIBOR	−0.812	0.606	1.000		
US/EURO	−0.715	0.466	0.789	1.000	
BITCOIN	0.491	−0.215	−0.564	−0.363	1.000

The R-Square of 0.81 shows that M1, HICP, EURIBOR, USD/EURO and BITCOIN contribute 81% of the regression model variance (Table 5). M1 includes cash in circulation, funds on settlement and current bank accounts. The results of the multiple regression model show that if the HICP increase, the European population will keep their money in longer-term deposits or transfer their accounts to foreign banks, including cryptocurrency. Additionally, if EURIBOR and USD/EURO increase, the money supply will reduce. Ceteris paribus, by increasing the price of bitcoins in the economy, the money supply will increase.

Table 5. Multiple linear regression model.

Variable	Dependent variable: M1
Constant	17.409 *** (2.188)
HICP	−1.485 *** (0.176)
EURIBOR	−1.342 *** (0.407)
US Dollar/EURO	−6.892 *** (1.817)
BITCOIN	0.001 ** (0.000)
R^2	0.81

** Significant at the 5% level. *** Significant at the 10% level.

4.7. Political or Legal Regime to Ensure Monetary Stability in the Age of Private Money

We could also explore what could happen if private money, as envisioned by Hayek, came to rule the world in the future. Given that central banks, in their monetary policy exercise, can ensure price stability and ensure the value of money by guarding against inflation, it is critical to examine what institutions and what regimes, legal or political, would fulfil these essential functions. By this, we mean a situation that we may call a "free banking system" without a central bank as the regulator, supervisor and in charge of monetary policy. However, the absence of such institutions regulating cryptocurrencies seems to allow extreme value fluctuations such as the 20% increase in the value of Bitcoin following a tweet by Elon Musk (Hackett 2021).

Importantly, it needs to be noted that this is not entirely unconventional. It was a feature of late 18th and early 19th century Scotland during economist Adam Smith's time. During this period, Scotland enjoyed a stable financial system which mainly arose from the pressure of private commercial banks that they placed among themselves or on each other to ensure that they behaved in a prudent manner (Selgin 2018). In this scheme of things, it was private banks that had the power to issue money. This self-regulation of banks worked because if a single bank overstretched, its reserves would quickly leak away to other banks, thus placing such a bank at the risk of failure. In essence, the absence of a central bank ensures discipline among private banks by ensuring they exercise restraint in their affairs. Besides, Canada did not have a central bank until the early 20th century, and during that period, it experienced both price stability and financial stability (Selgin 2018). There is some valid argument that central banks lead to instability since central banks' creation can lead to inflation and further blunts private banks' mechanism to discipline each other.

As such, we argue that if there were private money from private banks to replace central banks, there would be no need for a particular legal regime. This is because the private banks would devise a mechanism to self-discipline each other and ensure both financial and price stability in the process.

4.8. Global Currency

Regional integration and the resultant regional monetary unions have given rise to debates about the possibility of witnessing a global currency when the whole globe truly becomes a global village, which would entail the collapse of all national boundaries, at least economically, by removing all trade barriers and enabling a free trade flow all over (Andor 2018). Nevertheless, we do not think this is sufficient for us to witness a global currency. Given such a move's political ramifications, we argue that there will be the need for full economic globalisation and political globalisation and a single political authority source for a global currency to arise. Furthermore, given this, we are doubtful to witness a global currency in the 21st century.

The above conclusion does not take away from the fact that various countries, in particular, regions such as Western Europe, have integrated and adopted a single common currency, the euro. However, Western Europe is only a small part of the globe, and even the Eurozone continues to face problems, including threats of countries pulling away from the union (Johnson 2006). If we look back to the formation of the single currency in Europe, it is not difficult to see that the move had economic and political aspects (Johnson 2006). Therefore, it is critical to look beyond the currency and the economy into the political before making any valid assessment of whether this century will witness a global currency's emergence.

Let us first consider the economic aspects that need to be dealt with for proper integration that can pave the way for a global currency to arise (Andor 2018). There would be a need for increased competition in trade than is currently occurring, which is only possible if trade barriers and other trade constraints are removed at the global level. Such a move is difficult to imagine at the moment considering the nationalist and protectionist movements that have arisen in parts of Central and Eastern Europe, parts of South America, and the United States under President Donald Trump. The ethnic-nationalist sentiments and rhetoric appear to be holding sway and are against the opening up of industries and markets in the economy's particular sectors. This is an antithesis to competition and the possible adoption of a global currency. Secondly, there is a need for the further harmonisation of the financial services sector, which will require collaboration among regulators and the development of legal frameworks globally. This is a political process given that the legislative process in all democracies involves politicians, and it so often happens that political will for such initiatives is frequently missing. Thirdly, there would be a need to change national habits, which would involve giving up some of the tendencies people have become accustomed to. By this, we mean adopting the deferral of tax regimes, opening up borders, and facilitating people and capital's free flow.

4.9. Use of Money for Legal, Economic Functions

The evolution of money into its electronic forms and the other transformations that have attended this key institution of money have arguably made it alluring to illicit actors and criminals (Kovacs and Sandor 2016). As stated elsewhere, money serves various legal and economic functions, including being a store of value, a medium of exchange or as a payment system, and a unit of account, among other functions. Therefore, criminals may be incentivised to use money in different criminal activities such as corruption or even financing terrorist networks and activities. Money laundering, a worldwide problem confronting banking scholars, is a pernicious problem principally to the extent that it enables the cleansing of otherwise dirty and illegal money (Schneider 2010). Criminals can launder or clean billions of dollars of money acquired through illicit activities such as drug trafficking through real estate purchases. It, therefore, becomes difficult to trace the source of one's money as an investment whereby such money has been put into perfectly legal investments. Estimates indicate that between 2 to 5 per cent of the total global Gross Domestic Product (GDP), amounting to between USD 800 billion and USD 2 trillion, is laundered annually (UNODC 2016).

Financial institutions deploy significant amounts of resources both financially and in the form of human capital to deal with money laundering. Financial institutions incur substantial regulatory costs to ensure compliance by hiring compliance officers and implementing structures to ensure that money laundering is eliminated or detected. Equally, this comes at a cost to various actors involved in businesses by increasing the transaction costs since due diligence has to be conducted by banks, customers, businesses and others before opening a bank account, depositing money or even withdrawing substantial amounts of cash. To deal with this challenge of money laundering, governments have responded by increasing the regulatory burden on businesses both in quantity and complexity. For instance, the quantity of regulation is estimated to have tripled since the year 2011 to rein in money laundering.

Technological evolution has also affected efforts to combat money laundering and may thus contribute to the quest to make money perform legal, economic functions only. In this age of big data, the substantial growth in data availability on transactions and individuals involved in almost real-time can help financial institutions and regulators alike to monitor and control money laundering activities. However, financial institutions would need to hire and engage more persons experienced and trained in data analysis and anti-money laundering to tackle this problem. This notwithstanding, there is still insufficient and relevant data, time, and resources to make this ideal a reality. Reliance on old technology, procedures and techniques will hardly do in fighting money laundering.

Whereas traditionally, in the unsophisticated world of laundering, following the money was frequently sufficient in identifying the launderers, it is now essential to also study customers' behaviour. It is quite often the case that a particular customer or business looks legitimate when, in fact, it is not. It needs to be borne in mind that precisely because technology is morally neutral, it targets the bad guys who may wish to conduct illicit and illegal activities. Therefore, while technology has enormous potential to help regulators and financial institutions alike ensure that money is employed for legal, economic functions alone, it may also be used to further malevolent activities. Just like the future of money and combating money laundering appears to be in technology, so does the future of money laundering and other illegal activities. Purchasing and holding assets and holding them for some time before disposing of them while hiding the identity of the real owners of such assets that have formed the substance of money laundering are likely to be replaced by cybercrimes and the use of cryptocurrencies to perpetrate fraud.

Regulators and law enforcement authorities need to consider various measures to ensure that money is only used for legal and economic functions, even in its electronic form. First, regulators could require all financial institutions to record and report all electronic money transactions. Second, regulators need to collaborate with other agencies, seeing that some electronic products in particular countries are usually offered by entities other than financial institutions regulated by the relevant banking law regime. Third, regulators should focus on new and inventive encryption techniques to deal with the technologies and encryption techniques that launderers may employ to make it difficult to access their activities. Fourth, there is a need for continuous dialogue and cooperation between developers and providers of electronic money and electronic money products as this may help detect problem areas concerning law enforcement.

5. Conclusions

This paper has considered the lively debate of money's future to establish what money will be in the future. It began by seeking to answer the question of what money is and the economic functions it plays. It then examined the future of physical cash in light of electronic money and digital currency made possible by technological evolution. This paper noted that the various advantages that electronic money has and the inevitable push of technology would lead to an influx of digital money which will largely replace physical cash. However, due to some drawbacks of electronic money and human beings' psychological attachment to physical cash, this paper concluded that physical cash would not entirely disappear. Next, we sought to examine whether a global currency will arise in light of virtual currencies or whether there will be competition for various currencies. This paper argued that it is unlikely that there will be a global currency and that competition between currencies will persist, leading to the emergence of two or three major currencies. It further concluded that cryptocurrencies might not succeed in their quest to replace fiat money issued by central banks. This paper argued that the state would continue to control money through the central banks, given the inescapably political nature of money. This paper also made the case that sovereign currencies backed by the state will continue to dominate and was also melancholic on various regional monetary unions' prospects, given the wave of nationalism worldwide. In the unlikely event that the private sector through private banks replaces central banks in a world of private money, this paper

argued that there would be no need for an exceptional legal or political regime to ensure price and financial stability as private banks would self-discipline each other to ensure that, as happened in 18th century Scotland. Finally, this paper considered the various ways regulators can ensure that future money, particularly in its digital form, may be used only for legal, economic functions and not illicit activities.

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Generalized Trust and Economic Growth: The Nexus in MENA Countries

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Abstract: This study mainly examines the relationship between generalized/horizontal/social trust and economic growth in countries in the Middle East and North Africa (MENA) region, considering the substantial decline in their trust values since 2005. The study utilizes a multiple linear regression model based on panel data comprising 104 countries over the period from 1999 to 2020. Trust data were obtained from the last four waves of the World Values Survey (WVS). A Pooled Ordinary Least Squares (POLS) estimation technique was used, and interaction terms between trust and several dummy variables were employed. The results show an overall positive and significant relationship between trust and economic growth in the general model and for all country classifications, except for MENA, where the overall relationship is negative but almost negligible. Trust has the highest impact on growth in transition economies, followed in order by developing Asia, developed, developing/Sub-Saharan Africa, developing America, and then MENA countries. Further investigations reveal that the *overall* negative/reversed effect of trust on economic growth in MENA is only during waves 6 and 7, where the coefficients are sizable.

Keywords: generalized trust; horizontal trust; social trust; social capital; economic growth; democracy; MENA; developing countries; Arab Spring; WVS

JEL Classification: O17; O43; O57

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1. Introduction

Cultural and behavioral factors including trust have been explored in the academic literature relatively recently to decipher the reasons for persistent growth differentials across countries. Trust, research reveals, although only one constituent of social capital, is an imperative aspect for economic and social relations (Algan 2018). The concept of generalized/horizontal/social trust refers to the level of trust between individuals in a society unknown to each other—interpersonal trust, which is different from trust in institutions—institutional trust—or authorities, which is sometimes referred to as vertical trust. Generalized trust (or simply "trust" unless otherwise specified) is perceived as one of the main decisive drivers of economic performance/growth (Knack and Keefer 1997; La Porta et al. 1997; Zak and Knack 2001; Algan 2018). Research performed from 2009 onwards demonstrated the causality of this relationship (Algan and Cahuc 2010), which is transmitted through several channels. These channels include trust's boosting effects on efficiency, human capital accumulation, governance, investment and innovation, financial markets' operations, firms' organizations, labor markets' operations, and trade, which all directly and positively affect growth. Trust also plays a crucial role in enhancing the well-being of citizens, which directly affects their productivity and consequently economic growth. Trust, according to Arrow (1972) is an essential lubricant of a social system since it facilitates cooperation and mutually beneficial exchanges in the existence of imperfect information and incomplete contracts. This study is not interested in investigating the

channels through which trust affects growth. Rather, it is interested in testing how trust affected economic growth in general and particularly in the MENA countries.

Kasmaoui et al. (2018) is the only study that examined the trust–growth relationship in MENA countries, driven by the several changes the region has undergone recently, such as demographic transitions, the Arab Spring, and other economic changes. These events affected both the economic growth and the trust levels in the region. Their study focused on a sample of 60 countries that were included in only the sixth wave (2010–2014) of the World Values Survey (WVS), and their cross-country analysis showed a positive and significant impact of trust on growth in the overall sample. However, when the relationship was investigated only for the MENA countries in the sample, the results indicated that the impact was weaker compared to other countries. Since this study covered only a single, turbulent period the results may not be generalizable to the MENA region's overall trust–growth interconnection, suggesting room for further investigation.

MENA countries are of specific interest because they started with trust levels that are very comparable to those of developing Asian and developed countries, yet they are the only region that experienced a significant deterioration in their trust values across the last four waves of the WVS. Developing American countries also experienced reduced trust values throughout the four waves, but not as stark as the fall in those of MENA nations. As shown in Figure 1 and Table A1 (in Appendix A), in MENA, generalized trust dropped by 41% from wave 4 to 5, by 2% from wave 5 to 6, by 34% from wave 6 to 7, and by 62% over the entire period from wave 4 to 7.

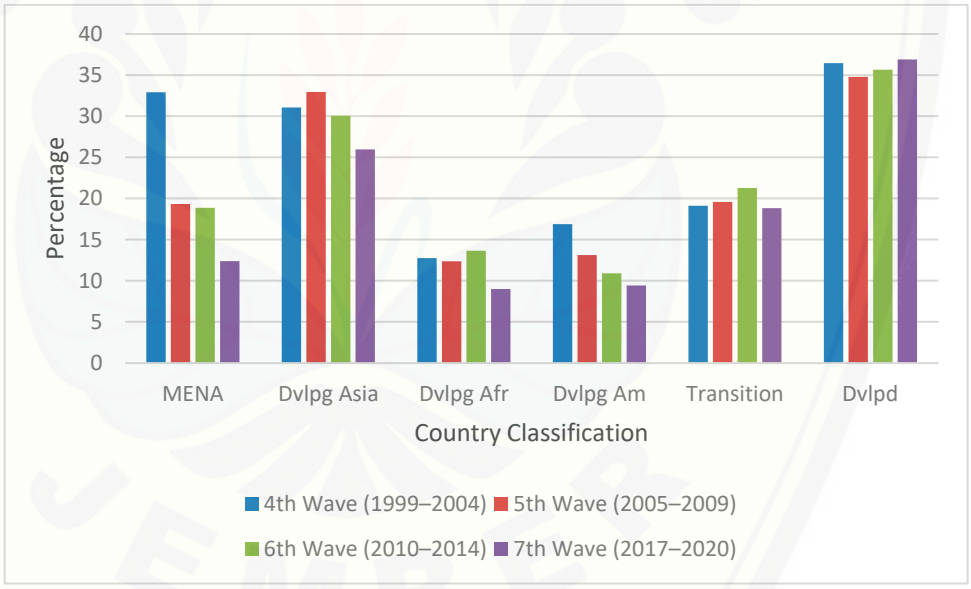

Figure 1. Generalized trust mean values by country classification and wave.

One possible reason for this decline is the Arab Spring, including the circumstances that led up to it (occurring during wave 5), its beginnings (during wave 6) and its lasting ramifications, from which several MENA economies are still suffering. The Arab Spring was exemplified by violence and upheaval in several countries as well as political and social fragmentation, even within individual families. Given the Arab regional identity, this implies that increased group tension during the uprising could harm interpersonal trust across the region (Spierings 2019). Furthermore, in several countries the actions of those who came into political power after the uprising may have changed people's general views on trustworthiness, particularly in those countries whose new leaders were untrustworthy and corrupt. Even before the Arab Spring, the economic, political, and social circumstances that led to its occurrence might have manifested themselves in the massive drop in the trust values described above. It is still an interesting observation and perhaps requires more in-depth research, that during the worst years of disruptions—that of the Arab Spring itself

(wave 6), trust did not drop as much as it did before the onset of the Arab Spring (from wave 4 to wave 5) and after it (moving from wave 6 to wave 7).

Many MENA countries were faced with several other major challenges before and during the uprising, such as chronic unemployment, declining remittances, and social and political unrest (Acheboune and Driouchi 2014; El-Katiri et al. 2014; Naufal and Vargas-Silva 2010). These challenges had a major impact on growth in many MENA countries and given the reduced level of interpersonal trust, it is interesting to investigate if the latter affected the former.

This study thus explores how generalized trust affects economic growth in MENA countries. This is done by comparing this relationship in the MENA region to other countries at various stages of economic development using a panel data set covering 104 countries during the period from 1999 to 2020. The period covered by the study was chosen based on the availability of data for MENA countries in the WVS, which began in the fourth wave (1999–2004) and has continued since then. Previous studies measured either the general impact of trust on growth, or the impact of different variables on the accumulation of trust in a certain economy but not for such an extended period as this study covers. Moreover, the impact of trust on growth in MENA countries has been investigated only once, using cross-country analysis and for only one wave as mentioned earlier. To the best of our knowledge, no previous studies have investigated the impact of trust on economic growth in MENA countries using panel data, and none have compared it to other countries in terms of economic development classifications. This study aims to fill these gaps in the literature. The results show that trust positively affects economic growth in the general model, and that an overall positive trust–growth relationship is strongest in transition countries, followed by developing Asia, developed, developing/Sub-Saharan Africa, developing America, and then MENA countries. MENA countries not only have the weakest trust–growth nexus, but this relationship even reversed its sign during the last two waves. The results of this study should be of interest to sociologists, economists, policymakers, and governments to help them understand the underlying reasons behind this unusual finding.

The remainder of this study is organized as follows: Section 2 provides a review on the trust literature and its relation to growth. Section 3 explains the data and the econometric model used. Section 4 presents and discusses the results. Finally, Section 5 concludes and offers policy implications.

2. Literature Review

2.1. Trust and ITS Measurement

The trust concept has been differently interpreted by many, resulting in different measures, and consequently different policy implications (Algan 2018). Mobilized by this, OECD (2017) have reviewed these differences and produced its "Guidelines on Measuring Trust". Following these guidelines, trust is defined as "a person's belief that another person [interpersonal trust] or institution [institutional trust] will act consistently with their expectations of positive behaviour" (p. 42). OECD (2017) differentiated between two types of interpersonal trust: generalized trust, which refers to trust in people unknown to the respondent, and limited trust, which refers to trust in people known to the respondent, such as family, friends, and close-by neighbors. This study only focuses on interpersonal generalized trust.

The OECD (2017) identified four various approaches to measuring the same concept of trust—three are survey-based and one is behavioral/experimental-based. The survey-based approaches vary according to the focus of the questions asked. The evaluation approach focuses its questions to the respondents on their views at the time of the survey—the present, while the expectations and the experiences approaches focus their questions on the respondents' views about the future and in the past, respectively. The survey data thus provide subjective information. Contrarily, the experimental-based approach focuses on lab experiments that are designed to evoke an array of social behaviors including trust and

capture actual behavior. Measures of trust based on experiments, although not subjective, are not and cannot be performed on a large scale, contrary to the survey-based ones, and thus cannot be used as "good predictors of macroeconomic outcomes" (Algan 2018).

In surveys, "the generalized trust question" (following the evaluation approach) or in other words, the "standard" measure of trust, is the most often used measure of interpersonal trust. Whereby respondents are asked "Generally speaking, would you say that most people can be trusted, or that you need to be very careful when dealing with people?", where the answers are binary, taking the value of 1 if the choice is that most people can be trusted and 0 otherwise (OECD 2017).

Whether this "standard" measure of trust is reliable (i.e., generates consistent results when measured at different periods of time) and valid (i.e., measures what it is supposed to measure) has been extensively discussed in the literature, with many scholars on opposite sides of the issue (Barro 1991; Beugelsdijk and Van Schaik 2005; Hardin 2002; Katz and Rotter 1969; Lundmark et al. 2016; Rice and Feldman 1997; Uslaner 2008, 2012; Volland 2010). Uslaner (2015) offered a thorough defense in response to each criticism of the "standard" measure. OECD (2017) identified several criteria, including but not limited to reliability, face validity, convergent validity, and construct validity to evaluate the statistical quality of the interpersonal generalized trust measure. The OECD (2017) also identified many issues with these survey-based data trust measures, such as stemming from nonofficial surveys, using very small sample sizes that are not always representative, with relatively poor coverage especially over time, and using different response scales. Nevertheless, the OECD (2017) found strong evidence for the reliability and the validity of the interpersonal generalized trust measures, as they were found to be consistent over time and across different sources of data, they had relatively low nonresponse rates and they have been found to be highly correlated with a sizable array of economic and social outcomes. According to Algan (2018), "for inter-personal trust there is a consensus on using generalized trust as the preferred measure" and that is why OECD (2017) recommended using them in official statistics vehicles.

2.2. Trust and Economic Growth—Theoretical Underpinnings

The causes of economic growth and development, Algan (2018) explained, have moved away from stressing the important role of capital (human and physical) accumulation and technological progress, to focusing on formal institutions' role in supporting or weakening market institutions that influence wealth accumulation and innovations, to then shifting attention towards deep-seated elements such as social capital and trust.

Trust boosts economic growth directly through several channels. It reduces transaction costs by solving the problems of collective action without the intervention of regulations (Ostrom 1990), which increases efficiency (Coase 1990) and thus stimulates growth. Trust augments human capital (Coleman 1988), which is a significant determinant of growth (Temple 2001) by increasing both the demand for and supply of education (Bjørnskov 2006). The demand for education increases since it solves the principle-agent problem of the hard to monitor tasks assigned to educated workers, while, through encouraging people to share their human capital, it generates positive outcomes/externalities by affecting the level of schooling, thus increasing its supply by the government. Trust enhances governance, a main growth factor, through broadening government accountability, achieving agreements even when the positions of politicians and voters are strongly polarized, and allowing for greater policy innovations when new challenges are met (Knack 2002). Trust increases investment rates and innovation (Whitely 2000; Algan and Cahuc 2014), both crucial growth determinants, through supporting the well-functioning of the financial markets, which is negatively affected by uncertainties that stem from moral hazard and contract enforcement difficulties (Algan and Cahuc 2014). Zak and Knack (2001) argued that distrusting brokers incurs a transaction cost on investors, which lowers the investment rate. Trust positively affects growth through the organization of firms (Algan and Cahuc 2014) by easing cooperation among anonymous individuals, which results in the surfacing and development

of private and public organizations as well as by favoring decisions' decentralization within organizations, which enhances their adaptability to changes in the environment (Fukuyama 1995; La Porta et al. 1997; Bertrand and Schoar 2006; Bloom et al. 2012). Trust supports the well-functioning of the labor markets (Algan and Cahuc 2014) through favoring cooperation between management and labor (Aghion et al. 2011), which encompasses a bundle of factors that support economic growth and well-being. Trust boosts international trade with foreign partners as it provides security for the gains of trade by lowering the risk of noncompliance with trade contracts (De Groot et al. 2004).

Trust also stimulates growth indirectly through its effect on the well-being of citizens. Reviewing several studies, Algan (2018) showed that trust positively affects the health of individuals—in terms of lower suicide rates, better mental health, lower rates of heart disease and death rates—and increases life satisfaction and happiness. Better health (Arora 2001) and life satisfaction and happiness (Bellet et al. 2020) have both been associated with higher productivity and consequently economic growth.

2.3. Trust and Economic Growth—Empirical Findings

Knack and Keefer's (1997) groundbreaking study examined the relationship between trust and economic growth across countries in a certain period (cross-section analysis). Using indicators from the World Values Survey (WVS), they found that trust positively affects growth. Zak and Knack (2001) using the model in Knack and Keefer (1997), confirmed those results and found that trust is positively correlated with investment rates and growth in per capita income.

La Porta et al. (1997) also used WVS trust data and cross-country analysis to confirm that trust promotes growth through enhancing government efficiency and participation in social organizations. Schmidt (2003) found that trust promotes growth by accumulating human and physical capital, increasing the spread of technology, and improving the level of functioning within institutions. Bjørnskov (2012) indicated that trust positively affects schooling and governance, both of which significantly affect growth. In their studies, both Schmidt and Bjørnskov depended on WVS trust data. Bjørnskov and Méon (2013) showed that trust results in improvements in education, the quality of institutions, and GDP per capita.

Similarly, but focusing on states rather than countries, Knack (2002), and Dincer and Uslaner (2010) found a significant direct relationship between trust and growth across the individual states in the U.S. Cui (2017) investigated the relationship across provinces in China and concluded that trust positively and significantly promotes growth in such provinces.

Dearmon and Grier (2009) were the first to update the method used in Knack and Keefer (1997) and Zak and Knack (2001) to incorporate panel estimation techniques. Using WVS trust data, they concluded that the effect of trust on economic development stems from its effect on human and physical capital. They also found that the marginal impact of trust on both of those forms of capital decreases as trust increases, which means that promoting trust would be most beneficial to low-trust countries (Dearmon and Grier 2011).

Utilizing panel estimation techniques as well, Roth (2009) demonstrated an inverse relationship between trust and growth. This result stemmed from including developed countries in the sample, and the explanation given was that the effect of trust on growth relies upon the initial level of trust in the economy. If the initial level of trust is already high (relative to other countries), the effect of trust on growth will be negative; if the initial level of trust is low, trust will have a positive effect on growth. This is supported to some extent by the findings in Dearmon and Grier (2011).

Volland (2010) using WVS trust data tested the robustness of the trust–growth relationship, particularly with respect to the claim that trust captures how well a country's institutions function. His results showed that trust positively and significantly affects growth and that the trust–growth relationship is indeed robust after controlling for respondents' perceptions of the functioning/quality of institutions. Peiró-Palomino and Tortosa-Ausina

(2013) studied the role of trust on economic development and showed that while trust is a principal driver of economic development, it is not relevant for poor countries and exhibits diminishing returns as an economy becomes richer. The irrelevance of trust for poor countries contradicts the findings in Knack and Keefer (1997), who proposed that trust is more relevant to a poor country whose rule of law and institutions are weak; in that situation, trust (an informal institution) substitutes for weak formal institutions, lowering transaction costs which could, in turn, increase output. In contrast, Zak and Knack (2001) suggested the idea of "low-trust poverty trap" wherein poor countries with low trust levels cannot use trust to lubricate growth and development.

Horváth (2013) was an exception to the studies discussed above. He utilized Bayesian Model Averaging to research the impact of trust on growth and focused on the robustness of the relationship and the role of model uncertainty. His results showed that trust is among the top determinants of, and has a positive impact on, long-run economic growth, and that for countries with a weak rule of law the effect of trust is stronger. Moreover, the findings were robust regarding the endogeneity of the trust–growth relationship.

Concerns about whether the correlation between trust and economic growth could go from income to trust, and not the other way around, as all the previous studies have demonstrated, have been put to rest by Algan and Cahuc (2010) who confirmed, after controlling for reverse causality and confounding factors, a steady causal relation moving from trust to income.

Algan and Cahuc (2014) plotted for 106 countries, their per capita income during 1980–2009 against their average generalized trust during 1981–2008, and found a steady correlation, where 20% of per capita income cross-country variation was associated with trust differences. Moreover, using regression analysis, they found that after controlling for several factors, trust continues to have a positive and significant effect on per capita income. Trust was calculated as the country average from replies to the "Generally speaking" trust question in five waves of the WVS, four waves of the European Values Survey, both covering the 1981–2008 period, and the third wave (2005) of the Afrobarometer.

Lopes and Rivera-Castro (2018) using WVS trust data for 79 countries during the 1994–2014 period, tested whether trust affected growth in democratic countries. Their results showed that democratic countries enjoying high trust levels have lower growth rates than nondemocratic countries with low trust levels. Their results also showed that democracy alone is not the reason behind the lower growth rates but rather the democracy–trust conjunction that increased government spending and reduced investment rates. This interesting finding is not far away from the conclusions of Dearmon and Grier (2011) and Peiró-Palomino and Tortosa-Ausina (2013) that highlighted the diminishing marginal returns of trust on growth in rich/developed countries, which usually enjoy high trust levels, since most rich/developed countries are in fact democratic. This democracy–trust association calls for further investigation in this study given that almost all MENA countries included score relatively low in their democracy indices and are thus considered nondemocratic.

3. Methodology

Prompted by the previously noted significant drop in trust values for MENA countries, the primary goal of this study is to investigate the trust–growth nexus in those countries. To do so, the first step is to test the hypothesis that generalized trust positively affects economic growth in general, as suggested in the existing literature. Then the MENA region's trust–growth relationship is compared to other country classifications to gain a better understanding of this relationship in the MENA region in particular.

To measure trust, as in most other studies, the generalized trust question from the WVS is used, and it is then measured as the percentage of respondents who choose the response, "most people can be trusted". The WVS consists of seven waves over the period from 1984 to 2020; on average, each wave is conducted over a four-year period. This study uses only the last four waves covering the subperiods 1999–2004, 2005–2009,

2010–2014 and 2017–2020 (published July 2020), respectively, because these waves include MENA countries. The total number of countries originally included in the sample was 104, including 15 MENA countries, but the final number is 92, as some countries were dropped due to missing variables. A list of the countries and the classification to which they belong is shown in Table A2 in Appendix A. This study adopts the base model used in Knack and Keefer (1997), Zak and Knack (2001), and updated by Volland (2010). Therefore, in addition to the main independent variable, *Trust*, other exogenous control variables affecting growth are used as discussed below. Table A3 in Appendix A provides a summary of the variables used in the model, their definitions, expected signs, and data sources.

Initial GDP Per Capita (GDPPC): The neoclassical growth model and the Absolute Convergence hypothesis postulate that poor countries grow faster than rich economies (Ramsey 1928; Solow 1956). According to Barro (2003), the convergence hypothesis suggests that countries with a relatively low initial level of GDPPC will experience an acceleration in economic growth during the observation interval. Hence, economic growth is expected to be inversely related to the initial level of GDPPC. Since this variable measures convergence, it should reflect the previous period's level of growth. Following Zak and Knack (2001), the initial level of GDP per capita growth is the first growth observation in the five years observation window; thus, it is referred to as $t - 5$.

Inflation: According to Gokal and Hanif (2004), high levels of inflation hamper economic growth because of the adverse costs it imposes on investment, its tax distortions, and its negative effect on countries' international competitiveness. On the other hand, referring to the Aggregate Demand—Aggregate Supply (AD-AS) model, an increase in growth increases inflation and thus a positive relationship between the two variables is possible. Nevertheless, the empirical literature shows an inverse relationship (Barro 1995; Bruno and Easterly 1995). Economic growth is therefore expected to be negatively correlated with inflation.

Life Expectancy: Life expectancy is a proxy for a country's quality of health care. Improvements in health conditions could decrease mortality rates, accelerating the growth of the population base and reducing income per capita. Similarly, countries with an aging population experience low levels of GDPPC growth due to the declining percentage of the population in the labor force (Bhargava et al. 2001; Sachs and Warner 1997). On the other hand, if a country experiences a drop in mortality rates after a demographic transition phase, an increase in life expectancy would reduce population growth and increase per capita income (Barro and Lee 1994; Bloom et al. 2000). Based on this, the relationship between economic growth and life expectancy cannot be confidently determined a priori.

Schooling Attainment: The level of schooling attainment is used as a proxy for human capital, which is a determinant of economic growth since an educated labor force is more productive and innovative (Mankiw et al. 1992; Nelson and Phelps 1966). Consequently, economic growth is expected to be positively correlated with schooling attainment.

Investment: Most growth models consider capital formation as an antecedent of economic growth. This strong and positive relationship has been established in both theoretical and empirical studies (Blomstrom et al. 1996; Ram 1989). This study also expects economic growth to be positively correlated with the level of investment.

Military Expenditure: Military expenditures may represent an opportunity cost, as they decrease spending on other productive activities such as human capital, and research and development, and thus negatively affects economic growth (Dunne and Vougas 1999; Dunne et al. 2002). An opposing view holds that military expenditures could accelerate economic growth by having a stimulative effect that results in higher aggregate demand, employment, innovation, and production (Chletsos and Kollias 1995). Therefore, the relation between economic growth and military expenditure cannot be assertively determined a priori.

Price of Investment Goods: Real investment rates are positively correlated with economic performance. However, most of the findings in the literature indicate that while the investment rate at domestic prices cannot explain changes in growth, relative prices of capi-

tal can (De Long and Summers 1991; De Long and Summers 1993; Taylor 1994). This study expects economic growth to be negatively correlated with the price of investment goods.

Trade Openness: Trade openness refers to an economy's trade policy orientation. Empirical evidence reveals that trade openness positively affects economic growth (Frankel and Romer 1999; Sachs and Warner 1995) in support of the endogenous growth theory, which postulates that trade has a positive impact on growth through innovation and technology spillovers (Grossman and Helpman 1991). Thus, economic growth is expected to be positively associated with trade openness.

Rule of Law: Rule of Law means the extent to which it is possible to secure property rights, or to uphold the integrity of contracts in a country. It represents institutional development, such as having a credible police force, public defenders and prosecutors, reforming the criminal code, and ensuring the integrity of the penal system. The empirical literature concludes that robust property rights are associated with improved economic performance (Clague et al. 1999; Knack and Keefer 1995). Therefore, this study expects economic growth to be positively associated with the rule of law.

Democracy: There is controversy in the literature regarding the effect of democracy on economic growth. Many scholars believe that democratic regimes stimulate growth more than their authoritarian counterparts because they robustly promote human capital accumulation and less robustly reduce income inequality, among other reasons (Clague et al. 1996; Haggard 1997; cited in Lopes and Rivera-Castro 2018). Other scholars believe the opposite because democratic regimes lower physical capital accumulation and increase government consumption as a ratio of GDP, both of which occur because of redistributive pressures (Rao 1984; Persson and Tabellini 1992; Blanchard and Shleifer 2001; Tavares and Wacziarg 2001; all cited in Lopes and Rivera-Castro 2018). Still, there are even others that found no relationship at all (Barro and Lee 1993; Alesina et al. 1996; cited in Lopes and Rivera-Castro 2018). Consequently, the democracy-growth relationship cannot be decisively determined a priori.

Based on the above, the general model used in this study, which is an extended form of the neoclassical growth model, is specified as follows:

$$Growth_{it} = \beta_0 + \beta_1 Trust_{it} + \beta_2 GDPPC_{it-5} + \beta_3 Infl_{it} + \beta_4 Lexpec_{it} + \beta_5 Schooling_{it} + \beta_6 Inv_{it} + \beta_7 Military_{it} + \beta_8 POI_{it} + \beta_9 Openness_{it} + \beta_{10} RLW_{it} + \beta_{11} Democ_{it} + \varepsilon_{it}$$

where the subscripts '*i*' and '*t*' denote the country and wave, respectively, and ε is the error term. The dependent variable is the growth rate of real GDPPC (measured in constant (2010) US dollars). Following Dearmon and Grier (2009), all annual macroeconomic data were made consistent with the WVS data by using an observation window for each country. That is, data related to waves 4, 5, 6 and 7 are averages of the periods 1999–2004, 2005–2009, 2010–2014, and 2017–2020, respectively. For level of education, the five-year interval closest to the first year of the wave is selected. For Democracy, wave 4 used the Economic Intelligence Unit's (EIU 2020) democracy indices first published values in 2006 and then from wave 5 to wave 7, the averages were taken as for the rest of the variables. The data set, which consists of 214 observations, is unbalanced, meaning that not all countries have four observation windows. STATA version 12.0 was used to perform all statistical analysis. Table A4 in Appendix A displays the descriptive statistics of all the variables used in this study, including all the interaction terms.

4. Results and Discussion

A multiple linear regression model is used to test the effect of each of the independent variable and the control variables on the dependent variable. As a first step, the dependent variable was checked for normality using the Shapiro–Wilk test and showed a *p*-value of 0.046. Since this is greater than 0.01, the null hypothesis should not be rejected, meaning that the dependent variable is considered normally distributed with 99% confidence. A Pooled Ordinary Least Squares (POLS) estimation technique is then used. The POLS approach is the best option since interaction terms for the trust variable with the various

countries' classification dummies will be introduced to the model later. Moreover, the dataset used is not the typical panel data that would allow for random or fixed effects estimation models, since roughly 27% of the countries are included in only one wave, 37% are present in two waves, 23% have observations in the three waves and just 13% of the countries are present in all four waves.

4.1. The General Model

Before interpreting the results of the general model (shown in Table 1, column 1), the Variance Inflation Factor (VIF) was employed to test for multicollinearity. As shown in Table 2a, there are no multicollinearity concerns since all VIF values are below 10. Heteroskedasticity was also examined using a Breusch–Pagan/Cook–Weisberg test. The probability of the chi-square value was 0.206, which is greater than the standard threshold of 0.05, indicating that the null hypothesis should not be rejected, i.e., the variance of the residuals is constant with 95% confidence. Next, a Ramsey regression specification-error test was utilized to test for omitted variables, which gave a *p*-value of 0.076; a value greater than 0.05 means that the model is correctly specified and that there are no omitted variables, with 95% confidence. Regarding endogeneity, theoretically speaking the way the data are used eliminate or greatly mitigate this problem. To be more precise, for education for instance, the five-year interval closest to the first year of the wave is selected, while for growth of the GDPPC it is the average of the whole interval; this means that education is to a great extent the leading variable and precedes growth of the GDPPC, which almost eliminates the endogeneity problem. For most of the other variables, averages are also taken for the whole five-year interval, which also to a great extent mitigate the endogeneity problem. Statistically, there is endogeneity if the covariance between any regressor and the error term is not zero. Thus, to make sure that there is no endogeneity, the simplest technique was used where the model was estimated then the residual was predicted and correlated with all the regressors. As shown in Table A5 in Appendix A, the correlation is zero, which means there is no endogeneity.

The value of the R-square obtained in this model is similar to those obtained in previous studies that analyzed the trust–growth relationship (Knack and Keefer 1997; Volland 2010; Zak and Knack 2001). The adjusted R-square is 0.33, indicating that the proposed model explains 33% of the total variance in GDPPC growth. The model is deemed to be sound since the F-statistic is equal to 0.00.

Regarding the coefficients of the variables, the coefficients of $GDPPC_{t-5}$ (although trivial) and *Infl* are negative and significant, as expected. The coefficients of *Lexpec* and *Military* are also negative and significant, while *Schooling*, *Inv*, and *RWL* have significantly positive coefficients, as expected. The coefficients of *POI, Openness*, and *Democ* are all insignificant. Regarding the *Trust* variable, it has a positive and significant coefficient of 0.0429, suggesting that a one-unit increase in the level of trust increases GDPPC growth on average by 0.0429 units, holding other variables constant. This outcome is consistent with the findings in previous studies (Bjørnskov 2006; Knack and Keefer 1997; Knack 2001; La Porta et al. 1997; Zak and Knack 2001).

Table 1. Results for the general model and the models with different trust interactions.

Dependent Var. Growth	**Coef. (1)**		**Coef. (2)**		**Coef. (3)**		**Coef. (4)**	
$GDPPC_{t-5}$	−0.0001	***	−0.0001	***	−0.0001	***	−0.0001	***
	(0.0000)		(0.0000)		(0.0000)		(0.0000)	
Infl	−0.0580	***	−0.0535	***	−0.0528	***	−0.0556	***
	(0.0113)		(0.0113)		(0.0112)		(0.0113)	
Lexpec	−0.0949	***	−0.0802	*	−0.0625		−0.0969	***
	(0.0298)		(0.0442)		(0.0443)		(0.0293)	
Schooling	0.1784	**	0.0925		0.0737		0.1971	***
	(0.0771)		(0.0905)		(0.0900)		(0.0762)	
Inv	5.9858	**	4.5016	*	3.5803		5.2405	**
	(2.4689)		(2.5154)		(2.4999)		(2.4505)	
Military	−0.2577	**	−0.2070	*	−0.2131	*	−0.3131	***
	(0.1123)		(0.1162)		(0.1146)		(0.1082)	
POI	−0.8394		−0.7602		−0.8042		−0.8440	
	(0.9451)		(1.0087)		(1.0018)		(0.9341)	
Openness	0.0037		0.0017		0.0017		0.0026	
	(0.0033)		(0.0033)		(0.0033)		(0.0033)	
RWL	0.5417	*	0.6808	**	0.6656	**	0.7282	**
	(0.3178)		(0.3296)		(0.3254)		(0.2951)	
Democ	−0.0090		−0.0105		−0.0162			
	(0.0124)		(0.0138)		(0.0138)			
Trust	0.0429	***	0.0607	***	0.0547	***	0.0602	***
	(0.0107)		(0.0139)		(0.0139)		(0.0124)	
MENA_Trust			−0.0667	***				
			(0.0191)					
DvlgAfr_Trust			−0.0389		−0.0367			
			(0.0615)		(0.0610)			
DvlgAm_Trust			−0.0489		−0.0581			
			(0.0355)		(0.0352)			
Transition_Trust			0.0056		0.0017			
			(0.0250)		(0.0248)			
Dvlpd_Trust			−0.0335	*	−0.0336	*		
			(0.0196)		(0.0193)			
MENAW4_Trust					−0.0528	**		
					(0.0222)			
MENAW5_Trust					−0.0213			
					(0.0361)			
MENAW6_Trust					−0.1206	***		
					(0.0307)			
MENAW7_Trust					−0.1721	***		
					(0.0616)			
Democ2_Trust							−0.0350	**
							(0.0152)	
_cons	8.4658	***	8.6085	***	8.2073	***	8.2871	***
	(2.0514)		(3.1239)		(3.1027)		(1.9170)	
Number of obs.	214		214		214		214	
F (11, 202) =	10.38		F (16, 197) = 8.62		F (19, 194) = 7.96		F (11, 202) = 11.06	
Prob > F	0		0		0		0	
R-squared	0.36		0.41		0.44		0.38	
Adj R-squared	0.33		0.36		0.38		0.34	
Root MSE	1.94		1.88		1.85		1.92	

Note: (1) Standard errors are between parentheses. (2) ***, **, * represent significance level at 1%, 5%, and 10% respectively.

Table 2. All Variance Inflation Factor (VIF) values for all carried regressions.

a			c			d		
Variable	**VIF**	**1/VIF**	**Variable**	**VIF**	**1/VIF**	**Variable**	**VIF**	**1/VIF**
RWL	5.52	0.18	Dvlpd_Trust	9.09	0.11	Democ2_Trust	10.11	0.10
$GDPPC_{t-5}$	4.39	0.23	Lexpec	6.48	0.15	RWL	4.90	0.20
Democ	3.48	0.29	RWL	6.32	0.16	$GDPPC_{t-5}$	4.54	0.22
POI	3.08	0.32	$GDPPC_{t-5}$	5.33	0.19	Democ2	4.11	0.24
Schooling	2.77	0.36	Democ	4.71	0.21	Trust	3.89	0.26
Lexpec	2.68	0.37	Schooling	4.13	0.24	POI	3.24	0.31
Trust	1.78	0.56	POI	3.78	0.26	Schooling	2.86	0.35
Inv	1.40	0.72	Trust	3.27	0.31	Lexpec	2.75	0.36
Openness	1.33	0.75	DvlgAfr_Trust	3.13	0.32	Inv	1.41	0.71
Military	1.31	0.77	Transition_Trust	2.09	0.48	Openness	1.34	0.75
Infl	1.28	0.78	DvlgAm_Trust	1.78	0.56	Infl	1.29	0.78
Mean VIF	2.64		Inv	1.57	0.64	Military	1.29	0.78
			Military	1.49	0.67	Mean VIF	3.48	
			MENAW4_Trust	1.43	0.70			
b			Openness	1.39	0.72	e		
Variable	**VIF**	**1/VIF**	MENAW6_Trust	1.36	0.73	**Variable**	**VIF**	**1/VIF**
Dvlpd_Trust	9.02	0.11	Infl	1.35	0.74	Democ2_Trust	4.95	0.20
RWL	6.28	0.16	MENAW7_Trust	1.21	0.83	RWL	4.87	0.21
Lexpec	6.25	0.16	MENAW5_Trust	1.14	0.88	$GDPPC_{t-5}$	4.43	0.23
$GDPPC_{t-5}$	5.18	0.19	Mean VIF	3.21		POI	3.08	0.32
Democ	4.60	0.22				Schooling	2.77	0.36
Schooling	4.05	0.25				Lexpec	2.65	0.38
POI	3.71	0.27				Trust	2.45	0.41
Trust	3.17	0.32				Inv	1.41	0.71
DvlgAfr_Trust	3.09	0.32				Openness	1.32	0.75
Transition_Trust	2.07	0.48				Infl	1.29	0.78
MENA_Trust	1.80	0.56				Military	1.24	0.81
DvlgAm_Trust	1.75	0.57				Mean VIF	2.77	
Inv	1.54	0.65						
Military	1.48	0.68						
Openness	1.38	0.73						
Infl	1.34	0.74						
Mean VIF	3.54							

4.2. The Economic Development Country Classifications' Model

Running the model for MENA countries alone to investigate the effect of trust on their economic growth was not feasible because of the small number of observations. Therefore, an interaction term between the *Trust* variable and a MENA dummy variable that takes the value of 1 if the country belongs to the MENA region and 0 otherwise, is added to see the impact of the *Trust* variable on growth if the observation is from a MENA country. Moreover, and for better comparability, the same is done with other economic development country classifications, since different country groups might have different effects on growth as the literature discussed before portrayed, and so another four interaction terms are added. As shown in column 2 of Table 1, these are between *Trust* and each of a developing/Sub-Saharan African countries' dummy, a developing American countries' (North, Central, Latin and the Caribbean) dummy, a transition countries' dummy,

and a developed countries' dummy (which includes developed North America, Asia, EU and Oceania). There is no interaction term between *Trust* and a dummy for developing Asia, because developing Asian countries are used as the chosen reference category for the other interaction terms, for three reasons. First, like MENA countries, they have a developing country status. Second, their trust values at the beginning of wave 4 were very comparable to those of MENA countries. Third, they represent more than quarter of the developing countries in the sample; thus, it serves as a good reference category. The coefficients of the *Trust* interaction terms (positive or negative), are then each added to the coefficient of the *Trust* variable and the result reflects the size and sign of the impact of trust on growth in the different country groups.

Once again, multicollinearity was tested and did not posit any concerns since all VIF values are under 10, as shown in Table 2b. Heteroskedasticity was also tested and the probability of the chi-square value is 0.205, indicating that it is not a problem. Omitted variables were also tested, which gave a *p*-value of 0.263, indicating that the model is correctly specified, with 95% confidence. Endogeneity was tested as well and the correlation values between the residual and the regressors were all zeros, as shown in Table A6 in Appendix A, indicating that it is not a problem.

Slightly better values are obtained for the R-square and adjusted R-square. The signs and significance (or lack thereof) of the coefficients for $GDPPC_{t-5}$, *Infl*, *Lexpec*, *Inv*, *Military*, *POI*, *Openness*, *RWL* and *Democ* are all similar to the results obtained from the general model. The magnitudes of the coefficients differ slightly, but not in a way that would cause any significant changes to the original interpretations. The main difference is seen for *Schooling*, which still has its original sign but is now insignificant with respect to growth.

The coefficient of *Trust* is positive and significant, suggesting that trust in developing Asian countries has a positive effect on economic growth, and that a one-unit increase in trust would increase growth in developing Asian countries by 0.0607 units. The coefficients of *DvlgAfr_Trust* and *Dvlg Am_Trust* are both negative while that of *Transition_Trust* is positive, but they are all insignificant, indicating that the effect of trust on developing African, developing American, and transition countries' growth is not significantly different than its impact on developing Asian countries. This result is in line with, and marginally reinforces the findings in Knack and Keefer (1997), which suggested that trust is more pertinent in relatively poor countries whose rule of law and institutions are weak. It also contradicts the results in Peiró-Palomino and Tortosa-Ausina (2013) that contended that trust is irrelevant to poorer countries. The coefficient of *Dvlpd_Trust* is negative and significant, supporting the results in Peiró-Palomino and Tortosa-Ausina's (2013) showing that trust exhibits diminishing returns in wealthy countries. For all the above country classifications, however, the overall effect of trust on growth is still positive, taking the values of 0.0664, 0.0272, 0.0218 and 0.0118 for transition, developed, developing African, and developing American countries, respectively.

Regarding the impact of trust on economic growth in MENA countries, the coefficient of *MENA_Trust* is negative and significant, indicating that the effect of trust on MENA countries' growth is significantly less (by 0.0667) than in developing Asian countries, with 99% confidence. This outcome supports the results in Kasmaoui et al. (2018). However, an increase of one unit in the level of trust in MENA countries, would decrease growth by 0.006 (0.0607–0.0667) units, holding all other variables constant. In other words, the impact of trust on MENA countries' growth is not just significantly less than in developing Asian countries, but it might actually negatively impact their growth. This negative impact, although it is small and can be considered negligible, is unusual. To summarize, the above results indicate that trust has the highest impact on growth in transition countries, followed in order by the countries of developing Asia (the reference category), developed, developing Africa, developing America, and then tailed by MENA countries, which showed an inverse relation between trust and growth.

This unusual finding, although small, warrants further investigation. One approach would be to determine whether this is a MENA-wave-specific finding, since this may

have been a result of the Arab Spring, which likely affected MENA's trust values. As discussed earlier, and as shown in Figure 1, the significant decline in trust values in MENA countries compared to other country-classifications in waves 5, 6 and 7 perhaps reflect the circumstances that led up to the Arab Spring, the Arab Spring itself and the repercussions of the Arab Spring, respectively. This hypothesis would call for using separate interaction terms between MENA and *Trust* in each of the different waves.

4.3. The MENA-Wave-Specific Model

To inspect the MENA-wave-specific issue, the model specification in column 3 of Table 1 was used, but this time the interaction term between MENA and *Trust* was specified by wave. For example, *MENAW4_Trust* is an interaction term between *Trust* and a dummy that takes the value of 1 if the country belongs to the MENA region and is in wave 4, and 0 otherwise. Although MENA includes Iran and Turkey and the focus here is on the Arab Spring, the results of a separate analysis (results not shown) in which Iran and Turkey are removed from the relevant dummies are not meaningfully different than the results in column 3. The usual tests were conducted for this model and showed no multicollinearity (see Table 2c), homoscedasticity (prob. chi-sq. = 0.29), no omitted variable bias (p-value = 0.18) and no endogeneity (see Table A7 in Appendix A). The results show that there are no significant changes with respect to all nontrust variables, except for *Lexpec* and *Inv*, which now became insignificant, as well as all non-MENA *Trust* variables.

Examining the coefficients of the new interaction terms reveals that *MENAW4_Trust* is negative and significant, indicating that the effect of trust on MENA countries' growth during wave 4 (1999–2004) is significantly smaller (by 0.0528) than in developing Asian countries, with 95% confidence. However, an increase in the level of trust in MENA countries by one unit is suggested to cause growth to increase by 0.0019 (0.0547–0.0528) units, holding all other variables constant. This coefficient, although it shows that trust does positively affect MENA countries' growth, is very small and can be considered negligible. The coefficient of *MENAW5_Trust*, although negative, is insignificant. This shows that during wave 5 (2010–2014), the effect of trust on MENA countries' growth was not significantly different than that of the developing Asian countries. Similar to the coefficient of *MENAW4_Trust*, the coefficients of *MENAW6_Trust* and *MENAW7_Trust* are both negative and significant. They are also larger than the *Trust* coefficient and are perhaps the reason behind the same finding in column 2. Unlike with *MENAW4_Trust*, a unit increase in the level of trust in MENA countries during waves 6 and 7 suggests a decrease in growth by 0.0659 (0.0547–0.1206) units and 0.1174 (0.0547–0.1721) units, respectively. These two overall coefficients are close, respectively, to the overall coefficients of Trust itself (that of the reference category; developing Asia) and *Transition_Trust*, but are in the opposite direction, suggesting that trust in MENA affected their growth negatively and significantly during these waves. Kasmaoui et al.'s (2018) results also showed the same overall negative and significant impact of trust on economic growth in MENA countries in wave 6, the period of their study, but they did not discuss this result in their paper. In fact, their estimates showed an overall effect of trust on growth in MENA ranging from −0.2884 to −0.3108, independent of the estimation technique (OLS or the 2SLS). Our result is thus consistent with that of Kasmaoui et al.

