How Do Global Value Chains Affect Real Effective Exchange Rates and Trade Openness? An Exposition

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Abstract

All common real effective exchange rate indexes assume trade is only in final goods, despite the growing presence of global supply chains. Extending effective exchange rate indexes to include such intermediate goods can imply radically different effective exchange rate weights, depending on the relative substitutability of goods in final demand and in production. Unfortunately, these shifts in weights are difficult to distinguish empirically because the two currencies most affected—the dollar and the renminbi—have moved closely together. As the renminbi becomes more flexible, however, it will be important to determine which assumptions are the most realistic.

Introduction

Few external indicators are more important for international policy analysis than the effective exchange rate. Policy makers are clearly interested in comparing the external competitiveness of their economy with others. Such calculations were relatively easy over the Bretton Woods fixed exchange rate period, since countries generally followed a fixed exchange rate against the dollar so that devaluations were normally against virtually all trade partners. However, things got considerably more complicated with the advent of the floating exchange rate regime in the 1970s. With the value of major currencies moving rapidly against each other driven by traders' assessments of market fundamentals and dynamics, effective exchange rates have become a standard metric for trade competitiveness. However, it remains unclear that these indexes have kept pace with the changing nature of international trade, especially the rise of global value chains. This suggests that there may be concerns about the accuracy of standard effective exchange rate calculations. To understand why, it is useful to explain the model behind effective exchange rate weights.

The technology for producing effective exchange rates has changed little since the late 1960s. Almost all the calculations used currently are based on the Armington assumption. In 1969 Paul S. Armington wrote an elegant paper in which he showed that, in a world in which goods produced by different countries were imperfect substitutes for each other and that the demand system for such goods had a constant elasticity, then (under some not terribly demanding assumptions) the competitiveness of a good could be assumed to depend on the relative prices of that good compared to all goods of that type.[1] The further simplification that each country produces just one good created the familiar effective exchange rate indices that are almost universally used today, including those produced by the BIS, ECB, Federal Reserve, the IMF, and the OECD, albeit with subtly different additional assumptions (for example on commodity trade).[2]

Like any such construct, the Armington approach has many limitations. It assumes that the exports of a country can be approximated by a single good, and that these country "goods" have the same elasticity of substitution across them. Possibly even more importantly, the model assumes that these goods are only used in final consumption. Such an assumption may have been a reasonable approximation at the time when the paper was written in the 1960s, when most production chains were located within countries and final

[1] Armington (1969). See also McGuirk (1987).

[2] See Zanello and Desruelle (1997) and Bayoumi, Jayanthi, and Lee (2006) on the IMF, Lorentan (2005) on the Federal Reserve, De Clercq and others (2012) for the ECB, Durand, Simon and Webb (1992) for the OECD, and Turner and Van't dack (1993) and Klau and Fung (2006) for the BIS.

goods were then exported. However, in a modern world of international value chains involving intermediate goods, such an assumption is much more questionable.

In response, several authors have recently proposed various approaches to calculating effective exchange rate weights that incorporate global value chains.[3] The key innovation is that, given the possibility of international trade in intermediates, price changes in one country can lead to expenditure switching not just at the final-demand stage, but also at the production stage. In contrast to Armington, effective exchange rates thus depend on the elasticity of substitution of intermediate goods in production in addition to the elasticity of substitution of final demand. However, while these papers report methodologies and real effective exchange rates, they do not explore the underlying logic of the differences in weights in any detail. This paper explains why the different assumptions matter for effective exchange rate calculations.

These modifications to the standard Armington model can matter a great deal for effective exchange rate weights. For example, it is quite possible that for some intermediate goods the effective exchange rate weight of certain countries is negative. To see this, consider a world of three countries, where Korea produces flat screens that Chinese firms put into computers that are exported to the United States. Does a depreciation in the Chinese currency raise or lower Korea's competitiveness (i.e., her exports of flat screens)? It all depends. If US consumers' demand for computers is not very price sensitive (e.g. if consumers allocate their budget to different goods in relatively fixed proportions) while Chinese producers' demand for flat screens is highly price sensitive (e.g. if Korean screens can be substituted with locally-sourced screens with relative ease), then a Chinese depreciation will lower Korean exports of flat screens because the fall in demand from Chinese producers will dominate the rise in final demand for computers. This is the conventional case in which a depreciation in the renminbi makes the won less competitive and hence the weight of China in Korea's effective exchange rate is positive. By contrast, if the demand for computers in the US is highly price sensitive while the demand for flat screen from Chinese producers is not very price sensitive, then Korea's competitiveness will rise because of the fillip to the demand for Chinese computers from the US dominates. In this case, the depreciation of the renminbi against the dollar has raised demand for computers and hence Korea's competitiveness—in other words, the weight of the renminbi in the won effective exchange rate is negative.

One reason for the new interest in more complex effective exchange rate indices is that we now have the tools to measure trade by types of goods. Researchers have linked together input-output tables across countries. This allows more complex effective exchange

[3] See Bems and Johnson (2015), Patel, Wang, and Wei (2017), and Bayoumi, Saito, and Thurman (2013). Other analysis of exchange rates and value chains include Ahmed, Appendino, and Ruta (2016), and Cheng and others (2016).

rate elasticities to be computed. It also allows for better calculation of how "open" a country is to intentional trade. Conventional measures of openness usually include imports of intermediate goods that are then reexported—so exports include foreign goods. By contrast, the calculations used for the rest of gross domestic product excludes intermediate goods to avoid double counting—so the value added of (say) a car excludes the cost of the steel used to make it. Excluding intermediate imports that are put into exports would make the calculation of trade consistent with the remainder of gross domestic product. Input-output tables make it possible to calculate such "value added" trade to be computed.

