COVID-19 containment measures and stock market returns: An international spatial econometrics investigation

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Abstract

We investigate the impact of governments' social distancing measures against the novel coronavirus disease 2019 (*COVID-19*) as this was reflected on 45 major stock market indices. We find evidence of negative direct and indirect (spillover) effects for the initial period of containment measures (lockdown).

JEL classifications: C23, G15, I18

Keywords: COVID-19; government policy responses; spillover effects; stock market volatility

Declarations of interest: none.

Acknowledgements: We are grateful to two anonymous referees for helpful comments and suggestions. All remaining errors are ours.

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1. Introduction

The coronavirus disease 2019 (*COVID-19*) outbreak shocked the world and triggered an unprecedented wave of uncertainty in real economies as well as in financial markets, as the latter reflect economic expectations. The way the international community handled the *COVID-19* outbreak is unprecedented in the history of pandemics, due to the synchronized global lockdown which limited economic activity for several months and traumatized society and financial markets. In addition, the risk of multiple future waves of lockdowns remains since a vaccine or a suitable treatment has not been officially adopted yet. Until an efficient treatment will be available, economic agents will behave with extreme caution, since they may expect that a recession wave will persist for several time periods (Kohlscheen et al., 2020).

The outbreak of *COVID-19* represents an exogenous to the economic system international event and, consequently, it is important to investigate the relation of this event to real economic variables, as well as to the performance of the global financial market. In the past, there have been many attempts to measure the impact of such exogenous events, such as epidemics or natural disasters, on economic variables (e.g., Nippani and Washer, 2004; Wang and Kutan, 2013). This time, the pandemic nature of *COVID-19* may help to understand the mechanisms through which such events may affect the international economy and people's well-being. Results of economic research on the recent pandemic may prove informative for policy makers in risk and loss management of possible similar future exogenous events.

While the economic consequences of the pandemic cannot be fully estimated yet, their extent will depend not only on the direct effects of the lockdown measures, but also on the spillover effects that these measures have on trade and financial partners. In this note, we contribute to two strands of the literature. The first is the growing literature of the novel *COVID-19* pandemic and its side effects on international stock markets (Al-Awadhi et al., 2020; Zhang et al., 2020; Zaremba et al., 2020). The second is the literature on international stock market spillovers. The outbreak offers a unique opportunity to assess the impact of an exogenous shock (infectious disease) on the stock markets by estimating the effect the containment measures had on these markets.

In order to evaluate the spillovers of the lockdown measures, we account for two alternative transmission mechanisms (trade and financial channels), thus being in line with Boissay and Rungcharoenkitkul (2020) who highlight the need for understanding the different transmission channels of the *COVID-19* shock to the economy.

We utilize spatial econometric techniques to account for both the direct and the indirect effects of the *COVID-19* social distancing measures and analyze the negative impact the latter had on international stock markets. In such a way, we can better assess the policy trade-offs that the governments had to undertake in their attempt to control the extent of the pandemic.

Our work follows the lines of Asgharian et al. (2013) who study financial markets co-movements and market sensitivity to exogenous shocks. To the best of the authors' knowledge, this is the first empirical assessment of the spillover effects of *COVID-19* containment measures on international stock markets.

2. Methodology

We estimate the following dynamic Spatial Durbin Model (DSDM) with fixed effects, which enables us to account for the increased degree of interdependency between stock markets:

$$smi_{it} = a + \tau smi_{it-1} + \psi \sum_{j=1}^{N} \hat{w}_{ij} smi_{jt-1} + \rho \sum_{j=1}^{N} \hat{w}_{ij} smi_{jt} + \beta_1 cgr_{it} + \gamma_1 \sum_{j=1}^{N} \hat{w}_{ij} cgr_{jt} + \beta_2 cases_{it} + \gamma_2 \sum_{j=1}^{N} \hat{w}_{ij} cases_{jt} + \mu_i + \varepsilon_{it} \quad (1)$$

