Global and country-specific factors in real effective exchange rates

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Abstract:

Using the Bayesian factor model, we decompose movements in real effective exchange rates, which can be considered a measure of external competitiveness, into global and country-specific factors. In data from a number of developed and developing countries, we find a particular global trend in these rates, but a substantial proportion of the variation in these rates is found to be country-specific. In addition, consistent with economic theory, this global factor is closely related to a trend in the global interest rate, while country-specific factors to idiosyncratic movements in countries' own interest rates.

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1 Introduction

Co-movements in exchange rates have been analyzed in the past in several contexts. The co-movements, which can be measured by the sensitivity of one currency to another in regression analysis or by the simple correlation coefficient, are important since changes in one currency indeed often affect the currency of other countries (e.g., McKinnon and Schnabl (2003)) particularly for those implementing a flexible exchange rate regime. Furthermore, currency interdependence has been examined in the context of inferring actual exchange rate regimes which may be deviating from officially announced ones (e.g., Frankel and Wei (2008)).

Co-movements in exchange rates are also underlined during financial crises; deterioration in one's currency value almost simultaneously affecting others by, for example, speculative attacks (e.g., Gerlach and Smets (1995), Masson (1998)). Such an effect is often called contagion in the academic literature, and has been increasingly prominent over recent years when a series of financial crises have affected the world economy. Such examples include the 1997 Asian crisis which erupted in Thailand, the Lehman Shock (2008) in the US, and the European sovereign debt crisis which started in Greece (2009). Each led not only its own economy but also its regional and/or the world economy into recession.

The majority of previous studies on co-movements seem to have investigated commonality in stock prices; furthermore, those on the foreign exchange markets have focused largely on bilateral nominal exchange rates (see the above literature and the next section). However, foreign exchange transactions are conducted in a global context with the involvement of more than two countries. Furthermore, it is surely of interest to researchers and policymakers to study the real effective exchange rate which is often regarded as an economic variable for measuring the external competitiveness of countries (e.g., UNCTAD (2012), Brixiova (2013)), and is considered, at least on theoretical grounds, as one important factor contributing to economic growth. Indeed, a number of empirical research projects have been conducted in order to investigate whether undervalued currencies will bring about economic growth (e.g., Bhalla (2008), Rodrik (2008), Mbaye (2012), UNCTAD (2012) and Brixiova (2013)).[2]

Against this background, this paper analyzes and quantifies co-movements in real effective exchange rates for a wide range of countries. There must be some level of correlation in these rates as they are affected by developments in international economies. However given that competitive and non-competitive countries co-exist in the global market, it would be of interest to quantify the level of their co-movements and determinants. We analyze the determinants based on previous studies which, without data decomposition, have used real interest rates to explain bilateral real exchange rates. Early studies tend to cast doubt on the credibility of this relationship for individual exchange rates (Edison and Pauls (1993), Edison and Melick (1999)); however, stronger evidence is reported by more recent studies (MacDonald and Nagayasu (2000), Byrne and Nagayasu (2010)) in the panel data context.

The distinguishing features of this paper are, first of all, that we shall decompose real effective exchange rates for a comprehensive number of countries to the global and country-specific factors using a Bayesian factor model. The number of countries under investigation in previous studies seems often rather limited (often fewer than 15 countries in previous studies summarized in Section 4). Obviously, data availability has been one issue for deciding the number of countries, at least in the past; however, many more countries now exist in the world.[3] This allows us to incorporate a more comprehensive definition of global movements in the estimation of real effective exchange rates. Another interesting feature of this paper is empirical clarification of the driving forces of global and country-specific factors in the panel data context. Thus unlike contagion studies, this paper does not emphasize the direction of causality from one country to another.

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[2] While there is no consensus among previous empirical studies, some confirmed a link between economic growth and real exchange rates through the trade channel (Bhalla (2008), Rodrik (2008)) and the productivity channel (Mbaye (2013).

[3] However, over the last decade much progress has been made in estimating multiple commonality in large data sets, especially in the area of studies on business cycles (Forni et al. (2000), Kose et al. (2003) and Foerster et al. (2011)) and general commodity (non-financial asset) inflation (Bernanke et al. (2005), Canova and Ciccarelli (2009) and Mumtaz and Surico (2012)).

2 The driving forces of real effective exchange rates

What are their driving forces? Among others, economic theory suggests that real exchange rates would be determined by the real interest rate differential or the productivity differential in tradable sectors (known as the Balassa-Samuelson theorem). Here we use real interest rates which are available for more countries, and shall summarize below their theoretical link following Obstfeld and Rogoff (1996). Their derivation of the model is more general than the conventional one using solely the purchasing power parity (PPP) theorem and the uncovered interest rate parity (UIRP) condition, in the sense that sticky prices are considered in the model.

Let's consider domestic inflation which can be explained by the Dornbusch-type inflation specification for an open economy.

$$\Delta p_{t+1} = \gamma\left(\mathrm{y}_t^d - \bar{y}_t\right) + \Delta \mathrm{s}_{t+1} + \Delta\tilde{p}_{t+1}^* \tag{1}$$

where y_t^d is the demand for home country output, s is the nominal effective exchange rate and p is the price. All variables are in log form, and Δ represents the differenced operator; therefore, $\Delta p_{t+1} = p_{t+1} - p_t$ becomes inflation. A variable with a bar indicates a natural level, and a foreign variable is denoted with an asterisk. In the presence of multiple partner countries, the latter can be thought of as a weighted average of foreign variables suggested by the tilde in Eq. (1). The $\gamma > 0$ implies that home inflation increases due to excessive demand for home products, exchange rate depreciation, and increases in foreign inflation. In such cases, there is no market clearance, i.e., $\Delta p_{t+1} \neq 0$.

Further, the demand for home products (y_t^d) is assumed to be expressed as:

$$y_t^d = \bar{y}_t + \delta(s_t - p_t + \tilde{p}_t^* - \bar{q}) \tag{2}$$

where $\delta > 0$. As in the previous studies, the long-run (or natural) real exchange rate ($\bar{q}$) is assumed to be fixed here. According to Eq. (2), the demand for domestic goods exceeds its natural level to an extent proportional to the level of currency misalignment.

Using the definition of the real exchange rate ($q_t \equiv s_t - p_t + \tilde{p}_t^*$) and the UIRP ($\Delta s_{t+1} = i_t - \tilde{\imath}_t^*$ where i_t is the nominal interest rate), Eqs. (1) and (2) yield:

$$\Delta p_{t+1} = \gamma\delta(q_t - \bar{q}) + i_t - \tilde{\imath}_t^* + \Delta\tilde{p}_{t+1}^* \tag{3}$$

In addition, using the Fisher parity condition ($i_t = R_t + \Delta p_{t+1}^e$ where R_t is the real interest rate and a variable with superscript *e* indicates an expected value) and rearranging Eq. (3) in term of the real exchange rate, we can obtain the following relationship:

$$q_t = \bar{q}_t - \frac{1}{\gamma\delta}(R_t - \tilde{R}_t^*) \tag{4}$$

Since γ and δ are theoretically positive, this equation asserts that there would be home currency depreciation when the real interest rate falls at home. Eq. (4) is an appropriate theoretical framework even when a country is confronted with very low nominal interest rates since real interest rates can be negative due to the presence of expected inflation. For the estimation, we consider the equation of exchange rate changes which is consistent with an a priori assumption of the standard factor model.

$$\Delta q_t = -\frac{1}{\gamma\delta}\Delta R_t + \frac{1}{\gamma\delta}\Delta\tilde{R}_t^* \tag{5}$$

We shall base our empirical analysis on Eq. (5): since there are two components (global and country-specific factors) in real effective exchange rates, each factor will be estimated by real interest rates. The global factor in real effective exchange rates is expected to be determined by the global interest rate ($\tilde{R}_t^*$), and the country-specific factor by idiosyncratic movements in the interest rates (R_t).

3. Data and preliminary analyses

Real effective exchange rate (Q) data are obtained from the International Financial Statistics (IFS) of the International Monetary Fund. They (IFS code: ..REUZF, 2005=100) are constructed using the consumer price indices (CPI) and weights determined by the size of trade (unit values) to each trading partner, and cover the sample period from 1980Q1 to 2014Q3 for 79 countries, including both advanced and developing economies (see Table 1). The country coverage and the sample period are determined by data availability from the IFS and maximize the total number of observations.[4] In the subsequent analysis, we analyze exchange rate growth, i.e., the first difference of log exchange rates ($\mathrm{Log}(Q_t/Q_{t-1})$), in order to be congruent with an a priori assumption of the data required for the factor model.

The basic statistics of exchange rates are summarized in Table 2. The sign of the average (ave) exchange rates suggests that the direction of exchange rate movements is diversified, and more than half (72 percent) countries have experienced a fall in exchange rates (Table 2). Furthermore, developing countries have experienced a higher level of exchange rate volatility than advanced countries, measured by the standard deviation (std. dev.). This outcome seems to be closely associated with deterioration in domestic economies; for example, Poland was confronted with acceleration in inflation from the late 1980s to the early 1990s.

Table 1 also provides information about data required to calculate real interest rates, which we obtain on the basis of the Fisher parity condition (real interest rates = nominal interest rates – expected inflation rates). Here, nominal interest rates are either the market rates or deposit rates, and as a proxy for expected inflation we assume ex ante inflation using the CPI. Data availability on the interest rate and CPI reduces the number of countries to 17 which have sufficient time-series data for statistical analysis and it turns out to be that most are advanced countries.

The time series properties of real exchange rates and interest rates are examined by panel unit root tests. In order to examine the null hypothesis of non-stationary data, we implement two types of tests; namely, Levin-Lin-Chu (2002) and Fisher-type (Choi 2001) tests. In order to take account of cross-sectional dependence, the LLC statistic is obtained by removing the cross-sectional mean from the original data prior to the test. The second test is based on Fisher (1932) who proposed pooling *p*-values from independent tests in order to create a statistic which can be used to assess unit roots in the panel data context. Furthermore, following Choi (2001), different specifications of the latter test are used. Table 3 reports strong evidence of a stationary process for

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[4] The other definition of real effective exchange rates which are available from the IFS. However, the country coverage for the alternative rates is much narrower than that based on the CPI.

changes in both real exchange rates and interest rates; the null is rejected at the one percent significance level in favor of the alternative of stationarity. While our data are effective rates, the stationarity of differenced exchange rates is consistent with previous studies on bilateral exchange rates which have achieved the stationarity after taking the first difference (Hallwood and MacDonald 2000).

