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GRANGER CAUSALITY TESTING FOR ARGENTINA MERVAL INDEX AND THE MAJOR WORLD STOCK MARKETS

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SUMMARY

In this paper are analyzed the causal links among a selected group of global stock market indices, with special focus on the role of Argentina MERVAL index. With this objective in mind, two types of non-conventional Granger causality test are performed in order to avoid the theoretical limitations of the traditional test which requires stationary time series. The first test is based in a surplus-lag VAR model and allows testing for Granger causality in the context of non-stationary processes. The second test rests on the estimation of a VARX model and is robust to non-stationarity; long memory; and non-modeled structural breaks. This second test also admits conditioning on endogenous modeled control variables. The estimations are performed using daily data for a long time period, being both testing procedures implemented in the programming language R. Finally the results from both tests are compared and interpreted in order to capture their economic meaning.

Keywords: ***Granger causality, time series, VARX, stock markets***.

Introduction

In this paper, we explore how Argentina MERVAL index is related with the major world stock markets. We use daily data for the period from 1998-12-15 to 2014-05-09 for twenty indices. The indices included and their corresponding countries are: MERVAL (Argentina); BVSP (Brazil); MXX (Mexico); GSPTSE (Canada); GSPC (United States of America); NDX (United States of America); FTSE (United Kingdom); IBEX (Spain); FCHI (France); GDAXI (Germany); SSMI (Switzerland); OMX (Sweden); BSESN (India); HSI (China); SSEC (China); SHENA (China); TWII (Taiwan); KS11 (South Korea); N225 (Japan); and AXJO (Australia). These indices accounts for 90% of the World total market capitalization, approximately.

On the one hand, there are reasons to believe that global stock markets are related, given that investors are constantly looking for new opportunities to earn cash fast, being this phenomenon know as arbitrage.

On the other hand, each market has a different basket of financial actives, fact that may break indices co-movements.

In this context, we analyze how MERVAL index responds to movements on the other markets, using Granger non-causality tests. The choice of this methodology is twofold: first, Granger causality provides an approximation to true causality, and second, it allows us to find markets which are "dominant" or "leading"; given that their movements help us to anticipate followers' movements.

Some previous works, such as Glezakos et al. (2007) and Paramati et al. (2012) tested for Granger causality using return rates (that is, the growth rates of the indices), but as Engle and Granger (1987) point out, if the indices are cointegrated, the correct procedure consist on also adding the long term relationship. Therefore, it is preferable working with a Vector Error Correction Model (VECM) or its Vector Auto Regressive (VAR) representation using the indices or their logarithm, instead of estimating a VAR on differences or in the growth rates.

Development

The indices close values adjusted for dividends and splits were obtained from finance.yahoo.com, and the exchange rates from oanda.com; except for Argentina in which case this source is employed until 2011-10-28. From this date up to 2014-05-09 we use the BONAR X quotations to approximate the underlying exchange rate given that for this period the official exchange rate does not show the true peso/dollar parity.

The indices were expressed in American dollars in order to isolate the distortions produced by the effect of currency depreciation. The growth rate of MERVAL index seems to be an extraordinary one in certain periods but this impression vanishes when the index is expressed in dollars. It is logic to think that investors compare international stocks performance using a common currency.

Classic Granger non-causality tests require stationary time series, provided that if any of the series is not I(0) the Wald test employed for testing restrictions in a VAR model does not follow its standard asymptotic distribution under the null hypothesis.

Toda and Yamamoto (1995) developed a Granger testing procedure based in an augmented-lag VAR model which allows us to testing for Granger causality in a non-stationary context. This test rests on the estimation of a reduced form VAR(p) model with s additional lags, being s the maximum integration order of the series under study. After that, standard Wald tests are computed considering only the first p lags. This test can be used whether all the variables have the same integration order (and possibly cointegrated), or in the case that there are variables with different integration order as well. Provided that all the series were found to be I(1), we incorporate only an additional lag to guarantee that the Wald tests follow the usual asymptotic chi-square distribution under the null hypothesis.

We also estimate an extension of the Toda Yamamoto test which was developed by Bauer and Maynard (2012).

In this latter procedure, three kind of variables are used: y_t is a vector of independent variables of order k_y; z_{1t} is a vector of exogenously modeled forcing variables of order k_{z1}; y z_{2t} is a vector of optional control variables of order k_{z2}. The objective is to test if z_{1t} Granger-cause y_t after controlling for z_{2t}. This test is done by means of the estimation of the following VARX model:

$$y_t = \sum_{j=1}^{p}\left(\psi_{y_j} y_{t-j} + \psi_{z2_j} z_{2t-j}\right) + \sum_{j=1}^{p_{z1}+1} \psi_{z_{1j}} z_{1t-j} + \varepsilon_{y,p} \tag{1}$$

and testing the joint parameter restriction $\psi_{z_{1j}} = 0$ for $1 \leq j \leq p_{z1}$. It must be noted that the condition $\psi_{z_{1,p+1}} = 0$ is not tested. The inclusion of the additional lag of z_{1t} guarantee that the Wald test asymptotic distribution is the usual one.

