

# Derivatives Markets Development and Country Political Risk

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Rupnik V. and M. Bogataj (Editors): The 2nd International Symposium on Operational Research in Slovenia, SOR'94. Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1994, 275 pp.

Rupnik V. and M. Bogataj (Editors): The 3rd International Symposium on Operational Research in Slovenia, SOR'95. Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1995, 175 pp.

Rupnik V., L. Zadnik Stirn and S. Drobne (Editors.): The 4th International Symposium on Operational Research in Slovenia, SOR'97. Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1997, 366 pp. ISBN 961-6165-05-4.

Rupnik V., L. Zadnik Stirn and S. Drobne (Editors.): The 5th International Symposium on Operational Research SOR '99, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1999, 300 pp. ISBN 961-6165-08-9.

Lenart L., L. Zadnik Stirn and S. Drobne (Editors.): The 6th International Symposium on Operational Research SOR '01, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2001, 403 pp. ISBN 961-6165-12-7.

Zadnik Stirn L., M. Basti and S. Drobne (Editors): The 7th International Symposium on Operational Research SOR'03, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2003, 424 pp. ISBN 961-6165-15-1.

Zadnik Stirn L. and S. Drobne (Editors): The 8th International Symposium on Operational Research SOR'05, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2005, 426 pp. ISBN 961-6165-20-8.

Zadnik Stirn L. and S. Drobne (Editors): The 9th International Symposium on Operational Research SOR'07, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2007, 460 pp. ISBN 978-961-6165-25-9.

Zadnik Stirn L., J. Žerovnik, S. Drobne and A. Lisec (Editors): The 10th International Symposium on Operational Research SOR'09, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2009, 604 pp. ISBN 978-961-6165-30-3.

Zadnik Stirn L., J. Žerovnik, J. Povh, S. Drobne and A. Lisec (Editors): The 11th International Symposium on Operational Research SOR'11, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2011, 358 pp. ISBN 978-961-6165-35-8.

Zadnik Stirn L., J. Žerovnik, J. Povh, S. Drobne and A. Lisec (Editors): The 12th International Symposium on Operational Research SOR'13, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2013, 390 pp. ISBN 978-961-6165-40-2.

Zadnik Stirn L., J. Žerovnik, M. Kljaž Borštnar, S. Drobne (Editors): The 13th International Symposium on Operational Research SOR'15, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2015, 559 pp. ISBN 978-961-6165-45-7.

Zadnik Stirn L., J. Žerovnik, M. Kljaž Borštnar, S. Drobne (Editors): The 14th International Symposium on Operational Research SOR'17, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2017, 567 pp. ISBN 978-961-6165-50-1.

Zadnik Stirn L., M. Kljajić Borštnar, J. Žerovnik, S. Drobne, J. Povh (Editors): The 15th International Symposium on Operational Research SOR'19, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2019, 618 pp. ISBN 978-961-6165-55-6.



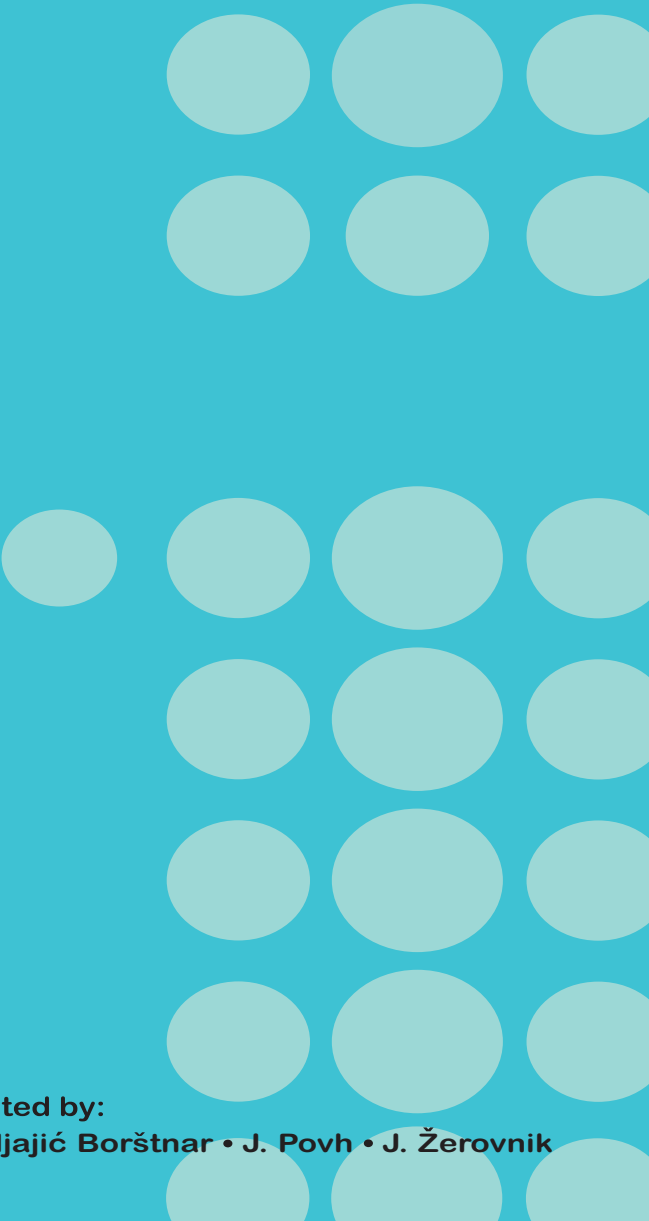
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# Preface

