Investigating Causal Spillovers among International Stock Markets

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Abstract
Recognizing how financial shocks are transmitted to national economies will enable policymakers to take appropriate fiscal and monetary policy action. Such actions will be able to prevent or reduce the intensity of shocks to critical macroeconomic variables. Observing the financial crises in countries of the European Union and Argentina, highlights the main similarities and differences they present in the context of their course in international economic conditions. This study investigates the relation among international stock indices of major importance and stock indices of less developed economies during normal periods and the Covid-19 pandemic by employing a Vector Autoregression (VAR) framework. Econometric outcomes indicate that the German DAX30 and the British FTSE100 indices are positively influential towards the Greek ATX and the Portuguese PSI20 indices. Notably, this impact is revealed to fade out as more lags are considered. Moreover, the French CAC40 index is found to exert negative effects on the Greek and Portuguese indices and its impacts also diminish as time passes. Notably, the Argentinian stock index is found to be both a transmitter of purely negative effects towards the Italian and the Spanish stock indices while impacts on the Greek and the Portuguese indices turn into positive with the evolution of time. Nevertheless, its influence on stock indices of more advanced economies (DAX30, FTSE100) is found to be weaker. This paper serves as a compass for interested investors in order to better allocate their resources during normal periods as well as during crises.

Keywords: Causal spillovers; international stock markets; vector autoregression;

JEL Classification: G15;

DOI: http://doi.org/10.24818/ejis.2023.06

1. Introduction

Spillovers among international stock markets are of primary importance for policymakers, regulators, investors and the financial press. Interconnectedness among stock indices of advanced and less developed economies have been at the epicenter of academic debates for decades. The last years this issue has re-emerged in the most dynamic manner as international markets are more connected with each other than ever such as in Chari and Henry (2014), Papadamou et al. (2019a,b; 2020); Jebabli et al., 2022). Therefore, by accounting for co-movements and studying causal spillover impacts, the interested investors benefit from additional knowledge that is critical for efficient asset allocation and improvement of the risk-return trade-off in their international portfolios. Notably, the existence of inter-linkages among stock indices consists one of the determinants of the

Received: 16 November 2022; Revised: 13 April 2023; Accepted: 15 May 2023

systemic financial risk in a worldwide level. Investigating the nexus among national stock indices that are highly representative of national economies would cast light on unknown aspects of the sources that lie at the root of creation of modern financial crises and could considerably help towards their better understanding and prevention.

This paper looks into the causal impacts generated among a range of important national stock indices in a global context. It should be emphasized that not only stock indices of countries in the same continent are investigated but also estimations about their connection with one the most characteristic and less developed Latin American economies (Argentina) is set under examination. It should be highlighted that the Argentinian economy has suffered numerous incidents of extremely inflationary pressures, national currency devaluations and has spent long periods under pressures for suffering or extending memoranda by the International Monetary Fund (IMF). Moreover, Argentina presents powerful connection with international markets due to elevated international commercial transactions. There are numerous articles in the literature such as Droller and Fiszbein (2021), Spruk (2019), Bekerman et al. (2015) that highlight historical and economic bonds between the European Union and Argentina. Thereby, this study employs daily closing prices about the national stock indices of very advanced economies in Europe as the German (DAX30), the French (CAC 40), and the British (FTSE100) indices as the former is highly representative of the wealthy Northern European economies and the latter stands for one of the most advanced markets in the European area. Apart from these, data about the representative Greek (ATG), Italian (FTSE MIB), Portuguese (PSI 20), Spanish (IBEX 35) and the Argentinian (S&P/BYMA) stock indices are used for estimating causal spillovers.

In order to study such causal relations, this paper employs the VAR framework and provides evidence that stock indices of advanced markets are more influential one to the other as well as towards specific developing countries depending on their geographical position, their trade relations and whether these countries are members of the Eurozone or have their own monetary authorities. On the other hand, developing markets are unable to influence advanced ones and present alternative patterns of impacts on other developing markets that are found to be not so influenced by advanced ones. This study is a very useful guide for investors for making correct investment decisions based on the linkages among international stock markets.

