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Nonlinearities in price convergence among Mercosur countries

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Abstract

The aim of this paper is to analyse the existence of price convergence in Mercosur. Two variables are considered, Consumer Price Indices to assess convergence in the goods and services markets and real interest rates, to analyse convergence in the money markets. For this purpose we have applied Kapetanios, Shin and Snell (2003) nonlinear unit root test, in order to take into account asymmetric speed of mean reversion, and Bierens (2000) co-trending analysis. The univariate analysis points only to convergence in real interest rates, whilst the multivariate analysis provides evidence of common trends in both markets.

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1 Introduction

Mercosur (*Mercado Común del Sur* in Spanish) was created in 1991 with the signing of the Asunción Treaty. Its main aim was to boost the freedom of movement of goods, services and factors of production as well as increasing macroeconomic policy coordination, creating, as a starting point, a customs union. The countries that signed this agreement were Argentina, Brazil, Uruguay and Paraguay. Since then, most of the South American countries have become associate members[1].

After the creation of Mercosur, the question of whether the creation of a monetary union would be appropriate has aroused a debate among both economists and policy makers alike, although there seems to be a general agreement on the contrary, based especially on the Optimal Currency Areas theory (see Levy-Yeyati and Sturznegger, 2000; Berg, Borensztein and Mauro, 2002; Corbo, 2001; Hochreiter, Schmidt-Hebbel and Winckler, 2002 among others). Nevertheless, after more than fifteen years since the creation of Mercosur, it is worth analysing the degree of economic integration within the area, or in other words, answering the question of whether economic integration will speed up economic convergence among countries (Karras, 1997). Karras (1997) and Camarero, Flôres and Tamarit (2006), have analysed economic convergence in Latin America and Mercosur, respectively. While the former finds weak evidence of convergence in income per capita in Latin America, the latter highlight the fact that there has been convergence in productivity among Mercosur countries. More recently, Neves, Stocco and Da Silva (2008) have tested whether Mercosur is an optimum currency area by testing for generalised PPP applying unit root tests. The authors find lack of evidence of PPP among Mercosur countries.

Nevertheless, there are several additional ways to measure the degree of economic integration between countries. For instance, purchasing power parity (PPP) can be understood as a measure of economic integration (Frenkel, 1981; Choudhury, McNown and Wallace, 1991; Wei and Parsley, 1995, and Laureti, 2001), since in the absence of trade costs, arbitrage should equalise prices of different countries, when measured in a common currency. In such a case we are talking about integration in the markets for goods. Furthermore, under the assumption of frictionless markets between countries, the real interest rate parity hypothesis should hold, i.e. real interest rates should converge. This this based on the assumption that uncovered interest rate parity (UIP) and relative PPP holds (see Ferreira and León-Ledesma, 2007 , among others). In addition, real interest rate convergence analysis might help us to evaluate the degree of macroeconomic coordination.

In this paper, we aim to complement the work by Karras (1997), Camarero et al. (2006) and Neves et al. (2008) by testing for convergence in the markets for goods and money. Specifically, we test for prices in a common currency and real interest rates convergence in the Mercosur countries, i.e. Argentina, Brazil, Chile[2], Paraguay and Uruguay, following the Bernard and Durlauf (1995) definition of convergence and common trends.

This definition of convergence can be empirically tested applying unit roots (Holmes, 2002; Camarero et al., 2006, and Ferreira and León-Ledesma, 2007) or cointegration techniques (Bernard and Durlauf, 1995, and Camarero et al., 2006). Although we apply unit root tests and cointegration techniques to test for convergence, unlike other papers in this field, our approach takes into account the existence of asymmetric speed of mean reversion towards equilibrium (Kapetanios, Shin and Snell, 2003) (KSS) and co-trending analysis (Bierens, 2000).

2 Measuring economic integration

In defining convergence (both in goods and money markets) we follow Bernard and Durlauf (1995) definition of convergence. These authors establish that a set of countries $i = 1, ...n$ converge if the long-term forecasts of the variable of interest y_t are equal at a fixed time t:

$$\underset{k \Rightarrow \infty}{lim} E(y_{1,t+k} - y_{i,t+k} | I_t) = 0. \tag{2.1}$$

In words, convergence implies that the countries have identical long-run trends, either stochastic or deterministic.