4. Empirics

There are several statistical approaches to analyzing co-movements in data. The traditional, and probably most popular, approach is to use correlation measures between data. Increased correlation is regarded as evidence of increased cross-country linkages, and high correlation during tranquil times with minimal risk premia is also interpreted as evidence of high capital market integration. Such research can be carried out either by simply calculating correlation coefficients among financial data or estimating the exchange rate equation of one country with other countries' exchange rates as explanatory variables. Based on this approach, previous studies have pointed out unstable interrelationships and increased correlation at the times of financial crises in equity markets (Longin and Solnik (1995), Liu et al. (1998), Reinhart and Carvo (1996), Bayoumi et al. (2007)). However, there are potential problems with this estimation approach. Obviously, the regression based approach requires an exogeneity assumption about explanatory variables. But it may be difficult to justify this assumption using volatile financial asset data. Furthermore, Forbes and Rigobon (2002) argue that the standard regression analysis fails to take into account market volatility which differs during crisis and non-crisis periods.

Alternatively, co-movements can be estimated using a factor model or a principal components approach. The factor model is often used to distinguish between global and country-specific elements, and according to this approach, increases in the proportion of the global factor become evidence of higher cross country linkages (Koedijk and Schotman (1989), Dungey (1999), Cayen et al. (2010)). The commonality in data can also be estimated by the principal components approach. For example, Nellis (1982) analyzed financial market integration using corporate and government bonds with the expectation that their yields will be dominated by common factors in a highly integrated financial market. Similarly, Volosovych (2013) studied financial market integration utilizing government bond yields from 1875 to 2009 and provided evidence of increased integration from the data through the end of the 20th century. However, the coverage of these studies is rather limited -- often less than 15 countries -- even when the factor/principal components approach is used.

This study follows the second strand of the literature (i.e., the factor model) in which all variables are treated as endogenous and which is thus more suitable for obtaining global factors from a large number of countries. We shall explain next about the statistical method used to identify the number of common factors.

4.1.Identifying the number of common factors

Are there any common movements in real effective exchange rates and real interest rates? This section attempts to investigate this by identifying the number of common factors in these data using an advanced statistical method (Alessi et al. 2010). While the factor model has been widely used in previous studies, the identification of the number of common factors has remained a big challenge for researchers.

Their statistical approach is an extension to Bai and Ng (BN, 2002), and thus is based on a factor model which for stationary data $(\mathbf{x}_{nt} = x_{1t}, \ldots, x_{nt})'$ is often expressed as:

$$\mathbf{x}_{nt} = \mathbf{\Lambda}_n \mathbf{F}_t + \boldsymbol{e}_{nt} \qquad t = 1, \ldots, T \tag{6}$$

where the data are standardized. The $\mathbf{F}_t$ is a $k \times 1$ vector of common factors, and $\mathbf{\Lambda}_n$ is a corresponding factor loading matrix $(n \times k)$, where k $(k < \min(\mathrm{n}, \mathrm{T}))$ represents the number of common factors. Since the size of loadings can differ among n, $\mathbf{\Lambda}_n \mathbf{F}_t$ can be viewed as common elements which include heterogeneous responses of each country (n) to common movements $(\mathbf{F}_t)$. The residual $(\boldsymbol{e}_{nt})$ which cannot be explained by **F**, is considered as idiosyncratic factors, and as in the standard model, common and idiosyncratic factors are assumed to be orthogonal. In our research setting, **x** becomes a vector of real effective exchange rates or real interest rates.

While there are several statistical methods such as the Scree Plot to decide the appropriate number of common factors, recently a number of information criterion-type (*IC*) methods have been proposed by BN (2001). However, while BN provides several forms of penalty functions, the numerical simulations suggest that their estimation criteria tend to be under- or over-estimating the true number of common factors (Alessi et al. (2010)). Thus we shall use a statistical method introduced by Alessi et al. (2010) who has modified the BN criteria by introducing the extra term ($c \in \mathbb{R}^{+}$) to the penalty function.

$$IC(k): \min_{0 \le r^* \le k} \quad \ln(\mathrm{V}(k, \hat{\mathbf{F}}^k)) + ckg(n,T) \tag{7}$$

where $\mathrm{V}(.) = (nT)^{-1} \sum_{i=1}^{n} \sum_{t=1}^{T} (\mathbf{x}_{nt} - \boldsymbol{\Lambda}_n^k \, \mathbf{F}_t^k)^2$. A penalty factor $g(n,T)$ will make adjustment to the statistics for over-fitting in order to avoid cases where the solution is always equal to $k = n - 1$. More concretely, the large (small) c represents over-(under-) penalization, and when $c = 0$, it means no penalization. Furthermore, for a given k, the appropriate number of common factors (r^*) corresponds to minimization of the sum of the residual squared and a penalty factor. Alessi et al. (2010) argue that c provides vital information about the number of common factors although this extra term does not affect the asymptotic performance in identifying the size of r^*. In that sense, their modification may seem trivial, but it has been shown to influence significantly the outcome with finite data (Alessi et al. (2010)).

Alessi et al. (2010) also argues that r^* should not be sensitive to the size of c. Thus once r^* is obtained, we shall check its stability by means of the S_c statistic:

$$\mathrm{S}_c = \frac{1}{J} \sum_{j=1}^{J} \left[r^* - \frac{1}{J} \sum_{h=1}^{J} r_h^* \right]^2 \tag{8}$$

As Eq. (8) suggests that a small S_c implies the stability of r^* since S_c approaches to zero when r^* converges to the average of previous values of its own. Thus according to Eq. (8), r^* should be chosen when S_c becomes zero, and Alessi et al. (2010) propose a graphical approach to evaluate it.

Our estimates for r^* and S_c are shown over a range of c in Figure 1. They are obtained with $k = 5$ for a set of real effective exchange rates and real interest rates, and we show that there is one common factor in both data. When several stability interval periods exist, we choose the second long interval following the practical guidance from Alessi et al. (2010). Thus Figure 1 seems to suggest that there is one common factor in a set of real effective exchange rates and that of real interest rates. We consider the former as their global movements in real effective exchange rates, and that from real interest rates as the global interest rate (i.e., $\tilde{R}_t^*$ in Eq. (5)). The global interest rate has been discussed by a number of researchers in the past; for example, the high correlation of real interest rates among advanced countries has been documented by Cumby and Mishkin (1986), Goodwin and Grennes (1994), Gagnon and Unferth (1995), and Monadjemi (1997), and a close relationship between advanced and emerging markets by Chinn and Frankel (1995).

4.2.Estimating global and country-specific factors

Given evidence of the global (common) factor found in the previous section, this study uses the factor model in order to calculate the size of this factor in our data. Several researchers have applied the Bayesian approach to the factor model in finance research. For example, Geweke and Zhou (1996) have analyzed financial portfolios based on the arbitrage pricing theory (APT) in the context of the Bayesian framework, which allows us to estimate a more complicated model than the Maximum Likelihood (ML) approach. We follow their approach to estimate the factor model with $\mathbf{F}_t \sim N(\mathbf{0}, \boldsymbol{I}_k)$ and $\boldsymbol{e}_{nt} \sim N(\mathbf{0}, \boldsymbol{\Sigma})$.

Apart from the number of common factors (r^*), one needs to deal with an identification issue. In particular, the number of parameters estimable has to meet the condition that $n \geq 2r^* + 1$ (Geweke and Zhou 1996) since the covariance matrix $\mathbf{v}$ is related with β and $\boldsymbol{\Sigma}$ through $\mathbf{v} = \boldsymbol{\Lambda}\boldsymbol{\Lambda}' + \boldsymbol{\Sigma}$, using the notation used to explain Eq. (6), where $\mathbf{v}$ has $n(n+1)/2$ elements and $\boldsymbol{\Lambda}\boldsymbol{\Lambda}' + \boldsymbol{\Sigma}$ with $nr^* + n$ elements.

Furthermore, given $\mathbf{\Lambda}$ is of full rank and the assumption that the first r^* rows of β are independent, $\mathbf{\Lambda}^{r^*}$ is a lower triangular $r^* \times r^*$ matrix with positive diagonal elements ($\mathbf{\Lambda}_{ii} > 0$ where i = 1.,…, r^*).

$$\mathbf{\Lambda}^{r^*} = \begin{pmatrix} \mathbf{\Lambda}_{11} & 0 & \cdots & 0 \\ \mathbf{\Lambda}_{21} & \mathbf{\Lambda}_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{\Lambda}_{r^*1} & \mathbf{\Lambda}_{r^*2} & \cdots & \mathbf{\Lambda}_{r^*r^*} \end{pmatrix} \tag{9}$$

We estimate Eq. (6) using the Bayesian approach with a prior distribution: $\mathbf{\Lambda}_{ij}$being normal with zero mean for $i \neq j$, and the likelihood function becomes:

$$\mathrm{p}(\mathbf{x}|\mathbf{F}, \mathbf{\Lambda}, \mathbf{\Sigma}) \propto |\mathbf{\Sigma}|^{-\frac{T}{2}} \exp(trace(-0.5\mathbf{\Sigma}^{-1}\mathbf{e}'\mathbf{e})) \tag{10}$$

This will be used to draw observations for parameters ($\mathbf{b}_i^*$) in the Gibbs sampling method for i = 1,…, r^* as:

$$\mathrm{f}(\mathbf{b}_i^*|\mathbf{F}, \sigma_i) \propto exp\left(-\frac{1}{2\sigma_i^2}(\mathbf{b}_i^* - \hat{\mathbf{b}}_i^*)'\mathbf{F}_i'\mathbf{F}_i(\mathbf{b}_i^* - \hat{\mathbf{b}}_i^*)\right) \tag{11}$$

where $\hat{\mathbf{b}}_i^*$ is the OLS estimate ($\mathbf{b}_i^* = (\mathbf{\Lambda}_{i1}, \dots, \mathbf{\Lambda}_{ii})$), and $\mathbf{F}_i$ contains the first r^* elements of **F**. The $\mathbf{b}_i^*$ is independently normally distributed. Furthermore, the diagonal elements of $\mathbf{\Sigma}$ follow the Inverted Gamma distribution.