Equation 1 may be rewritten in the form:

$$y_t = \psi_{x1} x_{1t}^{-} + \psi_{x2} x_{2t}^{-} + \varepsilon_{yt,p} \tag{2}$$

where $x_{1t}^{-} = z_{1t}^{-}$ y $x_{2t}^{-} = \left[y_t^{-'}, z_{2t}^{-'}, z_{1t-p_{z1}-1}^{'}\right]$, being $y_t^{-} = \left[y_{t-1}^{'},...,y_{t-p}^{'}\right]^{'}$; $z_{2t}^{-} = \left[z_{2t-1}^{'},...,z_{2t-p}^{'}\right]^{'}$; $z_{1t}^{-} = \left[z_{1t-1}^{'},...,z_{1t-p_{z1}}^{'}\right]^{'}$; $\psi_y = \left[\psi_{y1},...,\psi_{yp}\right]$; and $\psi_{z2} = \left[\psi_{z21},...,\psi_{z2p}\right]$. Or in staked form;

$$Y = X_1 \psi_{x1}^{'} + X_2 \psi_{x2}^{'} + \mathrm{E}_p \tag{3}$$

where $Y = \left[y_{p_{\max}+1}^{-},...,y_T^{-}\right]$, for $p_{\max} = \max\{p, p_{z1}+1\}$, and X_1, X_2, E_p stack x_{1t}^{-}, x_{2t}^{-} y $\varepsilon_{yt,p}^{-}$ in analogous fashion. Using this notation, the hypothesis are: $H_0 : \psi_{x1} = 0$; and $H_A : \psi_{x1} \neq 0$. Also, Bauer and Maynard (2012) demonstrate that under the null the Wald statistic

$$\hat{W} = vec\left(Y' X_{1.2}\right)'\left(\left(X_{1.2}' X_{1.2}\right)^{-1} \otimes \left(\frac{1}{T}\mathrm{E}_p' \mathrm{E}_p\right)\right) vec\left(Y' X_{1.2}\right) \tag{4}$$

has limiting distribution $\chi^2_{k_y p_{z1} k_{z1}}$, where $X_{1.2} = X_1 - X_2\left(X_2' X_2\right)^{-1} X_2' X_1$.

It must be noticed that the difference between both tests consist on the fact that the Bauer and Maynard (2012) version allows us to test for Granger causality controlling for other variables, isolating the net influence of a given index over the other one.

Results and Conclusions

In this section, we show the results obtained from the implementation of both Toda and Yamamoto (1995); and Bauer and Maynard (2012) Granger-causality tests.

The lag selection was done using the Akaike Information Criterion (AIC) provided that this criterion is preferred when the sample size is large enough, as in our case.

Table 1 shows the observed values of the chi squared statistic; the degrees of freedom; and the p-values of the Toda Yamamoto Granger-causality tests between MERVAL index and each of the other selected stock markets. According to the results, the Buenos Aires Stock Exchange index Granger-causes all the selected indices with exception of SSMI (Swiss Market Index), SSEC (Shanghai Stock Exchange Index), SHENA (Shenzhen A Index), and TWII (Taiwan Capitalization Weighted Stock Index). Also, MERVAL index is Granger-caused for almost all the indices, with exception of BVSP (Bovespa Index of Sao Pablo), GSPC (Standard & Poor's Index), and SHENA (Shenzhen A Index).

