The Penn Effect Revisited: New Evidence from Latin America

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Abstract

In this paper, we examine the role of relative productivity growth in real misalignment of exchange rates in Latin American countries. Specifically, we verify the validity of the Penn Effect for selected countries in this region. Our sample consists of fifteen countries from the Latin American region for the period 1951 to 2010. We employ both short- and long-panel data techniques, which allow us to experiment with estimators suitable for short and long time dimensions of panel data. The Penn Effect is found to be supported for the entire sample, and for subsamples. Relative productivity growth is dominant in the real exchange rate movement during periods of mild or weak speculative attacks, as compared with periods of severe speculative attacks. To correct for real misalignment of currencies in Latin America under speculative attacks, relative productivity growth must be sizeable.

Keywords: Penn Effect, real exchange rate, productivity growth, Latin America

JEL Classification: C23, F21, F31

1. Introduction

Countries in Latin America have experienced their fair share of real exchange rate misalignment and speculative attacks[1] over the past 50 years. Detailed evidence concerning the nature of speculative attacks and real exchange misalignment in Latin America can be found in Calvo (1996), Broner *et al.* (1997) and Broner *et al.* (2005). Real misalignment, especially severe forms of currency misalignment, is of grave concern because it could trigger a currency crisis. Goldfajn and Valdes (1996) contend that if a currency over-appreciates by more than 25 per cent, a smooth return is highly improbable, and state that in 90 per cent of the cases in which such a level of real misalignment occurred in their sample, the currencies involved collapsed.

In the literature on real misalignment of currencies in Latin America, various factors are identified as having contributed to the real misalignment. Edwards (1996) and Sachs and Tornell (1996), for instance, have blamed the Chilean and Mexican currency crisis on rigid nominal exchange rates with expansionary monetary policies. Blomberg *et al.* (2005) argue that political interests could induce excess real misalignment of currencies, and even currency crisis. They contend, for instance, that the authorities' decision to abandon the currency board arrangement that tied the peso to the US dollar stimulated the Argentine currency crisis in 2001 (see Blomberg *et al.*, 2005). In addition, Kalter and Ribas (1999) noted that government expenditure played a significant role in the Mexican real misalignment and currency crisis in 1994.

From the traditional perspective in the literature, relative productivity growth (or differentials) has been widely credited for real exchange misalignment (see Officer, 1976; Kravis *et al.*, 1982; Rodrik, 2008; Gluzmann *et al.*, 2012; Vieira and MacDonald, 2012). Indeed, the role of relative productivity growth on the real exchange rate was crucial to the verification of what is now known in the literature as the Penn Effect (see Samuelson, 1994). In essence, in terms of this theory, if the influence of productivity growth is neutralized alongside transaction costs and trade barriers, identical goods should trade at identical prices in different countries. However, as first noticed by Ricardo (1911), Harrod (1933), and Viner (1937), this does not happen. Balassa (1964), Samuelson (1964), and Bhagwati (1984) have

[1] A speculative attack is a situation in which investors (domestic and foreign) in the foreign exchange market sell their currency assets in enormous quantities, leading to a sharp depreciation of the local currency.

argued that productivity differences across countries imply that the purchasing power parity (PPP) would not always hold, as first conjectured by Cassel (1918).

In this paper, we aim to examine whether relative productivity growth has played a role in the real misalignment of currencies in Latin America – that is, we aim to test the validity of the Penn Effect for Latin American countries. Calderon and Schmidt-Hebbel (2003) found that productivity growth differences could not explain real exchange rate movements in Latin American and Caribbean countries during the period 1991 to 2001. They argued that even if these countries realised higher growth rates by implementing growth-oriented reforms, the subsequent growth would only be able to correct real misalignment in the short term; in other words, short-term growth would be insufficient to buffer the severity of speculative attacks experienced by these countries, especially during fixed exchange rate regimes. Our paper serves to explore whether their findings have changed over time, and, if the Penn Effect is supported, how large relative productivity growth differences will need to be in order to correct the impact of speculative attacks in Latin America.

It is well documented that during the period leading the peso crisis of 1994 and 1995 in Mexico and its subsequent impact on neighbouring countries (notably Argentina, Brazil and Chile), as well as other emerging economies (i.e. the Tequila Effect), countries in Latin America were very vulnerable to frequent speculative attacks (see Calvo, 1996). Since then, these countries have shifted from fixed or intermediate exchange rate regimes to mostly floating regimes (see Calderon and Schmidt-Hebbel, 2003). It is generally believed that speculative attacks are very severe during fixed exchange rate regimes (see Krugman, 1979; Flood and Garber, 1984; Calvo, 1996; Mishkin and Savastano, 2001). Here, we attempt to examine the influence of relative productivity growth on the real exchange rate during different episodes of speculative attacks. This is a contribution to the existing literature. To do this, we divide our sample into two: pre-peso crisis (1951–1995), and post-peso crisis (1996–2010). Figure 1 provides a useful guide for demarcating the two episodes of speculative attacks. It shows that the corrections in the exchange rate were sharper prior to the peso crisis (pre-1995) than afterwards.