Since Trust in MENA countries, in reality, was on average significantly lower during waves 6 and 7 than in previous waves, the above finding suggests that a unit decrease in the level of trust in MENA countries during waves 6 and 7 caused growth to increase by 0.0659 and 0.1174, respectively. The negative relationship between trust and growth proposed by Roth (2009) relates to the possible adverse effects of collective action. Olson (1982) argued that collective action and "collusion" (resulting from high generalized trust) could be used by a society to hamper economic reforms that could lead to improved economic performance. Thus, high interpersonal trust can negatively impact growth by reducing efficiency. Alternatively, low interpersonal trust may prevent detrimental collusions, allowing economic reforms to take place, and improving economic performance and thus

growth. One must, however, be cautious with this interpretation. Confirming that this is a causal relation requires further research, maybe even on a country-by-country basis. A correlation can, however, be deduced but the arguments will differ from one country to another—below are just two examples to clarify the point.

Before the January 2011 revolution, Egypt's growth rate was on average 2.2% during wave 4 (1999–2004), jumped to 4.2% during wave 5 (2005–2009), dropped to 0.7% during wave 6 (2010–2014) and increased to 2.9% during wave 7 (2017–2020) (World Bank 2018). From wave 4 to wave 5, Egypt's generalized trust values dropped from 38% to 19%, increased to 22% during wave 6 and dropped to 7% during wave 7. The trust–growth relationship in Egypt is clearly an inverse one. During the years of wave 4 and specifically wave 5, Diwan (2016) explained how economic privileges were given to businessmen who supported the regime and favored firms were given the opportunity to entirely monopolize the previously liberalized economic sectors. In 2010, for instance, thirty-two businessmen closely associated with ex-president Mubarak, obtained 80% of the total credit acquired by the formal private sector and gained 60% of this sector's overall profits, though they employed only 11% of Egypt's labor force. This government–businessmen "collusion" simultaneously caused growth on one hand but lowered institutional/governmental trust on the other hand. Algan and Cahuc (2014) argued and showed a high positive correlation between generalized trust and the quality of institutions. Rothstein and Stolle (2008) have also shown that the integrity of institutions and their transparency are among the principal influencers of generalized trust. This could explain the significant drop in trust values in Egypt during wave 5. The Egyptian revolution itself was a result of the dissatisfaction of Egyptians with their most important institutions; their government, the judiciary and the police, and explains their revolution slogan "Bread, Freedom and Social Justice." During the years of wave 6, understandably, growth dropped because of the political instability and the lack of investment at the time, but trust values increased since Egypt was going through a democratic transition, which positively impacted institutional trust. During the years of wave 7, a military figure in power, president Sisi was able to carry out economic reforms financed by the IMF, which explains the increased growth. Being less democratic thus allowed fierce subsidy cuts and other needed structural changes. However, this was coupled with lower generalized trust values that signified lack of institutional trust, probably a result of the government–military "collusion" or declining levels of democracy. The Arab Barometer (2020) showed that trust in the military, the judiciary and the government had significantly even lower values in 2019 compared to 2011. To summarize, the relatively high growth rates in Egypt in waves 5 and 7 are to a great extent due to the government–businessmen collusion and government–military collusion, respectively, and not in themselves a resultant of low generalized trust. These collusions are what led to the reduction in institutional trust, which is highly correlated to low generalized trust.

Another example is that of oil rich Iraq, which had average growth rates equal to 2.9% in waves 4 and 5 and reaching 3.7% in wave 6, but which were coupled with dwindling trust values starting at 47% in wave 4 and reaching 11% in wave 7. This inverse trust–growth association in Iraq tells a slightly different story than that of Egypt. Iraq's high growth rates, which reached 13% in 2016 (CIA 2021) are due to its structural characteristic as a state-run economy that depends primarily on its oil sector, and which represents 85% of the government revenue and 80% of its foreign exchange earnings (CIA 2021). Simultaneously, the civil war and the political turmoil in Iraq are but a reflection of lack of institutional trust and consequently low generalized trust.

The above examples do not support Roth's (2009) causal inverse trust–growth relation discussed earlier and calls for country-specific research to properly inspect this relationship in MENA.

4.4. The Democracy–Trust Model

To gain an even better understanding of the impact of trust on growth of the MENA countries, which are considered nondemocratic, the association between democracy and trust referred to earlier is tested, and a democracy–trust interaction term was generated. However, since it is always advisable for interaction terms to include at least one binary variable, *Democ* was replaced by *Democ2*. It took the value of 1 if *Democ* (the democracy index of a country) is greater than 60 and 0 if 60 or below. The EIU regards a country as a full democracy if its democracy index is above 80, a flawed democracy if its democracy index is greater than 60 and reaches up to 80, a hybrid democracy if its democracy index is greater than 40 and reaches up to 60, and an authoritarian country if its democracy index is equal or below 40. *Democ2* was then multiplied by *Trust* to get the interaction term.

As shown in Table 2d, when *Democ2* and *Democ2_Trust* were both included in the same regression (results not shown), the VIF score was greater than 10, signifying multicollinearity, and so *Democ2* was dropped from the regression. The new VIF scores in Table 2e are all below 10 and there are no issues regarding heteroskedasticity (prob. chi-sq. = 0.23), no omitted variable bias (p-value = 0.14) and no endogeneity (see Table A8).

The results of this new regression are shown in Table 1, column 4. Compared to column 1, there are almost no mentionable changes in the signs and the significance of the coefficients of all the variables as well as the adjusted R-square value. Regarding *Trust*, its coefficient is both positive and significant, suggesting that trust in nondemocratic (hybrid and authoritarian) countries has a positive effect on their economic growth, and that a one-unit increase in trust would increase growth in those nondemocratic countries by 0.0602 units. This finding supports that of Knack and Keefer (1997) and Lopes and Rivera-Castro (2018) in that trust is very important to developing and nondemocratic countries. *Democ2_Trust*, however, has a negative and significant coefficient, indicating that the effect of trust on democratic countries' growth is significantly less (by 0.0350) than in nondemocratic countries, with 99% confidence. This means that democratic societies' growth is hurt when compared to their nondemocratic counterparts because of their high generalized trust scores, because they are more attentive to redistributive pressures. This resonates well with the findings of Lopes and Rivera-Castro (2018). The overall effect of trust on democratic countries' growth is still positive though (equal to 0.0252), suggesting that trust still has a positive impact on democratic countries' growth but with diminishing returns. This echoes the finding regarding *Dvlpd_Trust*, discussed earlier, where the overall trust effect on growth was 0.0272.

A closer look at the economic and political country classifications in Table A2 in Appendix A shows that all developed countries are democratic, almost all MENA, developing African and transition countries are nondemocratic (or not consistently democratic), and almost half of the developing Asian and developing American countries are nondemocratic. In other words, the majority of democratic countries are the developed countries (64%), while the sweeping majority of the nondemocratic countries are the developing countries (74%). This provides a solid confirmation that the two different country classifications are to a great extent similar and that the same results regarding the trust–growth relationship would still hold. They both look at the same issue but from slightly different angles and they both reached the same conclusion; Trust is important for growth in developing and nondemocratic countries and also for developed democratic countries, but it exhibits diminishing returns in the latter.

One of the limitations of this study is the small number of countries for which data is available in all four of the waves studied, especially those belonging to the MENA region, which might have affected the results. As highlighted earlier, survey-based generalized trust measures have many shortcomings including their relatively poor coverage over time; however, they are reliable and valid (OECD 2017) and through including them in official surveys as recommended by OECD, they would eventually provide better country and year coverage and would consequently become very good macroeconomic predictors.

5. Conclusions

So, what do all the above results indicate with respect to the trust–growth nexus in MENA countries? The impact of trust on MENA countries' growth is the weakest when compared to other country classifications. The overall negative effect is very small and can be considered negligible. Regarding the MENA-wave-specific model, the impact of trust on MENA's growth during wave 4 is almost negligible, is not significantly different than that of developing Asian countries during wave 5, and is negative and significant during waves 6 and 7, resulting in a sizable reversal of the overall relationship between trust and growth from being positive during wave 5 to becoming negative. The examples from Egypt and Iraq show, however, that this relationship is most probably a correlation rather than a causation. Regarding the democracy–trust conjunction, no definitive conclusion could be inferred from the fourth model's specification about this relationship in MENA in specific. In general, what could be concluded is that trust in nondemocratic countries have showed a positive impact on those countries' growth. The results above thus imply that although a few MENA countries were able to grow with their dwindling trust values, this might not be sustainable since a virtuous trust–growth nexus has been firmly established in both developing and nondemocratic countries. Moreover, the declining trust values for the MENA countries would probably cause ill effects in the fabric of their societies and would have other adverse effects on their economies, especially in the long run. These issues require thus further investigation as to the reasons and impact of their effects from sociological, economic, and political perspectives.

Resting on the argument that trust changes and is affected by the environment (Putnam 2000), as evidenced in Figure 1, there is room for policies that could increase trust in general and in MENA countries in particular. One of these policies is related to boosting institutional trust through improving the transparency and integrity of institutions. An even more important policy is related to education programs that should encourage horizontal rather than vertical teaching practices, whereby, the relationships among students would become the main focus in the classroom and the primary emphasis would be on students working together in groups, which would strengthen the cooperation among the new generations, augment social capital and thus increase generalized trust (Algan 2018).

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Appendix A

Table A1. Generalized trust mean values with number of observations per country classification per wave.

Classification of Countries	4th Wave (1999–2004)		5th Wave (2005–2009)		6th Wave (2010–2014)		7th Wave (2017–2020)	
	Mean	# of Surveyed People	Mean	# of Surveyed People	Mean	# of Surveyed People	Mean	# of Surveyed People
MENA	32.9	16,516	19.32	11,819	18.86	16,827	12.39	9925
Dvlg Asia	31.07	12,414	32.94	11,901	30.05	15,688	25.97	20,187
Dvlg Afr	12.76	8198	12.37	9109	13.64	9868	9	3682
Dvlg Am	16.88	10,306	13.13	10,505	10.91	12,778	9.43	14,094
Transition	19.11	7562	19.58	6799	21.28	11,839	18.83	22,279
Dvlpd	36.45	9416	34.77	26,409	35.65	19,408	36.9	53,709

Table A2. List of countries in the sample. Economic development country classification is based on that of UNCTAD (United Nations Conference on Trade and Development). Democracy country classification (Democ2) is based primarily on data from EIU.

MENA (Dem)	DvgAsia(Dem)	DvgAfr (Dem)	DvgAm (Dem)	Transition (Dem)	Dvlpd (Dem)
Algeria (0)	Bangladesh (*)	BurkinFaso (0)	Argentina (1)	Albania (0)	Andorra (.)
Egypt (0)	China (0)	Ethiopia [a] (0)	Bolivia (0)	Armenia (0)	Australia (1)
Iran (0)	HongKong[a] (*)	Ghana (*)	Brazil (1)	Azerbaijan (0)	Austria (1)
Iraq (0)	India (1)	Mali (0)	Chile (1)	Belarus (0)	Bulgaria (1)
Jordan (0)	Indonesia (1)	Nigeria (0)	Colombia (1)	Bos.& Herzeg.(0)	Canada (1)
Kuwait (0)	Macao[a] (.)	Rwanda (0)	Ecuador (*)	Georgia (0)	Croatia (1)
Lebanon (0)	Malaysia (1)	S. Africa (1)	Guatemala (*)	Kazakhstan (0)	Cyprus (1)
Libya [a] (0)	Myanmar (0)	Tanzania (0)	Haiti[a] (0)	Kyrgyzstan (0)	Czech Rep. (1)
Morocco (0)	Pakistan (0)	Uganda (0)	Mexico (1)	Macedonia (*)	Denmark (1)
Palestine [a] (0)	Philippines (1)	Zambia (0)	Nicaragua (0)	Moldova (1)	Estonia (1)
Qatar (0)	Singapore (0)	Zimbabwe (0)	Peru (1)	Montenegro [a] (*)	Finland (1)
S. Arabia (0)	S. Korea (1)		Trin.&Tob. (1)	Russia (0)	France (1)
Tunisia (*)	Taiwan[a] (1)		Uruguay (1)	Serbia (1)	Germany (1)
Turkey (0)	Thailand (1)		Venezuela (0)	Tajikistan [a] (0)	Greece (1)
Yemen (0)	Vietnam (0)			Ukraine (*)	Hungary (1)
				Uzbekistan [a] (0)	Iceland [a] (1)
					Israel (1)
					Italy (1)
					Japan (1)
					Lithuania (1)
					Netherlands (1)
					N. Zealand (1)
					Norway (1)
					Poland (1)
					Puerto Rico [a] (1)
					Romania (1)
					Slovakia (1)
					Slovenia (1)
					Spain (1)
					Sweden (1)
					Switzerland (1)
					UK (1)
					USA (1)

Note: [a] Countries automatically dropped because of missing variables. * Countries do not have consistent Democ2 score across waves.

Table A3. Summary of variables used, their definitions, expected signs, and data sources.

Determinates of Growth	Variable	Variable Definition	Expected Sign	Data Sources
Dependent Variable	Growth	The growth rate of real GDPPC (measured in constant (2010) US dollars) during each observation window	NA	World Development Indicators (WDI)
Trust (Indep. Variable)	Trust	% of respondents who answered that most people can be trusted	+ve	WVS (Inglehart et al. 2014–2020)
Initial Level of GDPPC (Control Variable)	$GDPPC_{t-5}$	The first value of real GDPPC (measured in constant (2010) US dollars) in the observation window of each country	−ve	WDI
Inflation (Control Variable)	Infl	The annual percentage change in the price of the average consumer's goods basket	−ve	WDI
Life Expectancy (Control Variable)	Lexpec	Life expectancy of individuals in years	Ambiguous	WDI
Schooling Attain. (Control Variable)	Schooling	Average years of schooling for those above 25 years old	+ve	Barro and Lee (2010) & Human Development Report
Investment (Control Variable)	Inv	Share of investment in GDP	+ve	WDI
Military Expend. (Control Variable)	Military	Share of military expenditure as a percentage of GDP	Ambiguous	WDI
Price of Invest. Goods (Control Variable)	POI	Price level of investment goods relative to the US prices	−ve	Penn World Table (PWT) 9 (Feenstra et al. 2015)
Trade Openness (Control Variable)	Openness	The share of trade in GDP	+ve	WDI
Rule of Law (Control Variable)	RLW	The perception of individuals to the extent of confidence in rules, enforcement of contracts, courts and police. It takes the value between −2.5 and +2.5	+ve	Worldwide Governance Indicators
Democracy (Control Variable)	Democ	Democracy index expresses the quality of democracies as a number between 0 and 100	Ambiguous	EIU

Table A4. Descriptive statistics of all variables, including all the interaction terms.

Variable	Obs.	Mean	Std. Dev	Min	Max
Growth	229	2.53	2.37	−6.81	10.88
$GDPPC_{t-5}$	229	17,040.42	19,269.65	232.78	91,549.04
Infl	223	6.12	13.00	−0.49	174.21
Lexpec	228	73.84	7.35	44.57	84.81
Schooling	229	9.27	2.88	1.25	14.10
Inv	228	0.23	0.06	0.06	0.43
Military	215	2.06	1.35	0.36	9.97
POI	227	0.63	0.25	0.11	1.54
Openness	226	83.63	56.96	13.75	396.04
RWL	229	0.18	1.00	−1.75	2.04
Democ	227	61.42	20.21	18.74	98.80
Trust	232	24.91	16.36	2.10	73.90
MENA_Trust	232	3.07	8.79	0	50.50
DvlgAfr_Trust	232	1.01	3.79	0	25.30
DvlgAm_Trust	232	1.75	4.82	0	24.60
Transition_Trust	232	2.79	7.56	0	40.00
Dvlpd_Trust	232	11.33	19.54	0	73.90
MENAW4_Trust	232	1.13	6.57	0	50.50
MENAW5_Trust	232	0.50	3.61	0	38.60
MENAW6_Trust	232	1.06	4.79	0	38.50
MENAW7_Trust	232	0.37	2.18	0	15.90
Democ2	227	0.58	0.50	0	1.00
Democ2_Trust	227	15.96	19.36	0	73.90

Table A5. Correlation matrix including the residual for module specification # 1.

	$GDPPC_{t-5}$	Infl	Lexpec	Schooling	Inv	Military	POI	Openness	RWL	Democ	Trust	e1
$GDPPC_{t-5}$	1.00											
Infl	−0.21	1.00										
Lexpec	0.59	−0.40	1.00									
Schooling	0.56	−0.19	0.65	1.00								
Inv	0.22	−0.11	0.36	0.11	1.00							
Military	−0.16	0.14	−0.06	−0.09	−0.02	1.00						
POI	0.72	−0.23	0.50	0.64	−0.01	−0.21	1.00					
Openness	0.10	−0.09	0.24	0.29	0.22	−0.03	−0.03	1.00				
RWL	0.81	−0.30	0.65	0.60	0.32	−0.12	0.63	0.22	1.00			
Democ	0.66	−0.24	0.55	0.57	0.13	−0.35	0.59	0.06	0.77	1.00		
Trust	0.63	−0.13	0.39	0.32	0.19	−0.05	0.47	0.06	0.55	0.34	1.00	
e1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Table A6. Correlation matrix including the residual for module specification # 2.

	$GDPPC_{t-5}$	Infl	Lexp	Scho	Inv	Milit	POI	Open	RWL	Dem	Trust	MENA Trust	DvgAfr Trust	DvgAm Trust	Tran Trust	Dvlpd Trust	e2
$GDPPC_{t-5}$	1.00																
Infl	−0.21	1.00															
Lexpec	0.59	−0.40	1.00														
Schooling	0.56	−0.19	0.65	1.00													
Inv	0.22	−0.11	0.36	0.11	1.00												
Military	−0.16	0.14	−0.06	−0.09	−0.02	1.00											
POI	0.72	−0.23	0.50	0.64	−0.01	−0.21	1.00										
Openness	0.10	−0.09	0.24	0.29	0.22	−0.03	−0.03	1.00									
RWL	0.81	−0.30	0.65	0.60	0.32	−0.12	0.63	0.22	1.00								
Democ	0.66	−0.24	0.55	0.57	0.13	−0.35	0.59	0.06	0.77	1.00							
Trust	0.63	−0.13	0.39	0.32	0.19	−0.05	0.47	0.06	0.55	0.34	1.00						
MENA_Trust	−0.15	0.08	−0.10	−0.34	0.03	0.39	−0.31	−0.08	−0.22	−0.43	0.09	1.00					
DvgAfr_Trust	−0.16	0.23	−0.70	−0.37	−0.19	−0.14	−0.08	−0.19	−0.21	−0.20	−0.16	−0.10	1.00				
DvgAm_Trust	−0.16	0.05	0.06	−0.14	−0.13	−0.18	0.00	−0.21	−0.14	0.12	−0.23	−0.13	−0.10	1.00			
Transition_Trust	−0.21	0.07	−0.08	0.24	−0.19	0.10	−0.01	0.13	−0.28	−0.28	−0.04	−0.13	−0.10	−0.14	1.00		
Dvlpd_Trust	0.85	−0.19	0.53	0.58	0.12	−0.21	0.73	0.06	0.79	0.71	0.73	−0.21	−0.16	−0.22	−0.21	1.00	
e2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Table A7. Correlation matrix including the residual for module specification # 3.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	$GDPPC_{t-5}$	1.00																			
2	Infl	−0.21	1.00																		
3	Lexpec	0.59	−0.40	1.00																	
4	Schooling	0.56	−0.19	0.65	1.00																
5	Inv	0.22	−0.11	0.36	0.11	1.00															
6	Military	−0.16	0.14	−0.06	−0.09	−0.02	1.00														
7	POI	0.72	−0.23	0.50	0.64	−0.01	−0.21	1.00													
8	Openness	0.10	−0.09	0.24	0.29	0.22	−0.03	−0.03	1.00												
9	RWL	0.81	−0.30	0.65	0.60	0.32	−0.12	0.63	0.22	1.00											
10	Democ	0.66	−0.24	0.55	0.57	0.13	−0.35	0.59	0.06	0.77	1.00										
11	Trust	0.63	−0.13	0.39	0.32	0.19	−0.05	0.47	0.06	0.55	0.34	1.00									
12	DvgAfr_Trust	−0.16	0.23	−0.70	−0.37	−0.19	−0.14	−0.08	−0.19	−0.21	−0.20	−0.16	1.00								
13	DvgAm_Trust	−0.16	0.05	0.06	−0.14	−0.13	−0.18	0.00	−0.21	−0.14	0.12	−0.23	−0.10	1.00							
14	Transition_Trust	−0.21	0.07	−0.08	0.24	−0.19	0.10	−0.01	0.13	−0.28	−0.28	−0.04	−0.10	−0.14	1.00						
15	Dvlpd_Trust	0.85	−0.19	0.53	0.58	0.12	−0.21	0.73	0.06	0.79	0.71	0.73	−0.16	−0.22	−0.21	1.00					
16	MENAW4_Trust	−0.10	0.05	−0.08	−0.20	0.07	0.28	−0.22	−0.09	−0.10	−0.25	0.16	−0.05	−0.07	−0.07	−0.11	1.00				
17	MENAW5_Trust	−0.10	0.06	−0.06	−0.12	0.00	0.14	−0.11	0.00	−0.12	−0.17	0.02	−0.04	−0.05	−0.05	−0.08	−0.03	1.00			
18	MENAW6_Trust	−0.02	−0.01	−0.05	−0.23	−0.05	0.16	−0.12	−0.01	−0.12	−0.25	−0.01	−0.06	−0.08	−0.08	−0.12	−0.04	−0.03	1.00		
19	MENAW7_Trust	−0.09	0.05	0.04	−0.05	−0.01	0.14	−0.13	−0.02	−0.11	−0.18	−0.13	−0.05	−0.07	−0.07	−0.11	−0.03	−0.03	−0.04	1.00	
20	e3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Table A8. Correlation matrix including the residual for module specification # 4.

	$GDPPC_{t-5}$	Infl	Lexpec	Schooling	Inv	Military	POI	Openness	RWL	Trust	Democ2 Trust	e4
$GDPPC_{t-5}$	1.00											
Infl	−0.21	1.00										
Lexpec	0.59	−0.40	1.00									
Schooling	0.56	−0.19	0.65	1.00								
Inv	0.22	−0.11	0.36	0.11	1.00							
Military	−0.16	0.14	−0.06	−0.09	−0.02	1.00						
POI	0.72	−0.23	0.50	0.64	−0.01	−0.21	1.00					
Openness	0.10	−0.09	0.24	0.29	0.22	−0.03	−0.03	1.00				
RWL	0.81	−0.30	0.65	0.60	0.32	−0.12	0.63	0.22	1.00			
Trust	0.63	−0.13	0.39	0.32	0.19	−0.05	0.47	0.06	0.55	1.00		
Democ2_Trust	0.77	−0.18	0.51	0.54	0.13	−0.27	0.65	0.04	0.78	0.72	1.00	
e4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

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Banks' Performance and Economic Growth in India: A Panel Cointegration Analysis

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Abstract: The banking sector plays a crucial role in the economic growth of a nation. The purpose of this study is to examine the long-term association between banks' performance and the economic growth of a developing economy: India. The study used a panel of data of 20 public sector banks for the period 2009 to 2019. It applied the Pedroni and Kao test of co-integration, panel vector error correction model (VECM) dynamic, panel fully-modified ordinary least squires OLS (FMOLS), and dynamic OLS (DOLS) to estimate the relationship of interest margin return on assets, bank investment, and lending capacity of the bank with gross domestic product (GDP) of the country. The identification and incorporation of these bank-related variables are the innovations of this study. The results indicate that the bank-related variables are co-integrated with economic growth. Further analysis indicates a significant relationship between interest margin and return on assets with economic growth. In addition, lending capacity and investment activities are not significantly associated with economic growth, leading to the policy recommendation to improve upon these two factors in order to achieve higher growth rates.

Keywords: bank performance; economic growth; return on assets; bank investment; panel cointegration; India

JEL Classification: E44; G21; O11; O16

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1. Introduction

The financial services industry plays a significant part in the overall growth of an economy by generating employment, providing various investment avenues to the investors and financial services to the customers and the community (Berger et al. 1999). Economic growth actually leads to economic development, for which capital required is provided through the financial services industry (Beckett et al. 2000). Capital formation through the mobilization of resources by the financial services industry and accumulation should be the key element of economic growth strategy (Berger 2000). The banks in the economy aid in making funds accessible by moving excess funds from depositors (with no instant requirements of those funds) and channeling those funds as a credit to investors who have excellent ideas for generating surplus funds in the economy, but have a deficiency of the funds to implement those ideas (Nwanyanwu 2010). This generates income for the banks, ensuring profitability. It is enlightening to understand that the banking sector is a prominent one in the financial sector, as it has stood as one of the most extensive means of attracting many developing nations (Adeniyi 2006).

The relationship between a country's financial sector and the overall performance of a country's economy has been evaluated in various studies (Aurangzeb 2012; Tabash and Dhankar 2014; Abedifar et al. 2016; Boukhatem and Moussa 2018). All of these studies have jointly hypothesized that this relationship's significance is not a static parameter but a dynamic concept. Moreover, economies with a highly established financial system develop their economy at a high rate. However, banks and other financial institutions stay at the forefront of contributing to economic growth through their activities, such as giving resources to the general public and lending funds to various organizations for their progress and economic development. The financial sector, which is comprised of banks and other lending institutions, leads to sustainable economic growth by engaging in profitable investments and equalizing savings from surplus areas to areas of deficit.

Agreement on banks' significance in the economy is a matter of much academic interest. There is a lot of disagreement on the extent of its contribution to the economy, which is also debatable. Past studies have focused on a variety of measures of banks' size to describe variations of the banks on the economic progression. Very few studies have tried to examine the influences of banks' profitability on the development of the economy.

2. Theories and Literature Review

The two main theories available in literature that explain the role of banking performance variables and economic development are given below.

2.1. Theories

Schumpeter (1911) highlighted the value of finance in the development of the economic process. Additionally, the study focused on the significance of financial services in enhancing economic development and discussed the conditions when the financial sector might actively promote innovation and growth by examining and sponsoring productive investments. The mission of the Reserve Bank is to develop the convenience of proper financial facilities in the areas where banks still do not exist, ensuring access to financial services for all. More financial inclusion more will be the money circulation in the economy, which boosts the economy. Specifically, Robinson (1952) explained that as the demand for financial services rises, the output also rises, which favors the process of financial development. Other things being equal, the financial sector progress follows growth by earning through interest and assets (Srivastava 2012).

2.1.1. Anticipated Income Theory

H.V. Prochnow in 1945 developed this theory, and it suggests that banks must engage themselves in a wide variety of lending activities that may be comprised of amortized real estate mortgage lending, long term loans for generating economic activities, installments loan, and consumer loans by considering the likelihood fact of their repayment as they stimulate the cash flow that enhances liquidity, which depends upon the anticipated income of bank borrowers. This entails that high surplus reserves enhance all types of banks' profitability by enhancing lending investment funds' availability (Saeed et al. 2018).

2.1.2. Endogenous Growth Theory

Endogenous growth theory focuses on describing that economic development rate is a consequence of endogenous factors rather than external factors. Internal factors of institutions, such as investment decisions and innovation, or levels of technology change affect the economic growth process. Moreover, the theory also holds that long-run economic growth naturally depends upon financial institutions' policy measures (Romer 1994). The endogenous growth model expounds that inner elements disturb economic progress, even affecting exogenous productivity. The theory helps establish a framework of the relationship of variables used in the study, i.e., the link between the financial industry and the economy's progress.

2.2. Literature Review

For sustainable economic growth, the mobilization of domestic resources, self-reliance objectives, and the efficient utilization of investments are key policy focuses (Nasir et al. 2004). The causality exists in both ways between investment and economic growth (Bint-e-Ajaz and Ellahi 2012), but Madsen (2002) identified that investment mainly causes economic growth. Liang and Reichert (2006) conducted a study for developing and advanced countries, and revealed a causal association between financial sector growth and the development of an economy. The analysis proved causality between two variables, but the relationship was found to be more apparent in developing nations. The association between the financial sector and the growth of the economy has remained an essential concern to researchers. The profitability of a bank can influence the gross domestic product (GDP) by effecting financial stability. Greater bank profitability can enhance financial stability, which is beneficial for growth. As they offer higher returns to shareholders, banks can afford to raise capital from markets (Flannery and Rangan 2008). Rancière et al. (2008) suggest that nations with few fiscal emergencies are likely to experience higher growth than nations with constant financial fluctuations. This finding has been supported by the argument that financial liberties can increase emergencies, but they can also foster financial growth. Therefore, banks' profitability does not need to lead to the economy's positive growth through financial stability.

Tahir (2008) conducted research for Pakistan, and found a one-way causality amid the economic and financial industry's progress in the short and long term. Similarly, Awdeh (2012) found a one-way causal association from the economy's growth to the financial industry in Lebanon, supporting the growth-led finance hypothesis. Aurangzeb (2012), using time series analysis and causal analysis, found that the banking industry contributes considerably to Pakistan's economic improvement. Sharma and Ranga (2014) studied the Indian economy and determined that banks' saving deposits have a significantly affirmative effect on GDP. Emecheta and Ibe (2014) found that there is a significantly affirmative relationship between bank economic development and credit to the private sector and broad money in Nigeria. Mushtaq (2016) conducted a causal analysis and co-integration analysis for Pakistan from 1961 to 2013 amid economic progress and banking activity (deposit and credit) in Pakistan.

Hou and Cheng (2017) explored the short-term and long-term effects of banks' performance indicators on economic growth by using the generalized method of moments (GMM) method. The study indicates that the effect of the indicators depends on the growth of banks and the nation's income over time. The study strongly recommends that economies engage themselves in various financial activities to confirm a sustainable economic growth process. Saeed et al. (2018), through panel (Vector error correction model) VECM and using bank investment, innovation, lending capability, and interest margin, found innovations and bank investment to be the significant determinants of economic growth. Liu and Zhang (2018) explored the endogenous growth process amid the economy's financial system and growth. The study was based on panel data of 29 provinces of China. The study's theoretical findings demonstrated that there is a presence of an optimal financial structure that could meet various demands in the economic development process. The profitability of banks increases the financial stability of the economy, which helps in the growth of the nation (Claeys and Schoors 2007; Arena 2008). The more excellent financial stability helps achieve a stable economy. Pisedtasalasai and Edirisuriya (2020) studied diversification and the performance of commercial banks in Sri Lanka. The study found a two-way connection amid diversification and performance. It revealed an improvement in profitability of banks due to diversification.

A few researchers have not found much of a significant relationship between the financial sector and economic development like Robinson (1952) found to indicate finance as a reasonably insignificant economic growth variable. A study by Salami (2018) on the effect of interest rate on economic growth in Swaziland found a negative and significant association between the deposit interest rate (DIR) and GDP. This has been connected to the

way that DIR is the income of the deposit money banks, which might be utilized as lendable assets that may support profitability. Likewise, DIR is on money earned by the holders of the stores, so such monies can be transferred once again into the economy by a method for reinvestment that may thus enhance monetary development. It is normal that strategy creators on DIR would keep up stable arrangements that would empower stores/deposits, so that out of gear money could be changed over to methods for re-creation or means of production. A negative impact hence can be concluded that banks are paying more interest than they are receiving. The sample banks are public sector, but one of the reasons again could be that the ease of availing loans from private banks erodes the interest income of public sector banks.

The above kinds of literature (as per Table 1) clearly come up with the relationship between banks' performance and economic development. However, very few studies have been done in the Indian context with the variables of lending capacity, bank investment, return on assets, interest margin, and the annual growth rate of GDP on panel data from the time period 2009–2019. This time period is significant because it is post-sub-prime crisis of 2008.

Table 1. Summary of Literature.

Author	Result
Pisedtasalasai and Edirisuriya (2020)	Diversification in terms of assets by banks leads to improved performance of banks.
Saeed et al. (2018)	Using bank investment, innovation, lending capability, and interest margin found innovations and bank investment as the significant determinants of economic growth.
Salami (2018)	The impact of interest rates on economic growth in Swaziland found a negative and significant relationship between the deposit interest rate and gross domestic product (GDP).
Tahir (2008); Mushtaq (2016)	One-way causality amid the economy and financial industry's progress in the short and long term in Pakistan.
Babatunde et al. (2013); Claeys and Schoors (2007); Arena (2008); Liu and Zhang (2018)	Profitability, loans, and advances are positively and significantly affecting economic growth, while banks' deposits and assets do not influence Malaysia's economic growth.
Awdeh (2012); Nasir et al. (2004); Emecheta and Ibe (2014); Flannery and Rangan (2008); Hou and Cheng (2017)	Banking activity and economic performance are positively related.
Rancière et al. (2008)	Few fiscal emergencies are likely to experience higher growth than nations with constant financial systems.
Tahir et al. (2015)	Found a short-term, causal association between bank lending and economic development.
Liang and Reichert (2006); Bint-e-Ajaz and Ellahi (2012); Aurangzeb (2012)	Two-way causality between investments and economic growth.
Madsen (2002)	One way causality from investment to economic growth.

Source: made by the authors.

3. Research Methodology

The structure of these studies was built on panel data of scheduled commercial banks from 2009 to 2019. The scheduled commercial banks were comprised of 28 banks in 2009,

including the State Bank of India and its associate. However, it came down to only 20 banks in 2019, because of a few banks' mergers. Thus, this study finally considered those 20 banks which existed throughout the study. The period has been selected as the banks faced severe challenges after the financial meltdown of 2007–2008. The data is obtained from the official website of the Reserve Bank of India and Federal reserve economic data (fred.stlouisfed.org), accessed on 22 September 2020. The variables and their measures are summarized in Table 2 below.

Table 2. Variables for study, their measure, hypotheses, and literature.

Determinant/Variable	Measure/Proxy	Hypothesis (H)	Literature
Lending capability	Natural logarithm of total credit	H_1: The bank lending channel effect is negative in the long run to the economic growth of low income countries.	Tahir et al. 2015
Bank investment	Natural logarithm of investments	H_2: The investment activities of banks have a positive impact in the long run to the economic growth process of the country.	Bint-e-Ajaz and Ellahi 2012; Nasir et al. 2004
Interest margin	Natural Logarithm of Net interest margin	H_3: The interest margin of banks negatively affect the process of economic development	Neumeyer and Perri 2005; Anari and Kolari 2016
Return on assets (ROA)	Natural Logarithm of ROA	H_4: The return on assets of banks positively affects the process of economic development	Babatunde et al. (2013); Claeys and Schoors (2007); Arena (2008)

Source: Authors' own calculation.

A panel data co-integration has been conducted to check long-term association amid identified variables and economic development, but prior to that, the data has been subject to the property checks of a time series. A panel unit root test has been conducted to check the stationary property. The model taken for the study is

$$\text{Ln}Yi,t = \beta o + \beta 1\ \text{Ln}Lei,t + \beta 2\ \text{Ln}invi,t + \beta 3\ \text{Ln}ROAi,t + \beta 4\ \text{Ln}\ inti,t + \mu i,t \quad (1)$$

where; *Le*- denotes lending capacity, *inv*- denotes bank investment, *ROA*- denotes return on assets, *int*- denotes interest margin, and the annual growth rate of GDP is taken as a measure of the growth of the economy (*Y*).

3.1. Panel Unit Root Tests

The panel unit root test is considerably superior to that of the standard time-series unit root test in finite samples. The study employs various tests of the panel unit root, which is comprised of the LLC test, introduced by Levin et al. (2002); the IPS test, proposed by Im et al. (2003); and Fisher-type tests using ADF and PP tests, proposed by Maddala and Wu (1999). In Table 3, the LLC test's null hypothesis presumes that there is a standard unit root across the cross-sections, whereas the alternative hypothesis assumes no unit root across the cross-sections. The IPS, Fisher-PP, and Fisher-ADF tests presume that the individual unit root process prevails across all the cross-sections in Table 3. The null hypothesis of all three tests states that there is a unit root across the cross-sections of variables, whereas the alternative hypothesis state that there is no unit root across the cross-sections.

Table 3. Summary of group unit root test at level form.

Series: Lending Capacity, GDP, Investment, Net Interest Margin, Return on Assets				
Test	**LLC**	**IPS**	**ADF Fisher**	**PP Fisher**
Null	Considers the common unit root process	Considers individual unit root process		
Value	−0.27157	−11.8294	185.680	233.890
Significance	0.3930	0.0000	0.0000	0.0000

Note: Authors' own calculation.

The group panel test result through LLC suggests a unit root in the group sample, whereas IPS, ADF, and PP all suggest a positive relationship, which means the series is free from the unit root at the individual level. The panel group test further has been done for the first difference to get a stationary group shown in Table 4.

Table 4. Summary of group unit root test at first difference form.

Series: Lending Capacity, GDP, Investment, Net Interest Margin, Return on Assets				
Test	**LLC**	**IPS**	**ADF Fisher**	**PP Fisher**
Null	Considers the common unit root process	Considers individual unit root process		
Value	−3.09936	−19.8385	296.642	279.060
Significance	0.0010 *	0.0000 *	0.0000 *	0.0000 *

Source: Authors' own calculation. * Denotes significance at 1% level of significance

Hence, at the first difference, all variables are stationary and integrated to order one I(1).

3.2. Panel Co-Integration Test

The Engle and Granger (1987) examines a false regression's residuals done through I(1) variables or factors. It suggests that if factors are integrated, the residuals will be integrated at the level, and if not, then first order integration will be found.

$$Y_{it} = \alpha_i + \sum_{q=1}^{w} \beta_{qi} X_{qit} + \varepsilon_{it} \quad (2)$$

where $i = 1, \ldots, N$ indicates each bank in the sample and $t = 1, \ldots, T$ indicates the period. The variable α_i permits bank-specific fixed effects. The term ε_{it} signifies expected residuals, which demonstrate the deviation from a long-term association in the process. The fixed effect is used because the chi square statistic of Hausman test rejected the null hypothesis of random. The hypothesis of no co-integration ($R_i = 1$) is assessed by residuals as follows:

$$\varepsilon_{it} = R_i \varepsilon_i (t-1) + M_{it} \quad (3)$$

In this study, two tests of co-integration have been used. The first test is Pedroni (2004), and the second test is Kao (1999), which is based on Engle–Granger and enforces homogeneity on units in the panel set.

3.3. Pedroni Test for Panel Cointegration

For this test, the following regression equation is used:

$$yit = \alpha i + \delta it + \beta 1 ix1i, t + \beta 2 ix2i, t + \ldots + \beta mixmi, t + ei, t \quad (4)$$

where $t = 1, \ldots \ldots \ldots, T$; $i = 1, \ldots \ldots \ldots, N$; $m = 1, \ldots \ldots, M$ and x is expected to be I(1). The factors αi and δi are individual and drift effects, which may be fixed at zero if needed.

As mentioned above, if there is no co-integration, the residuals *ei,t* will be I(1). Generally, an auxiliary regression (Equation (5)) is run on the residuals obtained from Equation (4) and tested if I(1) for each cross-section.

$$e_{i,t} = \rho_i t_{i-1} + u_{it} \quad (5)$$

3.4. Kao Test for Panel Co-Integration

Kao (1999) suggested that

$$y_{it} = \alpha_i + \beta X_{it} + e_{it} \quad (6)$$

for

$$y_{it} = y_{it-1} + u_{i,t} \quad (7)$$

$$x_{it} = x_{it-1} + \varepsilon_{i,t} \quad (8)$$

where $t = 1, \ldots \ldots \ldots, T$ and $i = 1, \ldots \ldots \ldots, N$.

Kao then ran the pooled auxiliary regression:

$$e_{i\,t} = \rho e_{i\,t-1} + u_{i\,t} \quad (9)$$

The result of panel data in Table 5, co-integration suggests a co-integrating relationship as per the Kao test, because the ADF statistic is significant at a 1% level of significance. However, the Pedroni test shows no co-integration, as the *p*-values of the panel PP statistics, panel ADF statistics, group PP statistics, and group ADF statistics are insignificant at a 1% level of significance. Hence, we do not reject the null hypothesis.

Table 5. Test of p co-integration.

Test Name	Test Statistics	Statistic	Probability	Weighted	Probability
Pedroni statistics	Panel *v*-Statistics	−1.470686	0.9293	−2.218442	0.9867
	Panel rho-Statistics	3.909891	1.0000	3.812640	0.9999
	Panel PP-Statistics	0.051291	0.5205	−0.369908	0.3557
	Panel ADF-Statistics	−0.022509	0.4910	−0.425635	0.3352
	Group rho-Statistics	5.853543	1.0000	-	-
	Group PP-Statistics	−0.647024	0.2588	-	-
	Group ADF-Statistics	−0.703523	0.2409	-	-
Kao Statistics		ADF		*t*-Statistic −7.502337	Prob. 0.0000 *

Source: Authors' own calculation. * Denotes significance at 1% level of significance

3.5. VECM Panel

After the confirmation of cointegration, a panel vector error correction was conducted to see the convergence or the long run causality. The estimated equation is

$$\begin{gathered}\text{D(GDP)} = \text{C(1)*(GDP(}-1\text{)} + 0.000640025904353\text{*INTMARGIN(}-1\text{)} \\ - 0.00167270624665\text{*INVESTMENT(}-1\text{)} + 5.44422569915\text{E-}05\text{*LE(}-1\text{)} \\ - 0.00253819452049\text{*RA(}-1\text{)} - 0.0741922972213\text{) + C(2)*D(GDP(}-1\text{))} \\ + \text{C(3)*D(GDP(}-2\text{)) + C(4)*D(INTMARGIN(}-1\text{)) + C(5)*D(INTMARGIN(}-2\text{))} \\ + \text{C(6)*D(INVESTMENT(}-1\text{)) + C(7)*D(INVESTMENT(}-2\text{))} \\ + \text{C(8)*D(LE(}-1\text{) + C(9)*D(LE(}-2\text{)) + C(10)*D(RA(}-1\text{)) + C(11)*D(RA(}-2\text{)) + C(12)}\end{gathered}$$

Here, in Table 6 depicted C(1) is the error correction term (ECT), which has been found to be negative and significant (−1.8915). This indicates the convergence, i.e., the values get back to its mean value in the long run. Normally, the value of ECT should be between 0 and −1, but values between −1 and −2 are also probable and also indicate convergence, but with dampened fluctuations (Narayan and Smyth 2006).

Table 6. Value of coefficients.

	Coefficient	Std. Error	*t*-Statistic	Probability
C(1)	−1.891590	0.098550	−19.19421	0.0000
C(2)	0.814919	0.069943	11.65118	0.0000
C(3)	1.410280	0.123827	11.38913	0.0000
C(4)	0.005120	0.002779	1.842436	0.0658
C(5)	0.002089	0.002786	0.749931	0.4535
C(6)	−0.002445	0.003567	−0.685551	0.4932
C(7)	−0.002943	0.004057	−0.725527	0.4684
C(8)	−0.000110	0.000172	−0.639393	0.5228
C(9)	0.000106	0.000171	0.622498	0.5338
C(10)	−0.005120	0.001426	−3.591523	0.0004
C(11)	−0.000850	0.000959	−0.886805	0.3755
C(12)	−0.000604	0.000790	−0.764092	0.4451

Source: Authors' own calculation.

In other words, long-run causality runs from independent variables, especially interest margin and return on GDP assets.

3.6. Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) Panel

Though the OLS regression suggests a convergence in panel data, sometimes OLS leads to biased estimates. Thus, to confirm the estimates, this study conducted fully-modified OLS (FMOLS) and dynamic OLS (DOLS) below in table. FMOLS is a non-parametric approach. Furthermore, in order to deal with the corrections of serial correlation, FMOLS considers a possible correlation between the first difference of the regressors, the error term, and the presence of the constant term (Maeso-Fernandez et al. 2006). Both tests produce consistent estimates of the standard error, which can be used for postulation. The DOLS is a complete parametric approach and proposes a computationally fitting substitute to the FMOLS panel (Phillips and Moon 1999; Pedroni 2004); however, the downside of the DOLS estimator is that the degree of freedom gets lowered by leads and lags (Maeso-Fernandez et al. 2006). There are a number of options available for estimating the co-integration vector by using the panel data set, including with- and between-group—for instance, FMOLS and DOLS estimation techniques (Pedroni 2001) in Table 7.

Table 7. Fully-modified OLS (FMOLS) and dynamic OLS (DOLS) results.

Dep. Variable of Eco. Growth	FMOLS Results		DOLS	
	Coefficient	Probability	Coefficient	Probability
Lending capability	2.168183	0.1865	0.000237	0.8527
Return on asset	0.003645	0.0000 *	0.007509	0.1053
Interest margin	−0.009190	0.0000 *	−0.035686	0.0082
Bank investment	−0.000455	0.9220	0.041161	0.1533

Source: Authors' own calculation. * Significant at 1% level of significance.

If the co-integration exists among the study variables, then we use FMOLS estimations to identify the long-run association between economic growth, return on assets, lending capability, interest margin, and bank investment. In a co-integrated panel data set, if the OLS method for estimating the long-run equation is used, it results in biased estimation of the variables. Thus, the OLS estimation technique is unable to produce valid inference.

A residual diagnosis has also been conducted below Table 8, which found the data to be normally distributed (shown in Figure A1 in Appendix A), as the value of JB test statistics was 4.924 (p-value = 0.08525), which is insignificant at a 5% level of significance.

Table 8. Residual analysis.

Test of Normality	**Jarque–Bera**	***p*-Value**
	4.9242	0.085252
Test of Heteroskedasticity	**Breusch–Pagan–Godfrey statistics**	***p*-Value**
	168.856	0.0790

Source: Authors' own calculation.

The Breusch–Pagan–Godfrey test is a Lagrange multiplier test of the null hypothesis of no heteroskedasticity against heteroskedasticity. The value is insignificant at a 5% level of significance.

As per the result mentioned in Table 9, the PAC and AC values for autocorrelation analysis turned out to be insignificant at 1% and 5% of the significance of the first difference level. The Durbin–Watson value was also 2.95.

Table 9. Test of auto-correlation.

Autocorrelation	**Partial Correlation**		**AC**	**PAC**	***q*-Statistics**	**Probability**
.|. |	.|. |	1	0.010	0.010	0.0213	0.884
*|. |	*|. |	2	−0.069	−0.069	1.0029	0.606
**|. |	**|. |	3	−0.240	−0.240	12.837	0.005
**|. |	**|. |	4	−0.235	−0.255	24.261	0.000
*|. |	**|. |	5	−0.193	−0.277	31.995	0.000
.|* |	.|. |	6	0.122	−0.024	35.117	0.000
.|. |	*|. |	7	0.038	−0.153	35.423	0.000
.|* |	*|. |	8	0.114	−0.084	38.158	0.000
.|. |	*|. |	9	−0.047	−0.191	38.619	0.000

Source: Authors' own calculation. * significance at 1%, ** significance at 5% level of significance.

4. Findings

In this study, we examined the co-integration relationship between lending capability, bank investment, return on assets, interest margin, and India's economic growth for the period 2009 to 2019. For this purpose, the study used different panel unit root tests and panel co-integration tests to analyze the long-run and short-run dynamics between banking development variables and economic growth. The empirical findings are mixed in nature, as the LLS test for panel unit root suggested it was stationary at first difference level form, whereas others were at level form. However, LLS is for the group, so it is an important measure that needed to be further tested at first difference. This made the variable I(1).

Similarly, panel co-integration results were mixed, because the Pedroni test of co-integration suggested no co-integration, whereas the Kao test suggested co-integration. After the confirmation of co-integration, the vector error correction analysis was performed to check the error correction term's coefficient. The ECT was found to be negative and significant through ordinary least square, which suggested convergence.

Furthermore, to avoid OLS's biases, and for estimating the coefficients, the fully modified ordinary least square has been used, which suggests a long-term association of return on assets and interest margin with economic growth, whereas there was no association with lending capacity and investments for this sample period. The analysis rejects hypothesis 1 (H_1), that the investment activities of banks positively impact the short and long run of the country's economic growth process. However, there was a negative association between interest margin and economic development, as the coefficient of interest margin was −0.0091, which is negative and significant. The results of the analysis again support the third hypothesis (H_3), that the return on assets positively affects economic growth in the long run. The coefficient attained was 0.003645, which is positive and significant. The fourth hypothesis (H_4) was that banks' lending capacity

negatively affects low-income countries' economic growth in the long run, gets rejected, as the coefficient of lending capacity was 2.168183, which is positive and insignificant.

5. Conclusions

The present study's analysis suggests a long-term association between banks' performance and the growth of the economy. Bank profitability enhances growth. Bank profitability measured through return on assets helps economic growth in the long run, as the analysis gave a positive and significant coefficient. The lending capacity, though, is positive but insignificant. These findings support the growth parameters of anticipated income theory and confirmed that different forms of lending activities of the banking sector accelerate the pace of economic growth in less-developed economies. The interest margin has a negative but significant impact on the economy. Though net interest income plays a dominant role in the earning of banks (Angori et al. 2019) from a macro (welfare and monetary policy) perspective, low net interest margins (NIMs) are not necessarily bad. They can be a sign of a relatively competitive banking sector and of lower funding costs for the non-financial private sector. Banks' individual interest rate-setting abilities in highly competitive markets should be limited, potentially resulting in a more complete interest rate pass-through (Van Leuvensteijn et al. (2013); Committee on the Global Financial System (CGFS (2018)).

Investments do not have a significant association with India's growth in the given period. However, endogenous growth theory believes that an increasing rate of bank investment always opens new channels of business activities, which in turn enhances economic development through fund allocation to industrialists. The study confirms that profitability increases financial stability, which is in line with the findings of Claeys and Schoors (2007) and Arena (2008). In general, the analysis backs the observation of Athanasoglou et al. (2008), which suggests that banks' profitability is a precondition for the growth of the economy. Policy creators should be conscious about the effect their policies will have on banks' performance, as those banks have a continuous effect on the economy.

A stable banking sector is crucial for the economic growth of a country. Nevertheless, for the period under study, investment activities of the banks did not significantly impact economic growth. This leads to the scope of future research: to study the investment activities of banks in detail. Similarly, the lending capacity also did not impact economic growth significantly. These hint at unused funds available with the banks, as the lending capacity of banks are not contributing significantly to the economic growth of the country. Furthermore, the study provides evidence for a negative relationship between interest margin and economic growth. In this respect, further research is recommended by incorporating the effectiveness of monetary policy in line with the asymmetric relationship between interest rates and financial markets, as stated by Fullana et al. (2020) Lastly, improving upon the return on assets (ROA) is highly recommended to further economic growth.

The present study, though, found only two variables to be significant, but helps to understand the pattern and behavior of such variables. It helps to understand that how these variables moved in this duration, and how they have influenced the economy of India.

Finally, it is worth mentioning that the use of annual data might prove to be the limitation of our study, as analyzing the data with high frequency might not give the correct impact variables with annual data (Angori et al. 2019). The other limitation of this study is the number of years. If the years are increased, a panel data analysis will give a clearer picture, as a few analyses suggest that individual series might be stationary at the individual level. This can be improved by adding more years and a few more variables of the financial sector leading to economic growth that can be identified.

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Data Availability Statement: Data used in this paper are available from the official website of the Reserve Bank of India and Federal reserve economic data (fred.stlouisfed.org) at 22 September 2020. The data will be made available when demanded.

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Appendix A

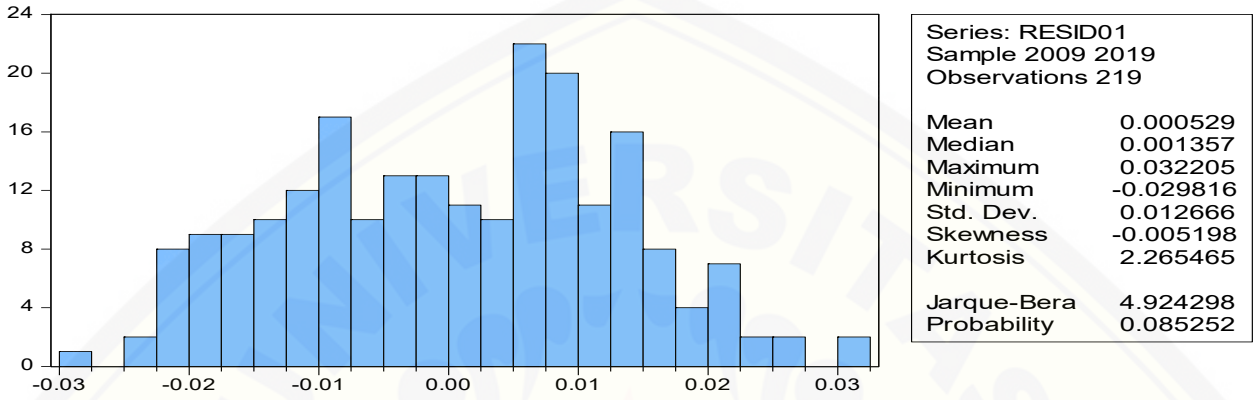

Figure A1. Test of normality. Source: authors' own calculation.

