ISSN 1440-771X

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Real Exchange Rate Movements in Developed and Developing Economies: An Interpretation of the Balassa-Samuelson's Framework

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April 2011

Working Paper 05/11

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April 22, 2011

Abstract

This paper investigates empirically the Balassa-Samuelson hypothesis (BSH) using annual data over 1970-2008 from 33 countries grouped into developed and developing countries. The innovative feature of our study is that we introduce a new approach for classifying traded and nontraded industries. Our proposed approach allows for country specific heterogeneity over each industry, and changes in classifications of industries across periods. We apply panel cointegration tests with group-mean panel dynamic ordinary least squares (DOLS) estimators suggested in Pedroni (2000, 2001) to examine the BSH. We also use persistence profiles in order to investigate the speed of adjustment to equilibrium in response to shocks on cointegrating relations, and employ them as a complementary tool for checking whether the long run relationships obtained from the tests are actually valid.

Our main finding is that there is not enough evidence in favour of the BSH nor in favour of purchasing power parity (PPP) in either developed or developing countries. In developed countries, there is strong evidence that higher growth countries will experience real exchange rate appreciation. However, this relation does not provide evidence in favour of the BSH. We actually find opposing evidence that as productivity growth in traded goods relative to that in nontraded goods increases, the real exchange rate tends to depreciate. For developing countries, our results support the BSH. However, the speed of reversion to equilibrium is very slow. We also find moderate evidence that comparatively rapidly growing developing countries will experience real exchange rate depreciation.

JEL Classification: C12, C23, F31, F43

Keywords: Balassa-Samuelson effect, real exchange rate, non-stationary panels, traded and nontraded sectors, persistence profile

1 Introduction

Economists who are concerned about long run movements in exchange rates have always recognized the importance of the Balassa-Samuelson hypothesis (BSH). Balassa (1964) and Samuelson (1964) provide an explanation of long-run real exchange rate behavior based on productivity differentials between traded and nontraded goods in economies with freely adjusting wages and prices. The argument is that higher productivity of traded goods relative to that of nontraded goods is associated with a higher relative price of nontraded goods - in other words, a real appreciation in exchange rate. In general, high growth countries are expected to have higher productivity of traded goods, so this leads to the prediction that rapid economic growth should be accompanied by real exchange rate appreciation. However, there is considerable controversy over this statement for real exchange rates among fast-growing countries, especially Asian countries. These developing countries, particularly China, India, and Vietnam, are "economies in transition" whose macroeconomic and commercial policies are evolving as their financial sectors and their infrastructures develop, and they do not seem to follow the BSH path. The puzzle is that while China experiences unprecedented export expansion, there is not a tendency for its real exchange rate to appreciate. This leads to an important question about whether the BSH effect can explain the long-run behavior of real exchange rates, especially in rapidly growing economies.

Basically, the BSH is based on the following three key assumptions. The first assumption is that traded goods are homogenous, in which case the purchasing power parity (PPP) condition is expected to hold in the long run. The real exchange rate is then influenced by the relative price of nontraded goods in two countries. However, the presence of pervasive intra-industry trade between countries suggests that goods and services are not homogeneous across countries but are differentiated by country of origin[1], leading to failures of the law of one price for their traded products[2]. The second assumption is slower productivity growth in the labor-intensive nontraded sector relative to that in the traded sector. Of course, this characterization of differential sectoral productivity growth need not always be true. During some periods of economic development, productivity growth may be higher in the nontraded sector, tending to depreciate the real exchange rate. Miyajima (2005) identifies numerous instances in which growth surges in developing countries have been associated with services rather than traded productivity growth. The third assumption is that for each country, the labour market clears and labour arbitrage equates wages in the traded and nontraded sectors. However, this assumption is suspect, as in most developing countries industrial wages are higher than service wages.

Much attention has been paid in the literature to the empirical validity of the BSH. However, the existing literature has so far provided mixed results. Choudhri and Khan (2005) provide evidence on the working of the Balassa-Samuelson mechanism for developing countries based on their estimation of the two main channels : the first channel links the real exchange rate to relative prices of nontraded goods and the second channel relates relative prices of nontraded goods to traded-nontraded productivity differentials. On the contrary, Drine and Rault (2004) find no long-run relationship between real exchange rates and productivity differentials in six Asian countries using panel data cointegration techniques. Based on panel data cointegration techniques, Solanes and Flores (2009) find some evidence for rejecting the BSH in OECD countries, but the studies of Drine and Rault (2005) and Chong et al. (2010) support the BSH in these

[1] See, for example, Dixon et al. (1982), McKibbin and Sachs (1991), Hertel (1997) and Dixon and Rimmer (2002)

[2] See, for example, Bergin, Glick and Taylor (2006), Drine and Rault (2005)

countries.

The diverging results of these studies might be the consequence of a lack of proper attention to the classification of industries into traded and nontraded sectors. Some papers do not pay any attention to this and use per capita GDP as a measure of the traded-nontraded productivity differential. Chong et al. (2010) and Drine and Rault (2005) take the relative GDP per capita ratio as representative of the relative productivity term. They find significant evidence for a long-run relationship between the real exchange rate and relative GDP per capita. This leads to their conclusion that the BSH can explain long-run real exchange rate movements in most OECD countries. However, the Balassa-Samuelson framework provides an explanation of long-run real exchange rate movements in terms of traded-nontraded productivity growth. For this reason, a conclusion based on per capita GDP rather than the productivity differential can be misleading as the former does not really imply the validity of the BSH. Furthermore, although some recent empirical literature has paid more attention to the classification between traded and nontraded goods, these classifications are still arbitrary, and they fail to allow for different patterns among industries in different countries and for trade endogeneity because each good is classified using traditional methods at the beginning of the sample and stays in that particular category over the remaining sample. For example, Choudhri and Khan (2005) investigate the long-run behavior of real exchange rates in sixteen developing countries by classifying traded sectors as the manufacturing and agricultural sectors and nontraded sectors by all other sectors, and then provide evidence in favor of the BSH for developing countries.

Although there are many existing empirical papers that examine the validity of the BSH, these studies fail to pay careful attention to the details of the Balassa-Samuelson framework. The purpose of this paper is to rectify these deficiencies and to clarify the debate over deliberate undervaluation in East Asian economies, especially in China and Vietnam through the two central questions: "Can the Balassa-Samuelson hypothesis explain long-run real exchange rate movements in developed and developing countries?" and "Does comparatively rapid growth in some countries necessitate long run real exchange rate appreciation with respect to less rapidly growing countries?"

In this paper, we assemble an unbalanced panel data set that includes annual time series from 1970 to 2008 for thirty-three countries including seventeen developing countries and sixteen developed countries. The paper studies the BSH in two country groups: developed and developing countries. We offer a new approach for classifying traded and nontraded sectors to obtain traded-nontraded productivity variables more appropriately, and then we apply the panel cointegration test developed by Pedroni (2000) which allows for heterogeneity among individual countries of the panel and controls for common time effects. The group-mean panel DOLS estimators suggested in Pedroni (2001) are applied to obtain the panel cointegrating vector in each of these two groups. Then we provide some support for the validity of the long run relations via persistence profiles. We also use persistence profiles to examine the speed of reversion to equilibrium, given various types of shocks.

Our main finding is that there is not enough evidence in favour of the BSH for this set of countries. In developed countries, there is strong evidence that higher growth countries will experience real exchange rate appreciation. However, this relationship is not a consequence of the BSH, as the BSH provides an explanation of real exchange rate behavior in terms of productivity growth. We find additional evidence that when productivity growth in traded goods increases relative to that in nontraded goods, the real exchange rate tends to depreciate. One possible reason for this story is the departure from PPP in traded goods for these countries. Moreover, this result is consistent with Edwards' (1988) work on developing countries that finds that productivity growth in traded sectors relative to nontraded sectors depreciates real exchange rates. This is possible if productivity growth creates positive supply effects in nontraded goods. If this more than offsets demand effects (income effects), which then exceeds supply in nontraded goods, this can induce a decline in their prices, implying real exchange rate depreciation.

For developing countries, there is some evidence that the real exchange rate has a positive long-run relationship with the traded-nontraded productivity differential. However, persistence profiles show that the speed of reversion to long-run equilibrium in these countries is very slow. We find that after a shock, the adjustment to long-run equilibrium takes at least five years. The sluggish rate of convergence in these relations can be explained by high transaction costs, trade barriers, foreign exchange rate intervention, imperfect competition, and costly information gathering. Moreover, this might be because real exchange rates are determined by other fundamentals together with productivity differentials, i.e. openness of the economy, government consumptions, foreign direct investment, net capital flow, trade liberalization, and terms of trade. Importantly, we find some evidence that higher growth episodes in developing countries are accompanied by real exchange rate depreciation. This finding is in line with the controversy over the undervaluation among developing countries.

The remainder of the paper is organized as follows. The theoretical framework is discussed in Section 2. Section 3 presents our criteria for the classification of industries into traded and nontraded sectors. Section 4 exposits the empirical analysis. Section 5 concludes.

2 Theoretical Framework

This section outlines the framework used in our empirical analysis. Since we wish to examine the validity of the BSH, we focus on the long-run relationship for real exchange rate movements. The long run is defined as the period over which complete adjustment of wages and prices occurs in the absence of nominal rigidity. That is, price follows the law of one price and wage equals the value of the marginal product of labor. We assume that each country has fixed endowments for both labor and capital to produce goods under perfect competition.

Let us consider a framework consisting of a large number of identical consumers and homogeneous firms. For convenience, we normalize households and firms to one. These economic agents optimize, i.e. they maximize some objective subject to the constraints they face. The representative firm produces both traded goods for exporting to international market and nontraded goods for consuming in the country.

We start with the demand side. Following Choudhri and Khan (2005), the preferences of each household in country i are assumed to be representable by a time-separable utility function. Therefore, at time τ, the household in country i maximizes its expected lifetime utility function as follows:

$$Max\ E\left\{\sum_{\tau=t}^{\infty}\delta^{\tau-t}U(C_{i\tau})\right\} \quad \text{with } \delta\in(0,1) \tag{1}$$

where δ is time discount factor and $C_{i\tau}$ indicates a consumption index for country i in period τ that includes consumption bundles for traded goods denoted by $C_{i\tau}^{T}$ and for nontraded goods denoted by $C_{i\tau}^{N}$. The consumption index can be represented as

$$C_i=(C_i^T)^{\bar{\gamma}_i}(C_i^N)^{1-\bar{\gamma}_i}/(\bar{\gamma}_i^{\bar{\gamma}_i}(1-\bar{\gamma}_i)^{1-\bar{\gamma}_i}), \tag{2}$$

where $\bar{\gamma}_i$ is the share of traded goods in aggregate consumption. According to Choudhri and Khan (2005), the Balassa-Samuelson analysis is simplified by the assumption that these shares are the same for all countries, so that $\bar{\gamma}_i=\bar{\gamma}$. Throughout this section, variables with superscripts $\{T,\ N\}$ indicate variables in traded and nontraded sectors, respectively.

Let P_i, P_i^T, and P_i^N denote the consumer price index, the price index for traded goods, and that for nontraded goods, respectively. We define P_i as the cost-minimizing price of C_i. Using equation (2), the price index is defined as

$$P_i=(P_i^T)^{\bar{\gamma}_i}(P_i^N)^{1-\bar{\gamma}_i}. \tag{3}$$

Now let us analyze the problem of the representative firm. The firm does not face a dynamic decision problem because the variables chosen at period τ do not affect the constraints and returns (profits) at later periods. Therefore, we consider the static profit maximization problem for the representative firm which is given by

$$\underset{K^T,K^N,L^T,L^N\geq 0}{Max}(P_i^T F_T(K_i^T,L_i^T)+P_i^N F_N(K_i^N,L_i^N)-R(K_i^T+K_i^N)-W(L_i^T+L_i^N)), \tag{4}$$

where K is the capital input, L is the labour input, W is the wage, R is the rental rate on capital, $F_T(K^T, L^T)$ and $F_N(K^N, L^N)$ are the production functions of traded and nontraded sectors, respectively. Under perfect competition, the factor prices equal the value of marginal product of factors in steady state. If we use a tilde over a variable to indicate the steady-state value of the variable, then the first order conditions imply

$$\begin{aligned} K^T &: \quad \widetilde{P}_i^T \frac{\partial F_T}{\partial \widetilde{K}_i^T} = \widetilde{R}, \\ K^N &: \quad \widetilde{P}_i^N \frac{\partial F_N}{\partial \widetilde{K}_i^N} = \widetilde{R}, \\ L^T &: \quad \widetilde{P}_i^T \frac{\partial F_T}{\partial \widetilde{L}_i^T} = \widetilde{W}, \quad \text{and} \\ L^N &: \quad \widetilde{P}_i^N \frac{\partial F_N}{\partial \widetilde{L}_i^N} = \widetilde{W} \quad . \end{aligned}$$

At the steady-state, the equilibrium is defined as

$$\frac{\widetilde{P}_i^N}{\widetilde{P}_i^T} = \frac{\partial F_T}{\partial \widetilde{L}_i^T} \Big/ \frac{\partial F_N}{\partial \widetilde{L}_i^N} = \frac{\widetilde{MP}_i^T}{\widetilde{MP}_i^N}, \tag{5}$$

where MP_i^T and MP_i^N are marginal productivities of traded and nontraded sectors, respectively.

Assume that the production function is a Cobb-Douglas function in both traded and nontraded goods so that

$$Y_i^N = A_i^N (K_i^N)^{\alpha_N} (L_i^N)^{\beta_N}, \quad \text{and} \tag{6}$$

$$Y_i^T = A_i^T (K_i^T)^{\alpha_T} (L_i^T)^{\beta_T},$$

where K_i^N and L_i^N represent the amounts of capital and labour used in the nontraded sector and K_i^T and L_i^T are those in the traded sector in country i. Then, at steady state:

$$\frac{\widetilde{P}_i^N}{\widetilde{P}_i^T} = \frac{\beta_T(\widetilde{Y}_i^T/\widetilde{L}_i^T)}{\beta_N(\widetilde{Y}_i^N/\widetilde{L}_i^N)} = \frac{\beta_T \widetilde{\theta}_i^T}{\beta_N \widetilde{\theta}_i^N}, \tag{7}$$

where θ_i^T and θ_i^N are the average products of labour for the traded and nontraded sectors, and β_T and β_N denote the labour elasticities of production for traded and nontraded sectors respectively. This equation shows the relationship between the relative price of nontraded goods to traded goods and the traded-nontraded productivity differential, which is one main channel of the BSH.