To examine the Penn Effect, researchers in the area of exchange rates have used different techniques and datasets with varying degrees of success. Empirical studies based on cross-sectional techniques have mostly refuted the validity of the Penn Effect (see De Vries, 1968;

Officer, 1976; Bergstrand, 1991; Choudhri and Schembri, 2010). Studies based on time series techniques have produced mixed conclusions (see Hsieh, 1982; Rogoff, 1992a; Strauss, 1995; DeLoach, 2001; Lothian and Taylor, 2008). However, the panel data studies have largely been very successful in supporting the Penn Effect (see De Gregorio *et al.*, 1994; Chinn, 1997; Canzoneri *et al.*, 1999; Genius and Tzouvelekas, 2008; Chong *et al.*, 2012).

A quick survey of the panel data studies shows that the authors employed either short-panel or long-panel data techniques, but not both (see De Gregorio *et al.*, 1994; Canzoneri *et al.*, 1999; Chong *et al.*, 2012). However, each approach has its limitations when estimating the coefficient of the relative productivity growth differential term in the model. Short-panel data techniques will typically produce coefficient estimates that are influenced by the country dynamics, whereas long-panel data techniques will produce coefficient estimates that are largely influenced by time dynamics. We departed from the existing studies in that we utilised both techniques in order to better assess the influence of relative productivity growth on the real exchange rate. This constitutes a methodological contribution of the paper. In addition, the Penn Effect is best verified when the dataset possesses two characteristics: the real exchange rate must show persistent misalignment over the study period, and productivity must exhibit the tendency to grow. Real exchange rates and relative productivity growth in Latin America have exhibited these two crucial attributes, further justifying our study.

The sample we employed in our study consisted of fifteen countries from the Latin American region for the period 1951 to 2010. The empirical results generally suggest that relative productivity growth has, indeed, played a crucial role in real misalignment of currencies in the Latin American region. The Penn Effect is well supported for these countries.

In the next section, we present the empirical methodology. The results are presented and discussed in section 3, while section 4 contains the concluding remarks.

2. Methodology

2.1 The Theoretical Model

The theoretical model which illustrates the implications of the Penn Effect was first rigorously presented in Rogoff (1992b). However, it must be noted that Harrod (1933) and Samuelson (1964) described the basic elements of the model in their works, and that Balassa

(1964) estimated a simple empirical model for the Penn Effect in his paper. Moreover, Kravis and Lipsey (1983), and Bhagwati (1984) also documented empirical evidence of the Penn Effect. The main feature of these earlier specifications is their focus on the supply side of the economy (see Officer, 1976; Hsieh, 1982; and Marston, 1987).

To bridge this theoretical gap, Rogoff (1992b) proposes a fully-specified model for the Penn Effect which has its conceptual roots in the general equilibrium framework containing two Cobb-Douglas production functions for two domestically produced goods. These two domestically produced goods are tradable "T" and non-tradable "N", which originated in the tradable sector and the non-tradable sector, respectively. Moreover, these two goods, Rogoff argues, are produced using three factors: labour "L", capital "K", and technology "A". Specifically, Rogoff assumes that the two goods follow production functions of the form:

$$Y_{Tt} = A_{Tt}K_{Tt}^{\theta_T}L_{Tt}^{1-\theta_T}, \quad (1)$$

$$Y_{Nt} = A_{Nt}K_{Nt}^{\theta_N}L_{Nt}^{1-\theta_N}, \quad (2)$$

where Y_{Tt} and Y_{Nt} denote the quantities of the tradable and the non-tradable goods at time t, respectively. θ_T and θ_N denote the share of L and K in the production of T and N, respectively; A_T and A_N are the stochastic productivity shocks in sectors T and N, respectively. Rogoff (1992b) assumes, in addition, that: (i) the *law of one price* holds in the tradable sector; (ii) there is perfect international capital mobility; (iii) there is perfect market competition; and (iv) there is perfect factor mobility between sectors of the economy. On the basis of these assumptions, he demonstrates that a change in the relative price of non-tradable goods depends on a change in the relative productivity of the two sectors in the form:

$$dp = (\theta_N/\theta_T)da_T - da_N, \quad (3)$$

where d is the differential operator; lower cases represent the logarithm of the variables; p is the relative price of non-tradable goods in terms of tradable goods; and a_T and a_N are the stochastic productivity shocks in the tradable and non-tradable sectors, respectively. Rogoff argues that a more realistic result can be achieved if we take capital and labour as given in each of the sectors – to avoid instantaneous inter-sectoral mobility within the economy – and if we assume that capital markets are closed to international borrowing and lending. In this case, we obtain the following result (see Rogoff, 1992b, p. 10):

$$dp = \beta_T da_T - \beta_N da_N - [(\beta_T - 1)dg_T - (\beta_N - 1)dg_N], \tag{4}$$

where β is the output–consumption ratio, and g is the logarithm of government consumption. Rogoff (1992b) contends that equation (4) is identical to equation (3) because productivity shocks in equation (4) have similar form and relations to productivity shocks in equation (3). The theoretical relations in (3) and (4) have enabled empirical studies to capture the role of the demand side of economies on long-run real exchange rates.

A review of the theoretical advancements that have been made following Rogoff's (1992b) paper is beyond the scope of our paper. We refer the interested reader to Asea and Mendoza (1994), De Gregorio *et al.* (1994), and Obstfeld and Rogoff (1996), for earlier studies. For recent studies, the reader should consider Ghironi and Melitz (2005), Bergin *et al.* (2006), and Méjean (2008).