$$\mathrm{f}(\sigma_i|\mathbf{F}, \mathbf{b}_i^*) \propto \frac{1}{\sigma_i^{v+1}} exp\left(\frac{-vs_i^2}{2\sigma_i^2}\right) \tag{12}$$

where $s_i^2 = T^{-1}\sum_{t=1}^{T} \boldsymbol{e}'\boldsymbol{e}$ and $v = T$. Geweke and Zhou (1996) discuss that vs_i^2/σ_i^2 equivalently follows the $\chi^2(T)$ distribution, and when **F** and **X** are jointly normally distributed, the conditional value of **F** and the covariance matrix can be shown as:

$$\mathrm{E}(\mathbf{F}_t|\mathbf{\Lambda}, \mathbf{\Sigma}, \mathbf{X}_t) = \mathbf{\Lambda}'(\mathbf{\Lambda}\mathbf{\Lambda}' + \mathbf{\Sigma})^{-1}\mathbf{X}_t \tag{14}$$
$$\mathrm{Cov}(\mathbf{F}_t|\mathbf{\Lambda}, \mathbf{\Sigma}, \mathbf{X}_t) = \mathbf{I} - \mathbf{\Lambda}'(\mathbf{\Lambda}\mathbf{\Lambda}' + \mathbf{\Sigma})^{-1}\mathbf{\Lambda}$$

The choice of prior distributions is always a challenge in Bayesian statistics, but those assigned to the parameters here are the standard ones often employed in applied research in economic and finance (Koop 2003). Our results from the Gibbs sampling method are based on 10,500 replications with 500 burn-in observations which seem to be adequate to achieve convergence.

One way to show the estimated global and idiosyncratic factors is to present their contribution to the overall variation in the real effective exchange rates. Thus, the significance of common and country-specific factors is analyzed using the variance decomposition method (Table 4). Our results suggest that a large portion (about 70 to 80 percent) of a variation in real effective exchange rates is attributable to the country-specific elements, and are generally invariant even if a different sample period and country coverage become research targets. Since this is the first attempt to decompose real effective exchange rates, we cannot compare with previous findings. However, one interesting outcome is that advanced countries have experienced a higher proportion of country-specific movements, implying relatively more heterogeneous responses of these countries in response to the recent financial crises (the Lehman Shock (2008) and the Greek and European sovereign debt crises (2009 onwards). In contrast, although it is not a significant difference, non-advanced countries follow more closely the common movements after the Lehman Shock.

4.3. Characteristics of latent factors

Next, we analyze the characteristics of the global factor by checking if this factor is persistent and contains a structural shift. If they are significant, we need to incorporate these characteristics in subsequent analyses. First, whether or not the global factor is persistent is examined by evaluating a fractional differencing parameter (*d*) which can measure persistence in time-series data. This parameter is the focus of unit root tests which often examine if data follow a stationary ($d = 0$) or unit root ($d = 1$) process. Here we allow the possibility that *d* does not need to be exactly one of these two extreme values. In that case the data can be shown to be stationary if $-1/2 < d < 1/2$, and have a long memory if $0 < d < 1/2$ (e.g., Granger and Joyeux (1980)).

We have estimated the size of *d* for $\mathbf{F}_t$, which is common across countries, by Geweke and Porter-Hudak (1983, GPH) and by Phillips (1999) who has modified the GPH method for nonstationary data by using the log periodogram regression. Our estimates from these two methods are -0.047 [0.263] and -0.180 [0.269] respectively where the numbers in brackets are standard errors. Thus our estimates of *d* are not statistically significant from zero, and provide evidence against the long memory of the global factor.

Therefore, it raises support for the specification of our factor model.

Furthermore, given the number of economic and financial crises during our sample period, we have also checked if global and country-specific factors contain a structural shift. In this connection, three statistical tests have been conducted to analyze the null hypothesis of no structural breaks: the sup*F*, ave*F*, and exp*F* tests (Andrew (1993), Andrew and Ploberger (1994)). They are popular approaches for detecting a structural shift in stationary data utilizing *F* statistics obtained from shortened sample periods (discarding the first and last 15 percent observations). The large size of these statistics becomes evidence of a structural shift in the data. In order to evaluate the statistical hypotheses, *p*-values are calculated following Hansen (1997).

Our results suggest evidence of structural shifts in country-specific factors of real effective exchange rates (Table 5, Figure 2); in contrast, there is no sign of structural breaks in the common factor. Therefore, it appears that abnormal changes in external competitiveness have been largely attributable to countries' own economic responses. This may be surprising because global financial crises have adverse impacts on many countries thus one may expect to have structural shifts in the common factor in real effective exchange rates. Thus again this implies that heterogeneity in real effective exchange rates results from country-specific factors.

5. Economic explanations of each factor

5.1. Country-specific factors

Then what would explain the country-specific factors in real effective exchange rates? Based on our findings on the characteristics of data, we analyze this using idiosyncratic components in real interest rates. Since the country-specific factors are supposed to be independent across countries, the Mean Group (MG) estimate approach which assumes no cross-sectional dependence across countries is used to understand the relationship between heterogeneity in country-specific real effective exchange rates and interest rates. The MG is useful for obtaining the sensitivity of these two rates while taking into account heterogeneous sensitivities (slopes) among countries (Pesaran and Smith

(1995)). We obtain the MG parameter for the panel data by averaging the parameters obtained from individual country analyses. Furthermore, given that there are structural breaks in our data, the specification of countries which have experienced structural breaks contain a dummy variable. This dummy is equal to one after the breakpoint identified by the *F* test (Figure 2), and otherwise is equal to zero. The countries which did not exhibit a structural break do not contain any dummy.

Table 6 summarizes results from the OLS and MG methods for the purposes of comparison. The parameters of real interest rates are of the most interest to us, and are reported to be negative and statistically significant, consistent with economic theory. While the size and the statistical significance of this parameter differ among countries, the negative relationship between country-specific movements in real effective exchange rates and interest rates has been confirmed in the majority of countries.

5.2.Global factor

Similarly, we analyze the relationship between the global component in the real effective exchange rates and the world real interest rates. Here, the global factor is calculated as $\mathbf{\Lambda}_n\mathbf{F}_t$ and thus differs among countries. However, being different from the country-specific factor, this global factor is expected to be correlated across countries. Therefore, we examine this relationship using the Augmented MG (AMG) which takes into account the common time effect in our panel data. This time effect captures common elements in the global factor, and thus yields consistent estimates. The estimation of the AMG consists of two steps, and first we obtain the time effects by means of the following equation. For a vector of common factors ($\mathbf{\Lambda}_n\mathbf{F}_t$),

$$\Delta\mathbf{x}_{nt} = b'\ \Delta\boldsymbol{z}_{nt} + c_t\Delta\boldsymbol{D}_t + \boldsymbol{e}_{nt} \tag{17}$$

where $\boldsymbol{D}$ is equal to one for a particular year and otherwise zero. Thus this dummy can be considered to capture the common factor. The second step involves the estimation of Eq. (18) using the common time effect obtained from Eq. (17):

$$\mathbf{x}_{nt} = b_n'\boldsymbol{z}_{nt} + c_n\mu_t + \boldsymbol{e}_{nt} \tag{18}$$

where $\mu_t = \hat{c}_t$.These two steps are estimated by the OLS, and the slope for panel data can be calculated by $\tilde{b} = N^{-1}\sum_{i=1}^{N} b_i$ (Eberhardt and Bond (2009)).

Table 7 summarizes the results from the AMG and confirms the positive and significant relationship between the global factor in the real exchange rates and the world interest rate. This relationship is consistent with theoretical predictions depicted in Eq. (5), and implies that a rise in the global interest rate will reduce the value of currencies worldwide. This table also presents country-specific (i.e., the first step) results, confirming the positive relationship between these two variables although the statistical significance differs among countries.

6. Conclusion

For a large group of countries, we have analyzed if there is any common trend in real effective exchange rates which can be regarded as a proxy for the external competitiveness of countries. Then, we have confirmed that there is a unique trend in these rates. However, the majority of movements in real effective exchange rates are found to be idiosyncratic rather than common factors. This implies that the external competitiveness of a country is rather country-specific and thus a country losing market competitiveness cannot solely blame external factors responsible.

Our further analysis suggests that this common trend can be explained by the global interest rate computed by the factor model, and in contrast the country-specific movements by idiosyncratic movements in interest rate changes. Therefore, our results imply that the world economies trend to lose competitiveness simultaneously, but that the degree to which competitiveness has changed is largely determined by their economic policies.

Our findings are also in contrast to previous studies which have often reported the relationship between exchange rates and interest rates. In particular, previous studies often find the wrong parameter sign for interest rates in an exchange rate equation. Recent studies point to the importance of private information, carry trades, investors' irrationality, risk premiums, among many others. While a direct comparison cannot be made between studies on nominal and real exchange rates, our results which are more consistent with theoretical predictions may be attributable to the consideration of low frequency data and the third country effect that has often been ignored in previous studies focusing on bilateral exchange rates.

References

Alessi, L., M. Barigozzi and M. Capasso (2010). Improved penalization for determining the number of factors in approximate factor models. Statistics and Probability Letters 80, 1806-1813.

Andrews, D. W. K. (1993). Tests for parameter instability and structural change with unknown change point. Econometrica 61(4), 821–856.

Andrews, D. W. K. and W. Ploberger (1994). Optimal tests when a nuisance parameter is present only under the alternative, Econometrica 62(6), 1383-1414.

Bai, J. and S. Ng (2002). Determining the number of factors in approximate factor models. Econometrica 70, 191-221.

Bayoumi, T., G. Fazio, M. Kumar, and R. MacDonald (2007). Fatal attraction: Using distance to measure contagion in good times as well as bad. Review of Financial Economics 16(3), 259 – 273.

Bernanke, B., J. Boivin, and P. S. Eliasz (2005). Measuring the effects of monetary policy: A factor-augmented vector autoregressive (FAVAR) approach. The Quarterly Journal of Economics 120(1), 387–422.

Bhalla, S. S. (2008). Economic development and the role of currency undervaluation. Cato Journal 28, 313–340.

Brixiova, Z., B. Egert, and T. H. A. Essid (2013). The real exchange rate and external com- petitiveness in Egypt, Morocco and Tunisia. African Development Bank Group Working Paper 187.