*This volume, Proceedings of the 16th International Symposium on Operational Research, called SOR'21, contains papers presented at SOR'21 (<https://sor.fov.um.si/>), organised by Slovenian Society INFORMATIKA (SDI), Section for Operational Research (SOR), University of Maribor, Faculty of Organisational Sciences, Kranj, Slovenia (FOV), and University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia (UL FS). The SOR'21 symposium, held 22-24 September 2021, was originally planned to take place in Bled, Slovenia, but was moved online due to the situation of COVID-19 in Slovenia and beyond. The volume contains blind peer-reviewed papers or abstracts of papers presented at the symposium.*

*The opening address at SOR'21 was given by Prof. Dr. Lidija Zadnik Stirn, President of SOR, Mr. Niko Schlamberger, President of SDI, representatives of FOV and UL FS, Prof. Dr. Mario Jadrić, President of Croatian Operational Research Society (CRORS), Dr Sarah Fores, manager of The Association of European Operational Research Societies (EURO), and presidents/representatives of some others Operational Research Societies from abroad.*

*SOR'21 is the scientific event in the field of Operational Research, another in the traditional series of biennial international OR conferences organised in Slovenia by SDI-SOR. It is the continuation of fifteen previous symposia. The main objective of SOR'21 is to promote knowledge, interest and education in the field of OR in Slovenia, Europe and worldwide in order to build the intellectual and social capital essential for maintaining the identity of OR, especially at a time when interdisciplinary cooperation is proclaimed as particularly important for solving problems in today's challenging times. By joining IFORS and EURO, the SDI-SOR has also agreed to collaborate with different disciplines, i.e., to balance the depth of theoretical knowledge in OR and the understanding of theory, methods, and problems in other fields within and outside OR. We believe that SOR'21 creates the advantage of these goals, contributes to the quality and reputation of OR by presenting and sharing new developments, opinions and experiences in the theory and practise of OR.*

*SOR'21 was highlighted by five distinguished keynote speakers. The first part of Proceedings SOR'21 contains invited abstracts, presented by five outstanding scientists: Assist. Prof. Nikolina Ban, University of Innsbruck (UIBK), Department of Atmospheric and Cryospheric Sciences, Innsbruck, Austria, Assist. Prof. Vedran Kojić, University of Zagreb, Faculty of Economics & Business, Zagreb, Croatia, Prof. Panos Patrinos, KU Leuven, Department of Electrical Engineering (ESAT), STADIUS Center for Dynamical Systems, Signal Processing and Data Analytics, Leuven, Belgium, Prof. Suresh P. Sethi, Eugene McDermott Chair Professor of Operations Management, Director, Center of Intelligent Supply Networks, Naveen Jindal School of Management, The University of Texas at Dallas, Dallas, USA, and Prof. Jerneja Žganec Gros, Alpineon Ltd, Ljubljana, Slovenia.*