Rejection of convergence as defined in (2.1) does not necessarily imply that individual prices are explained exclusively by country-specific factors. Prices might still respond to the same common trends but with proportional rather than identical stochastic components. This gives to the following definition of common trends: if the long-term forecasts of the variable of interest y_t are proportional at a fixed time for two countries, i and j, say, then they share a common trend:

$$\underset{k \Rightarrow \infty}{lim} E(y_{1,t+k} - \alpha y_{i,t+k} | I_t) = 0. \tag{2.2}$$

These definitions for convergence and common trends can be empirically tested using cointegration techniques (see Bernard and Durlauf, 1995). Thus, according to definition (2.1), for the individual price series to converge there must be one common (stochastic or deterministic) long-run trend, that is, $n-1$ cointegrating vectors, where n is the number of variables. If there are fewer than $n-1$ cointegrating vectors, there is evidence of common stochastic elements in the long-run behaviour of prices across countries, though not full convergence. Finally, the absence of cointegration would lead to individual prices being explained exclusively by idiosyncratic factors.

Cointegration (and therefore convergence) in a pair of variables can be tested using unit root tests (Camarero, Flôres and Tamarit, 2006): if the price differential between two countries i and j is stationary, convergence is accepted across both countries. A proper test for convergence requires, however, the use of multivariate techniques to test for either convergence or a common trend. Accordingly, in this paper we apply two groups of techniques. Firstly, we apply Ng and Perron (2001) and Kapetanios, Shin and Snell (2003) unit root tests and, secondly, Bierens (2000) co-trending analysis. These techniques are further explained in the next section.

3 Econometric Methodology

In order to test for unit roots in the price differential, we apply two groups of unit root tests, i.e. Ng and Perron (2001), and Kapetanios et al. (2003) and Bierens (2000) co-trending analysis.

Following Ng and Perron (2001), unit root tests based upon linear equations may suffer from two main puzzles. Firstly, they might have power problems when the autoregressive parameter is close to unity and. Secondly, when the errors of a moving average process are close to -1, it is necessary a lag length higher than the ones chosen by the Akaike or Schwartz information criteria, in order to avoid size problems. Accordingly, Ng and Perron (2001) propose a Modified Information Criterion (MIC) that controls for the sample size. Additionally, the authors propose a Generalised Least Squares (GLS) detrending method to avoid the power problem associated to the traditional unit root tests. Combining these two approaches, Ng and Perron (2001) obtain the following unit root tests: MZ_α and MZ_t that are the modified versions of the Phillips (1987) and Phillips and Perron (1988) Z_α and Z_t tests; the MSB that is related to the Bhargava (1986) R_1 test; and, finally, the MP_T test that is a modified version of the Elliot et al. (1996) Point Optimal Test.

In addition, prices -in particular when measured in a common currency- may follow a nonlinear path, due to the existence of trade barriers, transport costs or exchange rate interventions, preventing the mechanism of arbitrage from equalising prices [see Dumas (1992), Taylor and Peel (2000), Taylor et al. (2001), Kilian and Taylor (2003)]. This implies the existence of a inner regime whereby the variable is a unit root process, whereas in the outer regime the variable may revert to the equilibrium value, i.e. asymmetric speed of mean reversion. Furthermore, the recent economic crises in Latin America may have affected the interest rate differentials between these countries, yielding nonlinear adjustment of the interest differential.

Kapetanios et al. (2003) develop a unit root test in order to take into account the nonlinear adjustment of variables towards equilibrium. The reason for applying the latter is that linear unit root tests might suffer from lack of power in the presence of nonlinearities in the dynamics of the variables (Kapetanios et al., 2003) and, hence, they might not be able to distinguish between unit root and nonlinear stationary process. Thus, this test analyses nonstationarity under the null hypothesis against nonlinear but globally stationary exponential smooth transition autoregressive (ESTAR) processes under the alternative, i.e.

$$y_t = \beta y_{t-1} + \phi y_{t-1}(1 - exp\{-\theta y_{t-1}^2\}) + \epsilon_t \tag{3.1}$$

where $\epsilon_t \sim iid(0, \sigma^2)$. This approach assumes that the transition function is an ESTAR one. An ESTAR function is appropriate to model price movements, since this type of function assume that the shocks have a symmetric effect over the variable, regardless of the sign of the shock (Taylor and Peel, 2000). For practical purposes it is possible to reparameterise equation (3.1) as

$$\Delta y_t = \alpha y_{t-1} + \gamma y_{t-1}(1 - exp\{-\theta y_{t-1}^2\}) + \epsilon_t. \tag{3.2}$$

in order to test for the order of integration of the variables. The idea behind this technique is to test whether the variable is a unit root process in the outer regime. Accordingly, KSS impose $\alpha = 0$, that is, imposing that the variable is a unit root in the inner regime. However, an issue with equation (3.2) is that in order to test the null hypothesis $H_0 : \theta = 0$ against $H_1 : \theta > 0$ in the outer regime[3], the coefficient γ cannot be identified under H_0. In order to overcome this problem, KSS propose a Taylor approximation of the ESTAR model, i.e.

