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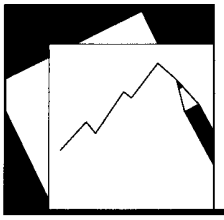

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Measuring Competitiveness: Trade in Goods or Tasks?

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Measuring Competitiveness: Trade in Goods or Tasks?

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Abstract

With global supply chains, any value added or production task can be traded as part of goods. This means that competitiveness can be measured either in terms of "tasks" (Bems and Johnson, 2012), or goods, but with goods prices reflecting the cost of tasks embedded in those goods. We show that when measuring competitiveness in goods, the formula used in computing the real effective exchange rates at the IMF (Bayoumi, Lee, and Jayanthi, 2005) needs to be expressed in terms of the price of value added and needs an additional term, which captures a gain or loss in competitiveness of goods due to outsourcing.

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I. INTRODUCTION

1. In the past few years, two alternatives to the Fund's standard formula for calculating real effective exchange rates (REER) have been proposed.[2] Both alternatives aim to address the implications of emerging global supply chains for assessing international price competitiveness. Bems and Johnson (2012) propose an alternative method based on trade in tasks and value-added trade data. Thorbecke (2011), as applied in Unteroberdoerster, Mohommad, and Vichyanond (2011), propose a so-called integrated effective exchange rate (IEER) that separately accounts for trade in intermediate inputs. Results from these alternative approaches can diverge from each other depending on the country. The main purpose of this paper is to propose a measure of competitiveness based on trade in goods as in the standard REER, but with the price of goods reflecting the cost structure of production with global supply chains. This is a new approach but shares the same intuition as was seen in IEER.

2. Bems and Johnson (2012) follow the original work by Armington (1969) and McGuirk (1987) closely, but make two important improvements. First, they switch from a world where goods are traded to a world where "tasks" are traded. With the growth of global supply chains, they argue that any task can be purchased either as intermediate inputs to production or as part of final goods consumed. They show that under certain conditions, the Fund's standard REER formula holds but the weights and the price index need to reflect value added or tasks. They compute REER indices using weights reflecting value-added trade patterns and prices for value added. They compute alternative REER indices for 42 countries from 1970 onwards and find that differences between standard REERs and their measures are driven by differences in prices, not weights. For example, they find that the Chinese REER measured in value-added terms has appreciated more since the early 2000s than the standard REER would suggest.

3. Thorbecke (2011) argues that in the context of global supply chains, analyzing the impact of exchange rate changes on trade needs to account for changes in the prices of imported intermediate inputs that are embodied in final goods exports. Based on this work, Unteroberdoerster, Mohommad, and Vichyanond (2011) compute an IEER which accounts for changes in the exchange rates of suppliers vis-à-vis the final export market currencies for a number of East Asian economies. They find that taking value-added in intermediate inputs into account, the Chinese IEER has appreciated less than the standard REER since 2008.

4. We argue that because of production sharing through global supply chains, changes in relative prices of goods have become less sensitive to domestic factor price movements, especially for emerging market economies. As a result, production sharing has helped some emerging market economies, such as China, to maintain competitiveness when faced with increasing prices of domestic production factors. To demonstrate this point, we construct a new index, REER in Goods, with prices of those goods reflecting "global supply chain" production structure. That is, goods are no longer produced using domestic production

[2] For the current method used at the Fund, see Bayoumi, Lee, and Jayanthi (2005).

factors only, but include production factors from abroad. More specifically, by expressing the price of goods as a function of price of production factors embedded in goods, we show that the Fund's standard REER formula needs to be expressed in terms of prices of factors (proxied by the GDP deflator[3]) and needs an additional term. This additional term captures the role of outsourcing or foreign value added in easing appreciation pressure coming from, for example, a relative increase in the cost of domestic factors of production or an appreciation of the nominal exchange rate. We compare this new index with the standard REER index and an index that reflects trade in tasks (REER in Tasks).