The key relationship between the real exchange rate and the relative price of nontraded goods is found by defining the log real exchange rate, q_i, by

$$q_i \equiv e_i + p_1 - p_i, \tag{8}$$

where e_i is the log nominal exchange rate of country i with respect to country 1, the reference country, and lowercase letters indicate values in logs. In our study, an increase in e_i implies exchange rate depreciation. Using equation (3), we can write the real exchange rate equation as

$$q_i = q_i^T + (1 - \bar{\gamma}_1)(p_1^N - p_1^T) - (1 - \bar{\gamma}_i)(p_i^N - p_i^T), \tag{9}$$

where $q_i^T \equiv e_i + p_1^T - p_i^T$ is log real exchange rate of traded goods. Substituting equation (7) into equation (9), and assuming that $\bar{\gamma}_i = \bar{\gamma}_1 = \bar{\gamma}$, we obtain

$$q_i = \phi_i + (1 - \bar{\gamma})[\log(\frac{\theta_1^T}{\theta_1^N}) - \log(\frac{\theta_i^T}{\theta_i^N})]. \tag{10}$$

This equation[3] represents the relationship between the long-run real exchange rate and the traded-nontraded productivity differential as stated in the BSH. It indicates that an increase in productivity of traded goods relative to nontraded goods in country i relative to the reference country ($\frac{\theta_i^T}{\theta_i^N} > \frac{\theta_1^T}{\theta_1^N}$) leads to a decrease in q_i, implying real exchange rate appreciation.

3 Classification of industries into traded and nontraded sectors

All goods and services are tradable to some degree. However, transaction costs place different limitations for different commodities. In general, goods and services in the traded sector can be traded across countries in international markets. Therefore, the price of traded goods and services will move closely with the world price and satisfy the Law of One Price and the Purchasing Power Parity condition (PPP). On the other hand, goods and services in the nontraded sector are not traded internationally. This might be because they are difficult to transport, or transportation costs are high, or their trade is limited by the imposition of tariffs and quotas. As a result, the price of nontraded goods and services will be determined by domestic demand and supply only. These are the main features differentiating traded and nontraded sectors.

In the literature, researchers have not paid close attention to the methodology used for classifying industries into traded and nontraded sectors. Until now, most approaches for measuring tradability are based on simple but rather arbitrary methods. Also, they are not flexible enough to allow for different patterns among industries in different countries and for trade endogeneity. This is the main weakness in the study of the

[3] When $\bar{\gamma}_i$ is approximately equal to $\bar{\gamma}$, we will then be able to approximate equation (10) using $q_i = \phi_i + (1 - \bar{\gamma}_i)[\log(\frac{\theta_1^T}{\theta_1^N}) - \log(\frac{\theta_i^T}{\theta_i^N})]$.

BSH because inappropriate classifications into traded and nontraded sectors adversely affect the calculations of productivity differentials and relative prices, which in turn confounds meaningful assessment of the BSH. In this paper, we carefully classify each industry in order to obtain better estimates of the productivity differentials. We combine two traditional approaches together using international trade information and follow the thrust of the Gonzalez-Soriano (1990) approach. Our classification reflects two of the above mentioned key differences between traded and nontraded sectors.

We initially apply the common arbitrary rule in the literature that uses a 10% threshold for the classification between traded and nontraded sectors. We then apply the price comovement tests of Gonzalez-Soriano (1990) to assess whether this is a reasonable classification, and adjust our classification if the price comovement tests suggest that this is appropriate. Combining these concepts with our new idea, the criteria for dividing between traded and nontraded commodity in this paper can be summarized as follows:

1. If the tradability ratio of an industry as measured by the sum of imports and exports to gross output is less than 0.1, the industry is considered as nontraded. However, this does not mean that all industries with a tradability ratio higher than 0.1 are classified as traded (as in the literature). Such industries can also be nontraded, depending on the movement of prices.

2. If the tradability ratio of an industry is more than 0.2, the industry is defined as a traded sector.

3. If the tradability ratio of an industry is between 0.1 and 0.2[4], we use sectoral price comovement tests to aid the classification.

Compared to a common threshold in the literature, it is clear that our criteria lead to more sensible outcomes for classifying industries into traded and nontraded sectors. If the tradability ratio is very small i.e. if it is less than 0.1, then it is reasonable that the industry is defined as nontraded. If the tradability ratio is quite large i.e. it is more than 0.2, then the industry is defined as traded. For an industry with a tradability ratio between 0.1 and 0.2, it is not immediately clear whether it should be defined as traded or nontraded. Our criteria employ more information and apply the price comovement tests to address this ambiguity.

[4] When the application of the 10% threshold together with the price tests leads to all sectors classified as traded, or when the tradability ratio of some countries is computed from the ratio of international trade to value added (inducing higher tradability ratio than a normal ratio because gross output includes intermediate consumption while value added does not), then we use new thresholds, instead. That is, 20% and 30% thresholds are applied in the cases of Malaysia, Brunei Darussalam, Sri Lanka, Netherlands, and Sweden. Also, if all sectors are still defined as traded at 20% and 30% thresholds, we apply thresholds of 30% or 40% instead, as in the case of Singapore and Vietnam. This may seem to be unreasonable but we have to recall that our main purpose for the classification is to divide all industries in one country into both two groups - traded and nontraded sectors – such that there is at least one industry in each group to examine the BSH. For this reason, we use the "comparative tradability" among industries within a country as our criteria. That is, although all industries in a given country should be actually classified as traded, if the tradability of an industry is relatively less than other industries within the country, it is sensible to classify that industry as nontraded. Note that it is not necessary to use a new threshold if the aim of the classification is to know the type of each industry with respect to tradeness, and not to examine the validity of the BSH.

3.1 Two main concepts that underlie the classification

Tradability Concept: Traded goods and services can enter international markets while nontraded goods and services are traded only in domestic markets. Therefore, tradability is measured as

$$\text{Tradability Ratio}_{i,t} = \frac{\text{imports}_{i,t} + \text{exports}_{i,t}}{\text{gross output}_{i,t}} \quad .$$

Sectoral Price Concept: The price of a traded commodity is more likely to satisfy the law of one price and the PPP condition than a nontraded commodity. That is, the movement of the price in a traded industry should be explained by the movement of the world price. For our study, the U.S. price is used as the world price[5]. The sectoral price comovement tests assume that prices are unit root processes. Actually, this assumption is formally tested and accepted but we do not provide the test results here because of space considerations. We adapt Gonzalez-Soriano price tests (1990) to account for unit roots, and the corresponding steps for the price comovement test are:

- Regress the log of the domestic sectoral price in domestic currency units, $p_t = \log(P_t)$ on the log of the world sectoral price in domestic currency units, $p_t^* = \log(P_t^*) + \log(E)$ to estimate

$$p_t = c + \beta p_t^* + \varepsilon_t.$$

Obtain the residuals, ecm_t from this regression.

- Estimate the associated 2-step error correction model. That is, run the regression of

$$\Delta p_t = \delta_1 + \alpha_1 ecm_{t-1} + \lambda_1 \Delta p_{t-1} + \omega_1 \Delta p_{t-1}^* + \eta_t$$

and

$$\Delta p_t^* = \delta_2 + \alpha_2 ecm_{t-1} + \lambda_2 \Delta p_{t-1} + \omega_2 \Delta p_{t-1}^* + \xi_t$$

over period 1970-2008, and use this to test the null hypothesis of no cointegration between prices. This is based on t tests on the coefficients, α_1 and α_2, of ecm_{t-1}. We use Newey-West robust standard errors in order to avoid the effects of serial correlation.

Case 1 *If at least one of these t coefficients is significant at the 5% level, we can conclude that there is a long run cointegrating relationship between domestic and world prices. The industry is then classified as traded.*

[5] Because of this, we cannot employ the price test in U.S. We use the 10 percent rule as in the literature.

Case 2 *If we fail to reject the null in both coefficients, the series are not cointegrated but there might be a short run comovement between them. We run the regression*

$$\Delta p_t = \gamma + \phi \Delta p^*_{t-1} + u_t$$

over the entire sample. Conduct a HAC consistent test on the coefficient, ϕ, of the world price. If ϕ is statistically significant at the 5% level and its sign is positive, we can conclude that the price of this industry in the country is determined by the world price, implying that it is traded. Otherwise, it is nontraded.

Note that in constructing the domestic price, we use industry sectoral gross value added data from the national accounts for each country. The implicit price index is defined as the ratio of nominal value added to the corresponding real value added for each industry. We provide more details and our results for the classification of the industries into traded and nontraded sectors in Appendix B.

It is worth noting that there are three main advantages in our criteria for the classification of industries into traded and nontraded sectors, compared to other approaches. First, rather than use only a "one size fits all" rule such as a 10% threshold rule for separating between traded and nontraded sectors, we employ more information to assess whether PPP holds. Second, in reality, productivity evolves over time and at a different rate for each industry. For this reason, productivity gains of a particular industry can turn goods and/or services in the nontraded sector into the traded sector endogenously. In our study, we can account for this trade endogeneity by classifying each industry into traded and nontraded sectors in each of three periods[6]. Actually, if data are more available, we can reassess our approach and allow the classification to vary over time in order to capture tradability appropriately in each period. Third, our classification allows for country specific heterogeneity over each industry. This will lead to classifying into traded and nontraded sectors corresponding to the actual degree of tradability in each country, unlike most previous approaches that keep the same classification across different countries. Overall, our criteria for classifying industries into traded and nontraded sectors can account for changes between traded and nontraded sectors in both cross-sectional and time dimensions. Until now, no previous approaches for classifying industries into traded and nontraded goods has done this.

4 Empirical Investigation

4.1 Data Description

We use an unbalanced panel data set of annual time series from 1970 to 2008 for thirty-three countries. The sample set is divided into two groups: seventeen developing countries and sixteen developed countries. The

[6] However, this depends on data availability.

main interest of this paper is to investigate the validity of the BSH and to clarify the debate over undervaluation in developing economies experiencing comparatively rapid economic growth. Therefore, fourteen countries in our sample are in East Asia, Southeast Asia, and South Asia, and several of these are now principal sources of global economic growth. Appendix A provides the details relating to countries and data sources.

We distinguish countries into two groups: developed countries and developing countries. In addition to the general differences between these two groups i.e. the level of economic development, there are several different aspects that might have an influence on the study of real exchange rate movement. First, the exchange rate systems of most developing countries after the collapse of the Bretton Woods system are still predetermined by a fixed nominal exchange rate regimes while those of developed countries are not. Second, exchange controls are more pervasive in developing countries so most currencies of developing countries are nonconvertible, inducing limitations of capital mobility. Third, imposing de facto taxes on several transactions in developing countries leads to multiple official exchange rates. Fourth, black markets for foreign exchange commonly exist in developing countries[7]. For these reasons, we separate countries into two groups in order to obtain more meaningful results from our study. As there are, however, some common features to these two groups, the application of the same or similar econometric techniques to study the real exchange rate behaviors is still acceptable.

In this paper, all variables of interest are in relative terms, which allows us to study real exchange rate movement, as explained by the BSH. We use two types of reference countries. First, the U.S. is used as a reference country, as in the literature. Second, we construct country specific "rest of the world" variables (or country specific "foreign" variables), namely world-based variables, computed from the cross-sectionally weighted average of all other countries, because the choice of each particular reference country can influence empirical results. As in Pesaran et al. (2004), our country-specific weights are based on average trade flows over 2002-2008. The use of world-based variables mitigates influences from outside countries and avoids biases from cross-sectional dependence with a particular reference country. The trade shares used to construct world-based variables are given in the 33×33 matrix in Table C1, Appendix C.

Throughout our analysis, capital letters indicate real values and lowercase letters denote values in logs. Note that a superscript * denotes a foreign variable (a variable of the reference country) and no superscript denotes a domestic variable. Most previous researchers define the real exchange rate as a relative price, although there are a number of arguments regarding which relative prices should be used. There are currently at least five different definitions of the real exchange rate in the literature: 1) $Q = \frac{EP^*}{P}$ PPP-based condition ; 2) $Q = \frac{EP^{T*}}{P^N}$ [8]; 3) $Q = \frac{P^T}{P^N}$; 4) $Q = \frac{P^M}{P^N}$; 5) $Q = \frac{P^X}{P^N}$ where Q is the real exchange rate, E is the nominal

[7] See more details in Edwards(1988)

[8] This definition of real exchange rate has been widely used in the study of developing countries. See, for instance, Edwards

exchange rate in terms of home currency per foreign currency, and P is the domestic price index. Note that Ps with superscripts T, N, M or X indicate the price indices of tradables, nontradables, importables, and exportables, respectively. We have to decide which price indices provide a good proxy for the real exchange rate and which countries should be chosen as the reference country. It is worth noting that the researchers and readers should pay close attention to the measurement of the real exchange rate first when dealing with real exchange rate series because choosing different real exchange rate measurements can result in different conclusions. See Edwards (1988) for more discussion.

In this paper, we define the real exchange rate as the ratio of the foreign price index to the domestic price index multiplied by the nominal exchange rate as measured in units of home currency per foreign currency. In other words, the log real exchange rate q_{it} of country i in period t is defined as $q_{it} = e_{it} + p^*_{it} - p_{it}$, where the price index p_{it} is the log consumer price index (CPI) and e_{it} is the log nominal exchange rate in terms of home currency. This is based on the PPP condition and uses a consumer price index (CPI) as a representative of the price index, P. We choose to use this definition because the CPI-based real exchange rate, called the PPP-based real exchange rate, is the most commonly used index of the real exchange rate in the literature and we can also avoid data limitation problems (as CPI series are available in most countries). Real appreciation of domestic currency leads to a fall in q_{it}. Moreover, the output term y_{it},which is used as a measure of economic growth, is derived from the log real GDP per capita.

It is important to classify economic activities into traded and nontraded sectors appropriately, in order to construct traded-nontraded productivity differentials. This is the weakest aspect of previous studies of the Balassa-Samuelson framework. We use the new classification that allows for changes in the classification in both cross-sectional and time dimensions that we discussed in Section 3 and in Appendix B. Due to data limitations, labour productivity is used as a proxy variable for total productivity. Outputs of traded and nontraded sectors are derived from value added for each sector in constant local currency units, and labour inputs measure the number of employees in each sector. Labour productivity is denoted by X_{it} and is computed from the ratio of outputs over labour inputs.

4.2 Unit Root Tests

Our analysis allows for the presence of unit roots, in keeping with much of the applied international trade literature. In this section, we examine the univariate properties of the data. We start with the augmented Dickey-Fuller (1979) test with generalized least squares detrending (ADF-GLS), developed by Elliott et al. (1996) on each cross-sectional unit[9]. However, we have limited spans of data, making inference difficult and

(1989), Elbadawi and Soto (1997), Baffes et al. (1999).

[9] In order to check robustness to the choice of unit root test statistics, we also apply ADF unit root tests to all series. We find that both ADF and ADF-GLS tests lead to similar results. We present only the results from ADF-GLS test in the appendix for reasons of space but the results from ADF tests are available from the authors upon request.

often inconclusive. Although we consider single country analysis, we are able to draw stronger inferences via the use of panel data techniques that utilize information from the cross-sectional units as well as time spans of data. We perform the cross-sectional augmented version (CADF) of the t-bar test propose by Im, Pesaran, and Shin (IPS) (1995, 2003), the inverse chi-squared test proposed by Maddala and Wu (1999), and Choi's (2001) inverse normal combination test. They can be used under very general assumptions that allow for different sample sizes, and different specifications of nonstochastic and stochastic components as well as cross sectional dependence in each cross-country unit. They investigate the null hypothesis that all cross-section series in the panel are unit root process against the alternative hypothesis that at least a significant fraction of the individual series in the panel are stationary. Large enough negative values reject the null for all tests except the inverse chi-squared test.