Byrne, J. P. and J. Nagayasu (2010). Structural breaks in the real exchange rate and real interest rate relationship. Global Finance Journal 21(2), 138–151.

Canova, F. and M. Ciccarelli (2009). Estimating multicountry VAR models. International Economic Review 50(3), 929–959.

Cayen, J.-P., D. Coletti, R. Lalonde, and P. Maier (2010). What drives exchange rates? new evidence from a panel of U.S. dollar bilateral exchange rates. Technical report, Bank of Canada Working Paper 2010-5.

Chinn, M. D. and J. A. Frankel (1995). Who drives real interest rates around the Pacific Rim: the USA or Japan? Journal of International Money and Finance 14(6), 801-821.

Choi, I. (2001). Unit root tests for panel data. Journal of International Money and Finance 20, 249–272.

Cumby, R. E. and F. S. Mishkin (1986). The international linkage of real interest rates: the European-US connection. Journal of International Money and Finance 5(1), 5-23.

Dungey, M. (1999). Decomposing exchange rate volatility around the Pacific Rim. Journal of Asian Economics 10(4), 525 – 535.

Eberhardt, M. and S. Bond, 2009, Cross-section dependence in nonstationary panel models: a novel estimator, MPRA No. 17870.

Edison, H. J. and W. R. Melick (1999). Alternative approaches to real exchange rates and real interest rates: three up and three down. International Journal of Finance & Economics 4(2), 93-111.

Edison, H. J. and B. D. Pauls (1993). A re-assessment of the relationship between real exchange rates and real interest rates: 1974–1990. Journal of Monetary Economics 31, 165–87.

Fisher, R. A. (1932). Statistical Methods for Research Workers 4th ed. Edinburgh: Oliver & Boyd.

Foerster, A. T., P.-D. G. Sarte, and M. W. Watson (2011). Sectoral versus aggregate shocks: A structural factor analysis of industrial production. Journal of Political Economy 119, 1 – 38.

Forbes, K. J. and R. Rigobon (2002). No contagion, only interdependence: Measuring stock market comovements. Journal of Finance 57(5), 2223–2261.

Forni, M., M. Hallin, M. Lippi, and L. Reichlin (2000). The generalized dynamic-factor model: Identification and estimation. The Review of Economics and Statistics 82(4), pp. 540–554.

Frankel, J. and S.-J. Wei (2008). Estimation of de facto exchange rate regimes: Synthesis of the techniques for inferring flexibility and basket weights. IMF Staff Papers 55(3), 384–416.

Gagnon, J. E. and M. D. Unferth (1995). Is there a world real interest rate? Journal of International Money and Finance 14(6), 845-855.

Gerlach, S. and F. Smets (1995). Contagious speculative attacks. European Journal of Political Economy 11(1), 45–63.

Geweke, J. and G. Zhou (1996). Measuring the pricing error of the arbitrage pricing theory. Review of Financial Studies 9, 557-587.

Geweke, J. and S. Porter-Hudak (1983). The estimation and application of long memory time series models. Journal of Time Series Analysis, 221-238.

Goodwin, B. K. and T. J. Grennes (1994). Real interest rate equalization and the integration of international financial markets. Journal of International Money and Finance 13(1), 107-124.

Granger, C. W. J and R. Joyeux (1980). An introduction to long-memory time series models and fractional differencing. Journal of Time Series Analysis 1(1), 15-29.

Hallwood, C. P. and R. MacDonald, 2000, International Money and Finance, 3rd ed., Oxford: Blackwell.

Hansen, B. E. (1997). Approximate asymptotic p values for structural-change tests. Journal of Business & Economic Statistics 15(1), 60-67.

Koedijk, K. and P. Schotman (1989). Dominant real exchange rate movements. Journal of International Money and Finance 8(4), 517 – 531.

Koop, G. (2003). Bayesian Econometrics. John Wiley & Sons.

Kose, M. A., C. Otrok, and C. H. Whiteman (2003). International business cycles: World, region, and country-specific factors. American Economic Review 93(4), 1216–1239.

Levin, A., C.-F. Lin, and C.-S. J. Chu (2002). Unit root tests in panel data: Asymptotic and finite-sample properties, Journal of Econometrics 108, 1–24.

Liu, Y., M.-S. Pan, and J. Shieh (1998). International transmission of stock price movements: Evidence from the U.S. and five Asian-Pacific markets. Journal of Economics and Finance 22, 59–69.

Longin, F. and B. Solnik (1995). Is the correlation in international equity returns constant: 1960-1990? Journal of International Money and Finance 14(1), 3–26.

MacDonald, R., and J. Nagayasu (2000). The long-run relationship between real exchange rates and real interest rate differentials: a panel study. IMF Staff Papers 47(1), 116-128.

Masson, P. R. (1998). Contagion-monsoonal effects, spillovers, and jumps between multiple equilibria. IMF Working Papers 98/142, International Monetary Fund.

Mbaye, S. (2013). Currency uundervaluation and growth: is there a productivity channel? International Economics 133, 8-28.

McKinnon, R. and G. Schnabl (2003). Synchronised business cycles in east asia and fluctuations in the yen/dollar exchange rate. The World Economy 26(8), 1067–1088.

Monadjemi M. (1997). International interest rates linkages: evidence from OECD countries. International Review of Financial Analysis 6(3), 229-240.

Mumtaz, H. and P. Surico (2012). Evolving international inflation dynamics: world and country- specific factors. Journal of the European Economic Association 10(4), 716–734.

Nellis, J. G. (1982). A principal components analysis of international financial integration under fixed and floating exchange rate regimes. Applied Economics 14 (4), 339–354.

Obstfeld, M. and R. S. Kenneth (1996). Foundations of International Macroeconomics. MIT Press.

Pesaran, M. H. and R. Smith (1995). Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics 68(1), 79-113.

Phillips, P. C.B., 1999, Discrete fourier transforms of fractional processes, 1999, Working paper No. 1243, Cowles Foundation for Research in Economics, Yale University.

Reinhart, C. M. and S. Calvo (1996). Capital flows to Latin America: Is there evidence of contagion effects? In G. A. Calvo, M. Goldstein, and E. Hochreiter (Eds.), Private Capital Flows to Emerging Markets After the Mexican Crisis, Peterson Institute Press: Chapters, pp. 151–171. Peterson Institute for International Economics.

Rodrik, D. (2008). The real exchange rate and growth. Harvard University.

UNCTAD (2012). Development and globalization: facts and figures 2012. UNCTAD: Geneva.

Volosovych, V. (2013). Learning about financial market integration from principal components analysis. CESifo Economic Studies 59(2), 360–391.

Table 1. List of countries and data sources

		Interest rates				Interest rates	
id	Country	Market rate	Deposit rate	id	Country	Market rate	Deposit rate
111	United States *	○		328	Grenada		
112	United Kingdom *			336	Guyana		
122	Austria *			361	St. Kitts and Nevis		
124	Belgium *			362	St. Lucia		
128	Denmark *			364	St. Vincent and the Grenadines		
132	France *			369	Trinidad and Tobago		
134	Germany *			419	Bahrain, Kingdom of		
136	Italy *			423	Cyprus *		
137	Luxembourg *			429	Iran, Islamic Republic of		
138	Netherlands *			436	Israel *		
142	Norway *			456	Saudi Arabia		
144	Sweden *	○		548	Malaysia		○
146	Switzerland *	○		564	Pakistan	○	
156	Canada *	○		566	Philippines	○	
158	Japan *	○		576	Singapore *		○
163	Euro Area			612	Algeria		
172	Finland *	○		618	Burundi		
174	Greece *			622	Cameroon		
176	Iceland *			626	Central African Republic		
178	Ireland *	○		646	Gabon		
181	Malta *			648	Gambia, The		
182	Portugal *			652	Ghana		
184	Spain *	○		662	Cote d'Ivoire		
193	Australia *	○		666	Lesotho		
196	New Zealand *			676	Malawi		
199	South Africa	○		686	Morocco		
218	Bolivia			694	Nigeria		
223	Brazil			724	Sierra Leone		
228	Chile			742	Togo		
233	Colombia			744	Tunisia		
238	Costa Rica			746	Uganda		
243	Dominican Republic			754	Zambia		
248	Ecuador			813	Solomon Islands		
273	Mexico		○	819	Fiji		
288	Paraguay			853	Papua New Guinea		
298	Uruguay		○	862	Samoa		
299	Venezuela, Republica Bolivariana de			924	China, P.R.: Mainland		
311	Antigua and Barbuda			944	Hungary		○
313	Bahamas, The			964	Poland		
321	Dominica						

Note: Advanced countries are marked with the asterisk.

Table 2. Basic statistics of changes in real effective exchange rates

Country	ave	std dev	Country	ave	std dev
United States	-0.155	6.584	Grenada	-0.052	5.254
United Kingdom	-0.079	7.268	Guyana	-6.341	23.622
Austria	0.176	2.352	St. Kitts and Nevis	0.042	4.043
Belgium	-0.318	3.514	St. Lucia	0.050	4.462
Denmark	0.253	3.218	St. Vincent and the Grenadines	-0.307	5.355
France	-0.505	3.185	Trinidad and Tobago	1.112	9.509
Germany	-0.382	3.980	Bahrain, Kingdom of	-1.800	7.602
Italy	0.159	4.967	Cyprus	-0.362	3.208
Luxembourg	-0.184	2.155	Iran, Islamic Republic of	-2.620	49.072
Netherlands	-0.142	3.508	Israel	0.294	5.665
Norway	0.040	4.307	Saudi Arabia	-2.495	7.304
Sweden	-1.023	6.547	Malaysia	-1.333	6.924
Switzerland	0.668	4.943	Pakistan	-1.902	6.611
Canada	0.066	6.432	Philippines	-0.615	9.582
Japan	0.172	10.687	Singapore	0.506	4.759
Euro Area	-0.592	7.840	Algeria	-3.262	13.585
Finland	-0.359	5.461	Burundi	-1.364	11.750
Greece	0.478	3.928	Cameroon	-0.889	9.364
Iceland	-0.754	9.467	Central African Republic	-1.516	10.954
Ireland	0.236	5.084	Gabon	-2.164	10.386
Malta	-0.222	3.535	Gambia, The	-3.730	10.803
Portugal	0.804	3.785	Ghana	-6.941	40.108
Spain	0.240	4.733	Cote d'Ivoire	-0.742	10.876
Australia	0.275	8.928	Lesotho	-2.638	17.021
New Zealand	0.892	8.516	Malawi	-3.161	19.247
South Africa	-2.039	12.151	Morocco	-1.122	3.817
Bolivia	-0.815	29.583	Nigeria	-2.474	38.498
Brazil	0.475	15.928	Sierra Leone	-2.599	36.069
Chile	-1.434	9.802	Togo	-1.322	10.839
Colombia	-0.875	10.661	Tunisia	-2.470	5.827
Costa Rica	-0.707	14.070	Uganda	-8.703	33.525
Dominican Republic	-1.111	14.358	Zambia	-2.106	28.105
Ecuador	-1.545	15.481	Solomon Islands	-0.281	11.148
Mexico	-0.398	15.487	Fiji	-1.262	6.964
Paraguay	-1.069	11.669	Papua New Guinea	-0.315	9.044
Uruguay	0.734	12.341	Samoa	-0.157	6.334
Venezuela, Republica Bolivariana de	1.203	20.395	China, P.R.: Mainland	-2.439	11.946
Antigua and Barbuda	-0.892	6.594	Hungary	1.405	6.249
Bahamas, The	-0.011	4.386	Poland	-5.726	46.158
Dominica	-0.466	4.742			

Note: “ave” shows the average value of exchange rates.