In the remainder of this paper: Section 2 presents the literature review about studies employing the VAR methodology and stock market spillovers, Section 3 provides the data employed and the methodology, Section 4 presents and analyzes the econometric findings. Finally, Section 5 concludes and proposes ways for future research.

2. Literature Review

There has been an increasing number of academic papers that employ Vector Autoregressive (VAR) methodologies for investigating the causal impacts in the form of spillovers that economic or financial variables generate among them. This has led to the VAR schemes being among the most popular econometric models for investigating the connection between variables of major importance in economies and financial markets. Dhakal et al. (1993), Lutkepohl and Reimers (1992), Dal Colle (2011), Neaime (2002), Neaime (2012), Deltuvaitė (2015) and Ono (2021) are some important papers that adopt VAR-based methodologies for their estimations.

Dhakal et al. (1993) investigate the linkages between money supply and share prices during the period of large fluctuations in the US stock markets (1973-1991) by employing a VAR methodology framework. They provide evidence that alterations in the money supply lead to direct and indirect effects on alterations in stock prices. Furthermore, Lutkepohl and Reimers (1992) use Granger causality estimations in cointegrated-VAR systems to examine US interest rates. They reveal that the long-term interest rate generates causal impacts towards the short-term interest rate and that possibility for reverse causality also exists. Dal Colle (2011) employs a cointegrated-VAR model to examine the finance-growth nexus under financial liberalization. They support that a long-run relation between financial and economic development exists in countries with a history of high inflationary pressures and crises events or other structural modifications. It is also argued that financial liberalization is influential towards the level of response of financial development to capital accumulation.

Neaime (2002) adopts the Engle-Granger efficient maximum likelihood test and finds a weak integration among the MENA markets (Morocco, Egypt, Jordan and Turkey) and strong integration between MENA markets and developed markets (U.S., U.K. and France). Neaime (2012) employs the causality-in-variance test of Cheung and Ng (1996) for detecting causal relations and identify causal patterns in the financial linkages between MENA stock markets and developed financial markets. Stock markets in Dubai, Egypt, Jordan, and Kuwait are highly correlated with the U.S. while Tunisia and Morocco are highly correlated with the French stock market, with the exception of Saudi Arabia, which is weakly correlated with developed equity markets. Deltuvaite (2015) looks into whether Granger causality exists between pairs of Baltic stock markets. The evidence provided presents that the degree of global integration of the Baltic stock markets is very low. The Latvian stock market is found to be more isolated at the global level comparing to other two Baltic stock markets whereas Estonian and Lithuanian stock markets are more interrelated. As concerns Ono (2021), a lag-augmented VAR model is employed to study causality impacts between economic policy uncertainty (EPU) and stock indices in OECD and non-OECD countries. They argue that causality appears in many countries but not for the entire period. Furthermore, stock indices are found to exert causality towards the EPU index so the stock price-leading hypothesis is confirmed.

Moreover, there is a large and still growing bulk of latest academic research focusing on the spillover impacts among stocks or stock indices or between stock indices and other financial assets or uncertainty measures. Baruni et al. (2016) provide evidence that the most liquid US stocks exert spillovers of bad and good volatility among them and that these impacts are asymmetric and change size over time in different sectors. The nexus among these stocks is found to become higher by a significant level during financial turmoil. When it comes to Gamba-Santamaria et al. (2017), they investigate spillover effects concerning stock indices of the US, Brazil, Chile, Colombia, and Mexico. It is shown that Brazil generates impacts towards most of the other countries while Chile, Colombia, and Mexico receive impacts. Emphasis is given to the higher connection and shock transmission from the US to Latin American stock markets during the outburst of the Global Financial Crisis.

Mensi et al. (2018) adopt a VAR-based methodology and examine the impacts among global and the US stock markets and the stock markets of Greece, Ireland, Portugal, Spain, and Italy. Their estimations provide evidence that recent crises increase the intensity of spillover impacts. More specifically, Ireland, Portugal, and Italy, the global and the US stock markets are revealed to exert shocks while the remaining stock markets receive shocks. Furthermore, Liao et al. (2021) look into the spillovers in the stock markets as well as the gold and the oil markets in periods of health crises. Findings indicate that significant

impacts appear and that returns of stocks are not much volatile despite the health crises. Such spillover impacts are very intense during the Covid-19 pandemic. It is also found that gold mainly receives impacts from stocks while oil exerts impacts on stocks.