2.2 The Empirical Model

To arrive at an empirically meaningful model, it is important to link the theory and empirics. For a single-country analysis, p in (4) is calculated by dividing the price of non-tradable goods by the price of tradable goods. However, for cross-country analysis, the bilateral real exchange rate between individual countries and a benchmark country is used (see Hsieh, 1982; Marston, 1987). Hence, we can use the real exchange rate and the relative price of non-tradable goods interchangeably (see Rogoff, 1992b, p. 8). This interpretation stems from the assumption that terms of trade is constant, so that the only source of real exchange rate fluctuation is changes in the relative price of non-tradable goods (see Rogoff, 1992b). Similarly, the relative real output per capita of the individual countries in terms of the benchmark country can be used to measure the relative productivity shocks of sectors N and T.[1] These characterizations actually work better in the current study, since data on the price of tradable and non-tradable goods are very limited for the countries considered.

[1] Many empirical studies have actually used this proxy. See, for example, Faria and León-Ledesma (2003), Bahmani-Oskooee and Nasir (2004), and Chong *et al.* (2012).

Our objective, in this paper, is to examine whether relative productivity growth is crucial to real misalignment of currencies in Latin American countries. The first step towards achieving this objective is to construct the real exchange rate misalignment index. This measure is used to proxy p in (4), the dependent variable which we are going to use for our analysis. Following Rodrik (2008), we extract the exchange rates (*XRAT*) and purchasing power parity (*PPP*) conversion factors from the Penn World Tables, version 7.1, compiled by Heston *et al.* (2012). We then construct the real exchange rate (under- or overvaluation) index as follows:

$$lnRER_{it} = ln(XRAT_{it}/PPP_{it}), \tag{5}$$

where i is the country under consideration, and t is a one-year time window. We use a one-year time window as against the five-year time window that has been used in studies such as those of Freund and Pierola (2008), Rodrik (2008), and Aghion *et al.* (2009) in order to capture the inherent noise effects in the annual dataset. Note that *XRAT* and *PPP* are denoted in national currency units per US dollar. When *RER* is more than unity, it implies that the currency is more depreciated than the purchasing power parity implies (see Rodrik, 2008). The US is used as the benchmark country because historically its non-tradable goods are more expensive than those of Latin American countries. In addition, most of the international transactions involving the Latin American countries and their trade counterparts are denoted in US dollars. Moreover, other studies have also used the US as the benchmark country (see, for example, Lothian and Taylor, 2008; Chong *et al.*, 2012).

The standard simple empirical model for examining the role of relative productivity growth in real misalignment of currencies takes the form:

$$lnRER_{it} = \gamma + \psi lnPROD_{it} + f_i + f_t + \xi_{it}, \tag{6}$$

where γ and ψ are parameters of the model, ψ measures the response of the real exchange rate within the Latin American countries due to relative productivity growth, $PROD_{it}$ is the index of relative productivity of country i in period t which is proxied by the real GDP per capita of the home country relative to that of the US[1], ln is the natural logarithm, and f_i and

[1] Officer (1976) argued against using productivity growth and recommended relative productivity growth. Hence, we utilized relative productivity in line with this recommendation.

f_t are fixed effects for country i and period t, respectively. ξ_{it} is the error term for country i at time period t.

The baseline argument for the existence of the Penn Effect is that non-traded goods are cheaper in poorer countries than in richer countries (see Harrod, 1933; Balassa, 1964; Samuelson, 1964; Bhagwati, 1984). Thus, the Penn Effect is valid if ψ is negative and significant (see Rodrik, 2008; Gluzmann *et al.*, 2012; Vieira and MacDonald, 2012). A number of studies have found ψ to be negative and significant (see, for instance, Gala, 2008; Rodrik, 2008; Gluzmann *et al.*, 2012; Vieira and MacDonald, 2012).

The possible drawback of equation (6) is that it could have been under-specified. In theory, other factors (such as government consumption, trade openness, and terms of trade) could contribute to real misalignment of currencies (see Rogoff, 1992b; De Gregorio *et al.* 1994; Vieira and MacDonald, 2012). To avoid the problem of misspecification, we fit a model with control variables in the form:

$$lnRER_{it} = \gamma + \psi lnPROD_{it} + \phi Z_{it} + f_i + f_t + \xi_{it}. \qquad (7)$$

All the variables in equation (7) except Z retain their definitions as before. Z is a vector of *1xq* variables representing the standard determinants of the real exchange rate considered in the exchange rate literature. In this paper, Z contains terms of trade, trade openness, and government debt burden. ϕ is a vector of *qx1* parameters to be estimated. ξ represents the white-noise error term.

To keep our results tractable, we first estimate equations (6) and (7) by short-panel data techniques (i.e. techniques suitable for the short time dimension). We start with the fixed-effects or within-effects estimator, using the robust variance option. Noting that the presence of endogeneity issues could render the results of the fixed-effects estimation meaningless, we follow up using the generalized method of moments (GMM) techniques developed for dynamic panels by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). We use both the difference GMM and the system GMM options to estimate equation (7). In each case, we report the one-step and the two-step results. The difference GMM estimator performs poorly if the autoregressive parameters are too large or if the ratio of the variance of the panel-level effect to the variance of idiosyncratic error is too large (see Arellano and Bover, 1995; Blundell and Bond, 1998). For this reason, we provide results for both estimators and check for model adequacy using the *Sargan Test* for orthogonality of the instruments and error terms.