*The Proceedings includes 118 papers or abstracts by 240 authors. Most of the authors of the contributed papers came from Slovenia (82), then Croatia (52), Hungary (23), Portugal (23), Serbia (17), Poland (9), Czech Republic (8), Slovak Republic (7), Spain (6), Netherlands (4), Bosnia and Herzegovina (2), Austria (1), Belgium (1), France (1), Germany (1), Romania (1), Ukraine (1), United Kingdom (1), and United States of Amerika (1). The papers published in the Proceedings are divided into Plenary Lectures (5 abstracts), eleven special sessions: Application of Operational Research in Smart Cities (6 papers), Computational Mathematical Optimization (7 papers and 6 abstracts), Data Science – Methodologies and Case Studies (10 papers), Graph Theory and Algorithms (2 papers),*

*High-Performance Computing and Big Data (3 papers), Industry & Society 5.0: Optimization in Industrial and Human Environments (6 papers), International Projects in Operations Research (2 papers), Lessons Learned from the COVID-19 Pandemic: Applications of Statistical and OR Methods (8 papers), Logistics and Sustainability (9 papers), Operational Research in Ageing Studies and Social Innovations (5 papers), Operations Research in Agricultural Economics and Farm Management (5 papers), and eight sessions: Econometric Models and Statistics (6 papers), Environment and Social Issues (5 papers), Finance and Investments (6 papers), Location and Transport, Graphs and their Applications (5 papers), Mathematical Programming and Optimization (5 papers and 1 abstract), Multi-Criteria Decision-Making (10 papers), Theory of Games (3 papers), and Problems Approaching OR (3 papers).*

*Proceedings of the previous fifteen International Symposia on Operational Research organised by the Slovenian Section on Operational Research, listed at <https://www.drustvo-informatika.si/sekcije/sor/sor-publikacijepublications/>, are indexed in the following secondary and tertiary publications: Current Mathematical Publications, Mathematical Review, Zentralblatt fuer Mathematik/ Mathematics Abstracts, MATH on STN International and CompactMath, INSPEC. It is expected that Proceedings SOR'21 will be covered by the same bibliographic databases.*

*The success of the scientific events at SOR'21 and of the present conference proceedings should be seen because of joint efforts. On behalf of the organisers, we would like to express our sincere gratitude to all those who assisted us in the preparation of the event. Without the dedicated and advice of the active members of the Slovenian Operations Research Section, we would not have been able to attract so many top-class speakers from all over the world. Many thanks to them. In addition, we would like to express our deepest gratitude to the prominent keynote speakers, the members of the Programme and Organising Committees, the reviewers who improved the quality of SOR'21 with their useful suggestions, the section chairs and all the numerous people - far too many to list individually here - who helped in organizing of the 16th International Symposium on Operational Research SOR'21 and compiling this proceedings. Finally, we thank the authors for their efforts in preparing and presenting the papers that made the 16th Symposium on Operational Research SOR'21 a success.*

*We would like to give special thanks to the Partnership for Advanced Computing in Europe (PRACE) for their financial support.*

*Ljubljana and Kranj, September 22, 2021*

*Samo Drobne  
Lidija Zadnik Stirn  
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# DERIVATIVES MARKETS DEVELOPMENT AND COUNTRY POLITICAL RISK

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**Abstract:** This paper investigates the impact of country political risk on currency derivatives market turnover for 19 countries. Previous empirical literature has confirmed the role that political risk has on financial institutions and the stock market development, whereas the relationship between currency derivatives and political risk has not been empirically investigated

Therefore, taking into account the heterogeneity of the selected currency derivatives markets and a possible heterogeneity in the relationship between derivatives turnover and political risk, heterogeneous non-causality test in panels are employed. This method successfully deals with both types of heterogeneity. The results have confirmed the heterogeneous causality of political risk on currency derivatives markets. Moreover, political risk has a more significant effect on currency derivatives turnover in countries with a less developed financial system.

**Keywords:** derivatives, country political risk, financial system development, non-causality test in heterogeneous panel.

## 1 INTRODUCTION

Many empirical papers [7], [3] found evidence that the level of development of a country's financial system is important for its economic growth. Thus, researchers [9] have focused on the development of financial markets as a part of the financial system. Major conclusions of all these researches are that the development of financial markets facilitates economic growth by providing important services and that financial markets provide services different from those provided by financial institutions. However, most of the existing empirical literature concentrates on stock markets and neglects other segments of financial markets. Therefore, we investigate currencies derivative markets because they provide different services to the economy with the aim of providing a deeper understanding of the sources of development of that specific financial market segment.

