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Can We Identify Balassa-Samuelson Effects with Measures of Product Variety?

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Abstract

The Balassa-Samuelson hypothesis – i.e. that real exchange rates between each pair of countries increase with the tradables sector productivities ratio between these countries, and decrease with their non-tradables sector productivities ratio – has been one of the most prominent frameworks in open economy macroeconomics for more than forty years. However, empirical studies have often been unable to confirm it. We argue that this might at least in part be due to measurement errors leading to downward-biased estimates. We test the Balassa-Samuelson hypothesis with innovative trade-based variety measures to differentiate between tradables and non-tradables sector productivities that do not suffer from such errors-in-variables. Using a pairwise regression approach, we find stable and very robust Balassa-Samuelson effects over all our specifications.

JEL-Classification: F40, F43

Keywords: Balassa-Samuelson, product variety, measurement errors, pairwise regressions

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1 Introduction and motivation

The concept of purchasing power parity (PPP) is closely linked to the tradability of goods and services. If all goods and services were tradable at no cost and entered each country's basket used to construct the aggregate price level with the same weight, arbitrage would ensure identical aggregate price levels for each pair of countries when expressed in a common currency at the going nominal exchange rate. However, empirical studies overwhelmingly find systematic deviations from PPP: aggregate price levels expressed in a common currency at going nominal exchange rates are generally higher in richer than in poorer economies. This empirical regularity was dubbed the "Penn effect" in Samuelson (1994).

By far the most prominent theoretical explanation for the Penn effect is the Balassa-Samuelson (BS) hypothesis (Balassa, 1964; Samuelson, 1964).[1] Balassa and Samuelson rationalise the Penn effect in a chain of arguments building on (a) purchasing power parity for tradables, (b) relative prices reflecting relative labour productivities, (c) homogenous national labour markets across sectors of production, and (d) greater differences in (labour) productivity across countries in tradable than in non-tradable production. Leaving (d) aside defines the productivity gap version of the BS hypothesis, i.e., the real exchange rate between each pair of countries j and h is the higher the higher country j's ratio between its tradables and non-tradables sector productivities compared to country h.

Even after more than forty years this basic chain of arguments remains the dominant explanation for the Penn effect, at times together with a number of more recent demand-side, general equilibrium, capital mobility, or new new trade theory refinements (for overviews of the relevant theoretical literature, see Asea und Cordon, 1994 or Tica and Družić, 2006). At the same time, recent empirical surveys reach contradictory conclusions: According to Sarno und Taylor (2002, p. 82) "overall the empirical evidence on the Harrod-Balassa-Samuelson effect is quite mixed," while Tica und Družić (2006, p.14) argue that "(t)he growing body of evidence makes it difficult to ignore the HBS theory."[2]

At least in part, the mixed empirical evidence on the BS hypothesis may be due to difficulties of correctly measuring productivities in tradables *versus* non-tradables sectors. Such measurement errors would lead to an endogeneity of the explanatory vari-

[1] Sometimes also referred to as Harrod-Balassa-Samuelson (HBS) hypothesis in reference to a much earlier contribution by Harrod (1933).

[2] Tica and Družić (2006) provide an overview over 58 empirical studies on the Penn and/or BS effect. Notable recent studies confirming the BS hypothesis include Ricci et al. (2008) who estimate panel cointegration relationships between real exchange rates and a set of fundamentals for a sample of 48 countries and Betts and Kehoe (2008) who show that the quarterly bilateral real exchange rate and the relative price of non-traded to traded goods are positively correlated for 1,225 country pairs over 1980–2005. In contrast, Lee and Tang (2007, p. 164) find that the Penn effect is "transmitted through the relative price between tradable goods, rather than through the relative price between tradables and nontradables" and Égert et al. (2006, p. 257) conclude in a meta-analysis that for transition economies the Penn effect "is affected by factors other than the usual Balassa–Samuelson effect."

ables and estimates that would very likely be downward-biased (on this *attenuation bias*; cf. Wooldridge, 2002). In fact, there are two reasons why the measurement of productivities in tradables *versus* non-tradables sectors may severely suffer from error.

First, sectoral productivities should in principle be represented by total factor productivities, which are hard to come by (Coricelli and Jazbec, 2004). They also involve sources of measurement error (Tica and Druzic, 2006), not least due to the necessity to assume specific (and often arbitrary) functional forms of production (Canzoneri et al., 1999).