In the long-panel data case (i.e. techniques suitable for the long time dimension), we first conducted stationarity tests for the variables. This step is important because, should the variables be non-stationary, the regression results would be spurious if the variables are not differenced. We checked the stationary status of the variables using the Levin, Lin and Chu (2002) and the Im, Pesaran and Shin (2003) tests for unit roots. Two of the variables, namely relative productivity and government debt burden, were non-stationary at levels, but the remaining ones were stationary at levels (see Table 2 in section 3). Since the variables are of mixed order of integration, cointegration testing is not applicable.[1] We proceeded to estimate equation (7) with six long-panel data techniques: (i) pooled OLS with iid errors; (ii) pooled OLS with standard errors, given correlation over states; (iii) pooled OLS with standard errors, given general serial correlation in the error (up to four lags) and correlation over states;[2] (iv) pooled OLS, given an AR(1) error[3] and standard errors that are correlated over states; (v) pooled FGLS with standard errors, given an AR(1) error; and (vi) pooled FGLS, given an AR(1) error and correlation across states (see Cameron and Trivedi, 2010).[4]

2.3 Data

The panel dataset of Latin American countries employed in this paper consists of fifteen countries[5] and covers the period 1951 to 2010. We used relative real GDP per capita to proxy relative productivity growth (i.e. domestic real GDP per capita divided by US real GDP per capita). The data on this variable was obtained from the Penn World Tables, version 7.1 compiled by Heston *et al.* (2012). Terms of trade is measured as pl_x/pl_m, and government debt burden is measured as csh_g. Both variables were extracted from Penn World Tables,

[1] For cointegration testing to be applicable in the panel data setting, all the variables must be non-stationary at levels.
[2] The Newey-West-Type standard errors based on Driscoll and Kraay (1998).
[3] For the reason for including an AR(1) error, see Beck and Katz (1995).
[4] All computations in the paper are carried out using STATA 13. The do-file is available upon request.
[5] These countries are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Uruguay, and Venezuela. We selected each of these countries by considering data availability for the study period.

version 8.0, compiled by Feenstra *et al.* (2013). Trade openness is measured as $openc$ and was extracted from Penn World Tables, version 7.1, compiled by Heston *et al.* (2012).

3. The Empirical Results

3.1 Influence of Relative Productivity on the Real Exchange Rate, 1951–2010

In Table 1, we report the empirical results for *Eqs.* (6) and (7) which were estimated using short-panel data techniques. Panel [1] shows the estimate for *Eq.* (6), the simple empirical model. The coefficient of relative productivity, ψ, is negative and weakly significant (i.e. $\psi = -.381$ and $t = -1.86$). Relative productivity growth appears to determine real misalignment of currencies in this model, and the Penn Effect is supported. The estimated impact of relative productivity growth on the real exchange rate is relatively high. This is not a cause for concern, since apart from relative productivity major determinants of real misalignments are not included in *Eq.* (6). In addition, potential endogeneity embedded in the within-effects estimation could also have caused the estimate to be so. In panel [2], we attempted to avoid the problem of misspecification by including some standard control variables. These control variables are terms of trade (*LNTOT*), trade openness (*LNOPEN*), and government debt burden (*LNGOV*). The within-effects estimation, after controlling for these variables, produced a negative and significant ψ at the 10 per cent level (i.e. $\psi = -.171$ and $t = -1.91$). The Penn Effect is supported here as well. The estimate of the coefficient term for relative productivity reduced significantly after controlling for model misspecification.

As we have pointed out, the potential presence of endogeneity bias may have resulted in ψ being weakly significant. For the robustness of our empirical results, we controlled for potential endogeneity bias by estimating *Eq.* (7) with the GMM system and difference estimators for both the one-step and the two-step cases. These results are reported in panels [3] to [6]. In all these cases, ψ is negative and strongly significant (i.e. around 1 per cent and 5 per cent significance levels). The difference GMM overestimates ψ. The *Sargan Test* indicates that the system GMM results are better. In addition, the estimated ψ in the case of the one-step and two-step system GMM appears closer to the within-effects estimate. Most important, the Penn Effect is present in all cases. The within-effects and system GMM results suggest that a 10 per cent increase in relative productivity growth leads to between 1.3 per cent and 1.6 per cent real appreciation of the currencies in Latin American countries.

We mentioned earlier that, like all other estimating techniques, the short-panel data techniques (i.e. techniques suitable for short time dimension) also have drawbacks. For instance, data on real exchange rates are not available over an extended period of time. This means that the power of the short-panel estimators is significantly lessened because the results tend to be influenced by country-effects. To provide estimates which do not suffer by being influenced by country-effects, we employed the long-panel data techniques (i.e. the six long-panel data estimators we stated in section 2).

However, before we estimated *Eq.* (7) with the six long-panel data techniques, we examined the data-generating process of the variables using the Levin-Lin-Chu (LLC), and the Im-Pesaran-Shin (IPS) tests for unit roots. The results for the unit root are reported in Table 2. As Table 2 shows, *LNRER* and *LNTOT* are level-stationary at 1 per cent significance level for both LLC and IPS. However, *LNPROD* and *LNGOV* were not level-stationary. Consequently, we differenced *LNPROD* and *LNGOV* once and they became stationary at 1 per cent significance level.