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Article

A Markov-Switching Model of Inflation in Bolivia

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Abstract: The Bolivian inflation process is analyzed utilizing a time-varying univariate and multivariate Markov-switching model (TMS). With monthly data and, beginning in the late 1930s, inflation is accurately described by a univariate TMS. The intercept for the high-inflation regime is significantly higher than for the low-inflation regime and the actual inflation rate mirrors the smoothing probabilities of the Markov process. Additionally, the predicted duration of each regime closely fits the periods when the country experienced low and inordinate high inflation rates. From a long-run perspective and utilizing a multivariate TMS, the results generally fall in line with what the quantity theory of money predicts. In the high-inflation regime, money growth increases inflation (almost) one-for-one, as classical economics contends. From a short-run perspective and in the high-inflation regime, inflation is almost exclusively explained by a negative output gap. In the low-inflation regime, lagged inflation is the most important determinant of inflation, in line with price stickiness expectations. Partitioning the sources of inflation demonstrate that, from a long-run perspective and in the high inflation regime, differences in inflation are mostly explained by GDP growth; in the low-inflation regime, money growth and velocity growth are the principal factors explaining the variance of inflation. From a short-run perspective, the output gap explains almost all regression variance in the high-inflation regime, and past inflation does the same during times of low inflation, though in both cases the R^2 is low which precludes making definite statements about the sources of variability in inflation.

Keywords: inflation; quantity theory of money; output gap

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1. Introduction

Models of inflation have typically specified the inflation process as a function of a wide set of macroeconomic and policy-related variables, often involving complicated dynamic structures. Since the 1990s, recognizing that structural changes are key in understanding time series variables, Markov-switching models have become ubiquitous in analyzing processes, such as inflation, that may be subject to occasional, discrete shifts over time. In this paper and for a period starting in the late 1930s, I conduct time-varying, univariate and multivariate analysis of inflation in Bolivia utilizing this methodology.

Bolivia seems the ideal setting for analyzing the process of inflation. In the last seven decades, it has experienced two episodes of severe inflation—the first between approximately 1953–1957; the last one between 1982–1985—and though it has experienced relative price stability since early in 1986, the prospects of once again experiencing significant price variability have not gone away. Specific issues that are explored here concern whether inflation in this country follows distinct paths over time; whether Milton Friedman (1963)'s assertion that inflation is always and everywhere a monetary phenomenon is true; and whether inflation might be explained from long- and short-run perspectives.

The theoretical underpinnings of inflation are well known. The monetarist theory of inflation—espoused by classical and monetarist economists—asserts that money supply growth is the cause of inflation. Keynesian economics argues that in the short run inflation might be caused by factors other than money growth, particularly those that may generate continuous demand shocks in an economy. Even though the objective of this paper does not include a formal testing of the competing theories on inflation, the Bolivian case does

represent an interesting case that sheds light on the process of inflation. The novelty of this work lies in the utilization of Markov-switching models to determine the causes of inflation in the short and long run in a country accustomed to great price volatility.

A summary of principal findings is this: inflation does not follow a linear stationary process; rather, it follows a nonlinear stationary process over time. In practical terms, this assertion implies that inflation is subject to discrete shifts between at least two states (also referred to as "regimes"), a high-inflation state, and a low-inflation state. Furthermore, when the principal determinants of inflation are analyzed in these two different regimes, there is evidence that in the high-inflation regime and from a long-run perspective, inflation is explained by growth in the broad measure of money supply (M2), velocity of M2, and real GDP; when the same exercise is done for the low-inflation regime, only growths in M2 and velocity impact inflation. From a short-run perspective and in the high-inflation regime, a negative output gap explains almost all variations in price; in the low-inflation regime; however, the principal determinant of inflation is lagged inflation, a proxy for inflation expectations.

There are three important contributions that this paper makes to the literature. First, to my knowledge, this is the first time that inflation in Bolivia is analyzed using a time-varying, Markov-switching model encompassing the period 1937–2020. Especially in countries, such as Bolivia, that have experienced hyperinflation more than once in their recent history, the utilization of Markov-switching models is fitting, as the inflationary process in those settings does not follow a linear process, but rather, changes, often brusquely, within short time intervals. Analyzing inflation as a non-linear process subject to regime changes is the principal justification for the utilization of a Markov-switching model in an economy that has experienced wild price fluctuations over time. Second, the determinants of inflation in the high-inflation and low-inflation regimes are analyzed from both long and short-run perspectives. Finally, the total variance in inflation is partitioned to determine the principal sources of variation in the dependent variable.

The rest of the paper is organized as follows: a brief literature review is provided in Section 2; Section 3 presents the Markov-Switching regime model; Section 4 introduces the data and the empirical results, and Section 5 concludes.

2. Literature Review

Although the Markovian switching mechanism was first considered by Goldfeld and Quandt (1973), Markov-Switching models began to be widely utilized after Hamilton's (1989) article on the analysis of nonstationary time series and structural changes in the parameters of an autoregressive process. It has been used to analyze nonlinear variables in many cross-sections of economics—and other sciences—being particularly ubiquitous in macroeconomics and finance. Engel (1994); Aït-Sahalia (1996); Driffill and Sola (1998); Campbell and Cochrane (1999); Maheu and McCurdy (2002); Acharya and Pedersen (2005); Rapach and Wohar (2005); Alexander and Kaeck (2008); Di Persio and Vettori (2014); Hamilton (2005, 2016); Ma et al. (2017); Fink et al. (2017); and Cabrieto et al. (2018) are a few of the articles where this methodology has been used to analyze the comportment of different macroeconomic and financial variables.

The utilization of Markov-Switching models in articles specific to inflation is also wide, with many focusing on the relationship between inflation and inflation uncertainty. Kim (1993a); Simon (1996); Bidarkota (2001); Moroney (2002); Binner et al. (2006); Amisano and Fagan (2013); Davig and Doh (2014); and Aye et al. (2016), are representative works in this area.

Several authors have also focused on the welfare costs of inflation. Lucas (2000) estimates that, in the US and for the period 1900–1994, the gain from reducing the inflation rate from 10 percent to zero is equivalent to an increase in real income of slightly less than one percent. Dai and Serletis (2019) use the Markov-switching approach to account for instabilities in the long-run money demand function and compute the welfare cost of inflation in the United States; they find that the welfare cost of inflation based on statistically

significant estimates of the money demand function declined significantly (by close to 50%) after the 1980s. Penha Penha Cysne and Turchick (2010) analyze the bias in estimating welfare costs of inflation when interest-bearing deposits are disregarded. Finally, though by no means exhaustively, Ascari et al. (2018) find that increasing trend inflation from 2 to 4 percent generates a consumption-equivalent welfare loss of about 4 percent. The findings presented here are a natural extension of those studies that emphasize the welfare costs of inflation. By concentrating on the principal determinants of inflation in different regimes and from long- and short-run perspectives, this paper highlights the factors policymakers should concentrate on to diminish the welfare costs of inflation.

On the explicit case of inflation in Bolivia there are a few articles that focus exclusively on this country, but none, to my knowledge, analyze inflation as a nonlinear process. Morales (1987) provides the more vivid qualitative description of the hyperinflation episode in the 1980s, but his analysis falls short of presenting convincing empirical evidence on the causes of it; Sachs (1986) also describes the 1980s hyperinflation crisis, emphasizing the stabilization efforts that were implemented to control further price hikes. As was the case with Morales (1987), Sachs's analysis is mostly qualitative, though he does run a regression linking monthly inflation rates with a one-month lag of inflation and changes in the black-market exchange rate and official exchange rate—both with respect to the US Dollar—and finds that the black-market exchange rate has a statistically significant impact on inflation. More recent studies include Bojanic (2013), estimating a GARCH-M model of inflation and investigating its linkages with measures of inflation uncertainty; Guerson (2015), who explores inflation dynamics and concludes that the monetary policy framework has contributed to the stabilization of inflation, with effective transmission through the bank lending channel; and Montero Montero Kuscevic et al. (2018), analyzing the effects of inflation and inflation volatility on GDP per capita.

The preceding review makes clear there is a gap in the literature concerning the analysis of the process of inflation in Bolivia, particularly for periods before 1980. Furthermore, available studies fail to account inflation as a nonlinear stationary process. This is a significant shortcoming in an economy that has experienced at least two hyperinflation episodes since the 1950s, hence the timeliness of the present study that captures the significant disruptions and—oftentimes—wild price fluctuations the country has experienced for most of its modern history.

3. Time-Varying Parameter Model with Markov-Switching Heteroscedasticity

Following Kim's (1993b) exposition, and assuming that there is indeed regime shifting in the inflation process, the dynamics of inflation in Bolivia can be analyzed utilizing a Markov-switching model that allows for conditional and unconditional heteroscedasticity. A key assumption of this type of model is that the stochastic trend and the stationary (autoregressive) component are subject to regime switching. The basic equations for the model are the folloing (the long-run specification for inflation—presented in Section 4—is utilized to describe the Markov-switching process):

$$\pi_t = \beta_{0t} + \beta_{1t}\%\Delta M2_t + \beta_{2t}\%\Delta Vel_t + \beta_{3t}\%\Delta rGDP_t + \epsilon_t \quad (1)$$

where π_t denotes the level of inflation at time t; $\%\Delta M2$ denotes the growth rate in M2; $\%\Delta Vel$ represents the growth rate in the velocity of M2, and $\%\Delta rGDP$ represents the growth rate in real GDP.

Let:

$$\beta_{it} = \beta_{it-1} + \omega_{it},$$

and assume

$$\epsilon_t \sim \left(0, \sigma_\epsilon^2\right),$$

$$\omega_{it} \sim \left(0, \sigma_{\omega i}^2\right),\ i = 0, 1, 2, 3$$

In vector notation and adding heteroscedastic disturbances,

$$\begin{aligned} \pi_t &= \beta_t X_t + \epsilon_t \\ \beta_t &= \beta_{t-1} + \omega_t \\ \omega_t &\sim (0,\ Q) \\ \epsilon_t &\sim (0, h_t) \\ h_t &= \sigma_0^2 + \left(\sigma_1^2 - \sigma_0^2\right) S_t, \end{aligned} \tag{2}$$

Suppose there are two regimes that describe the inflation process: a high-inflation regime and a normal, or low-inflation regime, i.e., $s_{i,t}$ $\Theta\{1,2\}$. The effects of the regressors on inflation could vary among regimes. If it is assumed that regime selection is governed by a first-order Markov-switching process, then, given past regimes, the probability of regime $s_{i,t}$ occurring is given by $P(s_{i,t}|s_{i,t-1}, s_{i,t-2}, \ldots, s_{i,t-k}) = P(s_{i,t}|s_{i,t-1})$. The time-varying Markov-switching model assumes that the transition probabilities from one regime to the other depend on transition variables z at year $t-k$, so that $P(s_{i,t}|s_{i,t-1}) = P(s_{i,t}|s_{i,t-1}, z_{i,t-k})$. Thus, the transition probabilities are defined as follows:

$$\begin{aligned} p_{11}(z_{i,t-k}) &= \frac{\exp\left(\beta_0+\beta_{i1}z_{i,t-k}\right)}{1+\exp\left(\beta_0+\beta_i z_{i,t-k}\right)}, \\ p_{22}(z_{i,t-k}) &= \frac{\exp\left(\beta_0+\beta_{i2}z_{i,t-k}\right)}{1+\exp\left(\beta_0+\beta_2 z_{i,t-k}\right)}, \end{aligned}$$

$$p_{12}(z_{i,t-k}) = 1 - p_{11}(z_{i,t-k}),\ p_{21}(z_{i,t-k}) = 1 - p_{22}(z_{i,t-k})$$

where p_{ij} is the probability of moving from regime i to regime j conditional on the transition variables (Diebold et al. 1994; Filardo 1994; Kim et al. 2008). If β_{i1} is positive (negative), a positive change in z decreases (increases) the likelihood of a transition from regime 1 to regime 2. The meaning of β_{i2} can be interpreted in the same way. The one-lag value of the growth rate in *M*2 was selected as the transition variable z to examine its effect on regime shifts of the inflation process.

With the transition probabilities defined above, Equation (2) is estimated using the maximum likelihood method. Define $\Omega_{i,t} = (X_{i,t},\ z_{i,t-k})$ as the vector of observed independent variables and transition variables up to year t and $\Psi_{i,t} = (\pi_{i,t},\ \pi_{i,t-1},\ \ldots,\ \pi_{i,1})$ as the vector of past information contained in π. Denoting the vector of parameters to be estimated by ϑ, the conditional log likelihood for all observations in the panel can be expressed as:

$$LL(\vartheta) = \sum_{i=1}^{N}\sum_{t=1}^{T} lnf(\pi_{i,t}|\Omega_{i,t}, \Psi_{i,t-1}; \vartheta)$$

where

$$\begin{aligned} &f(\pi_{it}|\Omega_{i,t}, \Psi_{i,t-1}; \vartheta) = \textstyle\sum_{j=1,2}\sum_{i=1,2} f(\pi_{i,t}, s_{i,t} = j, s_{i,t-1} = i, |\Omega_{i,t}, \Psi_{i,t-1}; \vartheta) \\ &= \textstyle\sum_{j=1,2} f(\pi_{i,t}|s_{i,t} = j, \Omega_{i,t}, \Psi_{i,t-1}; \vartheta) x \sum_{i=1,2} P(s_{i,t} = j|s_{i,t-1} = i, z_{i,t-k}) P(s_{i,t-1} = i|\Omega_{i,t}, \Psi_{i,t-1}; \vartheta) \end{aligned} \tag{3}$$

in which

$$P(s_{i,t} = j|s_{i,t-1} = i, z_{i,t-k}) = p_{ij}(z_{i,t-k}),$$

$$P(s_{i,t} = i|\Omega_{i,t+1}, \Psi_t; \vartheta) = \frac{f(\pi_{i,t}|s_{i,t} = i, \Omega_{i,t}, \Psi_{i,t-1}; \vartheta).P(s_{i,t-1} = i|\Omega_{i,t}, \Psi_{i,t-1}; \vartheta)}{\sum_i f(\pi_{i,t}|s_{i,t} = i, \Omega_{i,t}, \Psi_{i,t-1}; \vartheta).P(s_{i,t-1} = i|\Omega_{i,t}, \Psi_{i,t-1}; \vartheta)}$$

and

$$f(\pi_{i,t}|s_{i,t} = j, \Omega_{i,t}, \Psi_{i,t-1}; \vartheta) = \frac{1}{\sqrt{2\pi_n\sigma_s^2}} \exp\left(-\frac{\left(\pi_{i,t} - p_s\epsilon_{i,t-1} - \pi'_{i,t}\delta_s\right)^2}{2\sigma_s^2}\right)$$

By recursively computing the above equations, ϑ can be obtained by maximizing $LL(\vartheta)$ (the probability distribution of ML estimates is logarithmically concave).

4. Data and Empirical Results

The principal sources of data are Bojanic (2019), where a monthly consumer price index is provided for the period January 1937–January 2020 (The index is constructed by linking different consumer price indices that the Central Bank of Bolivia produced starting in 1937; its base month is January 2015. Further details on the construction of the index are provided in Bojanic (2019, pp. 15–17.); Central Bank of Bolivia for yearly data on M2, expressed in Bolivianos and covering the period 1940–2019 (https://www.bcb.gob.bo/?q=pub_boletin-estadistico, accessed on 3 July 2020); and the World Bank for real output and covering the period 1960–2018; real GDP figures are expressed in constant 2010 US Dollars (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?locations=BO, accessed on 3 July 2020). Inflation rates, velocity of M2, and potential output were obtained from standard manipulations of available data.

The variables described above were tested for the presence of unit roots and in all cases, the null hypothesis of a unit root was rejected, hence ensuring stationarity in all variables of interest. An initial assessment of the comportment of these variables is reported in Table 1, where summary statistics by decade are provided for key indicators. Appendix C reports pairwise correlation coefficients, covariances, and unit root tests for all relevant variables.

Table 1. Summary Statistics.

Period	Monthly Inflation Rate (%)		Yearly Inflation Rate (%)		Yearly M2 Growth Rate (%)		Yearly Growth Real GDP (%)	
	Mean	St. dev	Mean	St. dev	Mean	St. dev	Mean	St. dev
1937–1939	2.24	4.04	27.43	4.82	-	-	-	-
1940–1949	1.18	1.86	17.25	10.87	19.56	14.76	-	-
1950–1959	4.10	9.15	64.44	60.19	70.30	63.01	-	-
1950–1956	5.69	10.30	72.26	63.11	89.51	72.24	-	-
1957–1959	0.39	3.53	46.19	16.41	55.49	31.53	-	-
1960–1969	0.48	1.61	6.10	2.89	7.18	15.65	3.20	5.98
1970–1979	1.42	3.61	15.91	18.63	26.99	12.40	4.03	2.83
1980–1989	11.99	23.42	1383.07	3662.61	923.19	2240.06	−0.44	2.79
1980–1986	16.59	26.72	1969.28	4334.25	1319.25	2629.94	−1.93	1.69
1987–1989	1.26	1.28	15.25	0.71	−0.94	26.44	3.05	0.68
1990–1999	0.76	0.87	10.42	5.69	17.08	10.10	3.99	1.61
2000–2009	0.40	0.66	5.06	3.80	28.19	22.16	3.69	1.36
2010–2019	0.34	0.47	4.22	2.47	11.95	10.98	4.92	0.87

Source of data: Central Bank of Bolivia
Real GDP figures only available from 1960 to 2018

An immediate observation is that there is a visible positive correlation between inflation and the growth rate in M2—the correlation coefficient is +0.97—highlighting that, in Bolivia, these two variables go hand in hand, particularly during those periods where inflation is high. (The spike in inflation rates observed between 2007 and 2008 and 2010 and 2011 were the result of price increases in agricultural products in foreign markets. An appreciation of the Boliviano and contractionary monetary policies decreased inflation rates to target levels. Between 2013 and 2015, even though growth in GDP was high, the inflation rate decreased substantially.) Figure 1 corroborates this initial finding and shows that these two variables move very much in unison.

It is also noteworthy that inflation and real GDP growth are negatively correlated—the correlation coefficient is −0.38—but this negative relationship is not as visible if the hyperinflation years are excluded from the analysis. A preliminary conclusion from the decade-to-decade behavior of these variables is that there seem to be periods where the positive (negative) correlation between inflation and the growth rate in M2 (real GDP growth) is more visible, hence the necessity to analyze the relationship between these variables separating the high-inflation periods from the low-inflation ones.

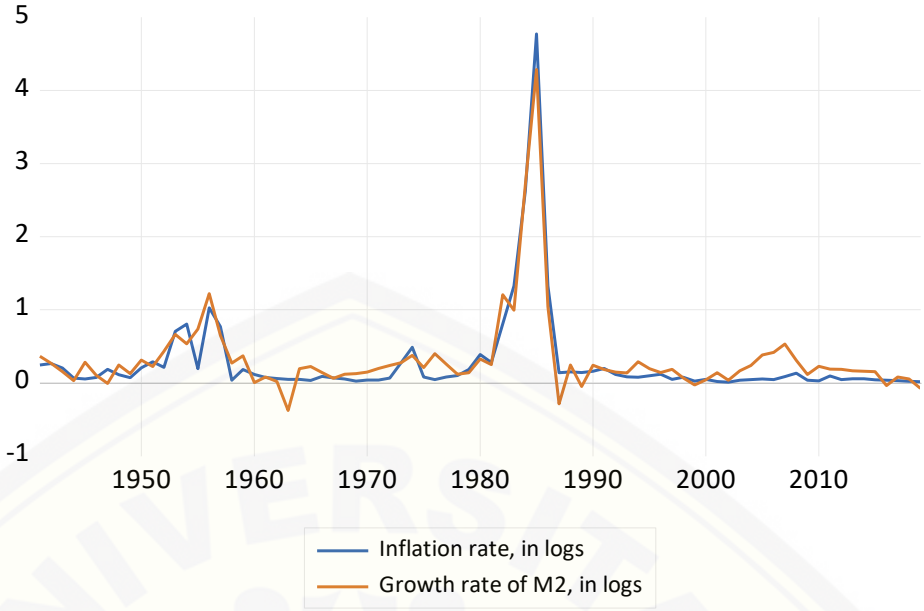

Figure 1. Yearly Inflation Rate and Growth Rate of M2, 1941–2019. Sources: Central Bank of Bolivia; Bojanic (2019).

4.1. Univariate Time-Varying Markov-Switching Model of Inflation

The process of inflation is first analyzed utilizing a time-varying univariate Markov-Switching model (TMS). Monthly inflation data have been available since 1937, hence the time-period covered is January 1937 through January 2020. The equation specification consists of a two-state Markov-switching model, with a single switching mean regressor *C* (the intercept) and four non-switching *AR* terms. The error variance is assumed to be common across the regimes and there are two probability regressors, the constant *C* and a one-period lag of the dependent variable since the model assumes time-varying regime transition probabilities. The inflation rate is expressed in natural logs. (Appendices A and B report results for the same specification when the inflation rate is expressed in percentages and when it is expressed as first differences of the natural log of the price level, respectively. The pattern of results is similar to the ones reported here.)

Table 2 reports summarized results for regime 1 (high inflation) and regime 2 (low inflation).

Table 2. Time-Varying Univariate Markov-Switching Model for Monthly Inflation.

	Regime 1—High Inflation		**Regime 2—Low Inflation**	
	Coefficient	**St. Error**	**Coefficient**	**St. Error**
Switching Regressor				
Constant	0.287 ***	0.011	0.015 *	0.008
# of Observations: 991				
Log-Likelihood: 1830.549				
Monthly Inflation Rate Expressed in Natural Logs				
Probability Regressors: C, $Inflation_{t-1}$, in Natural Logs				
Four Non-Switching AR Regressors Included in Specification; not Shown in Table				

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

As expected, the coefficient for *C* in regime 1 is significantly higher than in regime 2, implying that the expected mean value of inflation in the high inflation regime is higher than in the low inflation regime. Both coefficients are statistically significant, though at different levels of significance.

Table 3 presents the transition probability matrix and the expected duration of each regime.

Table 3. Time-Varying Transition Probabilities and Expected Durations of Regime 1 and Regime 2.

Transition Probabilities: P(i, k) = P(s(t) = k | s(t−1) = i) (row = i/column = j)			
		1	**2**
Mean	1	0.707	0.293
	2	0.021	0.979
		1	2
Std. Dev	1	0.047	0.047
	2	0.088	0.088
Expected Durations:			
		1	2
Mean		3.46 months	139.00 months
Std. Dev.		0.354	557.451

The results indicate that there is considerable state dependence in the transition probabilities, with a relatively higher probability of remaining in the low inflation regime (0.98 for the low inflation regime, 0.71 for the high inflation regime). The corresponding expected duration of each regime are 3.46 months (high inflation) and 139 months (low inflation). A visual summary of these findings is shown in Figure 2, where the smoothing probability of regime 1 (high inflation) is graphed along with the actual inflation rate. (Smoothed estimates for the regime probabilities in each period use the information set in the final period, in contrast to filtered estimates which employ only contemporaneous information. As Kim (1994) shows, using information about future realizations of the dependent variable improves the estimates of being in regime m in period t because the Markov transition probabilities link together the likelihood of the observed data in different periods.)

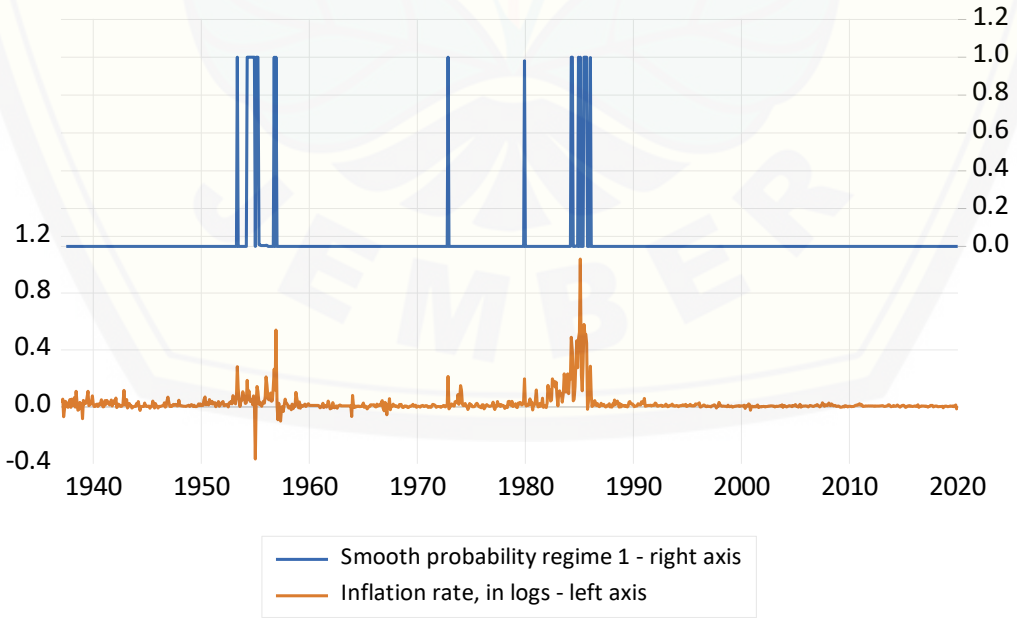

Figure 2. Smoothing Probability of Regime 1 (high inflation) and Monthly Inflation Rate.

As is evident from Figure 2, the obtained probabilities reflect the comportment of the inflation rate. The high inflation regime (regime 1) nearly coincides with those months where the country experienced its highest inflation rates hence the close fit between what

is predicted in the model and the actual evolution of prices during the entire period of interest. (The correlation coefficient between the smoothing probability of the high inflation regime and the monthly inflation rate (in logs) is +0.68).

4.2. Long Run, Multivariate Time-Varying Markov-Switching Model of Inflation

Utilizing yearly data for the period 1960–2018, the analysis of inflation from a long-run perspective is done by estimating a version of the quantity theory of money. Specifically, the standard quantity equation expressed in logs and in first differences is (Equation (4) is more appropriately defined as the equation of exchange. If it is assumed that the change in velocity is a random variable uncorrelated with money and real GDP growth, then the equation of exchange becomes the quantity theory of money):

$$\Delta m_t + \Delta v_t = \Delta p_t + \Delta y_t \tag{4}$$

where m is M2, v is velocity, p the price level, and y output. This can be rearranged as:

$$\Delta p_t = \Delta m_t + \Delta v_t - \Delta y_t \tag{5}$$

If it is assumed that in the long run both the money market and goods market are in equilibrium and that the trend of money velocity changes over time (Even though changes in the trend of money velocity are well documented—see, for instance, Bordon and Jonung (2004)—this might especially be true in Bolivia, where periods of severe price instability are not uncommon and where the unit of account has changed twice (in 1962 and in 1986) since the early 1960s. Velocity was estimated as follows: V = (nominal GDP)/M2, where both GDP and M2 are expressed in Bolivianos.) Then, framed as an unrestricted regression, the quantity theory becomes:

$$\pi_t = C + \beta_1 X_t + \beta_2 W_t + \beta_3 Z_t + \varepsilon_t \tag{6}$$

where π_t represents yearly inflation; X_t, W_t, and Z_t represent growth rates in M2, velocity, and real GDP, respectively; and ε_t is a disturbance term with $\varepsilon_t \sim (0, \sigma^2)$.

Equation (6) is estimated utilizing a two-state TMS model with four switching regressors (C and the growth rates, in natural logs, of M2, velocity, and real output) and one non-switching AR term. There are two probability regressors, the constant C and a one-period lag of the growth rate in M2. The latter is included so that the period t data for the regressor corresponds to the values influencing the transitions for $t-1$ to t. The inflation rate is also expressed in natural logs. Table 4 reports summarized results for the high inflation and low inflation regimes.

The results for both regimes generally fall in line with what the quantity theory of money predicts. Money growth and velocity growth increase, and GDP growth reduces, inflation. Moreover, in the high inflation case, the coefficient for money growth is 1.026, which very much reflects the prediction of the theory that money growth increases inflation one-for-one. In the low-inflation regime, the coefficient is still positive but below 1, which is unsurprising since M2 includes a much broader range of assets than M1. In other words, in countries experiencing hyperinflation and negative real interest rates—as was the case in Bolivia between 1983–1986—people have an incentive to hold most M2 assets as currency (M1) to be spent promptly to minimize the inflation tax. If real interest rates are positive, however—as is presumably the case when inflation is low—the inflation tax would be minimized by holding the minimum feasible portion of M2 as currency for transactions, causing β_1 to be smaller than 1.

Table 4. Time-Varying, Long-Run Multivariate Markov-Switching Model for Yearly Inflation.

	Regime 1—High Inflation		Regime 2—Low Inflation	
	Coefficient	**St. Error**	**Coefficient**	**St. Error**
Switching Regressors				
Constant	0.035	0.031	−0.038 ***	0.012
Growth Rate M2	1.026 ***	0.032	0.958 ***	0.010
Growth Rate Velocity	1.033 ***	0.154	1.026 ***	0.035
Growth Rate Real GDP	−1.786 ***	0.347	−0.025	0.245
R^2	0.99		0.99	
# of Observations: 57				
Log-Likelihood: 102.885				
All variables expressed in natural logs				
Dependent variable: inflation rate				
Probability regressors: C, $(\text{growth rate M2})_{t-1}$, in natural logs				
One non-switching AR regressor included in specification; not shown in table				

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Real GDP growth is negative in both regimes but is statistically significant only in the high inflation case. Additionally, the coefficient, −1.786, is significantly smaller than the quantity theory prediction that $\beta_3 = -1.0$, a result that might partially be explained by the well-known challenges of measuring accurate output figures in countries similar to Bolivia. (See, for instance, Loayza (1997) work on the challenges faced by Latin American nations in measuring the size of the informal sector and its impact to growth and development.)

Table 5 presents the transition probability matrix and the expected duration of each regime.

Table 5. Time-Varying Transition Probabilities and Expected Durations of Regime 1 and Regime 2.

Transition Probabilities: P(i, k) = P(s(t) = k | s(t−1) = i) (row = i/column = j)		**1**	**2**
Mean	1	0.480	0.520
	2	0.368	0.632
Std. Dev	1	0.081	0.081
	2	0.296	0.296
Expected durations:			
Mean		1.95 years	33.06 years
Std. Dev.		0.213	159.948

The results are similar to those obtained with the univariate TMS model. There is significant state dependence in the transition probabilities and there is a relatively higher probability of being in the low inflation regime (0.63 vs. 0.48 in the high inflation regime). Moreover, the expected durations of each regime are 1.95 years and 33.06 years for the high and low inflation regimes, respectively. These predictions are roughly in line with what happened to inflation during the 1960–2018 period: there were two years (1984 and 1985) where yearly inflation rates were above 1000 percent, and there were 38 years where inflation rates were below 10 percent. In the remaining 19 years, inflation rates exceeded 10 percent and fluctuated significantly, rising above 100 percent in 1982, 1983, and 1986.

Figure 3 shows the smoothing probability of regime 1 (high inflation) and the inflation rate.

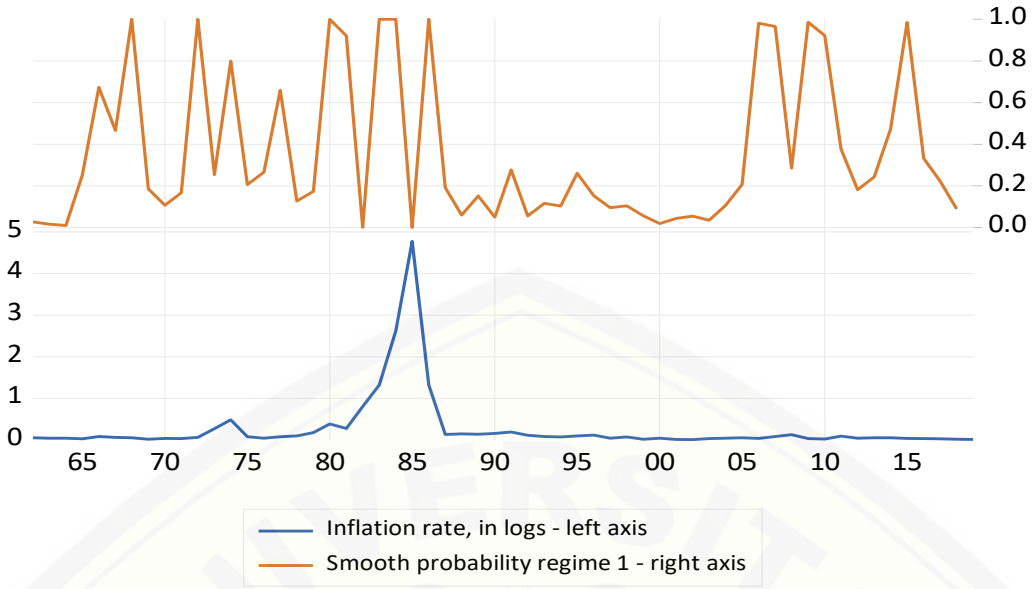

Figure 3. Long Run, Smoothing Probability of Regime 1 and Yearly Inflation Rate.

As depicted in Figure 3, the obtained probabilities do not fit the actual evolution of the inflation rate as closely as the empirical findings suggest. (The correlation coefficient between the smoothing probability of the high inflation regime and the yearly inflation rate (in logs) is +0.11.) However, given the more volatile nature of inflation during the late 1960s, 1970s, the high-inflation 1980s, and the period after 2008, when inflation rates once again reach the two-digit mark, the observed pattern of behavior of the smoothing probabilities is unsurprising.

4.3. Short-Run, Multivariate Time-Varying Markov-Switching Model of Inflation

The standard expression for the short-run aggregate supply curve is:

$$\pi_t = \pi^e + \gamma(Y_t - Y^p) + \varepsilon^\pi \quad (7)$$

where π_t is inflation at time t; π^e represents expected inflation; γ is a sensitivity factor; Y_t is output; Y^p stands for potential output (potential output was estimated utilizing the Hodrick–Prescott filter); and ε^π represents price shocks. The difference between Y_t and Y^p is referred to as the output gap and hence γ reflects how sensitive inflation is to fluctuations in the output gap.

If it is assumed that expectations are adaptive, then an appropriate indicator for expected inflation is past inflation. Additionally, if it is assumed that the country did not experience any significant price shocks, the short-run expression for inflation is:

$$\pi_t = \pi_{t-1} + \gamma(Y_t - Y^p) \quad (8)$$

where π_{t-1} represents inflation in the previous period.

Formulated in regression form, Equation (8) becomes:

$$\pi_t = C + \beta_1 X_t + \beta_2 W_t + \varepsilon_t \quad (9)$$

and π_t represents yearly inflation; X_t stands for inflation in the previous period; W_t is the output gap; and ε_t is a disturbance term with $\varepsilon_t \sim (0, \sigma^2)$.

Equation (9) is also estimated utilizing a two-state TMS model with three switching regressors (C, the log of inflation in the previous period, and the difference between the log of real GDP and the log of potential GDP) and one non-switching AR term. There are two probability regressors, the constant C and inflation in the previous period. Lagged

inflation is included so that the period t data for the regressor corresponds to the values influencing the transitions for $t-1$ to t. The dependent variable is also expressed in natural logs. Table 6 reports summarized results for the high inflation and low inflation regimes.

Table 6. Time-Varying, Short-Run Multivariate Markov-Switching Model for Yearly Inflation.

	Regime 1—High Inflation		**Regime 2—Low Inflation**	
	Coefficient	**St. Error**	**Coefficient**	**St. Error**
Switching Regressors				
Constant	0.786 **	0.371	0.048 ***	0.010
Previous Inflation (π_{t-1})	0.191	0.202	0.300 ***	0.099
Ouput Gap ($Y - Y^p$)	−26.769 **	11.023	0.195	0.174
R^2	0.33		0.01	
# of Observations: 58				
Log-Likelihood: 70.029				
All variables expressed in natural logs				
Dependent variable: inflation rate				
Probability regressors: C, $(\text{previous inflation})_{t-1}$, in natural logs				
One non-switching AR regressor included in specification; not shown in table				

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

The results indicate that in the high-inflation regime the most important determinant of inflation is a negative output gap, which occurs when actual output falls below potential output. Likewise, previous inflation does not have a statistically significant impact on current inflation, though β_1 does have the expected positive sign. In contrast, in the low-inflation regime, previous inflation is the most important predictor of current inflation—β_1 is positive and statistically significant—and the (positive) output gap does not seem to exert any influence. These results fit nicely with New Keynesian theory: during times of low inflation, nominal variables are sticky and hence current inflation depends on previous values of inflation. However, when prices no longer provide any useful information—as is the case during times of hyperinflation—past inflation plays no role in affecting current inflation. (The constant in regime 1 is significantly higher than in regime 2 and may, in part, justify why a negative output gap is the main determinant of inflation in the high-inflation regime. The constant prevents overall bias by forcing the residual mean to equal zero but may also capture the exclusion of relevant variables from the regression model. In the short run and during periods of high inflation, the standard expression for the short-run aggregate supply curve (Equation (8)) may include additional factors not considered here. Additionally, since specifications 7–9 aim to understand the principal variables that affect changes in the price level in the short run, perhaps a more appropriate indicator of inflation would be one where *monthly* changes in the price level are considered, rather than the yearly changes utilized here. Unfortunately, even though monthly inflation rates have been available since the late 1930s, there is no reliable monthly data on real GDP, which would be needed to estimate Equation (9). Not utilizing monthly data may also partly explain why inflation expectations do not play a more prominent role in the high-inflation regime.)

Table 7 presents the transition probability matrix and the expected duration of each regime.

The results are consistent with previous findings. As was the case with univariate TMS and long-run multivariate TMS, there is significant state dependence on the transition probabilities, with a greater probability of being in the low-inflation regime (0.82) than in the high-inflation regime (0.34). The expected duration of each regime is 4.43 years and 58.07 years for the high and low inflation regimes, respectively, roughly resembling the pattern of behavior observed with the long run multivariate TMS model.

Table 7. Time-Varying Transition Probabilities and Expected Durations of Regime 1 and Regime 2.

Transition Probabilities: P(i, k) = P(s(t) = k | s(t−1) = i) (row = i/column = j)		1	2
Mean	1	0.344	0.656
	2	0.183	0.817
Std. Dev	1	0.140	0.140
	2	0.340	0.340
Expected durations:			
Mean		4.43 years	58.07 years
Std. Dev.		20.913	52.272

Figure 4 shows the smoothing probability of regime 1 (high inflation) and the inflation rate.

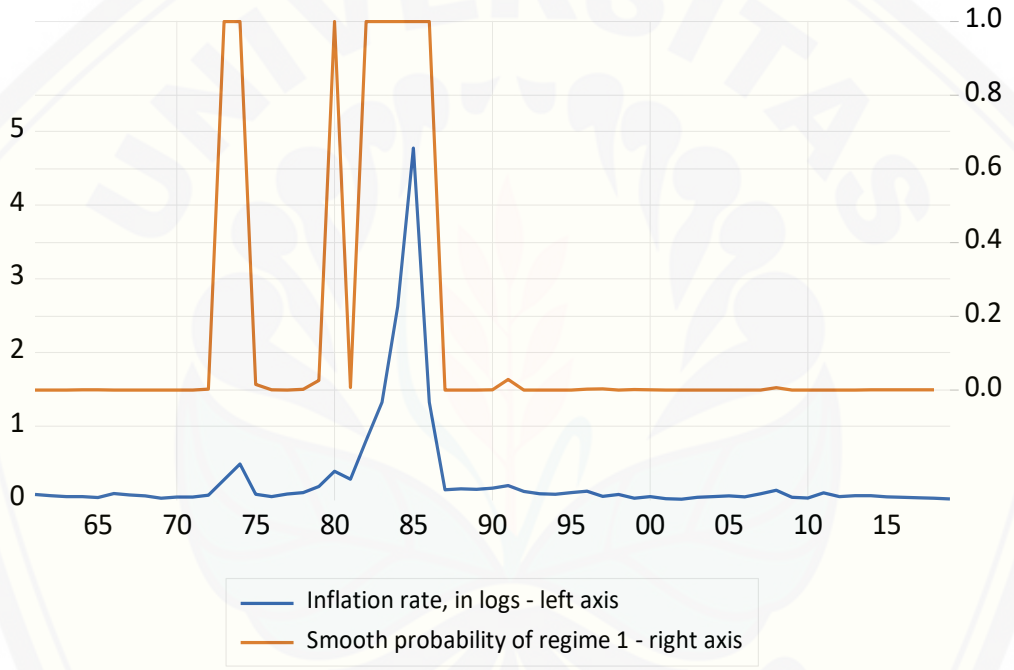

Figure 4. Short Run, Smoothing Probability of Regime 1 and Yearly Inflation Rate.

As depicted in Figure 4, the obtained probabilities closely fit the actual evolution of the inflation rate. (The correlation coefficient between the smoothing probability of the high inflation regime and the yearly inflation rate (in logs) is +0.68.) Years when there is a spike in inflation are echoed with rising smoothing probabilities, giving confidence that the empirical findings reflect fluctuations in the price level analyzed from a short-run perspective.

4.4. Partitioning the Sources of Inflation in the Long and Short-Run

Other things equal, the long-run multivariate TMS states that rapid money growth and velocity growth stimulate inflation, and real GDP growth mitigates it. Likewise, the short-run multivariate TMS contends that past inflation and the output gap determine inflation. However, what is the relative importance of each one of these variables in explaining inflation? Commonality analysis—a brief review is provided in Nathans et al. (2012)—is a method of decomposing the R^2 in a multiple regression analysis into the proportion of explained variance of the dependent variable associated with each independent variable.

For the long run multivariate TMS, the variance in the inflation rate explained by Equation (6) can be partitioned as:

$$V_\pi = \beta_1^2 V_x + \beta_2^2 V_w + \beta_3^2 V_z + 2\beta_1\beta_2 V_{xw} + 2\beta_1\beta_3 V_{xz} + 2\beta_2\beta_3 V_{wz} \quad (10)$$

where V_x, V_w, and V_z are the sample variances in X, W, and Z; V_{xw} is the sample covariance between X and W; V_{xz} is the sample covariance between X and Z; V_{wz} is the sample covariance between W and Z. The covariances between all combinations of the three variables are quite small, so the influences of money, velocity, and real GDP growth are nearly separate and additive. Substituting the regression coefficients from Table 4 and the sample variances $V_x = 3.610$; $V_w = 17.510$; $V_z = 39.549$; and covariances $V_{xw} = 3.4 \times 10^{-4}$; $V_{xz} = 5.3 \times 10^{-4}$; $V_{wz} = 3.0 \times 10^{-3}$, the explained regression variance for the high-inflation regime is:

$V_\pi = 3.797 + 18.675 + 126.100 - 3.5 \times 10^{-4} - 9.8 \times 10^{-4} - 5.5 \times 10^{-3} = 148.57$

3.797 Explained by money growth; 18.675 Explained by velocity growth; 126.100 Explained by real GDP growth; 3.5×10^{-4} Explained jointly by money growth and velocity growth; 9.8×10^{-4} Explained jointly by money growth and real GDP growth; 5.5×10^{-3} Explained jointly by velocity growth and real GDP growth.

Likewise, the explained regression variance for the low-inflation regime is:

$V_\pi = 1.023 + 4.174 + 0.017 - 1.2 \times 10^{-4} - 1.4 \times 10^{-5} - 8.5 \times 10^{-6} = 5.21$

In both cases, the covariances contribute almost nothing to explained regression variance. In the high-inflation regime, growth in real GDP contributes 126.10/148.57 = 0.849, or 84.9 percent of explained regression variance. Money growth contributes 3.797/148.57 = 0.026, or 2.6 percent, and velocity growth contributes 18.675/148.57 = 0.126, or 12.6 percent. In the low-inflation regime, the relative contributions of money growth, velocity growth, and real GDP growth are 19.64 percent, 80.12 percent, and 0.33 percent, respectively. Since the R^2 in both regimes is 0.99, the large differences in inflation are explained mostly by GDP growth in the high-inflation regime and by money growth and velocity growth in the low-inflation regime.

For the short run multivariate TMS, the variance in the inflation rate explained by Equation (9) can be partitioned as:

$$V_\pi = \beta_1^2 V_x + \beta_2^2 V_w + 2\beta_1\beta_2 V_{xw} \quad (11)$$

where, as before, V_x and V_w are the sample variances in X and W, and V_{xw} is the sample covariance between X and W. The latter is quite small, so the influences of past inflation and the output gap are nearly separate and additive. Substituting the regression coefficients from Table 6 and the sample variances $V_x = 23.469$; $V_w = 1278.638$; and covariance $V_{xw} = 0.417$, the explained regression variance for the high-inflation regime is:

$$V_\pi = 0.856 + 916232.480 - 4.260 = 916229.076$$

Past inflation and the covariance of past inflation and the output gap contribute almost nothing to explained regression variance, but the variance explained by the output gap is enormous. Ignoring the others, the output gap explains 916,232.480/916,229.076 ≈ 1.0 or 100 percent of explained regression variance. Even though the R^2 is only 0.33, differences in inflation are explained almost entirely by differences in the output gap.

The explained regression variance for the low-inflation regime is:

$$V_\pi = 1.035 + 0.763 - 7.2 \times 10^{-5} = 1.797$$

Past inflation contributes 1.035/1.797 = 0.576, or 57.6 percent of explained regression variance; the output gap contributes 0.763/1.797 = 0.424, or 42.4 percent; and the contribution of the covariance is nearly inexistent. With an R^2 of only 0.01, these results are taken with caution and no conclusions are drawn regarding the causes for differences in inflation in this regime.

5. Conclusions

Utilizing a time-varying univariate and multivariate Markov-switching model (TMS), the inflation process in Bolivia is described starting in the late 1930s. Having experienced at least two episodes of severe inflation in the 1950s and the 1980s, Bolivia stands alone as a country where a Markov process might very well be the right approach to analyze inflation.

The principal findings are these: with monthly data, the inflation process starting in 1937 is accurately described by a univariate TMS. The intercept for the high-inflation regime is significantly higher than for the low-inflation regime and the actual inflation rate mirrors the smoothing probabilities of the Markov process. Additionally, the predicted duration of each regime closely fits the periods when the country experienced low and inordinate high inflation rates.

From a long-run perspective and utilizing a multivariate TMS, the results generally fall in line with what the quantity theory of money predicts. In the high-inflation regime, money growth increases inflation (almost) one-for-one, as classical economics contends. Moreover, velocity growth increases, and real GDP growth decreases inflation, in accordance with expectations. In the low-inflation regime, both money growth and velocity are also positive and statistically significant, but real GDP growth is not, though it still has the predicted negative sign. The general conclusion is that inflation is a monetary phenomenon both in the high and low-inflation regimes, but the predictive power of how changes in the money supply affect inflation is clearer and closer to expectations in the high-inflation case. (There is a caveat to this conclusion. Even though growth in the money supply is a key determinant of inflation in both regimes, when the R^2 is decomposed to analyze the proportion of explained variance of the dependent variable associated with each independent variable, money growth is not the most important variable explaining inflation in either the high- or low-inflation regime.) The predicted expected duration of each regime is also aligned with the actual periods when the country experienced high and low inflation rates.

From a short-run perspective and utilizing a multivariate TMS, the findings indicate that in the high-inflation regime, inflation is almost exclusively explained by a negative output gap, though there is some indication that other factors might be at play. In the low-inflation regime, lagged inflation is the most important determinant of inflation, in line with price stickiness expectations. Unsurprisingly, in the high-inflation regime, lagged inflation is statistically insignificant, showing that, when prices no longer provide useful information, past price fluctuations play no role in affecting current inflation. Graphical analysis of smoothing probabilities and actual inflation rate demonstrate the accuracy of the empirical estimates and the predicted expected duration of both regimes align with the actual evolution of prices during the period of interest.

Partitioning the sources of inflation demonstrate that, from a long-run perspective and in the high inflation regime, differences in inflation are mostly explained by GDP growth; likewise, in the low-inflation regime, money growth and velocity growth are the principal factors explaining the variance of inflation. From a short-run perspective, the output gap explains almost all regression variance in the high-inflation regime, and past inflation does the same during times of low inflation, though in both cases the R^2 is low, which precludes making definite statements about the sources of variability in inflation.

An important conclusion is that, in countries such as Bolivia, that have experienced significant price fluctuations, inflation is best analyzed with models that allow for changes in the parameters affecting it over a set of different unobserved states. The results are likely to incorporate specific features of each state and hence generate more reliable estimates of the factors that affect inflation over time.

The principal policy implication concerns control of the money supply. Since it has been determined that from a long-run perspective the growth rate in M2 is a principal determinant of inflation both in high- and low inflation regimes, then it is up to the Bolivian Central Bank to make sure that the money supply does not grow out of hand. Further, and from a short-run perspective, restricting the growth in the money supply may also

dampen inflationary expectations, which has been found to be an important determinant of inflation in the low-inflation regime.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Time-Varying Univariate Markov-Switching Model for Monthly Inflation.

		Regime 1—High Inflation		**Regime 2—Low Inflation**	
		Coefficient	**St. Error**	**Coefficient**	**St. Error**
Switching Regressor Constant		65.682 ***	1.851	2.003 ***	0.576
# of Observations: 992 Log-Likelihood: −3032.42					
Time-Varying Transition Probabilities and Expected Durations of Regime 1 and Regime 2					
Transition probabilities: P(i, k) = P(s(t) = k | s(t−1) = i) (row = i/column = j)					
			1		2
Mean	1		0.444		0.556
	2		0.005		0.995
Expected durations:					
			1		2
Mean			1.80 months		197.33 months
Monthly inflation rate expressed in percentages Probability regressors: C, $inflation_{t-1}$ Four non-switching AR regressors included in specification; not shown in table					

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Appendix B

Table A2. Time-Varying Univariate Markov-Switching Model for Monthly Inflation.

		Regime 1—High Inflation		**Regime 2—Low Inflation**	
		Coefficient	**St. Error**	**Coefficient**	**St. Error**
Switching regressor Constant		0.461 ***	0.017	0.019 ***	0.006
# of Observations: 992 Log-Likelihood: 1801.414					
Time-Varying Transition Probabilities and Expected Durations of Regime 1 and Regime 2					
Transition Probabilities: P(i, k) = P(s(t) = k | s(t−1) = i) (row = i/column = j)					
			1		2
Mean	1		0.499		0.501
	2		0.004		0.996

Table A2. *Cont.*

	Regime 1—High Inflation		Regime 2—Low Inflation	
	Coefficient	**St. Error**	**Coefficient**	**St. Error**
Expected Durations:				
	1		2	
Mean	1.99 months		247.14 months	
Monthly inflation rate estimated as first differences of the natural log of the price level				
Probability regressors: C, $inflation_{t-1}$				
Four non-switching AR regressors included in specification; not shown in table				

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Appendix C

Table 3. Correlation, Covariances, and Unit Root Tests.

Pairwise Correlation Matrix (Long Run)				
	Inflation	**Growth M2**	**Growth Velocity M2**	**Growth Real GDP**
Inflation	1	0.96906	0.45202	−0.38046
Growth M2		1	0.24137	−0.34668
Growth Velocity M2			1	−0.01838
Growth real GDP				1
Pairwise Correlation Matrix (Short Run)				
	Inflation	Inflation (−1)	Real GDP	Potential Real GDP
Inflation	1	0.66289	−0.15535	−0.14014
Inflation (−1)		1	−0.16475	−0.14035
Real GDP			1	0.99692
Potential real GDP				1
Covariance Matrix (long run)				
	Inflation	Growth M2	Growth Velocity M2	Growth Real GDP
Inflation		0.46827	0.05805	−0.00928
Growth M2			0.00034	0.00053
Growth Velocity M2				0.00300
Covariance Matrix (Short Run)				
	Inflation	Inflation (−1)	Real GDP	Potential Real GDP
Inflation		0.34247	−0.05301	−0.04749
Inflation (−1)			−0.05617	−0.04752
Real GDP				0.22294
Unit Root Tests				
	Augmented Dickey-Fuller Test Statistic	Prob	Phillips-Perron Test Statistic	Prob
Inflation (Monthly)	−5.31437 ***	0.00000	−21.76118 ***	0.00000
Inflation (Yearly)	−7.909103 ***	0.00000	−7.909103 ***	0.00000
Yearly Inflation (−1)	−4.071251 ***	0.00000	−4.169057 ***	0.00000
d(M2)	−8.123352 ***	0.00000	−4.071977 ***	0.00190
d (Velocity M2)	−5.653667 ***	0.00000	−8.53470 ***	0.00000
d (Real GDP,2)	−12.06574 ***	0.00000	−12.58641 ***	0.00000
d (Potential Real GDP,2)	−2.16720 *	0.08300	−2.01162 *	0.08120

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

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COVID-19 Pandemic and Lockdown Fine Optimality

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Abstract: The first stream of economic studies on public policy responses during the COVID-19 pandemic focused on the stringency, the effectiveness, and the impact of the countries' interventions and paid rather little attention to the corresponding means used to support them. The present paper scrutinizes the lockdown measures and, particularly, examines the optimality of the lockdown fines imposed by countries worldwide towards ensuring citizens' compliance. Initially, a triad of fine stringency indicators are compiled, and the stringency of fines is evaluated in a comparative context, among the countries considered. Consequently, the fine stringency is incorporated into a regression analysis with various epidemiological, socioeconomic, and policy factors to reveal any drivers of fine variability. Finally, theoretical approaches behind fine optimality are capitalized and real data are used towards estimating the optimal fine for each country considered. The objectives of the paper are, first, to check for any drivers of fine stringency around the world and, second, to develop and test a formula that could be used in order to assist policy makers to formulate evidence-based fines for confronting the pandemic. The findings of the paper highlight that fines do not seem to have been imposed with any sound economic reasoning and the majority of countries considered imposed larger real fines, compared to the optimal ones, to support the lockdowns. The paper stresses the need for the imposition of science-based fines that reflect the social cost of non-compliance with the lockdown measures.