The remainder of this paper examines these issues in more detail. The next section discusses how new models of effective exchange rates work. This is followed by an analysis of which elasticities matter for the calculation of real effective exchange rates, and why it has been so difficult to differentiate these effects empirically. Next, the implications of switching to value added trade for assessments of trade openness are outlined. We conclude with a discussion of the implication for the construction of effective exchange rate indexes.

Effective Exchange Rate Weights in Theory

Modern theories of real effective exchange rates all rely on constant elasticity of substitution (CES) functions. Consider the basic CES demand for goods used by Armington:

$$U_t = \left(\sum_{i=1}^{n} \left(\frac{\omega_{it}}{\omega_t} \right)^{1/\rho} C_{it}^{(\rho-1)/\rho} \right)^{\rho/(\rho-1)}$$

where U_t is utility, ω_{it} are weights that sum to ω_t, C_{it} is consumption, and ρ is the elasticity of substitution. This functional form is attractive for effective exchange rate calculations because it allows goods to be aggregated into an "ideal" single composite good, so that the final demand for any good can be expressed as a function of the relative price of that good versus the (composite) price of the composite good. Hence:

$$C_{it} = A_{it} C_t \left(\frac{P_{it}}{P_t} \right)^{\rho}$$

where C_{it} is the consumption of the final good, A_{it} is an (approximate) constant, C_t is the composite good, and P_{it}/P_t is the relative prices of the final good compared to the price of the composite good.

The ability to aggregate across goods allows CES functions to be nested. This means that the model can look at the consequences of imports and exports of intermediate goods used in production as well as the final goods assumed by Armington. For example, in the model of Bems and Johnson (forthcoming) there are three nested CES functions.

Conceptually, firms first put together intermediate goods, which they next combine with domestic value added (labor, capital, and land) to create goods. These firms then either send their good on to be used in further production or to be consumed as final goods. This leads to a system in which the demand for a good depends on three elasticities of substitution, that across intermediate goods (σ), that between intermediate goods and domestic value added (γ), and that between final consumption goods (ρ). It is the interaction between these three elasticities than determine the real effective exchange rate weights of goods across countries.

In practice, it turns out the that the elasticity of substitution between the aggregate intermediate good and domestic value added (γ) plays a relatively minor role in the calculations. Consequently, when calculating alternative effective exchange rate weights, Bems and Johnson always set it equal to the elasticity of substitution across intermediate goods (σ). To illustrate the impact of different assumptions about the elasticities on production of intermediate goods and on final demand, Bems and Johnson report the effective exchange rate weights implied by three sets of assumptions on the elasticities of substitution, with the parameters designed to create similar sensitivities of aggregate trade to changes in exchange rates. The first calculation assumes that the elasticities of substitution for demand and production are all set to unity ($\sigma = \gamma = \rho = 1$).[4] The next calculation assumes that there is no possibility to substitute within the production process, while the elasticity of substitution for final goods is three ($\sigma = \gamma = 0$; $\rho = 3$). Finally, they also report effect exchange rate weights in which it is assumed that final demand is price insensitive, while the elasticity of substitution in production is high ($\sigma = \gamma = 1.5$; $\rho = 0$).

The first assumption—in which elasticities in production and demand are the same—produces a model with similar properties to the original Armington model, but where the weights "see through" the value chain to goods' ultimate destination. So, to take the example of Korean flat screens discussed earlier, while in the Armington model the assumption would be that the flat screens were consumed in China because it assumes all goods are final goods, in this version of the model the flat screens are treated as if they were directly exported from Korea to the United States. The fact that the flat screens are incorporated into Chinese computers along the way makes no difference. This is often termed "trade in tasks", on the logic that a good is an amalgam of components ("tasks') and that in this version of the model all that matters is the initial origin of the components which are incorporated in the final goods. Because the flat Korean screens are treated as a direct export from Korea to the United States, all that matters for the demand for flat screens is the dollar-won exchange rate. Any changes in the renminbi against either the won or the dollar are irrelevant and have no impact on the demand for Korean flat screens. In the rest of this paper, and following Bems and Johnson, we will call this a value added effective exchange rate.

[4] An elasticity of one is often assumed as it makes the nominal amount spent on a good invariant to its prices, which simplifies the calculation of weights of different goods in demand and production.

The second assumption—in which the demand for intermediate goods is completely price insensitive—produces a radically different result. In this a case, it is the demand for Chinese computers in the US that determines the demand for Korean flat screens since the Leontief production function means that Chinese producers use the same amount of Korean flat screens in each computer regardless of the price. As a result, the demand for Korea flat screens depends mainly on the renminbi-dollar rate and only a little bit on the won-dollar rate. This is because what matters is the price of the entire Chinese computer in the US market. If the renminbi depreciates against the dollar but the won stays unchanged against the dollar then the demand for flat screens rises since Chinese computers are cheaper. In effect, China has a negative weight in the Korean exchange rate since a deprecation of the renminbi increases demand for flat screens. On the other hand, if the won depreciates against the dollar but the renminbi does not, there is only a small increase in demand for flat screens (the depreciation of the won against the dollar lowers the cost of the flat screens in the US market, modestly lowering their price and increasing demand for Chinese computers). As this case illustrates, real effective exchange rate weights become quite complicated under this set of assumptions. In the rest of the paper, we will call this the Leontief production effective exchange rate.

Finally, in the case where the demand for intermediate goods is price elastic but final demand is price insensitive, the demand for Korean flat screens falls if the renminbi depreciates against the won regardless of what happens to the dollar, as Chinese producers will use fewer expensive flat screens in their computers. This is a case in which the only thing that matters for effective exchange rates is trade in intermediate goods—final demand does not matter at all. While empirically less interesting, this case serves as a useful conceptual benchmark. It is the antithesis of the Armington assumption that all that matters is demand for final goods, although in practice it generates similar results to the Armington model because in the Armington model trade in intermediate goods is misclassified as trade final goods. In the rest of the paper, we will call this the Leontief demand effective exchange rate.

