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A consistent set of multilateral productivity approach-based indicators of price competitiveness – results for Pacific Rim economies

Authors' List

Christoph Fischer, Deutsche Bundesbank,
and Oliver Hossfeld, Deutsche Bundesbank, Leipzip Graduate School of Management

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A consistent set of multilateral productivity approach-based indicators of price competitiveness – results for Pacific Rim economies

Christoph Fischer[a] Oliver Hossfeld[a, b]

[a] Deutsche Bundesbank, Wilhelm-Epstein-Str. 14, 60431 Frankfurt, Germany, christoph.fischer@bundesbank.de, oliver.hossfeld@bundesbank.de

[b] Leipzig Graduate School of Management, Jahnallee 59, 04109 Leipzig, Germany, oliver.hossfeld@hhl.de

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Keywords: Equilibrium exchange rates, productivity approach, price competitiveness, panel cointegration

JEL classification: F31, C23

Corresponding author: Christoph Fischer, Deutsche Bundesbank, Wilhelm-Epstein-Str. 14, 60431 Frankfurt, email: christoph.fischer@bundesbank.de, phone: +49 69 9566 2304. The study represents the authors' personal opinions and does not necessarily reflect the views of the Deutsche Bundesbank or its staff.

1. Introduction

Indicators of international price competitiveness for entire economies are widely used in economic policy circles. They are usually computed as the deviation of a current real exchange rate from a benchmark level. The challenge for the economist consists in designing a sensible and widely accepted benchmark level or equilibrium rate of the real exchange rate. Ideally, such a benchmark level needs to have a set of desirable properties: (i) It should be based on a theoretically convincing approach, so that it is widely acceptable as a norm and can be easily interpreted. (ii) The benchmark level should be general in the sense that it is computable for a large group of countries. (iii) The set of benchmark levels should be plausible, robust, and above all consistent across countries. (iv) To allow their use by policymakers, the benchmark levels should be computable at short notice, while at the same time reflecting the most recent state of economic affairs.

The present study proposes a methodology for computing equilibrium exchange rates which are supposed to fulfill all these requirements. Conceptually, the methodology is based on the productivity approach, which is mostly associated with Balassa (1964) and Samuelson (1964). To be sure, a simple empirical application of the productivity approach would not be novel. Commensurate with the objective of making the derived indicators of competitiveness a useful policy tool, however, the methodological approach of the present study includes a combination of several characteristics which, in our view, renders it a valuable contribution to the literature.

First, price and productivity data in *levels* are employed as opposed to using *indices*, as is frequently done in the respective literature. Level data are especially important in the present context. (i) Index levels are not comparable across countries. Since an equilibrium real exchange rate is basically a cross-country concept, a pure time series-based assessment foregoes potentially essential information. (ii) As is shown below, the theory suggests a relationship between relative productivity and relative prices in levels.

Second, the analysis rests on a large panel of data spanning 57 developed and emerging economies and up to 32 years. A large data set is likely to contribute to finding meaningful and robust results as indicated by Bahmani-Oskoee and Nasir (2005) in their summary of estimation results obtained in previous studies on the productivity approach.[1] In conducting a panel analysis of price and productivity data in levels, the

[1] According to Bahmani-Oskoee and Nasir (2005), other contributing factors include the omission of developing countries as well as a consistent data set in the sense that the variables are constructed in the same way for all the countries and are, ideally, obtained from a common source. Since our sample

empirical approach of the present paper is closely related to Cheung et al (2007, 2009) and Maeso-Fernandez et al (2006).[2]

In contrast to these studies, however, it is a third distinctive characteristic of the present analysis that it uses the bilateral estimates to calculate multilateral equilibrium rates, which are multilaterally consistent for all countries. Cheung et al (2007) have already noted that "... trade weighted rates are to be preferred to bilateral rates since the reliance on the latter can lead to misleading inferences about overall competitiveness" although they restricted their econometric analysis to the bilateral case.

Fourth, the analysis contains a discussion of the treatment of country-specific fixed effects obtained in the panel real exchange rate regression. This issue emerges as an inevitable consequence of the methodological approach chosen (cf also Phillips et al, 2013, and Maeso-Fernandez et al, 2006). Against this background, it is also examined how robust the assessment of currencies' misalignments is with respect to this choice.

Fifth, a simple projection method is proposed in order to enable an up-to-date daily assessment of price competitiveness, which is of particular importance for policymakers.

To sum up, the study proposes a set of competitiveness indicators which have a solid foundation in economic theory, are multilaterally consistent, reasonably robust, up-to-date, straightforward to compute and, therefore, useful for policy analyses on a day-to-day basis. This distinguishes our derived policy tool from several popular indicators, which typically lack at least one of these "ingredients".

Alternative strategies for an estimation of equilibrium exchange rates beyond the productivity approach notably include, first, the behavioral equilibrium exchange rate (BEER) approach introduced by Clark and MacDonald (1999) or similar reduced form regression-based approaches such as the IMF's new "EBA real exchange rate panel regression" approach (see Phillips et al, 2013) and, second, the fundamental equilibrium exchange rate (FEER) models introduced by Williamson (1983).[3] Typical BEER applications as well as the EBA real exchange rate regression approach by the IMF are usually characterized by the fact that explanatory variables are included in the regression equation in an ad-hoc fashion. However, the resulting uncertainty concerning the specification renders an interpretation of the estimated values as a norm doubtful.

excludes developing countries and all data used have been compiled by international sources using the same methodology for all countries, these two requirements are also fulfilled in our study.

[2] The benefits of using price level data are also emphasized by Thomas et al (2008, 2009), who introduce the weighted average relative price (WARP), which is a multilateral relative price level similar to the one defined in equation (3) of the present analysis.

[3] Cf the comprehensive survey articles by MacDonald (2000) and Driver and Westaway (2005).

Furthermore, the interpretation of the estimation results based on these approaches is impaired by the fact that real exchange rate indexes are usually employed in the regressions. In a panel context, this necessitates the inclusion of country fixed effect, which cannot be meaningfully interpreted.[4]

Equilibrium exchange rates derived from FEER models suffer from the drawback that they crucially depend on assumptions about the gap between the current and the equilibrium current account and on highly imprecise estimates of export and import elasticities (cf Bussiere et al, 2010, and Driver and Wren-Lewis, 1999). With a special focus on China, Schnatz (2011) demonstrates that small changes in these assumptions lead to extremely different real exchange rate assessments. Real effective exchange rate misalignments derived from the IMF's current account regression approach, which is also part of the EBA procedure, suffer from model uncertainty regarding the explanatory variables included in the underlying current account regression and from imprecise estimates of trade elasticities.

Whereas the analysis is based on estimates for a sample of 57 countries, the discussion of the results focuses on the Pacific Rim economies. Concerning the regional focus, the study is therefore related to Chinn (2000) and Kakkar and Yan (2012), two papers which consider narrower groups of East Asian economies. In recent years, the economic importance of the Pacific Rim region has significantly increased. At present, the three largest economies in the world border on the Pacific. Thus, the results for the group of Pacific Rim economies are of high policy relevance. While many of the results confirm expectations, some are at odds with prevailing views and will therefore be discussed in more detail.

Section 2 presents the theoretical framework for the empirical analysis. Section 3 gives a description of the data used. Section 4 presents a three-step strategy for the computation of the multilateral price competitiveness indicators and includes the estimation results. Section 5 discusses the impact of the treatment of fixed effects on the assessment, before section 6 presents the results for the Pacific Rim economies. The final section concludes.