Table 1

Toda and Yamamoto (1995) Granger causality tests

	chi2	df	p-value		chi2	df	p-value
MERV -> BVSP	88.24	31	0.0000	***BVSP -> MERV***	33.28	31	0.3570
MERV -> MXX	30.23	4	0.0000	***MXX -> MERV***	30.23	4	0.0000
MERV -> GSPTSE	29.95	9	0.0004	***GSPTSE -> MERV***	15.84	9	0.0704
MERV -> GSPC	35.57	9	0.0000	***GSPC -> MERV***	9.14	9	0.4249
MERV -> NDX	53.67	32	0.0096	***NDX -> MERV***	56.04	32	0.0054
MERV -> FTSE	24.36	9	0.0038	***FTSE -> MERV***	39.41	9	0.0000
MERV -> IBEX	16.10	3	0.0011	***IBEX -> MERV***	16.86	3	0.0008
MERV -> FCHI	50.52	27	0.0040	***FCHI -> MERV***	68.88	27	0.0000
MERV -> GDAXI	47.99	23	0.0017	***GDAXI -> MERV***	61.12	23	0.0000
MERV -> SSMI	7.75	6	0.2567	***SSMI -> MERV***	27.13	6	0.0001
MERV -> OMX	39.73	22	0.0116	***OMX -> MERV***	59.25	22	0.0000
MERV -> BSESN	18.80	9	0.0269	***BSESN -> MERV***	50.36	9	0.0000
MERV -> HSI	43.94	22	0.0036	***HSI -> MERV***	95.50	22	0.0000
MERV -> SSEC	0.95	3	0.8142	***SSEC -> MERV***	13.52	3	0.0036
MERV -> SHENA	1.01	3	0.8001	***SHENA -> MERV***	5.12	3	0.1634
MERV -> TWII	5.26	3	0.1535	***TWII -> MERV***	63.72	3	0.0000
MERV -> KS11	20.81	9	0.0135	***KS11 -> MERV***	82.84	9	0.0000
MERV -> N225	13.18	3	0.0043	***N225 -> MERV***	73.35	3	0.0000
MERV -> AXJO	53.57	20	0.0001	***AXJO -> MERV***	175.60	20	0.0000

Table 2

Bauer and Maynard (2012) Granger-causality tests

	chi2	df	p-value		chi2	df	p-value
MERV -> BVSP	50.69	31	0.0143	***BVSP -> MERV***	38.34	31	0.1708
MERV -> MXX	5.01	4	0.2861	***MXX -> MERV***	5.01	4	0.2861
MERV -> GSPTSE	36.71	33	0.3007	***GSPTSE -> MERV***	34.00	33	0.4193
MERV -> GSPC	41.67	27	0.0355	***GSPC -> MERV***	48.27	27	0.0072
MERV -> NDX	40.23	38	0.3716	***NDX -> MERV***	64.21	38	0.0050
MERV -> FTSE	9.77	4	0.0444	***FTSE -> MERV***	2.38	4	0.6666
MERV -> IBEX	2.68	2	0.2619	***IBEX -> MERV***	2.13	2	0.3443
MERV -> FCHI	0.61	4	0.9620	***FCHI -> MERV***	8.36	4	0.0792
MERV -> GDAXI	9.35	5	0.0961	***GDAXI -> MERV***	11.80	5	0.0376
MERV -> SSMI	6.91	6	0.3290	***SSMI -> MERV***	6.05	6	0.4173
MERV -> OMX	30.20	20	0.0667	***OMX -> MERV***	40.62	20	0.0042
MERV -> BSESN	17.89	14	0.2120	***BSESN -> MERV***	9.73	14	0.7815
MERV -> HSI	34.42	32	0.3524	***HSI -> MERV***	36.74	32	0.2585
MERV -> SSEC	6.59	4	0.1591	***SSEC -> MERV***	8.09	4	0.0884
MERV -> SHENA	6.09	6	0.4134	***SHENA -> MERV***	8.40	6	0.2102
MERV -> TWII	0.58	4	0.9649	***TWII -> MERV***	2.24	4	0.6917
MERV -> KS11	23.94	20	0.2452	***KS11 -> MERV***	18.73	20	0.5392
MERV -> N225	6.62	3	0.0851	***N225 -> MERV***	2.93	3	0.4030
MERV -> AXJO	6.40	4	0.1714	***AXJO -> MERV***	5.96	4	0.2024

There are several factors that may influence the causality relationships. First, the time zone: markets that open hours before than the other ones are expected, a priori, to be dominant. Second, if markets are a kind of mirror of real economies, movements in stock exchanges of trade partner countries probably will be related. Third, multinational firms which are quoted in various stock exchanges increase the degree of synchronization.

Table 2 shows the observed values of the chi squared statistic; the degrees of freedom; and the p-values of the Bauer and Maynard Granger-causality tests between MERVAL index and each of the other selected stock markets. The results point out that conditioning in other variables produces the break of many causality relationships. Using this analysis, MERVAL index only causes BVSP, GSPC, and FTSE indices, and it is only caused by GSPC, NDX, GDAXI, and OMX indices. Those relationships may be considered as “direct” relationships given that the effect of other markets is isolated.

To sum up, MERVAL index is related with almost all the other considered indices when the analysis is made in a pairwise base. On the other hand, when the analysis includes conditioning on endogenous modeled control variables, many of those relationships vanish.

It must be noted that MERVAL does not cause, and it is not caused by, any oriental market. Also, it is notable the fact that the Brazilian index does not Granger cause the MERVAL index.

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