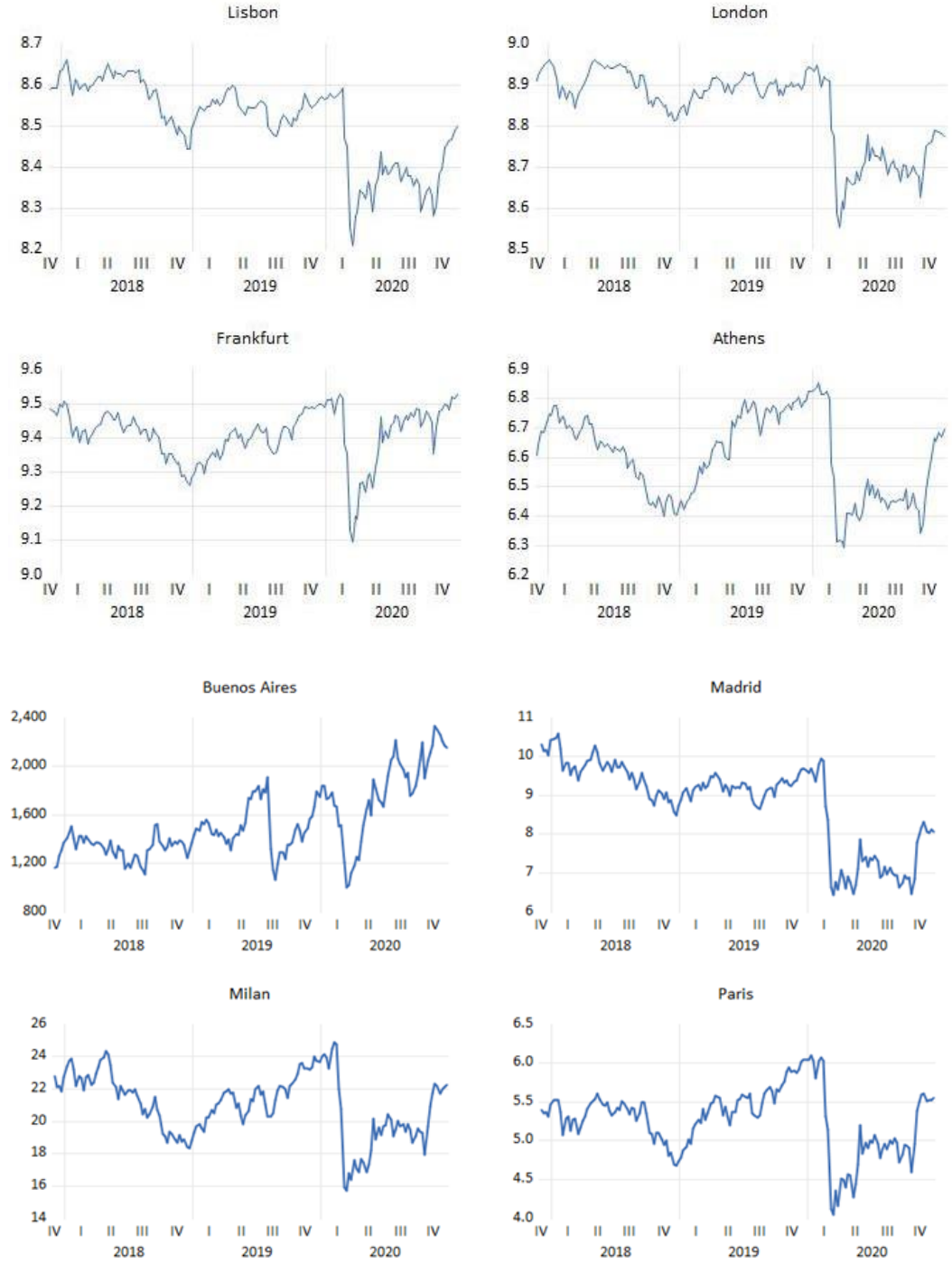
Balli et al. (2021) take into consideration a wide range of stock markets in a worldwide level and examine their relation with economic policy uncertainty, equity market uncertainty, and equity market volatility. It is argued that US stock markets generate effects towards global stock markets. It is also revealed that when the countries that receive impacts are characterized by high financial openness, intense trade with the US, and suffer fiscal problems then these impacts are stronger. Nevertheless, if these target markets are developed then they are not so vulnerable to US shocks. In the study of Zhang and Liu (2021), the impacts generated by stocks in China, Singapore, Thailand, Indonesia, Malaysia and Philippines are examined. It is supported that positive effects are exerted among these financial markets and that these linkages get more intense during the Asian Financial Crisis, the US subprime crisis, and the stock market crash in 2015. Moreover, Zhang et al. (2021) employ an advanced VAR specification to analyze the causal effects of energy and stock markets before and during the Covid-19. The pandemic is revealed to be responsible for higher spillovers between stocks and has led to stocks rendering more influential towards the energy sector.