Keywords: COVID-19 pandemic; lockdown measures; fines; optimality; stringency

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1. Introduction

The coronavirus disease (henceforth: COVID-19) was characterized as a pandemic by the World Health Organization (WHO) as, after its initial outbreak in Wuhan, China, it spread very fast to the rest of the world (WHO 2020a). Countries worldwide adopted a different set of social distancing measures to contain the virus and help decrease the rate of transmission among their citizens. The initial response of countries was to control their borders to decrease the incoming transmission from other countries (McBryde et al. 2020). When the local transmission was increased, domestic social distancing became the core concept underlying all the containment efforts around the world (Brodeur et al. 2020), and several measures were implemented to this end (Gabutti et al. 2020). The Oxford COVID-19 Government Response Tracker recognizes the following categories of restrictions: school closing, workplace closing, cancellation of public events, restrictions on gathering size, closure of public transport, stay at home requirements, restrictions on internal movement, and restrictions on international travel (Hale et al. 2020).

The optimal mix of policies and their effectiveness have been, extensively, studied even from the first stream of papers on the COVID-19 pandemic policy responses (Kong and Prinz 2020; Nussbaumer-Streit et al. 2020; Tian et al. 2020; inter alia). Many authors show that strict preventive policy measures seem to have worked in reducing peoples' mobility and thus adequately promoted the targets of social distancing (Lapatinas 2020;

Wielechowski et al. 2020). Nevertheless, this is not always the case, as state capacity also plays a role in rendering policy responses more effective (Frey et al. 2020). The general consensus is that there is not a "one-size-fits-all" policy mix and the policies should be adapted to the specific epidemiological, socioeconomic, and policy context of each country (European Centre for Disease Prevention and Control 2020). In particular, a lockdown is a policy option that may damage economic activity, with negative potential impacts on a range of economic sectors (Yu et al. 2020). It is noteworthy that even the WHO (2020b) stresses that any preventive measures that slow down social and economic activities should be taken with caution and only after careful examination. A critical parameter for the success of the social distancing measures is citizens' compliance. Governments worldwide mostly relied on fines to deter non-compliance (Beaumont 2020). It is widely known that fines have a major role in securing the compliance of citizens in a range of instances, such as traffic laws and smoking prohibition. For the COVID-19 pandemic, a relevant case study in Germany has shown that the imposition of fines had a decisive role in reducing the speed of transmission of the disease (Chae and Park 2020).

In general, fines, when supporting the enforcement of laws, play multiple roles, including incapacitation, deterrence, rehabilitation, and retribution (Piehl and Williams 2011). Bentham (1780 in O'Malley 2009) considered fines as a license paid arrear and, much later, Becker (1968) as a price which is a function of the violators' benefit and the cost to the society that the violation incurs. When attention is drawn to the optimality of fines, the very old principle that the punishment should fit the severity of the crime runs through the relevant research through the years (Montag and Tremewan 2018). Concerning traffic fines, for example, effective tickets should encompass three basic principles (Sun 2011; Hummel 2015): first, they should make the drivers aware of the externalities and social cost of disrespecting the traffic law; second, they should act as a constant reminder to drivers that they should respect the speed limits; third, they should be set by acknowledging that people tend to underestimate the danger of driving carelessly. On the same rationale, and regarding competition laws, Kobayashi et al. (2016) claim that fines should internalize the social cost to the violator considering also the probability of compliance together with the probability of getting caught. Incorporating the aforementioned rationale into the case of pandemics, the social cost of non-compliance could be approximated by the cost of treatment. Besides, an effective fine should, inter alia, incorporate factors such as the probability that someone is infected, the risk of a violator transmitting the virus, and the probability that an infected person would need hospitalization. Moreover, from an operational point of view, the probability of people violating the rules and the capacity of the authorities to spot the violators should, also, be considered. In general, several epidemiological, socioeconomic, and policy factors should be considered when fines are being set.

The imposition of well-documented fines is critical for conveying the right message to citizens in the sense that citizens will be able to understand the risk of not obeying the laws. This is extremely critical since people are aware of the measures taken in other countries and, thus, they can easily estimate if the stringency of fines in their country is analogous to the corresponding fines of other countries, ceteris paribus (Evans 2020; Richings 2020). When huge differences occur in the stringency of fines, which cannot be attributed to epidemiological, socioeconomic, and policy factors, reverse effects may turn up (Bull 2020; Verseck 2020). Particularly, people in a country where fines seem to be higher than normal may consider the policies as a means for restricting their freedom or increasing public revenues. Correspondingly, people in a country where fines seem to be lower than normal may think that the risk is lower than the government claims.

It is true that, despite the early warnings of scientists, governments were not highly prepared for confronting a disease on such a large scale (McKay and Dvorak 2020). The lack of preparedness may be due to structural factors, having to do with the countries' overall adequacy in providing reliable health services to citizens (Eissa 2020), but also because the impact of the disease was so asymmetric compared to many past simulations of various

task forces (Maxmen and Tollefson 2020). In many cases, countries imposed a state of emergency based on disease laws over a century old (Desval 2020; Ling 2020). Therefore, many governments had to issue special laws, acts, and decrees in order to adjust their policy responses to the particular challenges of the COVID-19 pandemic, just like Canada did when it adjusted the outdated Quarantine Act for confronting the SARS disease in 2003 (Ling 2020). These laws, acts, and decrees covered issues such as self-isolation and quarantines. Yet, a great number of countries, and especially the Western ones, did not have the experience to impose measures such as lockdowns and curfews as these measures had rarely been used in the past due to their incompatibility with the democratic political systems (Bull 2020). Moreover, policy responses were driven by the contextual economic, institutional, and political factors prevailing in each country (Ferraresi et al. 2020). Therefore, factors other than the epidemiological conditions might have driven the stringency of policy responses as well. As far as fines are concerned, in particular, governments faced a situation where they needed to define a value of a fine without the existence of a law or adequate formulas. The lack of previous experience may have rendered the selection of proper fines a rather difficult task. Notable is the example of France, where on the first day of the lockdown, the fine was set at EUR 35, just to be increased to EUR 135 on the day after (France 24 2020). This shows that even the most developed countries were not ready to justify the setting of the fines.

The present paper analyzes the way(s) different governments worldwide dealt with the imposition of fines to support lockdown measures and to what degree those measures were based on reasonable economic evidence considering the corresponding epidemiological, socioeconomic, and policy factors. It does so by examining the fines imposed by many governments for supporting compliance with "stay-at-home" measures in the first wave of the pandemic. In total, 44 countries, from different parts of the world, are considered. The analysis covers the first wave of lockdowns, starting with the Italian lockdown (10 March 2020) and ending with the Singaporean lockdown (7 April 2020), and is divided into two parts. The first part, more descriptive, answers the first research question of the paper which seeks to reveal whether the stringency of fines is driven by epidemiological, socioeconomic, and policy factors. To do so, initially, a triad of fine stringency indices is computed and then a composite index of fine stringency is compiled. Finally, the relationship among the values of the composite index with various epidemiological, socioeconomic, and policy variables is systematically tested in order to shed light on the factors that may have driven fine imposition for the considered countries. The second part answers the second research question which seeks to reveal what the optimal height of the fines would be, considering the epidemiological, socioeconomic, and policy factors of each country.

The contribution of the paper is twofold. First, it incorporates the critical issue of sound economic reasoning policy measures for the confrontation of a pandemic and the COVID-19 pandemic in particular. Second, it proposes a set of factors that could be considered for countries to set effective fines. The need for evidence-based fines is critical, especially when many citizens stand skeptical about the very existence of the virus. If the fines are estimated based on a specific rationale, they could be adjusted when major conditions change and so they can convey messages about the severity of the disease not only within a country but also in an international context. The paper could be used as a starting point for building global-driven standards for fine setting. This could lead to a more harmonized public policy response to pandemics, which could be extremely helpful for coping with the subsequent waves of COVID-19 or any future pandemics.

The paper proceeds as follows: the next section elaborates on data and methodology. The third section performs the empirical analysis and discusses the findings. The last section offers the conclusions and some policy recommendations.

2. Materials and Methods

2.1. Data

Lockdown is considered as a general "stay-at-home" governmental directive with restrictions on public gatherings and the use of public transport means. Particularly, two main types of "stay-at-home" directives are considered, namely, total and partial lockdowns. Total lockdown regards directives addressed to the whole population with a mandate not to leave home for the whole day without permission. In this type are, also, included cases where, in addition to the general mandate to leave home only with permission, curfews for specific hours or on specific parts of the population are imposed. Partial lockdown includes those cases where "stay-at-home" directives are enforced voluntarily, accompanied by sanctions only for special violations. These violations mainly concern the failure to keep a distance from others, public and private gatherings of members of different households, and excessive use of public means of transport. In this category are, also, included cases where partial lockdowns are complemented with curfews. Table A1 (Appendix A) presents in detail the type of lockdown and the date of imposition in each country.

In the first stage, data were collected for 62 countries that enforced lockdown measures and imposed fines in order to achieve the maximum compliance of their citizens. Yet, in a second stage, some outliers, as well as countries with unverifiable data, were identified and removed from the sample. Thus, the final sample consists of 44 countries. Data for the date and the type of lockdowns as well as for the size of the fines were retrieved from various online sources, comprising mostly governmental and news sites. Especially for the collection of the fines, official sources were not always easy to find and when this was possible, translations on the official documents would possibly lead to confusing results considering the large range of measures taken by the countries. Therefore, English language news sites and translations with the assistance of Google were used for collecting the information for the considered countries. Particular attention was given to the reliability of sources and a great effort was made in the cross-checking of the information for each country. The same holds for the collection of traffic fines that are, also, utilized in the paper. Tables A2 and A3 (Appendix A) provide the sources used for collecting lockdown fines and traffic fines, respectively. Fines are converted to the euro currency, considering the exchange rate at the time of the study (i.e., the year 2020).

Note that countries were included in the sample only when it had become evident that the fine imposed was a standard fine and not the maximum feasible fine (that rarely was imposed). Therefore, in order to avoid any biased estimations, the fines presented in the paper are the standard minimum fines imposed on citizens for a single violation of the lockdown rules. This distinction is important because the fines could be increased for repeated violations. Note, also, that the fines incorporated into the analysis are those that were announced by the governments to support a particular lockdown measure whose date of imposition is considered as the benchmark for the empirical analysis. Fines such as those associated with self-isolation of infected persons or the operation of an enterprise when this was forbidden are not considered.

2.2. Methodology

2.2.1. Is the Stringency of Fines Driven by Epidemiological, Socioeconomic, and Policy Factors?

To extract a comprehensive comparison among the countries considered, a triad of fine stringency indices is calculated by taking three different variables as a benchmark for the fines' stringency. The first Fine Stringency Index (FSI_1) is the ratio of the fine value to the minimum monthly wage. The second Fine Stringency Index (FSI_2) is the ratio of the fine value to the gross domestic product (GDP) per capita. The third Fine Stringency Index (FSI_3) is the ratio of the fine value to the maximum traffic fine among the traffic fines considered.

$$FSI_1 = {}^{LF}/_{MW} \quad (1)$$

$$FSI_2 = {}^{LF}/_{GDP_{PC}} \quad (2)$$

$$FSI_3 = {}^{LF}/_{MAX(TF_1, TF_2, TF_3)} \quad (3)$$

where FSI is the fine stringency index, LF is the lockdown fine, MW is the minimum monthly wage, GDP_{PC} is the GDP per capita, TF_1 is the traffic fine for red light crossing, TF_2 is the traffic fine for driving without wearing a seatbelt, and TF_3 is the traffic fine for using a mobile phone while driving.

Having estimated the three indices, the rank for each country, according to its score, in each index is extracted. Then the total fine stringency index is computed as the average ranking of each country. The lower the score of each country in the index, the larger the stringency of the corresponding fine.

$$TFSI = (RFSI_1 + RFSI_2 + RFSI_3)/3 \quad (4)$$

where $TFSI$ is the total fine stringency index, and $RFSI_1$, $RFSI_2$, and $RFSI_3$ are the rankings in the FSI_1, FSI_2, and FSI_3, respectively.

Is the Stringency of Fines Driven by Epidemiological Factors?

The scores of the TFSI are associated with key epidemiological variables, namely, the Total Active Cases per Million People (TAC_{PMP}) at the time of the imposition of the lockdown, the Transmission Rate (R) in the period just before the imposition of the fines and the Risk of Hospitalization for the general public (RoH) in each country.

The TAC_{PMP} variable is measured on the day that the lockdown was imposed. The active cases are collected by the crosstabulation of data provided by the websites Worldometer.info (2020) and Ourworldindata.org (2020). The R variable is the effective reproductive number of COVID-19. This variable is critical for capturing the dynamics of the pandemic since it shows how many secondary infections are generated by one infected person (Kohlberg, Elon, and Abraham Neyman 2020) and is heavily considered by governments worldwide in order to shape and evaluate any policy measures related to the containment of the pandemic (Fisher 2020). The estimation of the variable is based on the new daily infections, and therefore it puts weight on the active cases rather than on the total cases at the time of estimation. The R variable is estimated under an assumption regarding the generation interval. The generation interval is estimated as the difference between the time that the symptoms appear in a person and the symptom onset time of the people infected by him/her (Kenah et al. 2008). The paper considers the value of 4 as a realistic approximation of the generation interval considering that Du et al. (2020), in an early study in Wuhan, China, found that the average interval was 3.96 days.

$$R = \frac{New\ infections\ at\ the\ current\ week}{New\ infections\ before\ 4\ days} \quad (5)$$

The index is estimated on a weekly—and not on a daily—basis to eliminate any randomness of reported cases (Kohlberg, Elon, and Abraham Neyman 2020). The final R incorporated into the study is the average value of R for the five-day interval before the announcement of the lockdown under consideration.

The variable of RoH quantifies the risk of a patient being hospitalized due to infection, considering the general health and demographic characteristics of each country. The variable draws from Clark et al. (2020) that provide an estimation of the proportion of the population at high risk per county considering the age structure as well as the fraction of population with various underlying conditions.

Is the Stringency of Fines Driven by Socioeconomic Factors?

The scores of the total fine stringency index are associated with key socioeconomic variables, namely, the GDP_{PC}, the wider trust of citizens in the political system (TP), and the Police Reliability (PR).

The GDP_{PC} variable is used in order to see whether the stringency of fines is affected by the economic development level of the countries.

The *TP* variable is used in order to see whether countries with higher trust levels imposed lower fines. Bargain and Aminjonov (2020) shown that European regions whose citizens show a higher trust to their governments presented a higher level of compliance with the policy measures against COVID-19. The same stands for countries with higher civic capital (Barrios et al. 2020). Tullis (2020), under a different perspective, showed that governments which are aware of the high levels of citizens' trust and public support may enforce looser measures. The formula for constructing the variable builds on the 7-scale trust measurement provided by the World Economic Forum (WEF 2018) and the record for each country is extracted by taking the ratio of its score to the maximum score of 7.

The *PR* variable is used since several containment measures require the involvement of police forces in order to ensure citizens' compliance. To successfully deal with the pandemic, police forces need to intensify their tasks, often with the same number of resources. Overall, the adaptation of police forces to the new reality depends on their overall effectiveness and preparedness (Laufs and Waseem 2020). Therefore, regarding the fines, countries in which the police forces are reliable are expected to detect any violators more easily and secure the collection of fines and therefore impose lower fines. The formula for constructing the variable builds on the 7-scale trust measurement provided by the WEF (2019) and the record for each country is extracted by the ratio of its score to the maximum score of 7.

Is the Stringency of Fines Driven by Policy Factors?

The scores of the total fine stringency index are associated with key policy variables, namely, the Government Response Stringency Index (*GRSI*), the Type of the Lockdown (*LT*), and the Date of the Lockdown (*DoL*).

The *GRSI* variable refers to the overall stringency of measures implemented at the time of the fine imposition in each country. The variable refers to the Oxford COVID-19 Government Response Tracker, and, particularly, to the homonymous index that presents the stringency of responses according to how many of the 11 considered policy responses were implemented in each country at the time of the fine imposition (see https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker (accessed on 5 September 2020) for details). The index uses a 0–100 scale, with higher values denoting tougher measures.

The Type of Lockdown (*LT)* variable is a dummy variable that takes a value of 1 for total lockdowns and 0 otherwise (i.e., partial lockdowns). The test here is conducted to examine whether total lockdowns were associated with higher fines than those imposed in partial lockdowns.

The *DoL* variable is computed as the difference of the date of fine imposition in each country with the date of the Italian lockdown enforcement, which was the first to be realized among the countries considered.

Multivariate Analysis on TFSI Determinants

To detect whether, and to what extent, the epidemiological, socioeconomic, and policy factors considered are determinants of the lockdown fine stringency, the paper performs a series of regression analyses. The basic assumption, as stems from the preceding discussion, is that governments had imposed lockdown measures considering key epidemiolocal factors, such as the transmission rate (R) and the dispersion of the disease in the population, as measured by the total active cases per million people (TAC_{PMP}). Furthermore, the setting of fine size (fine stringency) is affected by considering the particularities of the countries, which is a joint elaboration of the three types of factors considered by the present study. An ordinary least squares model is composed where the *TFSI* scores of the countries are incorporated as the dependent variable and the different factors as independent ones. Before presenting the model, there are some issues to be discussed regarding the applicability of such a process. First, many independent variables may be correlated with other ones and therefore their estimated effect could be biased. Therefore,

a multicollinearity test is conducted and the collinearity diagnostics of the condition index and variance inflation factors (VIFs) are reported (Gujarati 2009).

Second, endogeneity and selection issues should also be considered. There are two main sources of endogeneity in regression analyses similar to the one conducted in this paper. The first occurs when the dependent variable is not only a response of the independent variable but also a predictor of it. This is called simultaneity bias. For the current setting, this type of endogeneity should not be a problem. This is because simultaneity bias arises mainly in panel data analysis which is not the case with the present research design (Lynch and Brown 2011). As was stated in the preceding sections, the present analysis seeks to reveal if the setting of the fines was driven by the consideration of the prevailing conditions in the countries under consideration. Therefore, the analysis ends at the time that the size of the fines is announced in public without seeking to test any potential effects of fines on those conditions after the date of the announcement. The latter question would require a different and more time-dynamic model setting, as the outcome (*TFSI*) would surely affect the predictors.

The second source of endogeneity stems from the omission of important variables, resulting in the presence of the omitted variable bias (Lynch and Brown 2011). This type of endogeneity may arise in the present analysis. Therefore, to limit the extent of this bias, we have included a number of variables able to quantify the prevailing epidemiological, socioeconomic, and policy conditions of each country. Moreover, to detect any endogeneity, we run multiple forms of regression analyses either by using instrumental variables or interaction terms to detect any meditation effects of the variables. The basic rationale behind the formulation of the various models is that the governments considered the *R* and TAC_{pmp} as the factors affecting their decision to take measures but the fines were imposed by taking into account other factors, too. Therefore, we sought to check if the effect of the other variables was mediated by these two variables. All regression analyses are then compared with the following baseline model (Equation (5)) which uses OLS to test the main effects of the considered variables. In the model, all epidemiological, socioeconomic, and policy factors are incorporated together with the D_{CSA}, D_{CEA} D_{ME}, D_{NA}, and D_{AFR} variables which are some regional dummies for Central–South America, Central–East Asia, Middle East, Northern Asia, and Africa. The dummies were formulated with reference to Europe.

$$\begin{aligned} TFSI = \alpha + \beta_{TACpmp} \times TACpmp + \beta_R \times R + \beta_{RoH} \times RoH + \beta_{GDPpc} \times GDPpc + \beta_{TP} \\ \times TP + \beta_{PR} \times PR + \beta_{GRSI} \times GRSI + \beta_{DoL} \times DoL + \beta_{DCSA} \times D_{CSA} \\ + \beta_{DCEA} \times D_{CEA} + \beta_{DME} \times D_{ME} + \beta_{DNA} \times D_{NA} + \beta_{DAFR} \times D_{AFR} \end{aligned} \quad (6)$$

After the introduction of different forms, we also present the results of a model with two additional interaction terms. This model comes up with substantially higher predictive power than the baseline model considering the improved value of the R^2 coefficient. The first interaction term ($\beta_{DOL*R} * D_{DoL}D_R$) shows how the transmission rate mediates the effect of the time lag between the Italian announcement of fines and the announcement in other countries. The second examines the same mediation effect but by considering the TAC_{pmp} ($\beta_{DOL*TACpmp} * D_{DoL}D_{TACpmp}$) variable. All in all, these interaction terms sought to reveal if the epidemiological factors had a stable effect on governments' choices for setting fines regardless of the time they had available to elaborate the fines for supporting lockdowns.

In the Results section, the pairwise relationships among fine stringency and all of the considered variables are first graphically presented and briefly commented upon. Then, the results of the multivariate models are presented and discussed with regard to the initial results.

2.2.2. What the Optimal Height of the Fines Should Be, Considering the Epidemiological, Policy, and Socioeconomic Factors of Each Country

The empirical analysis proceeds to a theory-driven evaluation of the imposed fines' optimality. Particularly, the empirical analysis capitalizes on the discussion on the fines' optimality under economic reasoning (Becker 1968; Polinsky and Shavell 1979, 2000; Mookherjee and Png 1994 inter alia) and a couple of formulas that may assist governments in formulating adequate fines to support the lockdown (or other) measures. The optimal fines for each country are estimated under both formulas and are compared to the actual ones.

Under the first formula, the fine is viewed as a function of the cost of treatment and of some pure epidemiological factors. The specification of the fine under epidemiological considerations is as follows:

$$Fine_{ep} = CoT * R * RoH * P(I) \quad (7)$$

where $Fine_{ep}$ is the Optimal Fine based on Epidemiological data, *CoT* is the Cost of Treatment, *R* is the transmission rate of COVID-19, *RoH* is the risk of hospitalization, and *P(I)* is the probability of being infected. Towards incorporating the *CoT* variable into the formula, the US tally is taken as a baseline and the cost for each country is adjusted accordingly by considering the differences among the standards of living (O'Brian (2020) estimated the average cost of treatment for a COVID-19 patient in the USA to be about USD 30,000). The adjustment is made according to the purchasing power parity conversion provided by The World The World Bank (2020). Towards incorporating the *P(I)* variable, the proportion of COVID-19 active cases to the total population is estimated. The COVID-19 cases may be either detected or undetected and therefore the real detected cases are multiplied by a relevant factor (10) in order to estimate the total real cases. To date, there is no general consensus about the underestimation of COVID-19 active cases. Bohk-Ewald et al. (2020), based on a sample of 10 countries, estimated that the real numbers could have surpassed the reported ones by 2 to 11 times, depending to the country under consideration. Wu et al. (2020), examining the USA, for the period between February and April 2020, found that the total cases could have exceeded the reported ones by 2 to 20 times. As the paper refers to the initial stage of the pandemic, when testing capacity was rather minimal, a factor of 10 is used in order to approximate the relationship between detected and undetected cases. The index could be further elaborated to incorporate only the susceptible portion of the population. Nevertheless, although the study refers to the first wave of the pandemic when immunity levels in the population were extremely low, it still provides an adequate representation of the probability that someone gets infected. It is noted that the index should incorporate such a metric to be used for estimating fines in the succeeding waves of pandemic.

$$P(I) = \left(\frac{detected\ active\ COVID-19\ cases * 10}{population} \right) * 100 \quad (8)$$

Under the second formula, the fine is viewed as a function of the first formula and some pure socioeconomic factors. The formula incorporates the rationale of Becker (1968) on fine optimality who, among other factors, highlighted the need for accounting for conditions that may make people more prone to incompliance as well the probability of getting caught when setting fines for law violations. The specification of the fine under epidemiological and socioeconomic considerations is as follows:

$$Fine_{ep+s} = \frac{Fine_{ep} * [1 - P(C)]}{P(D)} \quad (9)$$

where *P(C)* is the probability of compliance and *P(D)* is the probability of being detected. The *P(C)* variable is proxied by the *TP* variable. The *P(D)* variable is proxied by the *PR* variable.

Towards comparing the optimal fines to the actual ones, the Fine Optimality Deviation Index (*FODI*) is provided. *FODI* is provided in terms of epidemiological data only and in terms of both epidemiological and socioeconomic data.

$$FODI_{ep} = \left(\frac{|Fine_{actual} - Fine_{ep}|}{Fine_{ep}}\right) * 100 \quad (10)$$

$$FODI_{ep+s} = \left(\frac{|Fine_{actual} - Fine_{ep+s}|}{Fine_{ep+s}}\right) * 100 \quad (11)$$

3. Results

3.1. Descriptive Statistics

Table 1 presents some descriptive statistics for the actual fines and the fine stringency indices (data are available upon request). The minimum, the average, and the maximum fine values were EUR 7.00, EUR 415.35, and EUR 2555.43, respectively. The standard deviation value was EUR 697.20, indicating that enormous differences existed among the countries considered. The top five countries (i.e., the countries with the highest fines) were Saudi Arabia, Bulgaria, Ireland, Bahrain, and Thailand, whereas the bottom five countries (i.e., the countries with the lowest fines) were Zimbabwe, India, Hungary, Algeria, and Morocco. The FSI_1 indicates that the fines accounted for about 92% of the minimum monthly wage, on average. The highest value was observed in Bulgaria, and the corresponding lowest value was observed in the UK. The FSI_2 indicates that the fines accounted for about 4% of the GDP per capita, on average. The highest value was observed in Bulgaria, and the corresponding lowest value was observed in the UK. The FSI_3 indicates that the fines accounted for about 605% of the maximum traffic fine, on average. The highest value was observed in Thailand, and the corresponding lowest value was observed in Hungary. From the rankings of the countries according to the three indices, it is concluded that four countries, namely, Bulgaria, Thailand, Ukraine, and Saudi Arabia, are consistently in the group of countries with the harsher fines. Table A4 (Appendix A) provides the full records of the countries for the FSI_1, the FSI_2, the FSI_3, and the *TFSI*.

Table 1. Descriptive statistics on the actual fines and the fine stringency indicators.

Statistic	Fine (EUR)	Fine Stringency Index 1—FSI_1	Fine Stringency Index 2—FSI_2	Fine Stringency Index 3—FSI_3
Average	415.35	0.92	0.04	6.05
St.Dev	697.20	1.55	0.07	12.46
Min.	7.00	0.02	0.00	0.10
Max.	2555.43	7.76	0.34	56.72
Top 5	Saudi Arabia	Bulgaria	Bulgaria	Thailand
	Bulgaria	Thailand	Ukraine	Bulgaria
	Ireland	Ukraine	Thailand	Ukraine
	Bahrain	Saudi Arabia	Saudi Arabia	Ireland
	Thailand	Bahrain	Bahrain	Saudi Arabia
Bottom 5	Zimbabwe	UK	UK	Hungary
	India	France	France	UK
	Hungary	Hungary	Hungary	India
	Algeria	Zimbabwe	Panama	Greece
	Morocco	Denmark	Israel	France

Notes: Data for the fine and date of lockdown (DoL) are retrieved from multiple sources (see Table A2 of Appendix A). Data for FSI_1 are extracted from Worldometer.info (2020), for FSI_2 from countryeconomy.com (2020), and minimum-wage.org (2020). Data for the minimum wage of Italy, Norway, and Austria are rough estimations. Data for FSI_3 were retrieved from multiple sources (see Table A3 of Appendix A).

Table 2 presents some descriptive statistics for the epidemiological, socioeconomic, and policy factors. The average value of the TAC_{PMP} variable reached the level of

64.64 active cases. The highest value was observed in Ireland, and the corresponding lowest value was observed in Ukraine. The average value of the R variable reached the level of 2.79 new infections within a 4-day interval. The highest value was observed in Turkey, and the corresponding lowest value was observed in Bahrain. The average value of the *RoH* variable reached the level of 5%. The highest value was observed in Bulgaria, and the corresponding lowest value was observed in Kenya. The average value of the GDP_{PC} variable reached the level of EUR 16,564. The highest value was observed in Ireland, and the corresponding lowest value was observed in Zimbabwe. The average value of the *TP* variable reached the level of 45% on the seven-scale trust measurement. The highest value was observed in Singapore, and the corresponding lowest value was observed in Zimbabwe. The average value of the *PR* variable reached the level of 66% on the seven-scale trust measurement. The highest value was observed in Singapore, and the corresponding lowest value was observed in the UAE. The average value of the *GRSI* variable reached the level of 79.32 on the 0–100 scale. The highest value was observed in Jordan, and the corresponding lowest value was observed in Colombia. The average value of the *DoL* variable reached the level of 13.14 days after the Italian lockdown. The highest value was observed in Singapore, and the corresponding lowest value was observed in Spain.

3.2. Is the Stringency of Fines Driven by Epidemiological, Socioeconomic, and Policy Factors? Empirical Findings

Figure 1a–c visualize the relation between the *TFSI* and each of the epidemiological variables considered. The relation between the *TFSI* and the TAC_{PMP} variable does not have the expected negative sign and is statistically not significant (significance level: 0.571). The relation between the *TFSI* and the *R* variable, again, does not have the expected negative sign and is statistically not significant (significance level: 0.524). The relation between the *TFSI* and the *RoH* variable, though it has the expected negative sign, is statistically not significant (significance level: 0.306).

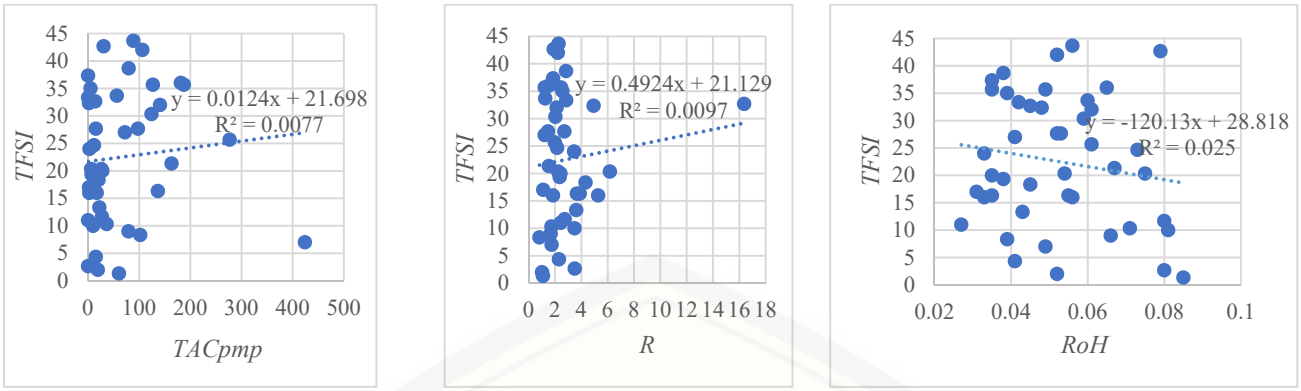
Overall, no statistically significant relationship is detected between the stringency of fines and the epidemiological variables considered. Moreover, in two out of the three cases considered, the variables do not have the expected (negative) signs.

Figure 2a–c visualize the relation between the *TFSI* and each of the socioeconomic variables considered. The relation between the *TFSI* and the GDP_{PC} variable is positive and statistically significant at the level of 10% (significance level: 0.055). This finding implies that less-developed countries imposed stricter fines than the richer ones. Nevertheless, this finding should be treated with caution due to the rather low value of the R^2 coefficient and the rather weak statistical significance of the estimated slope coefficient. The relation between the *TFSI* and the *TP* variable, though it has the expected positive sign, is statistically not significant (significance level: 0.607). The relation between the *TFSI* and the *PR* variable, again, though it has the expected positive sign, is statistically not significant (significance level: 0.607). Overall, only a weak relationship between fine stringency and GDP levels was found. Considering the results of all three regressions of socioeconomic factors, it is found that the socioeconomic conditions of each country hardly affected the imposition of lockdown fines.

Table 2. Descriptive statistics on epidemiological, socioeconomic, and policy variables considered.

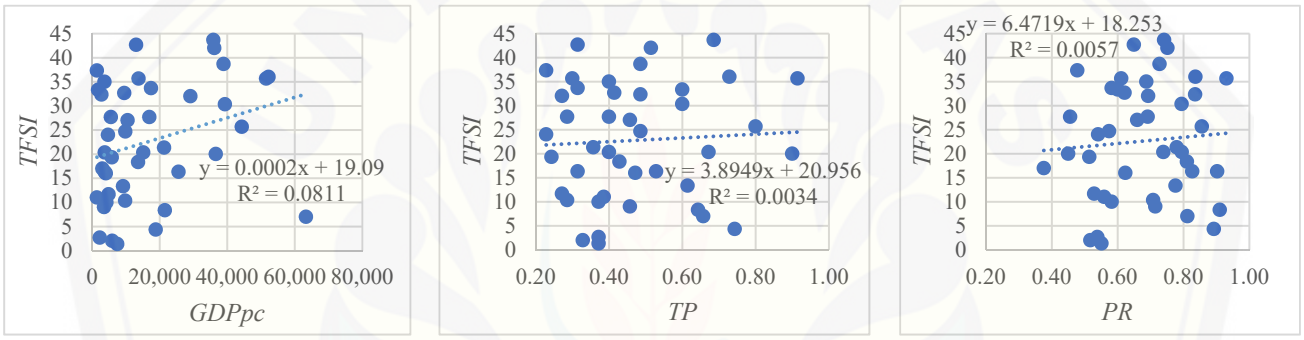
Statistic	Total Active Cases per Million People—TAC_{pmp}	Transmission Rate—*R*	Risk of Hospitalization—RoH	Gross Domestic Product per Capita—*GDPpc* (EUR)	Trust to Politicians—*TP*	Police Reliability—*PR*	Government Response Stringency Index—*GRSI* (0–100)	Date of Lockdown—*DoL* (Days)
Average	64.64	2.79	0.05	16,564	0.45	0.66	79.32	13.14
St.Dev	84.80	2.40	0.02	16,187	0.20	0.17	10.29	5.46
Min.	0.27	0.82	0.03	1406	0.00	0.00	53.70	4.00
Max.	424.08	16.36	0.09	63,340	0.91	0.93	100.00	28.00
Top 5	Ireland	Turkey	Bulgaria	Ireland	Singapore	Singapore	Jordan	Singapore
	Netherlands	Lithuania	Serbia	Denmark	UAE	Bahrain	Bolivia	Thailand
	Singapore	Albania	Bosnia	Singapore	Netherlands	Spain	Ecuador	Bulgaria
	Denmark	Morocco	Ukraine	Netherlands	Saudi Arabia	Saudi Arabia	Cyprus	Costa Rica
	Slovenia	Chile	Hungary	Belgium	Denmark	Netherlands	Morocco	Azerbaijan
Bottom 5	Ukraine	Bahrain	Kenya	Zimbabwe	Zimbabwe	UAE	Colombia	Spain
	India	Thailand	Bolivia	Kenya	Ecuador	South Africa	Chile	Albania
	Zimbabwe	Bulgaria	Iraq	India	Colombia	Zimbabwe	Singapore	Lithuania
	Kenya	Bolivia	Ecuador	Ukraine	Bosnia	Colombia	Turkey	Ecuador
	Bolivia	Costa Rica	Zimbabwe	Morocco	Italy	Thailand	Spain	Ukraine

Notes: Data for active cases and R are extracted from Worldometer.info (2020), Ourworldindata.org (2020); data for risk of hospitalization (RoH) are retrieved from Clark et al. (2020). Data for GDPpc are extracted from Worldometer.info (2020). Data for the trust of citizens in the political system (TP) variable are retrieved from the WEF (2018). Data for police reliability (*PR*) are extracted from the WEF (2019). There are no data for *TP* and *PR* for Iraq and Bolivia. Data for government response stringency index (*GRSI*) are found in Hale et al. (2020) and data for *DoL* are extracted from multiple sources (see Table A2 of Appendix A).



(**a**) (**b**) (**c**)

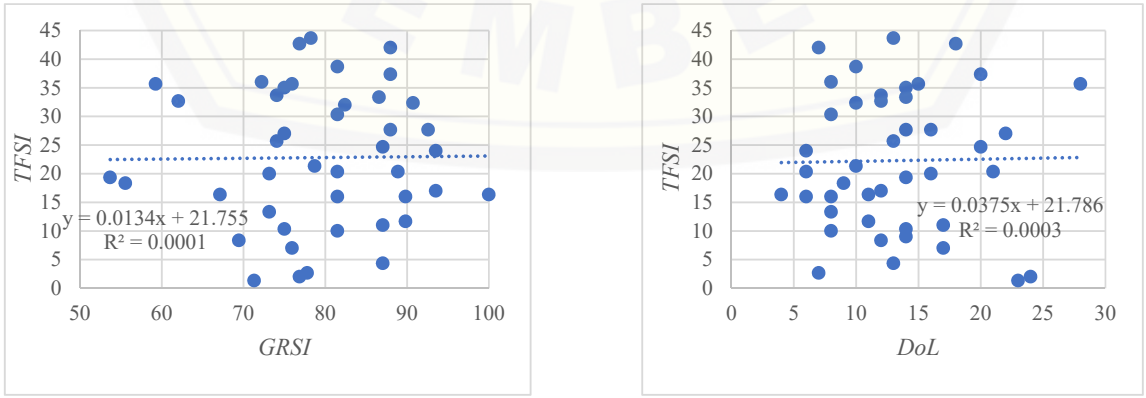
Figure 1. The relation between the total fine stringency index (TFSI) and each of the epidemiological variables considered. (**a**) The relationship between *TFSI* and TAC_{pmp}. (**b**) The relationship between *TFSI* and *R*. (**c**) The relationship between *TFSI* and *RoH*.



(**a**) (**b**) (**c**)

Figure 2. The relation between the *TFSI* and each of the socioeconomic variables considered. (**a**) The relationship between *TFSI* and GDP_{pc}. (**b**) The relationship between *TFSI* and *TP*. (**c**) The relationship between *TFSI* and *PR*.

Figure 3a,b visualize the relation between the *TFSI* and the *GRSI* and the *DoL* variables, respectively. The relation between the *TFSI* and the *GRSI* variable does not have the expected negative sign and is statistically not significant (significance level: 0.942). The relation between the *TFSI* and the *DoL* variable, again, does not have the expected negative sign and is statistically not significant (significance level: 0.914).



(**a**) (**b**)

Figure 3. The relation between the *TFSI* and each of the policy variables considered. (**a**) The relationship between *TFSI* and *GRSI*. (**b**) The relationship between *TFSI* and *DoL*.

Figure 4 visualizes the relation between the *TFSI* and the *LT* variable and shows that the rankings of the countries heavily overlap, irrespective of the type of lockdown imposed (i.e., either total or partial). This is also testified with the statistically not significant result of a Mann–Whitney test (Norusis 2004) (significance level: 0.314), which was performed in order to check whether the mean ranks of the two categories were similar. It is worth noting that countries that have among the highest fines (such as Thailand, Bulgaria, and Ukraine) had not imposed a strict lockdown but, rather, a loose one.

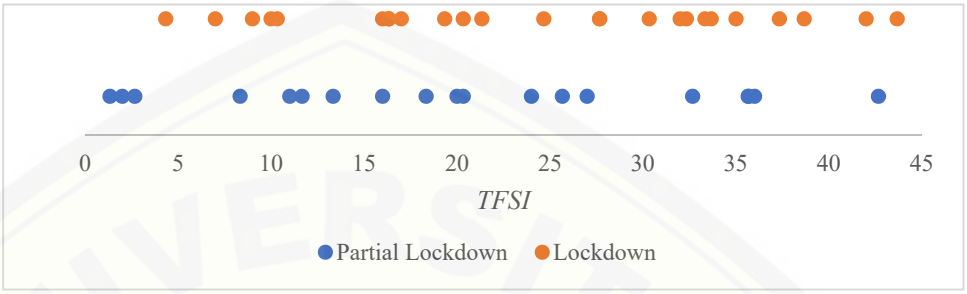


Figure 4. The relation between the TFSI and the type of lockdown (LT) variable.

Overall, no statistically significant relationship is detected between the stringency of fines and the policy variables considered. Apparently, it seems to be extremely hard to establish an economic rationale behind the actual fine imposition for lockdown enforcement.

Finally, Figure 5 presents the *TFSI* scores under a (macro-)regional perspective to account for any regional variability. The mean rankings of (macro-)regions overlap with each other and, therefore, no huge differences in the stringency of fines can be found for the different parts of the world. This is also testified by the statistically not significant result of a Kruskal–Wallis test (Norusis 2004) (significance level: 0.791).

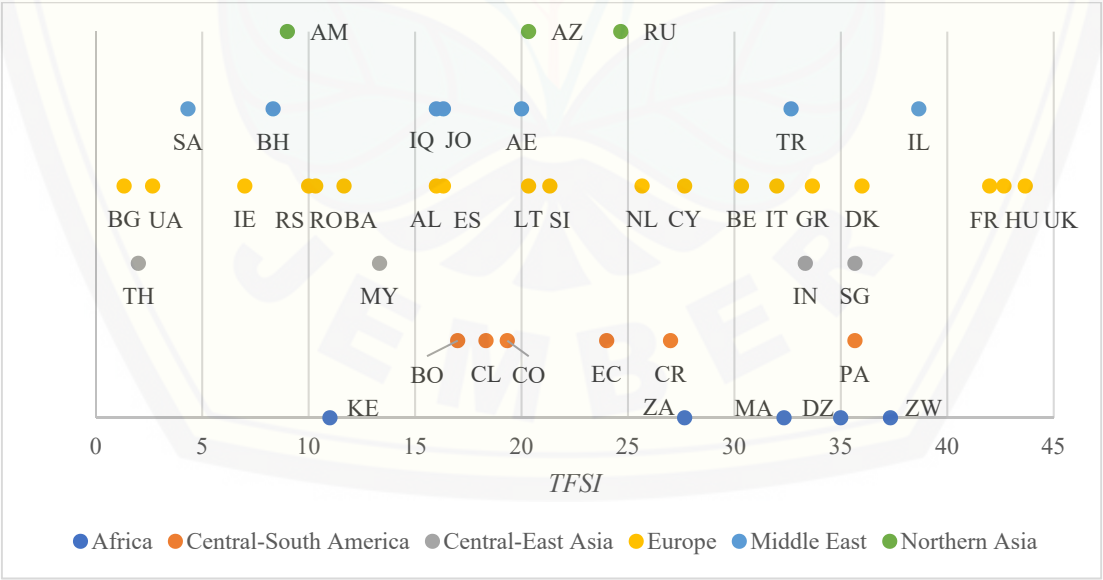


Figure 5. The TFSI under a (macro-)regional perspective.

3.3. Results of the Multivariate Analysis on Fine Stringency Determinants

After examining the individual relationship of the *TFSI* with the considered variables, the results of the multivariate modes are presented in Table 3. It should be noted that all outliers have been removed before the models' application and thus the final number of countries incorporated into the models is 38. As can be seen from the diagnostics of the

model, the interactions model outperforms the baseline model in terms of F value and significance as well as because of the higher R^2 value. The explanatory power of the model was increased by the inclusion of the additional variables, but still, 60% of the *TFSI* variance remains unexplained. This result validates the previous findings regarding the difficulty in explaining the rationale of the imposition of fines around the world. Moreover, the results of the analysis for the existence of multicollinearity show that no such issue arises from the data. The VIF values of the baseline model are all well below the threshold of 10, which is used as a reference point for indicating multicollinearity issues, while the VIF values of the variables of the second model are also lower than ten (10), except for the variables that are used for building the interaction terms. Nevertheless, this is a reasonable result as these variables present a high correlation with the interaction variables (Dormann et al. 2013).

Table 3. The results of the regression analyses of TFSI on the factors under consideration.

Type of Factors	Coefficient	Baseline Model		Interactions Model	
		Estimation	Variance Inflation Factor VIF	Estimation	Variance Inflation Factor VIF
	α	−10.388		15.311	
Epidemiological	β_{TACpmp}	−0.066	5.180	−0.107	13.460
	β_{R}	0.755	2.940	−6.826	8.760
	β_{RoH}	−240.183	4.770	−306.633	5.040
Socioeconomic	β_{GDPpc}	0.001 **	5.320	0.001 **	5.370
	β_{TP}	−18.278	3.650	−33.750	4.290
	β_{PR}	7.471	2.250	14.630	2.390
Policy	β_{GRSI}	0.409	1.760	0.314	1.830
	β_{DoL}	0.411	3.540	−1.203	12.100
Regional	β_{DCSA}	3.366	4.300	−3.806	4.920
	β_{DCEA}	−3.132	3.020	−4.461	3.110
	β_{DME}	−16.498	3.630	−20.741 *	3.770
	β_{DNA}	2.409	1.900	−4.834	2.390
	β_{DAFR}	4.689	4.080	−5.548	4.900
Interactions	β_{DOL*R}			1.043 *	7.66
	$\beta_{DOL*TACpmp}$			0.003	12.78
Regression Diagnostics					
	F	2.21		F	2.7
	Prob>F	0.045		Prob F	0.017
	Adj.R^2	0.2989		Adj R^2	0.408

Statistical significance at ** (<0.01) and * (<0.05) levels.

As for the estimated coefficients, in the first model, we only obtained one statistically significant estimation which regards the *GDPpc* variable. Considering the positive sign of the estimation, it is concluded that wealthier countries imposed rather lower fines than developing ones. As for the remaining variables, we observe a change in the sign of the variables TAC_{pmp} and *TP* with respect to the initial signs of the individual comparisons. Nevertheless, these differences are marginal and without any statistical significance. In the interactions model, three variables are found to be statistically significant. The estimation for the *GDPpc* coefficient retains its significance, hence, denoting that GDP had a role in fine setting. Additionally, there is a negative-signed significant estimation for the coefficient of the Middle East regional dummy, denoting that the countries of the area imposed heftier fines than European ones. This result should not be considered as contradicting the finding of the initial Kruskal–Wallis test (Figure 5), as the sample of the regression analysis is smaller than the initial one and thus it may lead to different findings. Despite this difference, the general impression is that there are not huge differences between the stringency of fines among the different regions of the world and Europe, as all other

coefficients are non-significant. Finally, between the two interaction terms, only the one representing the interaction of *DoL* and *R* is found to be statistically significant. Considering the negative sign of the main effects coefficient and the positive one for the interaction term, it is concluded that as we moved far from the first day of the imposition of the Italian fine, the effect of *R* in the setting of the fines was lowered. This may be because countries had the necessary time to also consider other factors that governments that had to take measures right after receiving the shocking pictures coming from the pandemic in Italy could not consider. In any case, this interaction should be treated with caution due to the lack of any statistical significance of the main effect coefficients of the two variables.

3.4. What the Optimal Size of the Fines Should Be, Considering the Epidemiological, Policy, and Socioeconomic Factors of Each Country. Empirical Findings

Figure 6a,b visualize the relation between the actual fines and the $Fine_{ep}$ and the $Fine_{ep+s}$ formulas. Considering the y = x identity line (i.e., the dotted line), for the $Fine_{ep}$, 33 out of 43 countries lie above the line and thus had imposed fines that were stricter than what the epidemiological data of these countries would imply. For the $Fine_{ep+s}$, the number of countries that overestimated the risks of the pandemic and thus imposed higher than optimal fines is 35. Six countries overestimated the real risks of the pandemic, imposing fines that exceed the EUR 500 level of those that would occur if epidemiological and social factors under both formulas were taken into account. Additionally, considering the first formula, it seems that the countries which underestimated the most the risk of the pandemic were all European, namely, the UK, France, and Hungary. Nevertheless, when the social factors are incorporated into the analysis (Figure 6b), the level of underestimation is reduced and the UK is surpassed by Panama.

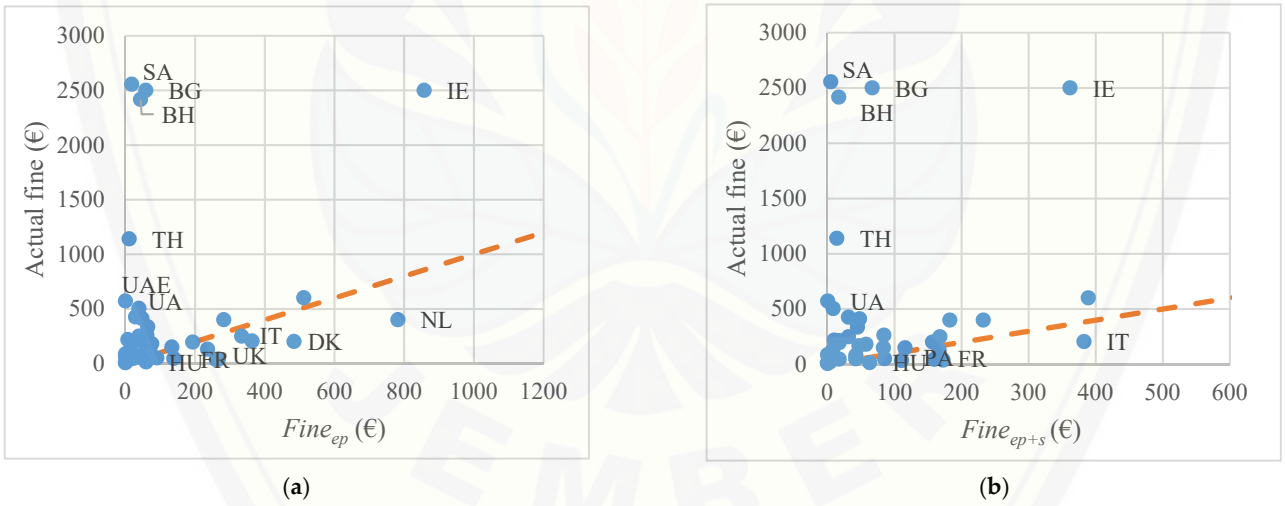


Figure 6. The relation between the actual and estimated fines. (**a**) The relationship between actual fines and those obtained by the epidemiological fines formula ($Fine_{ep}$). (**b**) The relationship between actual fines and those obtained by the epidemiological and socioeconomic formula ($Fine_{ep+s}$).

The current figures should be considered as only indicative of countries' real deviations. This is because the social cost, as expressed by the cost of COVID-19 patients' treatment, is a rough estimation, taking as a proxy the cost of treatment in the USA. Nevertheless, the formulas could be extremely useful for researchers and policymakers as they can reveal what the actual cost of treatment should be for the imposed fines to be justified by the prevailing conditions. For example, in the case of France, the cost of treatment was assumed to be EUR 21,700. With this record, it was found that France imposed fines that lay far below the optimal ones. For the French fines to be justified, the cost of treatment should not exceed EUR 3087 for the $Fine_{ep}$ formula and EUR 4776 for the $Fine_{ep+s}$ formula. Similar, for Costa Rica, which imposed higher than optimal fines under both fine specifications, the

cost of treatment should be around EUR 47,000 under the first formula and EUR 57,000 under the second to justify such harsh fines. These tallies would even exceed the respective cost of treatment in the USA.