Second, empirical studies testing the BS hypothesis typically assume *ad hoc* whether or not specific sectors are comprised of tradable or non-tradable activities and furthermore assume tradability to be constant over the period under investigation.[3] In contrast, recent new new trade theory models may be closer to the mark in endogenising tradability (cf., in the BS context, Ghironi und Melitz, 2004; Bergin, Glick und Taylor, 2006; Bergin and Glick, 2007), such that in particular declining trade costs increase tradability. In fact, empirical evidence can be interpreted as pointing in this direction (cf. Tica und Družić, 2006), as cross-section analyses with data since the 1960s give more indication of significant BS effects than those with older data or time-series analyses that do not reflect changes in the tradability of goods.

We steer clear of both possibilities of attenuation bias by analysing BS effects in panel data with an innovative approach of how to identify productivity of tradables production. This approach uses trade-based measures of product variety and allows for the tradability of individual goods to change over time: trade-based measures of product variety are, by definition, only available for tradables, and have additionally been identified as proxies for productivity (among others in Feenstra et al., 1999; Addison, 2003; Frensch und Gaucaite Wittich, 2009). This makes them ideal proxies for tradables sector total factor productivity.

Another essential feature of our study is that in contrast to most empirical work on BS effects it does not analyse relationships between measures of countries' multilateral real exchange rates and their productivities in a rather small sample. Instead, we agree with Betts and Kehoe (2008) in that the BS hypothesis is basically a bilateral concept, and thus follow their innovation to investigate real exchange rate measures and productivities for country pairs rather than for individual countries. In recognition of the above-mentioned extensions of the simplest BS framework this approach enables us to deal with supply or demand shocks irrespective of whether they are common or specific to country-pairs.

The remainder of this paper is organised as follows. Section 2 presents information on concepts, data and measurement. In section 3 we test the BS hypothesis with a pairwise regression approach, while the robustness of results is checked in section 4. Section 5 concludes.

[3] In the BS context, a notable exception to the *ad hoc* designation of tradables and non-tradables sectors is a study by Schmillen (2010) that distinguishes these sectors based on new economic geography theories that predict tradables to be more geographically concentrated than non-tradables.

2 Concepts, data and measurement

The real exchange rate between countries *j* and *h*, RER_{jh}, is defined as the deviation of their nominal exchange rate, e_{hj}, from purchasing power parity. Alternatively, it can be defined as the deviation of the ratio of two countries' aggregate price levels, P_j and P_h, from their nominal exchange rate,

$$RER_{jh} = \frac{e_{hj}}{P_h \; / \, P_j} = \frac{P_j \; / \, P_h}{e_{jh}}, \qquad (1)$$

Absolute purchasing power parity is equivalent to RER_{jh}= 1.

Based on the chain of arguments outlined in the previous section, the BS hypothesis states that the real exchange rate between countries *j* and *h* is the higher the higher country *j*'s ratio between its tradables and non-tradables sector productivities compared to country *h*:

$$RER_{jh} = \frac{P_j \; / \, P_h}{e_{jh}} = \frac{(A_j^T A_{h1}^N)^{1-\theta}}{(A_h^T A_j^N)^{1-\theta}}, \qquad (2)$$

where A^T and A^N are (total factor) productivities in the tradable and non-tradable sectors, respectively. Equal preferences across countries are described by constant and equal consumption expenditure shares for tradables and non-tradables, θ and $1–\theta$, respectively, with $0 < \theta < 1$.[4] Put differently, the real exchange rate between each pair of countries *j* and *h* increases with the tradables sector productivities ratio between countries *j* and *h*, and decreases with their non-tradables sector productivities ratio.

Empirical work on BS effects typically studies relationships between multilateral real exchange rate measures and productivities for panels of countries. The most popular measures of countries' multilateral real exchange rates are (i) effective real exchange rate indices, i.e., weighted bilateral nominal exchange rates deflated by consumer price indices with weights corresponding to the relative importance of partner countries in trade; and (ii) *comparative prices* – or *exchange rate gaps* in much of the literature –, as provided in the Penn World Tables (PWT).

Comparative prices are defined as the deviation of a country's nominal exchange rate against the international dollar from PPP. Each country's comparative price level is by construction a weighted real exchange rate against the international dollar, where the weighting scheme is based on the relative prices that underlie the derivation of the international dollar, thus providing a measure of the multilateral real exchange rate that is conceptually close and highly correlated with a trade-weighted real effective exchange

[4] For a simple exposition of the BS hypothesis – including a derivation of equation (2) – see Frensch (2006).

rate index.[5] Compared to effective real exchange rate indices, comparative prices (henceforth *p)* have two enormous advantages. First, they are much more widely available and second, they are internationally comparable in level terms. That is why we use them throughout the rest of this paper.

To measure productivity across all sectors of an economy we rely on real, i.e. PPP-adjusted per capita income, *y*. Both *y* and *p* are measured relative to the U.S. and are taken from the Penn World Tables, version 6.2 (for a comprehensive description of the data used, see the Data Appendix).