[4] In the case of the IMF's EBA real exchange rate panel regression approach, the problems associated with using indices as opposed to levels are also acknowledged by Phillips et al (2013): "A potential solution to these problems would be a regression analysis based on estimates of real exchange rate levels, rather than time series of exchange rate indices that cannot be compared across countries. Work to develop such a method is ongoing, for use in future EBA analyses." For a discussion about the interpretation of country fixed effects in this context, see section 5.

2. Theoretical framework

Froot and Rogoff (1995) develop a productivity approach model which formalizes the ideas of Balassa (1964) and Samuelson (1964). They consider two economies, domestic (*D*) and foreign (*F*), each of which produces two goods, a tradable (*T*) and a non-tradable (*N*), using a simple Cobb-Douglas production technology and capital and labor as inputs. Under the standard assumption that capital is mobile across sectors and countries whereas labor is only mobile across sectors, they derive an equilibrium value for the price of non-tradables in each economy. Combining the Froot and Rogoff (1995) setup with a definition of the real exchange rate yields, under assumptions to be discussed below, an equation for the long-run determination of the real exchange rate

$$q = \frac{\gamma(\alpha_T - \alpha_N)}{1-\alpha_T} \cdot \left(x_D - x_F\right) \tag{1}$$

as is shown in the Appendix. In equation (1), q denotes the log of the real exchange rate where an increase in q is a real appreciation of *D* against *F*, x_i is log total factor productivity (TFP) in country i, α_h is the production elasticity of capital in sector h, and γ is the weight of non-tradable's price in the general price level.

For the econometric implementation, one should note the following properties of (1). First, equation (1) constitutes a relation between relative productivity *levels* and relative price *levels*. This suggests that the information content of the cross-section of countries may be considerable and should not be ignored in the estimation, as it would be if price and productivity *indices* were used.[5] Second, as already observed by Froot and Rogoff (1995), the coefficient of relative productivity is positive if $\alpha_T > \alpha_N$. One may expect this inequality to be valid because the share of capital will usually be larger in the tradables sector. This implies that an increase in the relative productivity level of (both sectors of) the domestic economy raises the relative price level.

As usual, models like this rest on some simplifying assumptions. In the present case, these include the following. (i) For both sectors, the production elasticity of capital is common across countries, $\alpha_{h,D} = \alpha_{h,F} = \alpha_h$, (ii) the weight of non-tradable prices in the price level is the same across countries, $\gamma_D = \gamma_F = \gamma$, and (iii) the ratio of TFP between the two countries does not differ across sectors, $X_{T,D}/X_{T,F} = X_{N,D}/X_{N,F} = X_D/X_F$. Assumption (iii) implies that the country with superior productivity in one sector displays equally superior productivity in the other sector.

[5] In fact, Froot and Rogoff (1995) derived only a relation in growth rates. However, their model directly implies a relation in levels such as equation (1).

In the current modeling framework, assumptions (i) and (ii) are commonly made and go back at least to Froot and Rogoff (1995) and Obstfeld and Rogoff (1996), p 211, respectively. If these two assumptions do not hold, the equilibrium real exchange rate depends on a constant, the world real interest rate and on the productivities of each sector in each country as is shown in the Appendix. In an estimation of such an equation, Kakkar and Yan (2012) model the world real interest rate term as a stationary common factor. The possible existence of such a common factor suggests taking account of cross-sectional correlations in an estimation of equation (1).

A violation of assumptions (i) and (ii) would further suggest considering, in a real exchange rate regression, a separate series for each sector-specific productivity of both the domestic and the foreign economy instead of using economy-wide productivities. Even if both (i) and (ii) hold, assumption (iii) is additionally required to obtain equation (1), which entirely avoids the use of sector-specific productivities. In the empirical literature on the estimation of equilibrium real exchange rates, however, the use of economy-wide productivity series is common; see, for example, the IMF's new EBA approach (Phillips et al, 2013), Balassa (1964), Cheung et al (2007, 2009), Chong et al (2012), Lothian and Taylor (2008), and Maeso-Fernandez et al (2006). Given assumptions (i) and (ii), assumption (iii) is the minimum requirement for these approaches to be valid.

In the present study, we follow the literature specified above in using economy-wide instead of sector-specific productivity series for an estimation of the equilibrium real exchange rate according to equation (1). Our decision is mostly due to data availability considerations. After all, the objective of the proposed procedure is the computation of competitiveness indicators for economic policy purposes, which suggests that the benchmarks should be general, computable at short notice and up to date. The computation of policy-relevant representative multilateral benchmarks thus requires recent productivity data for a relatively large number of countries.

In fact, Ricci et al (2013) provide evidence that assumption (iii) may well approximate reality. They find for a sample of 48 industrial countries and emerging markets that the country-specific average labor productivity growth in tradables and the corresponding productivity growth in non-tradables are highly (positively) correlated.[6] This implies that, in the long term, economy-wide productivity shocks as they are considered here

[6] Interestingly, Ricci et al (2013) observe further that the difference between log tradable and log non-tradable productivity relative to trading partners is uncorrelated with log relative GDP per worker. This leads them to conclude that relative "GDP per worker may not be a good proxy for the Balassa-Samuelson effect", because its effect on the real exchange rate would be neutral. However, the neutrality proposition follows only under the assumption that the production elasticities in the two sectors are the same, $\alpha_T = \alpha_N$.

may be especially relevant for real exchange rate determination. Moreover, findings giving evidence of cointegration between real exchange rates and economy-wide productivity (cf section 4) suggest that these two variables form a meaningful long-term relationship and that no further variables, such as sector-specific productivities, are required for achieving cointegration.

3. The sample and the data

The sample of countries for which indicators of price competitiveness are to be calculated should include all the major industrial and emerging economies.[7] The group of 57 countries for which the European Central Bank and the Deutsche Bundesbank compute real effective exchange rates constitutes a broad and exogenous sample (cf Schmitz et al, 2012). It comprises the 17 countries of the European Monetary Union (EMU) plus 40 non-EMU countries, among them 17 Pacific Rim economies.[8]

As already stressed in the introduction, several reasons suggest the importance of using price and productivity level data as opposed to indices. Annual data on relative price levels are taken from the IMF's World Economic Outlook (WEO). The WEO provides "implied PPP exchange rates" as well as nominal bilateral exchange rates for all 57 countries of the sample.[9] A relative price level is obtained by dividing the former by the latter.

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[7] Bahmani-Oskoee and Nasir (2005) suggest that the low quality of less developed country data is responsible for disappointing estimation results of productivity approach regressions if such countries are included in the sample. Considering, moreover, the poor data availability, we refrain from including these countries in our analysis.

[8] The Pacific Rim economies of the sample are (listed in a clockwise fashion starting in the southwest of the Pacific): New Zealand, Australia, Indonesia, the Philippines, Singapore, Malaysia, Thailand, Hong Kong, Taiwan, China, South Korea, Japan, Russia, Canada, the United States, Mexico, and Chile. The remaining countries of the sample are Algeria, Argentina, Austria, Belgium, Brazil, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Morocco, the Netherlands, Norway, Poland, Portugal, Romania, the Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and Venezuela.

[9] For PPP exchange rates, the WEO resorts to International Comparison Program (ICP) data. ICP PPP exchange rates are multilaterally consistent in the sense that they are transitive. Given three countries *j*, *k*, *l*, transitivity implies $PPP_{j,k} = PPP_{j,l} / PPP_{k,l}$. Transitivity is assured by the application of aggregation procedures such as EKS. A detailed description of the methods used to compute PPP exchange rates is provided online in the ICP Handbook on the website of the World Bank.