The next natural step, after establishing that the data-generating process of the variables was mixed, was to report the results obtained from estimating *Eq.* (7) with the six long-panel data estimators. These results are reported in Table 3. Panels [1] to [3] report results obtained from the pooled OLS cases with different restrictions on the nature of the errors and correlation over states. For these cases, the estimated value of ψ is negative and highly significant (i.e. $\psi \approx -0.345$ and $-12.90 < t < -9.36$), meaning that a 10 per cent increase in productivity growth normally generates real appreciation of the currencies of these countries by approximately 3.45 per cent. Panels [4] to [6] report cases where AR(1) errors are included in the estimation, with some other restrictions placed on the model. In these cases, the estimated values of ψ have increased in absolute terms. ψ nevertheless remains negative and highly significant (i.e. $\psi \approx -0.40$ and $-9.12 < t < -4.23$). The approximate value of ψ implies that when relative productivity growth increases by 10 per cent, the real exchange rate appreciates by approximately 4 per cent. The Penn Effect is also clearly supported in the long-panel data case.

The main concern here is that the evidence presented above did not factor in the influence of speculative attacks to which these countries have been subjected, especially in the past. Calvo (1996) has argued that prior to the peso crisis of 1994 and 1995 in Mexico, countries in Latin America were very vulnerable to frequent speculative attacks. These speculative attacks were particularly severe in the Latin American countries because most of them practised fixed exchange rate regimes. Under typical speculative attacks, exchange rates experienced sharp corrections – this occurred in the Latin American countries (see Figure 1, for example). The influence of relative productivity on real exchange rate will therefore differ under severe speculative attacks and mild speculative attacks. Following the existing literature, we designated the period before 1996 as representing the period of severe speculative attacks, and the period from 1996 to 2010 as the period of mild speculative attacks. Hence, we divided the data into pre-peso crisis (1951–1995) and post-peso crisis (1996–2010). We then re-examined the role of relative productivity growth on real exchange rate by re-estimating *Eq.* (7) using these subsamples. These results are presented in turn.

3.2 Pre-peso Crisis, 1951–1995

Table 4 shows the estimates of *Eqs.* (6) and (7) generated using the short-panel data techniques. Panel [1] reports the within-effects estimate of *Eq.* (6), the simple empirical model. Here, the coefficient of relative productivity growth, ψ, is negative and weakly significant (i.e. $\psi = -.515$ and $t = -2.00$). After controlling for model misspecification (see Panel [2]), the impact of relative productivity on the real exchange rate was reduced to $\psi = -.287$ with $t = -1.88$. The Penn Effect is supported at 10 per cent level. The GMM estimates of *Eq.* (7) are reported in panels [3] to [6]. In all these cases, ψ is negative and significant (i.e. around 1 per cent and 10 per cent significance level). As we have already seen, the difference GMM overestimates ψ in this case too. The *Sargan Test* indicates that the system GMM results are better. The Penn Effect is present in all cases. The within-effects and system GMM results suggest that a 10 per cent increase in relative productivity growth leads to between 0.2 per cent and 2.7 per cent real appreciation of the currencies in the Latin American countries.

The results we obtained from estimating *Eq.* (7) with the six long-panel data estimators are reported in Table 5. Panels [1] to [3] report results obtained from the pooled OLS cases with different restrictions on the nature of the errors and correlation over states. The estimated value of ψ is negative and highly significant (i.e. $\psi \approx -0.303$ and $-9.71 < t < -6.85$). Panels [4] to [6] report cases where AR(1) errors are included in the estimation with some other restrictions placed on the model. The estimated values of ψ have increased in absolute terms. ψ remains negative and highly significant (i.e. $\psi \approx -0.34$ and -0.35, and $-6.87 < t < -3.02$).

3.3 Post-peso Crisis, 1996–2010

The within-effects estimates of *Eqs.* (6) and (7) are shown in panels [1] and [2] of Table 6. Here, we find overwhelming support for the Penn Effect. The coefficient of relative productivity growth, ψ, is negative and very significant in the simple model and the fully-specified model (i.e. $\psi = -.918$ and $t = -3.44$, $\psi = -.992$ and $t = -4.36$, respectively). The GMM estimates of *Eq.* (7) are reported in panels [3] to [6] of Table 6. ψ is negative and very significant in all these cases. The *Sargan Test* indicates that the system GMM results are better. The Penn Effect is strongly supported by the GMM results.

Table 7 shows estimated results of *Eq.* (7) using the six long-panel data estimators. Panels [1] to [3] report results obtained from the pooled OLS cases with different restrictions on the nature of the errors and correlation over states. The estimated value of ψ is negative and highly significant (i.e. $\psi \approx -0.408$ and $-14.02 < t < -9.32$). Finally, panels [4] to [6] report cases where AR(1) errors are included in the estimation, with some other restrictions placed on the model. The estimated values of ψ have increased in absolute terms. ψ remains negative and highly significant (i.e. $\psi \approx -.484$ and $-.494$, and $-14.15 < t < -6.44$).