The CADF test is developed to deal with the problem of heterogeneity in the panel and cross-sectional dependence on an unobserved common factor. According to Pesaran (2003), the common factor can be proxied by the cross-section average of $\overline{g}_t = N^{-1}\sum_{j=1}^{N} g_{jt}$ and its lagged values, $\overline{g}_{t-1}, \overline{g}_{t-2}, ...$ for N sufficiently large. Based on this idea, the cross-sectional averages of lagged levels and first-differences of the individual series are included in the ADF regression to deal with the problem of cross-sectional dependence. We have

$$\Delta g_{it} = a_i + b_i g_{i,t-1} + c_i \overline{g}_{t-1} + \sum_{j=0}^{p_i} d_{ij}\Delta\overline{g}_{t-j} + \sum_{j=1}^{p_i} \alpha_{ij}\Delta g_{i,t-j} + u_{it}. \tag{11}$$

The individual CADF test statistic is the t ratio of b_i associated with the lagged level of the dependent variable in the p^{th} order augmented regression (11). In our study, we construct the CADF test based on the ADF-GLS test of Elliott et al. to achieve satisfactory size and power for small values of N and T, especially in the presence of an unknown mean or trend. The lag length p is selected by the Bayes information criterion (BIC) with a maximum of 4 lags. We choose to use a truncated version of the individual test so that we can avoid the impacts of extreme outcomes affecting the value of test statistics, given that T is small. The truncated version of observed test statistic $t_i(N,T)$, namely $t_i^*(N,T)$ is constructed by

$$\begin{aligned}
t_i^*(N,T) &= t_i(N,T), \text{ if } -K_1 < t_i(N,T) < K_2 \ , \\
t_i^*(N,T) &= -K_1, \qquad \text{if } \ t_i(N,T) \leq -K_1 \ , \\
t_i^*(N,T) &= K_2 \ , \qquad \text{if } \ t_i(N,T) \geq K_2
\end{aligned}$$

where $K_1 = 6.19$ and $K_2 = 2.61$ for models with an intercept and $K_1 = 6.42$ and $K_2 = 1.70$ for models with a linear trend. Following Pesaran (2003), these values are computed from the mean and standard deviations so that $Pr[-K_1 < t_i(N,T) < K_2]$ is in excess of 0.9999. The truncated version of t statistic is used to generate the cross-sectionally augmented IPS (CIPS) test.

$$CIPS^*(N,T) = N^{-1}\sum_{i=1}^{N} t_i^*(N,T) \quad .$$

In the calculation of the inverse chi-squared test and the inverse normal test, the p-values of b_i, denoted by p_{iT} in each cross-sectional unit, are truncated to lie in the range [0.000001, 0.999999]. Then the truncated versions of p-values, p_{iT}^* , are used to construct the inverse chi-squared test and the inverse normal test as follows:

$$P^*(N,T) = -2\sum_{i=1}^{N} \ln(p_{iT}^*) \text{ and}$$

$$Z^*(N,T) = \frac{1}{\sqrt{N}}\sum_{i=1}^{N} \Phi^{-1}(p_{iT}^*),$$

where $P^*(N,T)$ is the truncated version of Fisher test and $Z^*(N,T)$ is the inverse normal test. Pesaran (2003) shows that the $CIPS^*(N,T)$ and $Z^*(N,T)$ tests have satisfactory size and power even for $T = 10$, while $P^*(N,T)$ is over-sized when T is small.

Throughout our study, we divide the data set into two groups - developing and developed economies - when applying panel techniques. Table C2 in Appendix C reports the test results for both univariate and panel unit root tests. Results for U.S.-based and world-based variables are given under the headings in sub-column 1 and sub-column 2 respectively. It is clear that log real exchange rates (q_{it}), log real GDP per capita ratios ($y_t^* - y_{it}$), and log traded-nontraded productivity differentials ($x_t^* - x_{it}$) of the reference country relative to the domestic country are $I(1)$ according to all unit root tests. Moreover, the unit root test on q_{it} can be implicitly used to test the validity of the PPP condition because this condition implies that real exchange rates are stationary. As shown in Table C2, we find that PPP does not hold in developing and developed groups, which corresponds to the BSH that the difference in relative traded-nontraded productivities can lead to persistent deviation from long-run equilibrium of real exchange rate movements. In the next section, we will investigate this idea using panel cointegration tests.

4.3 Testing for the long-run relations of real exchange rates

We firstly employ the standard time series cointegration tests in order to investigate the existence of any long-run relationships between real exchange rate and variables of the interest. Several tests, including the Engle and Granger (1987) cointegrating regression, the weighted symmetric cointegration test introduced by Cook and Vougas (2008), the error-correction test based on the lagged dependent variable by Banerjee (1998), and the bounds testing approaches developed by Pesaran et al. (2001) are employed together with critical values computed from empirical distributions, and it turns out that they produce little evidence on the long-run relationships between real exchange rates and the variables of interest. In order to ascertain whether this is the consequence of low power caused by short spans of data series, the KPSS test for the null of stationarity proposed by Kwiatkowski et al. (1992) and Shin (1994) is applied and we find that the null hypothesis cannot be rejected in most countries, consistent with the existence of cointegrating relationship among variables. This contradiction suggests that the test results from single-equation tests are unreliable because they suffer from unacceptably low power due to the short length of data i.e. our sample sizes vary from a low of 14 for Vietnam to 39 for developed economies. The results of these tests are available upon request, but are not provided here because of space considerations.

We turn to panel techniques applied to countries in developing-country and countries in developed-country groupings, using the panel aspect of our data to extract better information. We apply seven residual-based tests suggested by Pedroni (1999). The tests of Pedroni are based on the null hypothesis that for each country in a panel, variables of interest are not cointegrated against the alternative that there exists a single cointegrating vector for each country in panel. These tests assume cross-sectional independence in error terms. However, if there are common factors that effect all countries in a group, then these error terms are likely to be cross-sectionally correlated. Therefore, we include a set of common time dummies in the hypothesized cointegrating regression to control for common time effects in panels and to obtain independent remaining disturbances. That is, we estimate individual cointegrating regressions including time dummies, while allowing for heterogeneous long-run cointegrating vectors across members using:

$$g_{it} = \alpha_i + \lambda_t + \delta_i t + \beta_{1i} w_{it} + e_{it}, \quad for\ t = 1, 2, ..., T_i; i = 1, 2, ..., N$$

where T_i is the time dimensions of i^{th} country and N is the number of countries in panel. It is easy to see that the slope coefficient β_{1i} can vary across individual countries. Then we use the residuals, denoted by $\widehat{e}_{it}$, from this regression to estimate the appropriate autoregression:

For the case of constructing Pedroni's nonparametric statistics, we estimate

$$\widehat{e}_{it} = \widehat{\phi}_i \widehat{e}_{i,t-1} + \widehat{u}_{i,t}$$

and for the case of parametric statistics, we estimate

$$\widehat{e}_{it} = \widehat{\phi}_i \widehat{e}_{i,t-1} + \sum_{k=1}^{K_i} \widehat{\phi}_{i,k} \Delta \widehat{e}_{i,t-k} + \widehat{u}^*_{i,t}.$$

We collect the residuals from this autoregression. Next, we use these residuals to compute the long-run variance of $\widehat{u}_{it}$ in the former case and $\widehat{u}^*_{i,t}$ in the latter case. Then run the differenced regression,

$$\Delta g_{it} = b_{1i} \Delta w_{it} + \eta_{it}$$

and use a kernel estimator to compute the long-run variance of $\widehat{\eta}_{it}$. Using these long-run variances, we can construct seven different test statistics. Of these seven statistics, four –the panel v-statistic, the panel ρ-statistic, the panel t-statistic (nonparametric) and the panel t-statistic (parametric) - are based on pooling the data across the within dimension of the panel; in other words, they are based on estimators that effectively pool the autoregressive coefficient, ϕ_i, across different countries. For the last three tests – the group ρ-statistic, the group t-statistic (nonparametric) and the group t-statistic (parametric) - are based on the between dimension; in other words, they are based on estimators that simply average the individually estimated autoregressive coefficients for each country i. Therefore, it is obvious that given the null hypothesis of no cointegration ($H_0 : \phi_i = 1$ for all i), the within-dimension-based statistics assess the alternative hypothesis of a common value for the autoregressive coefficient, $\phi_i = \phi < 1$ for all i, while the between-dimension-based statistics allow for heterogeneity of the autoregressive coefficients across individual countries, $\phi_i < 1$ for all i under the alternative.

We investigate the validity of the BSH in both U.S.-based and world-based variables by testing for long-run cointegrating relationships between (1) q_{it} and $(y_t^* - y_{it})$, with y_{it} being commonly used in the literature as a measure of productivity; and (2) q_{it} and $(x_t^* - x_{it})$, which is the true version of the BSH. The hypothesized cointegrating regression for these tests are

$$q_{it} = c_i + \omega_t + \beta_i(y_t^* - y_{it}) + \varepsilon_{it} \tag{12}$$

and

$$q_{it} = d_i + \lambda_t + \gamma_i(x_t^* - x_{it}) + \xi_{it}, \tag{13}$$

where c_i and d_i are country-specific fixed effect parameters, and ω_t and λ_t are common-time effect parameters. We allow for different slope parameters, β_i and γ_i, across countries. Equation (13) follows directly from the BSH framework and so we expect γ_i to be positive. As an increase in traded productivity growth is predicted to be larger in comparatively higher growth countries, this leads to the prediction that rapid economic growth should be followed by real exchange rate appreciation, i.e. $\beta_i > 0$ in equation (12).

Table 1: The test results for Pedroni's cointegration tests on developed and developing countries

Pedroni's test	Developed Countries				Developing Countries			
	US base		World base		US base		World base	
	Eq(12)	Eq(13)	Eq(12)	Eq(13)	Eq(12)	Eq(13)	Eq(12)	Eq(13)
Within-dimension								
Panel v-statistic	2.93***	3.73***	2.12***	2.95***	1.62*	-0.61	0.31	-0.25
Panel rho-statistic	-2.70***	-5.22***	-0.98	-2.62***	-1.25	1.15	-0.05	0.84
Panel PP-statistic	-3.27***	-4.69***	-1.35*	-2.56***	-1.65**	0.72	-0.83	0.43
Panel ADF-statistic	-4.78***	-5.44***	-2.49***	-3.79***	-1.81**	0.75	-1.10	0.46
Between-dimension								
Group rho-statistic	-2.45***	-3.25***	0.15	-1.10	0.35	0.39	-0.77	-0.37
Group PP-statistic	-3.96***	-4.63***	-1.49**	-2.63***	-0.92	-1.72**	-2.08**	-2.30**
Group-ADF statistic	-5.69***	-5.55***	-2.66***	-4.16***	-0.62	-2.15**	-2.17***	-0.76

Note: The null hypothesis is no cointegration. *, **, *** indicate 10%, 5%, and 1% significance level, respectively. The critical value is determined by the standard normal distribution. The lag length in ADF-type regression of Pedroni's tests is selected by Schwarz information criteria with a maximum of 4 lags.

The results of the cointegration tests are presented in Table 1[10]. It is obvious that all seven test statistics can lead to different conclusions especially in the developing country group. According to Pedroni (1999), the comparative advantages of each test statistic in terms of small sample size and power properties depend on the underlying data-generating process (DGP). However, Pedroni (2004) shows that if the number of cross-sectional units $N = 20$ and time periods $T = 20 - 40$ in a DGP with $\phi = 0.9 - 0.95$ where ϕ is the autoregressive coefficient of residuals, the panel-t statistic and the group-t statistic have higher power than other test statistics. Therefore, we will focus on the results of four test statistics: the parametric panel t-statistic analogous to the ADF t-statistic, the nonparametric panel t-statistic analogous to the Phillips and Perron (1988) statistic , the parametric group t-statistic analogous to the ADF t-statistic, and the nonparametric group t-statistic analogous to the Phillips and Perron statistic.

Table 1 shows that in developed countries the null hypothesis of no cointegration between q_{it} and $(y_t^* - y_{it})$ as well as q_{it} and $(x_t^* - x_{it})$ is rejected at the 1% level of significance in both US-based and world-based cases. This implies that there are long-run relationships in levels between the real exchange rate and economic growth, as well as between the real exchange rate and the traded-nontraded productivity differential in the group of developed countries. However, in order to examine the validity of the BSH, it is necessary to consider the sign of cointegrating vectors for this group. This is examined in the next section. The test results for developing countries show some evidence supporting a long run relationship between the real exchange rate and economic growth. However, it is not clear whether the traded-nontraded productivity differential has a long-run effect on the real exchange rate or not. We will examine this relationship later via persistence

[10] To check the robustness of the tests, we apply Westerlund's error-correction-based cointegration test (Persyn and Westerlund, 2008). We find that both tests induce similar results. See Table C3 in Appendix C.

profile approach.

4.4 Group-Mean Panel Cointegrating Vectors

This section follows on from the results of the previous section. As we find evidence of long-run relationships among the variables of interest, it is useful to estimate the cointegrating vectors and consider the signs of long-run cointegrating coefficients to check closely for the presence of the BSH. Instead of using individual-country cointegration vectors that suffer from small-sample-size distortion, we employ the panel cointegration methods using both cross-sectional and time-series information to provide more efficient estimates of cointegrating vectors.

In the literature, some attention has been paid to the estimation of panel cointegrated regression models. Three common approaches used to estimate cointegrating vectors in panel data are ordinary least squares (OLS), fully modified OLS (FMOLS) suggested by Pedroni (1996, 2000), and dynamic OLS (DOLS) proposed by Kao and Chiang (1999), Mark and Sul (2003), and Pedroni (2001). In general, they allow for heterogeneous short-run dynamics, and pool the information along the within-dimension or along the between-dimension, depending on the long-run hypothesis of interest. Kao and Chiang (1999) and Pedroni (2001) examine the properties of the OLS, FMOLS, and DOLS estimators in a cointegrated regression and they find that the DOLS estimator has smaller size distortions and outperforms the others in both finite and infinite samples. That is, the OLS and FMOLS estimators are still be biased in finite samples due to the endogeneity of the regressors and/or the serial correlation in disturbances.

For this reason, we employ the panel DOLS estimator in our study. The main feature of DOLS is that it uses the differences of past and future values of cointegrated variables to control for the endogeneity and serial correlation. Next, we have to decide how to pool the data. For the within-dimension estimators developed by Kao and Chiang (1999) and Mark and Sul (1999), the cointegrating vectors are homogeneous across countries although they allow for heterogeneous short-run dynamics, individual-specific fixed effects, and a limited degree of cross-sectional dependence. This will be reasonable if countries in a panel have similar features such as countries in the Euro area. However, given that each country group in our data set includes many countries from different regions, the assumption of homogenous cointegrating vectors across individuals seems to be too restrictive.

Consequently, we choose to use the group-mean panel DOLS estimators suggested by Pedroni (2001) that utilize the between-dimension aspect of the panel. The between-dimension estimators have comparative advantages in terms of greater flexibility in the presence of heterogeneity of the cointegrating vectors and have a more useful interpretation, as it can be regarded as the mean value for the cointegrating vectors. Moreover, Pedroni (2000) studied the small sample properties of the within-dimension and between-dimension estimates and found that the group-mean panel DOLS estimators appear to have lower small-sample bias than the within-dimension panel DOLS estimators.