The connection between derivative markets and macroeconomic factors have not been investigated sufficiently regardless of their importance for hedging various economic risks. One of the rare research on this topic was conducted by [15]. They confirmed the existence of international bidirectional causality between derivatives markets and economic growth. In addition, they found that trade openness and government spending have a more pronounced effect on derivative markets than economic growth and inflation. Moreover, they found that the connection is stronger between macroeconomic factors and currency derivatives in higher-income countries than in upper-middle-income countries. In addition, [14] investigated currency derivative market turnover of emerging market economies to find why these markets have a small activity compared to the share of their economies in the global GDP or trade. They found that GDP per capita has a negligible effect on currency derivative market while the size of the bond market, the openness of the capital account, the amount of foreign trade and the size of external liabilities have a positive effect. Previous studies have concentrated on the effect that country macroeconomic variables have on currency derivative markets.

This paper goes one step further; it tries to find an empirical evidence about the relationship between currency derivatives market turnover and the country's political risk. Namely, empirical papers [7], [12], [1], [5] found that a country's law system and corruption in the country affect the development of the financial system. In addition, [8] argue that problems related to institutional quality in a country may develop uncertainty and send out misleading signals to the financial markets. Research [4] provides empirical evidence that political instability during political elections in South Korea increase speculative trading on derivative markets. Finally, [2] investigated 31 countries in the 1984–2016 period and found empirical evidence that countries with increased political instability and serious corruption tend to experience a real exchange rate depreciation. All the aforementioned results provide motivation to explore the influence of political risk on currency derivatives markets more deeply. Namely, the main motivation for using currencies derivatives is hedging currency risk. Higher political risk increases mistrust in the currency and, therefore, motivates economic agents to hedge risk. On the other hand, in countries with a more developed financial system there are more possibilities to hedge risk. Therefore, we suppose that the usage of derivative markets will be determined by the country's political risk and will differ depending on the level of development of the country's financial system.

Rare researches about currency derivative market turnover concentrate only on the effects of macroeconomic indicators. Regardless the fact that the quality of institutions plays a significant role in the development of financial markets, they are not included in modelling currency derivative market development. To fill this gap, this paper provides empirical evidence of the importance of the country's political risk on currency derivatives turnover.

The paper is organized as follows. In Section 2, data and methodology are described. In Section 3, the results are presented and discussed. In Section 4, the conclusions are given.

## 2 DATA AND METHODOLOGY

This dataset used in the research covers the monthly data from January 1994 to December 2020. For the political stability (PS) indicator, Political risk index from the International Country Risk Guide (ICRG) database is used. Political Risk Index covers the following 12 political and social features of a country: Government Stability, Socioeconomic Conditions, Investment Profile, Internal Conflict, External Conflict, Corruption, Military in Politics, Religious Tensions, Law and Order, Ethnic Tensions, Democratic Accountability, and Bureaucracy Quality. The value of the index can vary from 100 (Very Low Risk) to 0 (Very High Risk) points.

Derivative market data were collected from the Bank for International Settlements (BIS) - Derivative statistics. Our data set comprises data of turnover for all currencies derivatives (DER) from the BIS database that are traded on exchange markets all over the world. Currency derivative turnover is connected with a country that issues a currency. We included all the countries from the database except the Euro area countries because the political risk data for the whole region is not available. The data set consists of 19 countries, which are heterogeneous in their economic and financial development and social and political systems. Table 1 presents the countries according to the Financial Development Index, which summarises the development of financial institutions and financial markets in terms of their depth, access, and efficiency [13]. The country with the most developed financial system is Switzerland (0.98) and the country with the least developed financial system is South Africa (0.05). Different levels of financial development imply different possibilities of usage of currency derivatives for hedge foreign exchange risks.