In order to differentiate between tradables and non-tradables productivities, we rely on trade-based measures of product variety. One should note, however, that not all measures so far employed in the fast-growing body of literature on product variety would be suitable for this purpose: Amiti and Konings (2007) argue for instance that variety measures over imported inputs influence economy-wide productivity. Frensch and Gaucaite Wittich (2009) demonstrate that variety measures over capital good inputs, available *via* imports or production, behave as if they represented countries' aggregate states of technology. Variety measures over traded consumer goods would not be adequate for our purpose either, as they capture only part of tradables sector productivity.

Appropriate variety measures to capture tradables sector productivity can instead be defined over all exports, much in the spirit of new new trade theories. We follow this approach and base our export variety measurement on mirror data from twenty European and North American OECD importing countries for the time period between 1992 and 2004. These reporting countries' import data allow a differentiation first of all by 54 selected exporters (including the 20 reporters) which account for the bulk of reporters' total imports. Additionally, data can be disaggregated according to the lowest aggregation level of the SITC, Rev. 3 (5- and 4-digit basic headings) in the UN ComTrade database covering 3,114 basic headings or SITC categories. The standard cut-off value for disaggregated SITC-category trade-flows is 10,000 US-$. For each of the 54 exporters, the simplest trade-based count measure of export variety would record the number of different categories exported to at least one of the reporters, where data detail obviously depends on the level of aggregation of the trade classification used.

On the basis of our data set there are at least two procedures to increase detail in variety measurement. Both involve first assessing country *j*'s export variety with regard to destination *m*, and then aggregating.[6] Specifically, variety measurement may go beyond counting. More sophisticated methods include especially Feenstra's (1994) exact measure of variety constructed from a CES function with products entering non-symmetrically as a weighted count of *j*'s export categories on destination *m.* From these destination-specific measures, country *j*'s overall export variety can then be constructed along the lines of Hummels and Klenow (2005). We will come back to this procedure in section 4.

[5] Also, differentials between rates of change of the two measures are not systematically related to PPP-adjusted income per capita. Again, see Frensch (2006).

[6] Given the differentiation of our data by country, time, and category, computing this sort of product variety measures requires the manipulation of almost 45 million data points.

Our preferred way to increase data detail, however, does not rely on weighting count data, but rather on expanding the product space in analogy to Frensch and Gaucaite Wittich (2009). I.e., we differentiate exported categories by their country of destination. Accordingly, we first measure each exporter's destination-specific export variety with a simple count measure recording the number of different categories exported to a particular destination *m* a time *t*,

$$ExpCount\,1_{jm,t} = \sum\nolimits_{i \in I_{jm,t}} i \tag{3}$$

with $j = 1, \ldots 54$, $m = 1, \ldots, 20$, and $t = 1992, \ldots, 2004$. While I is the set of all SITC categories at our level of aggregation, $i = 1, \ldots, 3{,}114$, $I_{jm,t} \subseteq I$ describes the set of SITC categories, for which exporter j has positive exports to destination m in period t. Aggregation then means to sum count measures for each exporter over all twenty destinations,

$$ExpCount1_{j,t} = \sum\nolimits_{m} ExpCount1_{jm,t}\ , \tag{4}$$

where the maximum value of $ExpCount1_{j,t}$ is 62,280 (i.e., 3,114 SITC categories × 20 destinations).

3 Empirical strategy and benchmark results

3.1 Empirical strategy

In this paper, we combine our innovative use of trade-based variety measurement to differentiate between tradables and non-tradables productivities with our view of BS as a bilateral concept. Drawing on Betts and Kehoe (2008), we therefore study real exchange rate measures and productivities for a panel of 1,431 unique exporter country pairs rather than for the 54 individual exporter countries. Correspondingly, all our regressions are pairwise on bilateral log-linear differences in variables. This approach enables us to use fixed effects estimation procedures similar to those in the gravity literature to deal with supply or demand side shocks, in recognition of the above-mentioned extensions of the simple equation (2) BS framework.[7]

Accordingly, we estimate,

$$\log p_{j,t} - \log p_{h,t} = \gamma_0 + \gamma_1 (\log ExpCount1_{j,t} - \log ExpCount1_{h,t})$$

$$+ \gamma_2 (\log y_{j,t} - \log y_{h,t}) + \gamma_3 (\log demand_{j,t} - \log demand_{h,t}) + c_{jh} + k_t + \varepsilon_{jh,t} \quad (5)$$

Equation (5) rests on three building blocks: first, it assumes that overall productivity (i.e., PPP-adjusted per capita income, y) is a log-linear aggregation of tradables sector productivity and non-tradables sector productivity, and that export variety measures are a proxy for tradables sector productivity. Second, it captures time-varying country-specific demand effects by the inventory cycle, i.e., by real GDP shares of inventory investment (*demand*). Third, it includes country pair-fixed effects, c_{jh}, and period fixed effects, k_t, in order to account for all supply and demand shocks that are time invariant and specific to country pairs or time varying and common to all country pairs. Of course, this means that no time invariant parameters can be included in the regressions.