Table 4 presents some more detailed results regarding the optimality of fines in the various (macro-)regions worldwide, based on the $FODI_{ep}$ and the $FODI_{ep+s}$. The imposed fines deviated, in absolute terms, more than 43 times from their optimal fine when only epidemiological factors were considered and about 50 times when both epidemiological and socioeconomic factors were considered. These tallies show that when social data are incorporated into the estimation of an optimal fine, the deviation of countries seems to be amplified. For the first formula, the largest average deviation is found in Europe, as the fines deviate more than 51 times from their optimum value and the lowest deviation is found for the three countries of Northern Asia, where the deviation is only 123%. When the second formula is considered, the deviation of countries in the Middle East skyrockets, while the Northern Asian countries still present the largest optimality. Apparently, the majority of countries imposed stricter than optimum fines. In addition, underestimation was a major issue in the Middle East, where half of the considered countries imposed lower than optimal fines, and in Europe, since the proportion of countries with rather low fines reached 32%. In contrast, Africa, Central–East Asia, and Northern Asia did not have any country with these characteristics. Additionally, when social factors are considered, underestimation weakens. This is because half of the European countries that fell into this category under the first formula shifted to the category of overestimation and the Middle East remains the region with the largest proportion of countries that underestimated risk.

Table 4. Lockdown fine optimality using fine optimality deviation index (FODI).

Regions	$Fine_{ep}$			$Fine_{ep+S}$		
	FODI	Type of Deviation		*FODI*	Type of Deviation	
		Over	Under		Over	Under
Africa	5120%	5	0	4618%	5	0
Central–South America	2319%	5	1	830%	4	1
Central–East Asia	3574%	4	0	3846%	4	0
Europe	5866%	13	6	5329%	16	3
Middle East	3359%	3	3	10,594%	3	3
Northern Asia	123%	3	0	252%	3	0
Global	4321%	33	10	4957%	35	7

Table A4 (Appendix A) provides the full records of the countries for the *FODIep* and the *FODIep+s*. Concerning the *FODIep*, the top five countries with the highest deflection were Ukraine, Kenya, Saudi Arabia, Thailand, and Bolivia, whereas the top five countries with the lowest deflection were Singapore, Cyprus, Spain, Belgium, and Slovenia. Concerning the *FODIep+s*, the top five countries with the highest deflection were Ukraine, Saudi Arabia, Kenya, Bahrain, and Thailand, whereas the top five countries with the lowest deflection were South Africa, Israel, Denmark, Cyprus, and Turkey.

4. Discussion

The present paper, by examining the fine policy for backing lockdown measures in an international context, has revealed that the imposition of fines has been rather asymmetric and without clear economic reasoning. This is because the variations of the fines across countries do not seem to be driven by epidemiological, policy, or socioeconomic factors. As the regression analyses revealed, the only clear driver of fines found by the present study seems to be the level of the economic development of each country. Therefore, epidemiological factors played a minimal role and the policy-making differences that are usually found between developed and less-developed countries may have also driven the response of governments in terms of the imposition of fines. This was evident in the

study of Frey et al. (2020), who found that the level of democracy was inversely related to the stringency of the overall government response to COVID-19. The worrying fact of the study of Frey et al. (2020) is that stronger measures were not found to be more effective than less intensive responses. This may be also the case with fine stringency for two reasons.

First, because the less-developed countries imposed heftier fines, it is possible that COVID-19 may increase the inequalities among developed and less-developed countries at the policy level. Moreover, the analysis of the optimality of fines has revealed that the imposition of fines may also increase the inequalities within countries. Many citizens of countries, especially those with existing high levels of inequality, may see their economic position deteriorate further, as in many instances they cannot stay at home as they need to work to earn the essentials for living. This necessity is higher for informal workers, as they hardly receive state support (International Labour Organisation—ILO 2020). Nevertheless, the risk of violating lockdown rules results in a loss that exceeds their monthly salary. So, in situations where the state cannot apply adequate welfare policies, many people may take the risk to leave home and work, despite still risking more than their monthly income. The pressure exerted on citizens by the improper imposition of fines is added to other types of disparities amplified by the pandemic, in domains such as food security (Power et al. 2020; Wolfson and Leung 2020), migrants' living conditions (Sengupta and Jha 2020), capacity for protecting against diseases (Clouston et al. 2021), racial and ethnic disparities (Raine et al. 2020), and many other aspects of economic and social life.

Moreover, the very effectiveness of the fines as policy instruments may be jeopardized when they are not driven by the prevailing conditions. Therefore, citizens of many countries may turn out to be very reluctant towards the real intentions of their governments and may defy lockdowns. For example, Ukrainian citizens may find it very difficult to understand why they were faced with a fine that was five times higher than their minimum monthly salary and 39 times higher than the maximum fine for traffic penalties when, by the time of the imposition of lockdown, the country recorded the lowest number of active cases per million people of the countries of the sample. At the same time, the Netherlands, with 400 cases per million people, had imposed fines that accounted for 25% of the minimum salary and only 1.6 times the highest traffic penalty. The analysis of fine optimality has shown that the deviation of the real fine from an optimal fine did not exceed 100%, while the results for Ukraine showed that the fine imposed was over 774 to over 900 times higher than the optimal one, according to the formula considered for estimating the optimal fines.

5. Conclusions

In the time of an unprecedented pandemic outbreak, policy responses for the containment of the disease acquire great importance. Even though the need for adjusting preventive measures, such as lockdowns and border closures, in order to alleviate the economic shocks, is evident, there is, still, an absence of recommendations to guide countries in achieving a state of optimality when setting fines to support various types of responses. Since fines, when properly imposed, have been long recognized as effective means for enhancing citizens' compliance, it is evident that an effective fine policy may help countries to render their policy responses more successful and thus become more effective in confronting the COVID-19 pandemic. During a pandemic, and according to the standard economic theory, fines, to be effective, must incorporate the risks associated with the pandemic and thus consider all the factors that may affect the risk levels. For the citizens to perceive the role of the state as an institution that does its best to protect them, the latter should make explicit the factors considered to estimate the fines' size. Then, any differences will be well understood and thus people are expected to comply with the measures more easily. In contrast, when such great differences remain unexplained, people may lose their confidence in their governments and thus not follow the official guidelines. Without question, if fines are disproportionate to peoples' ability to pay them, then negative social effects may amplify inequalities.

Responding to this necessity, the paper proposes a couple of formulas for assisting governments in estimating evidence-based fines to support their measures. Even though these formulas should by no means be considered as a panacea, the paper fulfills its role in introducing and highlighting the need for open and evidence-based fine formulation. Given that the majority of countries considered overestimated the risk of the pandemic, by imposing fines that did not correspond to the epidemiological, policy, or socioeconomic conditions at the time of imposition, the need for a more thorough examination of fines and their overall role in confronting the pandemic still exists. To this end, the paper paves the way.

As with all particular issues related to the COVID-19 literature, there are many additional steps to be taken in order for more light to be thrown on the issue of fine optimality. As countries adjust their responses according to the severity of new waves of the pandemic, new data will become available and the samples for performing multivariate analyses will grow, thus enhancing the validity of the findings. Moreover, data not only on fines but also on some of their possible drivers will also become available as the literature on COVID-19 expands. Therefore, panel analyses on the drivers of fines and new variables, not considered by the present paper, could complement the present analysis. Moreover, questionnaires and relevant surveys could be also used to directly investigate the logic behind policy makers' decisions on fine settings. Those developments may lead to models of higher explanatory power which will more effectively treat any potential issues of omitted variables and potential sources of endogeneity. Finally, what remains as a future challenge is to expand the studies on how fines helped the confrontation of the pandemic. To this end, panel data will be extremely valuable.

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Appendix A

Table A1. Type of lockdown and date of imposition per country.

No.	Country	Region	Type of Lockdown	Date of Lockdown
1	Albania	Europe	2	16/3/2020
2	Algeria	Africa	2	24/3/2020
3	Armenia	North Asia	1	24/3/2020
4	Azerbaijan	North Asia	1	31/3/2020
5	Bahrain	Middle East	3	22/3/2020
6	Belgium	Europe	1	18/3/2020
7	Bolivia	South America	2	22/3/2020
8	Bosnia	Europe	4	21/3/2020
9	Bulgaria	Europe	3	2/4/2020
10	Chile	South America	4	19/3/2020

Table A1. *Cont.*

No.	Country	Region	Type of Lockdown	Date of Lockdown
11	Colombia	South America	1	24/3/2020
12	Costa Rica	Central America	4	1/4/2020
13	Cyprus	Europe	1	24/3/2020
14	Denmark	Europe	3	18/3/2020
15	Ecuador	South America	4	16/3/2020
16	France	Europe	1	17/3/2020
17	Greece	Europe	1	22/3/2020
18	Hungary	Europe	3	28/3/2020
19	India	Central Asia	1	24/3/2020
20	Iraq	Middle East	4	18/3/2020
21	Ireland	Europe	1	27/3/2020
22	Israel	Middle East	1	20/3/2020
23	Italy	Europe	1	10/3/2020
24	Jordan	Middle East	1	21/3/2020
25	Kenya	Africa	4	27/3/2020
26	Lithuania	Europe	3	16/3/2020
27	Malaysia	East Asia	3	18/3/2020
28	Morocco	Africa	1	20/3/2020
29	Netherlands	Europe	3	23/3/2020
30	Panama	Central America	4	25/3/2020
31	Romania	Europe	2	24/3/2020
32	Russia	North Asia	1	30/3/2020
33	Saudi Arabia	Middle East	2	23/3/2020
34	Serbia	Europe	2	18/3/2020
35	Singapore	East Asia	3	7/4/2020
36	Slovenia	Europe	1	20/3/2020
37	South Africa	Africa	1	26/3/2020
38	Spain	Europe	1	14/3/2020
39	Thailand	East Asia	4	3/4/2020
40	Turkey	Middle East	3	22/3/2020
41	UAE	Middle East	4	26/3/2020
42	UK	Europe	1	23/3/2020
43	Ukraine	Europe	3	17/3/2020
44	Zimbabwe	Africa	1	30/3/2020

Notes: Type of lockdown: 1. Lockdown, 2. Lockdown with curfew, 3. Partial lockdown, 4. Partial lockdown and curfew.

Table A2. Sources used for collecting data on lockdown fines.

No.	Country	Links
1	Albania	https://www.albaniandailynews.com/index.php?idm=40441&mod=2
2	Algeria	https://www.ispionline.it/it/pubblicazione/algeria-coronavirus-effects-nation-turmoil-25715
3	Armenia	https://www.evnreport.com/raw-unfiltered/armenia-state-of-emergency-guidelines
4	Azerbaijan	https://emerging-europe.com/news/azerbaijan-cracks-down-on-critics-amid-pandemic/
5	Bahrain	https://www.arabnews.com/node/1647041/middle-east
6	Belgium	https://www.aa.com.tr/en/europe/belgium-extends-coronavirus-lockdown/1806440
7	Bolivia	https://www.batimes.com.ar/news/latin-america/bolivia-begins-total-quarantine-postpones-presidential-election.phtml
8	Bosnia	http://hr.n1info.com/English/NEWS/a493883/Coronavirus-46-new-cases-confirmed-in-Croatia-tally-rises-to-361.html
9	Bulgaria	https://www.euractiv.com/section/health-consumers/short_news/bulgaria-update-covid-19/
10	Chile	https://www.senado.cl/hasta-540-dias-de-carcel-o-multa-de-un-millon-de-pesos-las/senado/2020-03-27/193738.html
11	Colombia	https://www.nytimes.com/2020/04/15/world/americas/virus-colombia-bogota-men-women.html

Table A2. *Cont.*

No.	Country	Links
12	Costa Rica	https://www.elmundo.cr/costa-rica/aprueban-leyes-en-primer-debate-para-aumentar-multas-por-incumplir-restriccion-vehicular-y-orden-sanitaria/
13	Cyprus	https://cyprus-mail.com/2020/03/30/coronavirus-harsher-penalties-measures-on-their-way/
14	Denmark	https://politi.dk/coronavirus-i-danmark/boedetakster-for-at-overtraede-restriktioner-som-foelge-af-covid-19 https://nyheder.tv2.dk/samfund/2020-03-11-danmark-lukker-ned-her-er-regeringens-nye-tiltag
15	Ecuador	https://www.garda.com/crisis24/news-alerts/329201/ecuador-additional-domestic-restrictions-announced-april-13-update-5
16	France	https://www.theguardian.com/world/2020/mar/24/how-strict-are-the-uks-distancing-rules-compared-with-other-countries
17	Greece	https://www.reuters.com/article/us-health-coronavirus-greece-curfew/greece-imposes-lockdown-after-coronavirus-infections-jump-idUSKBN2190Z1
18	Hungary	https://welovebudapest.com/en/article/2020/3/27/new-curfew-restrictions-in-hungary-from-tomorrow-saturday-28-march-1
19	India	https://www.straitstimes.com/world/coronavirus-how-some-countries-are-keeping-or-not-keeping-people-indoors
20	Iraq	https://aawsat.com/home/article/2187921/%D8%A7%D9%84%D9%85%D8%B7%D8%B1-%D9%88%D8%AA%D8%AC%D9%86%D8%A8-%D8%A7%D9%84%D8%BA%D8%B1%D8%A7%D9%85%D8%A9-%D9%8A%D9%8F%D9%86%D8%AC%D8%AD%D8%A7%D9%86-%C2%AB%D8%AD%D8%B8%D8%B1-%D8%A7%D9%84%D8%AA%D8%AC%D9%88%D9%84%C2%BB-%D8%A7%D9%84%D8%B9%D8%B1%D8%A7%D9%82%D9%8A
21	Ireland	https://www.theguardian.com/world/2020/mar/29/ireland-adapts-to-coronavirus-lockdown
22	Israel	https://www.al-monitor.com/pulse/originals/2020/03/armed-troops-enforce-israel-coronavirus.html
23	Italy	https://www.aljazeera.com/news/2020/03/italy-punishment-time-coronavirus-200312171128553.html
24	Jordan	https://en.royanews.tv/news/20448/Razzaz--Government-will-take-more-measures-based-on-the-evolving-circumstances
25	Kenya	https://www.aa.com.tr/en/africa/kenyan-under-curfew-amid-covid-19-pandemic-/1782727
26	Lithuania	https://www.lrt.lt/en/news-in-english/19/1160397/lithuanian-police-fine-over-150-people-for-flouting-quarantine-rules
27	Malaysia	https://www.bangkokpost.com/world/1897425/malaysia-extends-lockdown-by-2-weeks
28	Morocco	https://english.aawsat.com//home/article/2205271/morocco-arrests-450-individuals-violating-emergency-state-measures
29	Netherlands	https://www.bloomberg.com/news/features/2020-06-05/netherlands-coronavirus-lockdown-dutch-followed-the-rules
30	Panama	https://www.prensa.com/politica/en-la-noche-detenciones-por-incumplir-el-toque-de-queda-en-el-dia-la-calle-no-para-se-desafia-al-coronavirus/
31	Romania	https://www.bbc.com/news/world-europe-52370421
32	Russia	https://www.themoscowtimes.com/2020/04/13/how-do-moscows-coronavirus-lockdown-passes-work-a69960
33	Saudi Arabia	https://www.khaleejtimes.com/coronavirus-outbreak/covid-19-saudi-implements-curfew-10000-riyal-fine-jail-time-for-violators
34	Serbia	http://rs.n1info.com/English/NEWS/a586026/Minister-Up-to-700-people-violate-curfew-in-Serbia-all-face-severe-fines.html
35	Singapore	https://www.straitstimes.com/singapore/300-fine-for-flouting-measureshttps://www.straitstimes.com/politics/parliament-private-social-gatherings-of-any-size-no-longer-allowed-under-proposed-law
36	Slovenia	https://www.euractiv.com/section/coronavirus/short_news/slovenia-update-covid-19/1441892/
37	South Africa	https://www.iol.co.za/news/politics/you-could-be-fined-r1-000-r5-000-if-you-commit-the-following-lockdown-offences-47669568
38	Spain	https://www.thelocal.es/20200417/how-much-can-you-be-fined-for-breaching-spains-lockdown-and-how-to-appeal
39	Thailand	https://www.bloomberg.com/news/articles/2020-04-02/thailand-set-to-step-up-fight-against-coronavirus-with-a-curfew

Table A2. *Cont.*

No.	Country	Links
40	Turkey	https://en.rayhaber.com/2020/04/koronavirus-onlemleri-kapsaminda-20-yas-altina-sokaga-cikma-yasagi-geldi/
41	UAE	https://gulfnews.com/uae/crime/coronavirus-fines-of-dh2000-in-uae-if-you-leave-home-for-recreation-1.70691483
42	UK	https://www.reuters.com/article/us-health-coronavirus-britain-fines/britons-who-break-lockdown-face-30-pound-fine-pm-johnsons-spokesman-idUSKBN21B276
43	Ukraine	https://www.ukrinform.net/rubric-society/2899162-ten-facts-about-coronavirus-lockdown-in-ukraine.html
44	Zimbabwe	http://www.rfi.fr/en/international/20200404-booze-ban-in-zimbabwe-as-covid-19-lockdown-is-enforced

Table A3. Sources used for collecting the data on fines for traffic law violations.

No.	Country	Links
1	Albania	https://autotraveler.ru/en/albania/#.XrtH_MBS_IU
2	Algeria	http://autoalgerie.com/attachez-votre-ceinture,2040
3	Armenia	https://swift.rent/blog/driving-car-in-Armenia https://travelcar.am/rent-a-car-in-yerevan/travel-news/guide-to-driving-car-in-armenia
4	Azerbaijan	http://www.orangesmile.com/carrental/armenia/traffic_rules_habits.htm http://www.turan.az/ext/news/2018/6/free/Social/en/72710.htm https://karavan.az/main-traffic-rules-of-roads-in-azerbaijan/
5	Bahrain	https://bahrainofw.com/guide-traffic-laws-driving-bahrain/ https://services.bahrain.bh/wps/PA_GDTDhBoardServices/faces/javax.faces.resource/en/GDTLaw.pdf?rel=v1
6	Belgium	https://rijbewijs-online.be/en/belgium/traffic-rules/violations https://www.rac.co.uk/drive/travel/country/belgium/
7	Bolivia	https://bolivia.infoleyes.com/articulo/57049 https://www.osac.gov/Content/Report/6084aa33-fa35-4398-9caa-1846c1cdaf2d
8	Bosnia	https://www.sarajevotimes.com/new-law-fines-for-all-passengers-in-the-car-who-did-not-fasten-their-seatbelt/+&cd=1&hl=en&ct=clnk&gl=gr&client=firefox-b-d https://autotraveler.ru/en/spravka/penalties-for-using-mobile-phone-while-driving-in-europe.html#.Xrwy3MBS_IU
9	Bulgaria	https://myrentacar.com/en/journal/bulgaria/articles/pdd-shtrafy/
10	Chile	https://www.chiletraveltips.com/chile-traffic-violations-fine-fees-2019/
11	Colombia	https://www.colombia.com/actualidad/codigos-leyes/codigo-de-transito/Tit4Cp2-sanciones-por-incumplimiento.aspx
12	Costa Rica	https://costa-rica-guide.com/travel/transportation/car/traffic-violations-citations-tickets-fines-in-costa-rica/
13	Cyprus	https://www.offsite.com.cy/eidiseis/topika/sas-tsakose-i-trohaia-deite-posa-tha-plirosete-prostimo https://www.kathimerini.com.cy/gr/apopseis/arthrografia/iasonas-senekkis/tha-einai-apotreptikes-oi-nees-poines-gia-tis-troxaies-parabaseis https://www.kathimerini.com.cy/gr/kypros/ayxisi-sta-prostima-300-eyrw-me-kinito-sto-xeri
14	Denmark	https://www.fyidenmark.com/traffic-fines.html
15	Ecuador	https://ecuador.seguros123.com/aumento-de-multas-de-transito-en-el-2020/
16	France	https://www.connexionfrance.com/French-news/Drivers-and-passengers-warned-over-no-seat-belt-fines https://www.french-property.com/guides/france/driving-in-france/driving-offences-penalties
17	Greece	https://www.gocar.gr/news/feed/28768,Poia_einai_ta_prostima_gia_ypervolikh_ta.html https://www.newsauto.gr/news/neos-kok-pos-diamorfononte-i-vasikes-paravasis/
18	Hungary	https://www.orangesmile.com/carrental/hungary/traffic_rules_habits.htm https://zsebremegy.hu/rovid-hirek/mennyi-egy-gyorshajtas-es-egy-buszsavhasznalat/
19	India	https://www.business-standard.com/article/economy-policy/new-motor-vehicles-bill-2019-penalties-full-list-fines-for-traffic-rules-violation-from-children-driving-drunken-driving-rs-10000-fine-jail-all-you-need-to-know-119080100254_1.html

Table A3. *Cont.*

No.	Country	Links
20	Iraq	https://magazine.imn.iq/%D8%AA%D8%AD%D9%82%D9%8A%D9%82%D8%A7%D8%AA/%D8%AD%D8%B2%D8%A7%D9%85%D9%8F-%D8%A7%D9%84%D8%A3%D9%85%D9%80%D9%80%D9%80%D8%A7%D9%86-%D9%81%D9%8A-%D8%A7%D9%84%D8%B9%D8%B1%D8%A7%D9%82-%D9%82%D8%A7%D9%86%D9%88%D9%86%D9%8C-%D8%B4%D8%A8%D9%80%D9%80/
21	Ireland	https://www.theaa.ie/aa/motoring-advice/penalty-points.aspx
22	Israel	https://anglo-list.com/general-3/transport-18/traffic-fines-violations-israel https://en.globes.co.il/en/article-israel-raises-fines-for-traffic-violations-1001182358 http://archive.jewishagency.org/aliyah/content/42546
23	Italy	https://www.thetimes.co.uk/article/running-red-light-costs-italian-4-600-in-fines-plus-his-car-79rsv0xb8 http://www.aci.it/fileadmin/documenti/viaggia_con_noi/pdf/ing/Fines_for_foreign_motorists.pdf https://www.poliziadistato.it/articolo/cinture-di-sicurezza-e-casco
24	Jordan	https://www.rhinocarhire.com/Drive-Smart-Blog/Drive-Smart-Jordan.aspx#/searchcars https://www.hala.jo/2016/12/05/%D9%85%D8%B4%D8%B1%D9%88%D8%B9-%D9%82%D8%A7%D9%86%D9%88%D9%86-%D9%8A%D8%B1%D9%81%D8%B9-%D9%85%D8%AF%D8%A9-%D8%A7%D9%84%D8%AD%D8%A8%D8%B3-%D9%88%D8%A7%D9%84%D8%BA%D8%B1%D8%A7%D9%85%D8%A7%D8%AA-%D8%B9/
25	Kenya	https://www.capitalfm.co.ke/business/2018/11/ntsa-fines-and-penalties-for-traffic-offences/https://nairobinews.nation.co.ke/news/how-motorists-are-losing-millions-in-illegal-traffic-fines
26	Lithuania	https://www.alfa.lt/straipsnis/192119/lithuanian-roads-most-dangerous-in-europe
27	Malaysia	https://mypay.com.my/blog/post/Malaysias-Common-Traffic-Offences:-Are-You-Aware-Of-The-Rates https://en.wikipedia.org/wiki/National_Speed_Limits_(Malaysia)
28	Morocco	http://www.riad-rihani.com/Uk/visit-marrakesh/Morocco%20in%20practice/To%20move%20around
29	Netherlands	https://trans.info/en/netherlands-here-are-the-fines-for-road-traffic-offences-in-2020-163679 https://trans.info/en/netherlands-here-are-the-fines-for-road-traffic-offences-in-2020-163679
30	Panama	http://livinginpanama.com/living-in-panama/how-to-pay-traffic-ticket-panama/ https://cerquitita.com/estitlo-de-vida/multas-de-transito-costo-de-las-infracciones-mas-frecuentes-y-como-evitarlas/
31	Romania	https://en.wikipedia.org/wiki/Speed_limits_in_Romania https://www.promotor.ro/utile/ce-amenda-risti-daca-nu-porti-centura-de-siguranta-cand-stai-in-spate-18155861
32	Russia	https://www.angloinfo.com/how-to/russia/transport/driving/on-the-road https://www.rbth.com/lifestyle/328307-security-service-putin-seatbelt https://www.rbth.com/lifestyle/330604-paying-fines
33	Saudi Arabia	https://www.moi.gov.sa/wps/portal/Home/sectors/publicsecurity/traffic/trafficriyadh/contents/!ut/p/z0/04_Sj9CPykssy0xPLMnMz0vMAfIjo8ziDTxNTDwMTYy83UOcTQwcA50DAr09Q4wMLMz0vfSj8CsAmpCZVVgY5agflZyfV5JaUaIfUVKUmJaWmaxqAGUoFGVWJqZkqBrkJmbmqRqUZebngB1QrBCvUJAKdEdJZmqxfkF2VCQAec3urA!!/
34	Serbia	https://www.telegraf.rs/english/2904685-new-brutal-traffic-penalties-seat-belt-10000-alcohol-prison-new-punishment-for-violent-driving
35	Singapore	https://www.budgetdirect.com.sg/blog/car-insurance/speeding-offences-and-their-penalties-in-singapore https://www.straitstimes.com/singapore/viral-text-saying-anyone-on-phone-while-engine-is-running-will-lose-licence-on-the-spot-is https://www.directasia.com/blog/seatbelt-rules-in-singapore/
36	Slovenia	http://pnevmatike.amzs.si/en/758/49/Slovenia.aspx
37	South Africa	https://www.arrivealive.mobi/south-african-law-on-wearing-of-seatbelts http://www.autoworld.co.za/TrafficLaw.aspx
38	Spain	https://www.thelocal.es/20181031/why-now-more-than-ever-you-shouldnt-use-your-phone-while-driving-in-spain https://www.euroweeklynews.com/2017/11/13/belt-up-in-spain-and-dont-get-fined/ https://www.aph.com/community/holidays/speeding-fine-spain-cost-points-licence/

Table A3. *Cont.*

No.	Country	Links
39	Thailand	https://nashaplaneta.net/en/asia/thai/art-thailand-shtrafi-za-narusheniya-pdd https://www.bangkokpost.com/thailand/general/1220662/strict-seat-belt-rule-to-apply-from-april https://www.thaizer.com/travel-in-thailand/thailands-drivers-face-mobile-phone-ban/
40	Turkey	https://www.dailysabah.com/turkey/2018/10/27/fines-tighter-controls-target-traffic-violations-celebratory-gunfire https://www.hurriyetdailynews.com/parliament-passes-law-to-introduce-severe-traffic-fines-138011 https://www.sabah.com.tr/otomobil/2020/04/07/emniyet-kemeri-cezasi-2020-emniyet-kemeri-takmama-cezasi-ne-kadar-k1
41	UAE	https://gulfnews.com/how-to/your-money/all-139-uae-traffic-violations-fines-and-black-points-1.1546486
42	UK	https://www.thisismoney.co.uk/money/cars/article-6974171/Drivers-penalty-points-not-wearing-seat-belt-survey-suggests.html
43	Ukraine	https://destinations.com.ua/news/big-cities-life/214-updated-rules-for-drivers-in-ukraine-2018https://whatson-kyiv.com/human-traffic/ https://www.ukrinform.net/rubric-society/2579430-only-15-of-drivers-in-ukraine-use-seat-belts-survey.html
44	Zimbabwe	http://newsofthesouth.com/zimbabwe-police-reveal-road-traffic-fines-rates/

Table A4. Countries' records in the FSIs, TFSI, and FODIs.

No.	Country	FSI_1	FSI_2	FSI_3	$TFSI$	$FODI_{ep}$	$FODI_{ep+s}$
1	Albania	0.364	0.020	8.119	16.000	62%	91%
2	Algeria	0.100	0.006	0.596	35.000	378%	447%
3	Armenia	1.209	0.051	4.751	9.000	139%	215%
4	Azerbaijan	0.767	0.014	1.658	20.333	100%	383%
5	Bahrain	3.291	0.112	3.289	8.333	5433%	14,000%
6	Belgium	0.152	0.006	1.437	30.333	**25%**	49%
7	Bolivia	0.235	0.021	9.404	17.000	8509%	N/A
8	Bosnia	1.141	0.054	2.567	11.667	330%	212%
9	Bulgaria	7.755	0.336	50.000	1.333	4157%	3631%
10	Chile	0.850	0.025	1.084	18.333	425%	644%
11	Colombia	0.940	0.037	0.372	19.333	2985%	1994%
12	Costa Rica	0.388	0.016	0.370	27.000	195%	258%
13	Cyprus	0.156	0.009	1.765	27.667	12%	29%
14	Denmark	0.084	0.004	0.749	36.000	**58%**	28%
15	Ecuador	0.313	0.019	0.826	24.000	1731%	1184%
16	France	0.024	0.001	0.281	42.000	**86%**	**78%**
17	Greece	0.191	0.009	0.214	33.667	111%	79%
18	Hungary	0.027	0.001	0.101	42.667	**76%**	**77%**
19	India	0.247	0.007	0.203	33.333	3598%	5449%
20	Iraq	0.400	0.017	6.650	16.000	N/A	N/A
21	Ireland	1.460	0.039	20.833	7.000	192%	590%
22	Israel	0.101	0.003	0.332	38.667	**44%**	**21%**
23	Italy	0.170	0.007	0.510	32.000	**43%**	**46%**
24	Jordan	0.372	0.035	3.321	16.333	786%	1453%
25	Kenya	0.597	0.061	4.987	11.000	22,817%	20,766%
26	Lithuania	0.399	0.016	2.174	20.333	542%	690%
27	Malaysia	0.860	0.023	3.349	13.333	497%	1101%
28	Morocco	0.110	0.010	0.428	32.333	399%	711%
29	Netherlands	0.237	0.009	1.667	25.667	**49%**	119%
30	Panama	0.137	0.003	0.667	35.667	**67%**	**71%**
31	Romania	0.856	0.042	5.886	10.333	764%	757%
32	Russia	0.309	0.005	3.690	24.667	130%	157%
33	Saudi Arabia	3.472	0.136	14.879	4.333	13,757%	47,981%

Table A4. *Cont.*

No.	Country	FSI_1	FSI_2	FSI_3	$TFSI$	$FODI_{ep}$	$FODI_{ep+s}$
34	Serbia	1.198	0.100	3.273	10.000	1347%	1239%
35	Singapore	0.231	0.004	0.301	35.667	1%	1000%
36	Slovenia	0.411	0.019	1.333	21.333	42%	72%
37	South Africa	0.187	0.009	1.340	27.667	85%	18%
38	Spain	0.525	0.023	3.005	16.333	17%	54%
39	Thailand	4.859	0.191	56.716	2.000	10,201%	7833%
40	Turkey	0.111	0.005	1.332	32.667	**44%**	**41%**
41	UAE	0.668	0.014	2.002	20.000	1193%	5717%
42	UK	0.020	0.001	0.151	43.667	**87%**	**69%**
43	Ukraine	4.668	0.250	39.098	2.667	102,357%	87,697%
44	Zimbabwe	0.036	0.005	0.380	37.333	1921%	1151%

Notes: N/A: Indices are not provided due to the lack of data. $FODI_{ep}$, $FODI_{ep+s}$ scores in bold denote underestimation.

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Liquidity Spill-Overs in Sovereign Bond Market: An Intra-Day Study of Trade Shocks in Calm and Stressful Market Conditions

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Abstract: The purpose of this paper is to determine the liquidity spillover effects of trades executed in European sovereign bond markets and to assess the driving factors behind the magnitude of the spill-overs between different markets. The one minute-frequency limit order-book dataset is constructed from mid-2011 until end-2017 for sovereign bonds from the six largest euro area countries. It is used for the event study and panel regression model. The event study results revealed that liquidity spill-over effects of trades exist and vary highly across different order types, direction and size of the trade, the maturity of traded bonds, and various markets. The panel regression model showed that less liquid bonds and bonds whose issuer is closer by distance to the country of the traded bond have more substantial spillover effects and, at the same time, are also more affected by trades executed in another market. These results should be of interest to bond market participants who want to limit the exposure to the liquidity spillover risk in bond markets.

Keywords: high-frequency data; market liquidity; sovereign bonds; spillover

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1. Introduction

While fixed income market traders and analysts do not pay much attention to the liquidity situation when markets are sufficiently liquid, it becomes a critical issue when market liquidity suddenly evaporates. These tail risk events of liquidity shocks are mainly characterized by the sharp reduction in the number of traders who stand ready to buy and sell particular bonds and become a real concern to fixed income investors who base their decisions on the available bid and ask prices in the market. Alongside the period of increasing connectedness in asset markets, it is often a case that spill-overs, when (il-)liquidity spreads across different bonds or even markets, become a risk to the orderly functioning of the whole fixed income market. Besides, as "investors" trading returns are increasingly shaped by several basis points margin in a low-interest-rate environment, liquidity shocks could highly increase liquidity premium embedded in bond prices—this would have a significant impact on the valuations of bonds. Because market liquidity, i.e., the ease and speed of trading, is crucial to the functioning of financial markets, there has been a surge of interest in the topic of market (il)liquidity in recent years. This has been mostly the case after the European sovereign debt crisis when market participants witnessed deprived liquidity conditions (European System of Financial Supervision 2016). Nevertheless, there are still many unanswered questions. What causes these sudden liquidity shocks in fixed income markets? Do these events affect only some particular bonds or the whole market? Is there a contagion effect that reverberates among different bonds? This study tries (at least to some extent) to shed light on this topic by analyzing the impact of sovereign bond trade shocks and how they spillover to other bonds and markets.

The novelty of this paper is several-fold. To start with, we employ the large intraday sovereign bond quoting and trading dataset that contains multi-year information of trade shocks and quoting activity. To be specific, we derive minute-frequency limit order-book from tick-by-tick sovereign bond market data of Mercato dei Titoli di Stato (MTS) from June

2011 until December 2017. This relatively long sample period lets us analyze how trade shocks affect liquidity in distinct market periods: exceptionally stressful market conditions from end-2011 until start-2012 (i.e., peak of European sovereign debt crisis), relatively calm market period of 2013–2014, the "Bund-Tantrum" in mid-2015, the spikes of market tensions after "Brexit" vote and US presidential elections in 2016, and etc. To compare the results among different sovereign bond issuers, many markets are selected: Germany, France, Italy, Spain, the Netherlands, and Belgium. The event study method is employed to analyze the spillover of trade effect because this method is less prone to variable selection bias and reverse causality issues common with more complex econometrical models when analyzing spill-over effects between many different bonds with high-frequency data. Additionally, panel regression model is used to answer the question of what factors affect the strength of liquidity spillover effect among markets. Rigobon (2019) made a significant research on the empirical literature about international spillovers and contagion and made a conclusion that there was no single technique that could help to give the answer to the full-fledged problem. The author pointed that empirical studies of spill-overs and contagion were quite complicated applied issues. Glosten and Milgrom (1985) analyzed the spread of bid and ask prices, paid the most attention to insiders and liquidity traders, and used the approach that a bid-ask spread can be an informative factor. Other authors focused more on critical moments, which are especially important at a government level, attracting more funds or making suitable monetary policy. Dungey et al. (2006), using a latent factor model, analyzed the emerging and developed markets focusing more on the Russian crisis. The results showed that both markets experienced a contagion effect. Brière et al. (2012) made a research with a considerable database to investigate the stability of correlation matrices in different asset segments with the contagion tests, which were neutralized with respect to the globalization effects. Liquidity contagion effect analyzed by (Macchiati et al. 2020); Macchiati et al. (2020) and Cifuentes et al. (2005) while gravity model issues were investigated by Zhu and Yang (2008). Overall, the topic is very relevant and quite complicated, so it is essential to research this field from different perspectives. This study is focused on a vital market microstructure subject: how shocks of sovereign bond trades affect the prices and quantities of the limit order book. In the wake of the rapid increase of automated trading, there are relatively fewer transactions than the number of buy and sell orders submitted to the market, so an execution of a trade has more informational value for traders. Simultaneously, larger transactions are less suitable for trading on such increasingly automated markets as prices. Thus liquidity can instantly be moved against the participant who wants to trade. The trade execution should lead to an immediate liquidity spillover effect to the quoted prices and quantities of this bond because the trade can be executed only inside the central limit order book of the MTS market. Moreover, the sovereign bond markets are much more decentralized and fragmented than equity markets, so it is important to understand if a shock—trade of a particular bond—affects the liquidity situation only of the traded bond or does it also reverberate to other bonds of the same issuer, or maybe it even spill-overs to the sovereign bonds from other markets. In fact, the sudden liquidity dry-up for one bond might lead to a contagion effect that could become a severe threat to the functioning of the whole sovereign bond market and is critical to the financial stability. As a result, the liquidity spillover effect of trades is a rarely examined but increasingly important topic for investors, analysts, regulators, policymakers, and issuers of sovereign bonds.

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This paper consists of four main parts: the review of relevant literature; the description and examination of the data and methods that are used in this analysis; the results of event studies and discussion of liquidity spillover effects; findings from a panel regression model of possible factors that explain the magnitude of spillover effects between different European markets.

2. Literature Review

Although there is no analogous event study of liquidity spillover of trades with high-frequency European sovereign bond data, this chapter reviews the several strands of academic literature that is relevant for conducting this study: the microstructure of fixed income market, liquidity indicators of bonds, contagion effects among different asset markets, and liquidity spillover of sovereign bonds. It should be noted that while there are many studies on intraday market liquidity, most of them still concentrate on equity

markets and particularly on US markets He et al. (2020); Rappoport and Tuzun (2020); Honkanen and Schmidt (2017); Rindi and Werner (2017); Sheng et al. (2017); Shaikh (2018); Righi and Vieira (2014); Bein (2017); Diebold and Yilmaz (2009), given its size and the availability of high-frequency data. Some research papers are focused on the future market. Fassas and Siriopoulos (2019) studied the Greek market using the high-frequency data and tried to identify the relationships between spot and future prices. The authors revealed strong bi-directional dependence in the intraday volatility and pointed to the improvement of futures' pricing efficiency in the Athens financial market. But there is still relatively little research specific to liquidity spillover effects, especially on European sovereign bond markets.

Before analyzing the liquidity spill-over effects, it is important to analyze the liquidity spill-over effects. It is important to analyze the liquidity spill-over effects, and it is essential to understand the microstructure of the whole fixed income market. Bank for International Settlements (2016a) gives a comprehensive overview of the evolution of fixed income markets. For instance, it documents that the share of electronic trading in sovereign bond and other fixed-income markets is gradually increasing (mainly due to the rise of automated and high-frequency trading). However, the market structure is still fragmented between inter-dealer and dealer-to-client segments. Bond trading still lags development compared to other asset classes due to, more significant heterogeneity and complexity. Nevertheless, while the impact of automated trading on market liquidity is highly debatable, technological improvements enabled dealers to better monitor how the flow of orders changes in response to news and other shocks. Regarding European sovereign bond markets, a pan-European trading protocol of the central limit order-book has become a dominant feature (e.g., MTS market). However, it is still less technologically advanced and less liquid than the US sovereign bond market.

Market liquidity in different asset markets has been analyzed from various perspectives. One of the first inclusive studies is the paper of Kyle (1985), who states that there are three main liquidity dimensions: (1) tightness (cost of buying and selling a position); (2) depth (the size of order-book or amount of quotes); (3) resiliency (the speed of recovery of tightness and depth). While these three dimensions vary significantly depending on the size and type of trade, all measurements are essential for frequent traders. Tsuchida et al. (2016) also group metrics to these three categories, and distinguish volume, i.e., the trade size and turnover of each transaction. These authors find that the shock of economic indicator announcement has a negative effect on all liquidity dimensions. In contrast, the shock of monetary policy announcement has a positive impact on the volume indicators. Albagli et al. (2015) found significant monetary policy effects on developed and emerging bond markets.

Other import studies describing various liquidity metrics and dimensions are Sarr and Lybek (2002); Fleming (2003); Goyenko et al. (2009); International Monetary Fund (2015); Diaz and Escribano (2017); Broto and Lamas (2020); O'Sullivan and Papavassiliou (2019); Clancy et al. (2019); Barth and Kahn (2020); Jiang et al. (2020); Gupta et al. (2018); Kandil (2018) and White et al. (2018).

An overview of various liquidity indicators as well as microstructure of the European sovereign bond market is provided by Pellizon et al. (2013); Mahanti et al. (2008); Brunnermeier and Pedersen (2008); Chordia et al. (2007); Dunne et al. (2015); Galliani et al. (2014); Han and Pan (2017); Holden et al. (2014); MTS (2017); Kurosaki et al. (2015). By employing MTS tick-by-tick data, authors compose three types of indicators that they include in econometric models: (1) Bond-specific characteristics: coupon type, time-to-maturity, issued amount; (2) activity variables: number of trades and volumes, revisions per single order, quantities at the best bid and ask; (3) liquidity measures: bid-ask spread, a measure developed by Amihud (2002), measure composed by Roll (1985), and etc. With the help of an event-type method, Pellizon et al. (2013) found that dealers still withdraw from the bond market during periods of stress despite contractual agreements with market operators, especially for the longer-term and less liquid bonds. Besides, the liquidity of less liquid

bonds has a contagion effect on the broader market, while rapid increase of automated trading (proxied by order revisions) has not led to market resiliency improvement. In a similar study, Darbha and Dufour (2015) describe the European government bond market's microstructure and analyze how liquidity measures evolve during stressful and normal market conditions.

Regarding the studies about spillover effects in fixed income markets, the critical distinguishing feature is the determination of the impulse factor that reverberates through the markets. While liquidity spillover is quite a rare research topic, spillover of bond yields or prices has been well documented. Dufour and Nguyen (2011) analyze sovereign bond markets of the euro area countries for the pre-crisis period to assess the price responses to trades in different markets. They reveal that investors indeed require higher yields for bonds that exhibit more enormous trading impacts. Claeys and Vašíček (2014), using the variance decompositions of vector auto-regression model, studied bilateral linkages between EU sovereign bond spreads and tried to determine the origins of the shock, i.e., the specific sovereign bond market from which the spillover emanates to other markets. Their results indicate that the spillover effect increases substantially during stressful market periods. This effect varies highly across countries, e.g., financially stronger countries, such as the UK, Sweden, and Denmark, are much less affected by shocks from other EU countries. Bowman et al. (2015) examine the effects of FED's unconventional monetary policies on sovereign yields in seventeen emerging markets. Their event study findings suggest that the US monetary policy shocks significantly affect the sovereign yields in other countries. However, the strength and persistence of the effect vary significantly across the emerging markets. Papadamou et al. (2020) also investigated unconventional monetary policy effects, but they focused more on the economic variables and financial markets. The authors revealed a unified positive impact of quantitative easing (QE) on bond prices across different studies. The other interesting aspect was that a contagion effect from US QE to emerging markets was identified.

Levisauskaite et al. (2015) studied the relationships between EU government bond markets and found that the common currency and geographic proximity influence the correlations in different markets. Another study by Bank for International Settlements (2016b) reveals that price impact from large incoming orders have increased for US and Italian sovereign bonds. Still, the more significant price sensitivity has no clear sign of contagion effect.

The spill-overs of liquidity have been mostly studied between different types of assets. For instance, Tang and Yan (2008) use data from the US corporate bond, stock, option, and credit default swap (CDS) markets for computing correlations between liquidity measures. Their central finding is that the role of a common liquidity factor across the markets is more important than generally assumed. In particular, the illiquidity emanating from the CDS markets is found to spillover to other markets and leads to a statistically significant increase in credit spreads. In a relatively similar study, Calice et al. (2013) analyzed the spillover effects between the credit and liquidity spreads in nine Eurozone sovereign bond markets and the sovereign CDS market. They found significant variation in the spillover effect between maturities and among countries, e.g., in several markets (Greece, Ireland, and Portugal), the sovereign CDS market's liquidity has a substantial time-varying influence on sovereign bond credit spreads. Lin et al. (2013) investigated the liquidity risk spillover from equities to bond markets and found that the spillover of liquidity risk exists. International Monetary Fund (2015), relying mostly on the event studies, reveals that liquidity shocks spillover across different asset classes and that this effect has increased over time. Besides, the commonality of liquidity of different assets has increased due to widespread index investors' growth index. Moshirian et al. (2017) add that liquidity commonality is in weaker and riskier markets with poorer investor protection and less transparency. Smimou and Khallouli (2017) found that liquidity often spill-overs from smaller to larger more extensive German, French, and Italian markets in a similar vein.

Despite the increase of high-frequency bond data availability, still very few empirical papers analyze the liquidity spill-overs among different bonds and, especially on an intraday basis. One notable exception is the study by Schneider et al. (2016), which focuses on illiquidity risks, i.e., liquidity dry-ups, and how they spillover across Italian government bonds of different residual maturities. These authors use mainly three liquidity indicators at one-minute frequency: bid-ask spread, price impact of particular trade, and depth across the limit order book. They find, for instance, that shorter-term bonds are increasingly affected by the liquidity spill-overs from the long-term bonds and that market liquidity is less resilient and predictable when the bonds are less liquid.

To conclude the relevant studies review, it is clear that the literature is scarce on the topic of liquidity spill-overs in sovereign bond markets. Besides, liquidity spill-overs of trades, especially on an intraday basis, has been almost an unexplored research area, possibly due to the limited availability of high-frequency trade and order-book data that is a prerequisite for the robust spillover analysis in the financial markets where prices and liquidity conditions adjust instantly after the trade is executed.

3. Data and Methodology

This chapter defines the data, derived dependent and explanatory variables, and liquidity indicators that will be used in the empirical analysis. Two research methods that will be employed in the analytical part—the event study and the panel regression model—are briefly described afterward.

3.1. Data

Two different datasets from MTS are used to study liquidity spill-overs of trades in European sovereign bond markets: inter-dealer tick-by-tick trade and limit order book data. Sovereign bonds can be traded over-the counter or on the electronic exchanges; the latter can be further divided into dealer-to-dealer (inter-dealer) and dealer-to-customer platforms (Bank for International Settlements 2016a). MTS is the largest interdealer platform for European sovereign bonds with the central limit order-book mechanism (MTS 2017). While relatively fewer trades are executed on the MTS interdealer market, the number of orders submitted to the central limit order-book is much higher. Order revisions outnumber trades so vastly that trade-based indicators considerably underperform order-based indicators (Pellizon et al. 2013).

The preparation for the minute frequency order book closely follows the Darbha and Dufour (2015). To analyze the spillover effects on a discrete and high frequency period, limit orders for each bond are sampled to one-minute intervals. At the same time, all trade stamps are assigned to the nearest minute interval, and traded quantities are summed for each bond. Gkillas et al. (2020) forecasted realized volatility of the oil market using high frequency data as well but those authors used different types of Heterogeneous Autoregressive models of realized volatility (HAR-RV) and focused more on indexes of financial stress as a proper tool for more accurate forecasting.

The study covers the period from June 2011 until December 2017 for six major European sovereign bond markets. This time period encompasses heightened market conditions during the euro area sovereign debt crisis in end-2011—start-2012, environment of very low or even negative bond rates, central bank asset purchases, important political events (e.g., US and French presidential elections, "Brexit" vote) and various significant financial events (e.g., the "Bund-Tantrum"). During this period, the outstanding nominal value of -area sovereign bonds increased from around 6.1 tn EUR in June 2011 to 7.3 tn EUR in December 2017 (ECB 2017). Six European sovereign bond markets are chosen for the analysis: Germany, France, Italy, Spain, the Netherlands, and Belgium. Although these markets have the highest market capitalization in the euro area, they still have a lot of heterogeneity regarding credit risk, market depth, economic and financial developments, political events, etc.

The most frequently used liquidity indicator in this study is calculated accordingly (Jurkšas et al. 2018):

$$Order - Book\ Illiquidity\ Score\ _{t,5} = \frac{Spread_{t,5}}{Quantity_{t,5}} = \frac{\frac{1}{5}\sum_{j=1}^{5} P_{t,Ask(J)} - \frac{1}{5}\sum_{j=1}^{5} P_{t,Bid(J)}}{\sum_{j=1}^{5} Q_{t,Ask(J)} + \sum_{j=1}^{5} Q_{t,Bid(J)}} \quad (1)$$

where:

t—the time in minutes at which the limit order-book is calculated (e.g., before, at, and after the trade is executed);
P—the price of the limit order book, i.e., the mid-point of ask and bid price;
Q—the quantity that can be traded at a given quoted price;
"Ask" and "Bid"—the side of the limit order-book;
j—number of the priority of the offers in the limit order book (from 1st to 5th best Ask/Bid price and its corresponding quantity).

The order-book illiquidity score encompasses two main liquidity dimensions: cost and depth. The numerator is the average bid-ask spread of five best (i.e., closest to the mid-price) quotes. The denominator is the sum of quoted quantities corresponding to the five best ask and bid prices. In general, the lower the order-book illiquidity score and the average bid-ask spread, and the higher the corresponding quoted quantities, the more liquid the bond is. The order-book illiquidity score principally indicates the average transaction costs of the five best buy and sell orders, relative to their quantities, i.e., how, on average, the average bid-ask spread would be impacted if the amounts of the five best bids and five best asks would be transacted. So order-book illiquidity score positively represents a widely used price impact indicator created by Amihud (2002), although the latter indicator is calculated with trade and not limit order data. Five best bid/ask prices are chosen because dealers can observe in real-time the five best prices (with corresponding quantities) on each side of the limit order book in the MTS trading platform. Besides, Bank for International Settlements (2016b) states that simple bid-ask spreads and quantities at the best bid and ask price are no longer a representative indicator of liquidity conditions due to increased automated trading. However, the limit orders with prices that are far away from the mid-price have a very low probability of being hit by another incoming order, so the prices and, especially, quantities might also not reflect true "dealers" intentions.

3.2. Research Methods

The event-type study is the primary method used in this paper to analyze the liquidity spillover effect of sovereign bond trades. The execution of trade acts as a shock to the market because relatively fewer trades are executed during the day, and the transaction directly affects the limit order book. A trade is executed when a standing limit order is crossed by incoming market-order (that is immediately filled or killed) or another limit order. So a buy-side transaction results in the removal of the limit order with the lowest bid price, while a sell-side transaction leads to the elimination of the limit order with the highest ask price. As a result, bid-ask spread widens and illiquidity-score increases immediately after the trade is executed. So the event-type study is an appropriate method to analyze how the execution of the trade immediately reverberates to the quoted prices and quantities of this bond and helps to determine the average spillover effect across different bonds from the same or another country.

The results of this relatively simple statistical analysis method can be noticeably analyzed graphically. Besides, this method is less prone to possible errors and variable selection bias, which is often a case in more sophisticated econometrical models. International Monetary Fund (2015) argues that the event studies often help overcome the problem of reverse causality. The event studies are carried out by many authors, including Pellizon et al. (2013); Andrulytė and Jurkšas (2015); Blasi (2016); Tsuchida et al. (2016), etc.

The average value of a particular liquidity indicator (e.g., illiquidity score, bid-ask spread, quoted quantity) is calculated on a minute frequency from 15-min before until

15-min after a transaction of sovereign bond is executed. This time period is long enough to assess if the transaction resulted in a temporary or permanent liquidity spillover effect and if there was a particular dynamic of liquidity indicator even before the trade was executed. The average cumulative change (C_t) of a particular liquidity indicator before and after the transaction is calculated according to this formula:

$$C_{t,k} = \frac{1}{K}\sum_{k=1}^{K}(M_{t,k} - M_{0,k}) \quad (2)$$

where:

t—minutes after (+)/before (−) a trade is executed,
M_0—the value of bond liquidity indicator at the time of the trade,
M_t—the value of bond liquidity indicator at time t,
k—the number of observations at time t.

Several other critical computational transformations were performed. First, the cumulative changes of liquidity indicator at t minute before/after the trade were at first averaged across all observations on a monthly basis. This was done due to the computational efficiency (as it was not possible to calculate the limit order-book for the full sample period from 2011 at once). In this way, it was easier to compare the results during the time. Second, to reduce the effect of spurious outliers, winsorizing procedure was employed: 10% lowest and highest values were set to the value of the respectively 10 and 90 percentile of the liquidity indicator values among the bonds from the same country. Third, a simple mean of monthly winsorized cumulative liquidity changes was computed.

The average cumulative liquidity change was calculated for several different dimensions: the direction of the transaction, the buckets of bonds with different residual maturities, the size, and type of trade; across various markets. This distinction helps to comprehensively determine the bonds with the strongest spillover effects that emerge after the trades are executed.

In Section 5, a panel regression model is employed to assess the underlying reasons for the strength of trade liquidity spillover effects among different markets. This model is used to understand why after a transaction is executed in one market, the liquidity shock reverberates more strongly to some markets while less so, to others. So the dependent variable is the change of order-book illiquidity score in the market where no trades have been executed. Country-specific fixed effects were included in the panel regression model because fixing the group means (in this study—among bonds from various countries) helps in controlling the unobserved heterogeneity (Stock and Watson 2011) because bonds from different countries might be correlated with the level of the illiquidity score and the overall spillover effect.