3. Data and Methodology

Estimations take place in order to investigate the spillover causal impacts among major stock indices and stock indices of less developed economies. Data about the national stock indices have been extracted from the Yahoo.finance database and are expressed in weekly frequencies. All market quotes have been transformed into logarithmic differences for avoiding unit root phenomena. The period examined spans from 3 December 2017 until 27 December 2020. To be more precise, the German (DAX30), the British (FTSE100), and the French (CAC40) representative and national stock indices stand for financial markets in advanced economies. Furthermore, the Greek (ATG), the Italian (FTSE MIB), the Spanish (IBEX 35), the Portuguese (PSI 20) are the European stock indices of less advanced economies while the Argentinian S&P/BYMA represents one of the most important Latin American developing economies.

The methodology employed for estimating the causal impacts that each of these indices exerts on the remaining stock indices is based on Granger causality (Granger, 1969) and takes the form of the Vector Autoregressive (VAR) schemes. The VAR framework enables the examination of the connection between pairs or among multiple quantities as time progresses. This renders feasible the investigation of effects of previous values of variables on the other variables and offers estimations of impulse responses on shocks of the variables examined.

Figure 1. Logarithmic values of the stock indices examined



The general VAR scheme is expressed as follows in (1):

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \ldots\ldots + A_n y_{t-n} + e_t \qquad (1)$$

wherey_{t-i} shows the time evolution with i steps. Moreover, c shows the constant terms estimated and A stands for a matrix that is stable as time passes. Apart from these, e_t represents the errors terms with balanced deviations. Additionally, it should be noted that individual errors are not serially correlated as periods evolve.

In order to test whether series for examination are stationary before we proceed VAR in estimations, the Augmented Dickey-Fuller (ADF) test is applied to the variables investigated as displayed in ***Table 1***.

Table 1. ADF test results

Index	Levels	First Diff
ATG	0.3929	0.0000
CAC40	0.0804	0.0000
DAX	0.0681	0.0000
FTSE 100	0.3945	0.0000
FTSE MIB	0.1381	0.0000
IBEX 35	0.5565	0.0000
PSI 20	0.3298	0.0000
S&P/BYMA	0.1127	0.0000

It should be noted that only when variables are expressed in the form of first differences they present stationarity as the null hypothesis of a unit root is rejected. All the time series are found to be of an I(1) order.

4. Empirical Results

This study focuses on examining the linkages among national stock indices of countries. More specifically, the causal impacts that advanced European economies such as Germany and developing Latin American countries such as Argentina exert on the remaining markets is under investigation. This enables the comparison between spillover causal impacts generated by advanced markets versus those caused by less prestigious and considered to be less influential markets.

The first stage of our investigation focuses on the impacts that the Greek stock index receives from the stock indices (and their lagged values) of the three advanced markets under consideration. Thereby, the VAR model takes the returns of the ATG index as the dependent variable whereas the returns of the DAX 30, FTSE 100, and CAC 40 stock indices and their first lags as independent variables. Econometric findings are presented in ***Table 2***.

$$\Delta ATG_t = c_1 + \beta_1 \Delta DAX_t + \beta_2 \Delta DAX_{t-1} + \beta_3 \Delta FTSE\ 100_t + \beta_4 \Delta FTSE\ 100_{t-1} + \beta_5 \Delta CAC\ 40_t + \beta_6 \Delta CAC\ 40_{t-1} + \varepsilon_t$$