According to chapter 4 of this Handbook, ICP price data principally take into account different product characteristics across countries, even though it is acknowledged that the "… treatment of differences in the quality of goods and services in different countries is difficult both in theory and in practice". A more detailed description of the procedure applied to adjust product prices for different characteristics is given in the Handbook's section "Quality adjustments in the ICP". Focusing on the product characteristics which impact on prices, the ICP provides local price collectors with tight product specifications so that countries are "… in principle, pricing products of identical quality". If a product specification cannot be

Productivity data are taken from the Conference Board's Total Economy Database. Two alternative productivity measures are applied, labor productivity per hour worked and labor productivity per person employed.[10] Of these measures, labor productivity per hour worked is the preferred one because it probably approximates TFP more closely.[11] In particular, this measure is hardly biased by different levels of part-time work across countries. Both productivity measures assign cross-border commuters sensibly to the destination country, which is of particular importance for smaller countries in the sample. Unfortunately, productivity per hour worked is available only for 46 of the 57 countries in the sample, meaning that, for the remaining ones, it is only possible to compute indicators based on productivity per person employed.[12]

The data panel is unbalanced. For most countries in the sample, the observation period runs from 1980 through 2011. However, for two groups of countries, the series start as late as 1995. These are, on the one hand, all the former communist transition economies including two Pacific Rim countries, China and Russia. For many of them, no data are available during the 1980s. Moreover, market mechanisms, which are essential in the derivation of equation (1), did not play a role in price formation during socialist times, so that the theory is not applicable to them in this period. On the other hand, data for three economies that experienced hyperinflation during the 1980s are excluded prior to 1995 because hyperinflation was accompanied by enormous currency depreciation. The

exactly matched with a local product, the price of a close substitute good is used, which is then adjusted to the target specification. For a more general analysis of the impact of non-price factors on international competitiveness with a focus on emerging markets, see Benkovskis and Wörz (2013).

[10] Both productivity measures are expressed in constant 2010 US dollars and are converted to 2010 price levels with updated 2005 EKS purchasing power parities. The same type of data has already been used in Fischer (2010), and a closely related one in Maeso-Fernandez et al (2006). We choose EKS-based instead of Geary-Khamis-based productivity data because of the evidence of severe biases in Geary-Khamis-based income levels; cf Ackland et al (2013). In general, the measurement of internationally comparable productivity levels is challenging. It requires information on output, factor inputs and purchasing power parities. Measurement issues are discussed in Schreyer and Pilat (2001). The fact that all the productivity measures used are taken from a common source, the Conference Board's Total Economy Database, where they are compiled and computed in a way to make them internationally comparable and consistent, may reduce the data's susceptibility to measurement errors (cf the Methodological Notes provided on the Conference Board website). Still, notable revisions have shown the extent of uncertainty surrounding such productivity measures.

[11] The Conference Board's Total Economy Database also provides estimates of TFP growth rates obtained through a growth accounting exercise. However, corresponding TFP levels are not available. As discussed in Schreyer and Pilat (2001), their measurement is much more difficult and more controversial than that of labor productivity levels. In particular, this is due to problems in obtaining internationally comparable estimates of capital stocks.

[12] Pacific Rim economies for which labor productivity per hour is not available are China, Indonesia, Malaysia, the Philippines, Russia, and Thailand.

combined effect of hyperinflation and "hyper-depreciation" leads to highly imprecise measures for the relative price level.[13]

In order to obtain indicators of competitiveness for all 57 countries in the sample, data for an additional country are needed, which serves as the base country for the relative price and productivity levels.[14] Data, starting in 1980, on labor productivity per hour worked are available for only two countries that are not part of the sample: Colombia and Peru. Since Peru experienced hyperinflation in the 1980s, Colombia is chosen as the base country.

4. A three-step methodology for the computation of a broad and consistent set of multilateral indicators of price competitiveness

Based on the simple relation between relative productivity levels and relative price levels derived as equation (1) and the panel of data described in the previous chapter, the price competitiveness indicators are computed in three steps: 1) estimation of equation (1) following some preliminary data analysis, 2) computation of multilateral benchmarks for the real exchange rate, and 3) forecast of the current deviation from the benchmark.

4.1 Step 1: Preliminary data analysis and estimation

For the derivation of the benchmark real exchange rate, the fixed effects panel regression

$$q_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it} \tag{2}$$

is estimated, where q_{it} denotes the log price level of country i relative to the base country at time t, x_{it} the log relative productivity level, and α_i a country fixed effect. The error term ε_{it} is assumed to be iid.

The parsimonious bivariate specification represented by equation (2) has been chosen for several reasons. First, the aim of the estimation is to derive a fundamental, long-term

[13] The hyperinflation countries are Argentina, Brazil, and Turkey, none of which belong to the Pacific Rim group. When using labor productivity per hour worked, the time series for three further non-Pacific Rim countries start as late as 1995 because of a lack of data: Cyprus, Israel, and Malta.

[14] As a further benefit, the additional "external" base country considerably simplifies the calculation of forecasts because it allows the official real and nominal effective exchange rate series for the broad group of countries published by the ECB and the Bundesbank to be used to extrapolate the current deviation from the benchmark value.

benchmark for international competitiveness, a norm, and not to maximize the fit. The present specification directly implements equation (1) econometrically and thus reflects the theoretical framework. Second, as will be shown below, the cointegration analysis suggests that, for the determination of the relative price level in the long term, it is sufficient to take relative productivity into consideration. Further variables are not necessary to achieve cointegration. Or, to put it differently, while the two variables form an irreducible cointegration relationship, less parsimonious specifications (composed of more than these two variables) do not. In a systematic analysis of the issue, Hossfeld (2010) has found that variables other than productivity are relevant in determining real exchange rates only for a few countries during limited periods of time. As a consequence, omitted variable bias is expected to be small.

Because of the common base country of the time series in equation (2) and the possible presence of a stationary common factor due to theoretical considerations (see chapter 2), cross-sectional correlation is to be expected. The application of a relevant test that has been developed by Pesaran (2004) yields evidence of significant cross-sectional dependence.[15] Therefore, throughout the empirical analysis, special care is taken to appropriately account for this property of the data.

Before commenting on the estimation results, we present results obtained from panel unit root as well as panel cointegration tests. These were conducted in order to assess the time series properties of the variables involved and to check whether the empirical evidence supports the existence of long-run relationships among the variables.

In order to take account of the expected cross-sectional dependencies, the cross-sectionally augmented IPS test suggested by Pesaran (2007), a second generation panel unit root test, is implemented. In contrast to first generation panel unit root tests, which, at best, allow a common factor to have the same effect on each cross-section unit, this approach allows a common factor to have different effects on each cross-section unit. Compared to the classic IPS test, the individual ADF test regressions additionally include the lagged levels and first differences of the series as proxies for the effects of an unobserved common factor. The test results (available on request) clearly suggest non-stationarity of the series in levels but stationarity in first differences. This test outcome is robust to various choices of lag lengths in the test regressions.

Based on the evidence that the series are I(1) and in order to avoid a spurious regression, we test for cointegration in the next step. We apply a family of error

[15] On average, the absolute correlation between the residuals of the different countries is about 0.55 for the panel of 57 countries, highlighting the importance of accounting for cross-sectional dependence when conducting statistical inference.

correction-based tests proposed by Westerlund (2007). They not only allow for various forms of heterogeneity, but also provide *p*-values which are robust to cross-sectional dependencies by following a bootstrap approach. The tests are conducted to ascertain whether the null of no error correction can be rejected. If the null can be rejected, there is evidence in favor of cointegration. While two of the four tests are panel tests with the alternative hypothesis that the whole panel is cointegrated, the other two tests are group-mean tests with the alternative hypothesis that for at least one cross-section unit there is evidence of cointegration. For the group-mean test statistics, the error correction coefficient is estimated for each cross-section unit individually, and then two average statistics (the "G" statistics) are calculated. In the pooled tests, the series of each cross-section unit are "cleaned" of dynamic nuisance parameters, unit-specific intercepts and/or trends before the conditional panel error correction model is estimated to obtain a common estimate of the error correction term. This is then checked for significance.