4. Results of the Event Studies on Spillover Effects of Trades

This chapter presents four different graphical event studies of the spillover effects of trades: buy and sell-side of the transactions; bonds with different maturity (a term structure of liquidity spillover effect), various sizes of trades; across six euro area sovereign bond markets.

4.1. Direction of Trade

Before analyzing the liquidity spillover of trade, it is important to understand how different types of trades affect sovereign "bonds" prices and how this effect differs for the traded (direct impact) and non-traded (spillover effect) bonds. As market intelligence would confirm, buy-side transactions lead to the increase of the traded sovereign bond's mid-point price, while sell-side trades—to the decrease of the price up to several basis points (Figure 1). This effect seems to be permanent as the average price does not reverse even 15 min after the trade's execution. Importantly, the change of other bonds' prices from the same country as the traded bond is on average around five times smaller than the price

change of the traded bond. However, the prices of other (non-traded) bonds change much more (and with different sign) before the trade is executed than the price of the traded bond, meaning that the change of bond prices enters the endogenous "investors" decision process of selecting particular bonds that should be traded, i.e., the bonds whose price decrease has a higher probability of being bought.

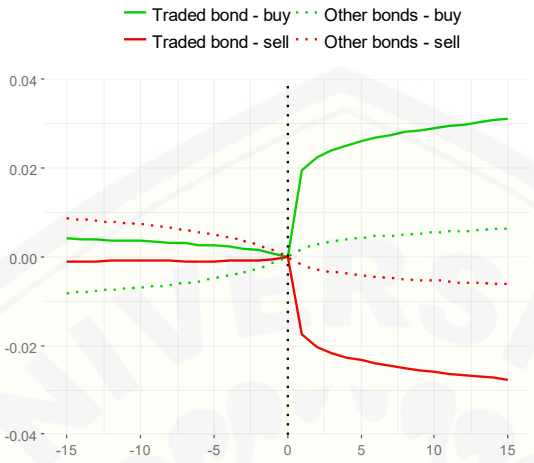

Figure 1. The trade effect on sovereign bond mid-point price 15 min before and after the trade was executed.

Although the trade effect on bond prices is opposite for buy and sell-side transactions (Figure 1), the impact is much more homogenous on liquidity. The liquidity diminishes only slightly after the sell-side trade rather than the buy-side transaction, and this difference becomes more evident in time (Figure 2). Notably, while the liquidity spillover from the prices of the traded to other bonds of the same country is noticeable, it is around ten times smaller than the effect on the traded bond's liquidity. The spillover effect is mostly visible on the first minute after the transaction is executed and entirely dissipates after around 5 min for the buy-side transaction and after about 15 min for the sell-side transaction, leaving the liquidity situation broadly unchanged. It is also worth stressing that before the transaction, the liquidity situation improves for the traded bond and deteriorates a bit for all other bonds. This observation again indicates that investors trade bonds whose liquidity is improving until the bond becomes sufficiently liquid for the trader.

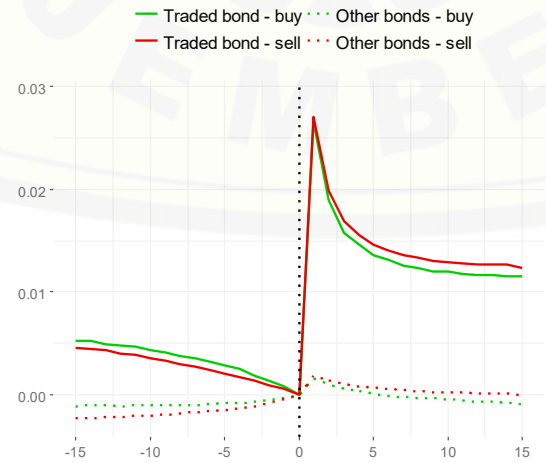

Figure 2. The trade effect on illiquidity-score 15 min before and after the trade was executed.

To a large extent, the bid-ask spread follows the pattern of illiquidity score. The average bid-ask spread of the traded bond increases most severely immediately after the

trade is executed and decreases somewhat afterward. Still, the negative effect does not disappear even after 15 min (Figure 3). The spillover to the bid-ask spreads of other bonds is also visible but comparatively much smaller (around 15 times) than for the traded bond. Still, the spillover effect does not dissipate even after 15 min.

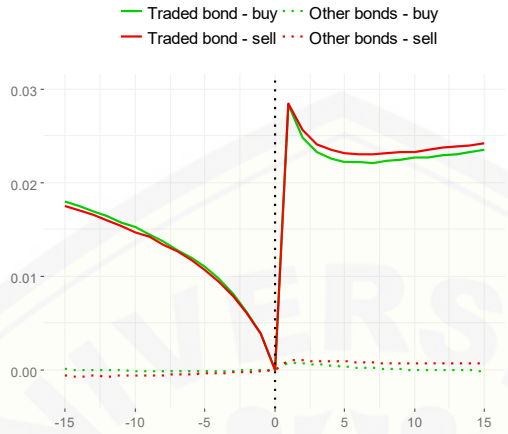

Figure 3. The trade effect on sovereign bond bid-ask spread (15 min before and after the trade is executed.

The impact of a trade shock on liquidity is also visible for the quoted quantities component of the illiquidity score. Quoted quantities of the traded bond decreased by almost eight million units on the first minute after the buy and sell-side transaction is executed (Figure 4). However, this effect completely disappears after several minutes and even attracts new traders to quote additional quantities. Interestingly, the quantities are decreasing sharply, while the bid-ask spread is tightening before the transaction is executed, possibly meaning that there is some kind of front-running behavior of market participants (e.g., leakage of information of incoming "clients" orders) that materialize in diminished quantities, especially before the sell-side transaction. A very similar pattern is visible for quantities of non-traded bonds from the same country as the traded bond, but around five times smaller in magnitude both before and after the transaction is executed.

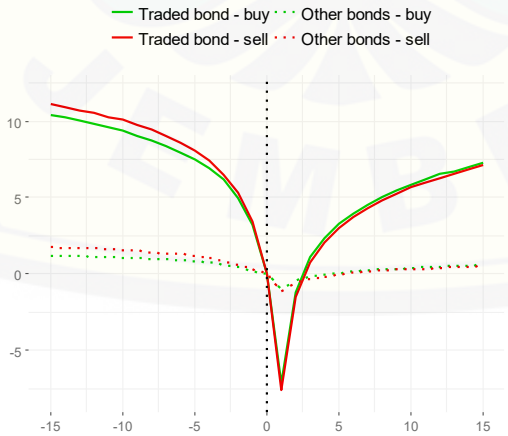

Figure 4. The trade effect on quoted quantities 15 min before and after the trade is executed.

4.2. Maturity Buckets

While the liquidity spillover effect seems to be relatively quiet small (i.e., on average, ten times smaller than the impact on the liquidity of the traded bond), there is a lot of heterogeneity across bonds with different residual maturities. The liquidity of bonds from the same country and residual maturity closer to the traded "bonds" maturity is affected

most detrimentally (Figure 5). This effect is strongest the first minute after the trade is executed; afterward, this negative effect gradually dissipates. Meanwhile, the liquidity of bonds with very different residual maturity than the traded bond is almost unaffected, i.e., around five times less than the liquidity of bonds with similar maturity as the traded bond on the first minute after the trade.

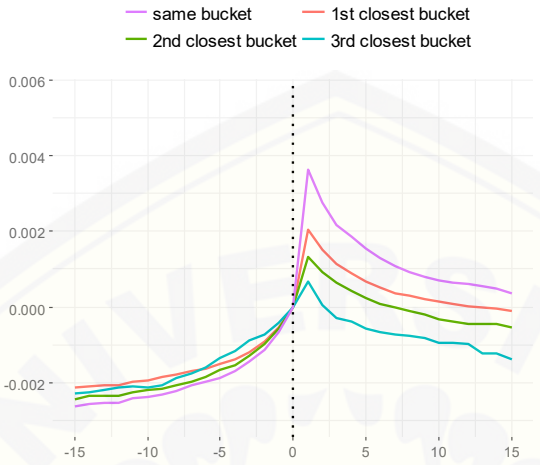

Figure 5. The spill-over effect on illiquidity score of different by residual maturity sovereign bonds 15 min before and after the trade is executed.

The liquidity spillover to non-traded bonds varies notably during time. The spill-over effect on the first minute after the trade is strongest during turbulent times (e.g., European sovereign debt crisis in 2011–2012, the "Bund-Tantrum" in mid-2015) and is almost negligible during calm market periods, e.g., 2013–2014 (Figure 6). The peak of spillover effect in end-2011 is almost ten times higher than at the beginning of 2014. Importantly, the liquidity of bonds with closer residual maturity to the traded "bonds" maturity is affected most significantly during the whole analyzed period, while the effect on the furthest by maturity bonds was even a bit negative for a couple of months in 2015. This probably speaks for the tight relationship between the spillover effect and the market risk sentiment (and therefore the magnitude of illiquidity score).

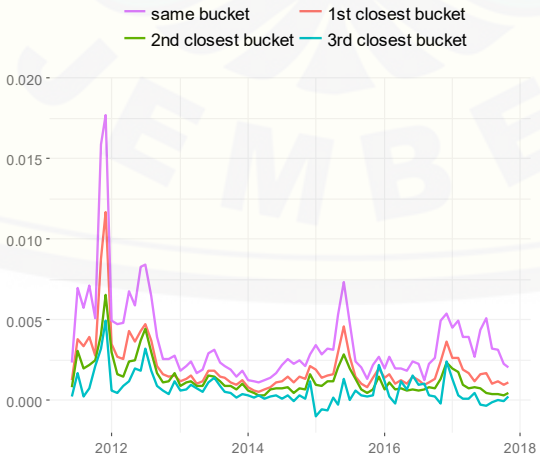

Figure 6. The spill-over effect on illiquidity score during time.

Both components of the illiquidity score of the non-traded sovereign bonds are negatively affected by the trade's execution, although this effect varies highly for bonds with different maturities. The quoted quantities (Figure 7) and the bid-ask spreads (Figure 8) are more severely affected for the bonds with similar residual maturity as the traded bond.

This is probably since bonds with similar maturity are regarded as close substitutes. In contrast, bonds with different maturity might have quite unlike characteristics and features that attract distinct types of investors (so-called "preferred habitat" investors). Notably, the magnitude of spillover effect on bid-ask spreads varies more than on quantities among different maturity bonds, i.e., the quantities of bonds with different maturities change relatively more homogenously than the bid-ask spreads. Also, quoted quantities return to the pre-trade state in around five minutes, while the spillover effect for spreads decreases much more gradually.

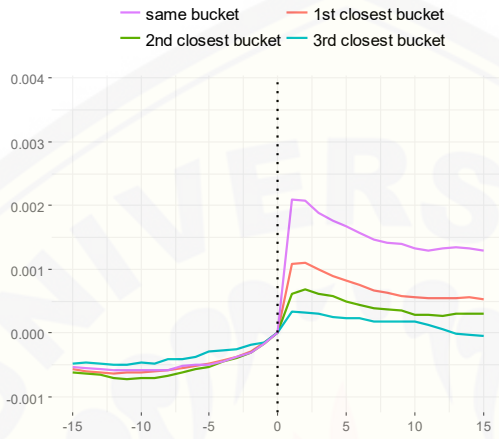

Figure 7. The spillover effect on bid-ask spreads of different by residual maturity sovereign bonds 15 min before and after the trade is executed.

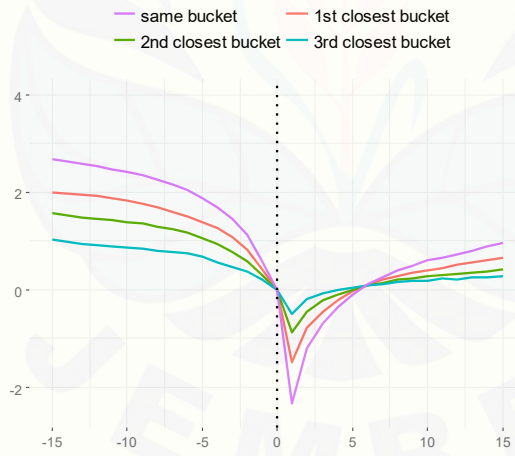

Figure 8. The spill-over effect quoted quantities of different by residual maturity sovereign bonds 15 min before and after the trade is executed.

4.3. Size of Transaction

The trade size of sovereign bonds also explains the difference in magnitudes of the liquidity spillover effect. The smallest value transactions have almost no liquidity spillover effect, while the largest transactions lead to a considerable detrimental effect (Figure 9). The differences of spillover effects between various sizes of transactions are also notable for both illiquidity score components: quoted quantities and spreads (not plotted here). The much higher spillover effect of the largest transactions holds during the whole review period, especially during stressful market conditions (Figure 10). As a result, the observed liquidity spillover effect should mainly be related to the largest transactions, while the smaller trades do not considerably affect liquidity. This result also implies that investors should deter from executing larger orders at once and divide them into smaller trades across longer time periods to reduce liquidity shocks.

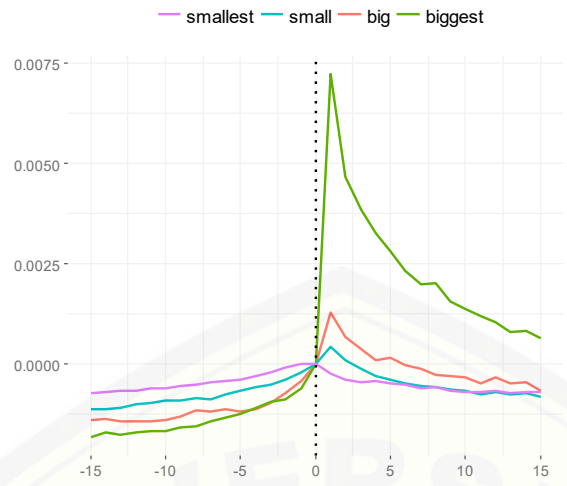

Figure 9. The spillover effect of different trade size on the illiquidity score of sovereign bonds 15 min before and after the trade is executed.

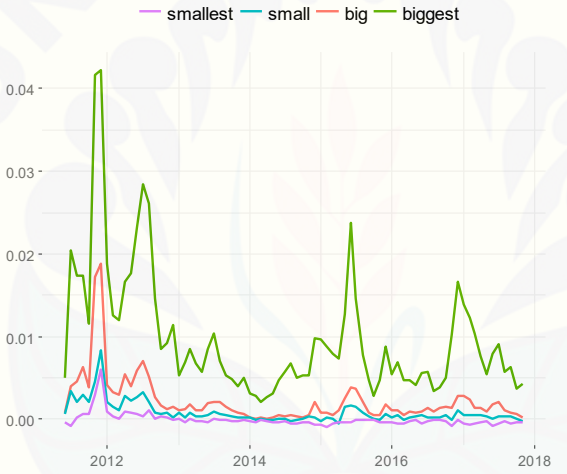

Figure 10. The spill-over effect of different trade size on the illiquidity score of sovereign bonds during time.

4.4. Issuing Country

The liquidity spillover effect varies highly among different markets. There are two notable country groups: the spillover is relatively small in sovereign bond markets from Germany, France, and Italy, while it is much more noticeable in smaller countries—Belgium, the Netherlands, and Spain (Figure 11). This segregation into two country blocks persists for both liquidity dimensions—the bid-ask spreads and quoted quantities (not plotted here)—as well as through time (Figure 12). The only notable exception is the more pronounced liquidity spillover in the Italian market during the European sovereign debt crisis. It is also important to note that the return of liquidity indicator to the pre-trade state is also very different among countries, i.e., the liquidity spillover effect is more permanent in Germany, France, and Spain, but seems to be temporary in Italy, Belgium, and the Netherlands.

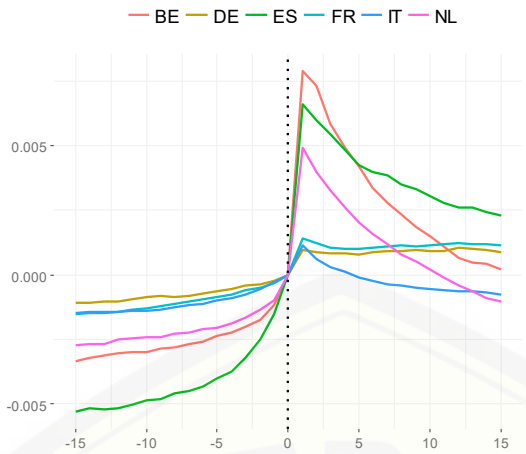

Figure 11. The spillover effect on illiquidity score of sovereign bonds in different countries 15 min before and after the trade is executed. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

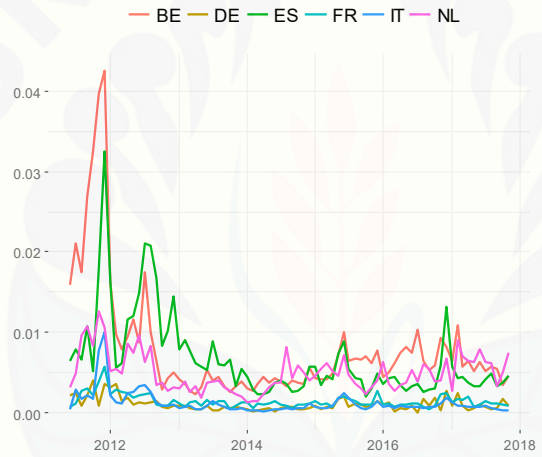

Figure 12. The spill-over effect on illiquidity score of sovereign bonds in different countries during time. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

5. Results of the Liquidity Spillover Effect from One Market to Another

This chapter focuses on the bilateral linkages among countries of the liquidity spillover effect. The first part reports the results of an event study of liquidity spillover from one market to, on average, all other markets. In the second part, the panel regression model results try to bring more light onto the possible determinants of these bilateral cross-country linkages.

5.1. Event Study of the Liquidity Spillover Effect from One Market to Another

Intuitively, a liquidity spillover effect of particular trade should be strongest for the bonds from the same market as the traded bond. It is the case with the spill-over effect of German trades (Figure 13) and French (Figure 14) sovereign bonds. This is especially evident immediately after the trade execution, because afterward the picture is potentially blurred by market-specific factors, e.g., the liquidity trend of Spanish bonds. The liquidity spillover effect to bonds from other countries is also visible, but this effect is around three times smaller than for the bonds from the same country. Interestingly, only Italian bonds seem to remain unaffected by the trades of German or French sovereign bonds, possibly because Italian bonds are the most traded bonds in the MTS market.

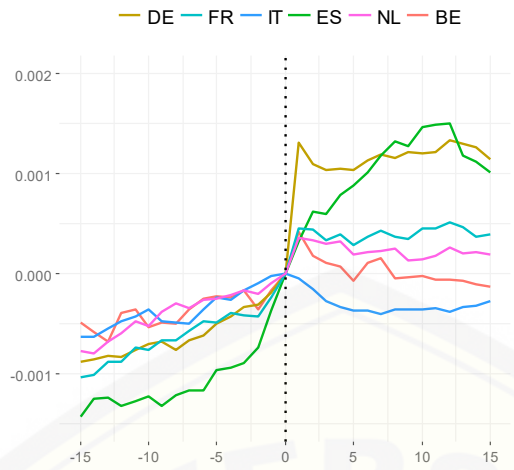

Figure 13. The liquidity shock spillover effect of trades of German sovereign bonds to different markets 15 min before and after the trade is executed. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

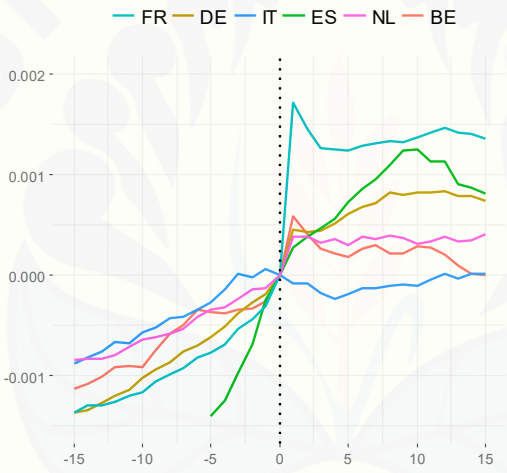

Figure 14. The liquidity shock spill-over effect of trades of French sovereign bonds to different markets 15 min before and after the trade is executed. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

Similar conclusions can be reached regarding the spill-overs emanating from Italian trades (Figure 15) and Spanish (Figure 16) sovereign bonds. However, the liquidity spillover from Spanish bonds trades to all other markets is comparatively much smaller (only Italian bonds are somewhat affected), meaning that trades of Spanish sovereign bonds have little informational value for traders from other countries. Interestingly, the liquidity of Spanish bonds is also highly affected by Italian bonds' trades, while there is limited effect on the bonds from other markets.

The spillover effect emanating from Belgium sovereign bonds trades (Figure 17) also seems to be comparatively small. In contrast, the spillover effect is a bit higher from the Netherlands sovereign bonds (Figure 18). After the trade is executed of the Netherlands sovereign bonds, the liquidity of German, French, and Belgian sovereign bonds are most negatively affected. At the same time, no effect is visible in Italian and Spanish markets. Meanwhile, the trades of Belgian sovereign bonds has only a marginal effect of bonds from all other markets; only the effect on own Belgian bonds is significant.

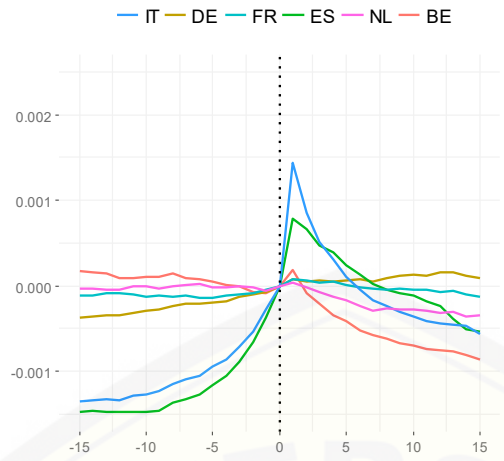

Figure 15. The liquidity shock spillover effect of trades of Italian sovereign bonds to different markets 15 min before and after the trade is executed. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

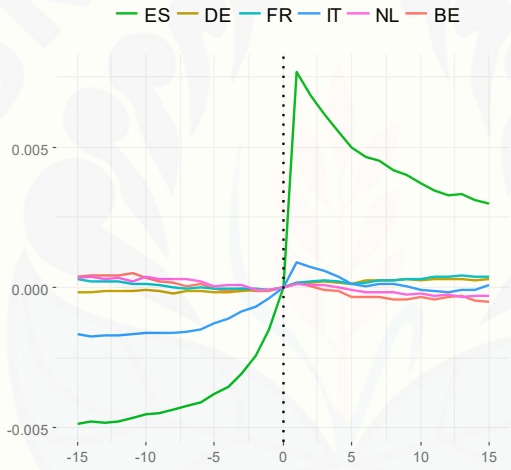

Figure 16. The liquidity shock spill-over effect of trades of Spanish sovereign bonds to different markets 15 min before and after the trade is executed. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

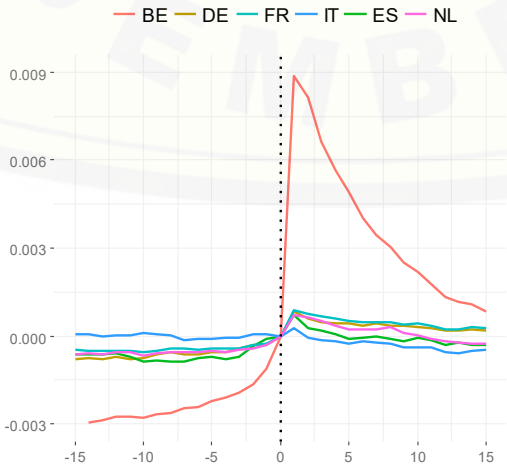

Figure 17. The liquidity shock spillover effect of trades of Belgian sovereign bonds to different markets 15 min before and after the trade is executed. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

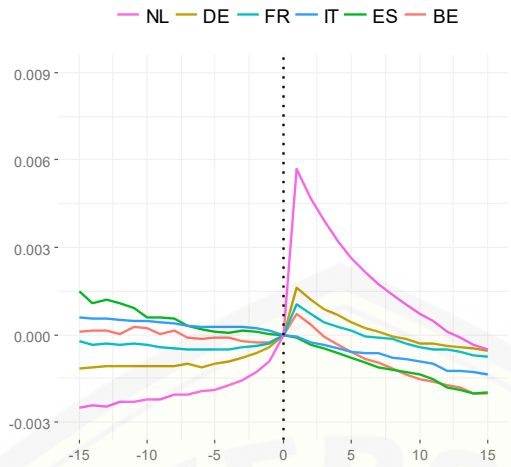

Figure 18. The liquidity shock spill-over effect of trades of Netherlands sovereign bonds to different markets 15 min before and after the trade is executed. Notes: BE—Belgium; DE—Germany; ES—Spain; FR—France; IT—Italy; NL—Netherlands.

5.2. Panel Regression Model of the Underlying Factors of Liquidity Spillover Effect from One Market to Another

To determine the underlying reasons for the strength of liquidity shock spillover effect among markets, a panel regression model was employed. The dependent variable is the monthly average of the changes of order-book illiquidity score immediately after the transaction is executed. As the analysis was carried out with monthly data from June 2011 until December 2017, 79 monthly averages for bilateral linkages in 6 markets led to overall 2370 bilateral observations. Country-specific fixed effects were included in the model, and the standard errors were clustered because the panel consists of different markets with heterogeneous liquidity levels.

As the spillover effect is related to bilateral linkages (i.e., the traded bond which is transmitting liquidity shock and the non-traded bond that is responding to the shock), two models with different explanatory variables were constructed. The first model focuses on the spill-over effect emanating from the trades of sovereign bonds of a particular market ("spill-over from", i.e., analyzing why the trade signal emanating from some markets is stronger, while from others—weaker. Most of the model's variables were constructed from the transactional data because this model concentrates on the sovereign bonds from which the spillover effect reverberates, i.e., from the traded bonds. The second model focuses on the strength of the spill-over effect to the bonds from another market than the traded bond ("spill-over to"). As this model is related to the sovereign bonds that are "receiving" spill-over effect, most of the variables were constructed from the limit order book data.

The first model results reveal that the strongest liquidity shock spillover effect arises from sovereign bonds that are less liquid and whose issuer is closer by distance to the country of another—non-traded—bond (Table 1). As transactions affect more severely the liquidity of the relatively less liquid and therefore more sensitive traded bonds, the spillover effect from such transactions is also stronger. This result directly relates to the Bank for International Settlements (2016a) and Pellizon et al. (2013) that risks of information leakage from illiquid securities are often much higher. Intuitively, the liquidity spillover effect is stronger when it emanates from the traded bond whose issuer is closer by distance to another sovereign bond issuer. However, other variables—number of transactions, average trade size, and residual maturity of the traded bond—has no statistically significant explanatory power (Table 1).

Table 1. Explanation of variables and results.

Variable	Description	Results
Spill-over FROM	Average monthly spill-over effect from the country of the traded bond (from which spill-over impact is measured) to non-traded bond from another country	Dependent variable
distance	The distance between the country of the traded bond and the country of another bond (in 1000 km)	−0.00028 ** (−8.55)
num_trades	The number of trades from which the spill-over effect is measured during a month	−0.018 (−1.41)
trade_size	The average trade size of bonds from which spill-over effect is measured during a month (in millions)	−0.0000195 (−0.9)
illiq_score	The average illiquidity score of bonds from which spill-over effect is measured at the time of the trade	0.0015 ** (12.02)
res_maturity	The average residual maturity of traded bonds at the time of the trade (in years)	−0.000017 (−1.68)

Note: The number in parentheses is the heteroscedasticity robust *t* value, ** indicates statistically significant variables at 5% level.

The second model results (i.e., spillover effect to another market) are quite similar to the results of the first model (Table 2). The closer the two countries are, the higher the liquidity shock spill-over effect to the bonds from another market than the traded bond. Also, the less liquid bonds are affected more severely. Nevertheless, this model reveals that the number of quoted bonds also matters: the higher the number of bonds from a particular issuer that is quoted in the particular market, the weaker is the liquidity shock spillover effect, possibly due to the dilution of the impact among different bonds. Interestingly, bonds with a higher number of limit order revisions are more affected, meaning that such bonds quickly incorporate new information transmitted by trades of bonds from another market—though this effect is significant only at the 10% significance level. This result is also confirmed by other studies that state that rapid technological changes enable dealers to quickly incorporate incoming information in the central order book. Only the residual maturity of the non-traded bond is not statistically significant, contrary to Schneider et al. (2016) (Table 2).

Table 2. Explanation of variables and results.

Variable	Description	Results
Spill-over TO	The average monthly spill-over effect to the bonds from the country of the non-traded bond (to which spill-over effect is measured)	Dependent variable
distance	The distance between the country of the traded bond and the country of another bond (in 1000 km)	–0.00038 ** (−8.51)
num_bonds	The number of bonds with standing limit orders at the time of the trade	−0.000026 ** (−4.35)
num_updates	The number of limit order revisions in the central limit order book	0.0000012 * 1.75
illiq_score	The average illiquidity score of bonds to which spill-over effect is measured at the time of trade	0.0024 ** (13.79)
res_maturity	The average residual maturity of non-traded bonds from another country than the traded-bond (in years)	−0.00003 (−0.77)

Note: The number in parentheses is the heteroscedasticity robust *t* value, ** indicates statistically significant variables at 5% level, *—at 10% level.

The main takeaway from the two-panel regression models is that it is difficult to relate particular bond-specific factors to the size of the liquidity shock spillover effect both from

and to another market. Only the distance between the countries and the relative liquidity of bonds help explain the spillover effect in both models. Possibly, other variables that are not directly related to the MTS bond market might be useful to explain these cross-country differences, e.g., the trading and quoting activity in other (including over-the-counter and futures) markets, linkages between different markets, and et cetera.

6. Conclusions

In our research, we tried identifying the liquidity spill-over effect. We wanted to reveal how different trades can influence sovereign bonds' prices and how this effect differs for the traded (direct impact) and non-traded (spill-over effect) bonds. Our event studies of spill-over effects of trades were carried out with minute frequency bond data from mid-2011 until the end-2017 for the six largest euro area markets. We determined that the outcome was permanent as the average price does not reverse even 15 min after the trade's execution. We would also like to point out that the change of other bonds' prices from the same country as the traded bond was smaller than the traded bond price change. However, the prices of other (non-traded) bonds change much more before the trade was executed than the price of the traded bond. The latter results mean that the change of bond prices entered the endogenous investors' decision process of selecting particular bonds that had been traded. Finally, we can conclude that the liquidity spill-over effect was relatively small. In the next step, we try to analyze maturity buckets. The liquidity of bonds from the same country and residual maturity closer to the traded "bonds" maturity was affected most detrimentally. Both components of illiquidity score—quoted quantities and bid-ask spreads—were more severely affected for the bonds with similar residual maturity as the traded bond.

The other interesting fact that we want to point is that the liquidity spill-over to non-traded bonds varies notably during time. The spill-over effect on the first minute after the trade was most robust during turbulent times and was almost negligible during calm market periods. We want to stress that the liquidity of bonds with closer residual maturity to the traded bonds' maturity was affected most significantly during the whole analyzed period. Such a tendency could be explained by the tight relationship between the spill-over effect and the market risk tolerance.

Because the trade size of sovereign bonds can also be used to explain the differences in magnitudes of the liquidity spillover effect, we included that factor. We have noticed that the smallest value transactions have almost no liquidity spillover effect, while the largest transactions lead to a considerable detrimental effect. So because of that, investors split the orders across more extended periods to avoid liquidity shocks.

Issuing country is also a significant factor for liquidity spill-over effects. We determined that the spill-over is relatively small in sovereign bond markets from Germany, France, and Italy. At the same time, it is much more noticeable in smaller countries—Belgium, the Netherlands, and Spain.

Finally, in our study, we tried to investigate the liquidity spill-over effects from one market to another. We revealed that the liquidity shock spill-overs are most robust for the bonds from the same issuing country as the traded bond rather than on the bonds from other countries. Regarding the strength of bilateral spill-over effects among different markets, the panel regression model results revealed that few liquid bonds and bonds whose issuer is closer by distance to the country of the traded bond has a more substantial reactive spillover effect. Such bonds are also affected more by the trades executed in another market. Also, the higher the number of bonds (mostly if they are less actively quoted) that are being listed in the particular market, the weaker is the liquidity spillover effect.

Results of this research should be of particular interest to the sovereign bond traders, analysts, market supervisors who actively monitor the dynamics of bond markets and try to understand the underlying reasons for market movements and liquidity dry-ups. Market liquidity can quickly evaporate after trades are executed even in another market.

Market participants should pay increasing attention to the cross-country effects and have a pre-emptive strategy to cope with the spillover shocks. Otherwise, increasing liquidity premium might reduce the efficiency of the trading strategies and negatively affect trading returns.

Author Contributions: Conceptualization, D.T. and R.K.; methodology, L.J.; software, L.J.; validation, D.T., R.K., and L.J.; formal analysis, L.J.; investigation, L.J.; resources, L.J.; data curation, L.J.; writing—original draft preparation, D.T.; writing—review and editing, D.T. and R.K.; visualization, L.J.; supervision, D.T.; project administration, D.T. All authors have read and agreed to the published version of the manuscript.

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Movement of Inflation and New Keynesian Phillips Curve in ASEAN

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Abstract: The development of the theory of dynamic inflation begins by linking wage inflation and unemployment. In further developments, factor of expectation is classified into inflation model. The study used inflation data is important for ASEAN, because ASEAN is one of the strengths of the international economy. This study analyzes the dynamics of inflation in the ASEAN using framework the New-Keynesian Phillips Curve (NKPC) model. The data used is the quarterly panel data from 5 ASEAN members in the period 2005.QI–2018.QIV. The study of this dynamic inflation applies quarter to quarter inflation data, meaning that the inflation rate is the percentage change in the general price of the current quarter compared to last quarter general price divided by the last quarter. The empirical results are estimated by using the Generalized Method of Moment (GMM), both of the system and first different indicates that the pattern formation of inflation expectations are backward-looking and forward-looking. In addition, the estimated NKPC models show the backward-looking behavior is more dominant than the forward looking. Changes in inflation are not entirely influenced by expectations of inflation in each country. Changes in inflation are also influenced by the output gap, changes in money supply, and exchange rate. Based on the findings of this study, it can be concluded that the NKPC models can explain the dynamics of inflation in each country in the ASEAN region.

Keywords: dynamic inflation; ASEAN; forward looking; backward-looking; NKPC

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1. Introduction

The dynamic economy of ASEAN member countries with high growth of outputs requires inflation control, which is based on a good understanding of inflation. Various studies on inflation using national data aggregation have been conducted, but only a few studies have concern about inflation and built a model of inflation based on data from a community of country (Wardhono et al. 2017). Ideally, the research that examines dynamic inflation using panel data of a community of country is also conducted to better understand inflation. The research is important because ASEAN is a community of big countries with regional growth differences that cause variations in inflation. These variations certainly cannot be seen using aggregate data but can be seen using data of each country. In addition, the calculation of consumer price index compiled by regions of the countries shows that inflation is a phenomenon of the rise in general price level.

Moreover, quoting Mehrotra et al. (2007), research using provincial data is important for big countries because the provinces throughout the country have different institutions, economic performance, and level of market development. Economic obstacles between regions, for example, trade obstacles, can also be a source of differences in inflation formation process (Wardhono et al. 2018). Furthermore, inflation differences between regions reduce the ability of a region to adjust the economic shocks. In addition, the role of inflation and inflation expectations in various areas that have various inflation dynamics also influences the effectiveness of monetary policy.

Research on interprovincial inflation has been carried out by Mehrotra et al. (2007) using data of China. In their research, they found the variation of inflation in each province and the forward-looking inflation component in 22 of the 29 provinces studied. Likewise, Chaban and Voss (2012) who examined inflation in Canada found a variation of inflation in 10 provinces. The contribution of this research compared to previous inflation studies is the use of panel data of 5 ASEAN countries, in contrast to Mehrotra et al. (2007) and Chaban and Voss (2012), who used provincial panel data. Furthermore, this research analyzes the dynamic inflation in ASEAN to use the framework of the new Keynesian Phillips curve (NKPC) model. In addition, this research will also see the effect of the output gap in each country and the monetary level in each country. Estimation of dynamic inflation used quarter-to-quarter (qtq) inflation data and the method used was the the Generalized Method of Moment (GMM) system for panel data.

2. Literature Review

The development model of dynamic inflation was pioneered by Calvo (1983) who created the NKPC model. The NKPC model assumes that in an imperfect competition in the market, companies can set prices based on markup above marginal cost. Furthermore, in every random period, there is a possibility $(1-\theta)$ for companies to rearrange the prices and a possibility θ for the companies not to change the prices. This condition can be written as

$$p_t = \theta p_{t-1} + (1-\theta) p_t*, \tag{1}$$

where the aggregate price level, p_t, consisting of rearranged prices, p_t*, and the old prices, p_{t-1} that did not change. The company's choice to rearrange the prices can be expressed in the following equation:

$$p_t* = \mu + (1-\theta\beta) \sum_{k=o}^{\infty} (\theta\beta)^k \theta p_{t-1} E_t mc^n_{t+k} \tag{2}$$

where μ is the value of optimal markup, β is the discount factor, and mc^n_{t+k} is nominal marginal cost. The sigma sign in Equation (2) shows the new prices, which are arranged based on the whole expectations mc^n_{t+k}. In addition, companies can also choose not to change the prices based on the weighted value of the expectation of future nominal marginal costs. Based on the conditions, Equations (1) and (2) can be arranged in a new equation that generates a new Keynesian Phillips curve (NKPC) model as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}(mc_t + \mu), \tag{3}$$

where inflation relates to expectations of future inflation and the difference in real marginal cost of its optimum level. In the general condition, aggregate real marginal cost is proportional to the difference between actual output and potential output. By this assumption, the NKPC becomes

$$\pi_t = \beta E_t \pi_{t+1} + \lambda y_t \tag{4}$$

where y_t is the output gap, i.e., actual output minus potential output, $(y^a_t - y^*_t)$, and $\lambda = \frac{(1-\theta)(1-\theta\beta)}{\theta}$.

For policy implications, Rudd and Whelan (2002, 2005a) state that NKPC inflation is influenced completely by forward-looking behavior. There is no inertia in inflation, which means that there is no structural impact of the past inflation on inflation. Then, solving the Equation (4) in a rational assumption obtains the equation:

$$\pi_t = \lambda \sum_{k=0}^{\infty} \beta^k E_t y_{t+k} \tag{5}$$

There are at least three policy implications of the NKPC model presented by Rudd and Whelan (2005a, 2005b). The first is the absence of inertia in the inflation model. Inflation is influenced entirely by forward-looking behavior. Second, the involvement of the lag inflation variable as a proxy for the future value from the output gap affecting inflation is not applicable. According to the supporters of NKPC, if the central bank is able to maintain the inflation target with credible policies, the role of lag inflation in the expectation becomes small. In this situation, inflation can be controlled at a low cost. However, if the policy is not credible, inflation expectations are compiled by the public based on the last occurrence of inflation (lag) and not the central bank's announcement. The latter policy implication is the occurrence of misleading nature of the non-accelerating inflation rate of unemployment (NAIRU)-based analysis, so NAIRU cannot be used as a macroeconomic policy guideline. Estimation of time-varying NAIRU showing low inflation can be explained by a decrease in NAIRU. Implicitly, this means that the central bank can increase the economic activities without having to increase inflation. In fact, models (4) and (5) show that there is a positive effect between output gap and inflation.

3. Methodology

This research used panel data of 5 countries that exist in ASEAN, ranging from year 2005 quarter 1 through year 2018 quarter 4. Most of the data were taken from the central bank of each country in ASEAN, ASEAN secretariat, International Monetary Fund (IMF), and the World Bank. Some of the variables used in the model are listed in Table 1.

Table 1. Variable definitions.

Variable	Symbol	Unit	Note
Inflation	$\pi_{i,t}$	Percent	Quarter-to-quarter provincial inflation
Actual output	y^a_{it}	IDR billion	Real GDP
Potential output	y^*_{it}	IDR billion	Obtained using Hodrick–Prescott (H–P) filter method
Output gap	y_{it}	Percent	$y_{it} = \frac{\left(y^a_{it} - y^*_{it}\right)}{y^*_{it}} \times 100\%$
Changes in the amount of real money supply	ΔM_{it}	IDR billion	ΔM_{it} is a real change in currency (ΔK_{it}) plus the change in real demand deposits (ΔG_{it}). ΔK_{it} is the current currency flow in the central bank and ΔG_{it} is the changes in deposits in each country.
ΔM_{it} compared to y^a_{it}	m_{it}	Percent	$m_{it} = \frac{\Delta M_{it}}{y^a_{it}} \times 100\%$

The following are the dynamic inflation models used in this research and refer to research conducted by Gali and Gertler (1999).

$$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it} \quad (6)$$

$$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it} + \delta_m m_{it} \quad (7)$$

where π_{it} is inflation, y_{it} is output gap, and m_{it} is monetary aggregate. Furthermore, γ_b and γ_f are defined as backward-looking and forward-looking parameters. The selection of estimation method is based on the NKPC model. Equation (8) can be rewritten as follows:

$$\pi_t = \lambda y_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + u_t \quad (8)$$

where y_t is the output gap $\left(y^a_{it} - y^*_{it}\right)$. In practice, $E_t\{\pi_{t+1}\}$ is usually converted into $\pi_{t+1} - \eta_{t+1}$, where η_t symbolizes a step forward of forecast error of inflation (Vinod 2010). The changes lead to the equation changing into

$$\pi_t = \gamma_0 + \lambda y_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + \varepsilon_t \quad (9)$$

Thus, an endogeneity problem arises because the error correlation ε_t with the regressor results in inconsistent estimates $\hat{\gamma}_0$, $\hat{\lambda}$, $\hat{\gamma}_f$, and $\hat{\gamma}_b$. If there is a problem of endogeneity, then

Ordinary Least Square (OLS) is inconsistent and the estimation method that should be used is GMM.

Mileva (2007) describes how the data panel and a model similar to Equation (8) can face problems. First, the endogeneity problem can appear where the regressor is correlated with the error term. Second, time-invariant characteristics of the province (fixed effect), such as geography and demography, may be correlated with the explanatory variables. The fixed effect in the error term consists of the observed and unobserved effects (Sadik-Zada 2019). Third, the emergence of a lag variable increases autocorrelation. Fourth, panel data have a short time dimension and relatively large space dimension. To solve the problem that arises, Mileva (2007) suggests using the Arellano–Bond GMM estimator or GMM system.

4. Results and Analysis

The testing of data integration order is made toward inflation-quarter data π_{it}, the output gap y_{it}, and monetary variable m_{it}. Order integration testing of panel data used the IPS test of Im, Peseran, and Shin (2003), LLC test of Levin, Lin, and Chu (2002), and Augmented Dickey–Fuller ADF Fisher test and Phillips-Perron Test (PP) Fisher test of Maddala and Wu (1999).

The overall unit root tests, either LLC, IPS, ADF Fisher, or PP Fisher, indicate that the null hypothesis, which contains a unit root, was rejected, so it is concluded that all data are integrated at the order level. The test results in Table 2 show that *p*-value is entirely under 5%, so it is concluded that there were no root units in all variables of level order. Because the data are integrated at the level order, level data in the estimated GMM model are used.

Table 2. Panel data unit root test at level order.

Variable		LLC	IPS	ADF Fisher	PP Fisher
		H_0 = Unit Root	H_0 = Unit Root	H_0 = Unit Root	H_0 = Unit Root
π_{it}	Statistik	−24.7837	−22.2389	562.340	527.364
	(prob)	(0.0000) *	(0.0000) *	(0.0000) *	(0.0000) *
y_{it}	Statistik	−19.4621	−27.8572	512.534	498.827
	(prob)	(0.0000) *	(0.0000) *	(0.0000) *	(0.0000) *
m_{it}	Statistik	−17.5328	−23.7583	482.837	852.723
	(prob)	(0.0000) *	(0.0000) *	(0.0000) *	(0.0000) *

Note: * significance at level α 5%.

Gali and Gertler (1999) compare the results of estimated NKPC models to show that the use of output gap in dynamic inflation models is not appropriate. In the explanation, they use a pair of independent variables of future inflation π_{t-1} and output gap y_{it} in the NKPC model. The estimation results of the NKPC using independent variable π_{t+1} and the variable of part of labor income share (s_t) show estimation of a positive parameter for π_{t+1} and (s_t). The econometric success provides the basis for Gali and Gertler (1999) and Gali et al. (2005) not to use the output gap, but part of the labor income in the model. Part of labor income is the labor income percentage compared to the total output of economy.

The NKPC model, developed by Gali and Gertler (1999), explains that inflation expectations and lag inflation simultaneously affect the prevailing inflation. This model assumes that the company determines the price level based on information on the past inflation (backward-looking rule-of-tumb), while the rest behaves as forward-looking.

Table 3 shows the estimated NKPC in model A using GMM with an instrument variable. Estimating the equation of the NKPC indicates backward-looking, forward-looking parameter estimation, and the significant output gap at α = 5%, which is indicated by a *p*-value of all parameters less than 5%. The *p*-value for the J-statistic is also greater than 5%. The null hypothesis, which states that there is no overidentification, is accepted. Model A also shows the direction of the coefficient backward-looking, forward-looking, and the output gap according to the theory (positive).

Table 3. Dynamic inflation model based on the New Keynesian Phillips Curve (NKPC).

		$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it}$		$\pi_{i,t} = \gamma_b \pi_{i,t-1} + \gamma_f \pi_{i,t+1} + \lambda y_{it} + \delta_m m_{it}$	
		(A)		(B)	
		π_{it}		π_{it}	
γ_b	Nilai parameter	0.086555		0.092685	
	t-statistik	5.51876		4.041432	
	(prob)	(0.0000) *		(0.0001) *	
γ_f	Nilai parameter	0.041260		0.044727	
	t-statistik	3.885509		3.487576	
	(prob)	(0.0001) *		(0.0005) *	
λ	Nilai parameter	0.04338		0.036467	
	t-statistik	3.698731		2.775005	
	(prob)	(0.0002) *		(0.0056) *	
δ_m	Nilai parameter			0.015129	
	t-statistik			8.293415	
	(prob)			(0.0000) *	
N		360		360	
Instrument rank		30		30	
Hansen test:					
J-stat.		29.78955		29.68664	
(prob)		0.3236		0.2807	
Rata-rata *lag*		0.095		0.102	
Wald-test:					
		$\gamma_b - \gamma_f = 0$	$\gamma_b + \gamma_f = 1$	$\gamma_b - \gamma_f = 0$	$\gamma_b + \gamma_f = 1$
Chi-square		9.3145	1529.900	5.986	746.564
(prob)		(0.0000)	(0.0000)	(0.0144)	(0.0000)

Note: * significance at level α 5%.

Results of the estimated NKPC model indicate the pattern of formation of inflation expectations is backward-looking and forward-looking. This means that inflation expectations are influenced by the experience of the past inflation and estimation of inflation expectations in the future. Notwithstanding the foregoing, it can be seen that the backward-looking parameter is greater than forward-looking. Hypothesis $\gamma_b - \gamma_f = 0$ or $\gamma_b = \gamma_f$ is also rejected by the Wald test. The chi-square value (9.31) and prob-value (0.0000) indicate that the value γ_b is not equal to γ_f. Based on the value of the parameter and Wald test, it is found that the behavior of *backward-looking* is more dominant in the formation of inflation expectations than that of *forward-looking* behavior.

Testing the number of parameters of *backward-looking* and *forward-looking*, the same as one $\gamma_b + \gamma_f = 1$, is also performed using the Wald test. This test is made to determine whether the establishment of expectations is perfect or full. The results of the Wald test with chi-square (1529.9) value and *p*-value (0.000) conclude that the hypothesis stating $\gamma_b + \gamma_f = 1$ is rejected. This means that the formation of inflation expectations is not full and in the long-term, the Phillips curve is not vertical. The test results indicate that inflation is also influenced by the output gap. The conclusion of the Wald test results is in line with the significant value of the output gap parameter λ, and this means that the output gap affects inflation.

NKPC estimation results also show the persistence of inflation in ASEAN. The average time of inflation adjustment of 0.095, which is calculated based on the method presented by Koyck (1954) (in Gujarati (2003)) shows that the average length of time of inflation adjustment is 0.095 quarter or approximately 1.1 week. This value indicates the low level of inflation persistence.

Model B shows the estimated results of the NKPC with additional monetary variables. Estimation of model B shows the estimation of *backward-looking* and *forward-looking* parameters, the output gap, and monetary variables is significant at $\alpha = 5\%$, which is indicated by *p*-value of all parameters less than 5%. The *p*-value for J-statistic is also greater than 5%. The null hypothesis, which states that there is no overidentification, is accepted. Table 3

also shows the direction of the coefficient of *backward-looking* and *forward-looking*, and the output gap of model B is in accordance with the theory (positive).

Of the estimated model B, it is found that the monetary variable turns out to affect inflation. This means that if relative money supply compared to GDP increases, the inflation will rise, while if it is decreased, it will lead to inflation decrease. In the estimation of model B, it can be seen that the significance level of the *backward-looking* parameter is always significant at $\alpha = 5\%$. This level of significance is the same as in model A. This means that the additional explanatory variable causes the reduced strength of the forward-looking parameter in influencing inflation.

Even if the level of significance of the forward-looking parameter declines, the estimated results of the NKPC model with a fixed monetary variable shows *backward-looking* and *forward-looking* determines the pattern formation of inflation expectations. Inflation is influenced by the experience of inflation in the past time and also the estimated inflation expectations in the future by the *backward-looking* parameter value greater than that of the forward-looking parameter.

Wald test results with *p*-value (0.000) for model B concludes that the hypothesis which states that $\gamma_b + \gamma_f = 1$ is rejected. This means that the formation of inflation expectations is not full in the NKPC model with additional monetary variables. Besides, the meaning of rejection of the hypothesis in the long term of the NKPC model is not vertical. The test results indicate that inflation is also affected by other significant variables in the model. In addition, the average time of inflation adjustment for model B is 0.102. Similar within the NKPC model (model A), the average time needed to adjust the inflation is about one week. This value indicates the low level of inflation persistence.

5. Discussion

According to the baseline NKPC, inflation is mainly an expectations phenomenon—if the central bank controls future inflation expectations, it controls the present value of inflation (Carré 2008). This explains why the expectations channel of transmission is central to monetary policy: "markets do the job" instead of the central bank. It is also why "expectations management" is so crucial in the modern view of optimal monetary policy under the inflation targeting regime—the expectations management is the root of monetary policy efficiency.

Consistency of positive direction parameter estimation of the Phillips curve and NKPC shows that the opinions of Gali and Gertler (1999) and Gali et al. (2005), which state that the output gap cannot be a proxy for economic activities, cannot be accepted. Based on these results, the use of the output gap in the estimated dynamic inflation model in this research may be confirmed. Moreover, in all estimated models, significant values of the output gap are obtained.

The conclusion that the output gap in ASEAN countries can be accepted as factors affecting inflation is the same as the conclusion of research conducted by Mehrotra et al. (2007). Variable significance of national output gap on inflation indicates that demand and supply of outputs in ASEAN are important variables that explain dynamic inflation. The high national economy in ASEAN, which causes actual output to be above its potential, has an implication on inflation in each country, and vice versa.

Based on the estimated NKPC model, either in reduced form (model A) or after the addition of monetary shock variable (model B), it is found that estimation parameters of *forward-looking* γ_f, or backward-looking γ_b, are entirely significant and marked positive. These results prove that the formation pattern of inflation expectations is *backward-looking* and *forward-looking*. This means that the inflation expectations are influenced by the experience of the past inflation and inflation expectations in the future.

Even if inflation is influenced by the behaviors of *backward-looking* and *forward-looking*, the NKPC estimation model results show that the behavior of *backward-looking* is more dominant than that of forward-looking. However, in all estimated models, the dominant value of component of *backward-looking* decrease when the explanatory variables in the

NKPC model is coupled with monetary variables. The findings of the dominance of *backward-looking* behavior is different from the predictions of the NKPC model and previous studies conducted by Gali and Gertler (1999); Gali et al. (2005); Abbas and Sgro (2011); and Mehrotra et al. (2007).

The results of the estimation of the model NKPC also find that the dynamics of inflation is not only influenced by expectations that underlie the behavior of the backward-looking and forward-looking. Other explanatory variables such as the output gap and monetary and cyclical variables also influence inflation.