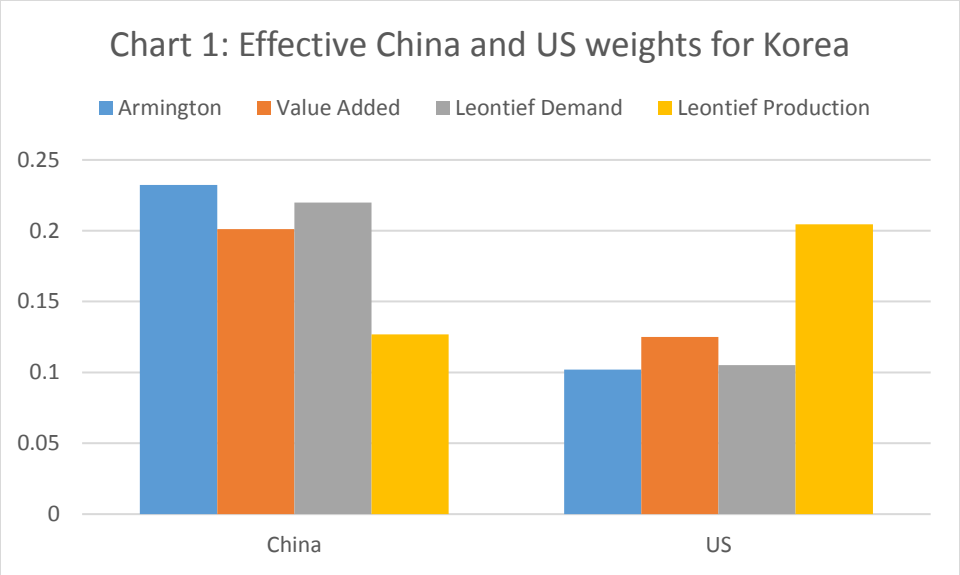
The key difference between the value added and Leontief demand exchange rates is the elasticity of substitution of intermediate goods in the production process. While it is unlikely that intermediate goods are literally defined by Leontief production, it is not unreasonably to think that the elasticity of substitution for intermediate goods is low within complex supply chains. It is often argued that there needs to be a close relationship between producers and their suppliers as producers ask their suppliers to provide very specific products (think of screens for iPhones). For suppliers to go to the expense of setting up a specific production processes to cater to these needs, they presumably would ask for some assurance that the producer will continue to buy their goods into the future. This suggests that the elasticity of substitution between such goods within such supply chains may indeed be relatively low. Bems and Johnson find that the crucial parameter for real effective exchange rate calculations is the *relative* elasticity of substitution for intermediate compared to final

goods, which suggests that actual outcomes for short-term movements in exchange rates are likely to lie somewhere between the value added effective exchange rate (with a relatively elasticity of 1) and the Leontief production exchange rate (with a relatively elasticity of 0).

One approach to this is to use sector-specific elasticities of substitution. See, for example, the trade models of Costinot and Rodriguez-Clare (2014), Ossa (2014) and Caliendo and Parro (2015) and the real effective exchange rate model of Patel, Wang and Wei (2017). This approach has promise if elasticities can be accurately measured across sectors, although such an approach adds to the complexity of the model and makes the underlying assumptions difficult to understand. In addition, an alternative approach is to divide goods into those that essentially operate in a global market with a single price and where trade patterns are driven by proximity, such as oil market and coal, and goods that are differentiated and designed for a specific purpose, such as flat screens for an iPhone.

Real Effective Exchange Rate Weights in Practice

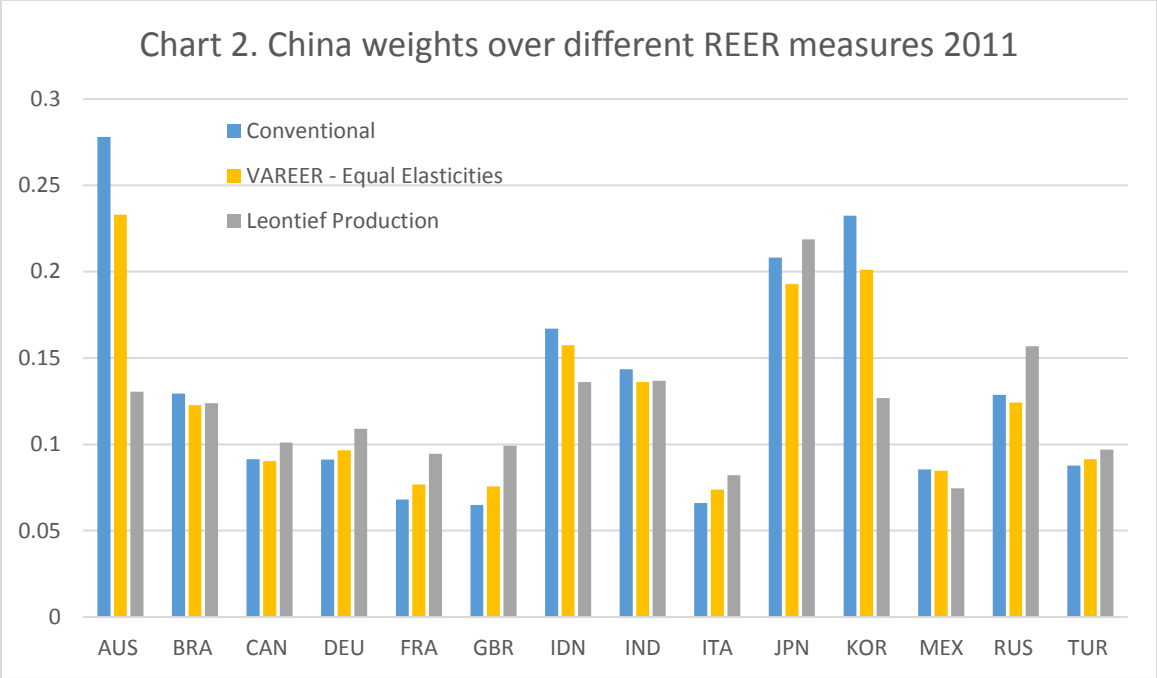
Chart 1 shows the relative weights of China and the United States in the real effective exchange rates of Korea for 2011 as calculated by Bems and Johnson for different assumptions about the elasticities of substitution: the conventional Armington effective exchange rate model, the value added model, the Leontief demand model, and the Leontief production model. The conventional Armington model, which assumes all goods are final goods, gives China a weight of 0.23 in the Korean real effective exchange rate and the US a weight of 0.10. The difference in these elasticities shrink modestly using the value added effective exchange rate—the weight of China in the Korean effective exchange rate falls to 0.20 and that in the dollar rises to 0.125, reflecting the fact that some Korean goods exported to China are incorporated into goods that are destined for the United States (as in the flat screen example). The less interesting case of Leontief demand for final goods is more similar to the conventional Armington result, with a real effective exchange rate weight of 0.22 for China and just over 0.10 for the United States. In all three cases, fluctuations against the renminbi are more important for Korean competitiveness than fluctuations against the dollar.

