

Podkaminer, Leon

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Discrepancies between Purchasing Power Parities and Exchange Rates under the Law of One Price: A Puzzle (partly) Explained?

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Leon Podkaminer

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Leon Podkaminer is Senior Economist at the Vienna Institute for International Economic Studies (wiiw) and Professor at Wyższa Szkoła Administracji (WSA), Bielsko Biała, Poland.

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Leon Podkaminer

**Discrepancies between
Purchasing Power
Parities and Exchange
Rates under the Law
of One Price: A Puzzle
(partly) Explained?**

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Abstract

European Comparison Project data (years 1999-2008) are used for an estimation of cross-country systems (AIDS) of consumer demand functions defined over durable and non-durable tradable goods and non-tradable services. General exchange equilibrium models of inter-EU trade generate equalized relative prices of tradable goods. But domestic relative prices of services become more dispersed and can move the PPP/ER ratios away from unity. PPP/ER discrepancies may be sustained even when there are no impediments to free trade.

Keywords: *Purchasing Power Parity, exchange rate, PPP/ER discrepancy, Law of One Price, Balassa-Samuelson Effect, trade integration, computable general equilibrium, cross-country systems of demand functions, Almost Ideal Demand System, tradable goods, non-tradable goods*

JEL classifications: *F11, F15, D12, D58, F31, O57*

Discrepancies between purchasing power parities and exchange rates under the Law of One Price: A puzzle (partly) explained?*

1 Introduction

Discrepancies between exchange rates (ER) and purchasing power parities (PPP) can be attributed primarily to presence of non-tradable goods ('services'). It is acknowledged that services do not have to obey the Law of One Price, at least directly. Because of that prices of services are assumed to be relatively free to vary in relation to prices on tradable goods across countries for extended spans of time. For that reason the prices of services entering the PPP calculations can drive a wedge between the PPP and ER. As is well known, demand for services rises with affluence and this fact is reflected in services being expensive relative to tradable goods in rich countries. Thus the PPP-ER gaps tend to be particularly large when it comes to comparing rich with relatively poor countries.

The Law of One Price, which stipulates the tendency for equalization of prices of tradable goods internationally, has been all along (since at least David Ricardo¹) a hard working horse of the pure theory of international trade. But more recent studies question the universal validity of the Law. Contemporary literature abounds on factors ignored in pure theory such as transaction, distribution and transportation costs, cross-country differences in indirect taxation, impacts of competition imperfections (e.g. 'pricing to market', persistence of high mark-ups on foreign trade and domestic distribution activities), policy-related barriers to trade (tariffs, quota, regulations) etc². All these impediments to frictionless international trade are undoubtedly there – and can be reflected in tradable goods' prices failing to equalize internationally. As documented e.g. in a recent study (Anderson and van Wincoop, 2004) the trade cost (broadly understood) content of prices of goods traded internationally tends to be enormous. Moreover, evidence is growing that the Law does not seem to operate even in the European Union – i.e. in an geographically compact area of sustained economic (partly even monetary) integration (see e.g. Allington et al., 2004; Dreger et al., 2007; Wolszczak-Derkacz and De Blander, 2009). Prices of comparable tradable goods remain dispersed: formal statistical tests generally fail to detect their convergence. It is therefore quite reasonable to attribute, at least partly, the existence (and persistence) of the gaps between PPP and ER to the non-satisfaction of the Law of One Price *also* with respect to the tradable goods.

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¹ See Froot, Kim and Rogoff (1995).

² Obstfeld and Rogoff (2000), Taylor and Taylor (2004) review a good deal of that literature.

Many questions remain unanswered: first of all why even close economic integration with apparently free, unobstructed and otherwise competitive-looking trade among not very distant places leaves prices of similar commodities clearly dispersed. Is something fundamentally wrong with the Law of One price – and with the neoclassical general equilibrium analysis in general? The question asked (and answered) in this Note is much more modest – though eventually it might relate to the former one. This question is: assuming the Law of One Price *does* equalize prices of tradable goods at no cost and instantaneously, would the gaps between purchasing power parities and exchange rates narrow? The answer to this question turns out to be ‘not necessarily’. Even under conservative neoclassical assumptions the complete equalization of prices in international trade may actually result in *widening* PPP-ER deviations.