5. We find that there are significant differences between the standard REER and REER in Goods. For example, reflecting a more pronounced increase in the relative prices of production factors (compared to the price of final consumption goods) for China, the REER in Goods suggests more appreciation over time than the standard REER. This result is similar to Bems and Johnson (2012). However, for many emerging market economies, including China, an appreciation owing to an increase in the price of domestic production factors is moderated by the use of foreign production factors embedded in goods. Our results therefore confirm that in a world with production sharing, a loss in competitiveness due to an increase in relative factor costs does not necessarily get translated into a loss in competitiveness of goods. This is the moderation effect of production sharing discussed in Thorbecke (2011) and Unteroberdoerster, Mohommad, and Vichyanond (2011).

II. MODEL

6. Original work by Armington (1969) and McGuirk (1987) is based on a model of consumer demand. For example, consumer in country *j* maximizes his or her utility subject to a budget constraint and chooses consumption demand of goods produced in countries 1 to n, $C_{1j}, \dots, C_{nj}$. They specify a utility function with the CES functional form. Prices $P_1, \dots, P_n$ are therefore prices that the consumer faces; which justifies the use of CPI.[4]

$$Max\ U(C_{1j}, \dots, C_{nj})$$
$$s.t. \bar{Y}_j = P_1 C_{1j} + \dots + P_n C_{nj}.$$

7. Based on the Armington model, the Fund's current formula (Bayoumi, Lee, and Jayanthi, 2005) in calculating the REER of country *j* is

$$REER_j = \prod_{k \neq j} \left(\frac{P_j R_j}{P_k R_k} \right)^{w_{jk}},$$

[3] The GDP deflator is an imperfect proxy for the price of production factors since it also captures changes in profits. However, in the absence of comprehensive and comparable data on factor costs, we argue that the GDP deflator is the best available proxy for factor costs.

[4] Assuming perfect competition, it can also justify the use of unit labor costs (assuming further that labor is the only factor of production) or GDP deflator as the price of final goods.

where R_j and R_k are respective exchange rates and w_{jk} is the trade weight that captures import competition (i.e., competition in country *j*), export competition (i.e., competition in trading partner country *k*) and the third market competition (i.e., competition between *j* and *k* in all other markets).

8. Bems and Johnson (2012) introduce global supply chains to this setting and also move away from a goods world to a value-added world. More specifically, they model intermediate input demand as well as consumption demand, by assuming a production function with a global supply chain structure (similar to the CES production function described below). For example, producer in country *j* minimizes his or her cost of production subject to gross production technology and chooses intermediate input demand of inputs produced in countries 1 to n, $X_{1j}, \dots, X_{nj}$ as well as factors of production, capital (K_j) and labor (L_j).

$$Min\ C(w_j, r_j, P_1, \dots P_n; X_j) = w_j L_j + r_j K_j + P_1 X_{1j} + \dots + P_n X_{nj}$$
$$s.t.\ X_j = F(L_j, K_j, X_{1j}, \dots, X_{nj}).$$

With resource constraints satisfied in both goods and factor markets, they solve for equilibrium level of gross output X_j. They then show that when the same functional form as in the original Armington is assumed to describe consumer preferences and production technology, the Fund's standard REER formula remains the same but the weights need to be calculated to reflect value-added (or task) trade patterns, and P_j value-added prices (proxied by the GDP deflator).

9. Our main goal is to show how production sharing can help a country's goods competitiveness when relative prices of goods do not rise as fast as the relative costs of domestic factors.[5] We therefore derive the price equation for (gross) goods that captures the global supply chain structure and replace the consumer price within the original Armington structure.[6] What simplifies greatly in deriving the REER formula with global supply chains is that the total cost function, production technology and the price equation, which can be derived by specifying technology, can all be expressed in terms of value added of all

[5] This reflects a gain in competitiveness stemming from participating in global supply chains. Symmetrically, some countries may face a loss in competitiveness when relative prices of goods rise faster than relative costs of domestic factors. Note that this gain/loss owing to participating in global supply chains refers to changes in relative prices over time, not to the level of relative prices. Outsourcing of production, typically from advanced economies to emerging markets, has often been driven by a lower level of labor costs, resulting in a gain in goods' competitiveness from participating in global supply chains. The gain addressed in this paper is distinct from this since the REER is about relative changes and not about levels.