3.4 Unifying the Results

Overall, the results suggest that the Penn Effect is well supported in the Latin American countries during the period 1951 to 2010. Essentially, the evidence suggests that relative productivity growth played a significant role in real misalignment of currencies in these countries for the period studied. The magnitude of the impact of relative productivity growth on real exchange rate misalignment estimated for the entire period lies somewhere between 2 and 4 per cent, on average. This finding is consistent with previous studies such as those conducted by Asea and Mendoza (1994), and Drine and Rault (2003). However, it contradicts those of Genius and Tzouvelekas (2008), and Astorga (2012), who found no evidence in support of the Penn Effect for a group of Latin American countries in their studies.

In addition to the above finding, our estimates show that relative productivity growth had a relatively weak impact on real misalignment of currencies during the period preceding the peso crisis (i.e. when speculative attacks were frequent and severe). The point estimate of this impact lies somewhere between 0.2 and 4 per cent. Relative productivity growth had a relatively strong impact on real misalignment of currencies after the peso crisis (i.e. when speculative attacks were mild and less frequent). The results differ somewhat from those reported by Calderon and Schmidt-Hebbel (2003), who found that productivity growth differences could not explain real exchange rate movements in Latin American and Caribbean countries during the period 1991 to 2001. Their assertion that higher output growth rates in these countries is not enough to correct real misalignment, especially under severe speculative attacks, is confirmed in this paper. This is because the impact of relative productivity growth on real exchange rate is found to be weak during the period preceding the peso crisis. Relative productivity growth is able to help correct real misalignment significantly only under moderate or weak speculative attacks. Relative productivity growth will therefore need to be very sizeable in order to correct the impact of speculative attacks on the currencies in Latin America.

4. Concluding Remarks

In this paper, we explored the role of relative productivity growth in real misalignment of currencies in Latin American countries. We specifically verified the validity of the Penn Effect for this group of countries. The sample we employed for our empirical analysis consisted of fifteen countries from the Latin American region for the period 1951 to 2010. Instead of using either short- or long-panel data techniques, as was done in earlier studies, we employed both techniques in order to report more convincing results. In addition, we separated the data into periods of frequent and speculative attacks and mild speculative attacks. This allowed us to assess the impact of relative productivity on real exchange rates in these countries during different episodes of speculative attacks. Overall, the results indicate that relative productivity growth has played a crucial role in the real misalignment of currencies in the Latin American region. Hence, the Penn Effect is supported by the empirical results. The influence of relative productivity growth is significantly stronger during episodes of mild speculative attacks than during episodes of severe speculative attacks. The empirical results that we obtained remain robust to endogeneity, general serial correlation in the error, and correlation over and across states, among other restrictions. These results have a key policy implication. To correct the impact of speculative attacks on currencies in these countries, relative productivity growth needs to be very sizeable. Growth-oriented policies designed to improve economic growth as a way of aligning currencies in the Latin American countries may not be successful if similar policies are not designed to moderate speculative attacks in these countries.

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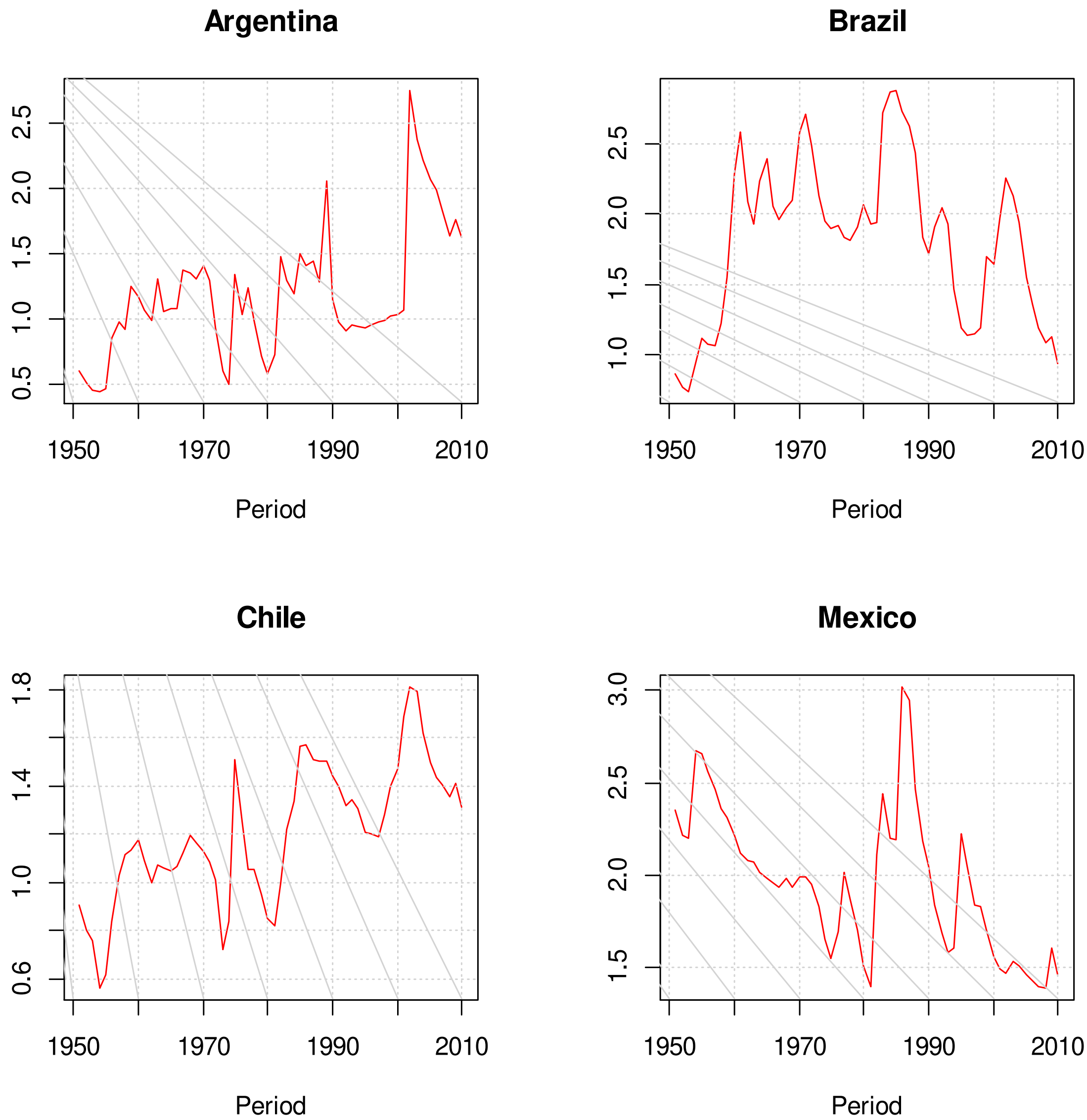

