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Full length research paper

A re-estimation of the impact of the subprime crisis on the economic growth of some emerging countries: Vector-Error correction model

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This paper deals with the analysis of a group of emerging countries so as to identify the scale of the subprime crisis on their economic growth. In this context, we will discuss a panel data analysis. We will try to econometrically examine the real impact of the crisis on the economic growth in six emerging countries through five channels: the interest rate channel, the wealth impact channel, the bank lending channel, the shock and uncertainty channel and the trade channel, over the period 2002-2011. According to the estimates of the VECM model, there is a long-run relationship between the consumer price index, the exports and the interbank spread on economic growth. However, the long-run estimate indicates no relationship between economic growth and volatility and the stock price performance.

Keywords: Sub-prime crisis, emerging countries, VECM, transmission channels.

JEL classification: E31, E44, F13.

INTRODUCTION

The financial crisis of 2007, which caused the collapse of several U.S. and European banks and tightened the credit conditions, eventually spread to the real economy leading to an economic recession despite the various plans of the economic recovery in the United States, in Europe and in the emerging countries.

Actually, in an economically interconnected world in a continuous way, the emerging countries, in general, were affected by the most severe crisis since the 1929 Great Depression. Most of the developing countries were hit by this crisis which had a major impact on the economic growth, investment, commodity prices, market capitalization companies, foreign exchange rates, aid to poor countries, unemployment, bankruptcies, etc. Not all the emerging countries were financially affected in the same way as the effects of the financial crisis on the real economy are different depending on the nature of the accumulation regime, the level of the short-term debt and the sign of the balance of current payments.

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Several studies focused on the degree of exposure of the emerging economies to external shocks. In particular, the contagion phenomena that appear after a crisis point to the growing influence of external, mainly financial, variables in the emerging countries (Kaminsky et al., 2003). The increasing openness of the emerging economies, both commercially and financially, as well as the episodes of the financial crisis showed the importance of external shocks. Moreover, the negative effects of these shocks spread from the financial sector to the real one, which leads to a significant slowdown of production. This phenomenon is explained by the lack of sustainability of the established exchange rate regimes during the last decade and the sensitivity of countries to external variations.

In several recent studies, the causal relationship between financial crises and economic growth has been invested. Cerra and Saxena (2008), tried to model the trajectory of an economy after a shock which might be: a financial crisis, a currency crisis, a civil war or an institutional change. The GDP growth rate is estimated on the basis of a univariate autoregressive specification to which indicators representing the shocks to the economy are added. The writers used panel data for a

large number of countries and showed that financial crises are accompanied by significant and persistent production losses and that a full return to production, on the trend level of the projected GDP before the crisis, is much unexpected.

De and Chiranjib (2011), attempted to analyze the impact of shocks of the global crisis on the Indian trade and industry. They used two models in their analysis: the panel data technique and the vector auto regression (VAR). The results of the panel estimation show that a change in the composition of trade is positively associated with a change in the composition of the manufacturing sector. Thus, the results of the VAR technique obtained by these authors indicate that the change in the composition of the industry responds significantly to exports to the United States, Japan, and the European Union in the crisis period.

By the same reasoning, Al Qaisi's research (2013), focused on the impact of the global financial crisis on the industrial sector in Jordan. Various financial ratios were estimated from the financial statements of the industrial firms for the period 2002-2008. The results showed that there was a negligible effect on the industrial sector in Jordan.

In this work, we discuss the problem of the impact of the subprime crisis on economic growth through several transmission channels. The objective of this paper is to identify the different transmission mechanisms of the financial crisis that affected the economic growth of six emerging countries. Given the limitations of the time series, the panel data are a particularly valuable source for the statistical analysis of the economic agents' behavior where approaches of the unit root tests and co-integration panel data are used. The analysis methodology consists in specifying an econometric model which explains the relationship between the transmission channels of the financial crisis and economic growth in the emerging countries. The use of this approach could be justified by the fact that, with the use of short-term relationships, causality tests and long-term estimates, the magnitude of the subprime crisis on economic growth in the emerging countries can be explained by different transmission channels. In what follows, we will develop, in a second section, the model and the applied data. In a third section, we will present the estimation results and the major conclusions.