[6] Goods include both final goods and intermediate inputs. The consumer price index, which is used in to compute the REER at the Fund is an imperfect proxy of the price of goods since it only covers the price of final goods, and only partially.

countries in the world. After all, goods must be a product of someone's value added. For example, the two expressions of total cost below are equivalent, where the first expression can be read off of any input-output tables, while the second needs to be calculated as in Koopman and others (2010):

$$Total\ Cost = w_j L_j + r_j K_j + \sum_i P_i X_{ij}$$
$$= q_j D_j + \sum_{i \neq j} q_i M_{ij},$$

where q_j is price of value added, D_j is the domestic production factor, and M_{ij} is the foreign production factors (from country $i \neq j$) used in country j. Equivalently, production function $X_j = F(L_j, K_j, X_{1j}, \dots, X_{nj})$ can be expressed in terms of value added, $X_j = G(D_j, M_{1j} \dots, M_{nj})$. The benefit of using these alternative expressions is the ability to express the price of goods in terms of the price of value added of all countries. This simplifies the REER formula greatly.

10. We find that the REER formula in the world with production sharing needs to be expressed in terms of the GDP deflator but also needs an additional term. The additional term is expressed as a weighted average of relative prices of foreign value added used in production (relative to that of trading partners). It captures the role of outsourcing or foreign value added in easing an appreciation pressure coming from, for example, a relative increase in the cost of domestic production factors or an appreciation of the nominal exchange rate. The IEER shares the same intuition. The rest of this section gives the derivation of the REER formula in more detail.

11. Suppose that a producer minimizes the following cost function for gross output $\bar{X}_j$

$$Min\ C(q_j, q_1, \dots; \bar{X}_j) = q_j D_j + \sum_{i \neq j} q_i M_{ij}$$

$$s.t. \bar{X}_j = \left(\delta_j D_j^{\frac{\sigma_j - 1}{\sigma_j}} + (1 - \delta_j) M_j^{\frac{\sigma_j - 1}{\sigma_j}} \right)^{\frac{\sigma_j}{\sigma_j - 1}} \quad and\ M_j = \left(\sum_{j \neq i} \varphi_{ij} M_{ij}^{\frac{\sigma_j^M - 1}{\sigma_j^M}} \right)^{\frac{\sigma_j^M}{\sigma_j^M - 1}}.$$

Note that production technology takes the two-level constant elasticity of substitution (CES) functional form, which separates the production of domestic value-added and foreign value added used in domestic production. σ_j is the elasticity of substitution between domestic value-added and aggregate foreign value-added imports and σ_j^M is the elasticity of substitution among foreign value-added imports from different countries. If $\sigma_j = \sigma_j^M$, we are back to the standard Armington world (i.e., one-level CES). δ_j is the domestic value-added

cost share in total cost, and φ_{ij} is the foreign country *i*'s value-added cost share in total cost of foreign value added.

12. Solving for the first order conditions, we can derive the cost function as a function of output and prices:

$$C\left(q_j, q_1, \dots; \bar{X}_j\right) = \left({\delta_j}^{\sigma_j} {q_j}^{(1-\sigma_j)} + \left(1-\delta_j\right)^{\sigma_j} {q_j^M}^{(1-\sigma_j)}\right)^{\frac{1}{1-\sigma_j}} \cdot \bar{X}_j,$$

$$\text{where } q_j^M = \left(\sum_{i \neq j} {\varphi_{ij}}^{\sigma_j^M} \, {q_i}^{\left(1-\sigma_j^M\right)}\right)^{\frac{1}{1-\sigma_j^M}}.$$

13. Under perfect (or monopolistic) competition, the price of output P_j equals average cost and therefore the price of goods P_j can be expressed as a function of the price of production factors q_j:

$$P_j = \left({\delta_j}^{\sigma_j} {q_j}^{(1-\sigma_j)} + \left(1-\delta_j\right)^{\sigma_j} {q_j^M}^{(1-\sigma_j)}\right)^{\frac{1}{1-\sigma_j}}.$$

Note that this implies that the CES aggregator of GDP deflators, which measure prices of production factors or value added of different countries, is the best available proxy to capture the cost of production and hence the price of goods when there is production sharing.