Table 1: Countries from the data set according to the Financial Development Index

	Country	FD index		Country	FD index		Country	FD index
1	Switzerland	0.96	8	Sweden	0.77	14	Turkey	0.53
2	Canada	0.9	9	Singapore	0.75	15	Russia	0.49
3	UK	0.9	10	China	0.65	16	Poland	0.47
4	US	0.9	11	Norway	0.65	17	Hungary	0.41
5	Japan	0.89	12	Brazil	0.63	18	Mexico	0.4
6	Australia	0.88	13	New Zealand	0.59	19	South Africa	0.05
7	South Korea	0.81						

According to the indicated heterogeneity between currency turnover, the difference between financial systems from currencies countries and a possible heterogeneity in the relationship between a country's political risk and derivatives turnover, Granger non-causality test in heterogeneous panel proposed by [6] is applied. Under null hypothesis, they assumed there is no causal relationship for any of the units of the panel. Under alternative hypothesis, they allow two subgroups of units, i.e., one subgroup where the causal relationship does not exist and another subgroup where the causal relationship exists. An additional advantage of this method is its heterogeneous impact for each unit in both subgroups. More precisely, each unit has its own coefficient. Finally, the benefit of this method is that its standardized panel statistics has good properties in the presence of cross sectional dependence. Namely, according to empirically proved interconnections between different financial markets, we expect the existence of the cross sectional dependence between different currency derivative markets.

In line with [6], our research question can be formulated by the following equation:

our research question can be written by the following equation:

$$DER_{it} = \sum_{k=1}^p \gamma^{(k)} DER_{i,t-k} + \sum_{k=1}^p \beta_i^{(k)} PS_{i,t-k} + \alpha_i + \varepsilon_{it}, i = 1, \dots, N, t = 1, \dots, T, \quad (1)$$

with  $p \in N^1$ . The method assumes that  $DER_{it}$  and  $PS_{it}$  are stationary. From Table 2, it is evident that  $DER_{it}$  and  $PS_{it}$  are stationary variables.  $\gamma_i^{(k)}$  are the coefficients of the k-th lag of the dependent variable  $DER_{it}$ ,  $\beta_i^{(k)}$  are the coefficients of the k-th lag of the independent variable  $PS_{it}$ .  $\alpha_i$  is the country's fixed or random effect while  $\varepsilon_{it}$  are i.i.d.  $(0, \sigma_\varepsilon^2)$ . According to the fact that derivatives react fast on the change in the country's political stability we choose one lag for Granger causality testing. For robustness, we used two lags, but the results did not vary significantly.

### 3 RESULTS

According to the fact that the Granger non-causality test requires stationary variables, our empirical part starts with the results of Pesaran unit root test [11] for panel data with cross sectional dependence. The results of unit root test are presented in Table 2.

<sup>1</sup> They also allow for instantaneous causality with a modification  $p \in N \cup \{0\}$ .

Table 2: The results of the Pesaran's unit root test

Variable	P value
DER	0.000
PS	0.000

The results of the unit root test indicate the stationarity of both variables. In the second step, the results of the Granger non-causality test in heterogeneous panel data is employed. Test results are presented in Table 3.

Table 3: The results of the Granger non-causality test in heterogeneous panel data

H0: PS does not causes DER		
	Value	p value
$\bar{Z}$	9.4014	0.0000
$\tilde{Z}$	9.2786	0.0000
Results by country		
Country	beta	p value
Australia	4.0664	0.8704
Brazil	-24.3917	0.869
Canada	21.6367	0.4537
China	-7.7356	0.339
Hungary	-0.8256	0.0311
Japan	-73.1267	0.2937
Mexico	-15.7874	0.0165
New Zealand	-13.0238	0.2156
Norway	-0.1116	0.9506
Poland	0.9292	0.2212
Russia	-88.564	0.0000
Singapore	-0.8837	0.5694
South Africa	-10.0915	0.0021
South Korea	20.4436	0.1718
Sweden	-2.3421	0.056
Switzerland	-7.1367	0.787
Turkey	-4.2784	0.0038
United Kingdom	-113.359	0.0016
United States	-259.4201	0.4773

Null hypothesis  $H_0$ : *There is no causal relationship for any of the countries in the panel*, is rejected with both  $\bar{Z}$  and  $\tilde{Z}$  with p value 0.000. For our data set, both values are adequate while for the dataset with a small T, only  $\tilde{Z}$  is relevant [10]. Therefore, it can be concluded that there are two sub groups of countries. For the first sub group, the Granger causality does not exist (Australia, Brazil, Canada, China, Japan, New Zealand, Norway, Poland, Singapore, South Korea, Switzerland, and the United States), while for the second sub group of countries (Hungary, Mexico, Russia, South Africa, Sweden, Turkey, and the United Kingdom) causal relationship exists. However, it is visible that most of the estimated coefficients beta have a negative sign. Moreover, all statistically significant betas have a negative sign.