Table 2. Impact of DAX and FTSE 100 on the variations of ATG

	Coeff.	Std. Error	p. value
c	0.0008	0.0023	0.7182
ΔDAX_t	0.4085	0.1456	0.0057
ΔDAX_{t-1}	0.0303	0.1453	0.8347
$\Delta FTSE\ 100_t$	0.5976	0.1829	0.0013
$\Delta FTSE\ 100_{t-1}$	0.1062	0.1826	0.5617
$\Delta CAC\ 40_t$	-0.0812	0.0705	0.2513
$\Delta CAC\ 40_{t-1}$	0.0246	0.0709	0.7293
R^2	0.5276		

It is noticeable that the coefficients of DAX 30 and FTSE 100 are the most statistically significant determinants of impacts on the ATG index. More specifically, DAX 30 exerts a positive effect equal to (0.4085) and FTSE 100 influences by a positive and larger level (0.5976). The lagged values of these indices are revealed that also exert positive impacts by in a statistically non-reliable manner. On the other hand, the French index is found to be less influential (-0.0812) and in a negative direction. Notably, the direction of effect alters when the first lag is examined. It should also be noted that the R-squared measure is modest, and this means that the estimation bears a reliable level of overall statistical significance. By a financial viewpoint, it should be emphasized that two out of three major markets are found to be positively influential towards the Greek stock index. This strengthens the notion that major economies Granger cause developing economies and that the performance of the latter is tightly connected with the performance of the former. The close relation between markets of different sizes and levels of growth informs us about the existence of international spillovers between pairs of radically different countries in the framework of globalization.

Furthermore, this study examines the linkages of the three major markets considered with the less developed stock market of Portugal. It should be stressed that econometric findings bear similarities with those regarding the case of Greece. It is revealed that the DAX 30 (0.5211) and the FTSE 100 (0.3107) indices are positively influential on the PSI 20 in a statistically significant manner, but the DAX 30 generates larger impacts than the FTSE 100. In tandem with findings about the Greek index, the coefficients of lags of the German and the British indices as well as the French index exhibit no statistical significance. It is remarkable that the R-squared value is very large (0.8042) so the regression results are trustworthy.

$$\Delta PSI\ 20 = c_2 + \beta_1 \Delta DAX_t + \beta_2 \Delta DAX_{t-1} + \beta_3 \Delta FTSE\ 100_t + \beta_4 \Delta FTSE\ 100_{t-1} + \beta_5 \Delta CAC\ 40_t + \Delta\beta_6 CAC\ 40_{t-1} + u_t$$

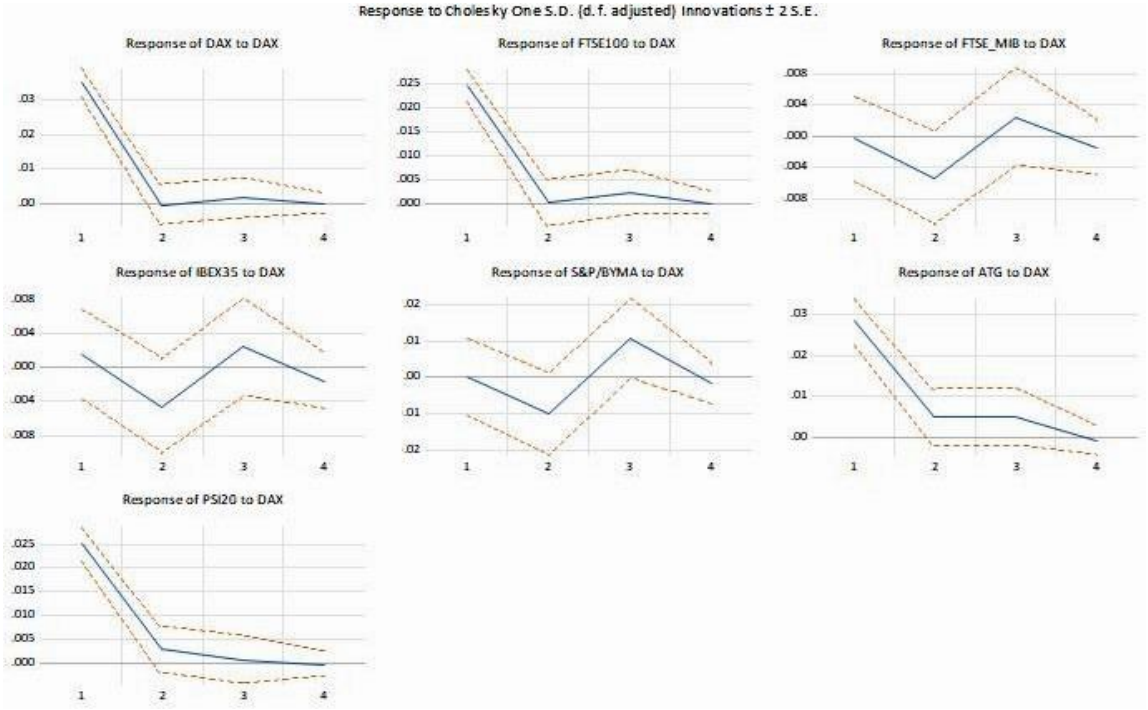
Table 3. Impact of DAX and FTSE 100 on the variations of PSI 20