According to the bootstrapped robust *p*-values shown in the right-hand column in Tables 1 and 2, all test results point towards cointegration at the 10%, two of them even at the 5% significance level for the specification in which labor productivity per person employed is used to approximate x_{it}. If labor productivity per hour worked is used instead, only three of the four statistics provide evidence of cointegration at the 10% level, one of them at the 5% level. However, even if evidence of cointegration seems somewhat stronger for the first specification, we regard the evidence to be satisfactory enough to continue with our analysis in both cases.[16]

Turning to the estimation results (see Table 3), it is well known that the OLS estimator is super-consistent if a set of variables is cointegrated. Marginal significance levels for the obtained estimates are based on Driscoll and Kraay (1998) standard errors, which account for within-group correlation, heteroskedasticity and cross-sectional correlation. Based on the simple fixed effects OLS regression, the estimated long-term elasticity of relative price levels to the relative productivity level is 0.35 for labor productivity per person employed and 0.47 for labor productivity per hour. Both of these coefficients are individually significant at the 5% level. The estimated elasticities are slightly larger than those reported by Cheung et al (2007), who conduct a similar exercise and find elasticity estimates in the range of 0.25 to 0.39.

As a robustness check, we additionally provide panel dynamic OLS (Mark and Sul, 2003) estimation results. By including leads and lags of the differenced regressors, these

[16] Among others, the lower significance levels may simply be a result of the lower number of observations available in the second specification.

estimators allow for endogeneity of the explanatory variables. Estimation results hardly change compared to the simple OLS fixed effects regression.

4.2 Step 2: Computation of multilateral benchmarks for relative price levels

In the estimation of equation (2), the variables are defined bilaterally against the specific base country. Implicitly, all the observations receive equal weights. A meaningful indicator of price competitiveness, however, needs to be a multilateral one, in which foreign competitors play a role commensurate to their importance. As with the computation of real effective exchange rates, such multilateral measures can be constructed by relating the variable of country *i* to the weighted average of the corresponding variable in the partner countries $j = 1, \ldots N$:

$$\breve{q}_{it} = q_{it} - \sum_{j=1}^{N} w_{ij} q_{jt} \tag{3}$$

$$\breve{x}_{it} = x_{it} - \sum_{j=1}^{N} w_{ij} x_{jt}, \tag{4}$$

where $w_{ii} = 0$ and $\sum_{j=1}^{N} w_{ij} = 1$. Parameter w_{ij} indicates the (constant) weight of country *j* for country *i*. It is derived in a standardized way from manufacturing trade between the two countries during the years 2007-09 and takes account of third-market effects.[17]

The (log of the) multilateral benchmark for the relative price level of country *i* given the relative productivity level in (4) may then be defined as

$$\breve{q}^{*}_{(a)it} = \hat{\beta} \breve{x}_{it}, \tag{5a}$$

[17] Schmitz et al (2012) give an account of the commonly agreed derivation method of the weights in the Eurosystem. A table of the weighting matrix for the $N = 57$ countries considered is shown on the Journal's website. For labor productivity per hour and the period prior to 1995 where $N < 57$, the weights are rescaled. An advantage of the proposed procedure is that current competitiveness assessments would not be affected if flexible instead of fixed weights had been used. This is due to the fact that bilateral values are weighted to obtain multilateral ones only after the estimation stage, and fixed weights do not differ from flexible weights for current observations. Theoretically, competitiveness assessments could be expected to be more heavily affected for observations further back in the past, where the difference between flexible and fixed weights tends to be somewhat larger. However, first, the primary purpose of our proposed procedure is to analyze more recent competitiveness developments, and, second, the proposed procedure is designed in such a way as to allow the use of flexible weights whenever it is regarded as being suitable. A simple correlation analysis of flexibly and fixed weighted CPI-based real effective exchange rates as provided by the ECB reveals that the series are highly correlated in levels and first differences for the available sample period from January 1993 to December 2013.

where $\hat{\beta}$ denotes the estimate of β from (2). Using (3) and (5a), the indicator of price competitiveness $\breve{M}$ which is the deviation from the benchmark (with $\breve{m}$ being the corresponding log deviation) is derived as

$$\breve{m}_{it} = \breve{q}_{it} - \breve{q}^*_{it} \tag{6}$$

$$\breve{M}_{it} = e^{\breve{m}_{it}}, \tag{7}$$

where $\breve{q}^*_{it}$ is a more general expression of the benchmark value. A value of $\breve{M}$ > 1, for instance, indicates that, conditional on its relative productivity level, the price level of the country in question is higher than that in the weighted average of its trade partners. According to this indicator, price competitiveness is 100*($\breve{M}$-1)% less favorable than in the weighted average of the trade partners.

4.3 Step 3: Forecast of the current deviation from the benchmark

In the procedure presented thus far, the indicator of competitiveness is computed using annual data. This and the usual publication lag means that the most recent value of the sample may date back two years or more. Since the indicator is intended for economic policy purposes, a forecast of the indicator values is essential. As fierce fluctuations in nominal exchange rates may noticeably affect price competitiveness in the short run, the ability to establish a forecast for the current day would be desirable. To this end, a two-step forecast procedure is proposed, whose two steps consist of a quarterly and a daily forecast.

For the quarterly forecast of productivity, index data on real GDP per capita are used. While data on population are available only in an annual frequency, their movements are highly inertial. Therefore, a relatively precise quarterly population series may be computed by interpolating the corresponding annual series. This series is extrapolated under the assumption that the population will continue to grow at the average rate of the last three years. Combining this series with a quarterly index of real GDP[18] yields a quarterly index series of real GDP per capita, Y_{it}. Then, the index of relative log GDP per capita is

$$\breve{y}_{it} = y_{it} - \sum_{j=1}^{N} w_{ij} y_{jt}. \tag{8}$$

[18] For one of the 57 countries in the sample, Algeria, no quarterly real GDP series is available. Algeria's productivity is therefore assumed to be constant in the medium and short term. Because of Algeria's tiny weight for practically all countries in the sample, this assumption does not entail any significant bias.