14. One approach to computing the price index for goods when there is production sharing is to estimate values for σ_j and σ_j^M, compute the price of goods produced in country *j*, P_j, and replace the CPI with this price index in computing the standard REER. There are pros and cons in doing so. One obvious advantage is that the price index computed this way would reveal the cost structure with global supply chains more accurately than an alternative approach described below, since the elasticity of substitution between domestic and foreign inputs is known to differ from that among foreign inputs (e.g., Saito, 2004). One disadvantage is that there is no consensus over the wide range of elasticities found in the literature.

15. An alternative is to assume that σ_j and σ_j^M approach 1, and hence production technology is described using the Cobb-Douglas functional form:

$$\bar{X}_j = {D_j}^{\delta_j} {M_j}^{(1-\delta_j)} = {D_j}^{\delta_j} \left(\sum_{j \neq i} {M_{ij}}^{\varphi_{ij}}\right)^{(1-\delta_j)}.$$

16. The attraction of this approach is that key parameters are measureable: δ_j is the domestic value-added cost share in total cost, and φ_{ij} is the foreign country *i*'s value-added cost share in total cost of foreign value added. In this case, the price of output is:

$$P_j = c_j \cdot {q_j}^{\delta_j} q_j^{M(1-\delta_j)} = c_j \cdot {q_j}^{\delta_j} \left(\prod_{i \neq j} {q_i}^{\varphi_{ij}} \right)^{(1-\delta_j)},$$

where the constant term, $c_j = \left({\delta_j}^{-\delta_j} (1-\delta_j)^{-(1-\delta_j)} \prod_{j \neq i} {\varphi_{ij}}^{-\varphi_{ij}} \right)$. The price of goods is expressed as a weighted average of prices of production factors or value added of different countries. Note that if the price of imported value added from each country *i* is expressed in local currency, it needs to be converted to country *j*'s currency where R_i and R_j are respective exchange rates:

$$P_j = c_j \cdot {q_j}^{\delta_j} \prod_{i \neq j} \left(\frac{q_i R_i}{R_j} \right)^{\varphi_{ij}(1-\delta_j)}.$$

Note that when there is no production sharing (i.e., $\delta_j = 1$) and no intermediate inputs are traded, the price of goods in country *j* equals the price of domestic production factors (or value added) $P_j = q_j$. Equivalently, the price of goods with no production sharing equals the price of final goods captured in the GDP deflator.

17. The REER of goods produced in county *j* under this setting is as follows:

$$\begin{aligned}
REER_j &= \prod_{k \neq j} \left(\frac{P_j R_j}{P_k R_k} \right)^{w_{jk}} \\
&= \prod_{k \neq j} \left(\frac{\left(c_j {q_j}^{\delta_j} \prod_{i \neq j} \left(\frac{q_i R_i}{R_j} \right)^{\varphi_{ij}(1-\delta_j)} \right) R_j}{\left(c_k {q_k}^{\delta_k} \prod_{i \neq k} \left(\frac{q_i R_i}{R_k} \right)^{\varphi_{ik}(1-\delta_k)} \right) R_k} \right)^{w_{jk}} \\
&= \prod_{k \neq j} \left(\frac{\left(c_j {q_j}^{-(1-\delta_j)} \prod_{i \neq j} \left(\frac{q_i R_i}{R_j} \right)^{\varphi_{ij}(1-\delta_j)} \right) q_j R_j}{\left(c_k {q_k}^{-(1-\delta_k)} \prod_{i \neq k} \left(\frac{q_i R_i}{R_k} \right)^{\varphi_{ik}(1-\delta_k)} \right) q_k R_k} \right)^{w_{jk}} \\
&= \prod_{k \neq j} \left(\frac{\left(c_j \prod_{i \neq j} \left(\frac{q_j R_j}{q_i R_i} \right)^{-\varphi_{ij}(1-\delta_j)} \right)}{\left(c_k \prod_{i \neq k} \left(\frac{q_k R_k}{q_i R_i} \right)^{-\varphi_{ik}(1-\delta_k)} \right)} \right)^{w_{jk}} \prod_{k \neq j} \left(\frac{q_j R_j}{q_k R_k} \right)^{w_{jk}}.
\end{aligned}$$