MODEL AND VARIABLES

To study the short-term relationship between the transmission channels of the financial crisis and economic growth, we estimate a vector error correction model (VECM). This model is a forced vector auto-regression model used for the co-integrated and non-stationary series. The VECM is built to minimize the behavior of the long-run relationships of the endogenous variables to converge to their co-integrating equilibrium while allowing, at the same time, a short-run adjustment dynamics.

Although Pedroni's statistics of the co-integration test (1999) can be used to test the existence of a long-term relationship between the variables, they do not give an assessment within the VECM framework. The VECM "Vector Error Correction Model" Method is used to estimate simultaneously several co-integration relationships in a co-integration system. In fact, there are several methods for the estimation of the co-integrating relationship between the variables in the model. Groen and Kleibergen (2003), presented the VECM in the following system:

$$\Delta x_t = ¢ + \bar{} .t + \Pi .x_{t-1} + \Gamma .W_t + £_t \qquad (1)$$

Let $x_{it} = \left(x_{it}^1, x_{it}^2, ..., x_{it}^k\right)'$ be a vector of k variable I(1) for a number of individuals $i = 1, \cdots, N$ for the period $t = 1, \cdots, T$. Vector $¢ = \left(¢_1, ¢_2, ..., ¢_k\right)'$ includes the individual effects N_k (supposed to be fixed) associated with each individual and each endogenous variable.

The θ vector includes the coefficients of the deterministic trend that are supposed to be different for each variable and for each individual. The Π matrix defines both the restoring forces and the co-integrating possible relationships. It is written as follows:

$$\underset{(Nk,Nk)}{\Pi} = \begin{pmatrix} \Pi_{11} & ... & \Pi_{1N} \\ ... & \Pi_{ij} & ... \\ \Pi_{N1} & ... & \Pi_{NN} \end{pmatrix} \qquad (2)$$

Where the Π_{ij} matrices have dimensions (k ;k). The ΓW_t term represents the set of the items related to the dynamics of the short-term adjustment. Broadly speaking, it is necessary to introduce the same p number of lags for all the individuals in the panel. Hence, we will have:

$$\underset{(Nkp,1)}{W_t} = (\Delta x'_{1,t-1}, ..., \Delta x'_{1,t-p}, ..., \Delta x'_{N,t-1}, ..., \Delta x'_{N,t-p}) \qquad (3)$$

And

$$\underset{(Nk,Nkp)}{\Gamma} = \begin{pmatrix} \Gamma_{11} & ... & \Gamma_{1N} \\ ... & \Gamma_{ij} & ... \\ \Gamma_{N1} & ... & \Gamma_{NN} \end{pmatrix} \qquad (4)$$

Where the Γ_{ij} matrices have dimensions (k;kp) and the individual vectors $\Delta x_{i,t-p}$ of dimensions (k;1) which contain the first delayed differences of the k endogenous variables of individual i.

The $£_t = (£_{1t}, £_{2t}, ..., £_{Nt})'$ vector contains the N vectors of individual residues $£_{it} = (£_{1t}^1, ..., £_{Nt}^k)'$ associated with k residues of each single VECM. With $£_t$ an i.i.d (0, Ω). The Ω matrix (non-diagonal block) is written as follows:

$$\underset{(Nk,Nk)}{\Omega} = \begin{pmatrix} \Omega_{11} & ... & \Omega_{1N} \\ ... & \Omega_{ij} & ... \\ \Omega_{N1} & ... & \Omega_{NN} \end{pmatrix} \quad (5)$$

Where Ω_{ij} are the matrices that have (k;k) dimensions.

The choice of the variables and the study period was determined by the availability of the data in the selected period and for the studied six emerging countries: Brazil, Chile, China, Malaysia, Mexico and Turkey, over a period of 120 observations. The data were collected on a monthly basis between January 2002 and December 2011 and obtained, on the one hand, from the IMF and the OECD and, on the other hand, from the central banks of the studied countries. The selected variables are defined as follows:

- LIPI is the natural log of industrial production index that represents a proxy of economic growth.
- LIPC is the natural log of the consumer price index that represents the price variable.
- LEXP is the natural log of exports that represents the commercial channel.
- SPREAD is the difference between the 3-month interbank rate and that of the Treasury bills. In addition, it is an indicator of the difficulties of refinancing banks in times of a crisis. The "spread" interbank variable is therefore a proxy of the (quantitative) liquidity problems faced by banks in times of a crisis and therefore of the financial effect.
- Volatility is the stock price variable that is a proxy of uncertainty in the global economy which affects the spending decisions of the economic agents. It is calculated by the square residuals.
- Performance is the natural log of the changes of the stock prices that represent a proxy for the total wealth of the agents. In fact, the share prices are a good indicator of the wealth of the different private agents (companies, households and financial institutions).