Table 3. The stationarity of real effective exchange rates and real interest rates

		Real exchange rates		Real interest rates	
		Statistics	p-value	Statistics	p-value
LLC	t	-2.879	0.002	-3.025	0.001
Inverse chi-square (34)	P	165.968	0.000	155.832	0.000
Inverse normal	Z	-9.721	0.000	-8.172	0.000
Inverse logit	L*	-11.111	0.000	-10.073	0.000
Modified inverse chi-square	Pm	16.003	0.000	14.774	0.000

Note: the LLC is the panel unit root test developed by (Levin, Lin and Chiu 2002), and others by Choi (2001).

Table 4. The variance decomposition of real effective exchange rates

	1981Q1-2014Q3		1999Q1-2014Q3		2008:Q3-2014Q3	
A group of countries	**ΛF**	***e***	**ΛF**	***e***	**ΛF**	***e***
All countries	0.228	0.772	0.233	0.767	0.333	0.667
17 countries	0.178	0.822	0.181	0.819	0.304	0.696
Non-advanced countries	0.214	0.786	0.178	0.823	0.400	0.600
Advanced countries	0.257	0.743	0.336	0.664	0.216	0.784

Note: **ΛF** represents common factors and ***e*** idiosyncratic factors.

Table 5. Structural shifts in the common and idiosyncratic factors

	expF	p-value	supF	p-value	aveF	p-value
Exchange rates (Common+idiosyncractic)						
United States	0.950	0.205	5.440	0.175	1.115	0.295
Sweden	0.470	0.444	3.478	0.406	0.753	0.452
Switzerland	0.705	0.299	6.504	0.109	0.794	0.430
Canada	2.314	0.036	8.941	0.036	2.604	0.069
Japan	5.765	0.000	16.950	0.001	7.248	0.001
Finland	3.157	0.012	11.444	0.011	2.037	0.114
Ireland	1.094	0.167	5.979	0.138	1.542	0.186
Spain	0.697	0.302	3.084	0.477	1.127	0.291
Australia	2.675	0.023	9.613	0.026	3.565	0.031
South Africa	0.434	0.474	5.009	0.211	0.500	0.621
Mexico	1.857	0.062	10.628	0.016	0.997	0.338
Uruguay	4.765	0.001	14.868	0.002	4.301	0.017
Malaysia	1.837	0.064	6.995	0.087	2.657	0.066
Pakistan	6.480	0.000	17.541	0.001	11.238	0.000
Philippines	3.844	0.004	12.373	0.007	4.667	0.013
Singapore	3.612	0.006	11.285	0.012	3.580	0.031
Hungary	2.903	0.017	10.338	0.019	2.674	0.065
Common factor						
	0.550	0.386	3.091	0.475	0.956	0.355
Idiosyncratic factor						
Canada	2.525	0.028	9.597	0.026	2.715	0.062
Japan	5.301	0.000	15.606	0.002	6.844	0.001
Finland	2.310	0.036	9.523	0.027	1.753	0.150
Australia	2.889	0.018	10.452	0.018	3.408	0.035
Mexico	1.576	0.088	10.580	0.017	0.739	0.460
Uruguay	3.741	0.005	12.108	0.008	3.561	0.031
Malaysia	2.153	0.044	8.530	0.043	2.493	0.076
Pakistan	13.346	0.000	34.030	0.000	13.108	0.000
Philippines	3.340	0.009	10.897	0.014	4.232	0.018
Singapore	3.726	0.005	11.968	0.009	3.873	0.024
Hungary	5.355	0.000	16.742	0.001	4.338	0.017

Note: the tests based on Andrew (1993) and Andrews and Ploberger (1994).

Table 6. OLS and Mean Group (MG) estimators for country-specific factors.

OLS	Coef.	Std Err	*p*-value		Coef.	Std Err	*p*-value
R	-0.012	0.002	0.000	Group-specific		Australia	
Dummy	0.251	0.051	0.000	R	0.012	0.038	0.743
Constant	0.000	0.021	0.997	Dummy	0.588	0.211	0.005
MG				Constant	-0.275	0.223	0.217
R	-0.032	0.016	0.042			South Africa	
Dummy	0.085	0.086	0.324	R	-0.030	0.020	0.129
Constant	0.036	0.055	0.514	Constant	0.082	0.101	0.417
Group-specific		United States				Mexico	
R	0.070	0.016	0.000	R	-0.020	0.009	0.022
Constant	-0.130	0.054	0.015	Constant	0.012	0.076	0.876
		Sweden				Uruguay	
R	-0.010	0.024	0.658	R	-0.007	0.003	0.034
Constant	0.035	0.115	0.760	Dummy	0.759	0.254	0.003
		Switzerland		Constant	-0.483	0.280	0.085
R	-0.099	0.041	0.015			Malaysia	
Constant	0.053	0.081	0.511	R	-0.094	0.034	0.006
		Canada		Constant	0.214	0.109	0.049
R	-0.051	0.032	0.109			Pakistan	
Constant	0.144	0.124	0.244	R	-0.056	0.020	0.005
		Japan		Dummy	0.683	0.133	0.000
R	-0.047	0.079	0.547	Constant	-0.230	0.084	0.006
Dummy	-0.781	0.308	0.011			Philippines	
Constant	0.525	0.299	0.080	R	-0.052	0.016	0.001
		Finland		Dummy	0.360	0.177	0.042
R	-0.066	0.023	0.004	Constant	0.057	0.115	0.619
Constant	0.221	0.111	0.046			Singapore	
		Ireland		R	-0.151	0.030	0.000
R	-0.048	0.017	0.005	Constant	-0.159	0.195	0.414
Constant	0.138	0.086	0.107	R	0.142	0.089	0.110
		Spain				Hungary	
R	-0.038	0.019	0.049	R	0.139	0.023	0.000
Constant	0.102	0.088	0.245	Constant	-0.002	0.074	0.976

Note: “R” is home interest rates, and “Dummy” is one after the structural break and zero otherwise. Mean Group (MG) estimations are based on Pesaran and Smith (1995).

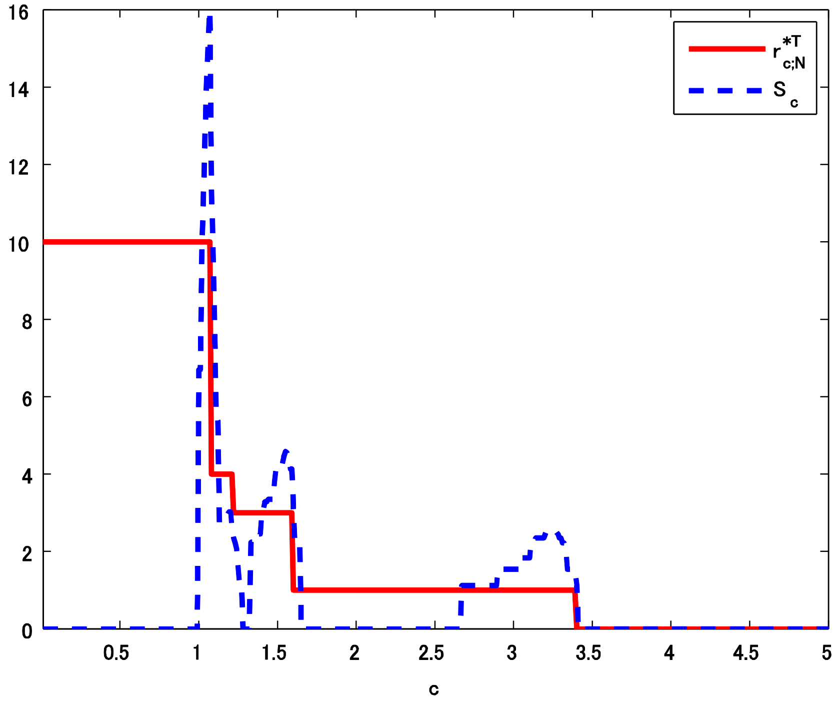
Table 7. Augmented Mean Group (AMG) estimators for common factors

	Coef.	Std.Err.	*p*-value	Coef.	Std.Err.	*p*-value
AMG					Australia	
R*	0.324	0.135	0.017	-0.070	0.119	0.560
Common	1.000	0.224	0.000	1.164	0.231	0.000
Constant	0.474	0.106	0.000	0.552	0.139	0.000
Individual countries		United States			South Africa	
R*	0.064	0.121	0.599	1.091	2.673	0.683
Common	0.244	0.219	0.266	0.693	0.351	0.048
Constant	0.116	0.132	0.380	0.329	0.211	0.119
		Sweden			Mexico	
R*	0.432	0.186	0.020	0.443	0.465	0.340
Common	1.467	0.269	0.000	1.029	0.360	0.004
Constant	0.696	0.162	0.000	0.488	0.216	0.024
		Switzerland			Uruguay	
R*	0.714	0.841	0.396	-0.190	0.154	0.218
Common	1.028	0.348	0.003	0.098	0.308	0.750
Constant	0.488	0.209	0.020	0.046	0.185	0.802
		Canada			Malaysia	
R*	0.126	0.122	0.302	0.200	0.156	0.198
Common	1.315	0.238	0.000	1.756	0.268	0.000
Constant	0.624	0.143	0.000	0.833	0.161	0.000
		Japan			Pakistan	
R*	-0.048	0.112	0.666	-0.165	0.813	0.839
Common	-1.353	0.216	0.000	2.024	0.302	0.000
Constant	-0.642	0.130	0.000	0.960	0.182	0.000
		Finland			Philippines	
R*	0.125	0.149	0.404	2.098	0.790	0.008
Common	0.830	0.299	0.005	2.638	0.308	0.000
Constant	0.394	0.180	0.028	1.251	0.185	0.000
		Ireland			Singapore	
R*	0.194	0.165	0.239	0.273	0.148	0.065
Common	0.618	0.297	0.038	2.221	0.269	0.000
Constant	0.293	0.179	0.101	1.053	0.162	0.000
		Spain			Hungary	
R*	0.168	0.151	0.267	0.051	0.155	0.740
Common	0.426	0.295	0.148	0.802	0.215	0.000
Constant	0.202	0.177	0.254	0.380	0.129	0.003

Note: The augmented MG (AMG) is based on Eberhardt and Bond (2009).