where i denotes a given country, t denotes a specific time period, smi is the daily stock market index return, cgr is the daily relative change of the Coronavirus Government Response Tracker index,[1] *cases* is the daily relative change of *COVID-19* total cases per million individuals, μ_i is the country-specific effect and ε_{it} is the error term. The variable *cases* is included in our specification to control for the severity of pandemic. Moreover, $\hat{w}_{ij}$ is the *ij*th element of a row standardized weighting matrix $\mathbf{W}$, with $\hat{w}_{ij} = \frac{w_{ij}}{\sum_j w_{ij}}$, $\sum_j \hat{w}_{ij} = 1$ and $w_{ij} = 0$ if $i = j$. The element w_{ij} is defined according to the interaction matrix used each time; trade relations matrix and financial linkages matrix. More specifically, in the case of the trade relations matrix[2] $w_{ij} = \frac{exports_{ij} + imports_{ij}}{GDP_i + GDP_j}$ if $i \neq j$ where imports, exports and GDP are expressed in US dollars, whereas $w_{ij} =$ bilateral financial investment in US dollars if $i \neq j$, in the case of the financial linkages matrix.

The specification in Equation (1) also allows us to control for omitted variable bias. Specifically, the dynamic nature of our model accounts for time-varying omitted variables (see Wooldridge, 2002), while time-invariant omitted variables are modeled

[1] The values of this index range from 0 (no lockdown measures in place) to 100 (total lockdown).
[2] We use the formula proposed by Frankel and Rose (1998).

through the fixed effects specification (see Baltagi, 2005). Two variants of the DSDM are estimated: one with and one without the spatial lag of the time lag of the dependent variable.

We use MLE (Maximum Likelihood Estimation) to estimate our spatial model. MLE is the preferred estimation method for our specification since it alleviates the endogeneity problem caused by the inclusion of the spatial autoregressive variable and the time lagged dependent variable (Elhorst, 2005; Lee & Yu, 2010). The need for a spatial specification is tested through the Pesaran test for cross-sectional dependence (Pesaran, 2004). The null hypothesis of cross-section independence is rejected for all variables indicating the need for a spatial specification (the corresponding results are available upon request).

To construct the interaction matrix (W), we consider two different market interconnectedness mechanisms. The trade relations mechanism, according to which trade partners with more intense trade flows have correlated business cycles (Frankel and Rose, 1998) and the degree of financial integration/linkages[3] (as proxied by the bilateral financial investments of each country). The data for the construction of the trade relations (financial linkages) matrix were retrieved from the World Bank's WITS database (the IMF's Coordinated Portfolio Investment Survey) for the year 2018 (2019).

3. Data and descriptive statistics

[3] Investors' adjustment of portfolios' exposures in one market leads to the transmission of idiosyncratic shocks to another market (Kodres and Pritsker, 2002).

The dataset used is a balanced panel that spans from January 2nd to April 8th 2020. The data for *smi* were retrieved from investing.com and finance.yahoo.com websites.

As noted above, *cgr* and *cases* are expressed in daily relative changes.[4] The data for *cgr* were retrieved from Oxford Coronavirus Government Response Tracker (OxCGRT) database (Hale et al., 2020), whereas those for *cases* from https://ourworldindata.org/coronavirus. An overview of the data about the Coronavirus Government Response Tracker index is presented in Figure 1, while the descriptive statistics for the variables used in our model are reported in Table 1.

[Figure 1 about here]

Since we use a high frequency dataset over a short time period, we do not control for other global factors and macroeconomic fundamentals (data unavailability and zero variance issues).[5]

[Table 1 about here]

4. Results and discussion

Our estimation results (Table 2) indicate a negative relationship between stock market returns and changes in the intensity of *COVID-19* containment measures (columns 2 through 5). In particular, an increase in the intensity of *COVID-19* non-pharmaceutical interventions in a given country leads to a decrease in the stock market returns of the same country (short and long-run direct effects). Moreover, our findings show the existence of negative spillover effects, since an increase in the

[4] The midpoint relative change ($\Delta x / \bar{x}$) was used in order to avoid issues related to infinite percentage changes when lockdown measures (COVID-19 cases) are first introduced (first appear).