Moreover, the decrease of the stock prices creates some difficulties in funding companies and depreciates the balance of companies and financial institutions whose assets are estimated at their market value. This situation penalizes the different investment projects.

Results and interpretations

In what follows, we will present three important steps: unit root tests, a co-integration test and the model estimates. As far as the unit root tests are concerned, we will be dealing with the tests of Levin et al. (2002), and Im et al. (2003). For the co-integration tests, we will go back to the tests of Pedroni (2004), and Westerlund (2007). Using the Panel data, we find it advisable to apply a number of tests in order to find out the best statistical specification of our model. Therefore, we will apply the tests of fixed and random effects, of Hausman and heteroskedasticity. Finally, we will move on to the estimation of the relationship between economic growth and the transmission channels of the financial crisis through the use of a VECM model.

Before estimating our basic model, we think it is necessary to test the stationarity of the selected variables. We actually refer to the LLC and IPS tests which are based on the assumption of no autocorrelation of residuals. Table 1 shows the different results obtained in our panel data of the unit root tests.

The LLC and IPS tests made us conclude that the IPI, CPI and EXP variables are not stationary in levels. These tests indicate that these three variables are integrated of order 1, while the SPREAD, Performance and Volatility variables are stationary in levels. The tests reject the null hypothesis of the unit root. Therefore, these variables are integrated of order 0. However, all the variables are stationary in first differences. In this regard, we will test the existence of one or more co-integrating relationships between the considered variables.

On the basis of the results of the panel unit root, the purpose of the co-integration tests on the heterogeneous panel data developed by Pedroni (2004), is to understand the fact that there is no co-integration null hypothesis for both heterogeneous and homogeneous panels. It is clear, from Pedroni's test estimates in Table 2, that there is at least one co-integrating relationship checked by one of the seven test statistics. Actually, the statistics "PP-Statistical Panel" could successfully exceed the three models.

According to this test, we cannot assert the existence of a long-run relationship between the variables. For this reason, we opted for a second test to confirm or infirm the existence of this co-integrating relationship. The test considered here is that of Westerlund (2007). Indeed, the results of the four test statistics are shown in Table 3 below. Among the four statistics, two, such as Ga and Pa, are in favor of the existence of a co-integrating relationship.

In general, we can say that there is a co-integrating relationship between the variables of the basic model. Therefore, we chose to use the vector error correction model (VECM) to check if there is a causal relationship between the considered variables. The results of the fixed effect test are shown in Table 4. At 5%, Fisher's

Table 1: The results of the unit root tests

Variables	LLC						IPS			
	In level			In first difference			In level		In first difference	
	ACAT	ACST	SCST	ACAT	ACST	SCST	ACAT	ACST	ACAT	ACST
LIPI	-2.64[a]	-2.24[b]	2.45	-34.9[a]	-31.6[a]	-29.4[a]	-5.2[a]	-4.93[a]	-33.8[a]	-32.08[a]
	(0.004)	(0.012)	(0.993)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LIPC	-4.11[a]	-2.26[b]	6.32	-13.4[a]	-12.1[a]	-10.1[a]	-4.40[a]	1.24	-13.6[a]	-13.9[a]
	(0.000)	(0.011)	(1.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.894)	(0.000)	(0.000)
LEXP	-0.46	-2.81[a]	3.99	-26.0[a]	-24.41[a]	-30.2[a]	-1.46[c]	-0.59	-27.8[a]	-26.7[a]
	(0.319)	(0.002)	(1.000)	(0.000)	(0.000)	(0.000)	(0.071)	(0.276)	(0.000)	(0.000)
SPREAD	-6.48[a]	-4.69[a]	-4.31[a]	-33.4[a]	-30.1[a]	-28.1[a]	-6.94[a]	-6.14[a]	-28.5[a]	-27.6[a]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Volatility	-20.4[a]	-18.4[a]	-17.4[a]	-20.9[a]	-19.7[a]	-25.8[a]	-17.3[a]	-17.3[a]	-27.6[a]	-26.9[a]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Returns	-21.2[a]	-19.3[a]	-20.8[a]	-13.0[a]	-13.0[a]	-28.1[a]	-20.5[a]	-20.3[a]	-28.5[a]	-27.7[a]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: (a), (b) and (c) show significance respectively at 1%, 5% and 10%. AC: with a constant, SC: without a constant, AT: with a trend, ST: with a trend. The p-value in (.).