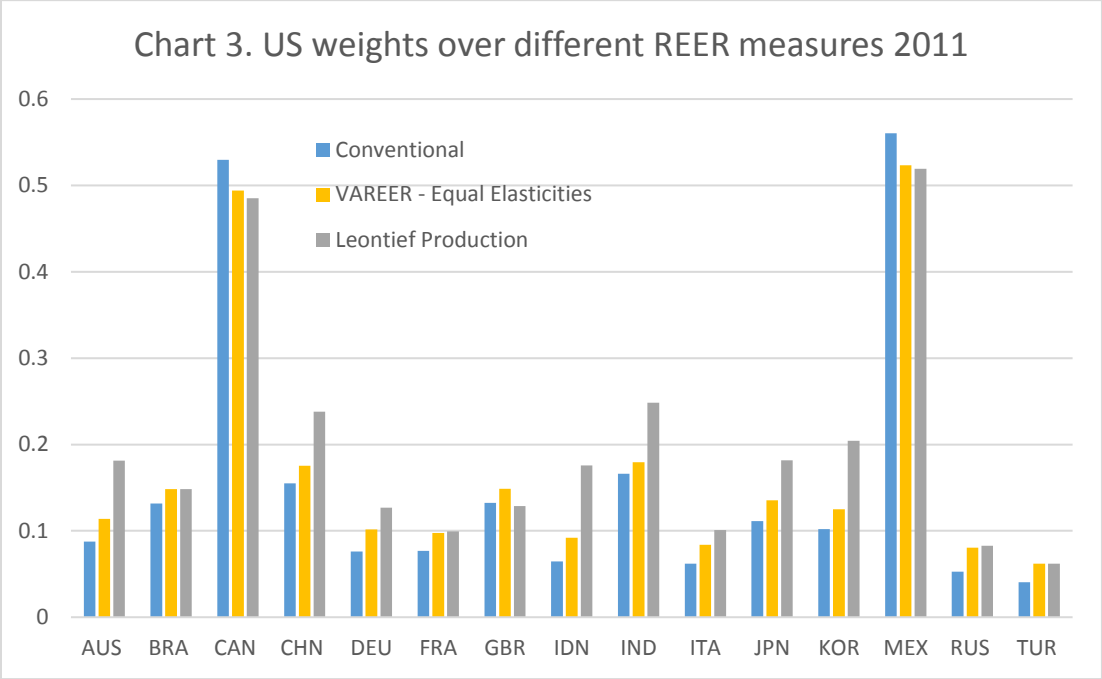


By contrast, there is a dramatic change in relative weights in the Leontief production effective exchange rate. In this case, the weight of China in the Korean effective exchange rate falls to just 0.125 while the weight in the US effective exchange rate rises to slightly over 0.2, implying that for Korean competitiveness fluctuations against the dollar are more important than fluctuations against the renminbi. As discussed earlier, the reason for the fall in the weight of China in the Korean real effective exchange rate and rise of the weight of the United States is that for Korean producers whose intermediate goods are incorporated into Chinese goods that are sent to the US market, any depreciation in the renminbi against the dollar leads to an increase in demand. The demand for Korean intermediate goods exported to China but ultimately destined for the United States depend crucially on the dollar-renminbi exchange rate, not simply the dollar-won rate.

While this is an extreme example, the basic intuition holds more generally. The weights derived from the conventional Armington calculations and the value added real effective exchange rate are quite similar, while those using Leontief production are quite different and depend heavily upon supply chains. To illustrate this, Chart 2 compares the weights on the renminbi for members of the G20 including in the Bems and Johnson data set using conventional Armington, value added, and Leontief production indexes, while Chart 3 repeats this procedure for the US dollar (the Leontief demand results are excluded as they are of little interest). [5]

[5] For simplicity of exposition, the analysis is limited to the G20 countries in the sample rather than the 41 countries used by Bems and Johnson.





Assuming Leontief production creates large falls in weight of China in the countries most involved in the Asian supply chain (particularly Australia and Korea) and modest increases in weights of countries principally involved in other supply chains (Canada, the United States, and members of the European Union). Similarly, the weight on the United States falls slightly for the countries in its supply chain—Canada and Mexico—but increases, often notably, for many other G20 countries, including China, Germany, and Japan.