Our main coefficients of interest are γ_1 and γ_2. The bilateral log-linear differences regression of comparative prices on both aggregate productivity and export variety measures proxying tradables sector productivity (*ExpCount*1) carries the implication that the variation in y due to tradables sector productivity will be caught by export variety, *ceteris paribus* leaving the non-tradables sector productivity variation in y to impact on p. Accordingly, based on the BS hypothesis the *ex ante* expectation in (5) is a posi-

[7] One drawback of using panel data lies in the potential non-stationarity of price and income data, implying that regression results from fixed effects models could potentially be spurious. This is of specific concern with panels too short for proper panel unit root testing. On the choice between fixed effects and alternative estimators for potentially non-stationary data, Fidrmuc (2009) uses cross-sectionally augmented panel unit root testing methods in the gravity context. He confirms that trade and income variables used in gravity regressions are integrated of order one. However, Fidrmuc (2009, p. 436) finds that, although fixed effects estimators may be biased, they are not only asymptotically normal and consistent in long panels but also perform "relatively well in comparison to panel cointegration techniques" in finite samples, concluding the potential bias of fixed-effects gravity estimators to be rather small.

tive impact for bilateral log-linear differences in variety and a negative one for log-linear differences in y.[8]

3.2 Results

Results reported in Table 1 indicate a highly significant and negative influence of bilateral log-linear differences in y on log-linear differences in comparative prices, and a highly significant and positive influence of log-linear differences in $ExpCount1$. This implies a confirmation of the BS hypothesis, i.e., that the real exchange rate between each pair of countries increases with the tradables sector productivities ratio between these countries and decreases with their non-tradables sector productivities ratio.

Besides, we find a positive and statistically significant coefficient associated with our demand variable. This confirms the influence of demand on comparative price levels as postulated for instance by Rogoff (1992).

– Table 1 about here –

[8] Strictly speaking, $\gamma_1 > 0$ and $\gamma_2 < 0$ are necessary but not sufficient for a confirmation of the BS effect. The latter requires an additional condition, e.g. $|\gamma_1|>|\gamma_2|$, that is, however, always met in our estimation results. It is straightforward to show that (5) is the reduced form of a model building on (a) constant and equal consumption expenditure shares for tradables and non-tradables, (b) export variety measures as a proxy for A^T, and (c) an extended BS framework including supply and demand shocks. Together with this structural information, equation (5) estimates suffice to identify all parameters of interest in the underlying model (see Appendix B). We are grateful to a referee for turning our attention to this identification issue.

4 Sensitivity

4.1 Choice of sample

Our results are very robust to a number of alternative specifications. For instance, they are robust to excluding Armenia and Belarus (for which we have very few observations) from our sample, as reported in column (2) of Table 2.

Table 2 about here –

4.2 Export variety measurement

Our major results are also very robust to variations in measuring export variety: a first such variation is to change the cut-off value for disaggregated SITC-category trade flows from 10,000 to 500 US-$, to define an alternative measure, *ExpCount*2. While this might potentially enlarge the noise in the underlying trade data it could also lead to an increase in variation.

Second, we already noted that variety measurement may go a long way beyond pure counting. As an alternative to our benchmark export variety count measure, we also use a weighted measure over all exported SITC items. This measure is constructed along Feenstra's (1994) exact measure of variety based on a CES function when products enter non-symmetrically, and aggregated over destinations *à la* Hummels and Klenow (2005). Specifically, we first define country j's export variety on destination m at time t, as

$$ExpVar\mathrm{HK}_{jm,t} = \frac{\sum_{i \in I_{jm,t}} Imports_m^i}{\sum_{i \in I} Imports_m^i} \tag{7}$$

with j, m, t , i, I, and $I_{jm,t}$ all defined as in section 2. In line with Feenstra and Kee (2007), *ExpVar*HK is thus comparable both over time and across exporter countries: $Imports_m^i$, i.e., total imports of m in category i, averaged across 1992–2004, correspond to the value of category i exports to m of the virtual reference country "world" over the same time period, where "world" is the total over all our 54 exporters. $ExpVar\mathrm{HK}_{jm,t}$ consequently equals world exports to m in the set $I_{jm,t}$ relative to world exports to m in all categories. Thus, $ExpVar\mathrm{HK}_{jm,t}$ depends on the set of categories exported by country j to m at time t, but not on the value of this trade. Accordingly, $ExpVar\mathrm{HK}_{jm,t}$ is a weighted count of j's export categories relative to world export categories such that export categories are weighted by their importance in world exports to m, with the advantage that this prevents a category from appearing important "…solely because j (and no other country) exports a lot to m in that category" (Hummels and Klenow, p. 710). If all categories are of equal importance, then $ExpVar\mathrm{HK}_{jm,t}$ is again simply the fraction of all categories in which j exports to m in period t.