In our study, the DOLS regressions for each country are estimated to obtain country-specific cointegrating vectors using

$$q_{it} = c_i + \beta_i(y_t^* - y_{it}) + \sum_{k=-K_i}^{p_i} \phi_{i,k}\Delta(y_{t+k}^* - y_{i,t+k}) + \varepsilon_{it}^* \tag{14}$$

or

$$q_{it} = \alpha_i + \gamma_i(x_t^* - x_{it}) + \sum_{k=-K_i}^{p_i} \lambda_{i,k}\Delta(x_{t+k}^* - x_{i,t+k}) + u_{it}^*. \tag{15}$$

That is, we augmented the cointegrating regressions (14) and (15) with lead and lagged differences of the regressors. Lag lengths are chosen by BIC, with a maximum lag and lead of 2 to control for the endogenous feedback effect. Note that in order to account for an exchange rate crisis, a change in regime of the exchange rate, or an exchange rate policy change which might induce irregular behavior of real exchange rates in some periods, we include the time dummy variables for that particular period in the cointegrating regressions. From these regressions, we can construct the group-mean panel DOLS estimators using $\widehat{\beta}_{GD} = N^{-1}\sum_{i=1}^{N}\widehat{\beta}_i$ and $\widehat{\gamma}_{GD} = N^{-1}\sum_{i=1}^{N}\widehat{\gamma}_i$, where $\widehat{\beta}_i$ and $\widehat{\gamma}_i$ are the conventional DOLS estimator for the i^{th} country in the panel.

Following the BSH, we expect both $\widehat{\beta}_i$ and $\widehat{\gamma}_i$ to be positive. Tables C4 and C5 in Appendix C display the estimates of the cointegrating coefficients from DOLS regression, when the U.S. is used as the reference country and when the reference country is the rest of the world. Importantly, it is interesting to note that in the developed countries, the group-mean slope estimates of the per capita GDP ratio are positive, taking the value of 0.80 when U.S. is used as the reference, and 0.15 when the world is used as the reference. This means that there is a positive long-run relationship between economic growth and the real exchange rate. That is, higher growth countries will tend to have real exchange rate appreciation. This result is consistent with the previous study of Chong et al.(2010) which led to their conclusion that favored the BSH in OECD countries. However, this relationship does not actually imply that the BSH effect exists in developed countries because the appreciation of real exchange rate is not the consequence of productivity growth in traded sectors as stated in the BSH.

As shown in Table C4, we find evidence that the productivity differential between traded and nontraded goods in the developed countries has a negative long-run relationship with the real exchange rate, with a slope estimate of -0.31 for the U.S. referenced case and -0.11 for the world referenced case. That is, when productivity growth in traded goods relative to that in nontraded goods increases, the real exchange rate tends to depreciate, inconsistent with the BSH. One possible reason for this story is a violation of PPP in traded good of these countries. However, the results are consistent with the findings of Edwards

(1988), that productivity growth in traded sectors relative to nontraded sectors depreciates the real exchange rate. While the BSH explains the effects of productivity growth, corresponding to the effect of income effects (demand effects) which dominate supply effects, Edwards (1989) model explains that productivity progress can depreciate the real exchange rate if productivity growth has positive supply effects and if these more than offset demand effects. In this case, it might be because workers move from traded sectors into nontraded sectors. As we define productivity as the ratio of GDP to the number of employed workers, moving to nontraded sectors results in an increase of the productivity in traded goods and a decrease of the productivity in nontraded goods. If supply effects dominate income effects, an increase in human resources of the nontraded sector would in turn exceed supply in nontraded goods and thus a decrease in their prices (the Rybczynski (1955) principle). This implies a depreciation in real exchange rates.

Table C5 shows that there is moderate evidence that economic growth in developing countries has a negative long-run relation with the real exchange rate, with a group mean slope estimate of -0.18 for the U.S. referenced case and -0.11 for the world referenced case. That is, comparatively rapid growth in developing countries is accompanied by real exchange rate depreciation. This finding is in line with the current controversy over the undervaluation of Asian currencies.

As the results of cointegration tests show, it is not clear whether the traded-nontraded productivity differential in developing countries has a long-run effect on the real exchange rate or not. If the productivity differential has a long-run relationship with the real exchange rate, this relation will satisfy the BSH. It implies that productivity growth in traded goods will be followed by real exchange rate appreciation, as the sign of cointegrating vectors is positive in both the U.S. referenced case and the world referenced case. On the other hand, if there is not a long-run (cointegrating) relationship between the real exchange rate and the traded-nontraded productivity differential, regression (15) for developing countries can be spurious. The conclusion that the real exchange rate movement in developing countries satisfies the BSH might be wrong.

4.5 Persistence Profile Approach

In this section, we focus on the "persistence profile" method for estimating the time profiles of the persistence effects of shocks on cointegrating relations. The persistence profile developed by Pesaran and Shin (1996) is a measure of the speed of convergence to a long-run equilibrium that uses a variance-based approach, and it provides unique time profiles regardless of the prior orthogonalization of the shocks. In our study, we will construct persistence profiles for cointegrating relations in order to investigate the speed of convergence to equilibrium in response to a system-wide shock, and use the persistence profile approach as a complementary tool for checking the validity of cointegrating relations we obtain from the indirect cointegration tests as performed in Section 4.3. The following is a brief summary of persistence profile approach.

Suppose that an $m \times 1$ vector, G_t is an $I(1)$ process and can be represented by the Wold representation:

$$\Delta G_t = \mu + A(L)\varepsilon_t, \quad t = 1, 2, ..., T \tag{16}$$

where $A(L) = \sum_{i=0}^{\infty} A_i L^i$ and A_i is absolutely summable, μ is an $m \times 1$ vector of constants, and ε_t is an $m \times 1$ vector of shocks, assumed to be serially uncorrelated with zero mean and a constant variance-covariance matrix, Ω.

Using the Beveridge and Nelson (1981) decomposition, the system (16) can be written as

$$G_t = \tau_t + w_t,$$

$$w_t = C(L)\varepsilon_t \quad and \quad \tau_t = \mu + \tau_{t-1} + A(1)\varepsilon_t \tag{17}$$

where $C(L) = \sum_{j=0}^{\infty} C_j L^j$, $C_j = -A(1) + B_j$, and $B_j = \sum_{i=0}^{j} A_i$.

Note that w_t is the stationary component of G_t. We assume that there exist r cointegrating relations such that the $r \times 1$ vector, $Z_t = \beta' G_t$ is stationary and so a necessary and sufficient condition for cointegration indicates that $\beta' A(1) = 0$, where $A(1)$ is the long-run multiplier matrix with rank$[A(1)] = m - r$. Using this decomposition, we can obtain a unique dynamic characterization for the cointegrating relations, Z_t. Hence, the cointegrating relations, $Z_t = \beta' G_t$ can now be written as

$$Z_t = \beta'\tau_t + \beta' w_t = \beta'\tau_t + \beta' \sum_{j=0}^{\infty} [-A(1) + B_j]\varepsilon_{t-j}$$

$$Z_t = \beta'\tau_t + \beta' \sum_{j=0}^{\infty} B_j \varepsilon_{t-j}.$$

Using (17), we obtain

$$Z_t = \beta'\mu + \beta'\tau_{t-1} + \beta' A(1)\varepsilon_t + \beta' \sum_{j=0}^{\infty} B_j \varepsilon_{t-j}$$

$$Z_t = \beta'\tau_0 + (\beta'\mu)t + \sum_{j=0}^{\infty} \beta' B_j \varepsilon_{t-j}. \tag{18}$$

The persistence profile in the context of the cointegrating relation is defined as

$$H_z(h) = V(Z_{t+h}|I_{t-1}) - V(Z_{t+h-1}|I_{t-1}) = \beta' H_G(h)\beta = \beta' B_h \Omega B_h' \beta. \tag{19}$$

The matrix $H_z(h)$ is defined as the difference between the conditional variances of the h-step-ahead and the (h-1)-step-ahead forecasts of cointegrating relations, given the information set up to time $(t-1)$. For this reason, it is reasonable to consider the matrix H as a measure of the persistence. Consider the case where $r = 1$ in our study, and β is an $m \times 1$ cointegrating vector. The scaled measure of the persistence profile of Z_t, denoted by a 1×1 vector, $h_z(h)$ is

$$h_z(h) = H_z(h)/H_z(0) = (\beta' B_h \Omega B_h' \beta)/(\beta' \Omega \beta), \tag{20}$$

where $h_z(0) = 1$. From this equation, it is worth noting that the persistence profile can be used to examine whether $\beta' G_t$ forms a cointegrating relation because if β is a cointegrating vector, then a necessary and sufficient condition for cointegration is that $\beta' A(1) = \beta' B_\infty = 0$ is followed by $H_z(h) \to 0$ as $h \to \infty$. On the one hand, in the case of cointegrated relations, the effect of shocks will approach zero and the relations return to long-run equilibrium as the horizon h increases. In contrast, the impact of a shock persists forever in the case of noncointegrated relations. This concept is used in our study as a complementary tool for confirming the existence of the long-run relationships.

Leaving the theoretical aspects of the persistence profiles aside for now, we turn to the question of how to estimate the impact of shocks to cointegrating relations. Assume that the $m \times 1$ vector, G_t is integrated $I(1)$ and follows a $VAR(p)$ representation. That is,

$$G_t = \mu + \phi_1 G_{t-1} + \phi_2 G_{t-2} + \phi_3 G_{t-3} + ... + \phi_p G_{t-p} + \varepsilon_t, \tag{21}$$

where $\phi_l, l = 1, ..., p$, are $m \times m$ coefficient matrices. Suppose that there exist r cointegrating relations in the system and so $\pi = \alpha\beta'$, where α and β are $m \times r$ matrices with rank$(\pi) = r < m$. Transforming (21) into the Vector Error Correction model (VECM), we have

$$\Delta G_t = \mu - \pi G_{t-1} + \sum_{l=1}^{p-1} \Gamma_l \Delta G_{t-l} + \varepsilon_t, \tag{22}$$

where $\Gamma_l = -\sum_{j=l+1}^{p} \phi_j$ for $l = 1, 2, ..., p-1$ and $\pi = I_m - \sum_{l=1}^{p} \phi_l$. This expression allows us to impose the cointegrating vectors as long-run restrictions. This can be done by creating $Z_t = \beta' G_t$ and then we regress ΔG_t on the intercept, Z_{t-1}, and $\Delta G_{t-1}, ..., \Delta G_{t-p+1}$. From equations (21) and (22), we can write the VAR(p) parameters ϕ_l in terms of π and Γ:

$\phi_1 = -\pi + I_m + \Gamma_1$,

$\phi_l = \Gamma_l - \Gamma_{l-1}$ for $l = 2, ..., p-1$,

$\phi_p = -\Gamma_{p-1}$.

We use these above relations together with estimates of $\mu, \pi,$and Γ from the VECM to generate estimates of ϕ_l for $l = 1, ..., p$. To apply Lemma 1 of Pesaran and Shin (1996), we assume that the VAR(p) specification G_t in (21) has a fundamental moving average representation as given in (16), and thus

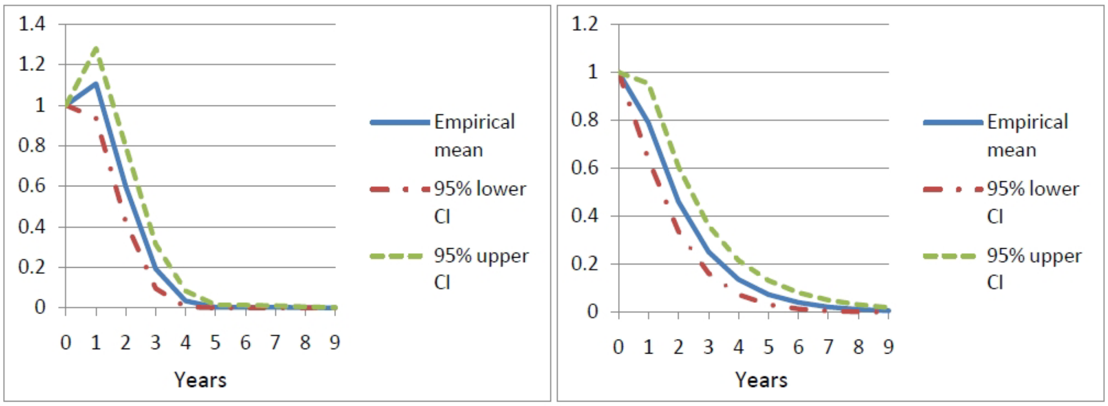
$$B_k = \phi_1 B_{k-1} + \phi_2 B_{k-2} + \phi_3 B_{k-3} + ... + \phi_p B_{k-p}, \qquad k = 1, 2, ... \tag{23}$$

where $B_0 = I_m$ and $B_k = 0$ for $k < 0$. From this, we can estimate the time profiles of the effects of shocks on cointegrating relation and use the persistence profile approach as a complementary tool for checking the validity of cointegrating relations

In our case, denote $G_{it} = [q_{it}, x_{it}^* - x_{it}]'$ for $i = 1, 2, ..., N$. Extension of the persistence profiles to panels is straight-forward. We estimate expression (22) for our panel of countries and allow for specific-country effects. The within-group estimator has a downward bias when time dimension, T is very small in a panel data regression with a lagged dependent variable. However, Judson and Owen (1999) investigate the appropriateness of competing estimation techniques for estimating dynamic panel data models and find that the within-group estimation performs better than many alternative techniques even if $T = 30$. This corresponds to the finding of Alvarez and Arellano (2003), that show that when a time dimension becomes larger (around 30), the bias is insignificant and so it can be ignored. For this reason, we choose to proceed with the within-group estimation in estimating parameters used for constructing persistence profiles.

We estimate persistence profiles to investigate the effects of system-wide shocks on long-run cointegrating relationships between the real exchange rate and the traded-nontraded productivity differential, and examine whether the persistence profiles converge to zero as the horizon increases. Figures 1 - 4 show the persistence profiles corresponding to the models that impose the long-term restrictions from the cointegrating vectors computed in Section 5.4. Figures 1A (2A) and 1B (2B) present the estimates of the persistence profiles for the developed group (developing group) in the cases that use the U.S. and the world as reference countries, respectively. These charts show that after a shock, the estimates of all persistence profiles converge to zero. Thus, this provides visual evidence in support of the hypothesis that there are long-run relationships between the real exchange rate and the productivity differential in both developed and developing countries. These results also help to clarify the presence of cointegrating relationships between the real exchange rate and the productivity differential in developing countries, as the test results of Pedroni's cointegration test are not clear. However, we can see that these relationships are very persistent. Once a system is shocked, the relations will require a long time - at least four years in developed countries and five years in developing countries - to converge to their long-run equilibrium. The sluggish rate of convergence in these relations can be explained by high transaction costs, trade barriers, capital controls, limits to arbitrage, foreign exchange rate intervention, imperfect competition, and costly information gathering. It is clear that these factors can be found widely in the world, particularly in developing countries.