Table 2: The results of Pedroni's co-integration test (2004)

Statistics	ATAC	STAC	STSC
V-statistical panel	-0.478	0.741	-1.629
	(0.683)	(0.229)	(0.948)
Rho- Statistical panel	-8.089***	-7.813***	-1.533***
	(0.000)	(0.000)	(0.062)
PP- Statistical panel	-8.238***	-7.396***	-2.448***
	(0.000)	(0.000)	(0.007)
ADF- Statistical panel	-1.279*	-1.823**	-0.227
	(0.097)	(0.034)	(0.410)
Rho- Statistical group	-8.991***	-9.158***	-1.297*
	(0.000)	(0.000)	(0.097)
PP- Statistical group	-8.987***	-8.883***	-2.564***
	(0.000)	(0.000)	(0.000)
ADF- Statistical group	-2.924***	-2.189**	-0.382
	(0.001)	(0.014)	(0.351)

Notes: *, **, *** Significance at 10%, 5%, and 1%.

Table 3: The results of Westerlund's co-integration test (2007)

Statistics	Coefficients	P-value
Gt	-2.995	0.185
Ga	-21.223	0.032***
Pt	-6.889	0.160
Pa	-18.039	0.024***

Table 4: Tests of fixed and random effects

	Fixed effects		Random effects	
Model	Empilé	LSDV	LM^I	LM^T
SCR	3.71	2.64	0.00	0.00
Dl	714	709	1	1
Statistics	$F^c = 71.333$		$LM^G = 2$	

Table 5: Test of serial correlation

	Value	Asymptotic distribution	Critical value	Decision
LM test (*fixed effect)*	516.530	N (0,1)	2.40	CS+
LM test (*joint*)	56.879	χ^2_2	9.26	CS+
DW test	0.19	dl=1,81*	du=1,83	CS+

Notes: CS +: represents the existence of a positive Serial Correlation. * Bhargava et al. (1982).

Table 6: Estimation of the Rho values of the six countries

Rho	1	2	3	4	5	6
Value	0.77	0.71	0.92	0.92	0.93	0.75

Table 7: Estimation of the final fixed effect model

Variables	Estimated value	Robust standard deviation	T Student	P-values
IPC	0.267	0.028	9.38	0.000***
EXP	-0.083	0.010	-8.09	0.000***
SPREAD	-0.001	0.000	-1.46	0.148
Volatility	$4.63e^{-6}$	$3.94e^{-6}$	1.17	0.243
Returns	-0.000	0.000	-0.85	0.398
Constant	4.158	0.165	25.39	0.000***
F(10,119)		151.09		0.000

tabulated statistics shows a high value of the F statistics, which leads to the rejection of the null hypothesis in favor of the fixed effect model.

The LM test of Breusch and Pagan (1980), is designed to test the random effect. At 5%, we reject the null hypothesis in favor of the random effect model per group. However, the null hypothesis of the random effect per period is accepted for the pooled model. Regarding the random double effect model, the null hypothesis of having zero variances for both the individuals and periods is largely rejected at 2 degrees of freedom. As inferred from the above two tests, the Hausman test (1978), is in favor of the fixed effect test where the Hausman statistics (157.17) rejects the null hypothesis with a significance level of 1%.

Durbin-Watson's test is applied to the first-order serial correlation, whereas the LM test is applied to check if there is a positive serial correlation in the panel data. While the latter test statistics exceeds the critical value and, hence, the former test statistics "DW" is below the lower critical value showing that there is a serial correlation in the model (Table 5).

At 1%, the obtained value rejects the null hypothesis of homoscedasticity (LM = 857.06). There is a large error heteroscedastic regression. Due to this high heteroscedasticity, we calculate the rho value for each variable (Table 6). It is clear from the table that there is a large problem of heteroscedasticity. From these results, we can deduce the final estimate of the fixed effect model shown in the following Table 7.