The overall result of assuming Leontief production is a modest fall in the importance of the renminbi in international trade and a significant increase in the role of the dollar. More precisely, the simple average of the renminbi effective exchange rate weights in the countries in Chart 2 falls from 13% to 12% while those of the dollar in Chart 3 rise from 16% to 20%. In short, assuming Leontief production implies a much larger role for the dollar, reflecting the importance of the United States as a consumer of final products that are assembled across many countries. While Charts 2 and 3 focus on the dollar and renminbi, similar patterns occur elsewhere. For example, assuming Leontief production reduces the weights of the euro area countries in the German and French indexes, as well as those for Russia and Turkey, but raise the importance of Euro area country weights for most other countries.[6] Interestingly, this includes Italy and the United Kingdom, suggesting that the latter two countries are not particularly well integrated into the European supply chain.

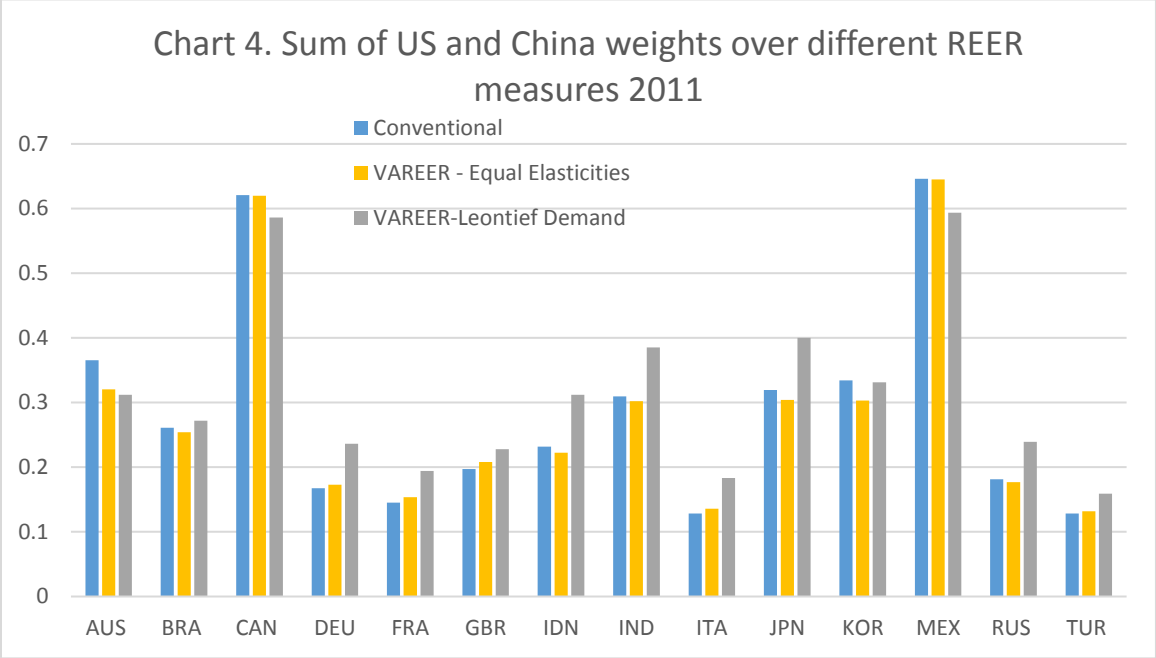
Empirically Comparing Differing Effective Exchange Rate Weights

While using Leontief production weights creates a *qualitatively* similar shift in weights across the Asian, NAFTA, and European supply chains—namely a fall in the weight of the central country (China, US, Germany) and rise in the weights of major countries outside the supply chain—*quantitatively* the results are dominated by the impact on the Asian supply chain. This is best illustrated by calculating the correlation between the changes in weights of the renminbi and the euro with those of the dollar. Shifts in the weight of the dollar and the renminbi between the conventional and Leontief production assumptions have a correlation of -0.6, implying that a decrease in (say) the weight on the renminbi is generally associated with an increase in the weight of the dollar. By contrast, changes in the weights of the dollar and the euro have a correlation of over 0.5, so increases in the importance of the dollar tend to be accompanied by increases in the weight on the euro.

These patterns help explain why it has been so difficult to empirically distinguish between the real effective exchange rates implied by different weighting schemes. Because the renminbi has historically been closely linked to the dollar, effective exchange rates calculated using Leontief production weights are not very different from those using Armington or value added weights. The case of Korea is illustrative. While the weight on the dollar in Korea's effective exchange rate in 2011 rises by .10 using Leontief production weights versus Armington weights, the renminbi's weight falls by around the same amount. Hence, the sum of the two weights is very similar. Since the dollar and the renminbi have tended to appreciate and depreciate against other currencies in tandem, the switch in weights has little impact on the estimated real effective exchange rate for Korea. As can be seen in

[6] The fact that Germany, the center of the European supply chain, has the same currency as many of its suppliers may also limit the impact on Euro weights.

Chart 4, the similarity across different weighting schemes of the sum of the Chinese and U.S. weights is not limited to Korea.



By contrast, as the dollar floats against the euro, appreciations in the dollar tend to be accompanied by depreciations in the euro. But since increases in the weight of the dollar caused by the switch to Leontief production weights tend to be also accompanied by increases in the weight on the euro, these effects also tend to cancel out in real effective exchange rate calculations.