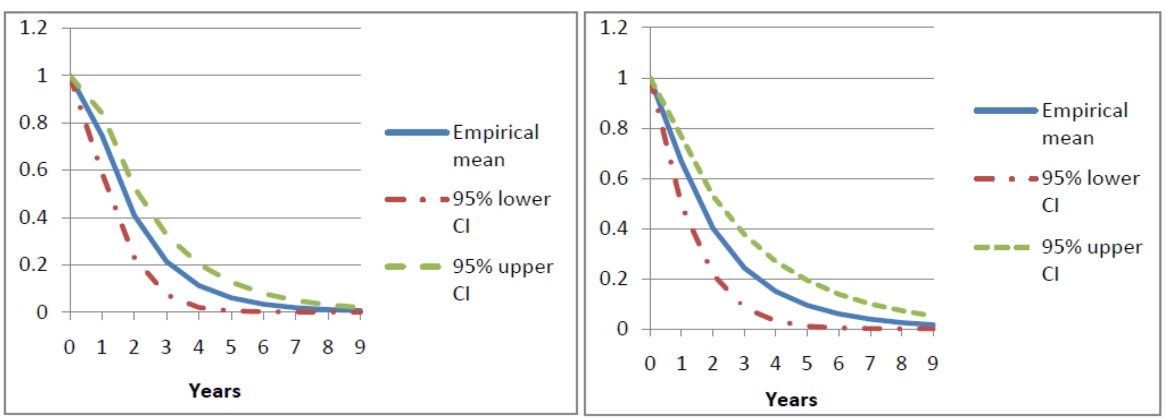
Figure 1: Estimated persistence profiles for the cointegrating relations in the group of developed countries



(A) (B)

Notes: each chart shows bootstrap mean estimates, together with 95% bootstrap confidence intervals. Figure 1(A) refers to the U.S.-based case and Figure 1(B) refers to the world-based case.

Figure 2: Persistence profiles for the cointegrating relations in the group of developing countries

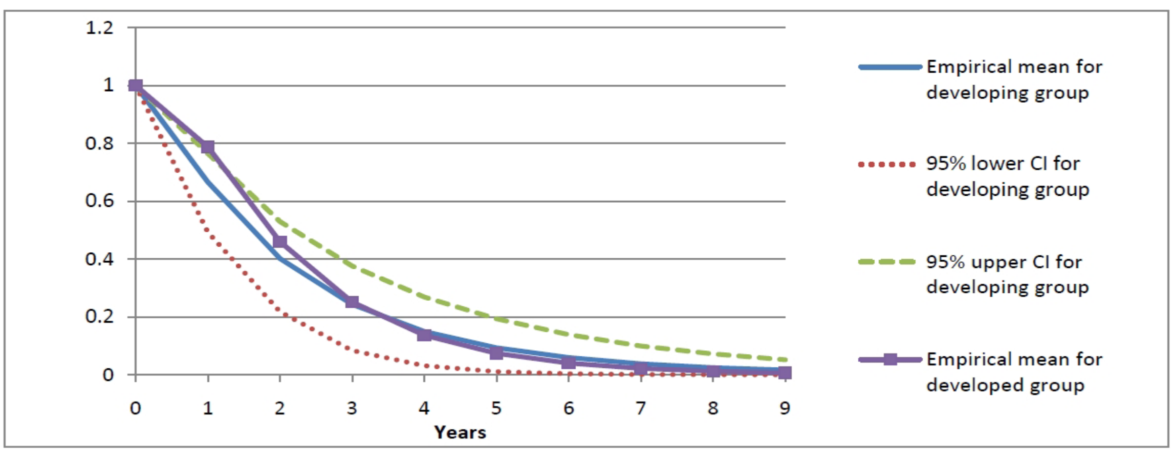


(A) (B)

See note in Figure 1.

It is important to note that bootstrap mean estimates[10] provide some evidence that once a system is shocked, the relationships between the real exchange rate and the productivity differential in developed countries converge to equilibrium at a faster rate than in developing countries, as expected. In the case of the U.S. referenced case, the persistence profiles for developed countries return to equilibrium within five years, while they approach equilibrium within eight years in developing countries. For the world referenced case, the impacts of a shock die out after eight years in developed countries, while in developing countries the adjustment is made after nine years. This finding corresponds to the results of Pedroni's cointegration tests. That is, for developed countries with the faster speeds of reversion to equilibrium, Pedroni's test provides strong evidence in favour of these cointegrating relations. By contrast, these relationships in developing countries can deviate from equilibrium for a long period of time. As a result, it is difficult to find evidence in favour of cointegrating relationships in developing countries using cointegration tests. Moreover, it might be surprising that for the world-based case, the 95% bootstrap error bands [11] of developing countries converge to zero at a much faster rate than the 95% error bands of developed countries, implying that the relationships in the developing group reach to equilibrium faster than in developed group. As shown in Figure 3, the estimated persistence profiles in both groups, however, lie within the 95% confidence bands of developing countries at all horizons. This implies that the difference of the speeds of convergence between these two groups are statistically insignificant at conventional levels.

Figure 3: Estimated persistence profiles for the cointegrating relations in developed and developing groups



Note: The 95% bootstrap error bands of developing group are shown.

[10] In order to avoid the problem of the small-sample sizes with respect to the validity of the confidence intervals estimated using the asymptotic theory, we apply the bootstrap estimates and bootstrap error bands, instead. However, the empirical means and the 95% confidence bands computed from the empirical distribution are quite similar to the point estimates and the 95% confidence bands based on the standard distribution at all horizons, especially in the case of developed countries.

[11] See Appendix D for computing the empirical means and bootstrap confidence intervals.

Although the speed of convergence to equilibrium is faster in developed countries than that in developing countries, we cannot conclude that there is more evidence in favor of the BSH in developed countries. This is because the traded-nontraded productivity differential in developed countries has a negative effect on the real exchange rate, inconsistent with the BSH. On the contrary, there is a positive relationship between the real exchange rate and the productivity differential between trade and nontraded goods in developing countries, corresponding to the BSH. However, the speed of convergence to long-run equilibrium is very sluggish.

In conclusion, countries in our data set do not generate enough evidence to support the working of the BSH. Although persistence profiles show that the movement of real exchange rates in developing countries might satisfy the BSH, it takes a long time, at least five years to reach their equilibrium. However, it is hardly surprising that the speed of convergence after shocks is low due to to high transportation costs, information costs, limits to arbitrage, imperfect competition, capital control, and non-tariff barriers. Also, it might be possible that there are other real exchange rate determinants such as government consumption, terms of trade, openness of the economy, net foreign assets, and real interest rate differential that influence long-run real exchange rate movements, together with productivity growth. We will reserve this issue for future research.

5 Conclusion

There is considerable controversy over the Balassa-Samuelson hypothesis (BSH) implication that comparatively rapid economic growth should be accompanied by real exchange rate appreciation. The main purpose of the paper is to examine the validity of the BSH and the links between the real exchange rate and the economic growth. This paper investigates the validity of the BSH in two country groups: developed and developing countries. The most innovative feature of our study is that we introduce a new approach for classifying traded and nontraded industries. Relative to previous studies, our new approach allows for different classifications of industries for different countries, and changes classifications of industries across periods. We apply the panel data cointegration test developed by Pedroni (2000), which allows for heterogeneity among individual countries in a panel and controls for common time effects. The group-mean panel dynamic ordinary least squares (DOLS) estimators suggested in Pedroni (2001) are applied to obtain the panel cointegrating vector in two country groups. We then use persistence profiles to examine the speed of adjustment to equilibrium in response to shocks on cointegrating relations, and use them as a complementary tool to ascertain the existence of cointegrating relations, particularly in developing countries where the results from our cointegration tests are inconclusive in terms of determining the existence of cointegration.

Our main finding is that there is not enough evidence in favor of the BSH in either developed or developing countries. In developed countries, there is strong evidence that higher economic growth will be followed by real exchange rate appreciation. However, this relationship does not imply the validity of the BSH because the BSH explains long-run real exchange rate movements in terms of productivity growth, rather than per capita income. This is a drawback of previous papers that use per capita Gross Domestic Product (GDP) as a measure of productivity, because it can lead to the wrong conclusion regarding the BSH. We actually find opposing evidence that as productivity growth in traded goods relative to that in nontraded goods increases, the real exchange rate tends to depreciate. One possible reason for this story is the departure from purchasing power parity (PPP) in traded goods in these countries. These results are consistent with the Edwards (1988) model, which predicts that productivity growth in traded sectors relative to nontraded sectors will depreciate the real exchange rate. This is possible if productivity growth has positive supply effects that more than offset demand effects (income effects), which in turn exceed supply in nontraded goods and thus decrease their prices, implying real exchange rate depreciation.

The real exchange rate has a positive long-run relationship with the traded-nontraded productivity differential in developing countries. However, the results from persistence profiles reveal low speeds of convergence to equilibrium after a shock. This might be because real exchange rates might be determined by other fundamentals, together with the productivity differential. Also, we find moderate evidence that comparatively rapidly growing developing countries will experience real exchange rate depreciation. This finding is in line with the controversy over undervaluation in developing countries, especially China and Vietnam.

Furthermore, a possible explanation for weak evidence in favor of the BSH in both developed and developing countries might be that some of BSH assumptions - PPP, the labour market clearing, slower productivity growth in nontraded sector relative to traded sector - do not hold in practice. Solanes and Flores (2009) provide an explanation based on violation of the law of one price, due to quality variations and market segmentation. That is, improvements in the relative quality of traded goods imply that goods and services are not homogeneous across countries.

The results for persistence profiles show that the speeds of reversion to long-run equilibrium after shocks on cointegrating relationships between the real exchange rate and the traded-nontraded productivity differential are higher in developed countries. This corresponds to the results of cointegration tests i.e. we find strong evidence in favor of cointegrating relationships between these two variables in developed countries, while there is only weak evidence in support of the long-run relationships in developing countries. However, the effects of shocks to these relationships in both developed and developing groups are very persistent. This might be explained by high transaction costs, trade barriers, capital controls, limits to arbitrage, foreign exchange rate intervention, imperfect competition, and costly information gathering. It is clear that these factors can be found widely in the world, particularly in developing countries.

Further research will use more general assumptions about real exchange rate movements and explore the role of additional factors such as government consumption, terms of trade, openness degree of the economy, net foreign assets, and real interest rate differential together with the traded-nontraded productivity differential.

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A Appendix

A.1 Countries and Data

The data set consists of unbalanced panel data from 1970 to 2008 for thirty-three countries which include seventeen developing countries and sixteen developed countries. The selection of countries and the choice of time periods are based on data availability. As the main interest of this paper is to investigate the validity of the BSH and especially to clarify the debate over possible undervaluation in developing economies experiencing comparatively rapid economic growth, fourteen of our sample are in East Asia, Southeast Asia, and South Asia, several of which are now the principal sources of global economic growth. The nineteen remaining countries are chosen from several continents - North America, Latin America, Europe, Africa, and Australia - to cover most of the main countries around the world and to obtain an appropriate measure for world variables. Table A1 shows the list of countries in our sample, divided into groups of developing and developed countries according to the International Monetary Fund's World Economic Outlook Report, April 2010.

Table A1: List of countries in developing and developed categories

Developing-Country Group	Developed-Country Group
China, Malaysia, Indonesia, Philippines,Thailand, Vietnam, Myanmar, India, Pakistan, Sri Lanka, Brunei Darussalam, Brazil, Mexico, Chile, Turkey, Argentina, South Africa	Japan, Korea, Singapore, Australia, New Zealand, Germany, France, Italy, Spain, Netherlands, United Kingdom, Canada, Norway, Sweden, Switzerland, United States

A.2 Data Sources

A.2.1 Consumer Price Indices (CPI)

The data source for all countries was the World Bank, World Development Indicators (WDI). For Germany, OECD Main Economic Indicators database (MEI) data were used for 1961-1990. Data from the IMF's International Financial Statistics (IFS) were used to complete gaps in the WDI series for China.

A.2.2 Nominal Exchange Rate

The data for all countries were the WDI exchange rate series.

A.2.3 GDP/Value added

The data source for all countries was the National Accounts Main Aggregates database, compiled by The United Nations (UN). We used GDP measured in current and constant 1990 local currency units, classified by economic activity (International Standard Industrial Classification: ISIC 3) into seven categories.

A.2.4 GDP per Capita

The GDP per capita (constant 2000 US$) series for all countries were from the WDI. GDP per capita series were not available for Myanmar.

A.2.5 Total employment and employment classified by economic activities (ISIC 3)

The main data source for all countries except Brunei Darussalam, was the LABORSTA database, compiled by the International Labour Organization (ILO). Brunei Darussalam data were from the IFS database. When data were not available for the entire sample period, the series were completed using WDI, IFS, or OECD series. The detail for total and sectoral employment series in each country is available on request.

A.2.6 Input-Output Tables

Input-Output tables for developed countries, Indonesia, Vietnam, India, Brazil, Mexico, Chile, Turkey, Argentina, and South Africa, were taken from the STAN OECD Input-Output database. For Philippines, Singapore, Pakistan, and Thailand, the input-output tables were from the National Statistical Departments. Input-output tables were not available for Malaysia, Myanmar, Brunei Darussalam, and Sri Lanka. In this case, we used the sum of exports and imports over GDP as a measure of the tradability ratio, and these data were from the UN Service Trade Database, UN Commodity Trade Database, and the UN National Accounts Official Country Data.

B Appendix

B.1 Classification of industries into traded and nontraded sectors

In the literature, researchers have not paid close attention to the methodology used for classifying industries into traded and nontraded sectors. Most work relies on "the degree of tradability" to determine a traded sector and a nontraded sector. Goods and services that are more tradable than others fall into the traded category. On the other hand, goods and services which are less tradable than others are classified as nontraded goods in the nontraded sector. This idea is applied in this paper as well, but until now, most approaches for measuring tradability are based on a simple but rather arbitrary method. According to the traditional approach, most researchers simply assume that manufactured goods are tradable and services are nontradable, because the service sector faces higher transaction costs of trade and obstacles from protectionist and subsidisation policies than manufacturing. Although this simple rule was reasonable several decades ago, it is unlikely to be valid in the present globalized economy because globalization now facilitates the possibility of trade in commercial services across countries.

De Gregorio et al. (1994), Betts and Kehoe (2001), and Bems (2008) propose another approach. They develop a measure of tradability based on the ratio of international trade (imports and/or exports) to the total supply (gross output) of each industry. However, this measure is subjective with respect to the determination of threshold between traded and nontraded outputs. De Gregorio et al. (1994), and Betts and Kehoe (2001) decide arbitrarily to use 10 percent of gross output as a threshold: the industry is defined as traded if the traded percentage is more than 10. Bems (2008) makes an assumption that the retail/wholesale trade industry is nontraded and use this industry as a benchmark. The classification of other industries is based on their tradability relative to the retail/wholesale trade industry. That is, if the ratio of total imports and exports to the gross output for an industry is higher than that of the benchmark industry (implying higher tradability), the industry is defined as a traded sector, but if the ratio is less, the industry is taken to be nontraded. Some researchers choose the real estate/business services industry to be a benchmark instead. Gonzalez-Soriano (1990) uses a quantity criterion, price tests, and discriminant analysis to classify Philippino industries as traded and nontraded.