	Coeff.	Std. Error	p. value
c	-0.0004	0.0010	0.6764
ΔDAX_t	0.5211	0.0665	0.0000
ΔDAX_{t-1}	0.0511	0.0664	0.4423
$\Delta FTSE\ 100_t$	0.3107	0.0835	0.0003
$\Delta FTSE\ 100_{t-1}$	0.0356	0.0834	0.6698
$\Delta CAC\ 40_t$	-0.0032	0.0322	0.9189
$\Delta CAC\ 40_{t-1}$	-0.024	0.0324	0.4506
$_R2$	0.8042		

As concerns the financial interpretation, it is revealed that members of the Eurozone (that is Germany) is more influential towards Portuguese financial markets than non-Eurozone members (that is the United Kingdom). This is contrast with findings about the Greek index where the reverse holds. Thereby, eastern Mediterranean markets (such as Greece) are estimated to be more affected by European members with own national currencies while western Mediterranean markets are more influenced by major European countries having adopted the common currency and being subject to the European Central Bank policies.

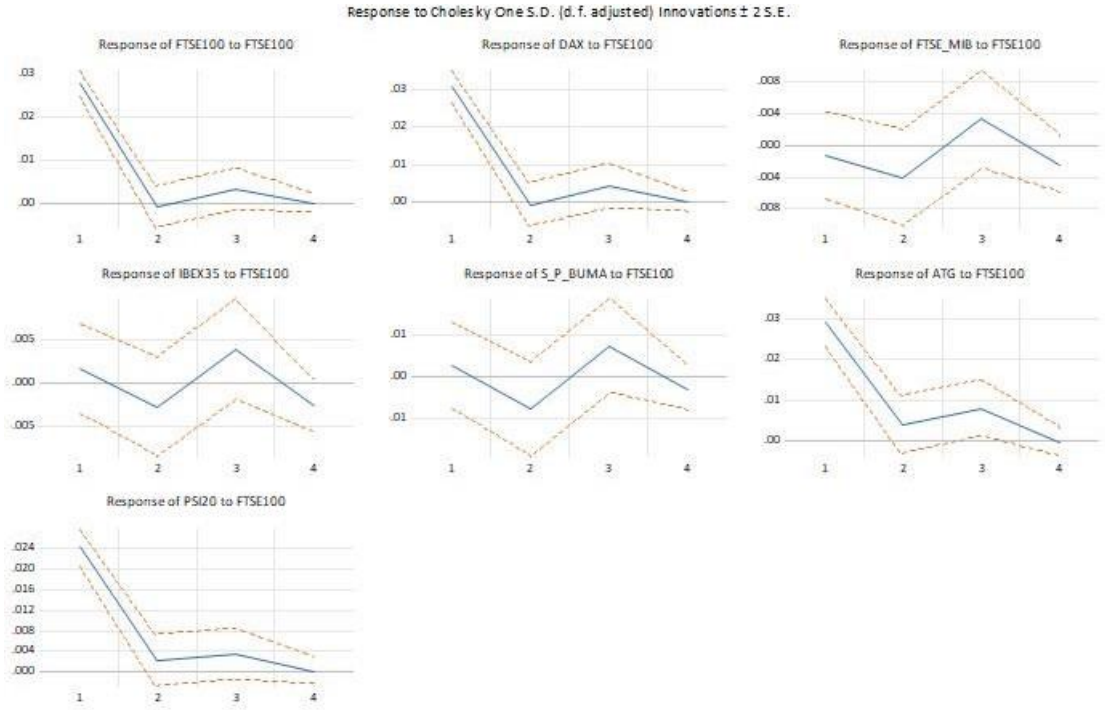
Moreover, examination proceeds by estimating the impulse response functions that the German DAX30, the British FTSE100, and the Argentinian S&P/BYMA generate on the remaining indices as displayed in ***Figures 2, 3***, and ***4***, respectively. It should be emphasized that the German index initially exerts negative impacts on all the indices examined. Moreover, it should be noted that the impact on the FTSE 100, the ATG, and the PSI 20 fades out more quickly than in the cases of the FTSE MIB, the IBEX 35, and the S&P/BYMA indices where the effect turns positive and then negative again but does not fade out rapidly. This informs that the stock index of the strongest European economy is more impactful towards other major European economies and some developing European economies, but this effect quickly vanishes. On the other hand, the effects on the remaining developing European markets as well as representative Latin American ones are weaker but last more. This is very important towards understanding how causal spillovers coming from advanced economies differentiate depending on their destinations.