From these destination-specific export variety measures, we derive internationally comparable variety measures for country *j* at time *t*, in line with Hummels and Klenow (2005, pp. 711) as geometric averages, according to

$$ExpVar\mathrm{HK}_{j,t} = \prod\nolimits_m (ExpVar\mathrm{HK}_{jm,t})^{s_{jm,t}} \tag{8}$$

$s_{jm,t}$ describes the share of destination *m* exports in *j*'s total exports in period *t*.

Columns (3) and (4) in Table 2 show that all results from section 3 are robust to using both the alternative cut-off value for disaggregated SITC-category trade flows and this rather sophisticated weighted measure over the SITC category product space.

4.3 Fixed effects

Frensch and Schmillen (2010) argue that estimating price-productivity relationships without the inclusion of other time-varying country-specific real factors, e.g. connected to reform effort, might bias estimates for Central and Eastern European countries, which make up a considerable part of our sample.

In terms of recent developments of the gravity approach to pairwise regressions, Baldwin and Taglioni (2006) and Baier and Bergstrand (2007) suggest a combination of time-invariant country-pair specific as well as time-varying country-specific effects as an alternative that accounts for potentially unobserved time-varying country-specific influences. As is evident from column (5) in Table 2, our results are very robust to using this set of alternative fixed effects.

5 Conclusions

We combine an innovative use of trade-based variety measurement to differentiate between tradables and non-tradables sector productivities with a pairwise regression approach to test the BS hypothesis that the real exchange rate between each pair of countries increases with the tradables sector productivities ratio between these countries, and decreases with their non-tradables sector productivities ratio. Our results confirm the BS hypothesis. They are very robust with respect to the choice of the sample, variable definitions, and gravity-inspired variations in the use of fixed effects in the pairwise regressions. Because we also steer clear of common possibilities of attenuation bias our results lend strong support to those who argue that – in spite of the sometimes inconclusive empirical evidence – the BS hypothesis deserves the attention it has received for more than forty years.

Our failure to reject the BS hypothesis has several important implications. The most central from an economic policy point of view is that any interpretation of real exchange rate or price developments in Central and Eastern Europe should take the BS effect into account as should any conclusion as to whether a (former) transition economy is ready to join the Euro zone.

References

Addison, D., 2003. Productivity growth and product variety: gains from imitation and education. World Bank Policy Research Paper 3023, Washington, DC.

Amiti, M., and J. Konings, Trade liberalization, intermediate inputs, and productivity: evidence from Indonesia. *American Economic Review 97*, 5, December 2007, pp. 1611–38.

Asea, P.K., and W.M. Corden, The Balassa-Samuelson model: an overview. *Review of International Economics 2*, 3, 1994, pp. 191–200.

Baier, Scott L., and Jeffrey H. Bergstrand, Do free trade agreements actually increase members' international trade? *Journal of International Economics 71*, 1, 2007, pp. 72–95.

Balassa, Bela, The purchasing power parity doctrine: a reappraisal. *Journal of Political Economy 72*, December 1964, pp. 584–96.

Baldwin, Richard E., and Daria Taglioni, Gravity for dummies and dummies for gravity equations. NBER Working Paper 12516, Cambridge, MA, September 2006.

Bergin, Paul, and Reuven Glick, Tradability, productivity, and international economic integration. *Journal of International Economics 73,* 1, 2007, pp. 128–151.

Bergin, Paul, Reuven Glick, and Alan M. Taylor, Productivity, tradability, and the long-run price puzzle. *Journal of Monetary Economics 53*, November 2006, pp. 2041–66.

Betts, Caroline M., and Timothy J. Kehoe, Real exchange rate movements and the relative price of non-traded goods. NBER Working Paper No. 14437, Cambridge, MA, October 2008.

Canzoneri, Matthew, Robert Cumby, and Behzad Diba, Relative labor productivity and the real exchange rate in the long run: evidence for a panel of OECD countries. *Journal of International Economics 47*, 1999, pp. 245-266.

Coricelli, Fabrizio, and Bostjan Jazbec, Real exchange rate dynamics in transition economies. *Structural Change and Economic Dynamics 15*, 2004, pp. 83–100.