$$\Delta y_t = \delta y_{t-1}^3 + \eta_t \tag{3.3}$$

where η_t is an error term. Now, it is possible to apply a t-statistic to test whether y_t is a I(1) process, $H_0 : \delta = 0$, or is a stationary process, $H_1 : \delta < 0$. Note that equation (3.3) may include lags of the dependent variables to control for autocorrelation.

Secondly, in order to analyse whether there is a unique common trend among all the countries, we apply Bierens (2000) nonlinear co-trending nonparametric test. This approach is based on the eigenvalues of matrices built from the partial sum of the variables, i.e.

$$\hat{M}_1 = \frac{1}{n}\left[F\left(\frac{1}{n}\right)F\left(\frac{1}{n}\right)' + ... + F(1)F(1)'\right] \tag{3.4}$$

$$\hat{M}_2 = \frac{1}{n}\left[dF\left(\frac{m}{n}\right)dF\left(\frac{m}{n}\right)' + ... + dF(1)dF(1)'\right] \tag{3.5}$$

where

$$F\left(\frac{t}{n}\right) = \left(\frac{1}{n}\right)(y_1 + y_2 + ... + y_t) \tag{3.6}$$

$$dF\left(\frac{t}{n}\right) = \frac{F\left(\frac{t}{n}\right) - F\left(\frac{t}{n} - \frac{m}{n}\right)}{\frac{m}{n}} \tag{3.7}$$

with y_t is the demeaned/detrended variable, $m = n^\alpha$ and n the number of observations. In order to obtain the number of co-trending vectors, r, it is only necessary to solve,

$$|\hat{M}_1 - \lambda\hat{M}_2| = 0 \tag{3.8}$$

Bierens (2000) shows that this test does not distinguish between nonlinear co-trending from cointegration. That means that if the variables are I(1) processes rather than stationary, the test becomes a cointegration test. The advantage of Bierens' approach is that, since it is a nonparametric test, nonlinear trends and any serial correlation process do not have to be specified.

4 Empirical Results

In order to test for price convergence (in the goods and money markets) in Mercosur we consider two types of variables; prices in a common currency (US dollar), p_t, and real interest rates, r_t.

Data have been obtained from the *International Financial Statistics* database, from the IMF. Consumer price indices have been transformed to a common currency, p_t, using nominal exchange rates versus the US dollar. The frequency of the price data is monthly and span 1980:1 to 2006:4. The real interest rate, r_t, has been computed as nominal interest rate minus inflation. The nominal interest rates considered for the analysis are the following; for Argentina, Brazil and Paraguay, the *Money Market Rate*; for Chile and Uruguay, the *Deposit Rate* and *Discount Rate* respectively. The interest rate data is also monthly and span 1990:10 to 2006:4.

In Tables 1 and 2 we display the results for the Ng and Perron (2001) and KSS unit root tests[4] for the price differential, dp_t, and real interest rate differential, dr_t, versus the benchmark country, Argentina. The reason for selecting Argentina as the benchmark country is because this country has suffered significant economic turmoils during the last decades, probably the worst ones within Mercosur. Therefore, in order to test for convergence among this group of countries, we have selected as benchmark the country that that would provide, in principle, less evidence in favour of the convergence hypothesis. The results show that for the price differentials there is poor evidence of convergence, since we are only able to reject the unit root hypothesis with the KSS test for the case of Brazil. The opposite results are found for the interest rate differential. We reject the null hypothesis of unit root with the KSS test in all cases and also with the Ng and Perron's test in Brazil and Uruguay. Therefore, taking into account the possibility of nonlinear adjustment of the real interest rate differential, we find evidence of convergence in real interest rates. A robustness analysis has been performed in order to test the convergence hypothesis for different benchmark countries. However, the main results do not differ from the analysis having used Argentina as the benchmark[5].