Figure 2. Impulse response analysis of DAX



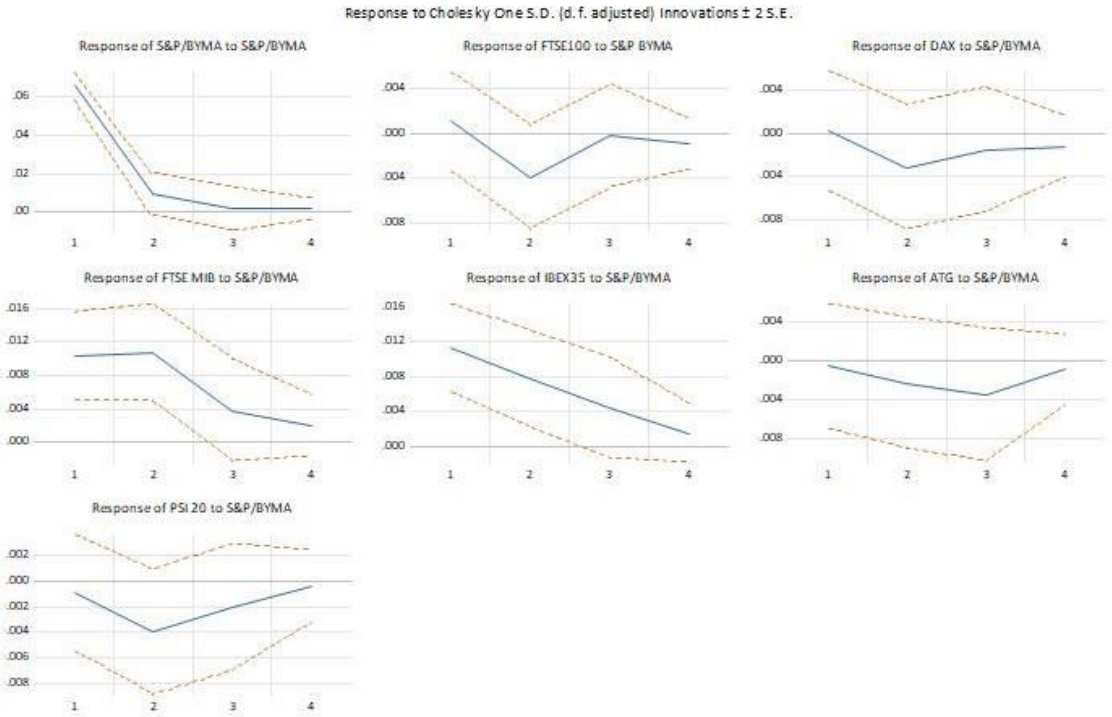
Results are somewhat similar when impulse response analysis of the impacts of FTSE 100 takes place. It can be seen that the DAX 30, the ATG, and the PSI 20 react strongly to shocks in the British index but these effects vanish quickly. On the contrary, the FTSE MIB, the IBEX 35, and the S&P/BYMA indices respond negatively in a weaker degree and then the impact renders positive but does not fade out. These findings are almost identical with the case of the DAX 30 being the generator of shocks. Therefore, it can be safely argued that advanced economies cause powerful and short-lived effects on other major economies but impacts on developing economies are weaker but persist over time. This shows that causal spillovers towards smaller economies depend on their regional position as well as perhaps with their trade relations with the shock generating country.