Égert, Balázs, László Halpern, and Ronald MacDonald, Equilibrium exchange rates in transition economies: taking stock of the issues. *Journal of Economic Surveys 20*, 2, 2006, pp. 257–324.

Feenstra, R., New product varieties and the measurement of international prices. *American Economic Review 84*, 1, 1994, pp. 157–177.

Feenstra, R., and H. Kee, Trade liberalisation and export variety: a comparison of Mexico and China. *The World Economy 30*, 1, 2007, pp. 5–21.

Feenstra, R., D. Madani, T.-H. Yang, and C.-Y. Liang, Testing endogenous growth in South Korea and Taiwan. *Journal of Development Economics 60*, 2, 1999, pp. 317–341.

Fidrmuc, Jarko, Gravity models in integrated panels. *Empirical Economics 37*, 2, 2009, pp. 435–46.

Frensch, Richard, Balassa-Samuelson, product differentiation and transition. OEI Working Paper 266, Munich, November 2006.

Frensch, Richard, and Vitalija Gaucaite Wittich, Product variety and technical change. *Journal of Development Economics 88*, 2, March 2009, pp. 242–257

Frensch, Richard, and Achim Schmillen, The Penn effect and transition: the new EU member states in international perspective. Mimeo, OEI Regensburg, September 2010.

Ghironi, F. and M.J. Melitz, International trade and macroeconomic dynamics with heterogeneous firms. *Quarterly Journal of Economics 120,* 3, 2005, pp. 865–915.

Harrod, Roy F., *International Economics*. 2nd revised ed., Nisbet and Cambridge University Press, London and Cambridge, 1933.

Hummels, D., and P. Klenow, The variety and quality of a nation's exports. *American Economic Review 95*, 3, 2005, pp. 704–723.

Lee, Jaewoo, and Man-Keung Tang, Does productivity growth appreciate the real exchange rate? *Review of International Economics 15*, 1, 2007, pp. 164–187.

Ricci, Luca Antonio, Gian Maria Milesi-Ferretti, and Jaewoo Lee, Real exchange rates and fundamentals: a cross-country perspective. IMF Working Paper No. 08/13, Washington, DC, January 2008.

Rogoff, K., 1992, Traded goods consumption smoothing and the random walk behavior of the real exchange rate. *Bank of Japan Monetary and Economic Studies 10*, 2, pp. 1–29.

Samuelson, Paul A., Theoretical notes on trade problems. *Review of Economics and Statistics 46*, March 1964, pp. 145–54.

Samuelson, Paul A., Facets of Balassa-Samuelson thirty years later. *Review of International Economics 2*, 3, October 1994, pp. 201–26.

Schmillen, Achim, Are wages equal across sectors of production? A panel data analysis for tradable and non-tradable goods. OEI Working Paper 285, Regensburg, June 2010.

Sarno, L., and M. P. Taylor, *The Economics of Exchange Rates*. Cambridge University Press, Cambridge, UK, 2002.

Tica, J., and I. Družić, The Harrod-Balassa-Samuelson effect: a survey of empirical evidence. EFZG Working Paper 0607, Faculty of Economics and Business, University of Zagreb, 2006.

Wooldridge, Jeffrey, *Econometric Analysis of Cross Section and Panel Data.* MIT Press, 2002.

Text figures and tables

Table 1: **Benchmark regression**

	(1) OLS with country-pair-fixed and period-fixed effects
Dependant variable:	$\log p_{j,t} - \log p_{h,t}$
Constant	0.0843*** (0.0183)
$\log ExpCount1_{j,t} - \log ExpCount1_{h,t}$	0.5325*** (0.0193)
$\log y_{j,t} - \log y_{h,t}$	-0.4365*** (0.0326)
$\log demand_{j,t} - \log demand_{h,t}$	-0.2541*** (0.0946)
Observations (cross sections = country pairs / time)	16,253 (1,431 / 1992–2004)

Notes:: The cut-off value for disaggregated SITC-category-level trade-flows to construct *ExpCount*1 is 10,000 US-$. * (**, ***) indicates significance at 10 (5, 1) per cent. Bilaterally clustered standard errors are in parentheses.