18. The first product sum captures the role of outsourcing or foreign value added in easing an appreciation pressure coming from a relative increase in the cost of domestic

production factors or an appreciation of the nominal exchange rate. For example, when there is no production sharing (i.e., , $\delta_k = \delta_j = 1$), no intermediate inputs are traded and thus the competitiveness in prices of goods is that in prices of final goods or equivalently that in factor costs:

$$REER_j = \prod_{k \neq j} \left(\frac{P_j R_j}{P_k R_k}\right)^{w_{jk}} = \prod_{k \neq j} \left(\frac{q_j R_j}{q_k R_k}\right)^{w_{jk}}.$$

With production sharing, however, relative prices of goods do not necessarily appreciate at the same rate as relative factor costs or as the rate of nominal appreciation. For simplicity, let us suppose that trading partners do not outsource (i.e., δ_k=1). In such a case, an increase in relative prices of goods due to an increase in relative cost of domestic production factors or a nominal exchange rate appreciation can be moderated by a decrease in relative costs of foreign production factors:

$$REER_j = \prod_{k \neq j} \left(\frac{P_j R_j}{P_k R_k}\right)^{w_{jk}} = c_j \prod_{i \neq j} \left(\frac{q_j R_j}{q_i R_i}\right)^{-\varphi_{ij}(1-\delta_j)} \prod_{k \neq j} \left(\frac{q_j R_j}{q_k R_k}\right)^{w_{jk}}.$$

The moderation effects (the first product sum) are larger, the larger the foreign value-added cost share $1 - \delta_j$ is. This expression captures the intuition that underlies the IEER.[7]

III. Empirical Applications

A. Alternative REER Indices

19. In this section, we present empirical examples of three different measures of competitiveness. Main sources of data are: the OECD Input-Output Database, the OECD Bilateral Trade Database, the United Nations Comtrade, the World Economic Outlook and the International Financial Statistics. In order to be able to compare with the standard REER index, we use the same formula as in Bayoumi, Lee, and Jayanthi (2005) as a starting point for all three measures. One difference from the standard REERs is the number of countries

[7] One caveat of this approach is an implicit assumption that aggregate supply is fixed at ex-ante equilibrium. Armington derives the demand for a product in a particular market using a two-step procedure: (i) the demand for the good in general is derived by maximizing a utility function; and (ii) the demand for a good produced by an individual country is determined by minimizing the cost of purchasing the amount of the good derived in the first step. We assume that the intermediate input demand is determined by cost minimization for a given level of aggregate supply $\overline{X}_j$ and the demand for consumer goods by utility maximization subject to a given level of factor income (which is a also function of aggregate supply). Keeping the standard trade weights in our analysis implies that the aggregate supply $\overline{X}_j$ remains fixed at ex-ante equilibrium. Bems and Johnson (2012) instead solve for an equilibrium level of output where aggregate supply equals aggregate demand. The formula for trade weights is different, reflecting differences in goods versus value-added trade patterns.

included: we use only 42 OECD countries and emerging markets where input-output tables are available.[8]

- *Standard REER*: The standard measure of competitiveness currently used at the IMF is computed as follows:

$$REER_j^{Standard} = \prod_{k \neq j} \left(\frac{P_j R_j}{P_k R_k} \right)^{w_{jk}},$$

where P_j and P_k are measured by the consumer price index (CPI) and w_{jk} are the weights computed using gross trade data taken from the United Nations Comtrade.