We next present the results of the multivariate analysis using the con-trending approach developed by Bierens (2000). Previously, applying Bierens (1997) unit root test, the order of integration of the variables has been tested, since, in order to perform this analysis, all the variables have to be integrated of the same order. The results[6], indicate that all the variables in levels are unit root processes. In this case, the nonparametric co-trending analysis becomes a nonparametric cointegration test (Bierens, 2000). The null hypothesis of this test is that there are r cointegrating vectors versus the alternative of $r - 1$. The results are displayed in Table 3 and point to the existence of four cointegrating vectors ($r = 4$) and one common stochastic trend for both variables, hence, the existence of a unique common trend implies a certain degree of convergence in prices and real interest rates in Mercosur.

This conclusion highlights the fact that the elimination of trade barriers and the opening of the capital account have boosted price convergence in the South Cone. Our results are then complementary to those found by Neves et al. (2008) since, with the application of nonlinear technics and co-trending analysis, we are able to find stronger evidence in favour of convergence in this group of countries.

5 Conclusions

Aiming at contributing to the literature on Latin America's convergence, in this paper, we have analysed whether there exists price convergence (in the goods and money markets) among Mercosur countries. In order to do so we have applied nonlinear unit root tests and co-trending analysis, which overcome some of the issues related to traditional (linear based) approaches. The results support the hypothesis of price convergence, in particular when looking for common trends, not only in the markets for goods but also in the money markets for this group of countries.

Notes

[1]Venezuela signed the joining agreement in June 2006, but her full membership has to be ratified by Paraguay and Brazil.

[2]Although Chile is only an associate member of Mercosur we have included it in the sample due to her high degree of economic interaction with the remaining countries of the South Cone.

[3]Note that the process is globally stationary provided that $-2 < \phi < 0$.

[4]Note that only an intercept has been included as deterministic component in the auxiliary regressions of the tests, since the introduction of a time trend and the rejection of the null in this case will not imply convergence, i.e. the series must be stationary, not only in variance but also in mean.

[5]Results available upon request.

[6]Available on request to the authors.

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Table 1: Ng and Perron (2001) unit root tests results

Country	Variable	MZ_{α}^{GLS}	MZ_{t}^{GLS}	MSB^{GLS}	MP_{T}^{GLS}
Brazil	dp_t	1.48	1.16	0.78	50.07
	dr_t	**-22.31**	**-3.33**	**0.14**	**1.11**
Chile	dp_t	1.95	2.00	1.02	86.93
	dr_t	0.01	0.01	1.09	65.73
Paraguay	dp_t	-1.37	-0.57	0.41	12.14
	dr_t	0.15	0.19	1.25	87.68
Uruguay	dp_t	-1.37	-0.57	0.41	12.14
	dr_t	**-9.60**	**-2.11**	**0.22**	**2.85**

Note: The lag length to compute the test has been chosen using the modified AIC (MAIC) suggested by Ng and Perron (2001). Rejection of the null hypothesis is given in bold. The critical values for the above tests have been taken from Ng and Perron (2001):

Model including a constant

	MZ_{α}^{GLS}	MZ_{t}^{GLS}	MSB^{GLS}	MP_{T}^{GLS}
1%	- 13.80	-2.58	0.17	1.78
5%	-8.10	-1.98	0.23	3.17
10%	-5.70	-1.62	0.27	4.45

Table 2: KSS nonlinear unit root test results

Country	Variable	lags	KSS statistic
Brazil	dp_t	11	**-2.97**
	dr_t	3	**-10.09**
Chile	dp_t	0	-1.15
	dr_t	2	**-5.12**
Paraguay	dp_t	0	-1.15
	dr_t	2	**-4.78**
Uruguay	dp_t	0	-1.18
	dr_t	5	**-4.43**

Note: The test has been computed including only a constant as the deterministic component. The lag length for the auxiliary regression has been selected by the AIC. Critical values at the 10%, 5% and 1% are -2.62, -2.92 and -3.50, respectively and have been computed by Monte Carlo simulation with 5,000 replications. Rejection of the null hypothesis is given in bold.

Table 3: Bierens (2000) nonlinear co-trending analysis

Variable	r	Test statistic	Critical Value 10%	Critical Value 5%
p_t	1	**0.043**	0.351	0.465
	2	**0.073**	0.535	0.674
	3	**0.176**	0.703	0.860
	4	**0.407**	0.861	1.034
	5	1.677	1.014	1.219
r_t	1	**0.043**	0.351	0.465
	2	**0.075**	0.535	0.674
	3	**0.133**	0.703	0.860
	4	**0.327**	0.861	1.034
	5	1.801	1.014	1.219

Note: The null hypothesis is the existence of r co-trending vectors against the alternative that there are $r-1$ co-trending vectors. Acceptance of the null is in bold.