Table 2: **Sensitivity regressions**

	(2) OLS with country-pair-fixed and period-fixed effects	(3) OLS with country-pair-fixed and period-fixed effects	(4) OLS with country-pair-fixed and period-fixed effects	(5) OLS with country-pair-fixed and time-varying country-fixed effects
Dependant variable:	log $p_{j,t}$ – log $p_{h,t}$	log $p_{j,t}$ – log $p_{h,t}$	log $p_{j,t}$ – log $p_{h,t}$	log $p_{j,t}$ – log $p_{h,t}$
Constant	0.0859*** (0.0197)	0.0779*** (0.0177)	0.1019*** (0.0194)	-0.3467*** (0.0863)
log $ExpCount1_{j,t}$ – log $ExpCount1_{h,t}$	0.5511*** (0.0206)			0.6075*** (0.0265)
log $ExpCount2_{j,t}$ – log $ExpCount2_{h,t}$		0.5538*** (0.0185)		
log $ExpVar\mathrm{HK}_{j,t}$ – log $ExpVar\mathrm{HK}_{h,t}$			0.4597*** (0.0166)	
log $y_{j,t}$ – log $y_{h,t}$	-0.4183*** (0.0339)	-0.4317*** (0.0313)	-0.2430*** (0.02786)	-0.5599*** (0.0477)
log $demand_{j,t}$ – log $demand_{h,t}$	-0.2581*** (0.0982)	-0.1832* (0.0938)	-0.6491*** (0.0875)	
Observations (cross sections = country pairs / time)	15,324 (1,326 / 1992–2004)	16,253 (1,431 / 1992–2004)	16,253 (1,431 / 1992–2004)	16,253 (1,431 / 1992–2004)

Notes: The cut-off value for disaggregated SITC-category-level trade-flows to construct *ExpCount*1 and *ExpVarHK (ExpCount*1) is 10,000 (500) US-$. * (**, ***) indicates significance at 10 (5, 1) per cent. Bilaterally clustered standard errors are in parentheses

Appendix A: Data

Export variety measurement is based on importer countries' data extracted for twenty European and North American OECD countries between 1992 and 2004.

Trade data commodity classification, country and period coverage

The Standard International Trade Classification, Revision 3 (SITC, Rev.3) was used at all aggregation levels (1-, 2- and 3-digit levels for checking totals, 4- and 5-digit levels for counting SITC categories). There are 3,121 *basic headings* or *basic categories* in the SITC, Rev.3, 2,824 at the 5-digit level and 297 at 4-digits, that are not disaggregated any further. The 3-digit group 334 (petroleum products), which is divided into eight final headings in SITC, Rev.3, is in fact not subdivided by many reporting countries, so we treat it as a single heading. This leaves 3,114 *basic categories*, as the level of aggregation of the SITC, Rev.3 to work with.

Table A1: **Exporter and reporting importer countries**

1	Albania	19	<u>United Kingdom</u>	37	Malta
2	Armenia	20	Georgia	38	<u>Netherlands</u>
3	<u>Austria</u>	21	<u>Germany</u>	39	<u>Norway</u>
4	Azerbaijan	22	<u>Greece</u>	40	Poland
5	<u>Belgium and Luxembourg</u>	23	Hong Kong	41	<u>Portugal</u>
6	Bulgaria	24	Croatia	42	Romania
7	Belarus	25	Hungary	43	Russia
8	Bosnia and Herzegovina	26	<u>Ireland</u>	44	Slovakia
9	<u>Canada</u>	27	<u>Iceland</u>	45	Slovenia
10	<u>Switzerland</u>	28	<u>Italy</u>	46	<u>Sweden</u>
11	China	29	Japan	47	Thailand
12	Cyprus	30	Kazakhstan	48	Tajikistan
13	Czech Republic	31	Kyrgyzstan	49	Turkmenistan
14	<u>Denmark</u>	32	South Korea	50	<u>Turkey</u>
15	<u>Spain</u>	33	Lithuania	51	Ukraine
16	Estonia	34	Latvia	52	<u>United States</u>
17	<u>Finland</u>	35	Moldova	53	Uzbekistan
18	<u>France</u>	36	Macedonia	54	Serbia and Montenegro

Notes: Belgium and Luxembourg are treated as one country as reported until 1998. Reporting importers are the twenty underlined European and North American OECD countries as of 1992. All 54 countries are exporters, these exporter countries generally account for 80–95 per cent of reported imports. Czech, Slovak and Macedonian exports are available in importer countries' data only from 1993 onwards.