To illustrate the similarity of real effective exchange rate using different weighting schemes, Table 1 reports the correlations between Bems and Johnson's estimates of real effective exchange rates over time using the Armington weights, the value added weights, and the Leontief production weights for the countries in Charts 2-4 except Russia. As can be seen in the first column, the average correlation over 1980-2011 between the Armington and Leontief production real effective exchange rates is 0.9.[7] The correlation between the value-added and Leontief production weights is much higher. The average correlations between these real effective exchange rates is 0.994 and is above this average for Korea and Australia, countries where the weight of China and the US differ greatly across the two approaches. Strikingly, despite treating value chains in very different ways, the two series are almost identical. The much higher correlations between the value added and the Leontief production real effective exchange rates suggests that the main differences come from using Armington

[7] The 1980-2011 data were constructed by extending the Bems and Johnson calculations for 1995-2011 back using an earlier data set which cover 1980-2009. Russia is not included in this extended data set.

weights, not from differences in the assumption about the elasticity of substitution in production coming from value added versus Leontief production weights.

Table 1. Correlations of Different Real Effective Exchange Rate Indexes, 1980-2011

	Armington vs Leontief production	Value Added vs Leontief production
AUS	0.986	0.997
BRA	0.855	0.999
CAN	0.976	0.993
CHN	0.988	0.999
DEU	0.733	0.992
FRA	0.965	0.982
GBR	0.919	0.997
IDN	0.908	0.997
IND	0.993	0.999
ITA	0.866	0.990
JPN	0.924	0.997
KOR	0.785	0.989
MEX	0.947	0.999
TUR	0.719	0.985
USA	0.943	0.997
Average	0.900	0.994

These results explain why it has proved very difficult to differentiate empirically between these real effective exchange rate estimates despite considerable conceptual differences. However, this will not last. The high correlations reflect the fact that the renminbi has closely shadowed the dollar, most notably in cases such as Australia and Korea. As the renminbi moves to greater flexibility against the dollar, the differences in completeness implies by differing assumptions about global supply chains will become much more apparent.

Estimated Exchange Rate Elasticities Using Different Real Effective Exchange Rates

Import and export models were calculated by country level using a simple log-linear specification. For each country REER-trade pair, we check if the residual of the regression in levels is stationary. If so, the model is estimated in levels; otherwise it is re-estimated in first differences.[8] Most countries in our sample show cointegration in the value added (Leontief

[8] We are grateful to Weicheng Lian for sharing the data and codes used in IMF (2015). Note, however, that while IMF (2015) estimates four set of equations (from REER to import/export prices, and from import/export prices to trade volumes), here we estimate only two (from REER to trade volumes).

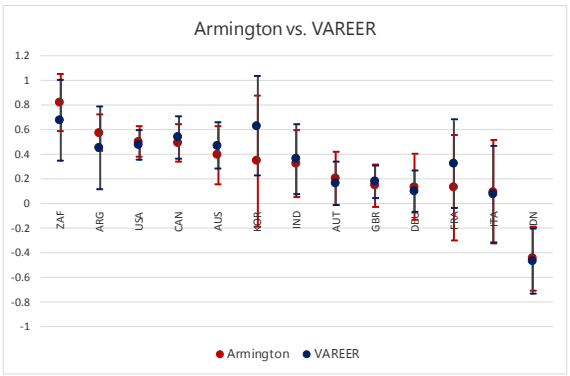
production) real effective exchange rate-real imports relation, and in the equivalent export relation. Most of the data span 1970 to 2011. The equation for imports includes real domestic demand, exports (both also interacted with a GFC dummy), a non-fuel price index, an oil price index, and a time trend. The controls in the exports equation are: real foreign demand (also interacted with a GFC dummy), real unit labor costs, a non-fuel price index, an oil price index, and a time trend. See IMF (2015) for variable definitions. Results reported here correspond to G20 economies with at least 25 years of data. The findings are qualitatively identical for non-G20 countries that meet this minimum data requirement; these additional results are available upon request.

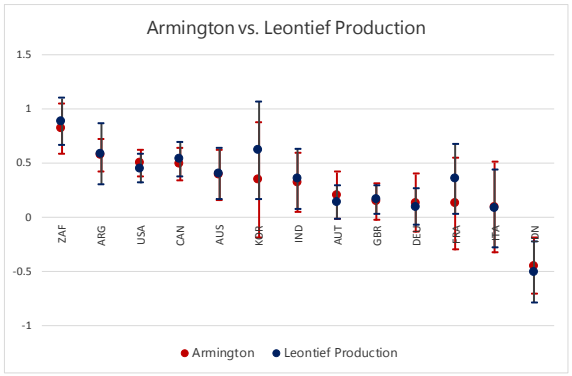
By and large, import elasticities to different REER measures appear statistically indistinguishable. Chart 5 reports two sets of comparisons between import elasticity estimates. The first set of comparisons contrast the elasticity of imports estimated using the value added real effective exchange rate and the Armington real effective exchange rate. The estimates are statistically indistinguishable from one another. The comparison between Armington elasticities and Leontief production elasticities yields the same results.

Export elasticities also appear insensitive to the REER measure used. Chart 6 shows the comparison of export elasticities using different REER measures. The elasticity of exports to Armington real effective exchange rate is very similar to the elasticity from the value added or Leontief production model. Moreover, the small differences are statistically insignificant.

The findings are robust to alternative specifications. To account for the possibility that trade variables exhibit a stochastic trend but the real exchange rate measures do not, we have also estimated the model with trade variables in first differences and the real exchange rate in levels. The results are robust to this alternative specification. As another robustness check, we also estimated the first two equations in IMF (2015) for the different REER measures (see footnote 7). The conclusions reached under this alternative specification are the same as those described above.