- *REER in Goods*: The REER proposed in this paper is computed as follows:

$$REER_j^{Goods} = \prod_{k \neq j} \left(\frac{c_j \prod_{i \neq j} \left(\frac{q_j R_j}{q_i R_i} \right)^{-\varphi_{ij}(1-\delta_j)}}{c_k \prod_{i \neq k} \left(\frac{q_k R_k}{q_i R_i} \right)^{-\varphi_{ik}(1-\delta_k)}} \right)^{w_{jk}} \prod_{k \neq j} \left(\frac{q_j R_j}{q_k R_k} \right)^{w_{jk}},$$

where q_j and q_k are proxied by the GDP deflator, and φ_{ij} is the foreign country *i*'s value-added cost share, and δ_j is the domestic value-added cost share in total cost. To obtain foreign value-added shares, we supplement the OECD Input-Output Database with the OECD Bilateral Trade Database. By making the proportionality assumption as in Koopman and others (2010), we first decompose gross exports of country *j* into domestic value added and intermediate inputs by source. Intermediate inputs from country *i* (including domestic country *j*) are then decomposed into domestic value added of country *i* and intermediate inputs by source (which are then assumed to contain no further foreign value added). The reason for using export demand rather than total final demand to compute domestic value added shares is to capture the cost structure of tradables rather than that of goods more generally.

- *REER in Tasks*: The first order approximation of the Value-Added Real Effective Exchange Rate (VAREER) proposed in Bems and Johnson (2012) is computed as follows:

$$REER_j^{Tasks} = \prod_{k \neq j} \left(\frac{q_j R_j}{q_k R_k} \right)^{v_{jk}},$$

where q_j and q_k are proxied by the GDP deflator and v_{jk} are the weights computed using value-added trade data. For the empirical application in this paper, the same

[8] The standard weights used to compute the REER, the so-called "INS weights," include only partner countries with a weight above 1 percent in trade and therefore the number of partner countries in INS weights varies both over time and across countries. A comparison of our gross trade based weights for the mid 2000s with the latest available INS weights suggest that the larger coverage of trading partners results in minor changes in the REER indices.

formula as above is used but trade and output data are adjusted using value-added data.[9] For example, to obtain value-added exports, we multiply gross exports used to compute $REER_j^{Standard}$ by the domestic value-added share in exports as in Hummels, Ishii, and Yi (2001) based on the OECD Input-Output Database. Adjusted home sales are computed using value-added exports and value-added output (obtained by multiplying gross output by the domestic value-added share in output). These adjustments are used in the construction of new weights for manufacturing and non-tourism services only, whereas other components of the REERs (weights for commodities and tourism) are computed as described in Bayoumi, Lee, and Jayanthi (2005). GDP deflator data are mainly quarterly and taken from the WEO or the IFS. Lower frequency source data have been intrapolated to generate monthly data.

B. Standard REER versus REER in Tasks

20. We first compare the standard REER that is based on trade in goods, but not adjusted for imported intermediates, and REER in Tasks, our approximation of the Bems and Johnson (2012) VAREER index. There are significant empirical differences between the two REERs that also vary across countries. This is illustrated for selected countries in Figure 1. For China and Japan, the REER in Tasks suggests more appreciation over time than the standard REER. For China the difference emerges from the early 2000s onwards, reflecting a gradual increase in domestic production costs, whereas for Japan the difference emerges in the early 1990s narrowing somewhat in the early 2000s. In cumulative terms the REER in Tasks suggest an additional close to 30 percent appreciation for both countries. For the United States, the REER in Tasks suggests a gradual improvement in competitiveness over time (about 15 percent in cumulative terms) compared to the standard REER. For Germany, the compression in domestic labor costs contributed to a decline in the REER in Tasks from the mid 1990s onwards. Overall, these differences are similar to those reported in Bems and Johnson (2012).[10]

[9] Value-added trade weights computed here are different from those computed in Bems and Johnson (2012) for two main reasons. First, Bems and Johson (2012) solve analytically for value-added trade weights and compute weights according to the new formula. Our value-added trade weights are only a first order approximation of their value-added trade weights. Second, their value-added trade weights change every year while ours only three times during the sample period (mid 1990s, early 2000s, and mid 2000s) as in the standard trade weights currently used at the Fund. There may also be differences in the underlying input-output data used to compute value-added trade.

[10] The differences are similar but smaller since value added trade weights in this paper are only a first order approximation of the value added trade weights computed in Bems and Johnson (2012).