All countries where the political stability causes change in turnover on currency derivative markets have low Financial development index, with the exception of the UK and Sweden,

which implies that in countries with not developed financial system political stability decreases the liquidity on derivative markets. This in turn implies that higher country risk motivates market participants to trade with currency derivatives. More precisely, political instability attracts more speculative traders on the currency derivate market.

#### 4 CONCLUSION

This paper investigates the role of a country's political stability on the currency derivatives turnover. The results indicate that the growth of a country's political stability has a heterogeneous impact on the currency derivatives turnover. More precisely, our results reveal that the effect of political stability is more pronounced for currencies derivatives from the countries with less developed financial systems than for the currencies derivatives from the countries with a more developed financial system. However, these results impose a need for future research. First, it indicates that macroeconomic models of derivatives have to be extended with indicators of a country's political risk. Additionally, in further research the index of political risk has to be decomposed so as to discover which parts of the index are most connected with turnover of currency derivatives.

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#### References

- [1] Ahmad, N., Ali, S. 2010. Corruption and financial sector performance: A cross-country analysis. *Economics Bulletin*. 30: 303-308.
- [2] Bahmani-Oskooee, M., Hadj Amor, T., Nour, R., Rault, C. 2019. Political Risk and Real Exchange Rate: What Can We Learn from Recent Developments in Panel Data Econometrics for Emerging and Developing Countries?. *Journal of Quantitative Economics*, 17: 741–762, <https://doi.org/10.1007/s40953-018-0145-4>.
- [3] Bijlsma, M., Kool, C., Non, M. 2018. The effect of financial development on economic growth: a meta-analysis. *Applied Economics, Taylor & Francis Journals*, 50(57): 6128-6148. DOI: 10.1080/00036846.2018.1489503.
- [4] Chen, C., Tang, W. 2009. Are the hedgers or speculators? Evidence from South Korea's Political Elections. *Emerging Markets Finance & Trade*. 45 (1):19-30. <https://doi.org/10.2753/REE1540-496X450102>.
- [5] Dima, B., Barna, F., Nachescu, M. 2018. Does rule of law support the capital market?. *Economic Research - Ekonomska istraživanja*, 31:1, 461-479, DOI:10.1080/1331677X.2018.1432371.
- [6] Dumitrescu, E.I., Hurlin, C. 2012. Testing for Granger non-causality in heterogeneous panels. *Economic Modelling*. 29: 1450–1460. <https://doi.org/10.1016/j.econmod.2012.02.014>.
- [7] King, R.G., Levine, R. 1993. Finance, entrepreneurship and growth. *Journal of Monetary Economics*. 32 (3): 513-542, [https://doi.org/10.1016/0304-3932\(93\)90028-E](https://doi.org/10.1016/0304-3932(93)90028-E).
- [8] Law, S. H., Azman-Saini, W. 2008. The Quality of Institutions and Financial Development. MPRA Paper, 12107.
- [9] Levine, R., Zervos, S. 1998. Stock Markets, Banks, and Economic Growth. *American Economic Review*. American Economic Association. 88: 537-558.
- [10] Lopez, L., Weber, S. 2017. Testing for Granger Causality in Panel Data. *The Stata Journal*. 17(4): 972–984. <https://doi.org/10.1177/1536867X1801700412>.
- [11] Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22 (2): 265–312. <https://doi.org/10.1002/jae.951>

- [12] Porta, Rafael La, Lopez- de- Silanes, F., Shleifer, A., Vishny, R.W. 1998. Law and Finance. *Journal of Political Economy*. 106 (6): 1113-155. doi:10.1086/250042.
- [13] Svirydzenka, K. (2016): Introducing a New Broad-based Index of Financial Development. IMF Working Paper WP/16/5, IMF.
- [14] Upper, C., Vslly, M. (2016). Emerging derivatives markets?. *BIS Quarterly Review*. BIS. Available at: [https://www.bis.org/publ/qtrpdf/r\\_qt1612g.htm](https://www.bis.org/publ/qtrpdf/r_qt1612g.htm) [Accessed 21/01/2021].
- [15] Vo, D.H, Nguyen, P. V., Nguyen, H., M., Vo, A., T., Nguyen, T., C. 2020. Derivatives market and economic growth nexus: Policy implications for emerging markets. *The North American Journal of Economics and Finance*. 54: 1062 -9408, <https://doi.org/10.1016/j.najef.2018.10.014>.

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