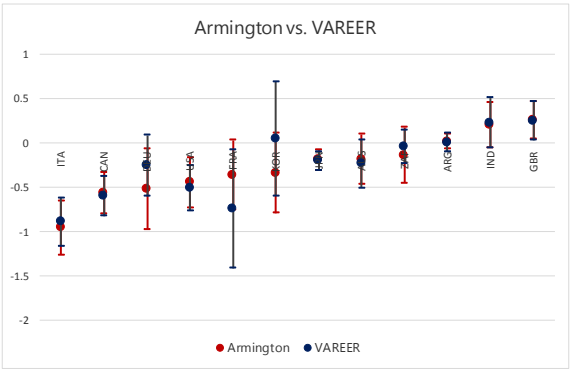
Chart 5. Import Elasticities with Different REER Measures

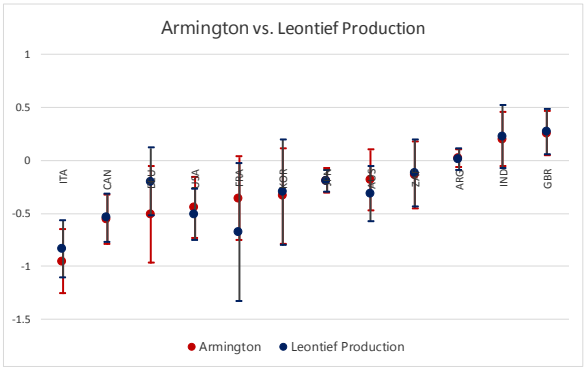




Note: The confidence bands correspond to 5 percent significance levels.

Chart 6. Export Elasticities with Different REER Measures





Note: The confidence bands correspond to 5 percent significance levels.

Real Effective Exchange Rate Weights Over Time

The rise in importance of China in global trade implies another important dynamic to the path of real effective exchange rates over time. As late as 1999, when the Euro was formed, China is no more than a bit player in the global trading system. Its average weight in other G20 countries is less than 0.04 using either an Armington, value added, or Leontief production weights, compared to weights of over 0.20 for the dollar and the euro. Given the marginal importance of China in the global trading system in 1999, the negative correlation between the changes in US and China weights (which already existed in 1995) is much less important than the positive correlation between US and Euro area weights (which also already existed in 1995).

Over the intervening period, the role of the dollar and the Euro shrank while that of the renminbi increased by over three-fold. By 2011, as discussed earlier, the importance of the renminbi was not much less than the dollar or the Euro, reflecting both rapid growth and the opening of the economy after entry to the WTO in 2001. While the importance of the yen

declined over the same period, the net impact was an increase in the importance of Asia and Asian supply chains in the global economy.

These trends have two implications for real effective exchange rate calculations. The first is the importance of having dynamic weights over time. Given rapid increases in the role of China and other emerging markets in the global trading system, it is important to allow their weights to change over time. Second, the increasing importance of east Asia, with its complex international supply chains, underlines the centrality of assumptions about elasticities of demand for intermediate goods. As already discussed, this trend has been obscured by the stability of the dollar-renminbi exchange rate.

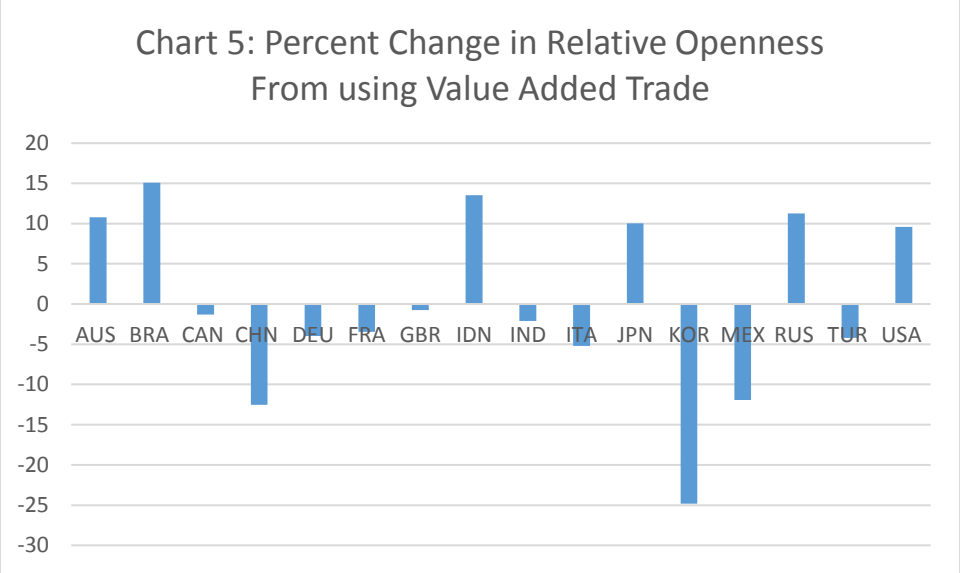
More generally, complex East Asian international supply chains are a precursor of changes elsewhere. In Europe, Germany is the center of a global supply chain that largely stretches east, while in North America the United States is the center of a supply chain involving Canada and Mexico. As these supply chains deepen, the importance of assumptions about the production chain will become ever more important. As an aside, it is also worth noting that the growing importance of these supply chains has not led to any strong dynamic toward fixed exchange rates within the main members of the supply chain. N Asia the trend has been to more exchange rate flexibility, and the NAFTA members have floating exchange rates against each other. Even in Europe, where membership of the Euro is a long-term objective for all members of the European Union except for those with specific opt-out clauses, the supply chain has largely been built to countries without fixed exchange rate arrangements with the center.