For the *medium term*, it is assumed that the movements of $\breve{y}_{it}$ approximate those of $\breve{x}_{it}$ such that the medium-term quarterly forecast of relative productivity, $\breve{x}_{i,\tau+u}$, is computed as

$$\breve{x}_{i,\tau+u} = \breve{x}_{i\tau} + \breve{y}_{i,\tau+u} - \breve{y}_{i\tau}, \tag{9}$$

where τ is the last annual observation of $\breve{x}_{it}$ and $\breve{q}_{it}$ in the sample and $\tau+u$ denotes the last quarterly observation of real GDP for any country *i* in the sample except Algeria.[19] Because of the publication lag in real GDP figures, this series will still not cover the most recent months. However, for the *short term*, it should be innocuous to assume a constant relative productivity:

$$\breve{x}_{i,\tau+u+v} = \breve{x}_{i,\tau+u}, \tag{10}$$

where $\tau+u+v$ denotes the present day. Real effective, ie multilateral, exchange rates based on consumption price indices are used for the medium-run forecast of the relative price levels. Conceptually, the log of this series, denoted $\breve{z}_{it}$, corresponds exactly with $\breve{q}_{it}$. It differs, however, in that, like $\breve{y}_{it}$, it does not contain any information on levels. The *medium-term* quarterly forecast of the relative price level, $\breve{q}_{i,\tau+u}$, is thus computed as

$$\breve{q}_{i,\tau+u} = \breve{q}_{i\tau} + \breve{z}_{i,\tau+u} - \breve{z}_{i\tau}. \tag{11}$$

For the remaining few months, the stickiness of goods prices suggests that relative price levels may be assumed to be constant. This implies that log nominal effective exchange rate series, $\breve{s}_{it}$, available in a daily frequency, can be used for the *short-term* daily forecast in the second step:

[19] Since $\breve{y}_{it}$ denotes *relative* log GDP per capita, and thus $\breve{Y}_{it}$ *relative* GDP per capita, the annual value $\breve{Y}_{i\tau}$ is simply the average of the four quarterly values of $\breve{Y}_i$ in the year τ. Correspondingly, $\breve{Z}_{i\tau}$ and $\breve{S}_{i,\tau+u}$, whose logged values occur in equations (11) and (12), are computed as the average of the quarterly values of $\breve{Z}_i$ in the year τ and the average of the daily values of $\breve{S}_i$ in the quarter $\tau+u$.

$$\breve{q}_{i,\tau+u+v} = \breve{q}_{i,\tau+u} + \breve{s}_{i,\tau+u+v} - \breve{s}_{i,\tau+u}. \tag{12}$$

Summing up, quarterly forecasts of relative price and productivity levels are obtained in a first forecasting step through (9) and (11). In a second forecasting step, these medium-term forecasts are then updated to the present day by a short-term forecast of relative price levels obtained from (12) given (10). Although $\breve{y}_{it}$, $\breve{z}_{it}$ and $\breve{s}_{it}$ are index series, equations (9) to (12) preserve the level information of the last observation of relative price levels, $\breve{q}_{i\tau}$, and relative productivity levels, $\breve{x}_{i\tau}$, for the corresponding forecasts. If $\breve{x}_{i,\tau+u+v}$ and $\breve{q}_{i,\tau+u+v}$ are inserted into (5a) and (6), respectively, equation (7) yields a forecast for the present-day deviation of price competitiveness from its benchmark, $\breve{M}_{i,\tau+u+v}$. Note that this forecast is not meant to represent a short-term value of $\breve{M}_i$. Rather, it is an approximation of the current daily value of a long-term concept.

5. Treatment of country fixed effects and the impact on the benchmark

Since a country fixed effects panel method is used for the estimation of the elasticity β in equation (2), the benchmark for the multilateral relative price level can be defined in two alternative ways. In *approach (a)*, the benchmark is simply the product of the estimate of β and multilateral relative productivity as shown in equation (5a). As a consequence, the log deviation from the benchmark consists of the relative residual and the relative fixed effect in this approach (cf equations (6), (2) and (5a)):

$$\breve{m}_{(a)it} = \breve{\hat{\alpha}}_i + \breve{\hat{\varepsilon}}_{it}, \tag{13a}$$

where the estimated multilateral relative fixed effect and the estimated multilateral relative residual are defined as

$$\breve{\hat{\alpha}}_i = \hat{\alpha}_i - \textstyle\sum_{j=1}^{N} w_{ij}\hat{\alpha}_j \tag{14}$$

$$\breve{\hat{\varepsilon}}_{it} = \hat{\varepsilon}_{it} - \textstyle\sum_{j=1}^{N} w_{ij}\hat{\varepsilon}_{jt}. \tag{15}$$

In an alternative *approach (b)*, however, the estimated relative fixed effect is included in the benchmark determination; the log deviation of the benchmark consequently consists simply of the relative residual:

$$\breve{q}^*_{(b)it} = \hat{\breve{\alpha}}_i + \hat{\beta}\breve{x}_{it} \tag{5b}$$

$$\breve{m}_{(b)it} = \hat{\breve{\varepsilon}}_{it}. \tag{13b}$$

The only difference between the two approaches is the treatment of the relative country fixed effect. It is part of the misalignment in approach (a) whereas it is part of the benchmark in approach (b). In traditional economic applications with index data, approach (b) has often been used without further discussion. In recent years, however, some studies employing level data have not used panel fixed effects regressions for the estimation of (2) but instead methods such as, for example, pooled OLS, in which the fixed effects are not estimated at all. The resulting equilibrium real exchange rates are conceptually close to the ones obtained with approach (a), in which both fixed effects and residuals are estimated but are not separated in the computation of the benchmark. Early examples include Cheung et al (2007) and Fischer (2010). Meanwhile, the IMF is also considering changing its calculation of equilibrium exchange rates from approach (b) combined with index data to approach (a) combined with level data; cf footnote 4.

The application of pooled OLS for equation (2) is occasionally criticized as biasing the estimation results. In the present case, the estimated value of β is somewhat larger when pooled OLS instead of a fixed effects panel regression is used (cf Table 3). The calculated deviation from the benchmark, however, is hardly affected by the estimation method if approach (a) is used for the fixed effects estimates. Nevertheless, the fixed effects panel results are used throughout the study in order to avoid any such criticism.

Concerning the treatment of the fixed effects in determining the benchmark, the estimated multilateral fixed effect, $\hat{\breve{\alpha}}_i$, and thus the difference in the indicator of price competitiveness between the two approaches, $\breve{m}_{(a)it} - \breve{m}_{(b)it}$, is small for many countries. However, there are also several, including some of the Pacific Rim economies, for which the difference is quite substantial, as will be shown in the next chapter.

To give an example of the difference in the interpretation of the two approaches, let us assume that the ratio of the average relative price level in a given country and its average relative productivity level is significantly higher than in its trade partners. Approach (a) would report on average a low competitiveness for such a country. In approach (b), however, average values of relative prices and productivity just define the benchmark and thus neutral price competitiveness. Given average relative productivity, approach (b) would only assess competitiveness as unfavorable if domestic prices exceeded their historical average.

The example illustrates first that long-term deviations from the benchmark, ie from a neutral level of price competitiveness, may occur in approach (a), where they are represented by the fixed effect in (13a), but not in approach (b). It shows secondly that levels do not play a role for price competitiveness in approach (b). The country-specific level information is generally absorbed in the estimated country fixed effect. If the fixed effect is used to compute the benchmark, as it is in approach (b), the (log of the) indicator of price competitiveness, $\breve{m}_{it}$, which is the deviation from the benchmark, does not contain any level information (see (13b)). Thus, there is no need to use relative level data instead of indices if the benchmarks and the indicators of price competitiveness are calculated according to this approach. The same data normalized to any arbitrary index would have yielded the same competitiveness assessment result. In contrast, if some index data without any level information are used in the analysis, it makes no sense to apply approach (a) because, in such a case, the fixed effects and thus the levels of the computed indicators have no meaning.

Therefore, approach (b) is obligatory if any index data are used, as was common in most traditional studies on real equilibrium exchange rates; approach (a), however, is the natural choice if the analysis involves only level data, as in the present case. Since the fundamental concern of an equilibrium real exchange rate and the notion of price competitiveness is the cross-country relation, it would be inappropriate in our view to discard the most significant cross-country information in the data by choosing approach (b). Moreover, the theoretical framework suggests a relationship in levels, as is shown in equation (4).