[5] Exchange rates are the only exception. However, the inclusion of exchange rates in our specification did not change qualitatively our results.

government response intensity in a given country leads to a decrease in the stock market returns in the interrelated countries (short and long-run indirect effects). All in all, spillover effects complement direct effects, thus intensifying the negative impact of lockdown measures on the performance of stock markets. Specifically, our findings suggest that a 10% increase in the relative change of the stringency index will result in a decrease between 0.2% and 0.5% in the stock market returns (average total effects). The above results hold for all four specifications and irrespective of the linkage measure considered. However, at this point, it should be noted that the estimated indirect (spillover) effects do not capture only spillovers due to trade relations and financial linkages between countries but also global co-movement effects of stock markets[6] (Asgharian et al., 2013).

[Table 2 about here]

A striking result of our analysis is that spillover effects are larger than direct effects. While this may seem counterintuitive, it is not uncommon since cumulating spillover impacts over many cross-sectional units (even when averaged) may result in effects of high magnitude (see LeSage and Dominguez, 2012). The nature of interdependencies (financial market spillovers) in our analysis further supports this result. However, to further check the robustness of the above finding, we re-estimated our model excluding China and the USA. The results, which are available upon request, indicate that there is no qualitative change in our estimates (indirect effects are still larger than direct effects).

[6] Although global co-movement effects can be isolated by controlling for factors that drive stock markets globally (such as CBOE volatility index and oil price), the cross-section invariant nature of these factors, together with the nature of our dataset do not allow us to include them in our specification.

5. Conclusion

In this study, we apply spatial econometric techniques to estimate the effect of *COVID-19* containment measures on 45 stock market indices. The results indicate that stock market returns, and the intensity of lockdown measures are negatively related. The examination of *COVID-19* pandemic impact on a number of areas such as social trust and concomitant transaction costs, social security, costs of capital and political stability can be considered as topics for future research (an early review of possible future research agendas is extensively discussed in Goodell (2020)).

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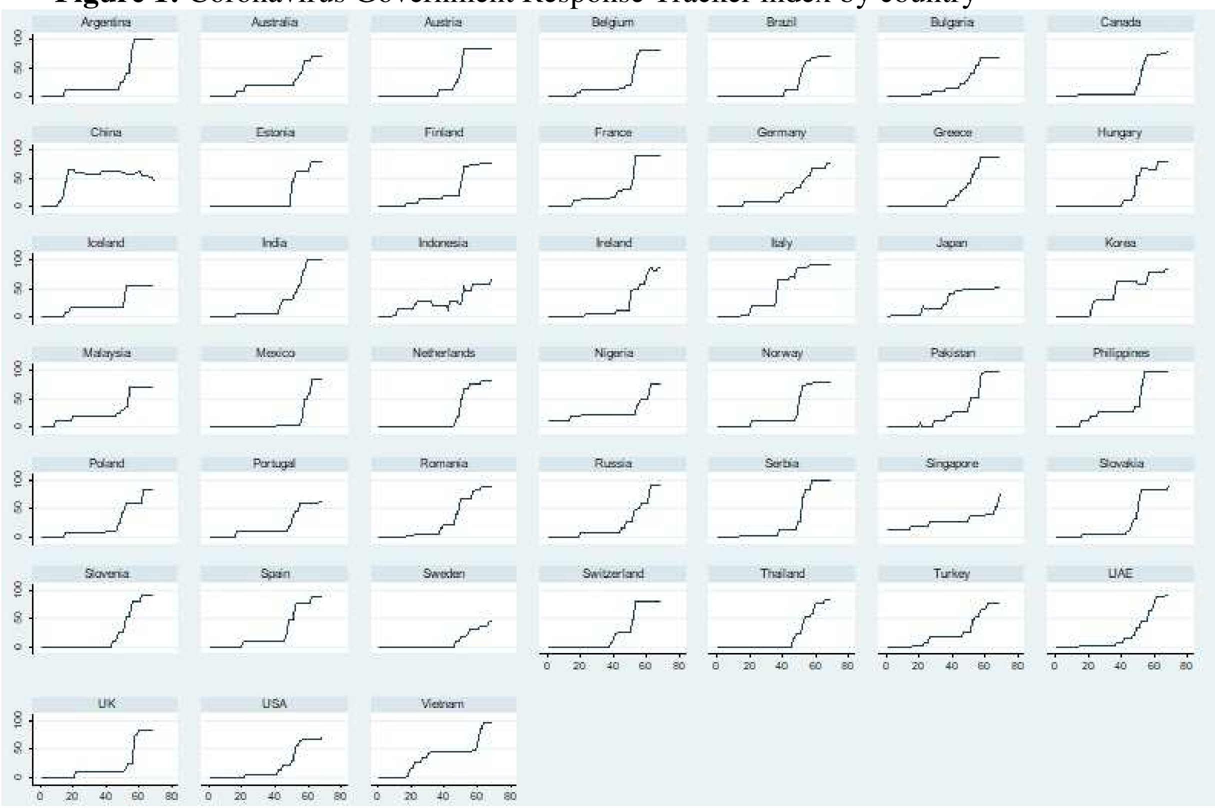
Tables and Figures