Sec. 2 briefly discusses the possibility of capturing the ER-PPP deviations in simplest models of ‘pure’ theory of international trade. Sec. 3 proposes a simple model capable of reflecting these deviations. Sec. 4 discusses issues related to the data to be used for estimation of the system of cross-country system of demand equations underlying the model. Sec. 5 presents the parameter estimates for a cross-country Almost Ideal Demand System (AIDS). Sec. 6 presents and discusses the general exchange equilibrium solutions to that model. Sec. 7 shows that the PPP/ER ratios following equalization of relative prices of tradable goods quite often move away from unity. Sec. 8 concludes.

2 PPP-ER discrepancies in simple neoclassical models of international trade

In the simplest neoclassical model of international trade there are two countries, each capable of producing the same two final (consumption) goods, both homogeneous (e.g. Ricardo’s ‘wine and cloth’). These goods are subject to free and costless exchange. Under the usual assumptions (on endowments, technologies, preferences and competition) versions of this canonical model generate a single, unique, relative price for the two goods. This price obtains internationally, as well as domestically in either country. Of course, besides equilibrating demand and supply, the relative price leaves both countries with balanced trade. Being neoclassical, the model cannot not say anything about absolute price levels in either country – and of course about the absolute magnitudes of the exchange rate and the purchasing power parity. It is pretty obvious though that if the absolute prices in one country’s currency happen to be multiples of absolute prices in the other country’s currency (m being the multiple) then the exchange rate would be just that $1/m$ – and so would be the purchasing power parity, irrespectively of the differences in the countries’ consumption structures³. Thus, in the simplest neoclassical trade model there is no place for a gap between PPP and ER. This is not quite surprising: the model assumes

³ Formally, PPP is defined here as the geometric mean of the bilateral Paasche and Laspeyres price indices. When the *relative* prices of the two goods are the same in both countries, the latter two indices are both equal $1/m$ irrespective of the national consumption structures - and the PPP equals $1/m$.

equalization of the relative prices and does not allow for the presence of non-tradable goods.

A simple model with predominantly neoclassical features which underlies the (huge) literature on the Balassa-Samuelson Effect⁴ has also two countries producing two homogeneous goods – of which only one is considered tradable. Although the model underlying the B-S Effect has been extensively referred to in the exchange rate economics (see e.g. Sarno, 2005), it is fraught with fundamental conceptual difficulties. As demonstrated in Podkaminer (2003), when rigorously interpreted, this model can hardly yield any meaningful statements⁵. Of course this not the place to reiterate the reasons why the model behind the BSE cannot advance our understanding of the ER-PPP issues. Perhaps it is sufficient to notice, that this model actually rules out international trade – though it is also assumed that the Law of One Price equalizes the price of the single tradable good. But, when one – by assumption precisely the same tradable good - is produced in each country, there is no reason to engage in trade: Portugal does not have any reason to trade its ‘wine’ for... *the same wine* supplied by England. Moreover, unless there is some *third* commodity (e.g. gold), each country would end up with domestic consumption equal domestic supply. How, under autarchy, the price equalization would come about? And, relative to price of what commodity would the prices of tradable good equalize? One possibility for that equalization to make sense would be to assume that different countries use the same fiat money – i.e. to get rid of exchange rates. Certainly the tradable goods’ equalization cannot be understood as being relative to the prices of the non-tradable good in individual countries. That the price of tradable goods relative to the price of non-tradable services varies systematically over time and space is indisputable.

3 PPP-ER deviations in the simplest neoclassical model of international trade

For a simple neoclassical model of international trade to make sense it has to have at least two countries and *two* tradable goods. For that model to allow for the emergence of discrepancies between PPP and ER it has to have at least one non-tradable good as well.