6. Results for Pacific Rim economies

Results for the multilateral indicators of price competitiveness of the 17 Pacific Rim economies in the sample are shown in Table 4. For most countries, they are based on the regression, in which labor productivity per hour worked is used. Only for those countries for which this variable is not available does the table include labor productivity per person employed-related results. The figures heading the columns of the table refer to the indicator of price competitiveness, ie the estimated deviation of the multilateral relative price level from its benchmark as of 28 October 2013; they are expressed in percentage points, formally 100*($\breve{M}$-1)%. A positive value of 20, for instance, indicates that the relative price level of the country in question exceeds the benchmark by 20%. This implies that the country's price competitiveness is less favorable than the weighted average of its trade partners. In such a case, the column "[15;25]" would be marked. Results are marked "×", "○" or "⊗" depending on whether they are based on approach (a), approach (b) or both approaches (a) and (b), respectively.[20]

For a majority of the Pacific Rim economies in the sample, approaches (a) and (b) yield the same conclusion. However, for a few, notably Japan and Russia, the results differ substantially according to the approach taken. We first consider the results obtained with approach (a) because, as explained in the previous chapter, we consider these to be superior indicators of competitiveness. Approach (b) results would also have been obtained if some of the data contained no level information. Therefore, differences between the results from approaches (a) and (b) also give a sense of the impact of using index data as opposed to data in levels.

The table demonstrates that the relative price levels in the commodity-exporting Pacific Rim economies Australia, Canada, Chile, Mexico and New Zealand exceed their corresponding benchmarks by at least 15%. These results confirm the widespread perception of an "overvaluation" of their currencies. As an example, the minutes of the Reserve Bank of Australia's November 2013 monetary policy meeting state that "... the Australian dollar, while below its level earlier in the year, remained uncomfortably high. Members noted that a lower level of the exchange rate would likely be needed to achieve balanced growth in the economy" (Reserve Bank of Australia, 2013).[21] The commodity-price boom in the years prior to the outbreak of the financial crisis and again in 2010 to early 2011 clearly contributed in these countries to price and wage increases which were apparently not matched by equal rises in productivity.

Three further Pacific Rim economies are found to display severely low price competitiveness levels, namely Indonesia, the Philippines, and, surprisingly, China. For Japan, Thailand, Russia, Singapore and South Korea, moderately low to moderately high competitiveness levels are found. Countries whose relative price levels are very

[20] Particularly the interpretation of the results obtained for the East Asian countries deserves some caution, however, because network trade, which is especially strong in this region (see Athukorala, 2009), may lead to measurement errors in GDP and productivity data. For the case of Ireland, Honohan and Walsh (2002) reveal that a severe upward bias in labor productivity figures can be traced back to a small number of multinational corporations which apparently took advantage of low taxes and standard transfer pricing rules to locate " … a very high fraction of the enterprise's global profits in Ireland". However, this caveat applies to any analysis in which data on GDP or productivity are used for this set of countries.

[21] Still, it might be argued that the productivity approach's definition of an equilibrium exchange rate needs to be extended in cases of commodity exporting countries where the world market price exceeds extraction costs considerably. Then, however, price competitiveness and a corresponding norm need to be redefined appropriately. Generally, a careful country-specific investigation of the factors that are responsible for the computed deviation from the equilibrium value is recommended.

low compared to the benchmark, rendering their price competitiveness highly favorable, include two “first generation East Asian tiger” economies (Taiwan and Hong Kong), one of the “second generation Southeast Asian tiger” economies, Malaysia, and interestingly the United States.

While many of these results are in line with expectations, those for the three dominant Pacific Rim economies (the United States, China and Japan), in particular, merit closer inspection. To this end, the development of the relevant variables over time is shown in Figures 1 to 3. These graphs trace $\breve{q}_{it}$ by $\breve{x}_{it}$, ie relative price levels on the vertical axis by relative productivity on the horizontal axis. Both variables are expressed in logs and relative to the trade-weighted average of the partner countries. Therefore, a combination of positive levels on both axes such as, for example, for most periods in the United States indicates that both price and productivity levels exceed those of the average trade partner (cf Figure 1). By contrast, both variables are negative in China, which implies below-average price and productivity levels (cf Figure 2). The Japanese economy, finally, is characterized by above-average relative price levels and below-average productivity levels (cf Figure 3).

[Insert Figures 1-3 here]

In these figures, a small dot indicates a relative price and productivity level combination for the country in question in a given year. The large dot is the forecast for 28 October 2013. Lines connect the dots in chronological order. Thus, the small dot connected to the large one characterizes the situation in 2011, the next small one in 2010, and so on. For the United States and Japan, the observation period starts in 1980, for China in 1995. The straight solid line represents $\breve{q}^*_{(a)it}$, the log benchmark according to approach (a), the dashed line is $\breve{q}^*_{(b)it}$, the log benchmark according to approach (b).[22] Both benchmarks depend positively on productivity. The vertical distance between one of the dots and a straight line is the log deviation from the benchmark, $\breve{m}_{it}$.

[22] In approach (b), the estimated fixed effects crucially affect the level of the benchmark and thus the assessment. As is shown in equation (5b), however, it is not the estimated fixed effect, $\hat{\alpha}$, which determines the constant of the log benchmark in this approach but, instead, the estimated multilateral relative fixed effect, $\breve{\hat{\alpha}}$. This implies that the composition of the sample affects the level of benchmark (b). The present sample is unbalanced in the sense that the number of countries considered from 1995 onwards exceeds that of the years until 1994. Therefore, the estimated relative multilateral fixed effect prior to 1995 differs for each country from that in 1995 and later. The dashed line in Figures 1-3 indicates benchmark (b) only for the later period. The relevant benchmark (b) for the earlier period is not shown.

Figure 2 demonstrates that China's relative productivity and price levels have increased steadily over the past decade. In 2008, price competitiveness moved from being slightly favorable into slightly unfavorable territory. Subsequently, it deteriorated further because price levels rose faster than the increase in productivity warranted. The results for the early years of the new century are in line with those of Cheung et al (2009), who find no serious undervaluation of the renminbi at that time. The finding of the present, unfavorable level of Chinese price competitiveness, however, stands in stark contrast to studies such as, for example, Bergsten and Gagnon (2012), who claim China is using manipulation to keep its currency undervalued. One reason for the different conclusions between the two studies is that Bergsten and Gagnon (2012) do not consider any relative prices in their assessment (but, instead, foreign exchange reserves and current account balances). This may seem surprising given the objective of their study, which includes the request for an adjustment of a specific relative price, the nominal exchange rate.

Against the background of this discussion, Figure 1 illustrates, interestingly, that relative prices in the US have been below their estimated benchmark for a decade now.[23] The combination of high trade deficits and a fairly low price level given the United States' high productivity suggests that it may not be the real exchange rate that needs to be adjusted to move US trade into balance, but domestic demand. In particular, the solution to the long-standing problem of US trade deficits may lie in a long-term rise in the US savings rate and not in a nominal effective US dollar depreciation.

Figure 3 illustrates the case of Japan. There, relative price levels persistently exceeded their benchmark levels (denoted by the straight solid line), although the recent yen depreciation helped to partly close the gap. Note, however, that according to approach (b) – the vertical distance to the dashed line – relative prices have been comparatively low in recent years. The large vertical distance between the two straight lines in the case of Japan is the result of the substantial relative fixed effect, $\breve{\tilde{\alpha}}_i$. This means that Japanese price levels have been permanently high relative to those of Japan's trade partners, although they are currently low by historical standards. Since the latter result would be the only one available for an analysis using index data, such an analysis would prematurely assess the Japanese overall price competitiveness as excellent. Instead, the long-term lack of real exchange rate adjustment (to the approach (a) benchmark) may be an indication that structural factors such as a lack of economic openness (rather than an overvalued currency) could be the root cause of Japan's elevated price level.