Figure 1: Coronavirus Government Response Tracker index by country



Notes: Each graph illustrates the Coronavirus Government Response Tracker index by each country. The horizontal axis depicts the time dimension and the vertical axis the corresponding index.

Table 1: Descriptive statistics

Variables	Obs.	Mean	Standard deviation	Min.	Max.
Stock market index returns (*smi*)	3,105	-0.0038	0.0284	-0.1854	0.1302
Relative change of Coronavirus government response index (*cgr*)	3,105	0.062	0.274	-2	2
Relative change of total *COVID-19* cases per million individuals (*cases*)	3,105	0.142	0.316	0	2

Notes: The countries included in our analysis are the following: Argentina, Brazil, Canada, Mexico, USA, Nigeria, Austria, Belgium, Estonia, Finland, France, Germany, Iceland, Ireland, Italy, Greece, Hungary, Bulgaria, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, UK, China, India, Indonesia, Japan, Korea, Malaysia, Pakistan, Philippines, Singapore, Thailand, UAE, Vietnam and Australia.

Table 2: Stock market index returns and coronavirus government response

	Dependent variable: Stock market index returns (*smi*)			
interaction matrix (*W*):	trade relations	trade relations	financial linkages	financial linkages
smi_{t-1}	-0.0854***	-0.149***	-0.0216	-0.185***
	(0.0266)	(0.0413)	(0.0241)	(0.0390)
cgr	-0.00152	-0.00144	-0.00163	-0.00138
	(0.000994)	(0.000982)	(0.00106)	(0.00100)
cases	-0.00293**	-0.00294**	-0.00518***	-0.00471***
	(0.00133)	(0.00134)	(0.00134)	(0.00132)
$W*smi_{t-1}$		0.107***		0.244***
		(0.0410)		(0.0406)
*W*cgr*	-0.00803**	-0.00702**	-0.00398*	-0.00339
	(0.00323)	(0.00338)	(0.00219)	(0.00218)
*W*cases*	-0.00904***	-0.00774***	-0.0106***	-0.00766***
	(0.00266)	(0.00268)	(0.00173)	(0.00157)
ρ	0.817***	0.822***	0.668***	0.693***
	(0.0340)	(0.0336)	(0.0454)	(0.0429)
Short-run effects				
cgr Direct effect	-0.00296**	-0.00269**	-0.00190*	-0.00160*
	(0.00123)	(0.00116)	(0.00109)	(0.000960)
cases Direct effect	-0.00463***	-0.00459***	-0.00590***	-0.00541***
	(0.00146)	(0.00157)	(0.00132)	(0.00140)
cgr Indirect effect	-0.0523**	-0.0466**	-0.0155**	-0.0139**
	(0.0212)	(0.0231)	(0.00612)	(0.00688)
cases Indirect effect	-0.0629***	-0.0584***	-0.0421***	-0.0360***
	(0.0201)	(0.0195)	(0.00751)	(0.00740)
cgr Total effect	-0.0553**	-0.0493**	-0.0174***	-0.0155**
	(0.0220)	(0.0238)	(0.00646)	(0.00715)
cases Total effect	-0.0675***	-0.0630***	-0.0480***	-0.0414***