Figure 1. Identifying the number of common factors

a) Real effective exchange rates



b) Real interest rates

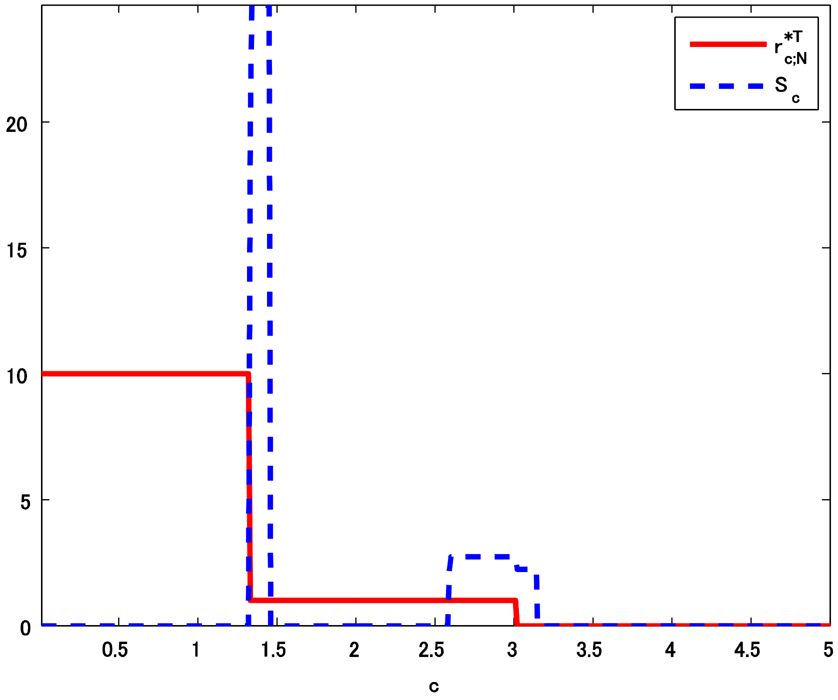
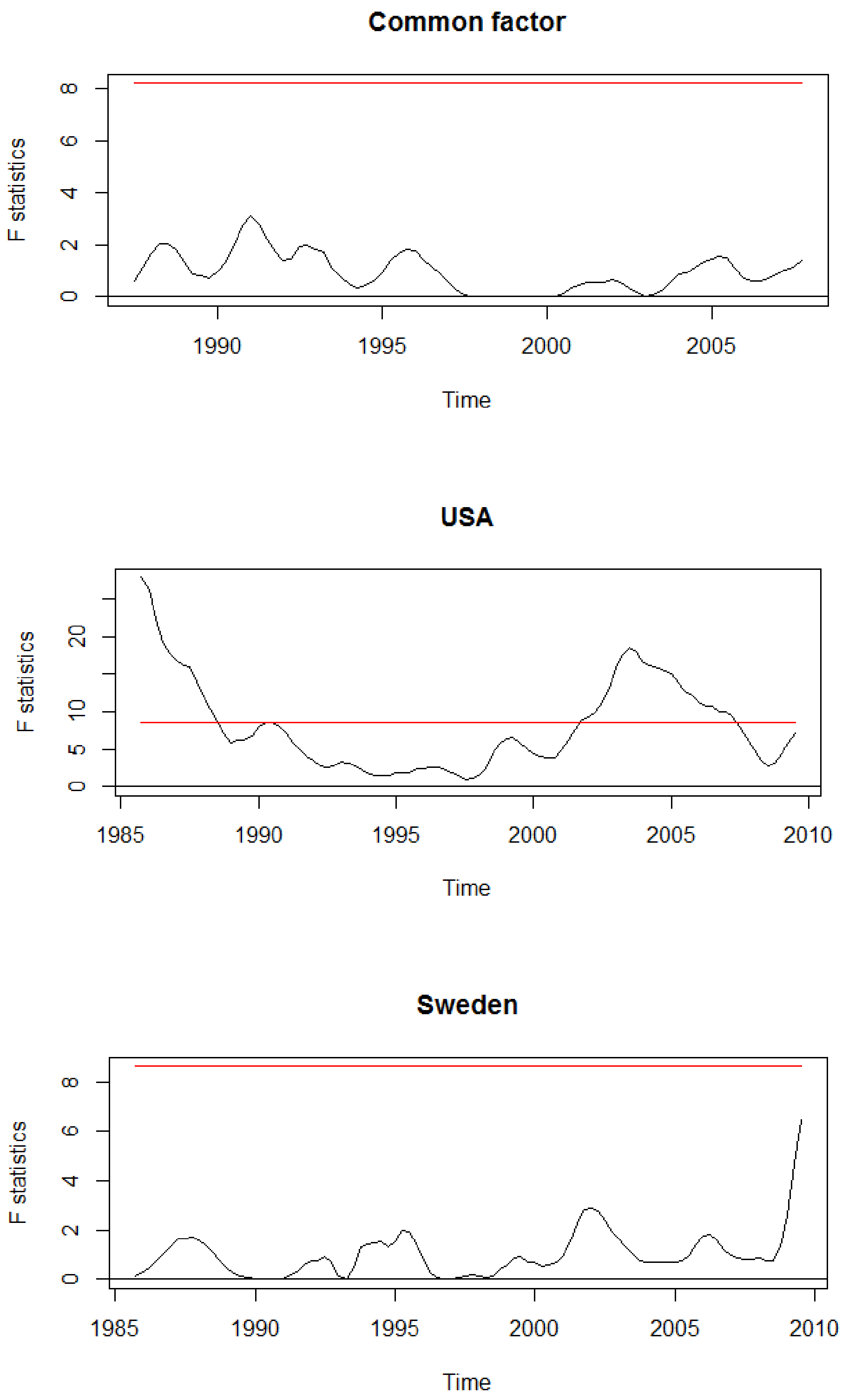
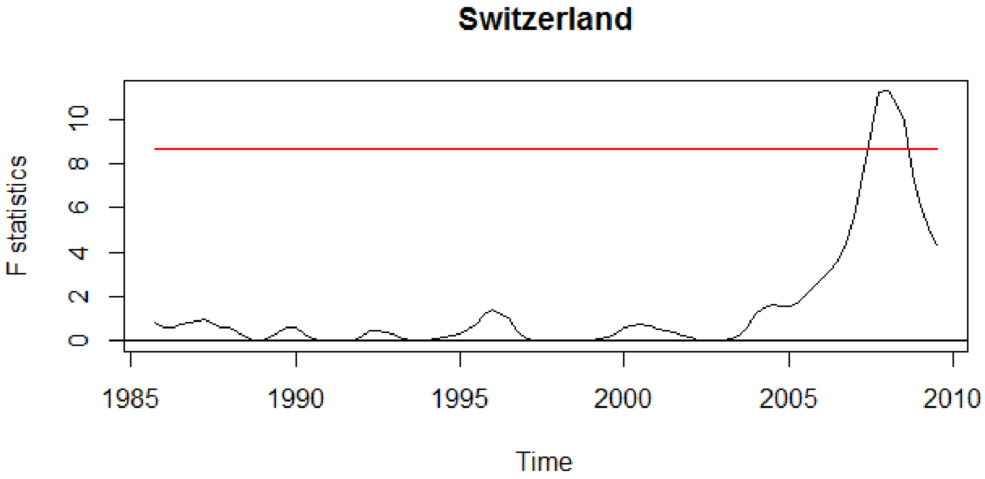