[23] The very high relative price levels in the upper part of the figure characterize the situation in the early 1980s before the strength of the US dollar was tackled by the Plaza Accord in September 1985.

For another Pacific Rim economy, Russia, the analysis also yields a large relative fixed effect, albeit with the opposite sign. This can be inferred from Table 4, specifically from the discrepancy between the results for the two approaches in the Russian case. Russia's results are exemplary for most transition economies, in which relative price levels were low before starting to converge to benchmark (a) in the last two decades.

7. Conclusions

In the present study, a relatively simple productivity approach-based method for calculating a consistent set of multilateral indicators of price competitiveness for a broad group of 57 industrialized and emerging economies is developed. The method is aimed at providing a tool for policy analysis and thus seeks to ensure that the indicators exhibit a set of desirable properties. The procedure consists of the following three steps: estimation of a panel regression, computation of multilateral benchmarks and forecast of present day indicator values. In contrast to much of the related literature, we i) employ price and productivity data in levels as opposed to indices, ii) derive multilateral instead of bilateral norms, and iii) discuss and analyze the impact of whether country-specific fixed effects should be regarded as an equilibrium phenomenon or be attributed to the misalignment.

The discussion of the results focuses on the 17 Pacific Rim economies in the sample. First, it is shown that the treatment of the country fixed effect does not influence the assessment of price competitiveness in the majority of countries considered. For some of the countries, however, the repercussions can be quite substantial. It is proposed to exclude the fixed effect from the calculation of the benchmark competitiveness level. The assessment of price competitiveness for many of the Pacific Rim economies considered is obviously in line with expectations. As an example, the relative price levels of commodity exporters currently exceed their corresponding benchmarks substantially. By contrast, the price competitiveness of the "first generation East Asian tiger" economies Taiwan and Hong Kong is estimated to be very high. Other results may be more controversial. The relative price level in the US, for instance, falls considerably short of the benchmark, while the price competitiveness of China is found to be rather low. The results for these two countries as well as for Japan are discussed in some detail.

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Appendix

In Froot and Rogoff's (1995) model, two goods, tradables (*T*) and non-tradables (*N*), are both produced in two economies, domestic (*D*) and foreign (*F*). Each sector *h* in each country *i* uses a simple Cobb-Douglas production technology

$$Y_{h,i} = X_{h,i} \cdot K_{h,i}^{\alpha_{h,i}} \cdot L_{h,i}^{1-\alpha_{h,i}}, \quad \text{(A1)}$$

where *Y*, *K*, *L*, *X*, and $\alpha_{h,i}$ denote real output, capital, labor, total factor productivity (TFP), and the production elasticity of capital in sector *h* of country *i*, respectively.[24] Under the assumption that capital is mobile across sectors and countries whereas labor is mobile across sectors but not across countries, profit maximization yields

$$p_{N,i} = A_i + \frac{1-\alpha_{N,i}}{1-\alpha_{T,i}} p_T + \frac{\alpha_{N,i}-\alpha_{T,i}}{1-\alpha_{T,i}} r + \frac{1-\alpha_{N,i}}{1-\alpha_{T,i}} x_{T,i} - x_{N,i} \quad , \quad \text{(A2)}$$

where $A_i = (1-\alpha_{N,i}) ln\left(\frac{1-\alpha_{T,i}}{1-\alpha_{N,i}}\right) + \frac{\alpha_{T,i}(1-\alpha_{N,i})}{1-\alpha_{T,i}} ln(\alpha_{T,i}) - \alpha_{N,i} ln(\alpha_{N,i})$ is a constant, the prices of both goods, p_h, and the return on capital, *r*, are expressed in the foreign currency, and a lower-case letter denotes a variable in logs. As an addition to the Froot and Rogoff (1995) setup, a broad-based real exchange rate between countries *D* and *F* may be defined as

$$Q = \frac{S \cdot \tilde{P}_{N,D}^{\gamma_D} \cdot \tilde{P}_T^{1-\gamma_D}}{P_{N,F}^{\gamma_F} \cdot P_T^{1-\gamma_F}} \quad , \quad \text{(A3)}$$

where *S* denotes the nominal exchange rate expressed in foreign per domestic currency units such that an increase in *S* represents a nominal appreciation of the domestic currency, $\tilde{P}_h$ is the domestic price of good *h* expressed in domestic currency such that $P_h = S \cdot \tilde{P}_h$, and γ_i is the weight of non-tradable's price in the general price level of country *i*. An increase of *Q* indicates a real appreciation of *D*.

[24] Note that this is a generalization of Froot and Rogoff's (1995) model, in which $\alpha_{h,D} = \alpha_{h,F} = \alpha_h$ is assumed.

Taking logs and inserting (A2) into (A3) yields

$$q = \gamma_D A_D - \gamma_F A_F + \left(\gamma_F \frac{\alpha_{T,F} - \alpha_{N,F}}{1 - \alpha_{T,F}} - \gamma_D \frac{\alpha_{T,D} - \alpha_{N,D}}{1 - \alpha_{T,D}}\right)(r - p_T)$$
$$+ \gamma_D \left(\frac{1 - \alpha_{N,D}}{1 - \alpha_{T,D}} x_{T,D} - x_{N,D}\right) - \gamma_F \left(\frac{1 - \alpha_{N,F}}{1 - \alpha_{T,F}} x_{T,F} - x_{N,F}\right) \quad , \qquad \text{(A4)}$$

an equation, according to which the equilibrium real exchange rate is determined by the world real interest rate measured in the price of the tradable and by productivity in each of the sectors of both countries.

Under the assumptions that the production elasticities of both sectors are common across countries, $\alpha_{h,D} = \alpha_{h,F} = \alpha_h$, and that the same is true for the weight of the non-tradable's price in the general price level, $\gamma_D = \gamma_F = \gamma$, equation (A4) becomes

$$q = \gamma \frac{1 - \alpha_N}{1 - \alpha_T}\left(x_{T,D} - x_{T,F}\right) - \gamma\left(x_{N,D} - x_{N,F}\right) \quad . \qquad \text{(A5)}$$

If it is further assumed that the ratio of TFP between the two countries does not differ across sectors,

$$\frac{X_{T,D}}{X_{T,F}} = \frac{X_{N,D}}{X_{N,F}} = \frac{X_D}{X_F} \quad , \qquad \text{(A6)}$$

the equilibrium real exchange rate is determined by the ratio of national productivity levels

$$q = \frac{\gamma(\alpha_T - \alpha_N)}{1 - \alpha_T} \cdot \left(x_D - x_F\right). \qquad \text{(1)}$$

Tables

Table 1: Westerlund ECM-based panel cointegration test between log relative prices and log relative labor productivity per person employed; full sample of 57 countries[a]

Statistic	Value	Z-Value	*p*-value	Robust *p*-value
G_t	-2.335	-4.687	0.000	0.037
G_a	-7.526	-0.533	0.297	0.063
P_t	-15.785	-4.884	0.000	0.080
P_a	-6.772	-4.322	0.000	0.043

a Test regressions include one lead and one lag of the regressors in first differences. Number of bootstrap replications to obtain robust *p*-values set to 400.

Table 2: Westerlund ECM-based panel cointegration test between log relative prices and log relative labor productivity per hour worked; reduced sample of 46 countries[a]

Statistic	Value	Z-Value	*p*-value	Robust *p*-value
G_t	-2.223	-3.365	0.000	0.073
G_a	-7.220	-0.096	0.462	0.095
P_t	-13.657	-3.861	0.000	0.108
P_a	-6.407	-3.325	0.000	0.048

a Test regressions include one lead and one lag of the regressors in first differences. Number of bootstrap replications to obtain robust *p*-values set to 400.