	(0.0209)	(0.0204)	(0.00815)	(0.00822)
Long-run effects				
cgr Direct effect	-0.00236**	-0.00225**	-0.00185*	-0.00150*
	(0.00102)	(0.000960)	(0.00106)	(0.000837)
cases Direct effect	-0.00382***	-0.00388***	-0.00573***	-0.00495***
	(0.00126)	(0.00133)	(0.00129)	(0.00124)
cgr Indirect effect	-0.0345***	-0.0370**	-0.0144**	-0.0180**
	(0.0126)	(0.0173)	(0.00570)	(0.00892)
cases Indirect effect	-0.0412***	-0.0464***	-0.0393***	-0.0470***
	(0.0112)	(0.0142)	(0.00670)	(0.0110)
cgr Total effect	-0.0368***	-0.0392**	-0.0163***	-0.0195**
	(0.0131)	(0.0178)	(0.00601)	(0.00924)
cases Total effect	-0.0450***	-0.0502***	-0.0450***	-0.0519***
	(0.0117)	(0.0149)	(0.00733)	(0.0117)
Country fixed effects	*Yes*	*Yes*	*Yes*	*Yes*
LogL	7794.6484	7807.2015	7633.9635	7726.1150
No. of countries/observations	45/3,060	45/3,060	45/3,060	45/3,060

SDM vs. SEM likelihood ratio test ($\chi^2(2)$)	35.47***	23.39***	70.60***	50.77***

Notes: LogL: Log-pseudolikelihood. The last row reports the likelihood ratio test statistic for testing the common factor constraint (see Florax et al., 2003); failing to reject the null hypothesis indicates a Spatial Error Model (SEM) nested within a Spatial Durbin Model (SDM) (i.e., H_0: $\theta = -\rho\beta$). Based on the results, the common factor constraint is rejected for all specifications implying the superiority of the SDM. Regression results were generated in Stata using the -xsmle- command (Belotti, et al., 2017). The direct short-run effect of *cgr* is equal to $tr(\mathbf{S}_1)/N$ where $\mathbf{S}_1 = [\mathbf{I} - \rho\mathbf{W}]^{-1}[\beta_1\mathbf{I} + \gamma_1\mathbf{W}]$, $\mathbf{I}$ is an $N \times N$ identity matrix and N is the number of countries; the short-run total effect is equal to $N^{-1}\mathbf{z}'_N\mathbf{S}_1\mathbf{z}_N$, where $\mathbf{z}_N$ is a $N \times 1$ vector with each element equal to one; the short-run indirect effect is equal to the difference between the total and the direct effect. The long-run direct, total and indirect effect are similarly defined, but instead of $\mathbf{S}_1$ matrix, we use $\mathbf{S}_2 = [(1-\tau)\mathbf{I} - (\rho + \psi)\mathbf{W}]^{-1}[\beta_1\mathbf{I} + \gamma_1\mathbf{W}]$. The corresponding effects for *cases* are defined in a similar way (for a more thorough treatment, see LeSage and Pace (2009)). Robust standard errors are reported in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.