The weakness of the above classification methods is that the chosen thresholds are subjective, and different thresholds lead to different classifications. Inappropriate classifications into traded and nontraded sectors adversely affect the calculations of productivity differentials and relative prices, which in turn confound meaningful assessment of the BSH. In this paper, we classify each industry carefully in order to obtain better estimates of the productivity differentials and relative prices. We combine previous approaches together with international trade information and follow the thrust of the Gonzalez-Soriano (1990) approach. Our classification reflects two of the above mentioned key differences between traded and nontraded sectors. First, the output of the traded sector is traded internationally but that of the nontraded sector is mostly consumed domestically. This can be examined by using the information from input-output tables (I-O table) or social accounting matrices (SAMs) for each country, in order to determine tradability, measured as the sum of an actual industry's exports and imports over gross output[12]. Second, the movement of the price of traded goods and services will be close to the world price while the price of nontraded goods and services will be different in each country. This idea can be examined by using simple econometric methods that assess whether PPP holds or not. We combine the results of both empirical exercises to classify industries into traded and nontraded sectors to minimize the mistakes from each. That is, due to the subjective nature of using a threshold such as a 10% rule for separating traded and nontraded sectors, we adjust the threshold by using more information that assesses whether PPP holds. We note that although a reliance on PPP by itself might avoid the subjectivity of a threshold rule, this might lead to a mistake in some countries because

[12]Due to the limitation of data availability, tradability is measured as the ratio of sectoral imports and exports to sectoral gross value added in Malaysia, Brunei Darussalam, and Sri Lanka and the ratio of exports to gross value added for each sector in Myanmar.

some traded goods might be exchanged across countries but only in a regional segmented market such as the South-East Asia market. In such cases the prices of the goods in this market might be different from the world price or the U.S. price, so that PPP tests will not fully reflect the traded nature of the industry.

For our study, we examine seven sectors classified by the international standard industrial classification (ISIC 3) – (1) Agriculture, hunting, forestry, and fishing (ISIC A-B); (2) Mining and Utilities (ISIC C, E); (3) Manufacturing (ISIC D); (4) Construction (ISIC F); (5) Wholesale, retail trade, restaurants and hotels (ISIC G-H); (6) Transport, storage and communication (ISIC I); and (7) Other activities (ISIC J-P). We note that productivity evolves over time and at a different rate for each industry. For this reason, productivity gains of a particular industry can turn goods and/or services in the nontraded sector into the traded sector endogenously. We will account for this trade endogeneity by classifying each industry into traded and nontraded sectors in each of three periods. This classification will be based on tradability ratios, depending on the availability of I-O tables and SAMs in each country, and it will allow for an industry to change between being traded and nontraded sector across different periods.

As there is no exact threshold for dividing between sectors uniformly for all countries, we initially apply the common arbitrary rule in the literature that 10% is a threshold for the classification between traded and nontraded sectors. We then use the price tests of Gonzalez-Soriano (1990) to assess whether this is reasonable classification, and adjust our classification if the price tests suggest that this is appropriate. The results for the classification of traded and nontraded sector based on our criteria are in Table B1 and B2[13].

[13] The results of tradability ratio and price test are not reported here. They are available from the authors on request.

Table B1: Summary of the classification of traded and nontraded sectors in Asia using our purposed criteria

Period	Country	Agriculture, hunting, forestry, fishing	Mining, Utilities	Manufac-turing	Construc-tion	Wholesale, retail trade, hotels restaurants	Transport, storage communi-cation	Other activities
East Asia								
mid-2000s	China	N	N	T	N	T	T	N
early-2000s	China	N	N	T	N	T	T	N
mid-1990s	China	N	N	T	N	N	T	N
mid-2000s	Japan	N	T	T	N	N	T	N
early-2000s	Japan	N	N	T	N	N	T	N
mid-1990s	Japan	N	N	T	N	N	T	N
mid-2000s	Korea	N	T	T	N	T	T	N
early-2000s	Korea	N	T	T	N	T	T	N
Southeast Asia								
2008	Malaysia	T	T	T	T	N	T	T
mid-2000s	Indonesia	N	T	T	N	T	T	N
early-2000s	Indonesia	N	T	T	N	T	T	N
mid-1990s	Indonesia	N	T	T	N	T	T	N
2000	Philippine	N	T	T	N	N	T	N
2005	Thailand	N	T	T	N	T	T	N
1998	Thailand	N	T	T	N	N	N	N
1990	Thailand	N	T	T	N	N	N	N
early-2000s	Vietnam	N	T	T	N	T	T	N
2005	Singapore	T	T	T	N	T	T	T
2000	Singapore	T	N	T	N	T	T	T
mid-2000s	Myanmar	T	T	T	N	N	N	T
2007	Brunei	T	T	T	N	N	T	N
South Asia								
mid-2000s	India	N	N	T	N	N	N	N
early-2000s	India	N	N	T	N	N	T	N
mid-1990s	India	N	N	N	N	N	T	N
early-2000s	Pakistan	T	T	T	N	N	T	N
2007	Sri Lanka	T	T	T	N	N	T	N

Note: T represents "Tradable", N represents "Nontradable".

Table B2: Summary of the classification of traded and nontraded sector in selected countries using our proposed criteria

Period	Country	Agriculture, hunting, forestry, fishing	Mining, Utilities	Manufac-turing	Construc-tion	Wholesale, retail trade, restaurants and hotels	Transport, storage and communi-cation	Other activities
mid-2000s	Australia	T	T	T	N	N	T	N
early-2000s	Australia	T	T	T	N	N	T	N
mid-2000s	US	T	T	T	N	N	N	N
early-2000s	US	T	N	T	N	N	N	N
mid-1990s	US	T	N	T	N	N	N	N
early-2000s	N Zealand	T	T	T	T	T	T	N
mid-1990s	N Zealand	T	N	T	N	T	T	N
mid-2000s	Germany	T	T	T	N	T	T	N
early-2000s	Germany	T	T	T	N	T	T	N
mid-1990s	Germany	T	N	T	N	T	T	N
2006	France	T	T	T	N	N	T	N
early-2000s	France	T	T	T	N	T	T	N
mid-1990s	France	T	T	T	N	T	T	N
mid-2000s	UK	N	T	T	N	T	T	T
early-2000s	UK	N	T	T	N	T	T	T
mid-1990s	UK	N	T	T	N	T	T	T
mid-2000s	Italy	T	T	T	N	N	T	N
early-2000s	Italy	T	T	T	N	N	T	N
mid-1900s	Italy	N	N	T	N	T	T	N
mid-2000s	Spain	T	T	T	N	N	T	N
early-2000s	Spain	T	N	T	N	N	T	N
mid-1990s	Spain	T	N	T	N	N	T	N
mid-2000s	Netherland	T	T	T	N	T	T	N
early-2000s	Netherland	T	N	T	N	N	T	N
mid-1990s	Netherland	T	N	T	N	N	T	N
mid-2000s	Canada	T	T	T	T	T	T	N
early-2000s	Canada	T	T	T	T	T	T	N
mid-1990s	Canada	T	T	T	T	T	T	N
mid-2000s	Brazil	T	T	T	N	N	N	N
early-2000s	Brazil	N	N	T	N	N	N	N
mid-1990s	Brazil	N	N	T	N	N	N	N
mid-2000s	Mexico	T	T	T	N	T	T	N
mid-2000s	Chile	T	T	T	N	T	T	N
mid-1990s	Chile	T	T	T	N	T	T	N
mid-2000s	Norway	T	T	T	N	T	T	N
early-2000s	Norway	T	T	T	N	T	T	N
mid-1990s	Norway	T	T	T	N	T	T	N
mid-2000s	Sweden	N	T	T	N	T	T	N
early-2000s	Sweden	N	N	T	N	T	T	N
mid-1990s	Sweden	N	N	T	N	T	T	N
mid-2000s	Turkey	N	T	T	T	T	T	N
early-2000s	Turkey	N	T	T	T	T	T	N
mid-1990s	Turkey	N	T	T	N	T	T	N
early-2000s	Switzerland	T	T	T	N	T	T	N
mid-1990s	Argentina	T	T	T	N	N	T	N
mid-2000s	S. Africa	N	T	T	N	T	T	N
early-2000s	S. Africa	T	T	T	N	T	T	N
mid-1990s	S. Africa	T	T	T	N	N	T	N

See Note in Table B1.

Alternative classifications of industries into traded and nontraded sectors that have been used in previous literature are reproduced below to demonstrate the differences between our classification and others.

1. The traditional classification of industries into traded and nontraded sectors

	Industries	Classification
1.	Agriculture, hunting, forestry, and fishing	T
2.	Manufacturing	T
3.	Mining and Utilities	N
4.	Transport, storage and communication	N
5.	Construction	N
6.	Wholesale, retail trade, restaurants and hotels	N
7.	Other activities	N

2. The classification of industries using the disaggregated methodology of the United Nations (Solanes and Flores (2009))

	Industries	Classification
1.	Agriculture, hunting, forestry, and fishing	T
2.	Mining	T
3.	Manufacturing	T
4.	Transport, storage and communication	T
5.	Utilities	N
6.	Construction	N
7.	Wholesale, retail trade, restaurants and hotels	N
8.	Other activities	N

3. Country-specific classification using the 10% ratio of total import and export to gross output (allowing for changes in classification across periods)

Period	Country	Agriculture, hunting, forestry, and fishing (ISIC A-B)	T / N	Mining, Utilities (ISIC C,E)	T / N	Manuf-acturing (ISIC D)	T / N	Constr-uction (ISIC F)	T / N	Wholesale , retail trade, restaurants and hotels (ISIC G-H)	T / N	Transport, storage and communica -tion (ISIC I)	T / N	Other activities (ISIC J-P)	T / N
East Asia															
mid-2000s	China	0.043	N	0.078	N	0.291	T	0.064	N	0.184	T	0.153	T	0.086	N
early-2000s	China	0.026	N	0.060	N	0.238	T	0.048	N	0.116	T	0.098	N	0.036	N
mid-1990s	China	0.042	N	0.075	N	0.213	T	0.050	N	0.056	N	0.130	T	0.029	N
mid-2000s	Japan	0.042	N	0.161	T	0.288	T	0.028	N	0.068	N	0.136	T	0.018	N
early-2000s	Japan	0.026	N	0.087	N	0.215	T	0.017	N	0.054	N	0.110	T	0.011	N
mid-1990s	Japan	0.016	N	0.061	N	0.177	T	0.014	N	0.041	N	0.102	T	0.014	N
mid-2000s	Korea	0.037	N	0.286	T	0.510	T	0.035	N	0.118	T	0.368	T	0.048	N
early-2000s	Korea	0.044	N	0.217	T	0.536	T	0.034	N	0.160	T	0.443	T	0.053	N
Southeast Asia															
2008	Malaysia	1.040	T	0.975	T	1.422	T	0.361	T	0.000	N	1.274	T	0.261	T
mid-2000s	Indonesia	0.055	N	0.480	T	0.420	T	0.119	T	0.169	T	0.260	T	0.115	T
early-2000s	Indonesia	0.049	N	0.476	T	0.490	T	0.175	T	0.193	T	0.347	T	0.118	T
mid-1990s	Indonesia	0.038	N	0.427	T	0.311	T	0.110	T	0.158	T	0.224	T	0.101	T
2000	Philippine	0.093	N	0.708	T	0.875	T	0.034	N	0.064	N	0.383	T	0.193	T
2005	Thailand	0.094	N	0.464	T	0.545	T	0.002	N	0.441	T	0.265	T	0.054	N
1998	Thailand	0.096	N	0.271	T	0.495	T	0.001	N	0.066	N	0.090	N	0.068	N
1990	Thailand	0.104	T	0.253	T	0.437	T	0.000	N	0.059	N	0.067	N	0.022	N
early-2000s	Vietnam	0.248	T	0.738	T	0.531	T	0.275	T	0.492	T	0.608	T	0.227	T
2005	Singapore	0.779	T	0.498	T	1.449	T	0.213	T	0.681	T	0.845	T	0.361	T
2000	Singapore	0.627	T	0.280	T	1.430	T	0.250	T	0.560	T	0.792	T	0.304	T
mid-2000s	Myanmar	0.229	T	1.557	T	0.453	T	0.000	N	0.009	N	0.132	T	0.139	T
2007	Brunei	0.770	T	1.062	T	0.636	T	0.000	N	0.000	N	1.640	T	0.030	N
South Asia															
mid-2000s	India	0.030	N	0.061	N	0.229	T	0.058	N	0.079	N	0.098	N	0.096	N
early-2000s	India	0.039	N	0.037	N	0.222	T	0.081	N	0.105	T	0.124	T	0.056	N
mid-1990s	India	0.025	N	0.039	N	0.186	T	0.060	N	0.125	T	0.136	T	0.040	N
early-2000s	Pakistan	0.161	T	0.629	T	1.118	T	0.000	N	0.015	N	0.815	T	0.088	N
2007	Sri Lanka	0.472	T	0.709	T	0.771	T	0.007	N	0.000	N	0.399	T	0.087	N
2005	Nepal	0.659	T	1.068	T	0.930	T	0.032	N	0.282	T	0.351	T	0.150	T
2007	Bangladesh	0.312	T	0.868	T	0.589	T	0.003	N	0.003	N	0.260	T	0.049	N

Note: 1. T represents "Traded" , N represents "Nontraded".
2. The numbers in the table report tradability ratio.