Table 3: Estimated long-term elasticities[a]

	Pooled OLS	Panel OLS (FE)	Pooled DOLS	Panel DOLS (FE)	Panel DOLS (FE+TD)
(1)	0.40***	0.35**	0.43***	0.35***	0.43***
(2)	0.54***	0.47**	0.51***	0.46***	0.52***

a Specification (1) uses labor productivity per person employed, specification (2) labor productivity per hour worked. For all DOLS regressions, one dynamic lag and lead are included. For pooled OLS and panel OLS results, marginal significance levels are based on Driscoll and Kraay (1998) standard errors. FE and TD denote the inclusion of fixed effects and time dummies, respectively. ***,**,* denote significance at the 1, 5, and 10% level, respectively.

Table 4: Results for the multilateral indicator of price competitiveness of 17 Pacific Rim economies as of 28 October 2013; deviation from the benchmark in percentage points[a]

	<-25	[-25;-15[	[-15;-5[	[-5;5[	[5;15[	[15;25[	≥25
New Zealand							⊗
Australia							⊗
Indonesia*						⊗	
Philippines*						⊗	
Singapore			×		○		
Malaysia*		×		○			
Thailand*				⊗			
Hong Kong		⊗					
Taiwan	⊗						
China*						⊗	
South Korea		○	×				
Japan		○			×		
Russia*			×				○
Canada						⊗	
USA		×	○				
Mexico						×	○
Chile						⊗	

[a] A positive value indicates that the relative price level exceeds the estimated benchmark level, ie price competitiveness is low. × indicates a result obtained using approach (a), ○ a result obtained using approach (b), and ⊗ results for both approaches (a) and (b). Generally, the results are based on the regression in which labor productivity per hour worked is used. However, * denotes countries for which results based on labor productivity per person employed are shown due to a lack of data on labor productivity per hour worked.

Figures

Figure 1: Indicator of price competitiveness for the USA since 1980

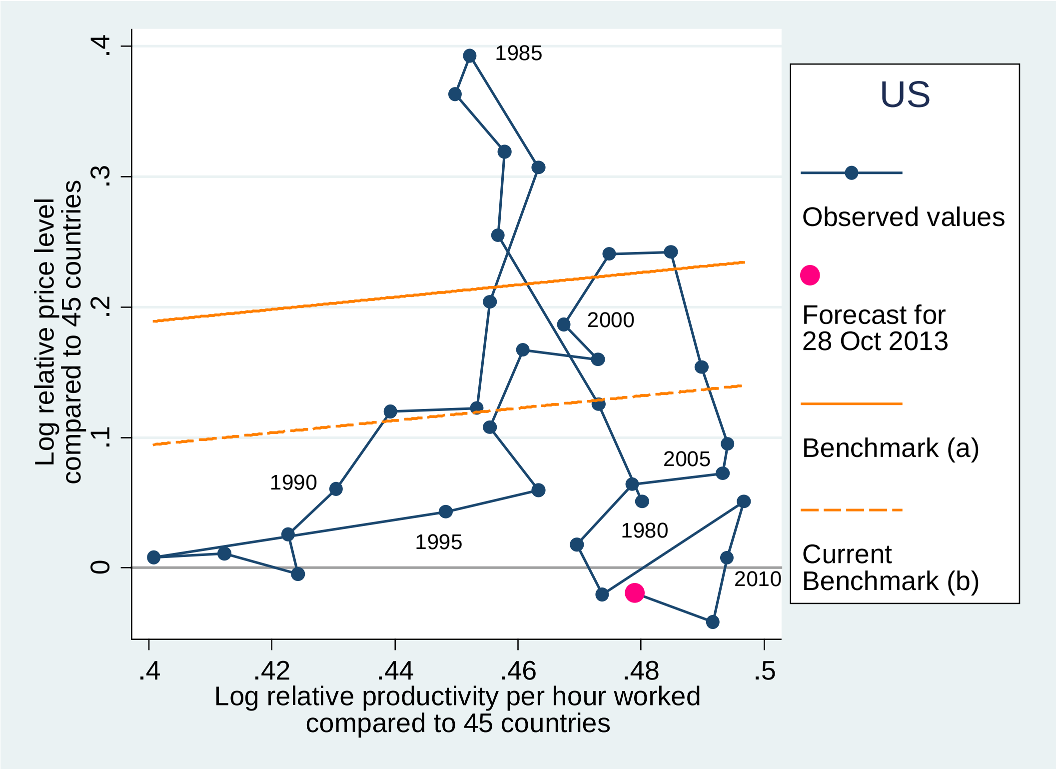

Figure 2: Indicator of price competitiveness for China since 1995

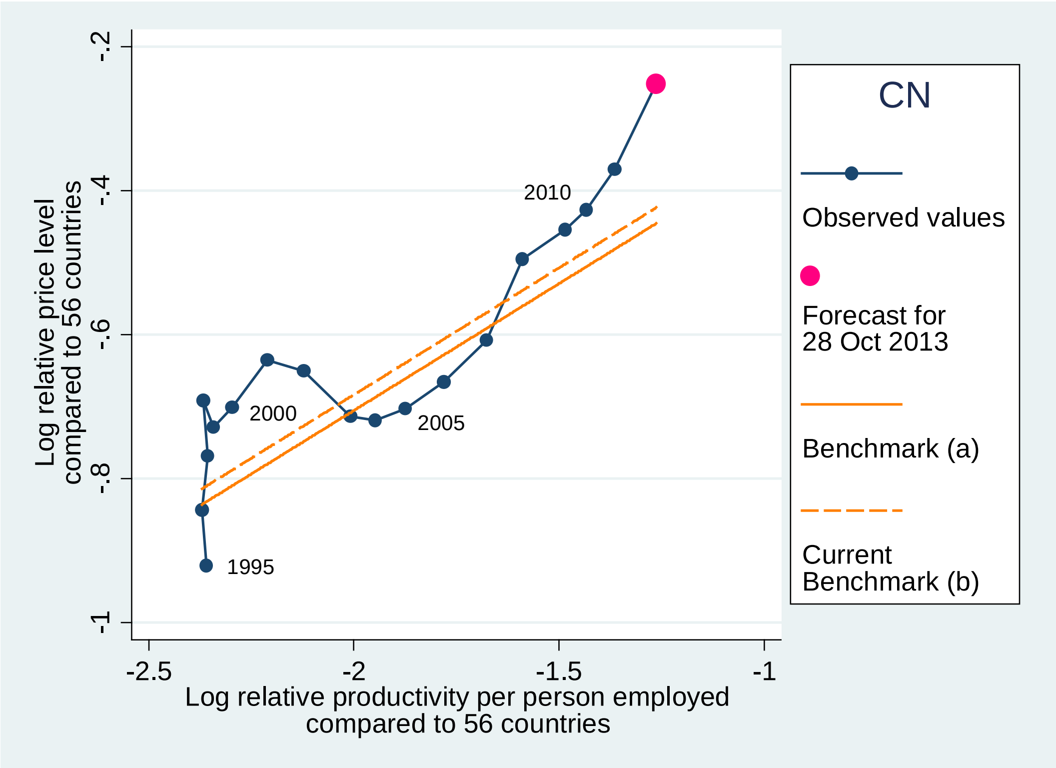

Figure 3: Indicator of price competitiveness for Japan since 1980