The conclusion states that the money supply in ASEAN that has an effect on regional inflation is the same as the conclusion of previous research that examined the effect of the amount of money on inflation. These results indicate that the regulation of the money supply in ASEAN can be used to control inflation and to prescribe monetary policy at the national level. The final conclusion that can be drawn from the estimation results is that the level of inflation persistence is low. The average value for inflation adjustment time is about one week. This means that if there is a shock that causes inflation to differ from its equilibrium point, economic actors will quickly adjust the existing inflation back to its equilibrium value.

Since 2002, the Philippines has been adopting inflation targeting framework as its guide in reaching price stability for the purpose of determining monetary decisions. The Philippines adopted a floating exchange rate system in 1970 (Wardhono et al. 2014). This was caused by the existence of government consideration toward a steady exchange rate system that became a treasure of an overexchange rate fluctuation. The implication of the floating exchange rate system was also consistent to ITF. Through this path, exchange rate movement was impacted by actual inflation and expected inflation (Report, Bangko Sentral NG Pilipinas 2015).

Indonesia has been adopting an inflation targeting framework since 2005, which previously used monetary policy that applied base money as a policy framework. Indonesia has begun to implement a floating exchange rate system since 1997 until now. The purpose of the policy of Bank Indonesia is to maintain exchange rate stability and safeguard the Rupiah value stability, in order to maintain stability in the prices of goods and services reflected in inflation (Wardhono et al. 2016). A floating exchange rate policy is also consistent with the implementation of the monetary policy framework, i.e., inflation targeting framework. Malaysia is one of the ASEAN members that does not implement an inflation targeting framework as a monetary decision. Malaysia uses the interest rate framework as one of its national monetary decision targets. The main instrument of its monetary decision is the overnight policy rate (OPR). Malaysia seems to implement a flexible inflation target decision, although it does not officially adopt IT as its decision guide. In 2002, Malaysia used the steady exchange rate system; later, on 21 July 2005, it was changed to a floating exchange rate system. This transformation is a response of a structural change that happened in the domestic or international region. Since 2000, Thailand has adopted an inflation targeting framework. Thailand adopted a floating exchange rate system in July 1997, and the system is also consistent with the inflation target policy framework (ITF) adopted by Thailand in 2000. The implication of inflation targeting framework and the floating exchange rate system indicate that the Baht exchange rate is determined by the market. In implementing the system, the Bank of Thailand does not target a fixed amount for the exchange rate, but the Bank of Thailand will intervene in case of excessive volatility, as the Bank of Thailand is consistent with the policy of an inflation targeting framework.

6. Conclusions

The result of the estimated NKPC model in ASEAN found that the dynamics of inflation is not only influenced by expectations that underlie the behaviors of *backward-looking* and *forward-looking*. Other explanatory variables such as the output gap and monetary variables also influence inflation. The conclusion stating that the amount of money supply in each country influences inflation is the same as the conclusion of previous

research that examines the influence of money on inflation. These results suggest that the regulation of money supply in each country can be used to control inflation, such as monetary policy prescriptions at a national level.

The final conclusion that can be drawn from the results of estimation is that the level of inflation persistence is, in fact, low. The average value of the inflation adjustment time is about one week. This means that if there is a shock that causes inflation to be different from the point of equilibrium, the economic actors quickly adjust the existing inflation back to the equilibrium value.

Thus, the policy that can be taken in supporting the economy in ASEAN is the policy of inflation control that can be made by optimizing the control policy of monetary aggregates (money supply) in each country. The central bank can set the target of money supply to control inflation. Both fiscal and monetary policies must be credible and trusted by economic agents because they determine the price fluctuations.

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Regional Heterogeneity of Preferences and Intergovernmental Transfers

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Abstract: We develop a model with optimal shares of intergovernmental transfers, and we apply a simulation analysis of our model for the case of Mexico. The main outcomes of this paper are as follows: First, we provide optimal shares of intergovernmental funds to be allocated in each state considering the regional distribution of the benefits of local public spending in Mexico. Second, our analysis shows that the regional heterogeneity of preferences across regions should be an important determinant of federal funds allocated to state governments. Third, the current system of finance relies on a tax revenue sharing accord that emphasizes nationwide tax collection issues as the main determinants of intergovernmental transfers and local spending. Our analysis provides a contrast between how fiscal policy is conducted, and feasible choices of policy reform. Fourth, our analysis of simulation identifies winners and losers from policy reform, and so our analysis contributes to a better understanding of the advantages and shortcomings of the current policy of intergovernmental transfers, providing feasible ways to improve the outcomes of subnational government spending.

Keywords: intergovernmental transfers; fiscal federalism; income distribution; efficiency; heterogeneity of preferences

JEL Classification: H7; H77; O15; H21

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1. Introduction

State governments in Mexico depend in a significant way on the intergovernmental transfers from the central government, since these transfers represent, approximately, 84% of the total public revenue of state governments. Some intergovernmental transfers in Mexico, called "participaciones", are assigned to states using a linear formula that takes into account the growth of the general fund of resources collected by different taxes in Mexico, the evolution over time of gross domestic product in each locality, and the evolution over time of tax revenue collection in each locality. Intergovernmental transfers can also be discretionary through specific agreements or "convenios", and therefore intergovernmental transfers are likely to be motivated by the electoral and political concerns of policy makers.

This suggests that the intergovernmental transfers that finance the vast majority of local public spending in Mexico are not necessarily determined by the regional distribution of social benefits associated with local public spending in Mexico. However, most theoretical normative models suggest that Pareto efficient allocations should be correlated with the regional distribution of the social marginal benefits of local public spending. Since the finance of important goods and services provided by state governments, such as education, health services, local infrastructure, and anti-poverty programs, is highly dependent on intergovernmental transfers in Mexico, it is relevant to ask: what should be the optimal way to allocate intergovernmental transfers to state governments?

The normative theory of public spending and taxation is the relevant framework to answer this important question of policy design. This theory assumes that policy is

designed to maximize a social welfare function that incorporates, in a coherent way, the preferences of the society in terms of local public spending (see Atkinson and Stiglitz 1972, 1976, and more recently Saez and Stantcheva 2016). In addition, the literature on fiscal federalism (see Oates 1972; Boex and Martinez-Vazquez 2007; Boadway 2007; Boadway and Shah 2007, among many others) has emphasized that, in economies with central, state, and local governments, the design of fiscal policy should recognize the regional heterogeneity of preferences for public goods. In other words, there are localities in which individuals prefer high or low public spending, and therefore, the resources allocated for public spending should correspond with the preferences of residents in each locality.

International empirical evidence also suggests that the regional heterogeneity of preferences is an important determinant of subnational public spending (see Hankla et al. 2019). In empirical studies, the heterogeneity of preferences is approximated by the sociodemographic characteristics of residents in each region. In particular, the evidence suggests that localities with a higher proportion of women, elder people, educated residents, or minorities are correlated with localities with high subnational public spending (see for example Holsey and Borcherding (1997); Ferris (1983); Bergstrom et al. (1982), among many others).

As such, theory and international empirical evidence suggest that the heterogeneity of preferences is an important determinant of intergovernmental transfers. To further explore this idea, we develop a theoretical model in which we characterize explicit rules for the optimal allocation of federal funds to state governments. Our theoretical analysis contributes to the literature by focusing on the regional distribution of social weights of households in the social welfare function as a relevant determinant of policy design. These social weights represent the principles of policy design of the policy maker, or might also represent the priorities (or objectives) of the policy maker while designing policy. In particular, we develop a full characterization of the regional distribution of social weights by using a function in which these weights are associated with the heterogeneity of preferences of individuals for local public spending.

In addition, we develop a simulation analysis to test the goodness of fit of our theory to the observed proportion of intergovernmental transfers allocated to each state in Mexico. As such, this paper contributes to the literature by providing several interesting insights for the analysis of policy design of intergovernmental transfers in Mexico. First, and as we mentioned before, we provide theoretically calculated shares of intergovernmental funds to be allocated in each state in Mexico, which take into account sociodemographic characteristics, such as the median age, the proportion of women to men, an index of dependency that shows the proportion of dependent or vulnerable individuals in a household, and the per capita income in each state in Mexico.

Second, some of our predicted shares of intergovernmental transfers from our simulation analysis show a surprisingly high correlation with the observed allocation of intergovernmental transfers to state governments in Mexico. Therefore, we conclude that the regional heterogeneity of preferences across regions seem to be an important determinant of federal funds allocated to state governments in Mexico. Third, our results from the simulation analysis might provide a contrast between how fiscal policy is conducted and how fiscal policy could be conducted if intergovernmental transfers match the regional heterogeneity of preferences for public goods. Fourth, our simulation analysis identifies winners and losers from policy reform, contributing to a better understanding of the advantages and shortcomings of the current policy of intergovernmental transfers and the feasible ways to improve the outcomes of subnational government spending.

Our paper is structured as follows: Section 2 provides a literature review. Section 3 develops our theoretical analysis to incorporate how the regional distribution of heterogeneity determines the social weights of households in the social welfare function, and the effects of this on the allocation of intergovernmental transfers to state governments. Section 3 also discusses the data used for the simulation analysis. Section 4 in-cludes the results of our simulation analysis. Section 5 concludes.

2. Literature Review

As mentioned before, the financing of important local goods and services, such as education, health services, local infrastructure, and anti-poverty programs, is highly dependent on intergovernmental transfers in Mexico. As such, our interest is to ask: what should be the optimal way to allocate intergovernmental transfers to state governments in Mexico? There is a large amount of literature on the role of intergovernmental transfers in economies with multiple levels of government. A starting point is the analysis of Oates (1972, 1995), who considers benevolent policy makers and emphasizes the tradeoff between the heterogeneity of preferences for local public goods and the efficiency in the provision of these goods. (There is also a large quantity of literature on the political economy of intergovernmental transfers. However, political economy models are out of the scope of this paper, but the interested reader might consult Khemani (2007) and Borck and Owings (2003)). More recent literature on fiscal federalism has also emphasized that the design of fiscal policy should recognize that the resources allocated for public spending should correspond with the preferences of residents in each locality (see Boex and Martinez-Vazquez (2007); Boadway (2007) and Hankla et al. (2019)).

Another line of research suggests that there could be localities with high tax revenue, and others with scarce access to fiscal resources, implying an unequal ability of local governments to supply local goods and services. In this context, a rationale for the central government is to implement intergovernmental transfers to achieve a more equitable allocation of resources (see Ladd and Doolittle 1982; Boadway and Flatters 1982; Boadway 2006; and Bernd-Spahn 2007, among many others). Feldstein and Wrobel (1998) contend that local governments might fail in redistributing income because households with high income might migrate to localities with low taxes, while low-income households will migrate to those localities with high pro-poor transfers. These types of incentives would make the anti-poverty programs implemented by state and local governments inefficient. As such, intergovernmental transfers could be central for the federal government in implementing a common tax structure and a spending program to fight poverty and reduce the inequality in the distribution of income, while eliminating the incentives of regional migration caused by differentiated local taxes and spending.

Many others have emphasized that an important rationale for intergovernmental transfers is to achieve a more efficient allocation of resources by avoiding excessive tax and the spending competition of subnational governments, and by incorporating the spillover effects of local spending. For instance, Boadway and Flatters (1982); Smart (1998) and Bucovetsky and Smart (2006) argue that taxes and spending under fiscal decentralization lead to excessive deadweight costs from tax competition among local governments. Instead, tax and spending policies formed by the central government could reduce the coordination failures associated with decentralized tax and spending policies, and provide a more efficient tax and spending system that avoids wasteful tax and spending competition.

In addition, the decentralized provision of local public goods with interregional spillovers will produce suboptimal local public goods, because state and local governments have no incentives to incorporate the interregional spillovers from local public spending (for arguments in favor of subnational governments providing local public goods, see Hankla et al. 2019). In this case, the central government should design a system of Piguvian taxes and transfers to achieve a Pareto efficient allocation of resources.

The analysis of this paper is more closely concerned with the issues of efficiency studied in the literature of fiscal federalism. To the best of our knowledge, the paper that is the closest to our analysis is the one conducted by Rodríguez and Rodríguez (2019). They study the role of intergovernmental transfers in Mexico, but their focus is primarily on equity in the allocation of resources, while in this paper we focus on efficiency, since we incorporate the role of the heterogeneity of preferences for local public goods as the main determinant of intergovernmental transfers and the size of local public spending. Our analysis contributes to the literature by offering a theoretical model that seeks to explain the optimal allocation of intergovernmental transfers.

The most important distinction of our analysis from the existing theory is that, while the literature focuses on the role of the preferences and constraints of households as the main determinants of intergovernmental transfer (as we also do in this paper), at the center of our analysis is the role of the regional distribution of social weights of households in the social welfare function of policy makers. (To the best of our knowledge, Atkinson and Stiglitz (1972) offered the first analysis of the role of the distribution of social weights in the social welfare function. However, they applied this analysis to the study of optimal taxation, while we focus our analysis on intergovernmental transfers and the size of local public spending. In addition, our simulation is applied for economies such as the Mexican one, where there is a great deal of fiscal centralization.) These social weights represent the relative importance of the wellbeing of families in policy design. To see this, note that the wellbeing of a household in some locality might have a higher weight in the social welfare function than the wellbeing of another household in another locality, because these weights might represent some principles of policy design (such as equity and efficiency). Since the distribution of social weights of households in the social welfare function might represent one of the interests of policy makers, these weights could be consequential in the design and reform of policy.

In addition, we calibrate our theoretical model with real data from the Mexican economy, and this exercise yields interesting insights for the analysis of policy reform of intergovernmental transfers in Mexico. First, by using real data from the Mexican economy we can calculate the optimal shares of intergovernmental transfers for several cases of interest. Our results show a surprisingly high correlation of our predicted shares of intergovernmental transfers with the real allocation of intergovernmental transfers to state governments in Mexico. These findings suggests that the regional heterogeneity of preferences across regions seems to be an important determinant of the federal funds allocated to state governments in Mexico.

Moreover, the predicted shares of transfers from our model provide a contrast between how fiscal policy is conducted and how fiscal policy could be reformed if intergovernmental transfers reflect more closely the regional heterogeneity of preferences for public goods in Mexico. Finally, our predicted shares give us an idea of who would benefit from and who would lose out as a result of feasible policy reforms. This could contribute to a better understanding of the advantages and shortcomings of the current policy of intergovernmental transfers, and provides feasible ways to improve the outcomes of subnational government spending.

3. Methodology

3.1. The Model

The preferences and budget constraints of an individual living in locality $i = 1, 2 \ldots . I$ are characterized by the utility function of a representative household living in the locality. The preferences are characterized by $\mu_i = x_i + \beta_i ln(g_i)$, where x_i is a private good, g_i is a public good provided in locality i, and $\beta_i > 0$ is a parameter measuring the intensity of preferences for the public good (the higher the value of β_i, the higher the marginal utility of local public spending for the representative household living in locality i). The budget constraint of the representative household in locality i is $x_i = e_i(1 - \tau_i)$, where e_i is an endowment and τ_i is proportional income tax. The indirect utility of this individual is given by $v_i(e_i, \tau_i, g_i) = e_i(1 - \tau_i) + \beta_i ln(g_i)$. The population size in each of the localities is given by $N_i \; \forall i$.

We consider an economy fiscally centralized in which there is a central government and I local governments. Spending and taxing decisions are determined by the central government, while local governments are simple administrators of the provision of the public good in their localities. The central government collects tax revenue from all regions of the country by imposing a uniform proportional income tax $\tau_i = \tau \; \forall i$ and determines intergovernmental transfers, denoted by T_i, to finance local public goods in all regions. As such, $T_i = g_i \; \forall i$.

The central government selects the regional distribution of intergovernmental transfers $\{T_1, T_2, \ldots..T_I\}$ and the proportional income tax τ to maximize a nationwide social welfare function $\Psi = \sum_{i=1}^{I} \Phi_i \Psi_i$, which is a weighted sum of the welfare of residents of each locality, indexed by $i = 1, 2 \ldots .I$, and $\Psi_i = N_i\, v_i(e_i, \tau_i,\ T_i)$ is the social welfare of locality i. In the nationwide social welfare function Ψ, the parameter $\Phi_i > 0$ is the social marginal utility of the representative household living in locality i. This social weight shows the importance, for the policy maker, of a household living in locality i with endowment e_i in the society, and therefore, it might reflect the priorities (or objectives) of the policy maker in the distribution of net benefits from goods and services provided by subnational governments.

In designing policy, the central government considers the nationwide distribution of social benefits of local public goods and the nationwide social welfare costs associated with taxation. The government faces the following trade-offs in the design of intergovernmental transfers: On the one hand, a marginal increase in the income tax implemented by the central government reduces the private consumption of all residents in the economy. This constitutes a social marginal cost. On the other hand, the government collects tax revenue and redistributes resources in the economy through intergovernmental transfers that finance local public goods in the economy. This is the social marginal benefit. In the optimal level of intergovernmental transfers in locality i, there is equilibrium, whereby the social marginal benefit of increasing local public spending in locality i is equal to the social marginal costs of taxation. The other trade-off for policy design is that the central government allocates resources through intergovernmental transfers, taking into account that USD 1 allocated in locality i has an opportunity cost equivalent to the marginal benefits of local public goods in neighbor localities.

Following our previous description of the welfare calculus of policy design, Figure 1 shows the social marginal cost of federal taxes and the social marginal benefit of intergovernmental transfers allocated in locality i. (In the Appendix A, Proposition A1 shows that, in our model, the social marginal costs are constant (see condition (A4) in Proposition A1 of the Appendix A) and the social marginal benefits are decreasing (see condition (A3) in Proposition A1 of the Appendix A).) Figure 1 also shows that the net fiscal incidence (a measure of the benefit–cost analysis of local public spending) is positive, that is, the net surplus from allocating intergovernmental transfers is the area of consumer surplus above the social costs of T_i^* (which is the squared area that is obtained by multiplying the social marginal costs by T_i^*).

As such, the problem of tax and intergovernmental transfer policy design is given by:

$$Max_{\{T_1, T_2, \ldots..T_I\}, \tau} \quad \Psi = \sum_{i=1}^{I} \Phi_i \Psi_i \tag{1}$$

$$s.t:\ i)\ \Psi_i = N_i v_i(e_i, \tau_i,\ g_i) \tag{2}$$

$$ii)\ \sum_{i=1}^{I} T_i = \tau \sum_{i=1}^{I} N_i e_i \tag{3}$$

$$iv)\ T_i = g_i\ \forall i \tag{4}$$

Equation (1) is the nationwide social welfare, Equation (2) shows the aggregate welfare of residents of locality i, Equation (3) is the budget constraint of the central government, the left-hand side is the total amount of intergovernmental transfers allocated to all subnational governments and the right-hand side is the revenue of the central government derived from income taxation. Equation (4) says that the intergovernmental transfers of the central government finance local public spending in all localities.

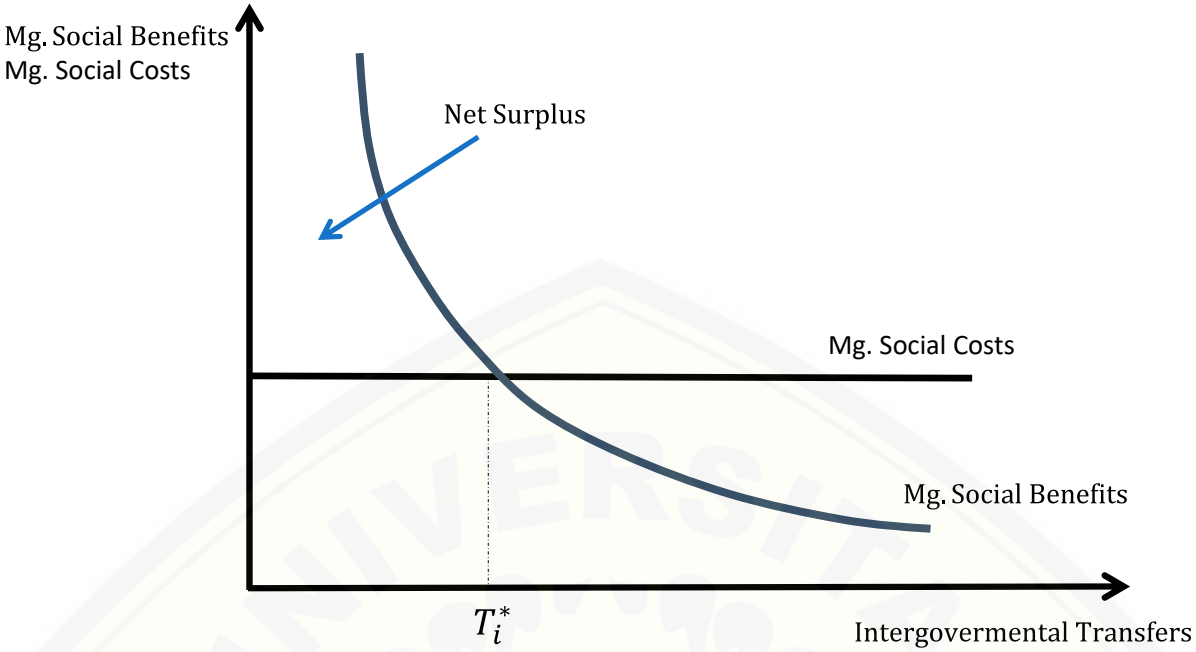

Figure 1. The welfare calculus of intergovernmental transfers.

In what follows, we characterize the equilibrium in the intergovernmental transfers of the central government to subnational governments $i = 1, 2 \ldots I$.

Proposition 1. *The optimal level of inter-governmental transfer to a state government in locality i is given by*

$$T_i^* = \Phi_i N_i \beta_i \left\{ \frac{\sum_{i=1}^{I} N_i e_i}{\sum_{i=1}^{I} \Phi_i N_i e_i} \right\} \forall i = 1, \ldots I \tag{5}$$

Proof. See the Appendix A. □

Proposition 1 says that the optimal allocation of inter-governmental transfers that finance local public spending in locality i depends positively on the country's aggregate income, $\sum_{i=1}^{I} N_i e_i$, and the marginal social utility of local public spending in locality i, $\Phi_i N_i \beta_i$, and depends negatively on the country's weighted aggregate income $\sum_{i=1}^{I} \Phi_i N_i e_i$. The higher the country's aggregate income, the higher the tax revenue of the central government and the higher the intergovernmental transfers that finance public spending in all localities (including locality i). The higher the weighted aggregate income, $\sum_{i=1}^{I} \Phi_i N_i e_i$, the higher the social marginal costs from income taxation, and the lower the public spending in the whole country (including locality i). The higher the social marginal utility of public spending in locality i, $\Phi_i N_i \beta_i$, the higher the social marginal benefits of spending in the locality, and the higher the T_i^*. Note that increases in the social marginal utility of the residents of locality i in the social welfare of the central government, that is, increases in Φ_i, in the size of population of the locality i (N_i), and the intensity of preferences for public goods, β_i, lead to increases in the social marginal utility of public spending in locality i, and consequently, increases in intergovernmental transfers to the locality T_i^*.

3.2. Symmetric Social Weights and the Regional Allocation of Intergovernmental Transfers

In this section, we analyze how the allocation of social weights determines the regional distribution of intergovernmental transfers. The allocation of social weights in the social welfare function might be explained by the preferences (or priorities) of policy makers in terms of the distribution of the regional preferences of citizens for local public goods, the

regional distribution of the population, etc. For our analysis, it is useful to characterize a benchmark outcome in which all households of all localities receive the same weight in the social welfare function of the central government. That is, $\Phi_i = \Phi_j = \Phi \; \forall i \neq j$. This case reflects a symmetry in the way households, living in different regions, are treated by the central government. In this case, the social welfare function of the central government is considered to satisfy the unanimity and symmetry properties, by which all households have the same marginal social utility. (This social welfare function is said to be symmetric because all households have the same marginal social utility in the social welfare function.)

In addition, we will consider another special case in which all households across localities have homogeneous preferences, that is to say, $\beta_i = \beta_j = \beta \; \forall i \neq j$. Although the assumption of the homogeneity of preferences might seem unrealistic, it is relevant because this benchmark equilibrium could be used for comparative purposes for the case of interest in which there is heterogeneity in the preferences for subnational public spending.

Proposition 2. *If $\Phi_i = \Phi_j = \Phi \; \forall i \neq j$ then the optimal allocation of intergovernmental transfers is given by*

$$T_i^* = N_i \beta_i \; \forall i \tag{6}$$

Proof. Result follows trivially from Proposition 1. □

Proposition 2 shows that in the case in which there is heterogeneity in the preferences of individuals for local public spending across localities, then the optimal allocation of intergovernmental transfers that finances local public spending in all localities depends *only* on the regional distribution of social marginal benefits of local spending in each locality, $N_i \beta_i$. That is to say, localities with higher than average population and higher than average preferences for local public goods, β_i, should receive higher than average transfers, and the size of local public spending should also be higher than the nationwide average.

A special case in Proposition 2 is the case in which there is homogeneity in the preferences of individuals living in different localities. In this case, the optimal allocation of intergovernmental transfers depends *only* on the regional distribution of social marginal benefits of local spending in each locality, which is given by $N_i \beta$. That is to say, localities with higher than average marginal utility of government spending should receive higher than average intergovernmental transfers. In this economy, localities with higher than average population and intensity of preferences for local public goods should receive higher than average transfers, and the size of local public spending should also be higher than the nationwide average.

3.3. The Regional Distribution of Preferences, Household's Weights in the Social Welfare Function and Intergovernmental Transfers

The literature on public economics suggests that the heterogeneity of preferences for subnational spending is an important determinant of the demand of individuals for government spending (see Oates 1972). The basic idea is that different regions might have different intensities of preferences for local public goods. Localities with residents with higher than average marginal utilities from public spending (in our model, localities with higher than average values of β_i) will also derive higher than average social marginal benefits from public spending. An optimal allocation of intergovernmental transfers requires that the higher the marginal utility of public spending is in a locality, the higher the transfer should be to that locality, otherwise local public spending would be sub-optimal.

Taking into account the regional distribution of the net fiscal incidence of government intervention, policy makers can assign weights that are positively related with the intensity of preferences in each locality; that is to say, localities with high net fiscal incidence derived from local public goods should be assigned a high social weight in the social welfare function (see Figure 2 and Equation (7)).

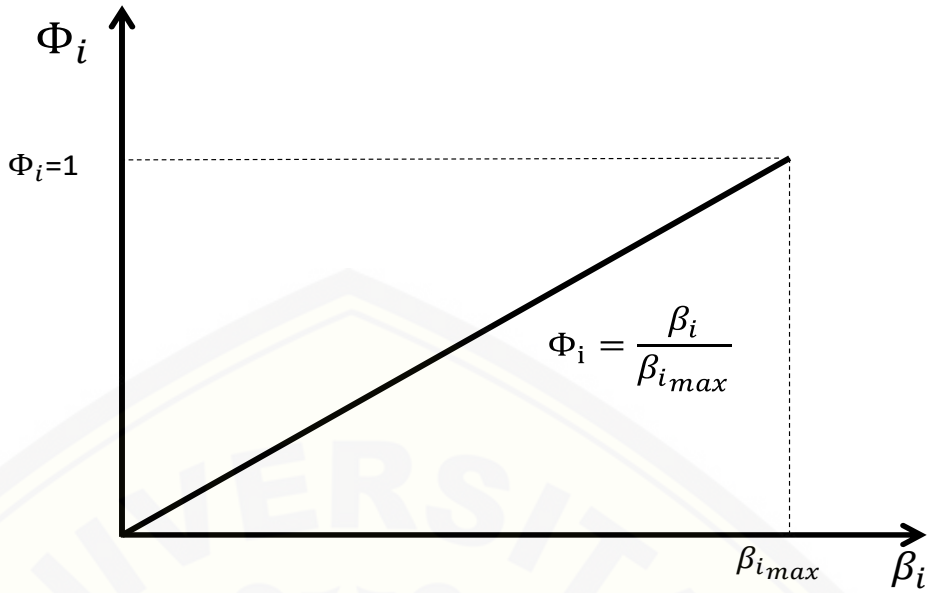

Figure 2. Weights assigned to households' wellbeing in the social welfare function.

To characterize such a possibility, we define the locality with the highest parameter of intensity of preferences for public spending by $\beta_{imax} = Max\{\beta_1, \beta_2 \ldots\ldots \beta_I\}$. In this case, the allocation of weights for each locality Φ_i satisfies the following (see Figure 2):

$$\Phi_i = \begin{cases} \frac{\beta_i}{\beta_{imax}} & \forall\ \beta_i \leq \beta_{imax} \\ 0 & \forall\ \beta_i > \beta_{imax} \end{cases} \tag{7}$$

We also define $E_h(\beta_i) = \sum_{i=1}^{I} h_i \beta_i$ as the nationwide weighted average of the parameter of intensity of preferences β_i and $h_i(e_i)$, which is the share of income in locality i over the nationwide income, satisfying:

$$h_i(e_i) \in (0, 1] :\ h_i(e_i) = \frac{N_i e_i}{\sum_{i=1}^{I} N_i e_i} \quad \text{and} \quad \sum_{i=1}^{I} h_i(e_i) = 1 \tag{8}$$

In what follows, Proposition 3 characterizes the size of intergovernmental transfers $T^*_{i\beta}$ for a case in which the social weights assigned to the welfare of households are assigned to incorporate the heterogeneity of preferences for local public spending (or equivalently, policy makers assign a high social weight to households from those localities with high net surplus from local public spending), and Proposition 4 compares $T^*_{i\beta}$ with a case in which the policy maker assigns the same social weight to all households, that is, T^*_i.

Proposition 3. *If the allocation of social weights is determined by a regional distribution of preferences given by*

$$\Phi_i = \begin{cases} \frac{\beta_i}{\beta_{imax}} & \forall\ \beta_i \leq \beta_{imax} \\ 0 & \beta_i > \beta_{imax} \end{cases}$$

then the optimal allocation of intergovernmental transfers is denoted by$T^*_{i\beta}$*, such that*

$$T^*_{i\beta} = N_i \beta_i \left\{ \frac{\beta_i}{E_h(\beta_i)} \right\} \forall i \tag{9}$$

where $E_h(\beta_i) = \sum_{i=1}^{I} h_i\beta_i$ *is the nationwide weighted average of the parameter of intensity of preferences for localities and*

$$h_i(e_i) \in (0,1] : \; h_i(e_i) = \frac{N_i e_i}{\sum_{i=1}^{I} N_i e_i} \text{ and } \sum_{i=1}^{I} h_i(e_i) = 1 \tag{10}$$

Proof. See the Appendix A. □

Proposition 3 says that for a case in which the interregional heterogeneity of preferences for local public goods determines the allocation of social weights Φ_i, the distribution of intergovernmental transfers $T^*_{i\beta}$ depends positively on the aggregate intensity of preferences in locality i, $N_i\beta_i$, and on the ratio of the parameter of intensity of preferences of locality i to the nationwide average intensity of preferences in the economy, given by $\frac{\beta_i}{E_h(\beta_i)}$. The higher this ratio in locality i is, the higher the intergovernmental transfers should be to that locality.

Proposition 4 compares $T^*_{i\beta}$ with a case in which the policy maker assigns the same social weight to the welfare of all households, that is, T^*_i.

Proposition 4. *If the allocation of social weights in the social welfare function is determined by a regional distribution of preferences determined by*

$$\Phi_i = \begin{cases} \frac{\beta_i}{\beta_{imax}} & \forall\ \beta_i \leq \beta_{imax} \\ 0 & \forall\ \beta_i > \beta_{imax} \end{cases}$$

and if a locality i satisfies

$$\beta_i \;\geq\; E_h(\beta_i) \quad \textit{then} \quad T^*_{i\beta} \;\geq\; T^*_i \tag{11}$$

Proof. This outcome is derived by comparing $T^*_{i\beta}$ from Proposition 3 and T^*_i from Proposition 2. □

Proposition 4 shows that if policy makers are concerned about the interregional heterogeneity of preferences for local public spending, then those localities with values of β_i higher than $E_h(\beta_i) = \sum_{i=1}^{I} h_i\beta_i$ (that is, the nationwide weighted value of the intensity of preferences for local public spending) will receive higher transfers relative to the situation in which all households have the same interregional social weight in the social welfare function, that is to say, if $\beta_i \;\geq\; E_h(\beta_i)$ then $T^*_{i\beta} \;\geq\; T^*_i$.

3.4. Simulations of Optimal Shares of Intergovernmental Transfers Predicted by Our Theory

In this section, we use our theory to predict the values of shares (proportions) of intergovernmental transfers for each state government in México. Our analysis can be used to identify the advantages and disadvantages of the current system of allocating local public finance in Mexico. In particular, Table 1 shows the different assumptions of how the principles of policy design translate into social weights (see column A), the predictions of our theory for the optimal allocation of intergovernmental transfers (see column B of Table 1), and the implied proportions of intergovernmental transfers in relation to the total amount of resources devoted from the central government to state governments (see column C of Table 1). The shares (or proportions) of intergovernmental transfers are defined as follows: consider T^*_i as the amount of intergovernmental transfers allocated by the central government to the government of state i. The share of intergovernmental transfers in the state is the proportion of the transfer in the locality T^*_i over the total amount of resources for intergovernmental transfers. As such, the share is given by $s^*_i = \frac{T^*_i}{\sum_{i=1}^{I} T^*_i}$,

where $\sum_{i=1}^{I} T_i^*$ is the total amount of resources devoted from the central government to state governments.

Table 1. Social weights and optimal shares of intergovernmental transfers.

Principles of Policy Design	Social Weights (A)	Optimal Transfers T_i^* (B)	Shares of Intergovernmental Transfers $s_i^* = \frac{T_i^*}{\sum_{i=1}^{I} T_i^*}$ (C)
M1. Unanimity and symmetry (equal weights) but there is heterogeneity of preferences	$\Phi_i = \Phi_j = \Phi \ \forall i \neq j$ $\beta_i \neq \beta_j \ \ \forall i \neq j$	$T_i^* = N_i \beta_i$	$s_i^* = \frac{N_i \beta_i}{\sum_{i=1}^{I} N_i \beta_i}$
M2. Weights based on preferences and regional heterogeneity of preferences	$\Phi_i = \begin{cases} \frac{\beta_i}{\beta_{imax}} & \forall \ \beta_i \leq \beta_{imax} \\ 0 & \forall \ \beta_i > \beta_{imax} \end{cases}$	$T_{i\beta}^* = \frac{N_i(\beta_i)^2}{E_h(\beta_i)}$	$s_{i\beta}^* = \frac{N_i(\beta_i)^2}{\sum_{i=1}^{I} N_i(\beta_i)^2}$
M3. Weights based on income and regional heterogeneity of preferences	$\Phi_i = \begin{cases} \frac{e_i}{e_{imax}} & \forall \ e_i \leq e_{imax} \\ 0 & \forall \ e_i > e_{imax} \end{cases}$	$T_{ie}^* = \beta_i N_i e_i \left\{ \frac{\sum_{i=1}^{I} N_i e_i}{\sum_{i=1}^{I} N_i (e_i)^2} \right\}$	$s_{ie}^* = \frac{\beta_i N_i e_i}{\sum_{i=1}^{I} \beta_i N_i e_i}$

We develop a simulation analysis of our theoretical model, and for that purpose we use real data from the Mexican economy to calculate the size and regional distribution of shares of intergovernmental transfers to state governments for the cases in which the central government is concerned about the regional distribution of preferences for local public goods. We also develop a simulation analysis of our theory for a case in which the social welfare function satisfies the properties of unanimity and symmetry (that is to say, all social weights of households are the same, $\Phi_i = \Phi_j = \Phi \ \forall i \neq j$) but there is heterogeneity of preferences (the values of β_i change according to the sociodemographic characteristics of residents of each locality); see model 1, denoted as M1.

Model 2 (denoted as M2, see the second row of in Table 1) assumes that policy makers allocate social weights in the social welfare function according to the intensity of preferences of individuals across localities. A policy maker concerned with maximizing the nationwide welfare will assign a weight that is higher than average to those localities with higher than average net surplus from subnational government spending. In other words, policy makers take into account the intensity of preferences of localities while designing policy. Model 2 uses the sociodemographic characteristics of residents, such as age, gender, proportion of individuals considered vulnerable, etc., to allocate those weights. Model 3 (denoted as M3, see third row in Table 1) also takes into account the heterogeneity of the preferences of residents across localities, but uses the per capita income of residents to approximate the preferences of residents for subnational government spending. As such, the difference between models 2 and 3 is that model 2 uses the sociodemographic characteristics and model 3 uses the per capita income of residents.

For the simulation analysis, we use real data from the Mexican economy, and substitute the relevant parameters on population, the socio-demographic variables that are the proxies for the parameter related to the intensity of preferences for public spending and per-capita income, into the equilibrium conditions shown in Table 1 (see columns B and C). The source of all of our data for the simulation analysis is Instituto Nacional de Estadistica, Geografia e Informatica (INEGI), which is the government's official source of data for economic and sociodemographic information in Mexico. In particular, for our analysis of simulation, we use data on state population for the year 2015 (recall that in our theory state population is given by the parameter N_i), and for the parameter of the intensity of preferences (which is the parameter β_i in our theory), we use real data of the social characteristics of the residents in each state, such as age, gender, education, and the real state per capita gross domestic product for the year 2015 (which in our model is represented by parameter e_i). The basic assumption is that higher preferences for goods and services from the government in a locality should lead to more government spending in the locality. As we mentioned before, international evidence suggests that localities with a higher

proportion of women, elderly people, educated residents, and minorities are correlated with localities with higher subnational public spending (see Ferris (1983), Bergstrom et al. (1982), Holsey and Borcherding (1997), among many others). Many studies find that subnational government spending is a normal good, that is, the higher the state income, the higher the demand for government spending (for a survey analysis on this issue see Holsey and Borcherding 1997).

Table 2 shows the sociodemographic characteristics for the year 2015, which are to be used as proxies for localities with a high demand for local public spending, such as the median age of residents in each state, the index of dependency (which is the number of individuals 60 years old or more and between 0 and 14 years old for each 100 persons), the proportion of women to men, and the per capita state income. Table 2 also shows the state population and its regional distribution (that is, the share of population in the states) and the regional distribution of intergovernmental transfers (that is, the share of intergovernmental transfers allocated to states in Mexico), which is the sum of federal participations and contributions. Table 2 also shows that there is significant variance in the regional distribution of intergovernmental transfers in Mexico, with the state of Mexico receiving 11.3% of federal funds while Baja California Sur receives only 0.86%. The average share of intergovernmental transfers in 2015 was 3.13%.

Table 2. Summary statistics of sociodemographic characteristics of states in Mexico.

State	State Population	Share of Population in States	Median Age	Index of Dependency	Proportion of Women to Men	Per Capita State Income	Share of Intergovernmental Transfers
Average	3,748,077	3.13%	26	53.52	1.05	151,389	3.1%
Standard Deviation	3,153,752	3%	2	5	0.03	116,427	2.2%
Max.	16,225,409	13.53%	33	63.80	1.11	707,942	11.3%
Min.	715,095	0.60%	23	42.30	0.98	55,552	0.86%

In what follows, Figures 3–5 illustrate the significant regional heterogeneity of sociodemographic characteristics in Mexico. For instance, Figure 3 shows the regional distribution of population in Mexico in 2015, Figure 4 shows the index of dependency, and Figure 5 the annual per capita state income in 2015.

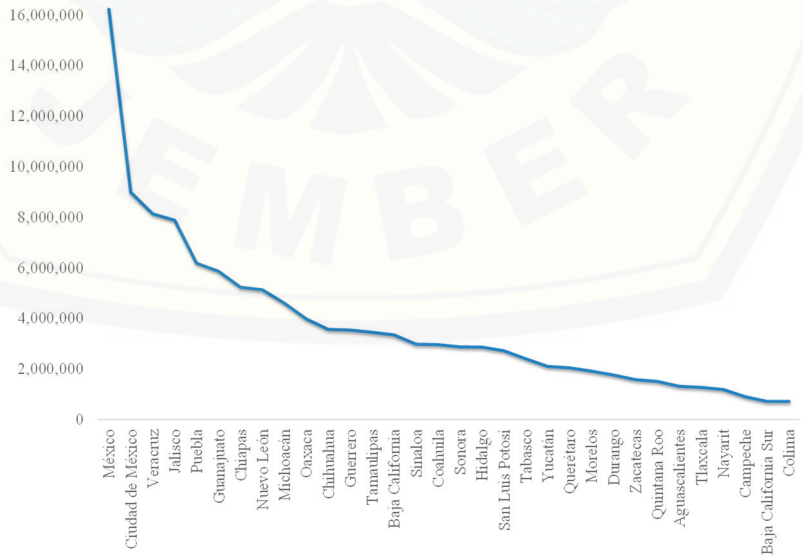

Figure 3. State population 2015 (persons). Source: Instituto Nacional de Estadistica, Geografia e Informatica (INEGI).

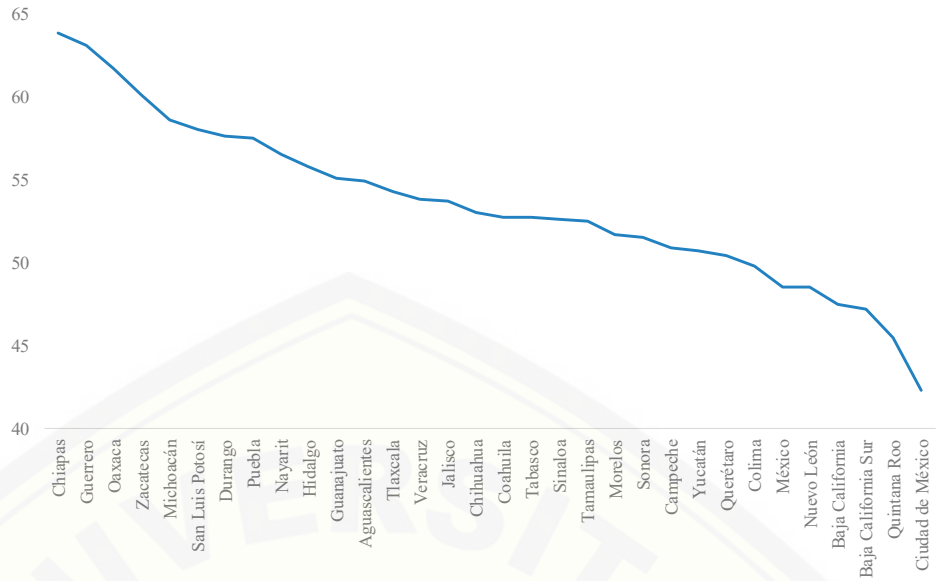

Figure 4. Index of dependency 2015. Source: INEGI.

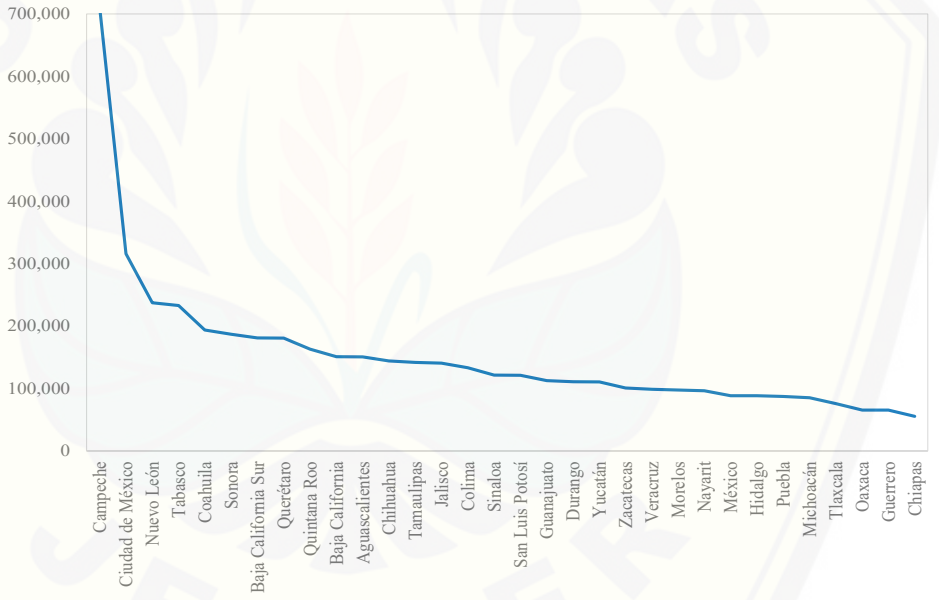

Figure 5. Per capita annual state income, 2015 (pesos). Source: INEGI.

4. Results

In this section we present our results from the simulation analysis of our theoretical models in Table 1 using data on state population N_i, state per capita income e_i, and sociodemographic characteristics, to represent the parameters of the intensity of preferences β_i and the determination of social weights Φ_i. Our simulation analysis provides several interesting insights regarding the optimal allocation of intergovernmental transfers from the central government to state governments in Mexico. First, our M2 model (see second row of Table 1) that considers that social weights can be assigned according to the heterogeneous preferences of individuals over public spending provides shares of intergovernmental transfers that are surprisingly close to the observed data (Figure 6 shows how well our predicted shares of intergovernmental transfers fit the observed data), and suggests that the heterogeneity of preferences across states in Mexico is an important determinant of intergovernmental transfers.

One possible explanation of this high correlation is that the tax structure determining tax revenue, which finances intergovernmental transfers in Mexico, captures the heterogeneity of preferences not through the regional distribution of social benefits from local public spending, but through the linear formula that takes into account the growth of the general fund of resources collected by different taxes in Mexico, the evolution over time of gross domestic product in each locality, and the evolution over time of tax revenue collection in each locality. In addition, intergovernmental transfers that are discretionary, through different specific agreements or "convenios", are likely to be motivated by the electoral and political concerns of policy makers. As such, the political process can be a collective choice mechanism that captures the heterogeneity of the preferences of voters through different state elections in Mexico, and allocates more resources to those states with a high density of population, which is correlated with the proportion of votes that parties might obtain in a nationwide election.

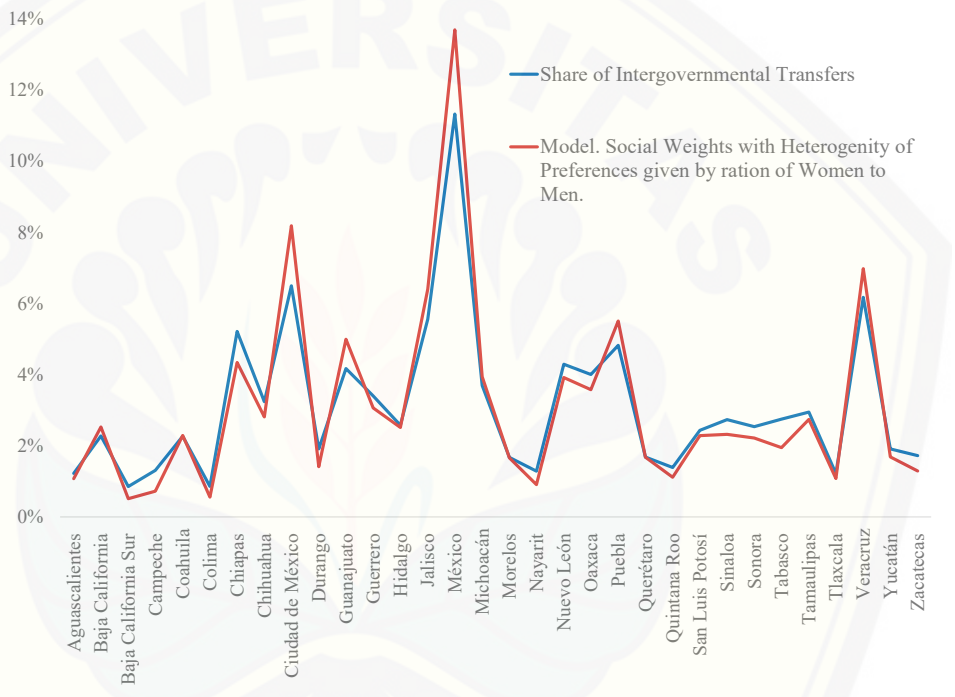

Figure 6. Observed shares of intergovernmental transfers and estimated shares determined by a model with social weights allocated according to the ratio of women to men.

Table 3 (see below) displays the different correlations of our predicted shares with the observed shares of intergovernmental transfers, and shows that the model with the highest correlation with the observed shares of intergovernmental transfers allocated to state governments, equal to 0.99, is the model in which policy makers assign social weights according to the heterogeneity of preferences of residents of each state (see Figure 6 and the fourth column of Table 3), and we use the ratio of women to men as a way to incorporate the heterogeneity of preferences across states. That is, social weights are given by $\Phi_i = \frac{\beta_i}{\beta_{imax}}$, where β_i is the ratio of women to men in state i and β_{imax} is the state with the highest value of the ratio of women to men in the sample (see column 4 of Table 3).

Table 3 also shows that the model in which social weights are the same across localities but in which there is heterogeneity of preferences of individuals for local public spending (that is, the model M1 in Table 3, where social weights are constant for all localities $\Phi_i = \Phi$ but the parameter of intensity of preferences for local public spending across regions is different, that is, $\beta_i \neq \beta_j \; \forall i \neq j$) also has a correlation with the observed shares of intergovernmental transfers equivalent to 0.99 (see column i of Table 3). In particular, for this outcome, we simulate the value of β_i in locality i by considering the index of dependency in each state.

The predicted shares of the model that incorporates the index of dependency to allocate social weights in the social welfare function (see column 2 in Table 3) has a correlation with the observed data of 0.96. This model assumes that policy makers allocate social weights across localities according to $\Phi_i = \frac{\beta_i}{\beta_{imax}}$, where β_i is the index of dependency of state i and β_{imax} is the state with the highest value of index of dependency in the sample. The model that uses the median age of the state to allocate social weights shows a correlation of 0.95 (see column 3 in Table 3). This last model assumes that policy makers allocate social weights of individuals across regions according to $\Phi_i = \frac{\beta_i}{\beta_{imax}}$, where β_i is the median age of residents of state i and β_{imax} is the state with the highest median age in the sample.

Table 3. Correlations of the simulation analysis.

Model M1. Same Social Weights and Heterogeneity of Preferences. Heterogeneity Based on Dependency Index **(1)**	**Model M2. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Dependency Index** **(2)**	**Model M2. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Median Age of Residents** **(3)**	**Model M2. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Ratio of Women to Men** **(4)**	**Model M3. Social Weights Allocated by Per Capita Income and Heterogeneity According to Dependency Index** **(5)**	**Model M3. Social Weights Allocated by Per Capita Income and Heterogeneity According to Median Age** **(6)**	**Model M3. Social Weights Allocated by Per Capita Income and Heterogeneity According to Ratio of Women Over Men** **(7)**
0.99	0.96	0.95	0.99	0.73	0.65	0.71

In summary, our models that consider that social weights can be assigned according to the heterogeneous preferences of individuals over public spending provide shares of intergovernmental transfers with a surprisingly high fit to the observed data, and suggest that the heterogeneity of preferences across states in Mexico is an important determinant of the intergovernmental transfers.

Second, models that incorporate per capita income as a way to allocate social weights in the social welfare function (see model M3 in Table 2 and see columns 5, 6 and 7 in Table 3) show lower levels of correlation with the observed allocation of intergovernmental transfers. That is, models in columns 5, 6 and 7 of Table 3 assume that policy makers allocate social weights of individuals across regions according to $\Phi_i = \frac{e_i}{e_{imax}}$, where e_i is the per capita income of state i and e_{imax} is the state with the highest per capita income in the sample. In addition, models in columns 5, 6 and 7 of Table 3 use the dependency index (see column 5), the median age of residents in each state (see column 6), and the ratio of women to men (see column 7) as a way to estimate the heterogeneity of preferences through parameters of sociodemographic characteristics of residents.

The correlations of predicted shares of models 5, 6 and 7 with observed data on state shares of intergovernmental transfers are, respectively, 0.73, 0.65 and 0.71 (see Table 3). This particular finding suggests that policy makers in the central government might not effectively use the regional inequality in the distribution of income to allocate intergovernmental transfers in Mexico. An important implication of this finding is that our simulation analysis might provide useful predicted shares concerning how optimal intergovernmental transfers should be allocated in Mexico if the relative importance of each state in the social welfare function is associated with per capita income in each state.