Figure 3. Impulse response analysis of FTSE100



When it comes to the causal impacts that come from the Argentinian index, it can be seen that a range of different patterns are revealed depending on the country that is influenced. Notably, the stock indices of advanced economies (DAX 30, FTSE 100) are negatively affected in the beginning by a very small level and this impact renders positive afterwards and then is stabilized. The Argentinian index is found to be much more influential towards the Italian and the Spanish indices but this effect is decreasing as time passes. As concerns the effects on the Greek and the Portuguese indices, they are small and decreasing but then increase.

Figure 4. Impulse response analysis of S&P/BYMA



From a financial viewpoint, it is evident that developing markets are not able to significantly affect advanced economies. It is noticeable though that small economies could be influential towards a certain number of other developing or troubled economies. To be more precise, Argentinian stock markets are negatively influential towards two important Mediterranean economies. This could be attributed to similar characteristics between them that are able to cause investor fear and lead to downwards movements in their stock markets. Another explanation could be that when the Argentinian stock market performs well, risky investors prefer to invest in this country than to other risky countries such as the Mediterranean stock markets.

5. Conclusion

This paper investigates the spillover causal impacts of European advanced and developing stock markets and the developing Argentinian stock market from the end of 2017 until the end of 2020 that has been a period of many fluctuations in global financial markets. More specifically, the German DAX30, the British FTSE 100 and the French CAC 40 indices represent the advanced stock markets while the Italian FTSE MIB, the Greek ATG, the Portuguese PSI 20, the Spanish IBEX 35 and the Argentinian S&P/BYMA stand for the developing markets. The Vector Autoregressive (VAR) methodology is employed for conducting estimations. All data are employed in weekly frequencies and transformed into logarithmic differences.

Econometric results by VAR estimations and impulse response functions reveal that the advanced DAX 30 and FTSE 100 indices but not the CAC 40 index are influential towards major economies while also exert effects on specific developing economies in different manners. More specifically, they prove to be strongly and negatively influential towards the Greek and the Portuguese indices, but these impacts quickly fade out. On the other hand, they are less and negatively influential on the Italian and the Spanish indices, but these effects then turn positive and persist over time. When it comes to impacts of the Argentinian index, it is found to be much more influential and in a negative direction towards the Italian and the Spanish indices.

Thereby, it should be highlighted that developing economies exert causal impacts on other developing economies in an efficient manner while are unable to affect advanced economies. On the contrary, advanced economies are influential on developing markets but their level of influence depends on the origin and the destination of the impact. Notably, it is found that members of the Eurozone (that is Germany) are more impactful towards Portuguese stock markets than non-Eurozone members (such as the UK). Nevertheless, eastern Mediterranean markets (such as Greece) are receivers of stronger impacts from European members with own national currencies, but western Mediterranean markets are primarily affected by major European countries that have adopted the Euro.

This study contributes to better understanding the causal relations between pairs of stock indices and informs the interested reader about how he should take correct investment decisions based on the impacts that one index exerts on the other. To the best of our knowledge, this is the first study that investigates the specific stock indices with this exact methodology. Avenues for further research should include the examination of the causal linkages among a wider array of financial assets with advanced econometric methodologies. Moreover, models with data rich environment (DFMs) could be adopted. Moreover, the impact of macro variables in stock markets interdependence should be

examined and market-specific characteristics that lie behind such interdependence should be explored. Last but not least, the effect of exogenous unanticipated events such as the Covid-19 pandemic on markets should be investigated.

Acknowledgment: The authors would like to thank the participants of the 14th International Conference: Economies of the Balkan and Eastern European Countries (EBEEC 2022), Florence, for useful comments in an earlier version of this paper.

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