Figure 2. F test for the common and idiosyncratic factors

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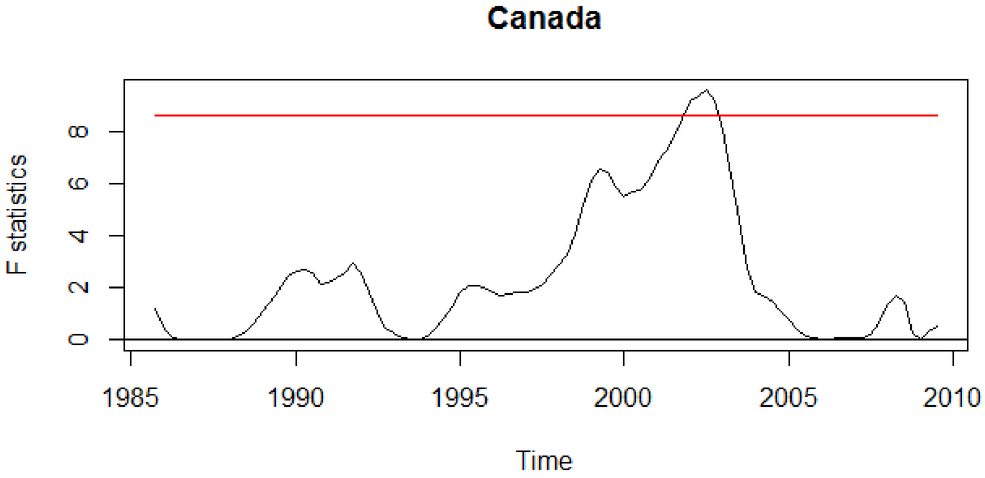
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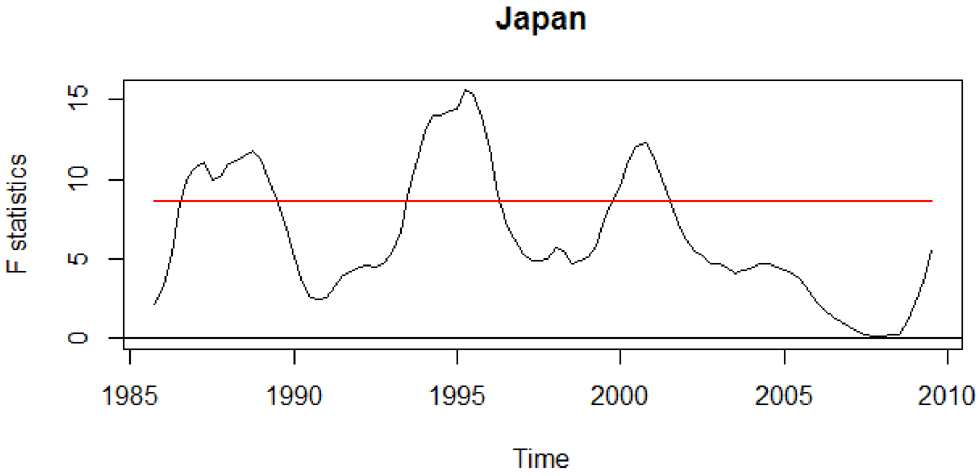
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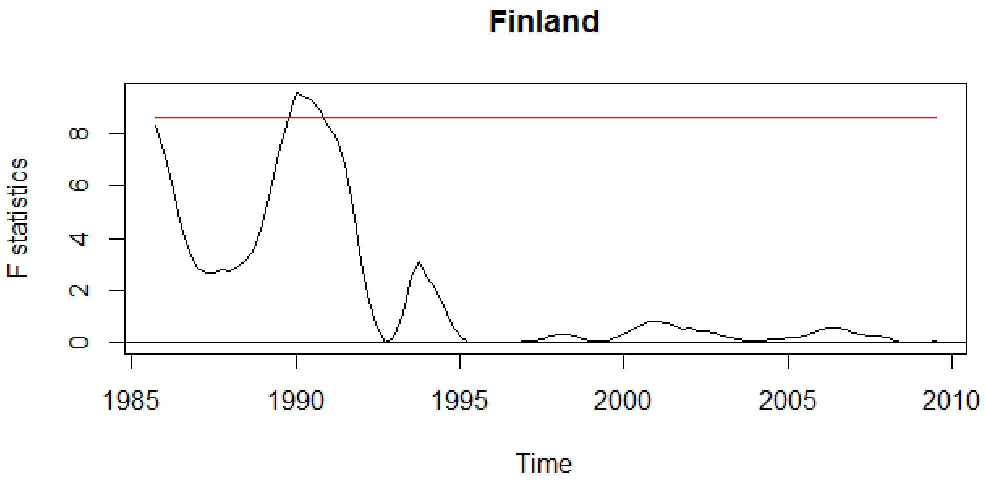
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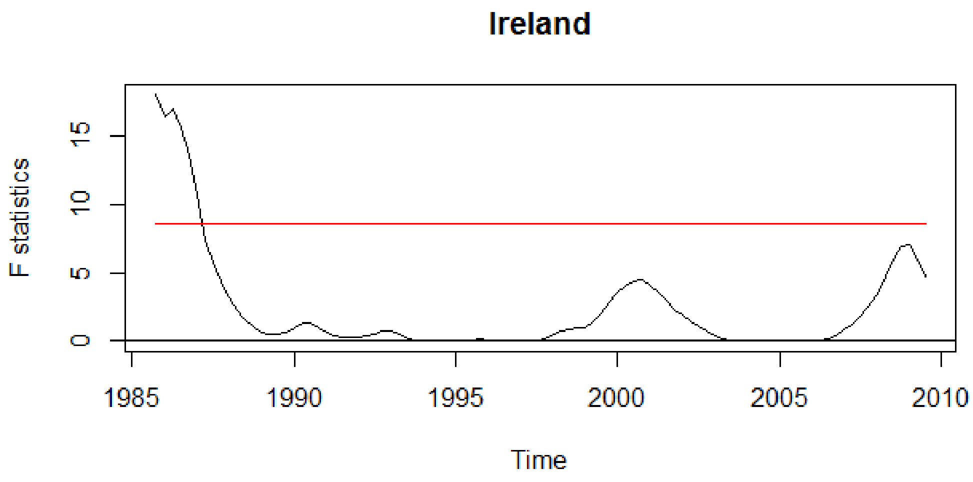
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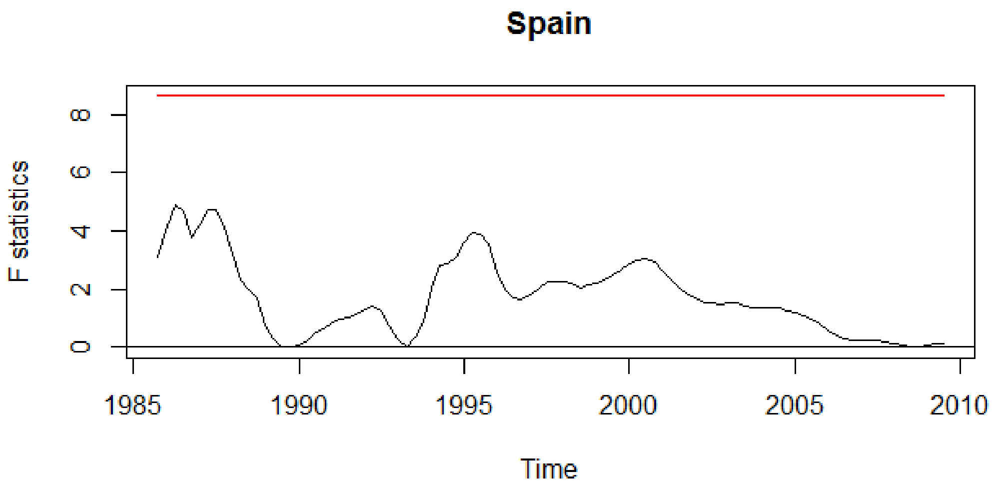
Spain
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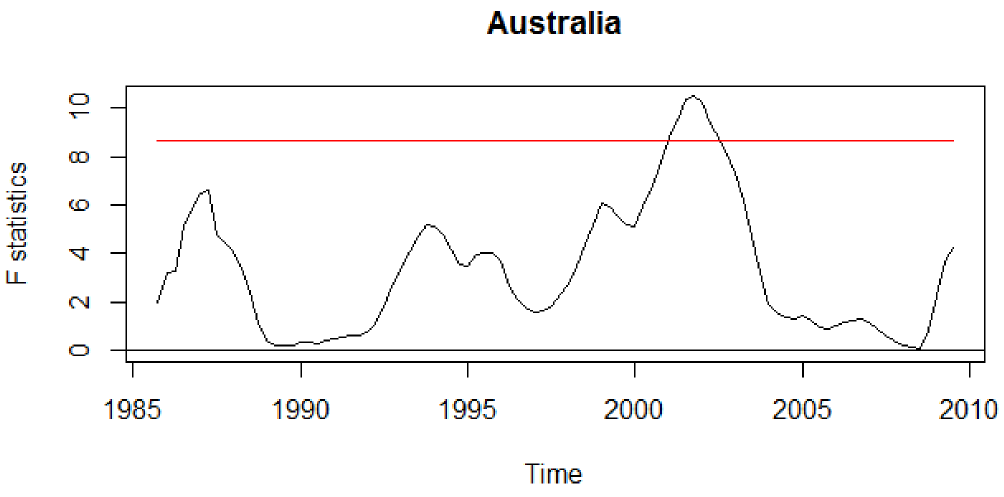
1985
1990
1995
2000
2005
2010
Time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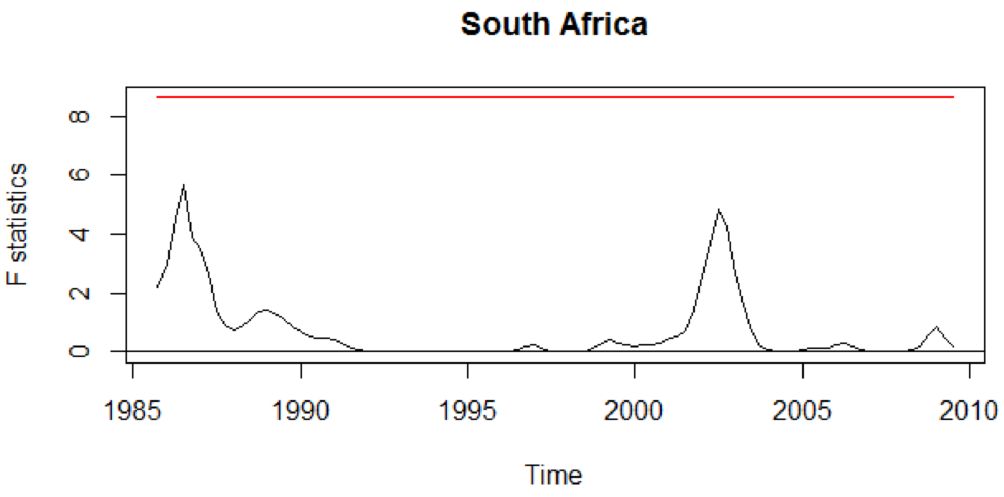
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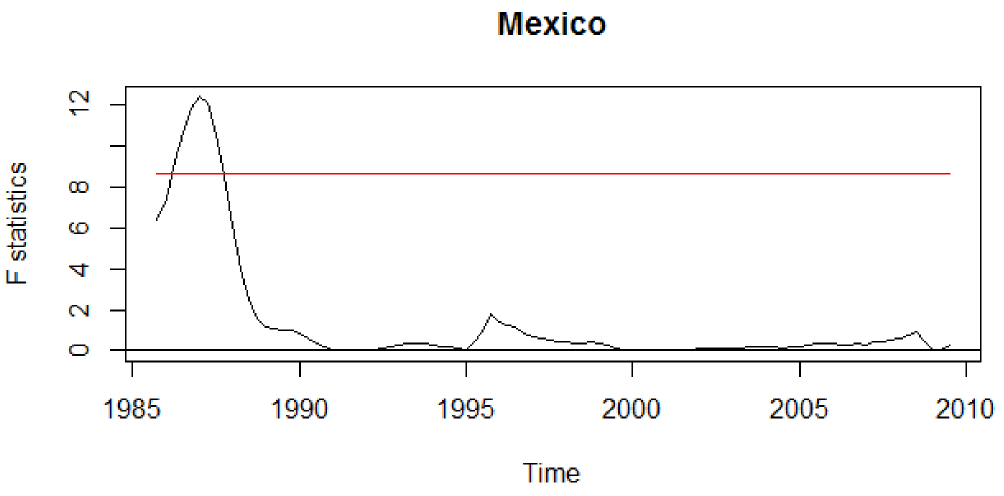