The model to be considered here has 25 countries: all EU Member States (excluding Luxembourg and Malta). The two tradable goods are defined as ‘non-durable consumer goods’ and ‘durable consumer goods’, and the item ‘non-tradable services’ is identified as ‘household consumption other than consumption of non-durable and durable goods’ (to be

⁴ Original Balassa (1964) and Samuelson (1964) expositions of the Effect are pretty informal. The first ‘rigorous’ formulations of the model giving rise to the Effect are due to De Gregorio et al. (1994) and Froot and Rogoff (1995).

⁵ Empirical applications sometimes follow intuitions, even if these have been shown to be conceptually void. On that principle there have been huge amounts of econometric studies devoted to the quantification of Balassa-Samuelson Effect. It is worth noticing that these studies are not supportive of the hypothesis on the empirical adequacy of BSE. Summarizing many years of econometric research on BSE (also one’s own), Égert (2007, s. 1) finds it proper to make the following statement: ‘...our estimation results provide the obituary notice for the Balassa-Samuelson effect’.

defined in some detail shortly). Each country's 'average consumer' in any specific year is characterised by six numbers: real per capita quantities of consumption of the three items defined above (Q_n , Q_d , Q_s) and their respective partial purchasing power parities (P_n , P_d , P_s). The numbers come (after some modification to be described shortly) from Eurostat which has been running the European Comparison Project. The PPPs are calculated vs. the EU-27 average levels, and the real quantities consumed, at PPPs, are computed accordingly. Of course, the six numbers are fully consistent with the overall PPPs for household consumption, reported by Eurostat.

The relative price of durable vs. nondurable tradable goods ($\pi = P_d / P_n$) is far from being the same across countries. The coefficient of variation of national relative prices π varies from 0.173 in 1999 (the earliest year for which the consistent unified ECP data are available) to 0.150 in 2004 and 0.131 in 2008. This certainly can be due to the fact that the compositions of both aggregates may significantly vary from country to country. That is, for instance, durables in some countries may consist primarily of specific goods that are relatively rare in some another countries. For the purposes of this Note, we shall be disregarding the existence of compositional effects and treat the dispersion in π as a sign of non-satisfaction of the Law of One Price, or the failure – for whatever reason - of inter-EU trade to equalize the relative price of two homogeneous tradable goods. In terms of pure theory of international trade the observed bundles of tradable goods are distributed sub-optimally. The distribution could have been improved through additional exchange among countries.

Assume, conventionally, that the country k (identified with its 'representative consumer') is characterised by the system of well-behaved demand functions:

$$Q_n^k = Q_n^k(M^k, p_n^k, p_d^k, p_s^k)$$

$$Q_d^k = Q_d^k(M^k, p_n^k, p_d^k, p_s^k)$$

$$Q_s^k = Q_s^k(M^k, p_n^k, p_d^k, p_s^k)$$

Where $M^k = p_n^k Q_n^k + p_d^k Q_d^k + p_s^k Q_s^k$ is the total per capita income (or consumption expenditure), in nominal terms, in country k .

Being well-behaved (and thus in particular homogeneous of degree zero in prices and income), the above demand equations can be written equivalently in terms of two relative prices $\pi^k = p_d^k / p_n^k$ and $P^k = p_s^k / p_n^k$:

$$Q_n^k = Q_n^k(M^{k*}, \pi^k, P^k)$$

$$Q_d^k = Q_d^k(M^{k*}, \pi^k, P^k)$$

$$Q_s^k = Q_s^k(M^{k*}, \pi^k, P^k)$$

$$\text{Where } M^{k*} = Q_n^k + \pi^k Q_d^k + P^k Q_s^k$$

Let us now assume the countries engage in mutual trade, exchanging some non-durables available to them in return for some durables available to some other countries. Under the standard assumptions this trade, beneficial to all parties involved, would be concluded (with the help of the Walrasian Auctioneer) at the single (hopefully unique) relative price $\pi = p_d/p_n$ leaving the total availabilities (supplies) aggregated over all participating countries unchanged and the values of each country's imports equal to the values of its exports.

Formally, the equalized relative price of the two tradable goods has to satisfy either of the following two equations⁶:

$$\sum_k L^k \underline{Q}_n^k = \sum_k L^k Q_n^k(M^{k*}, \pi, P^k) \tag{1}$$

$$\sum_k L^k \underline{Q}_d^k = \sum_k L^k Q_d^k(M^{k*}, \pi, P^k)$$

Where L^k stands for population of country k .