Third, our simulation identifies winners and losers from policy reform in which policy makers in the central government incorporate some form of heterogeneity of preferences in the determination of social weights in the social welfare function. To calculate winners and losers from policy reform, we estimate the difference between the implied optimal shares of intergovernmental transfers from our models and the observed shares of intergovernmental transfers in Mexico in 2015. If the central government changes the allocation of intergovernmental transfers from the current allocation system towards assigning the priorities in policy making shown in models 2, 3 and 4 (see Table 3), then the states that would benefit from this change would be states with higher intensities of preferences for local public spending, that is, states with higher than average dependency index, higher than average median age, and higher than average ratios of women to men, because those states are estimated to have higher than average demand for local public spending.

Thus, the states that would receive a higher proportion of intergovernmental transfers would be the state of Mexico, Colima, Jalisco Guanajuato and Veracruz, with an average gain for each state of this group of 1.09 percentage points of the total amount of intergovernmental transfers (see Figures 7–9 and Tables 4 and 5). (Although the states of Mexico and Colima lose under the implied allocations in model M2, where weights are allocated according to the heterogeneity of preferences based on dependency index (see model 2 in Table 4), these states have net gains under the implied shares of model M2 with weights assigned according to median age of residents (see model 3) and gender (see model 4).) States that would lose resources are Ciudad de Mexico, Tabasco, Campeche, Durango, and Coahuila, with an average loss for each state of this group of −0.56 percentage points of the total amount of intergovernmental transfers. These outcomes are explained by the regional distribution of sociodemographic characteristics of residents in each locality. States with higher than average values of the sociodemographic characteristics (such as higher than average values of the dependency index, the median age of residents in each state, and the ratio of women to men) would obtain higher shares of intergovernmental transfers.

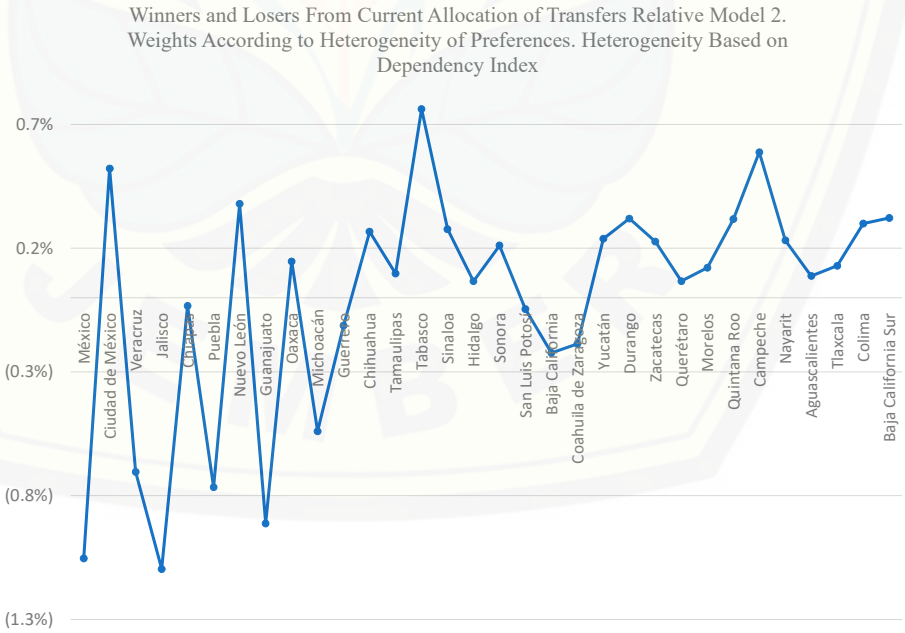

Figure 7. Winners and losers from policy reform using the heterogeneity of preferences in the determination of social weights in the social welfare function.

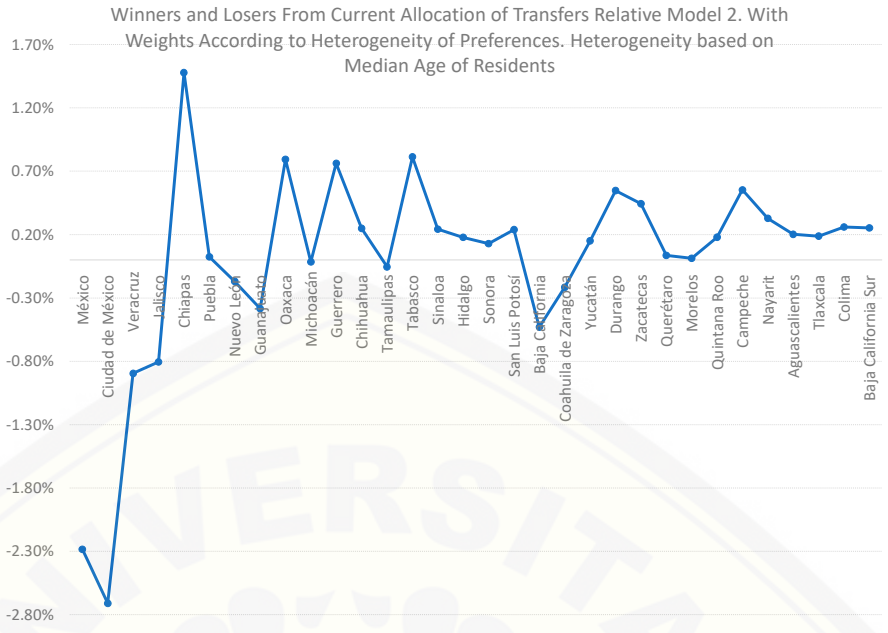

Figure 8. Winners and losers from policy reform using the heterogeneity of preferences in the determination of social weights in the social welfare function.

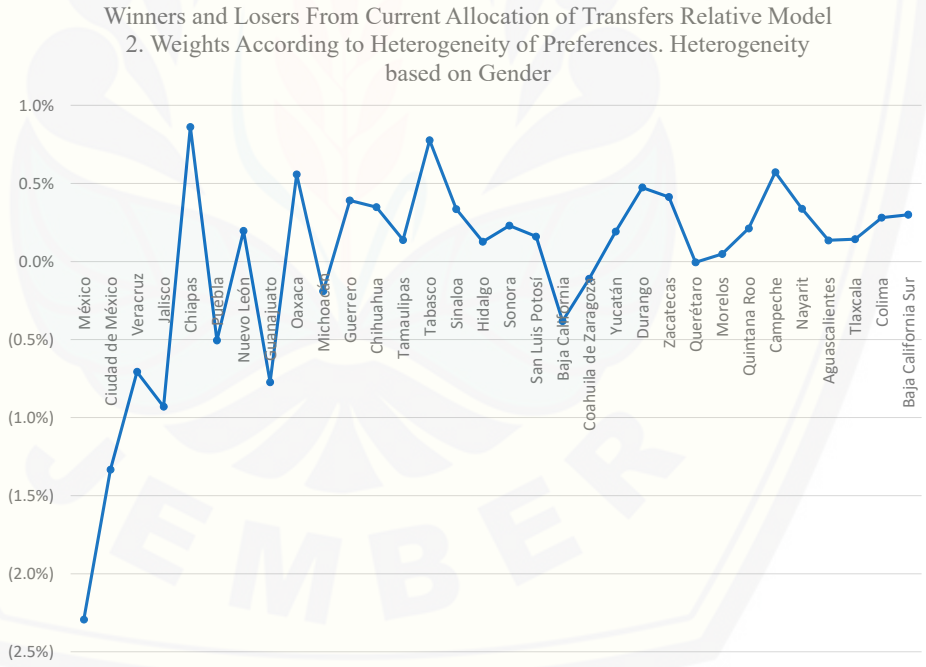

Figure 9. Winners and losers from policy reform using the heterogeneity of preferences in the determination of social weights in the social welfare function.

Table 4. Main winners of a change from the current system of intergovernmental transfers towards assigning households weights based on heterogeneity of preferences.

State	Model M2. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Dependency Index (2)	Model M2. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Median Age of Residents (3)	Model M2. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Gender (4)	Average Gains Models (2), (3), (4)
México	−0.1%	2.3%	2.4%	1.5%
Colima	−1.8%	4.7%	1.7%	1.6%
Jalisco	1.1%	0.6%	0.8%	0.8%
Guanajuato	1.1%	0.0%	0.8%	0.6%
Veracruz	0.7%	1.2%	0.8%	0.9%
Puebla	1.2%	−0.4%	0.7%	0.5%

Table 5. Main losers of a change from the current system of intergovernmental transfers towards assigning Households weights based on heterogeneity of preferences.

State	Model. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Dependency Index (2)	Model. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Median Age of Residents (3)	Model. Weights According to Heterogeneity of Preferences. Heterogeneity Based on Gender (4)	Average Loss Models (2), (3), (4)
Zacatecas	−0.04%	−0.49%	−0.43%	−0.32%
Coahuila	−0.30%	−0.25%	−0.43%	−0.33%
Durango	−0.20%	−0.65%	−0.50%	−0.45%
Campeche	−0.62%	−0.55%	−0.59%	−0.59%
Tabasco	−0.79%	−0.89%	−0.80%	−0.83%
Ciudad de México	1.03%	−2.03%	−0.87%	−0.62%

Fourth, if the central government changes the allocation of intergovernmental transfers according to the priorities of policy design displayed by models 5, 6 and 7 (see Table 3), that is, policy makers use per capita state income in the determination of social weights in the social welfare function, then the states that would benefit from this change would be those states with higher than average per capita income, along with higher than average dependency index, higher than average median age, and higher than average ratios of women to men, because those states are estimated to have higher than average demand for local public spending. As such, the states that would receive a higher proportion of intergovernmental transfers are Colima, Nuevo Leon, Campeche, Chiapas and Jalisco, with an average gain for each state in this group of 3.72 percentage points of the total amount of intergovernmental transfers (see Figure 10). The states that would lose resources would be Ciudad de Mexico, State of Mexico, Oaxaca, Guerrero, and Puebla, with an average loss for each state in this group of −2.4 percentage points of the total amount of intergovernmental transfers.

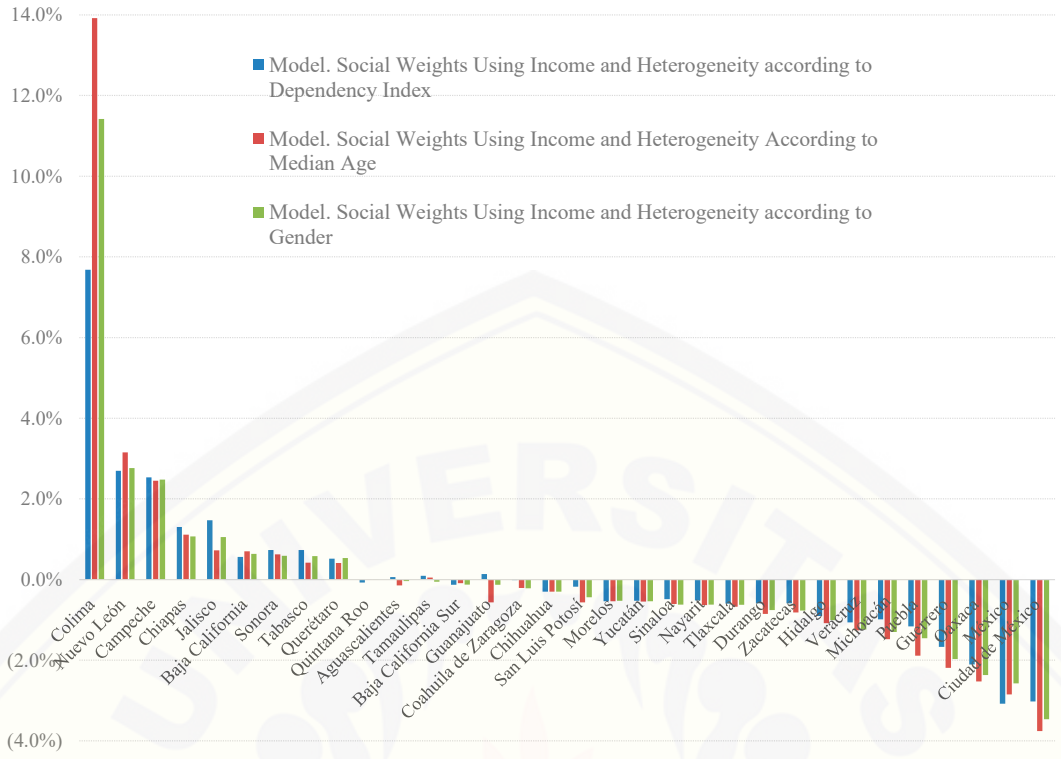

Figure 10. Winners and losers from policy reform towards using the per capita state income in the determination of social weights in the social welfare function.

Finally, it is worth noting that our analysis considers mainly the fiscal structure of the Mexican economy, and it does not incorporate many political institutions and fiscal structures used globally. For this reason, the model presented here should be expanded by taking into account specific political and fiscal institutions considered in other countries if we are interested in applying this model for other economies. However, it is also noteworthy that our model could be applied for those economies with a significant degree of fiscal centralization.

5. Conclusions

In this paper, we develop a theory of the optimal allocation of intergovernmental transfers and a simulation analysis that provide shares of intergovernmental transfers to be allocated to state governments in Mexico. The optimal allocation of intergovernmental transfers is a particularly important piece of fiscal policy in Mexico, due to the fact that there is high fiscal centralization in Mexico's economy, and important goods and services provided by all levels of government in localities are financed through intergovernmental transfers. This paper contributes to the theoretical literature on the optimal design of intergovernmental transfers by developing a theory that incorporates a regional distribution of social weights in the social welfare function of policy makers. The determination of social weights might show principles of equity and efficiency in policy design or the priorities of policy makers while designing intergovernmental transfers. In this paper we focus only on issues of efficiency.

These principles or priorities of policy makers might be reflected in the formula for the allocation of intergovernmental transfers, and in the discretionary allocation of federal funds to different localities. Here, our analysis contributes to the literature by providing exact optimal rules to determine federal funds assigned to state governments in Mexico. In particular, we argue that social weights in the social welfare function might be associated with the regional distribution of preferences for local public spending, which, in our model, are determined by the sociodemographic characteristics of residents of states, such as age, gender, the proportion of dependents in a household (proportion of individuals with ages

less than 14 years old and older than 65 years old), and per capita income of residents in each state.

In this paper we also develop a simulation analysis that contributes to the literature in several ways. First, our calculations based on our simulation model suggest that the regional heterogeneity of preferences across regions seem to be an important determinant of federal funds allocated to state governments in Mexico. Second, we provide a contrast between how fiscal policy is conducted and how fiscal policy might be conducted, to recognize the regional distribution of benefits and costs from local public spending in order to maximize the nationwide welfare in Mexico. Third, our simulation provides a set of winners and losers from a policy reform in which policy makers in the central government incorporate some form of heterogeneity of preferences in the determination of social weights in the social welfare function. As such, our analysis contributes to a better understanding of the advantages and shortcomings of the current policy of intergovernmental transfers, and feasible ways to improve the outcomes of subnational government spending.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Proposition A1. *The optimal allocation of intergovernmental transfers to the subnational government in locality i is given by*

$$T_i^* = \Phi_i N_i \beta_i \left\{ \frac{\sum_{i=1}^{I} N_i e_i}{\sum_{i=1}^{I} \Phi_i N_i e_i} \right\} \forall i \tag{A1}$$

Proof. The problem of policy design can be stated as follows:

$$\delta = \sum_{i=1}^{I} \Phi_i N_i \{ e_i(1-\tau) + \beta_i ln(T_i) \} + \lambda \left\{ \tau \sum_{i=1}^{I} N_i e_i - \sum_{i=1}^{I} T_i \right\} \tag{A2}$$

where λ is a Lagrange multiplier. The first order conditions are:

$$\frac{\partial \delta}{\partial T_i} = \frac{\Phi_i N_i \beta_i}{T_i^*} - \lambda^* = 0 \quad \forall\, T_i^* > 0 \tag{A3}$$

$$\frac{\partial \delta}{\partial \tau} = -\sum_{i=1}^{I} \Phi_i N_i e_i + \lambda^* \sum_{i=1}^{I} N_i e_i = 0 \quad \forall\, \tau^* > 0 \tag{A4}$$

$$\frac{\partial \delta}{\partial \lambda} = \tau^* \sum_{i=1}^{I} N_i e_i - \sum_{i=1}^{I} T_i^* = 0 \quad \forall\, \lambda^* > 0 \tag{A5}$$

Rearrange the first order conditions to show that

$$T_i^* = \Phi_i N_i \beta_i \left\{ \frac{\sum_{i=1}^{I} N_i e_i}{\sum_{i=1}^{I} \Phi_i N_i e_i} \right\} \quad \forall i \tag{A6}$$

□

Proposition A2. *If the allocation of social weights is determined by a regional distribution of preferences given by*

$$\Phi_i = \begin{cases} \frac{\beta_i}{\beta_{imax}} & \beta_i \leq \beta_{imax} \\ 0 & \forall\, \beta_i > \beta_{imax} \end{cases} \tag{A7}$$

then the optimal allocation of intergovernmental transfers is denoted by $T_{i\beta}^*$ *such that*

$$T_{i\beta}^* = N_i \beta_i \left\{ \frac{\beta_i}{E_h(\beta_i)} \right\} \quad \forall i \tag{A8}$$

where $E_h(\beta_i) = \sum_{i=1}^{I} h_i \beta_i$ *is the nationwide weighted average of the parameter of intensity of preferences* β_i and

$$h_i(e_i) \in (0, 1] : \; h_i(e_i) = \frac{N_i e_i}{\sum_{i=1}^{I} N_i e_i} \tag{A9}$$

Proof. From Proposition A1, the optimal level of intergovernmental transfers is given by:

$$T_i^* = \Phi_i N_i \beta_i \left\{ \frac{\sum_{i=1}^{I} N_i e_i}{\sum_{i=1}^{I} \Phi_i N_i e_i} \right\} \forall i \tag{A10}$$

If priorities in policy are determined by social weights that reflect a concern over the interregional distribution of preferences for local public spending, such that

$$\Phi_i = \begin{cases} \frac{\beta_i}{\beta_{imax}} & \forall\, \beta_i \leq \beta_{imax} \\ 0 & \beta_i > \beta_{imax} \end{cases} \tag{A11}$$

then use $\Phi_i = \frac{\beta_i}{E_{max}(\beta_i)}$ $\forall i$ to show that $T_{i\beta}^*$ is given by:

$$T_{i\beta}^* = \frac{\beta_i}{\beta_{imax}} N_i \beta_i \left\{ \frac{\sum_{i=1}^{I} N_i e_i}{\sum_{i=1}^{I} \left\{ \frac{\beta_i}{\beta_{imax}} \right\} N_i e_i} \right\} \forall i \tag{A12}$$

equivalent to

$$T_{i\beta}^* = \beta_i N_i \beta_i \left\{ \frac{\sum_{i=1}^{I} N_i e_i}{\sum_{i=1}^{I} \beta_i N_i e_i} \right\} \forall i \tag{A13}$$

Note that we can define $h_i(e_i)$ as the share of income in locality i from the nationwide income, in the following way:

$$h_i(e_i) \in (0, 1] : \; h_i(e_i) = \frac{N_i e_i}{\sum_{i=1}^{I} N_i e_i} \; \wedge \; \sum_{i=1}^{I} h_i(e_i) = 1 \tag{A14}$$

and define $E_h(\beta_i)$ as the nationwide weighted average of the parameter of intensity of preferences β_i such that

$$E_h(\beta_i) = \sum_{i=1}^{I} h_i \beta_i \tag{A15}$$

Use the former condition in $T^*_{i\beta}$ to show

$$T^*_{i\beta} = N_i\beta_i \left\{ \frac{\beta_i}{E_h(\beta_i)} \right\} \forall i \tag{A16}$$

□

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Digital Leadership in the Economies of the G20 Countries: A Secondary Research

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Abstract: Digitalization in leadership practice requires broader research. Today's economic leaders must be in line with the global mindset in supporting a culture of innovation. The purpose of this study is to investigate the digital leadership capabilities of the G20 countries in terms of digital readiness, innovation, and competitiveness 4.0 and to determine the relationship between these variables. The global digital readiness index 2019 (Cisco 2020) was utilized to obtain data on digital readiness (X), the global innovation index (Cornell University et al. 2019) was applied for the data collection on innovation (Y1), and the global competitiveness 4.0 index (WEF 2019) was used to obtain data on competitiveness 4.0 (Y2). All data were cross-sectional for the year 2019. Digital readiness consists of basic needs, human resources, ease of doing business, business and government investment, start-up environment, technology infrastructure, and technology adoption. The components of innovation are institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs. Competitiveness 4.0 is about institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamism, and innovation capability. We found that G20 countries had the digital leadership capability in digital readiness, innovation, and competitiveness 4.0. The G20 countries were leaders in global digitalization. Some of them were consistent in digital readiness and innovation. Some were consistent in digital readiness and competitiveness 4.0, and some others were consistent in their 4.0 innovation and competitiveness 4.0. Digital readiness, innovation, and competitiveness 4.0 positively related to each other.

Keywords: digital leadership; digital readiness; innovation; competitiveness 4.0; G20; secondary research

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1. Introduction

Victory in an economy cannot be separated from the leadership success that exists inside. It depends on the digital capabilities of the countries' economies. Economic activities and globalization are broadly inseparable from the existence of digitalization (Strielkowski et al. 2020; Abdurakhmanova et al. 2020; Borremans et al. 2018). However, most of the research on digital leadership investigated at the microeconomic level. There were over 2,000,000 documents on Google Scholar when we put "digital leadership" as keywords. Scopus showed more than 2000 results, and there were more than 1000 in Web Science. In addition, there were more than 500,000,000 on the Google search engine. The literature on economic leadership remains relative and general in the 21st century (Wang and Torrisi-Steele 2017). Thus, research on digital leadership on a macroeconomic scale is vital to understand leadership knowledge more broadly.

Flexibility in responding to digitalization is a measure of the success of global businesses that will encourage the revival of the countries' economies (Shkarlet et al. 2020). Business actors use supporting infrastructures that include resources and management using computer networks (Barefoot et al. 2018). It is a solution to economic problems in creating product-oriented efforts (Watanabea et al. 2018). Internet penetration and a high degree of digitization of device usage are prerequisites for its development (Nagy 2017). Through asymmetric information and the agency relations (Veselovsky et al. 2018), digitalization brought a significant technological change in the economy (Curran 2017).

Digital development is a demanding aspect for all economies to maintain their leadership positions (Gapsalamov et al. 2020). The G20 is an international forum that brings together the world's major economies. Its members account for more than eighty percent of the world's GDP, seventy-five percent of global trade, and sixty percent of the world's population. This forum has been conducting meetings annually since 1999. The innovations made by the G20 forum, either individually or collectively, have tremendous implications for global outcomes. Its members are the big producers of technology and drivers of digitization as well as education. In total, they account for nearly 95 percent of all investment in research and development. Nearly 90 percent of all scientific publications on artificial intelligence came from members of the G20. The opportunities and challenges posed by digital transformation and subsequent production revolution technologies increase the importance of policies that can help world countries take advantage of these new technologies at risk (OECD 2019). Understanding the leadership capabilities of the G20 countries is vital. G20 countries must be ready to engage in digitalization. They must also be innovative and competitive.

After the global crisis, the process of deglobalization has intensified and has raised questions about which countries will be the world economic leaders. The global leadership change in the economy means a profound rearrangement of economic systems (Shavshukov and Zhuravleva 2020). An economy with low digitization tends not to be psychologically empowering (Zeike et al. 2019), because digital leadership is a combination of digital culture and digital competence. Thus, the digitalization of business processes and changes in leadership practices are factors that must be taken into account more seriously today (Jakubik and Berazhny 2017). Economic leadership must be in line with a global mindset and be more creative in supporting the culture of innovation (Mihardjo et al. 2019). After focusing on increasing productivity, efficiency, and profitability, all economic leaders realize that the approach and culture in leading must adapt (Bolte et al. 2018). Digital leadership strongly encourages market orientation in the economy (Sasmoko et al. 2019). It generates knowledge about the new digital world, modern technology, and interpersonal skills (Kalashnikov et al. 2019). A clear digital leadership image must be built together with high intrinsic value to grow with technological change (Breuer and Szillat 2019). Digital leadership is also known as e-leadership or virtual leadership (Saputra and Saputra 2020). It is about creating an expanding digital environment that leads to a high level of effectiveness, productivity, and morale (Roman et al. 2018). The digital technology that will disrupt nearly every industry has become a reality. However, it is an economic opportunity (Kane et al. 2016).

Governments around the world are all at different phases of their digital transformation and have varying priorities on their national agendas toward building a digital economy. Agile digital government is the first and foremost essential step in establishing and developing a modern digital economy with comprehensive growth (DGRA—The Foundation of Digital Development, the Core Team 2020). The impact of automation, artificial intelligence, and the Internet of Things (IoT) is felt almost everywhere, in all countries, industries, and everyday life. However, while the impact of digitization is widespread, the benefits it yields are distributed unevenly. This study aims to determine the digital leadership capabilities of the G20 countries in terms of digital readiness, innovation, competitiveness 4.0, and to investigate the relationship between these variables. It explains digital leadership at a macroeconomic scale which is key to economic growth in the G20 countries.

Our paper focuses on digital leadership in the G20 countries in the context of the economy. It is structured as follows: first, the introduction explains a research gap and the linkages between the economy and the digital leadership capabilities of the G20 countries. Second, the literature review describes the definitions and pillars of digital readiness, innovation, and competitiveness 4.0. Third, methodology explains measurement variables, hypotheses, and research design. Fourth, results and discussion elaborates the digital readiness, the innovation, and the competitiveness of the G20 countries globally, the consistency and the correlation between the three variables, and their implications. Last but not least, the conclusion summarizes the discussion concerning the overall objectives of the study. Moreover, it states the limitations of the research that are the niches for future research.

2. Literature Review

All economies are facing challenges for the next generation (Maresova et al. 2018). Regarding the circular economy (Basl and Doucek 2019), digitization, robotization, and automation are the main goals in the industry trend 4.0. Digitalization is a mystery in various fields of study related to industry 4.0 and globalization. Industry 4.0 uses the terms digitization and transformation a lot (Machado et al. 2019) and requires high digital performance measurement by countries to see their maturity in facing this paradigm. Common ideas about digital readiness are scarce, especially in academia. New technology and business have clouded the focus on it (Bican and Brem 2020). Readiness refers to the knowledge, skills, and capabilities of technical infrastructure. It is the guide to digitization for processing and utilizing their resources as efficiently and effectively as possible (Pai et al. 2020). The term "readiness" has also led to innovation (Lokuge et al. 2019). Digital readiness is a strong desire to adopt digital technology to create new opportunities (Debrenti 2020). It is vital for individuals, organizations, industries, and even countries to achieve their economic goals faster and in bigger ways. Digital readiness is indeed a scourge for conventional competitive advantage in the economy (Ertan 2018).

Global innovation connects to local digitalization (Isaac et al. 2019). Digital technology becomes a driver of innovation and modern global economic growth and has contributed to national competitiveness (Nesterova et al. 2018; Sepashvili 2020). Innovation has been the basis for and has created a dependency on the modern competitive economy in economic growth. Territorial competitiveness is the subject of studies in various branches of the economy. In general, competitiveness is the ability to realize a mission (objectives, functions, and tasks) with the quality and value required in a competitive market. Competitiveness refers to the ability to maintain relatively high levels of income and employment while remaining open to international competition (Dmitrieva and Guseva 2019). Being competitive, economic actors must embrace technological innovation's applications (which is also one of the biggest challenges today) and, in parallel, must face the fifth industrial revolution (Manta 2019).

Digital readiness was defined using a holistic model based on seven components, including technological aspects such as technology, infrastructure, and technology adoption, but also measuring the ease of doing business, human capital development, business and government investment, basic human needs, and the start-up environment (Yoo et al. 2018). All countries facilitate digital services for their people equally to be able to develop internally and externally (Florin et al. 2012). Several indices that measure digital readiness are DESI (European Commission), NRI (Portulans Institute), World Economic Forum, DAI (World Bank) DRI (Cisco Systems), DiGiX (BBVA Research), Banco Bilbao Vizcaya Argentaria, GCI (World Economic Forum), and World Economic Forum DB (World Bank). It is also related to the digital maturity index (Zhang et al. 2019), network readiness index, computer information technology development index, cybersecurity index, digital competitiveness index, and digital evolution index (Plutova et al. 2019). National innovation activities have been hindered by the demanding progress and speed of globalization (Lee et al. 2020).

Building our understanding of the factors supporting digital readiness, seven different components to build a complete picture of a county's digital readiness were provided by the Cisco Global Digital Readiness Index 2019. First, basic needs. The true value of technology and infrastructure is delivered through a population's ability to take advantage of it. Second, human capital. The ability to utilize and create advanced digital services is determined in part by the digital skills level within the workforce. Third, ease of doing business. Because human capital skills can only contribute to the economy if people are gainfully employed, having a thriving business ecosystem is another key determinant of a country's digital readiness. Fourth, business and government investment. Building digital infrastructure and capabilities requires significant investment on behalf of both governments and businesses. Fifth, start-up environment. Start-ups create new innovations that can benefit entire markets and communities. Sixth, technology infrastructure. Infrastructure plays a key role in enabling countries to advance digital services. Seventh, technology adoption. The level of technology availability, utilization, and adoption reflects a country's current level of digital readiness. The seven components to measure innovation were provided by Cornell University Global Innovation Index 2019 including institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs. Competitiveness 4.0 were explained by WEF Global Competitiveness Index 2019 consisting of twenty pillars, which are institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamism, and innovation capability.

3. Methodology

The overall objective of this study is to determine the digital leadership capabilities of the G20 countries. Figure 1 show the main variables, which are digital readiness (X), innovation (Y1), and competitiveness (Y2). The seven components of digital readiness are basic needs, human capital, ease of doing business, business and government investment, environment start-ups, technology infrastructure, and technology adoption (Cisco 2020). The seven components to measure innovation are institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs (Cornell University et al. 2019). Competitiveness 4.0 has twenty pillars: institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamism, and innovation capability (WEF 2019).

In pursuit of the purposes, we defined the following specific objectives: objective 1—to determine the consistency between digital readiness and innovation of the G20 countries; objective 2—to determine the consistency between digital readiness and competitiveness 4.0 of the G20 countries; objective 3—to determine the consistency between innovation and competitiveness 4.0 of the G20 countries; objective 4—determine the consistency between digital readiness, innovation, and competitiveness 4.0 of the G20 countries; and objective 5—to determine the relationship between digital readiness, innovation, and competitiveness 4.0. Once these objectives had been established and a review of the existing literature conducted, we formulated the following hypotheses:

Hypothesis 1 (H1). *Digital readiness has a positive relationship with innovation.*

Hypothesis 2 (H2). *Digital readiness has a positive relationship with competitiveness 4.0.*

Hypothesis 3 (H3). *Innovation has a positive relationship with competitiveness 4.0.*

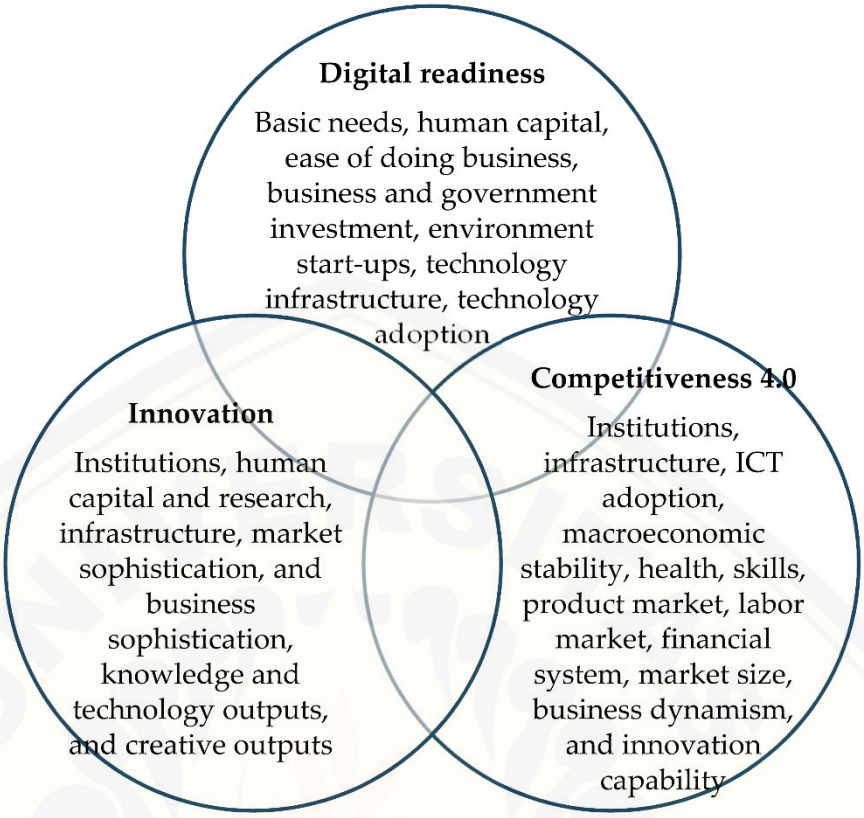

Figure 1. Digital readiness, innovation, competitiveness 4.0.

We followed the Wallace Foundation on secondary research (Workbook B; secondary data analysis). Figure 2 includes four steps in secondary research (Wallace n.d.): identifying the source of information, collecting existing data, normalizing data, and analyzing data. In the first step, the sources of information we used are the global digital Readiness index 2019 (Cisco 2020), the global innovation index 2019 (Cornell University et al. 2019), and the global competitiveness index 4.0 2019 (WEF 2019). We used a cross-sectional approach for the year 2019 data. In the second step, we used the global digital readiness rankings, the global innovation rankings, and the global competitiveness rankings. Based on these data, in the third step, we tabulated a digital rating for global digital readiness, global innovation, and global competitiveness 4.0 for the G20 countries. Next, in the fourth step, we conducted a comparative analysis between the G20 global digital readiness data and the G20 global innovation data, between the G20 global digital readiness data and the global competitiveness 4.0 data, and between the global innovation data and the global competitiveness 4.0 data. This was done to see whether the global digital readiness, global innovation, and global competitiveness ratings showed consistencies. Finally, we conducted a Pearson correlation analysis using SPSS to determine the relationship between the three variables. We used the available scores in the sources of each country based on each variable.

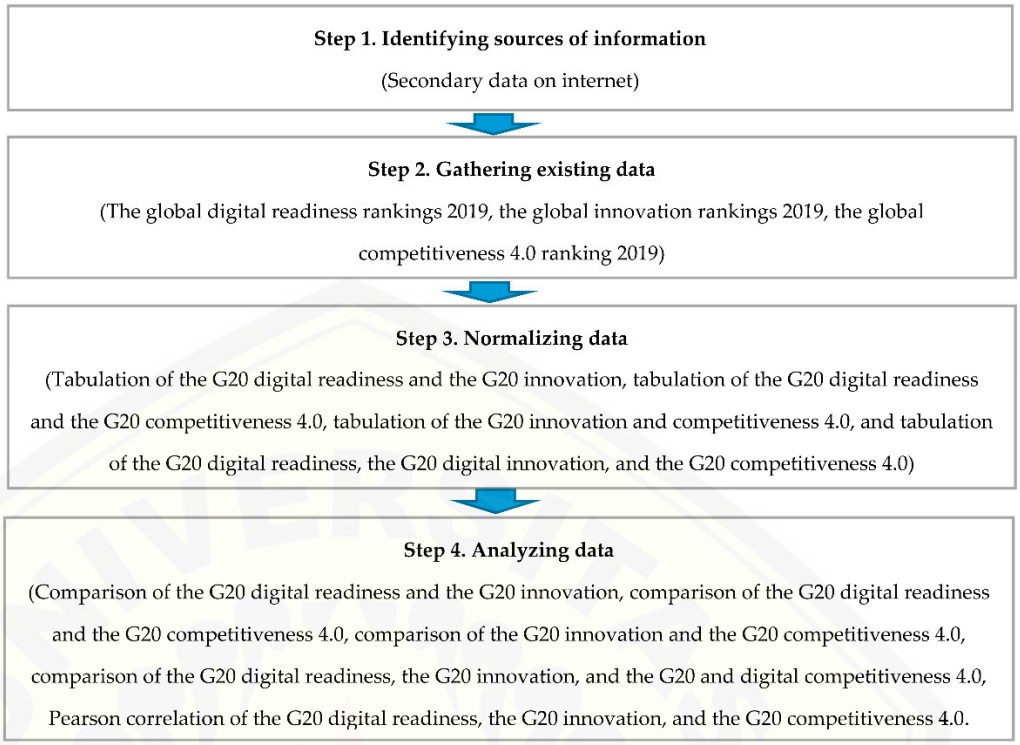

Figure 2. Steps in secondary research (Wallace n.d.).

4. Results and Discussion

4.1. Global Digital Readiness of G20 Countries

This subsection shows the digital readiness score of the G20 countries, a basis for analyzing objective 1 (consistency between digital readiness and innovation), objective 2 (consistency between digital readiness and 4.0 competitiveness), and objective 4 (consistency between digital readiness, innovation, and competitiveness of 4.0). Based on secondary data in the form of scores and stages from the global digital readiness index 2019, we compiled the digital readiness data for the G20 countries as shown in Table 1. Each country had a digital readiness score derived from seven components (basic needs, human resources, ease of doing business, business and government investment, start-up environment, technology infrastructure, and technology adoption). The score determined what stages each country had gone through. Countries in the activate stage were going through the earliest stages of digitalization dynamics with an average digital readiness score of 6.24 out of 25. Countries that were in the accelerate stage were those with average digital readiness scores of 11.82. They had taken several steps forward and had the opportunity to accelerate their digital readiness. In the third stage, amplify, they were the countries with an average digital readiness score of 17.89. They were matured into digital but were not a guarantee for sustainability.

Table 1 showed that the G20 countries were categorized into amplify and accelerate stages. All G20 countries' digital readiness scores ranged between 9.6 and 19.03 on a scale of 25. The G20 countries in the amplify stage were (1) the United States of America, (2) South Korea, (3) Australia, (4) The United Kingdom, (5) Germany, (6) Japan, (7) Canada, and (8) France. The other eleven G20 countries in the accelerate stage were (1) Italy, (2) Russia, (3) Saudi Arabia, (4) China, (5) Argentina, (6) Turkey, (7) Mexico, (8) Brazil, (9) Indonesia, (10) South Africa, and (11) India.

Table 1. Scores and stages of digital readiness for G20 countries in 2019.

Ranks	G20 Countries	Scores (0–25)	Stages
1	The United States of America	19.03	Amplify
2	South Korea	18.22	Amplify
3	Australia	17.89	Amplify
4	The United Kingdom	17.86	Amplify
5	Germany	17.85	Amplify
6	Japan	17.69	Amplify
7	Canada	17.33	Amplify
8	France	16.25	Amplify
9	Italy	14.84	Accelerate
10	Russia	13.63	Accelerate
11	Saudi Arabia	13.40	Accelerate
12	China	13.22	Accelerate
13	Argentina	13.06	Accelerate
14	Turkey	12.88	Accelerate
15	Mexico	12.34	Accelerate
16	Brazil	12.31	Accelerate
17	Indonesia	11.68	Accelerate
18	South Africa	11.39	Accelerate
19	India	9.6	Accelerate

Source: Adopted from The Global Digital Readiness Index 2019 (Cisco 2020).

4.2. Global Innovation of G20 Countries

In line with the previous subsection, this subsection will explain the score of the innovation of G20 countries for analyzing objective 1, objective 3 (consistency between innovation and competitiveness 4.0), and objective 4. We compiled innovation data for the G20 countries as shown in Table 2 based on secondary data in scores and income groups from the global Innovation Index 2019. The four income categories were HI = high income; UM = upper-middle-income; LM = lower-middle-income; and LI = low income. Table 2 shows that the eleven countries in the HI category were (1) the United States of America, (2) The United Kingdom, (3) Germany, (4) South Korea, (5) Japan, (6) French, (7) Canada, (8) Australia, (9) Italy, (10) Saudi Arabia, and (11) Argentina. The six countries in the UM category were (1) China, (2) Russia, (3) Turkey, (4) Mexico, (5) South Africa, and (6) Brazil. The two countries in the LM category were (1) India and (2) Indonesia.

Even though China was in the UM category, its innovation score (institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs) was higher than the innovation ranks of Japan, France, Canada, Australia, Italy, Saudi Arabia, and Argentina. India's innovation rank was higher than the innovation ranks in Mexico, South Africa, Brazil, Saudi Arabia, and Argentina despite being in the LM category.

Table 2. Scores and incomes of G20 countries in 2019.

Ranks	G20 Countries	Scores (0–100)	Incomes
1	The United States of America	61.73	HI
2	The United Kingdom	61.30	HI
3	Germany	58.19	HI
4	Republic of Korea (South Korea)	56.55	HI
5	China	54.82	UM
6	Japan	54.68	HI
7	France	54.25	HI
8	Canada	53.88	HI
9	Australia	50.34	HI
10	Italy	46.30	HI
11	Russia (Russia Federation)	37.62	UM
12	Turkey	36.95	UM
13	India	36.58	LM
14	Mexico	36.06	UM
15	South Africa	34.04	UM
16	Brazil	33.82	UM
17	Saudi Arabia	32.93	HI
18	Argentina	31.95	HI
19	Indonesia	29.72	LM

Source: Adapted from Cornell University Global Innovation Index 2019 (Cornell University et al. 2019).

4.3. Global Competitiveness 4.0 of the G20 Countries

This subsection describes the global digital competitiveness score 4.0 of the G20 countries to analyze objective 2, objective 3, and objective 4. We collected competitiveness 4.0 data for the G20 countries as shown in Table 3 based on secondary data in scores and differences from the previous year from the global competitiveness report 2019. The six countries had increased: namely, (1) Korea, (2) France, (3) Saudi Arabia, (4) Italy, (5) South Africa, and (6) Brazil. On the other hand, the ten countries experienced a downgrade compared to the previous year's ranking. They were (1) the United States of America, (2) Japan, (3) Germany, (4) The United Kingdom, (5) Canada, (6) Australia, (7) Mexico, (8) Indonesia, (9) India, and (10) Argentina. The three other stable ones were namely (1) China, (2) Russia, and (3) Turkey.

Despite the decline, the United States of America still had the highest scores obtained from assessing institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamism, and innovation capability. The highest increase was by South Africa (+7). On the contrary, the highest decrease was by India (−10).

Table 3. Global competitiveness 4.0 scores and their fluctuations of G20 countries in 2019.

Ranks	Countries	Scores (0–100)	Fluctuations from 2018
1	United States of America	83.7	Decrease (−1)
2	Japan	82.3	Decrease (−1)
3	Germany	81.8	Decrease (−4)
4	The United Kingdom	81.2	Decrease (−1)
5	Korea Representative	79.6	Increase (+2)
6	Canada	79.6	Decrease (−2)
7	France	78.8	Increase (+2)
8	Australia	78.7	Decrease (−2)
9	China	73.9	Stable
10	Saudi Arabia	70.0	Increase (+3)
11	Italy	71.5	Increase (+1)
12	Russia Federation	66.7	Stable
13	Mexico	64.9	Decrease (−2)
14	Indonesia	64.6	Decrease (−5)
15	South Africa	62.4	Increase (+7)
16	Turkey	62.1	Stable
17	India	61.4	Decrease (−10)
18	Brazil	60.9	Increase (+1)
19	Argentina	57.2	Decrease (−2)

Source: Adapted from WEF Global Competitiveness Report 2019 (WEF 2019).

4.4. Consistency between Digital Readiness Ranks, Innovation Ranks, and the Competitiveness 4.0 Ranks of G20 Countries

This subsection elaborates the consistency between global digital readiness, global innovation, and global competitiveness 4.0 of the G20 countries. We compare the ranks described in the previous subsections to analyze objective 1, objective 2, objective 3, and objective 4.

Table 4 showed that the United States of America was the only G20 country consistent in its digital readiness, innovation, and competitiveness 4.0 and consistently ranked the highest. The six G20 countries that had partial consistency, or only two of the three variables (digital readiness, innovation, and competitiveness 4.0), were namely (1) Germany (innovation and competitiveness), (2) England (digital readiness and 4.0 competitiveness), (3) Japan (digital readiness and innovation), (4) France (innovation and competitiveness 4.0), (5) South Africa (innovation and competitiveness 4.0), and (6) Brazil (digital readiness and innovation). The twelve other countries that did not show consistency in the three variables were (1) South Korea, (2) Australia, (3) China, (4) Canada, (5) Italy, (6) Russia, (7) Arabic Saudi, (8) Turkey, (9) Argentina, (10) Mexico, (11) India, and (12) Indonesia.

Table 4. Global digital readiness ranks, global innovation ranks, global competitiveness 4.0 ranks and their consistencies of the G20 countries.

Digital Capabilities' Ranks	Digital Readiness Ranks	Innovation Ranks	Competitiveness 4.0 Ranks	Consistencies
1	The United States of America	The United States of America	The United States of America	Full
2	South Korea	The United Kingdom	Japan	No
3	Australia	Germany	Germany	Partial
4	The United Kingdom	Republic of Korea (South Korea)	The United Kingdom	Partial
5	Germany	China	Korea Rep.	No
6	Japan	Japan	Canada	Partial
7	Canada	France	France	Partial
8	France	Canada	Australia	No
9	Italy	Australia	China	No
10	Russia	Italy	Saudi Arabia	No
11	Saudi Arabia	Russia (Russia Federation)	Italy	No
12	China	Turkey	Russia Federation	No
13	Argentina	India	Mexico	No
14	Turkey	Mexico	Indonesia	No
15	Mexico	South Africa	South Africa	Partial
16	Brazil	Brazil	Turkey	Partial
17	Indonesia	Saudi Arabia	India	No
18	South Africa	Argentina	Brazil	No
19	India	Indonesia	Argentina	No

Source: Adapted from Global Digital Readiness Index 2019 (Cisco 2020); Global Innovation Index 2019 (Cornell University et al. 2019); Global Competitiveness 4.0 Report 2019 (WEF 2019).

4.5. Correlation between Global Digital Readiness Scores, Global Innovation Scores and Global Competitiveness 4.0 Scores of the G20 Countries

This subsection explains the correlation between global digital readiness, global innovation, and global competitiveness 4.0 of G20 countries. We compare the scores described in Sections 4.1–4.3 to analyze objective 5 (the relationship between digital readiness, innovation, and competitiveness 4.0). Based on the digital readiness score, innovation and competitiveness 4.0, Table 5 showed that the United States was the G20 country with the highest score. In terms of digital readiness, South Korea was second best and Australia third. Britain was second best and Germany third when it comes to innovation. Japan was in second place and Germany third in terms of 4.0 competitiveness. (1) The United States, (2) South Korea, (3) Australia, (4) the United Kingdom, (5) Japan, and (6) Germany were the countries with the highest digital capabilities.

Table 5. Global Digital Readiness Scores, Global Innovation Scores and Global Competitiveness 4.0 Scores of the G20 Countries.

Ranks	G20 Countries	Digital Readiness Scores	Innovation Scores	Competitiveness 4.0 Scores
1	The United States	19.03	61.73	83.7
2	South Korea	18.22	56.55	79.6
3	Australia	17.89	50.34	78.7
4	The United Kingdom	17.86	61.30	81.2
5	Germany	17.85	58.19	81.8
6	Japan	17.69	54.68	82.3
7	Canada	17.33	53.88	79.6
8	France	16.25	54.25	78.8
9	Italy	14.84	46.30	71.5
10	Russia	13.63	37.62	66.7
11	Saudi Arabia	13.40	32.93	70.0
12	China	13.22	54.82	73.9
13	Argentina	13.06	31.95	57.2
14	Turkey	12.88	36.95	62.1
15	Mexico	12.34	36.06	64.9
16	Brazil	12.31	33.82	60.9
17	Indonesia	11.68	29.72	64.6
18	South Africa	11.39	34.04	62.4
19	India	9.6	36.58	61.4

Source: Adapted from the Global Digital Readiness Index 2019 (Cisco 2020); Global Innovation Index 2019 (Cornell University et al. 2019); and Global Competitiveness 4.0 Report 2019 (WEF 2019).

Table 6 showed a significant and strong positive relationship (0.600–0.799) existed between digital readiness and innovation (0.603). There was also a significant and strong positive relationship between digital readiness and competitiveness of 0.77. Meanwhile, a significant and very strong positive relationship (0.800–1000) existed between innovation and competitiveness 4.0 (0.931). Table 7 show that hypothesis 1, hypothesis 2, and hypothesis 3 are accepted.

Table 6. Pearson Correlations between Digital Readiness, Innovation, and Competitiveness 4.0 of the G20 Countries.

		Digital Readiness	Innovation	Competitiveness
Digital Readiness	Pearson correlation	1	0.694 **	0.770 **
	Sig. (two-tailed)		0.001	0.000
	N	19	19	19

Table 6. *Cont.*

		Digital Readiness	Innovation	Competitiveness
Innovation	Pearson correlation	0.694 **	1	0.932 **
	Sig. (two-tailed)	0.001		0.000
	N	19	19	19
Competitiveness	Pearson correlation	0.770 **	0.932 **	1
	Sig. (two-tailed)	0.000	0.000	
	N	19	19	19

** Correlation is significant at the 0.01 level (2-tailed). Source: Output of SPSS conducted by the authors (2020).

Table 7. Conclusion of Hypotheses.

Hypotheses	Pearson Correlation	Conclusions
H1. Digital readiness and innovativeness are related	0.694	Accepted
H2. Digital readiness and competitiveness 4.0 are related	0.770	Accepted
H3. Innovation and competitiveness 4.0 are related	0.931	Accepted

Source: Output of SPSS conducted by authors (2020).

4.6. Discussion

The results of this study have shown that digital leadership exists at a macroeconomic or country level. We proved empirically that the G20 countries had digitally ready basic needs, human capital, ease of doing business, business and government investment, start-up environment, technology infrastructure, and technology adoption in 2019. They had innovative institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs in 2019. They also had competitive 4.0 institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamism, and competitive innovation capability in 2019.

Because the world digital capability was explained through digital readiness only by Cisco in 2019, the results of this research showed that digital readiness collectively explained with innovation by WIPO in 2019 and competitiveness 4.0 by WEF in 2019. We indicate that the G20 countries had high innovation in institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge, technology outputs, and creative outputs in 2019. It was in line with the global outcomes achieved by the G20 countries either individually or collectively. Moreover, the G20 countries have had competitiveness 4.0 in institutions, infrastructure, ICT adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamism, and innovation capability. It followed the fact that the G20 countries were the big producers of technology and drivers of digitization. Eventually, our finding showed that the G20 countries had high and wide digital capabilities, not only digital readiness, or only innovation, or even competitiveness 4.0 only. It matched with the world's major economies that had been achieved by the G20 countries as an international economics forum.

5. Conclusions

Digital readiness, innovation, and 4.0 competitiveness are positively and significantly related. The G20 countries had the digital leadership in digital readiness, innovation, and

competitiveness. It is a consideration at the macroeconomic level not microeconomics. The digital readiness of the G20 countries had been compared in innovation and the competitiveness of 4.0. Indeed, these three variables could be analyzed simultaneously. The G20 countries were adopting digital technology to create new opportunities. They were the drivers of modern global economic growth. They depended on the competitive economy to determine economic growth and realize the global mission (goals, functions, tasks).

The G20 countries were leaders in global digitization. The United States of America, Japan, and Brazil were consistent in digital readiness and innovation. The United States of America and the United Kingdom were consistent in digital readiness and competitiveness 4.0. The United States of America, Germany, France, and South Africa were consistent in their 4.0 innovation and competitiveness. In particular, the United States of America was the only G20 country consistent in digital readiness, innovation, and 4.0 competitiveness. Inconsistencies were in more G20 countries, namely in 12 countries. They were (1) South Korea, (2) Australia, (3) China, (4) Canada, (5) Italy, (6) Russia, (7) Saudi Arabia, (8) Turkey, (9) Argentina, (10) Mexico, (11) India, and (12) Indonesia. It showed that the consistency between digital readiness, innovation, and 4.0 competitiveness in the G20 was still low in that time.

This paper focuses on digital leadership capabilities. It contributes to the main preceding works through an original idea from us. We combined global digital readiness researched by Cisco in 2019, innovation researched by (Cornell University et al. 2019), and competitiveness 4.0 researched by (WEF 2019) to be the main components of digital leadership capabilities in the economy. In this context, we used the G20 countries as the objects.

Further research will need to analyze digital capabilities in more groups of countries such as Asian countries, European countries, developed countries and developing countries. Digital capabilities at the macroeconomic level are closely related to the gross domestic product, inflation, unemployment, government spending, interest rates, and exchange rates. It is a niche and a need for future study.

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