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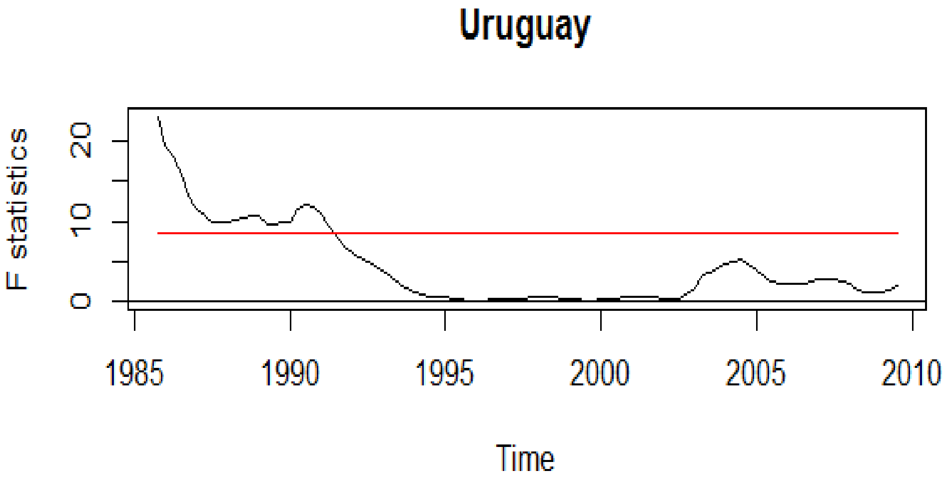
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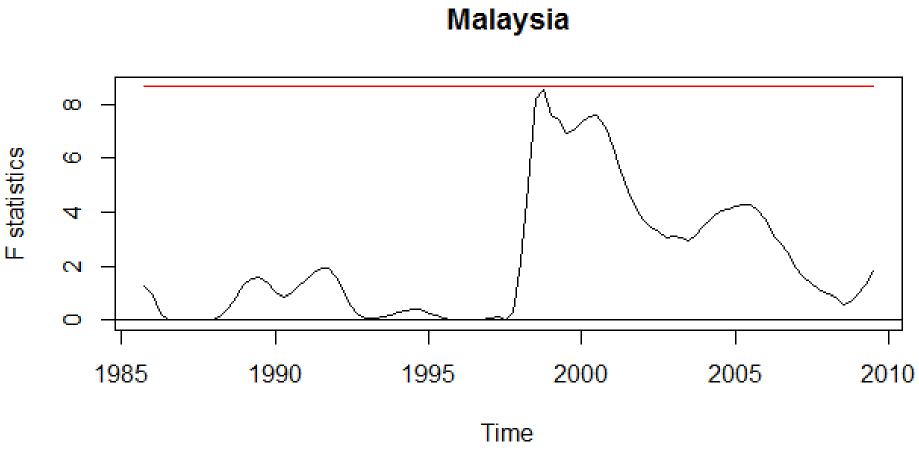
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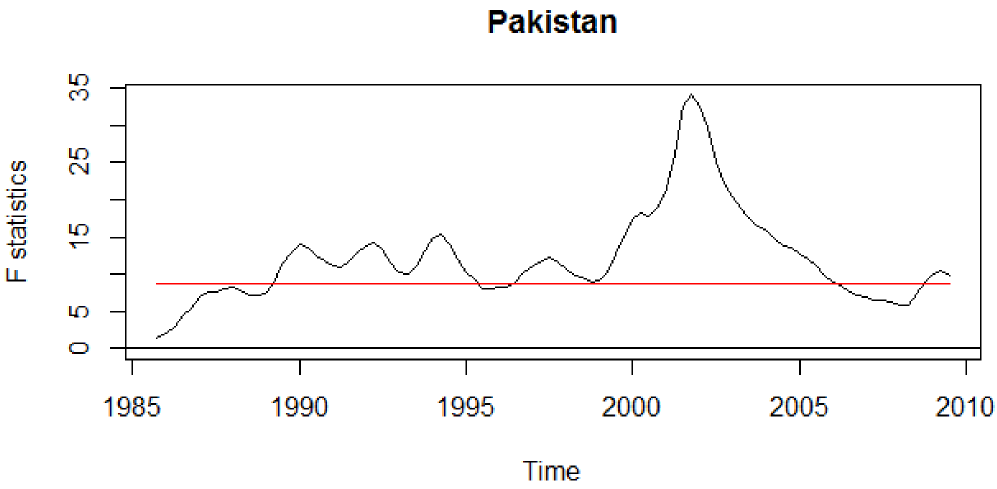
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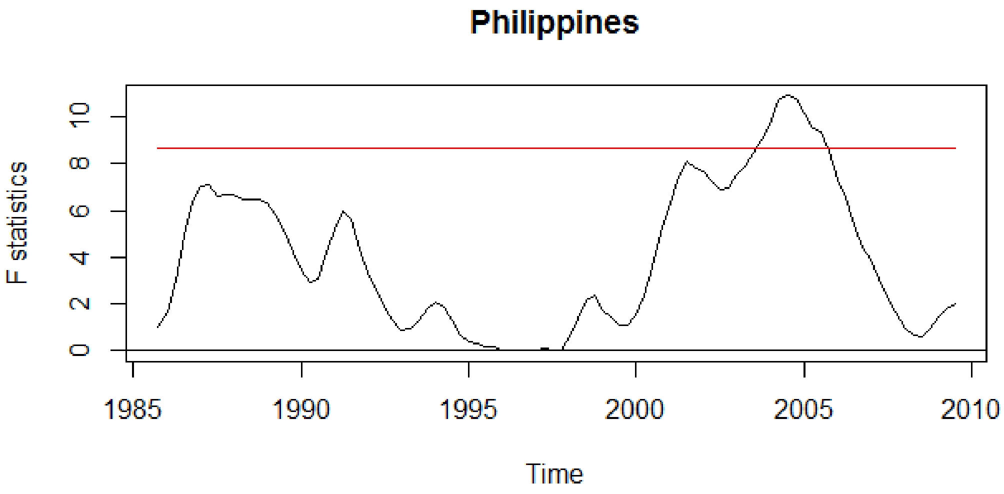
Philippines
F statistics
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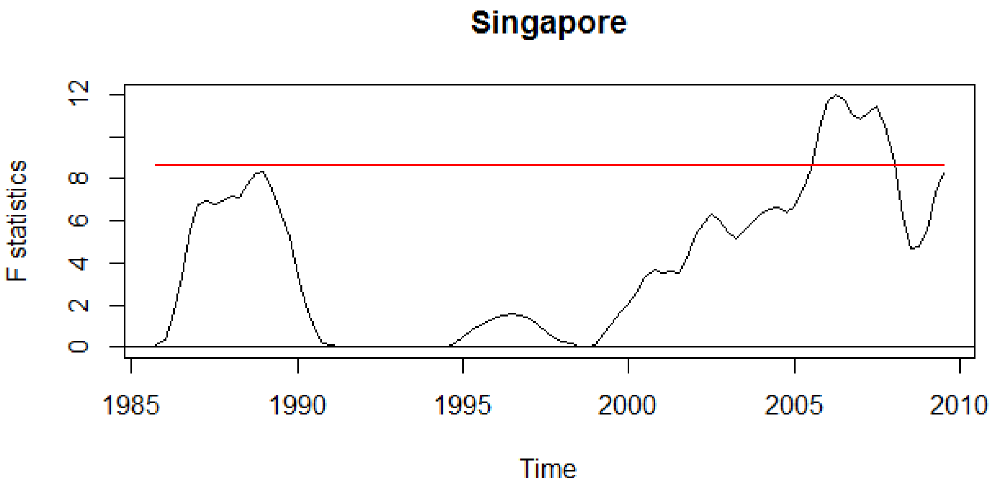
2005
2010
Time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F statistics
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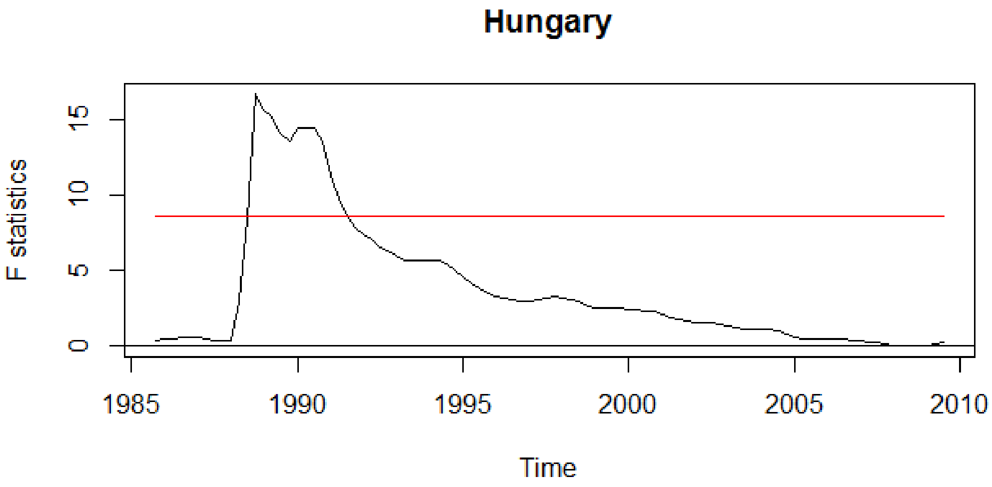
2010
Time


Hungary
F statistics
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1985
1990
1995
2000
2005
2010
Time