Openness and Real Effective Exchange Rate Weights

Another implication of focusing on international supply chains is that the distinction between trade in final and intermediate goods alters assessments of the relative openness of different countries to trade. This is most clear when thinking about the Armington model and the value-added model. For the Armington effective exchange rate index, the correct measure of trade openness is gross trade, since all exports and imports are treated as final goods and hence are equally important. For value added trade indexes, on the other hand, trade openness should be measured using only domestic value added. This means that countries that include a high proportion of imported components in their exports will appear relatively less open than countries whose exports contain fewer imported goods. Openness is a more complex concept when using Leontief production assumptions, since effective exchange rate weights depend on how and where the value added is used. However, even in this case, value-added trade is a better approximation of true openness than gross trade. Indeed, the dangers of using gross trade has always been recognized, which is why in some extreme cases—such a Hong Kong where gross trade has often exceeded output—an adjustment is normally made for reexports. The Netherlands is another case where such adjustments are

common given the importance of entrepôt trade along the Rhine. However, such changes are seldom made on a consistent basis across all countries

Chart 5 shows the implications of switching form gross trade to value added trade on the relative openness of G20 countries. As expected, switching to a value added concept lowers the relative openness to trade for countries that are heavily involved in the downstream parts of value chains, since these are the countries where imported components are the most important. Relative openness falls by 25 percent in Korea and over 10 percent in China and Mexico, along with smaller falls for other members of the European supply chain and Canada. This is offset by rises in relative openness of 10-15 percent in many commodity exporting countries not closely associated with global value chains (Argentina, Australia, Brazil, Indonesia, and Russia) as well as Japan (which has little processing trade) and the United States (the consumers of last resort).



These calculations of openness largely reinforce the earlier analysis on changing exchange rate weights, raising the role of the US and Japan in global trade and the reducing the importance of China and Korea. Indeed, at least as regards the comparison of the Armington and value added weights, the two calculations are largely reflecting the same phenomenon—namely the importance of domestic production and consumption in trade. However, this assessment also depends upon the types of goods being traded. In particular, the rise in openness of raw material producers should not necessarily translate into higher bilateral weights on these countries in a well-specified effective exchange rate model.

Recall that the constant elasticity of substitution approach used in the Bems and Johnson calculation assumes that all countries produce differentiated goods. This may be a good approximation for complex manufactured intermediate goods of the type often exported by Korea or Japan, but makes less sense for the commodities used in production typically

produced by a country like Australia, since raw material such as coal are essentially identical across countries. This implies a single global price for coal that depends on global demand and supply conditions and hence that the competitiveness of Australian coal exports are linked with all coal exporters and importers, rather than specifically with China, which actually imports Australian coal. Indeed, the IMF effective exchange rate methodology assumes that Australian coal exports and linked to those who demand and supply coal, in other words to the global market for coal. Accordingly, the implication of the changes in relative openness implied by value added trade should be viewed quizzically for commodity producers, as by and large these goods have very high elasticities of substitution and hence single prices set by global supply and demand.

This issue is not limited to traditional raw materials, such as coal. The same analysis applies to "commoditized" manufactured goods, such as bulk steel or memory chips. These are standard components that are essentially slotted into products at the appropriate moment, and where the exact source of supply is not important—one computer chip is very much like another. As in the case of oil or coal, or copper or aluminum, the elasticity of substitution is such markets is high, leading to a single global price in which trade patterns are dominated by costs of transportation. This implies a two-tier system for analyzing intermediate manufactured goods. Those that are "commoditized" and should be treated as being part of a single global market, and those that are "custom-made" and should be treated as differentiated goods.

Conclusions

The increasing importance of international value chains is a major trend in the trade landscape.[9] Unfortunately, the technology of calculating effective exchange rates has not caught up. All of the major effective exchange rates used by policy makers assume that all goods are traded for final consumption. While this was never an accurate assumption, it is becoming steadily less tenable over time. The key question, however, is whether switching to a better and more accurate approach would make a significant difference to calculated real effective exchange rates. In other words, whether the added theoretical and computational complexity coming from accounting for global value chains is worth the trouble, or the simpler approach currently being used provides a reasonable approximation.

The answer from this analysis is that it depends. To the extent that the elasticity of substitution of intermediate goods is similar to the elasticity of substitution across final goods, then the current set of weights is not too bad approximation to the correct ones. If, on the other hand, the elasticity of substitution within the production chain is much lower than in final demand, then adding global value chains can create quite different weights. This is most

[9] See, for example, IMF (2016) for a discussion of the role of global supply chains in explaining the rate of growth of trade over time.

obvious in the case of the countries most integrated into the Asian supply chain, such as Korea and China. Because the Asian supply chain is the most advanced, these are the countries for which the issues is clearest.

If the effective exchange rate weights are so different, then one would expect it to be easy to empirically distinguish between the alternative explanations. However, the peculiarities of Chinese exchange rate policy make this difficult. Because the Asian supply chain largely involves assembling products for export to the United States, falls in the weight of China in effective exchange rate indexes are largely offset by increase in the weight of the United States. But since the renminbi fluctuates so little against the dollar, it is difficult to pick up this trend in the data. Over the past, alternative real effective exchange rate series have been highly correlated, and difficult to distinguish from each other. Over the future, however, as the renminbi becomes more flexible against the dollar, these differences in weights will matter a great deal.

This suggests that it is important to get a handle on the appropriate assumptions now. This will involve looking more directly at the characteristics of complex supply chains, in which suppliers provide very specific part for devices—for example, screens for an iPhone. How does the elasticity of substitution for suppliers in such a supply chain compare with the elasticity of demand for the final product, and what does that imply about effective exchange rate weights?

In addition, there are clearly other types of components which are standardized and simply slotted into final goods—such as DRAM chips. Since these are standard components the elasticity of substitution is high and the price set by a global supply and demand, very much like traditional commodities such as coal or copper. This suggests that the adjustments already made, at least in the IMF real effective exchange rate calculations, for highly traded commodities that assumes that they compete with all producers and consumers of that good, needs to be extended to certain types of industrial goods.

This implies a two-fold agenda for the future. First, examining how to differentiate "commoditized" goods from highly differentiated goods, and then determining the relative substitutability of differentiated intermediate goods in production versus final demand. The seemingly staid world of effective exchange rate weight calculations may be about to become a lot more interesting.

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