The main results existing in this table show that if we increase the consumer price index by 1%, this will lead to an increase of economic growth by 0.267%, if we know that this result is statistically significant at 1% and has a

Table 8: Granger causality panel test

Variables	ΔLIPI	ΔLIPC	ΔLEXP	ΔSPREAD	ΔVolatility	ΔReturns	Error correction term
ΔLIPI	-	20.75* (0.054)	17.51 (0.131)	18.85* (0.092)	16.12 (0.185)	9.11 (0.693)	-0.009*** (-5.489)
ΔLIPC	16.26 (0.179)	-	21.65** (0.041)	14.84 (0.250)	0.80 (1.000)	6.39 (0.894)	-0.001*** (-1.613)
ΔLEXP	3.47 (0.991)	25.08*** (0.014)	-	6.72 (0.875)	5.86 (0.922)	16.69 (0.161)	-0.019*** (-3.423)
ΔSPREAD	19.31* (0.081)	4.00 (0. 983)	23.26** (0.025)	-	5.78 (0.926)	8.56 (0.740)	0.100** (2.099)
ΔVolatility	10.86 (0.450)	0.877 (1.000)	6.66 (0.879)	3.68 (0.988)	-	8.67 (0.730)	-19.542 (-0.664)
ΔReturns	49.50*** (0.000)	9.46 (0.662)	18.42 (0.103)	25.69*** (0.011)	5.11 (0.954)	-	2.460 (5.853)

confidence level more than 99%. On the contrary, exports negatively affect economic growth, that is, if we increase them by 1%, this will reduce economic growth by 0.083%. This result is statistically significant at the threshold of 5%.

Let us move now to the results of the causality test of Granger and the long-term panel estimates. In fact, the search for the maximum number of lags in the 6-variable model VAR, through the use of the AIC and SBC criteria, confirms that there is a maximum number of lags equal to 12. The following step is to identify the causality direction through the use of the VECM model. Actually, in Table 8, we present the different results of the causality panel test in the Granger sense.

According to the results reported in Table 8 above, in the Granger sense, there are:

- An apparent relationship between economic growth and the interbank spread has a positive and statistically significant impact on economic growth. Moreover, causality is noticed between economic growth and the stock price returns.
- An important causality between the CPI and economic growth. Indeed, economic growth has a positive and significant effect on the consumer price index. Similarly, causality is noticed between the CPI and exports.
- A clear relationship is also noticed between the exports and the CPI. This means that the consumer price index can affect the exports. Moreover, it seems that there is a causal link between the SPREAD and the exports.
- A final causal link is noticed between economic growth and the interbank spread. This indicates that economic growth causes the interbank spread. In addition, there is a causal link between the interbank spread and the stock price returns.
- The analysis of the impulse response functions to predict the reaction of economic growth in the emerging economies to shocks on the endogenous variables (Figure 1) helps us acquire the following information:
- The rise of the consumer price index has contributed positively to economic growth. This effect has been stable throughout the period.
- The impulse response function shows that the impact of a negative shock through exports will have a negative effect on economic growth. This effect appeared from the fifth year and continued until the end of the period.
- The interbank spread has no long-term effect on economic growth.
- The impact of a decrease of the stock price volatility is certainly negative on economic growth. This effect seems to negative throughout the period.
- A positive shock through the stock price returns will have a positive effect on economic growth. However, this effect continues to be stable and growing.

The estimated long-term relationship in panel (Table 9) shows that only the CPI, EXP and SPREAD variables have a significant impact on economic growth. Actually, on the basis of this estimate, we found a positive and significant effect between economic growth and the consumer price index.

Emerging countries found themselves at the risk of higher inflation during the financial crisis. To avoid this risk, central banks in the emerging countries raise the interest rates. Consequently, the rise in the interest rates causes the demand and subsequently production to drop, the thing which hampers economic growth.