Figure 1: Over and undervaluation in key Latin American countries during the period 1951–2010.

Table 1: Results for the Short-Panel Data (1951–2010)

LNRER	[1] FE (Within)	[2] FE (Within)	[3] Diff-GMM [One-Step]	[4] Sys-GMM [One-Step]	[5] Diff-GMM [Two-Step]	[6] Sys-GMM [Two-Step]
LNPROD	-.381*	-.171*	-.223***	-.158**	-.889***	-.127**
	(-1.86)	(-1.91)	(-4.02)	(-2.74)	(-2.66)	(-2.31)
LNTOT		-.053	-.182***	-.115***	-.419***	.003
		(-0.54)	(-2.96)	(-2.98)	(-3.92)	(0.01)
LNOPEN		.347**	.068***	.028	.693*	.491***
		(3.00)	(2.08)	(1.60)	(1.94)	(3.01)
LNGOV		.130	.228***	-.022	1.23**	.280
		(0.83)	(4.63)	(-1.10)	(2.39)	(1.52)
Time Dummies	yes	yes	yes	yes	yes	yes
Country Dummies	yes	yes				
Group Average			57	58	57	58
Number of Lags			2	2	2	2
Sargan Test [Prob > chi-squared]			0.000	0.000	.854	.999
Observations	900	900	855	870	855	870

Note:

(1) t-statistics are in parentheses.

(2) *, ** and *** denote significance at 10%, 5% and 1%, respectively.

(3) FE = Fixed-effects Estimator, Diff = Difference Estimator, and Sys = System Estimator.

Table 2: Tests for Unit Roots of the Variables at Levels and First Difference

Variable	LLC [t_{δ}^{*}]	IPS [$z_{\tilde{t}-bar}$]
LNRER	-3.8609***	-4.2894***
LNPROD	-2.3807**	-0.6648
LNTOT	-2.7475***	-3.3534***
LNOPEN	-2.5068***	-2.7696***
LNGOV	-0.5704	-0.5663
Δ*LNPROD*	-17.4591***	-16.8599***
Δ*LNGOV*	-24.7958***	-18.7936***

Note:
(i) ** and *** denote rejection of H_0 at 10% and 5%, respectively.
(ii) Δ denotes the first difference operator.

Table 3: Results for Long-Panel Data Techniques (1951–2010)

Variable	[1] OLS_iid	[2] OLS_cor	[3] OLS_DK	[4] AR1_cor	[5] FGLSAR1_cor	[6] FGLSCAR
LNPROD	-0.345***	-0.345***	-.345***	-.404***	-0.404***	-.402***
	(-10.14)	(-12.90)	(-9.36)	(-4.23)	(-5.20)	(-9.12)
LNTOT	-.0331	-0.0359	-.033	-.0652	-.065	-.069**
	(-0.71)	(-0.78)	(-.33)	(-1.06)	(-1.37)	(-2.28)
LNOPEN	.092***	.092***	.092	.4231***	.423***	.401***
	(3.67)	(3.78)	(1.63)	(8.29)	(11.11)	(16.18)
LNGOV	-.015	-.015	-.015	.113	.113**	.039
	(-0.57)	(-0.76)	(-0.46)	(1.88)*	(2.21)	(1.40)
Constant	-3.349	-3.349	-3.349	3.117	3.117	6.78*
	(-2.14)**	(-1.81)*	(-0.86)	(0.52)	(0.80)	(1.87)
Time Dummies	yes	yes	yes	yes	yes	yes
Group Average	60	60		60		
Observations	900	900	900	900	900	900

Note: *, ** and *** denote rejection of H_0 at 10%, 5% and 1%, respectively.