The equations (1) contain 25 unknowns P^k ($k=1, \dots, 25$) which are the national relative prices of services in terms of the national relative price of non-durable tradable good *plus* one single unknown π . It is postulated here that in addition to (1) the 26 unknowns satisfy 25 equations

$$\underline{Q}_s^k = Q_s^k(M^{k*}, \pi, P^k) \quad k=1, \dots, 25 \tag{2}$$

The satisfaction of (2) keeps each country's demand for non-tradable services at the levels actually reported.

Suppose the system of equations (1)-(2) is numerically specified and solved, yielding the equalized relative price of the two tradable goods π° , the modified (by volumes of exports and imports) quantities of tradable goods consumed and the vector of national relative equilibrium prices of services: P^{k° . Given the solution to (1)-(2) it is easy (conceptually, if not quite computationally) to calculate the purchasing power parities for individual countries for the post-price-equalizing-trade situation. However, direct comparison of these post-trade PPPs with the original ones (Eurostat's) is not possible. The original PPPs are defined in relation to absolute prices (normalized at 1 for the average for the entire EU) while the PPPs derived from the solutions to (1)-(2) are defined in terms of *relative* prices (though these are also normalized at 1 for the entire EU). However, comparability of pre-trade and post-trade PPPs is still possible. The original Eurostat data can always be presented in terms of the relative rather than absolute prices. Of course, comparisons of the pre- and post-trade PPPs do not seem to convey some obviously informative messages. However, things get more interesting if one observes that the solutions to (1)-

⁶ The satisfaction of one of (1) implies satisfaction of the other.

(2) (as well as the original data presented in relative terms) can be used to calculate the PPPs for the aggregate consisting of the tradable goods only. The following ratio

$$\frac{\text{PPP}_{\text{all consumption}}}{\text{PPP}_{\text{tradable goods}}} \quad (3)$$

is interpreted as the PPP/ER ratio obtaining in the neoclassical world described by the model just defined above. The ratio (3) can be computed also for the original situations reflected in the Eurostat data (i.e. prior to price-equalizing free trade). It must be reiterated that being neoclassical, the model in question is incapable of saying anything about absolute price levels obtaining, post-trade, in individual countries, absolute purchasing power parities and absolute values of the exchange rates. Needless to say, it also cannot possibly allow for the effects of capital (or money) flows which certainly affect the exchange rates 'in real life'. Nor can it allow for imbalanced trade among countries (as such trade would imply necessity to allow for capital flows of some sort). Moreover, in keeping with the tradition of pure theory of international trade, it abstracts from the existence of goods other than the consumption ones. Neither capital goods nor intermediate inputs are considered. It also ignores any trade with the Rest of the World: our 25 EU countries represent the whole World here. Finally, any 'imperfections' (trade costs, barriers to trade, differences in indirect tax rates, oligopolistic practices etc) possibly interfering with the operation of the Law of One Price are ruled out.

The strategy followed in this Note, should by now become somewhat clearer. The ultimate goal is to compute the ratios (3) for the pre- and post-price-equalizing-trade situations for a sufficiently long span of time and then to check whether the price-equalizing free trade is always moving the ratio (3) towards unity. Podkaminer (1999), working with the then available European Comparison Project data for 1990, found many instances of the ratio (3) actually moving away from unity – i.e. the evidence that free trade and price equalization may actually enlarge the deviations between exchange rates and purchasing power parities. But that outcome may have been due to the imperfection of data on many European countries then undergoing traumatic changes, amid very high inflation and continuing presence of prices being officially administered, with shortages/rationing of consumer goods and services distorting the reported data.

4 The data issues

This Note works with a subset of the country data available (as of April 2010) from Eurostat's European Comparison Project (ECP henceforth). ECP supplies a wealth of information on purchasing power parities and 'real' (PPP-adjusted) quantities for almost all European countries (currently excluding however the post-Soviet countries other than the three Baltic states), Japan and the USA for the consecutive years 1999 through 2008. For some time now, the true core of ECP has been restricted to the EU-27 countries. (The

results for all non-EU countries do not contain comparable data for the aggregates of consumer goods which are of interest here).