Period	Country	Agriculture, hunting, forestry, and fishing (ISIC A-B)	T / N	Mining, Utilities (ISIC C,E)	T / N	Manufac-turing (ISIC D)	T / N	Constr-uction (ISIC F)	T / N	Wholesale, retail trade, restaurants and hotels (ISIC G-H)	T / N	Transport, storage and commun-ication (ISIC I)	T / N	Other activities (ISIC J-P)	T / N
mid-2000s	Australia	0.227	T	0.395	T	0.329	T	0.048	N	0.118	T	0.219	T	0.053	N
early-2000s	Australia	0.292	T	0.412	T	0.320	T	0.060	N	0.102	T	0.188	T	0.056	N
mid-2000s	US	0.138	T	0.119	T	0.247	T	0.050	N	0.054	N	0.095	N	0.036	N
early-2000s	US	0.135	T	0.089	N	0.231	T	0.043	N	0.053	N	0.092	N	0.031	N
mid-1990s	US	0.118	T	0.067	N	0.191	T	0.035	N	0.050	N	0.100	T	0.024	N
early-2000s	N Zealand	0.322	T	0.119	T	0.461	T	0.114	T	0.275	T	0.288	T	0.080	N
mid-1990s	N Zealand	0.218	T	0.092	N	0.438	T	0.083	N	0.209	T	0.333	T	0.066	N
mid-2000s	Germany	0.190	T	0.226	T	0.633	T	0.090	N	0.160	T	0.235	T	0.063	N
early-2000s	Germany	0.168	T	0.118	T	0.558	T	0.089	N	0.139	T	0.205	T	0.058	N
mid-1990s	Germany	0.151	T	0.070	N	0.449	T	0.061	N	0.100	T	0.179	T	0.035	N
2006	France	0.229	T	0.399	T	0.580	T	0.000	N	0.098	N	0.246	T	0.045	N
early-2000s	France	0.209	T	0.197	T	0.538	T	0.079	N	0.143	T	0.217	T	0.056	N
mid-1990s	France	0.207	T	0.147	T	0.418	T	0.068	N	0.165	T	0.152	T	0.051	N
mid-2000s	UK	0.179	T	0.268	T	0.510	T	0.055	N	0.186	T	0.174	T	0.130	T
early-2000s	UK	0.159	T	0.248	T	0.490	T	0.069	N	0.176	T	0.160	T	0.111	T
mid-1990s	UK	0.132	T	0.190	T	0.500	T	0.054	N	0.126	T	0.165	T	0.106	T
mid-2000s	Italy	0.111	T	0.248	T	0.523	T	0.023	N	0.093	N	0.123	T	0.046	N
early-2000s	Italy	0.101	T	0.221	T	0.495	T	0.026	N	0.091	N	0.134	T	0.043	N
mid-1990s	Italy	0.098	N	0.172	T	0.439	T	0.030	N	0.113	T	0.144	T	0.042	N
mid-2000s	Spain	0.238	T	0.214	T	0.531	T	0.028	N	0.081	N	0.221	T	0.073	N
early-2000s	Spain	0.238	T	0.189	T	0.535	T	0.068	N	0.065	N	0.223	T	0.074	N
mid-1990s	Spain	0.201	T	0.094	N	0.414	T	0.052	N	0.060	N	0.171	T	0.046	N
mid-2000s	Netherland	0.475	T	0.347	T	0.874	T	0.137	T	0.343	T	0.546	T	0.144	T
early-2000s	Netherland	0.473	T	0.284	T	0.877	T	0.139	T	0.299	T	0.541	T	0.107	T
mid-1990s	Netherland	0.437	T	0.216	T	0.816	T	0.142	T	0.277	T	0.519	T	0.090	N
mid-2000s	Canada	0.266	T	0.479	T	0.708	T	0.113	T	0.144	T	0.333	T	0.084	N
early-2000s	Canada	0.276	T	0.491	T	0.790	T	0.124	T	0.146	T	0.266	T	0.094	N
mid-1990s	Canada	0.250	T	0.342	T	0.698	T	0.127	T	0.116	T	0.206	T	0.124	T
mid-2000s	Brazil	0.120	T	0.163	T	0.266	T	0.034	N	0.072	N	0.061	N	0.032	N
early-2000s	Brazil	0.072	N	0.084	N	0.171	T	0.030	N	0.090	N	0.098	N	0.038	N
mid-1990s	Brazil	0.028	N	0.096	N	0.156	T	0.012	N	0.031	N	0.163	T	0.017	N
mid-2000s	Mexico	0.142	T	0.287	T	0.585	T	0.071	N	0.139	T	0.124	T	0.030	N
mid-2000s	Chile	0.372	T	0.616	T	0.459	T	0.067	N	0.171	T	0.365	T	0.069	N
mid-1990s	Chile	0.269	T	0.599	T	0.365	T	0.080	N	0.122	T	0.352	T	0.042	N
mid-2000s	Norway	0.265	T	0.773	T	0.551	T	0.105	T	0.179	T	0.577	T	0.092	N
early-2000s	Norway	0.254	T	0.808	T	0.533	T	0.104	T	0.221	T	0.542	T	0.104	T
mid-1990s	Norway	0.181	T	0.701	T	0.517	T	0.103	T	0.214	T	0.526	T	0.081	N
mid-2000s	Sweden	0.190	T	0.208	T	0.811	T	0.145	T	0.290	T	0.320	T	0.124	T
early-2000s	Sweden	0.175	T	0.158	T	0.777	T	0.145	T	0.273	T	0.255	T	0.110	T
mid-1990s	Sweden	0.134	T	0.161	T	0.706	T	0.131	T	0.235	T	0.255	T	0.083	N
mid-2000s	Turkey	0.068	N	0.155	T	0.336	T	0.106	T	0.117	T	0.139	T	0.042	N
early-2000s	Turkey	0.095	N	0.134	T	0.350	T	0.157	T	0.208	T	0.348	T	0.067	N
mid-1990s	Turkey	0.089	N	0.120	T	0.294	T	0.079	N	0.133	T	0.242	T	0.054	N
early-2000s	Switzerland	0.145	T	0.176	T	0.546	T	0.128	T	0.205	T	0.260	T	0.130	T
mid-1990s	Argentina	0.166	T	0.146	T	0.249	T	0.027	N	0.022	N	0.102	T	0.008	N
mid-2000s	S. Africa	0.201	T	0.519	T	0.251	T	0.062	N	0.154	T	0.207	T	0.049	N
early-2000s	S. Africa	0.169	T	0.546	T	0.267	T	0.063	N	0.140	T	0.181	T	0.050	N
mid-1990s	S. Africa	0.130	T	0.555	T	0.191	T	0.059	N	0.096	N	0.119	T	0.034	N
2000	S. Arabia	0.161	T	0.629	T	1.118	T	0.000	N	0.015	N	0.815	T	0.088	N

Note: 1. T represents "Traded" , N represents "Nontraded". 2. The numbers in the table report tradability ratio.

When we compare the classification of industries into traded and nontraded sectors using different approaches, we find that the classification using our method supports standard practice used by the United Nations (UN). However, it is more flexible and realistic than UN approach in two main respects. First, our classification allows for changes between traded and nontraded sectors across time. Thus, our approach can capture trade endogeneity while other approaches cannot. Second, it allows different classifications of industries for different countries. In some countries, the agriculture sector should be traded while in others it should be defined as nontraded. It is obvious that our classification is superior to others because it can account for changes in cross-sectional and time dimensions. Moreover, when we consider the 10% ratio approach (used in several papers) with allowing the classification to change over time, we find that use of the 10% rule leads to most of sectors being classified as traded. That is, the 10% rule defines not only the manufacturing sector as traded, but also service sectors such as construction in many countries are classified as traded. Although our approach is based on a 10%-20% ratio, we note that changing the threshold to 15%-25% would have only a small effect on the classification between traded and nontraded sectors.

C Appendix

Table C1: Trade weights based on direction of trade statistics

	China	Japan	Korea	Malaysia	Indonesia	Philippines	Thailand	Viet Nam	Singapore	Myanmar	Brunei.	India	Pakistan	Sri Lanka	Australia	N. Zealand	Germany	France	U.K.	Italy	Spain	Netherland	Canada	Brazil	Mexico	Chile	Norway	Sweden	Turkey	Switzerland	Argentina	S. Africa	U.S.
China	0.00	0.22	0.24	0.11	0.10	0.09	0.11	0.16	0.11	0.21	0.04	0.12	0.14	0.06	0.14	0.10	0.06	0.04	0.05	0.05	0.04	0.06	0.05	0.09	0.05	0.12	0.03	0.04	0.07	0.03	0.10	0.09	0.14
Japan	0.20	0.00	0.18	0.14	0.21	0.20	0.22	0.14	0.10	0.05	0.30	0.05	0.06	0.05	0.17	0.12	0.03	0.02	0.04	0.02	0.02	0.03	0.03	0.05	0.03	0.10	0.02	0.03	0.03	0.04	0.02	0.11	0.10
Korea	0.11	0.08	0.00	0.05	0.07	0.06	0.04	0.08	0.05	0.04	0.11	0.04	0.04	0.03	0.06	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.05	0.01	0.01	0.03	0.01	0.01	0.03	0.04
Malay.	0.03	0.03	0.03	0.00	0.05	0.06	0.07	0.04	0.18	0.05	0.06	0.03	0.04	0.03	0.03	0.03	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02
Indon.	0.02	0.04	0.03	0.04	0.00	0.02	0.04	0.03	0.09	0.02	0.11	0.03	0.03	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Philip.	0.02	0.02	0.02	0.02	0.01	0.00	0.02	0.02	0.03	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Thai.	0.02	0.04	0.02	0.06	0.04	0.04	0.00	0.05	0.05	0.33	0.05	0.02	0.02	0.02	0.03	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.01
Viet N.	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.02	0.01	0.00	0.01	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Singap.	0.03	0.03	0.03	0.16	0.13	0.09	0.07	0.11	0.00	0.12	0.10	0.06	0.03	0.07	0.05	0.03	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.02
Myanma	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brunei.	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
India	0.02	0.01	0.02	0.02	0.03	0.01	0.02	0.02	0.03	0.09	0.01	0.00	0.04	0.19	0.03	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.00	0.02	0.00	0.01	0.01	0.01	0.02	0.03	0.01
Pakista	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S.Lank	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Austra.	0.03	0.04	0.03	0.03	0.04	0.02	0.04	0.06	0.03	0.01	0.08	0.04	0.02	0.02	0.00	0.25	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.03	0.01
N. Zeal	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Germa	0.07	0.04	0.05	0.04	0.03	0.04	0.03	0.04	0.04	0.02	0.01	0.07	0.07	0.04	0.04	0.04	0.00	0.25	0.17	0.23	0.20	0.31	0.02	0.08	0.03	0.04	0.16	0.21	0.21	0.33	0.04	0.15	0.06
France	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.00	0.03	0.03	0.02	0.02	0.02	0.15	0.00	0.11	0.17	0.24	0.11	0.01	0.04	0.01	0.04	0.09	0.08	0.09	0.12	0.02	0.05	0.03
U.K.	0.03	0.03	0.02	0.02	0.02	0.01	0.03	0.02	0.03	0.01	0.05	0.06	0.07	0.10	0.05	0.04	0.11	0.11	0.00	0.08	0.10	0.12	0.03	0.03	0.01	0.02	0.23	0.11	0.10	0.06	0.02	0.10	0.04
Italy	0.02	0.02	0.02	0.01	0.01	0.00	0.01	0.02	0.01	0.01	0.00	0.03	0.04	0.03	0.02	0.02	0.10	0.13	0.06	0.00	0.13	0.06	0.01	0.04	0.01	0.04	0.04	0.05	0.12	0.12	0.03	0.04	0.02
Spain	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.06	0.12	0.05	0.09	0.00	0.04	0.00	0.03	0.01	0.03	0.03	0.03	0.06	0.04	0.04	0.04	0.01
Nethe.	0.03	0.02	0.02	0.03	0.02	0.06	0.02	0.02	0.02	0.00	0.00	0.02	0.03	0.02	0.01	0.01	0.12	0.08	0.09	0.06	0.06	0.00	0.01	0.05	0.01	0.04	0.10	0.08	0.04	0.05	0.03	0.04	0.02
Canada	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.02	0.03	0.02	0.04	0.01	0.01	0.01	0.01	0.02	0.24
Brazil	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.09	0.01	0.01	0.01	0.01	0.30	0.02	0.02
Mexico	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.00	0.03	0.03	0.00	0.04	0.00	0.00	0.00	0.01	0.03	0.00	0.14
Chile	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.01
Norwa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.04	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.13	0.01	0.00	0.00	0.00	0.00
Sweden	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.03	0.02	0.02	0.03	0.00	0.01	0.00	0.01	0.12	0.00	0.02	0.01	0.00	0.01	0.01
Turkey	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.02	0.01	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00
Switzer	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.05	0.02	0.01	0.01	0.01	0.06	0.04	0.02	0.05	0.02	0.02	0.00	0.01	0.00	0.00	0.01	0.02	0.04	0.00	0.01	0.02	0.01
Argen.	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.11	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.01	0.00
SAfrica	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01
U.S.	0.22	0.24	0.19	0.19	0.12	0.23	0.15	0.13	0.15	0.02	0.06	0.19	0.21	0.20	0.13	0.14	0.12	0.08	0.17	0.09	0.05	0.09	0.75	0.26	0.74	0.19	0.08	0.11	0.10	0.11	0.15	0.13	0.00

Note: Trade weights are computed as average shares of exports and imports over 2002-2008 displayed in columns by country such that a column, but not a row, sums to one.