Table 4: Results for the Short-Panel Data Techniques (1951–1995)

LNRER	[1] FE (Within)	[2] FE (Within)	[3] Diff-GMM [One-Step]	[4] Sys-GMM [One-Step]	[5] Diff-GMM [Two-Step]	[6] Sys-GMM [Two-Step]
LNPROD	-.515*	-.287*	-.293***	-.016*	-.417*	-.026**
	(-2.00)	(-1.88)	(-4.07)	(-1.86)	(-1.85)	(-2.31)
LNTOT		-.059	-.106	-.097**	-.093	-.120
		(-0.73)	(-1.56)	(-2.18)	(-0.89)	(-0.43)
LNOPEN		.463**	.214***	.071***	.090	.173**
		(4.38)	(4.55)	(3.15)	(0.36)	(2.20)
LNGOV		.163	.189***	-.043	.379	-.075
		(0.88)	(3.16)	(-1.59)	(0.83)	(-0.55)
Time Dummies	yes	yes	yes	yes	yes	yes
Country Dummies	yes	yes				
Group Average			42	43	42	43
Number of Lags			2	2	2	2
Sargan Test [Prob > chi-squared]			0.000	0.000	.884	.999
Observations	675	675	630	645	630	645

Note:

(4) t-statistics are in parentheses.

(5) *, ** and *** denote significance at 10%, 5% and 1%, respectively.

(6) FE = Fixed-effects Estimator, Diff = Difference Estimator, and Sys = System Estimator.

Table 5: Results for Long-Panel Data Techniques (1951–1995)

Variable	[1] OLS_iid	[2] OLS_cor	[3] OLS_DK	[4] AR1_cor	[5] FGLSAR1_cor	[6] FGLSCAR
LNPROD	-.303***	-.303***	-.303***	-.341***	-.341***	-.352***
	(-6.85)	(-9.71)	(-7.40)	(-3.02)	(-3.56)	(-6.87)
LNTOT	-.025	-.025	-.025	-.063	-.063	-.068**
	(-0.47)	(-0.50)	(-.21)	(-.87)	(-1.14)	(-2.04)
LNOPEN	.109***	.109***	.109	.428***	.428***	.389***
	(3.52)	(3.78)	(1.47)	(7.11)	(9.34)	(13.89)
LNGOV	-.052	-.052**	-.052	.105	.105*	.034
	(-1.59)	(-2.15)	(-1.10)	(1.45)	(1.72)	(1.00)
Constant	-11.11**	-11.11***	-11.11*	-4.554	-4.554	-2.198
	(-4.42)	(-3.92)	(-1.95)	(-0.53)	(-0.77)	(-0.44)
Time Dummies	yes	yes	yes	yes	yes	yes
Group Average	45	45		45		
Observations	675	675	675	675	675	675

Note: *, ** and *** denote rejection of H_0 at 10%, 5% and 1%, respectively.

Table 6: Results for the Short-Panel Data Techniques (1996–2010)

LNRER	[1] FE (Within)	[2] FE (Within)	[3] Diff-GMM [One-Step]	[4] Sys-GMM [One-Step]	[5] Diff-GMM [Two-Step]	[6] Sys-GMM [Two-Step]
LNPROD	-.918***	-.992***	-.453***	-.453***	-.840***	-.333***
	(-3.44)	(-4.36)	(-9.05)	(-7.70)	(-9.56)	(-3.50)
LNTOT		-.315	-.149	-.164	.067	.134
		(-1.35)	(-1.22)	(-1.55)	(0.44)	(0.91)
LNOPEN		.576***	.195**	-.127***	.214	-.140
		(3.51)	(2.19)	(-4.11)	(1.53)	(-1.49)
LNGOV		-.156**	.083	-.033	.296	.034**
		(-2.61)	(0.59)	(-0.65)	(1.06)	(2.25)
Time Dummies	yes	yes	yes	yes	yes	yes
Country Dummies	yes	yes				
Group Average			12	13	12	13
Number of Lags			2	2	2	2
Sargan Test [Prob > chi-squared]			0.000	0.000	0.895	0.963
Observations	225	225	180	195	180	180

Note:

(7) t-statistics are in parentheses.
(8) *, ** and *** denote significance at 10%, 5% and 1%, respectively.
(9) FE = Fixed-effects Estimator, Diff = Difference Estimator, and Sys = System Estimator.

Table 7: Results for Long-Panel Data Techniques (1996–2010)

Variable	[1] OLS_iid	[2] OLS_cor	[3] OLS_DK	[4] AR1_cor	[5] FGLSAR1_cor	[6] FGLSCAR
LNPROD	-.408*** (-11.50)	-.408*** (-14.02)	-.408*** (-9.32)	-.484*** (-6.51)	-.485*** (-6.44)	-.494*** (-14.15)
LNTOT	.592*** (4.25)	.592*** (4.20)	.591*** (7.15)	.014 (0.13)	.012 (0.14)	.019 (1.38)
LNOPEN	.121*** (3.67)	.121*** (4.13)	.121*** (3.57)	.274*** (4.07)	.276*** (5.57)	.281*** (13.91)
LNGOV	.034 (1.11)	.034** (2.35)	.034* (2.08)	.041 (0.80)	.042 (0.68)	.042*** (6.54)
Constant	14.768** (2.22)	14.768 (1.47)	14.768 (0.99)	16.752 (0.93)	16.781* (1.83)	16.156*** (6.77)
Time Dummies	yes	yes	yes	yes	yes	yes
Group Average	15	15		15		
Observations	225	225	225	225	225	225

Note: *, ** and *** denote rejection of H_0 at 10%, 5% and 1%, respectively.