However, we can say that there is a relationship between economic growth and the interbank spread which is negative and significant. Therefore, it seems clear that the interbank market is an important vector of the transmission mechanisms of financial stress in the

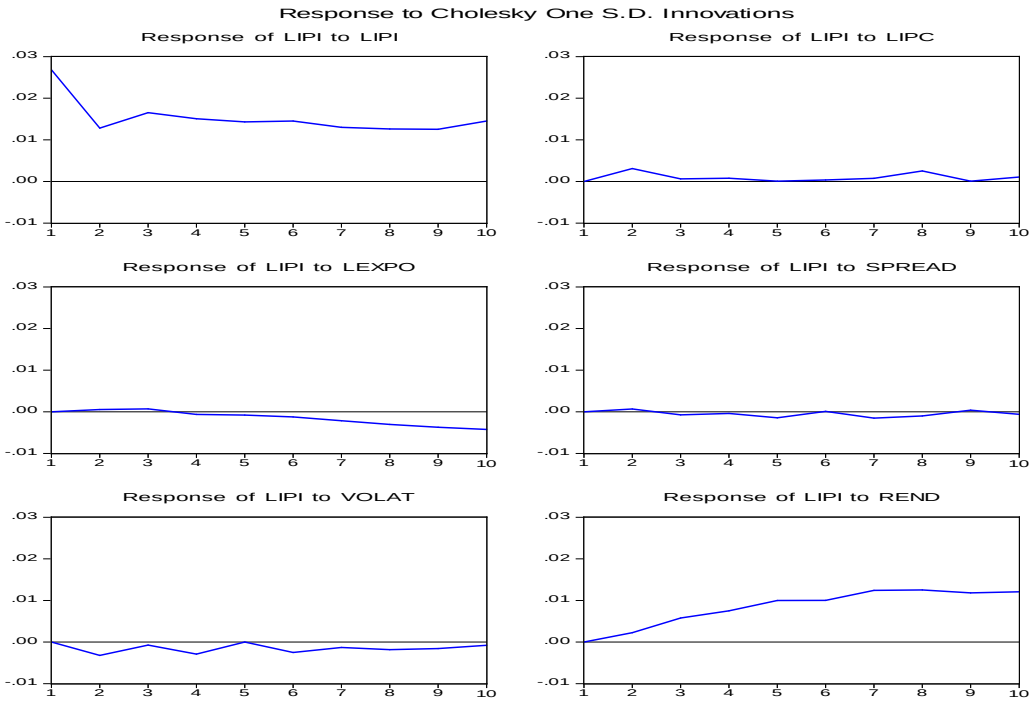

Figure 1: The impulse response functions

Table 9: Long run panel relationship

Dependent variables	LIPI	LCPI	LEXP	SPREAD	Volatility	Returns
LIPI	-	1.049*** (0.000)	-1.006*** (0.000)	2.155*** (0.000)	163.48 (0.216)	-0.066 (0.974)
LIPC	0.884*** (0.000)	-	3.063*** (0.000)	-3.889*** (0.000)	-179.63 (0.212)	1.077 (0.628)
LEXP	0.052*** (0.000)	-0.020*** (0.000)	-	0.849*** (0.000)	13.231 (0.484)	-0.383 (0.189)
SPREAD	-0.008*** (0.000)	0.005*** (0.003)	0.106*** (0.000)	-	-0.059 (0.992)	0.010 (0.915)
Volatility	-1.21e^{-5} (0.212)	-1.31e^{-5} (0.216)	-5.18e^{-5} (0.484)	-1.85e^{-6} (0.992)	-	-0.001*** (0.017)
Returns	0.000 (0.628)	-2.23e^{-5} (0.947)	-0.006 (0.189)	0.001 (0.915)	-5.748** (0.017)	-

emerging countries. The magnitude of this transmission is related to the depth of the financial ties between the developed and the emerging countries.

The stock market does not affect the economic growth of the emerging countries. Neither the stock price volatility nor the returns on the stock prices has a significant effect on economic growth. In other words, the long-term estimation indicates no long-term relationship between economic growth and the stock market variables. Nevertheless, the results suggest a negative and significant relationship between long-term volatility and the stock price returns. This result can be explained by the interdependence of the stock markets in these countries.

Conclusion

Our key results indicate that emerging countries are expected to take political and economic measures to alleviate the negative effects of the subprime crisis on economic growth. To conclude, we can say that our

results empirically demonstrate that the trade channel is the most important source of long-term growth for the emerging countries. Actually, these countries, as an integrated group in the global economy, were affected by the disruptions caused by the subprime crisis. Although considering the financial variables helps a better understanding of the impact of the financial shocks on the emerging markets, the macroeconomic consequences of these shocks are not yet fully analyzed. Therefore, we find it necessary to deepen this study through the integration of new information variables or regional variables so as to take into account the regional relationships between the emerging countries.

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