Source: Direction of Trade Statistics, 2002-2008, IMF

Table C2: Individual ADF-GLS and Panel CADF-GLS Unit Root Tests

Country	q_{it}		$y^*_t - y_{it}$		$x^*_t - x_{it}$		Δq_{it}		$\Delta(y^*_t - y_{it})$		$\Delta(x^*_t - x_{it})$	
	US base	World base	US base	World base	US base	World base	US base	World base	US base	World base	US base	World base
Individual ADF-GLS unit root tests												
Developing Country												
China	-2.02	-1.66	-1.26	-1.21	-2.30	-1.31	-4.65**	-3.02*	-3.84**	-3.52**	-3.38**	-4.46**
Malaysia	-1.02	-0.80	-2.93	-2.69	-2.19	-2.15	-4.32**	-4.57**	-4.23**	-4.05**	-4.51**	-4.83**
Indonesia	-1.00	-1.01	-2.43	-2.57	-3.17	-4.05**	-6.25**	-6.56**	-3.86**	-3.94**	-6.26**	-5.02**
Philippines	-1.57	-2.13	-2.40	-1.88	-2.43	-4.54**	-4.69**	-5.68**	-4.00**	-3.17**	-3.83**	-3.78**
Thailand	-1.47	-1.22	-2.65	-2.73	-3.34*	-4.19**	-4.44**	-5.58**	-3.16**	-3.54**	-0.49	-0.61
Vietnam	-2.25	-1.30	-2.42	-1.87	-1.98	-2.18	-0.37	-1.87	-1.57	-1.97	-2.90*	-3.94**
Myanmar	0.20	0.50	-	-	-2.02	-2.24	-1.39	-3.09**	-	-	-4.00**	-4.19**
Brunei.	-2.48*	-1.61	-1.97	-1.57	-3.09	-3.51	-2.54*	-4.63**	-5.22**	-4.86**	-3.81**	-1.18
India	-0.47	-0.70	-0.62	-0.53	-2.20	-3.52*	-5.06**	-5.21**	-4.33**	-4.67**	-6.39**	-5.88**
Pakistan	-0.72	-0.72	-2.40	-1.50	-2.11	-2.42	-5.63**	-5.44**	-3.13**	-3.12**	-6.59**	-7.62**
Sri Lanka	-0.99	-1.27	-1.94	-2.05	-2.26	-2.27	-4.33**	-4.26**	-3.34**	-3.16**	-4.29**	-4.47**
Brazil	-1.04	-1.04	-1.90	-1.90	-1.85	-2.02	-5.21**	-5.25**	-2.08	-1.98	-5.34**	-7.15**
Mexico	-2.63*	-4.30**	-2.67	-2.58	-3.66	-1.83	-6.24**	-6.87**	-3.91**	-3.91**	-3.17**	-3.57**
Chile	-0.99	-1.54	-2.31	-2.28	-2.46	-2.92	-3.44**	-5.64**	-3.89**	-4.19**	-2.84*	-3.66**
Turkey	-1.19	-1.38	-2.31	-2.40	-1.43	-1.34	-4.48**	-1.15	-5.91**	-6.02**	-2.87*	-3.46**
Argentina	-2.62*	-1.80	-1.99	-1.43	-2.23	-3.96*	-6.26**	-6.29**	-4.52**	-4.88**	-5.29**	-7.18**
South Africa	-1.19	-1.04	-1.65	-1.40	-3.06	-2.12	-5.08**	-5.52**	-3.36**	-3.08**	-5.31**	-5.14**
Panel CADF-GLS unit root tests												
CIPS	-1.24	-1.82	-2.10	-2.13	-2.68	-2.97	-4.26**	-4.46**	-3.99**	-4.03**	-4.45**	-4.32**
Fisher	28.52	40.11	18.63	19.99	35.70	50.86*	175.26**	210.22**	216.27**	212.87**	244.15**	225.57**
Inverse normal	2.32	-0.72	1.87	1.72	-1.03	-2.03*	-9.41**	-10.79**	-11.46**	-11.46**	-11.82**	-11.21**
Developed Country												
Japan	-1.18	-1.05	-1.59	-1.54	-3.13	-1.45	-4.42**	-5.39**	-4.20**	-4.33**	-3.28**	-2.96*
Korea	-2.25	-2.89**	-1.41	-1.66	-1.35	-0.63	-4.79**	-5.42**	-5.05**	-5.62**	-3.69**	-4.25**
Singapore	-2.96**	-1.15	-1.49	-2.02	-2.80	-2.82	-4.32**	-4.95**	-4.04**	-3.49**	-5.62**	-4.47**
Australia	-2.62*	-1.91	-1.81	-0.93	-1.65	-1.83	-4.11**	-5.38**	-5.92**	-4.31**	-4.23**	-5.88**
New Zealand	-3.81**	-2.48*	-2.50	-1.83	-2.71	-1.61	-4.15**	-4.33**	-3.90**	-3.09**	-4.44**	-5.24**
Germany	-2.61*	-2.06	-2.80	-2.43	-4.62**	-1.89	-4.15**	-6.14**	-4.27**	-3.68**	-2.44	-7.19**
France	-2.73*	-2.22	-2.26	-1.60	-2.56	-1.65	-4.55**	-6.12**	-4.58**	-3.11**	-3.83**	-5.16**
United Kingdom	-2.09	-1.44	-1.90	-1.61	-2.64	-3.10	-4.45**	-5.12**	-5.92**	-4.79**	-4.02**	-6.23**
Italy	-2.77*	-1.87	-1.12	-0.08	-2.19	-3.24	-4.96**	-6.02**	-5.11**	-1.67	-3.63**	-5.57**
Spain	-1.91	-0.93	-2.49	-3.18	-1.70	-1.79	-3.89**	-5.51**	-4.37**	-3.26**	-4.81**	-5.66**
Netherland	-1.60	-1.60	-2.06	-1.35	-3.87**	-5.31**	-4.77**	-6.93**	-4.51**	-3.82**	-9.30**	-7.19**
Canada	-2.11	-1.82	-2.33	-2.23	-1.95	-2.01	-3.39**	-4.50**	-4.41**	-3.54**	-3.90**	-4.29**
Norway	-2.14	-1.43	-2.28	-2.19	-3.08	-2.37	-4.16**	-5.62**	-4.10**	-3.85**	-2.78*	-5.74**
Sweden	-2.66*	0.10	-2.29	-2.14	-1.89	-1.22	-4.07**	-6.54**	-4.28**	-3.00*	-3.60**	-3.41**
Switzerland	-1.19	-1.09	-3.13	-3.00	-2.05	-2.33	-4.42**	-5.99**	-4.59**	-4.15**	-4.43**	-6.48**
United State	-	-1.67	-	-3.58*	-	-2.56	-	-5.08**	-	-5.19**	-	-3.60**
Panel CADF-GLS unit root tests												
CIPS	-2.38*	-1.84	-2.14	-1.570	-2.76	-2.63	-5.17**	-5.16**	-4.23**	-3.78**	-5.29**	-5.48**
Fisher	52.65	43.00	17.80	34.10	51.14*	46.13	281.14**	333.661**	204.03**	189.01**	278.19**	397.32**
Inverse normal	-2.94	-1.08	1.50	0.53	-1.75	-1.09	-14.47**	-15.82**	-11.72**	-10.50**	-14.29**	-17.60**

Note: 1. The test statistics for all variables are based on regressions that include only an intercept, with the exception of ($y^*_t - y_{it}$) and ($x^*_t - x_{it}$), which also include a linear trend.

2. The numbers in the table report test statistics. Each test statistic has a different critical value, because they have different number of observation.

3. *, and ** indicate significance at 5 and 1 percent levels, respectively. The critical values of these statistics are computed using 20,000 simulations.

4. The lag lengths in the regressions are chosen using BIC Order Selection with the maximum lag of 4.

5. All panel unit root statistics are in truncated version.

Table C3: The test results for Westerlund's cointegration tests for developed and developing countries

Wester-lund Test	US base				World base			
	$q_{it},(y_t^*-y_{it})$		$q_{it},(x_t^*-x_{it})$		$q_{it},(y_t^*-y_{it})$		$q_{it},(x_t^*-x_{it})$	
	P-value	**Robust P-value**	**P-value**	**Robust P-value**	**P-value**	**Robust P-value**	**P-value**	**Robust P-value**
Developed Countries								
Panel Statisitcs								
Pt	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.04
Pa	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.02
Group-mean Statisitics								
Gt	0.00	0.00	0.00	0.01	0.00	0.05	0.00	0.02
Ga	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.02
Developing Countries								
Panel Statistics								
Pt	0.00	0.24	0.07	0.41	0.00	0.32	0.16	0.46
Pa	0.00	0.29	0.22	0.46	0.00	0.39	0.17	0.51
Group-mean Statisitics								
Gt	0.17	0.42	0.71	0.80	0.19	0.37	0.01	0.19
Ga	0.61	0.54	0.62	0.67	0.26	0.27	0.70	0.68

Note: 1. The null hypothesis is no cointegration.

2. The numbers in the table indicate P-values and Robust P-values which are computed using Bootstrap 400 replications.

3. The tests are based on one lag and one lead.

4. The width of the Bartlett kernel window used in the semi-parametric estimation of long run variances is determined to be 3.

Table C4: Estimated individual and the group-mean panel DOLS coefficients in developed countries

Country	**US Base**				**World Base**			
	$\widehat{\beta}_i$	**t-value**	$\widehat{\gamma}_i$	**t-value**	$\widehat{\beta}_i$	**t-value**	$\widehat{\gamma}_i$	**t-value**
Japan	2.94**	9.63	-0.84**	-2.09	3.02**	5.22	-1.56**	-12.02
Korea	-0.06	-0.83	0.09	0.67	0.04	0.44	-0.07	-0.97
Singapore	-0.07	-0.7	-0.15	-1.14	0.64**	2.58	-0.06	-0.28
Australia	1.55*	1.87	-0.78**	-2.39	0.14	1.01	-0.59**	-2.28
New Zealand	-0.24	-0.83	-0.07	-0.42	-0.40**	-3.08	-0.35**	-2.35
Germany	0.71	0.7	-0.11	-0.38	0.28	0.9	0.39*	1.92
France	0.2	0.18	-1.31**	-2.9	0.92**	4.22	-0.57**	-2.23
UK	2.19**	2.22	-0.42**	-3.33	-2.55**	-2.74	-0.85**	-5.38
Italy	-0.05	-0.05	-0.23	-1.67	2.29**	3.4	-0.24	-0.58
Spain	1.46	1.63	0.5	1.6	-2.41**	-5.43	0.59**	2.08
Netherlands	0.56	0.57	-0.23	-1.44	-0.57**	-2.22	0.14	0.74
Canada	1.92**	2.91	0.60**	5.17	1.01**	4	0.40**	2.8
Norway	0.02	0.06	-0.33	-1.44	0.49	1.28	0	0.01
Sweden	1.75**	2.12	-1.61**	-5.39	0.87**	3.7	-0.58**	-9.09
Switzerland	-0.87**	-2.52	0.3	0.77	-0.64**	-2.17	0.99**	2.52
U.S.***	-	-	-	-	-0.77**	-4.14	0.63**	3.26
Group Mean	**0.8**		**-0.31**		**0.15**		**-0.11**	

Note: 1. *, ** indicate 10%, 5% rejection level, respectively.

2. Test statistics are computed using HAC Newey-West covariance estimators.

3. The optimal lag length is chosen by the BIC information criterion with a maximum of 2 lags.

4. *** means that the DOLS regression with world-based real exchange rate includes a dummy variable to capture the impact of a level change in intercept.

5. **** means that the DOLS regression with world-based and U.S.-based real exchange rates includes a dummy variable to capture the impact of a level change in intercept.

Note that the DOLS regressions for each country are estimated using

$$q_{it} = c_i + \beta_i(y_t^* - y_{it}) + \sum_{k=-K_i}^{p_i} \phi_{i,k}\Delta(y_{t+k}^* - y_{i,t+k}) + \varepsilon_{it}^*$$

or

$$q_{it} = \alpha_i + \gamma_i(x_t^* - x_{it}) + \sum_{k=-K_i}^{p_i} \lambda_{i,k}\Delta(x_{t+k}^* - x_{i,t+k}) + u_{it}^*.$$

Table C5: Estimated individual and the group-mean panel DOLS coefficients in developing countries

Country	**US Base**				**World Base**			
	$\widehat{\beta}_i$	**t-value**	$\widehat{\gamma}_i$	**t-value**	$\widehat{\beta}_i$	**t-value**	$\widehat{\gamma}_i$	**t-value**
China	-0.21**	-5.58	-0.37	-1.6	-0.71**	-3.11	-2.37**	-5.2
Malaysia	-1.24**	-9.75	0.83**	3.81	-0.69	-0.81	0.98**	3.86
Indonesia	-2.04**	-6.63	0.88**	3.39	-2.84**	-2.12	1.23**	4.56
Phillipine	0.70**	3.55	0.33**	4.09	0.26**	3.22	0.29**	3.31
Thailand	-0.59**	-5.82	0.77**	4.71	-1.00**	-6.89	1.04**	5.56
Vietnam	-0.21	-0.67	0.39**	2.55	-0.08	-0.47	0.37**	6.32
Myanmar****	-	-	-2.39**	-4.92	-	-	-0.42	-0.54
Brunei	0.04	0.61	0.23**	3.99	-0.11**	-2.94	0.17**	4.36
India***	-1.35**	-2.62	0.59**	5.49	0.01	0.06	0.82	1.42
Pakistan	-3.51**	-6	0.93**	3.1	2.47**	7.96	0.91**	2.55
Sri Lanka	-1.21*	-1.76	0.04	0.62	-0.66	-0.36	-0.1	-1.31
Brazil****	3.90**	5.24	0.39**	3.95	1.35**	3.08	0.27**	2.61
Mexico	-0.19	-0.93	-0.40**	-2.98	0.11	0.59	-0.72**	-5.72
Chile***	-0.76*	-1.8	1.18**	4.29	-2.13**	-3.56	2.58**	6.8
Turkey	2.29**	2.73	-0.48**	-3.94	1.43**	3.56	-0.72**	-7.11
Argentina***	0.64*	1.82	1.51**	8.25	0.26	1.14	-0.34	-0.54
South Africa	0.81**	5.54	2.52**	5.6	0.53**	4.42	-1.73	-1.59
Group Mean	**-0.18**		**0.41**		**-0.11**		**0.13**	

Note: See Table C4.

Note that the DOLS regressions for each country are estimated using

$$q_{it} = c_i + \beta_i(y_t^* - y_{it}) + \sum_{k=-K_i}^{p_i} \phi_{i,k}\Delta(y_{t+k}^* - y_{i,t+k}) + \varepsilon_{it}^*$$

or

$$q_{it} = \alpha_i + \gamma_i(x_t^* - x_{it}) + \sum_{k=-K_i}^{p_i} \lambda_{i,k}\Delta(x_{t+k}^* - x_{i,t+k}) + u_{it}^*.$$

D Appendix

D.1 Empirical distribution of the estimated persistence profiles

In this appendix, we describe how to construct the empirical distribution used for obtaining the empirical means and the 95% confidence intervals for the estimated persistence profiles, as suggested by Pesaran and Shin (1996). First, we follow the steps involved in the estimation of the persistence profiles in Section 4. That is, we estimate the vector error correction model allowing for country-specific intercepts as follows:

$$\Delta G_{it} = \mu_i + \alpha Z_{i,t-1} + \sum_{l=1}^{p-1} \Gamma_l \Delta G_{i,t-l} + \varepsilon_{it},\ i = 1, 2, ..., N \text{ and } t = 1, 2, ..., T_i$$

where $G_{it} = \{q_{it}, x_t^* - x_{it}\}$, and $Z_{it} = \beta' G_{it}$ (β is a cointegrating vector). In our study, there is only one cointegrating vector imposed. Note that the optimal lag length is chosen by the BIC information criterion with a maximum of 4 lags. Obtain the estimates ($\widehat{\mu_j}$, $\widehat{\alpha}$, $\widehat{\Gamma}_1$, and $\widehat{\Omega}$) and the residuals $\widehat{\varepsilon}_{it}$. Then we can compute the estimated coefficients of the VAR(p) specification, denoted by $\widehat{\phi}_1$, $\widehat{\phi}_2, ..., \widehat{\phi}_p$ using these estimates.

We allow for the possibility of the contemporaneous correlations among the estimated residuals. Because of this, we have to transform the estimated residuals to obtain the transformed residuals which are contemporaneously independent. This can be done by using the Choleski decomposition of $\widehat{\Omega}$, given $\Omega = S^{-1} S'^{-1}$. Denote the transformed residuals be $\xi_{it} = S\widehat{\varepsilon}_{it}$ where S is the lower triangular Choleski decomposition. Next bootstrap from these residuals to get a new draw of residuals, say ($\widehat{\xi}_{it}^b$, $i = 1, 2, ..., N$, $t = 1, 2, ..., T_i$ and b refers to the b^{th} replication). We use random draws from the collection of transformed residuals with replacement. Then we recover $\varepsilon_{it}^b = S^{-1}\xi_{it}^b$ and use a new set of these bootstrap residuals to generate a bootstrap sample of G_{jt} for the b^{th} replication based on the relations below:

$$G_{it}^b = \widehat{\mu_i} + \widehat{\phi}_1 G_{i,t-1}^b + \widehat{\phi}_2 G_{i,t-2}^b + ... + \widehat{\phi}_p G_{i,t-p}^b + \varepsilon_{it}^b$$

where $t = p+1, p+2, ..., T_i$. We use the actual observations of G in the initial process i.e. $t = 1, 2, .., P$. Now we obtain a new sample G_{it}^1, $i = 1, 2, .., N$, $t = 1, 2, ..., T_i$ and thus we can compute the persistence profiles for each horizon. This procedure is repeated 10,000 times, and we then construct the empirical distribution in the usual way. The empirical mean and the 95% confidence intervals are easily constructed from this empirical distribution. Note that we check for explosive solutions in each replication of the VAR(p). If they are found, we exclude those cases and rely only on the remaining cases. For the developed country group, we are found explosive solutions very rarely (only 4 and 5 explosive cases of 10,000 replications for the U.S. referenced case and the world referenced case, respectively). This implies that the empirical distributions are very close to the true models. In our total of 10,000 replications, explosive cases were around 3 percent of the sum for the U.S. referenced case, and 10 percent for the world referenced case in developing group, and these explosive cases were excluded from the simulations. Thus, the empirical distributions were relied on around 9,700 and 9,000 cases in the U.S. referenced and the world referenced cases repectively. This is not of concern, given that our sample size is small.