Table A2: **Variables used in regressions (1) – (5) in Tables 1 and 2**

Variable	Definition	Source	Notes	Summary Statistics			
				Mean	Std. Dev.	Min	Max
p	Comparative prices, measured relative to the U.S.	Penn World Tables version 6.2	PPP over GDP divided by the exchange rate times 100. PPP and the exchange rate are both expressed as national currency units per US dollar. PPP is the number of currency units required to buy goods equivalent to what can be bought with one unit of the base country. In the PWT, PPP is calculated over GDP, i.e., PPP is the national currency value of GDP divided by the real value of GDP in international dollars. The international dollar has the same purchasing power over total U.S. GDP as the U.S. dollar in a given base year.	66.69	43.33	3.42	193.80
y	PPP-adjusted income per capita, measured relative to the U.S.	Penn World Tables version 6.2	Obtained from an aggregation using price parities and domestic currency expenditures for consumption, investment and government of August 2001 vintage.	44.48	28.31	3.70	100
Demand	Real GDP shares of inventory investment	World Development Indicators 2009	Inventory investment is obtained as total minus gross fixed capital formation.	0.0110	0.0362	-0.1213	0.4356
*ExpCount*1	Count measure of export variety	Own computations based on ComTrade	Count data export variety measurement with differentiation of exported categories by country of destination with a maximum value of export variety of 62,280. Defined over 3,114 SITC Rev.3 categories × 20 destinations. Cut-off value for disaggregated category trade flows is 10,000 US-$.	12,226	12,417	60	45,984
*ExpCount*2	Count measure of export variety	Own computations based on ComTrade	Count data export variety measurement with differentiation of exported categories by country of destination with a maximum value of export variety of 62,280. Defined over 3,114 SITC Rev.3 categories × 20 destinations. Cut-off value for disaggregated category trade flows is 500 US-$.	15,704	14,355	91	50,066
ExpVarHK	Weighted export variety measure	Own computations based on ComTrade	Weighted export variety without differentiation of exported categories by country of destination *à la* Feenstra (1994), aggregated along Hummels and Klenow (2005). Defined over 3,114 SITC Rev.3 categories.	0.5263	0.3203	0.0040	0.9695

Appendix B: Identification

A structural form

All variables of interest are defined in terms of time-varying log-linear differences between pairs of countries j and h, such that for all variables $x_{j,t}$ and $x_{h,t}$, $\boldsymbol{x}$:= log $x_{j,t}$ – log $x_{h,t}$. Then, productivity decomposition, proxying tradables sector productivity by export variety, and BS with specific effects can be expressed as,

$$\boldsymbol{y} = a\,\boldsymbol{y}^{T} + (1\text{-}a)\boldsymbol{y}^{N},\ 0 < \alpha < 1 \qquad \text{(B1)}$$

$$\boldsymbol{y}^{T} = \boldsymbol{ExpCount1} \qquad \text{(B2)}$$

$$\boldsymbol{p} = \beta_0 + \beta_1\,\boldsymbol{y}^{T} + \beta_2\,\boldsymbol{y}^{N} + \beta_3\,\boldsymbol{demand} + c_{jh} + k_t + \varepsilon_{jh,t} \qquad \text{(B3)}$$

H_0 according to the BS reasoning: $\beta_1 > 0$, $\beta_2 < 0$.

Rearranging for indirect least squares estimation

From (1), $$\boldsymbol{y}^{N} = \boldsymbol{y}/(1\!-\!a) - a\,\boldsymbol{y}^{T}/(1\!-\!a) \qquad \text{(B1')}$$

With (B1') in (B3),

$$\boldsymbol{p} = \beta_0 + \beta_1\,\boldsymbol{y}^{T} + \beta_2\,[\boldsymbol{y}/(1\!-\!a) - a\,\boldsymbol{y}^{T}/(1\!-\!a)] + \beta_3\,\boldsymbol{demand} + c_{jh} + k_t + \varepsilon_{jh,t}$$

and with (B2),

$$\boldsymbol{p} = \beta_0 + [\beta_1 - \beta_2 a/(1\!-\!a)]\,\boldsymbol{ExpCount1} + \beta_2\,\boldsymbol{y}/(1\!-\!a) + \beta_3\,\boldsymbol{demand} + c_{jh} + k_t + \varepsilon_{jh,t} \qquad \text{(B4)}$$

Estimation equation

(B4) can be re-written as

$$\boldsymbol{p} = A + B\,\boldsymbol{ExpCount1} + C\,\boldsymbol{y} + D\,\boldsymbol{demand} + c_{jh} + k_t + \varepsilon_{jh,t} \qquad \text{(B5)}$$

$$A = \beta_0 \qquad \text{(B6)}$$

$$B = \beta_1 - \beta_2 a/(1\!-\!a) \qquad \text{(B7)}$$

$$C = \beta_2/(1\!-\!a) \qquad \text{(B8)}$$

$$D = \beta_3 \qquad \text{(B9)}$$

Parameter identification

With (B8) and (B1), $\beta_2 < 0$ iff $C < 0$ (B10)

With (B7) and (B8) $\beta_1 = B + C\,a$ (B11)

such that $\beta_1 > 0$ if $C < 0$ and $B > 0$ and $|B| > |C|$ (B12)