Because of the anomalous price/income conditions obtaining in Luxembourg, that country is not accounted for in further analyses. Luxembourg's very high income level happens to be combined with the relative price (goods/services) that is not much different from that recorded in that country's much less affluent neighbours. Luxembourg does not conform to the Regularity. This anomaly can be explained by the country's tiny size and location between neighbours characterized by much lower income levels. Prices of goods and services, including housing rents, recorded in Luxembourg cannot diverge radically from those prevailing in towns or shopping centres located a few miles away – just across the (nearby) borders. The Law of One Price does seem to work in this rather unique instance – also as far as consumer services are concerned.

The opposite irregularity (comparatively high relative prices of services at a relatively low income level) could be detected in some smaller countries highly dependent on income from foreign tourism (e.g. Malta). This country is excluded from further analyses too.

At present the ECP reports the purchasing power parities and nominal, as well as 'real' (PPP-adjusted), quantities of consumer goods (sub-divided into durable consumer goods, semi-durable consumer goods and non-durable consumer goods) and consumer services. The first, minor, problem is that ECP offers data for *three* sub-categories of consumer goods – while one could be perfectly satisfied with data for two sub-categories. Of course, the aggregation of data for durables and semi-durables did not entail any difficulty. A more serious problem is that for most countries the aggregates for the two consumer items (goods and services), differ appreciably from the reported data on the '*national household final consumption expenditure*'. Just to illustrate this point, consider the 'raw' ECP data for Germany and Spain in, let us say, 2005. The nominal German p.c. expenditures on the consumption of consumer goods and services equalled 7809 and 7440 euro respectively (15249 euro in total) - while the p.c. nominal *household* final consumption was as much as 15593 euro. The opposite situation was reported for Spain, where the nominal p.c. expenditures on consumption of consumer goods and services were 5427 and 7132 euro respectively (12559 euro in total) - while the nominal p.c. household final consumption reportedly equalled only 11935 euro. The discrepancies are attributable primarily to the households' consumption realised abroad (in the German case), or to foreigners' consumption (in the Spanish case). Earlier Eurostat reports contained all information (nominal and real quantities as well as purchasing power parities) pertaining to the item called '*net purchases abroad*'. That item tightly corresponded to the discrepancies between the household final consumption expenditure and the sum of the consumer goods and services (see e.g. Eurostat/OECD, 2004). Eurostat no longer reports the '*net purchases abroad*', but leaves the discrepancies without further comment. Whatever the nature of the

discrepancies in question, it quite obvious that they have to be consistently removed from the ECP data – if that is to be used for the estimation of the conventional systems of households' demand functions to be used in specification of (1)-(2).

The way to get rid of the discrepancies followed in work underlying the results reported in this paper assumes that in each country instance the discrepancies (in volumes, values and the purchasing power parities) referred to above reflect net purchases abroad and that the purchases in question target only the consumer services. In other words it is assumed that while abroad, the tourists buy only services. (A part of 'services' is after all tradable – though these tradable services do not move physically across the national border to reach the consumer. Instead, it is the foreign consumer which crosses the border to enjoy them). The households in the tourism-importing countries (such as Germany) are thus assumed to consume more of services than reported by the ECP for Germany (and as much either of the consumption goods as reported). Conversely, households in the tourism-dependent countries are assumed to consume less of services than reported by ECP for their countries – and unchanged quantities of goods. Further, it is assumed that while the purchasing power parities of the consumer goods are equal to the purchasing power parities of the households' final consumption expenditure *on goods*, the purchasing power parities of households' final consumption of services remain to be assessed – taking into account services consumed both domestically and abroad. (In other words the foreigners buy, or nationals sell, services that can be different – in terms of their purchasing power parities - from the services they purchase as households domestically). Finally, it is postulated that the *real* quantities of services actually entering households' final consumption expenditure (and the corresponding services' purchasing power parities) must be consistent with the overall purchasing power parities for the *household* final consumption expenditure. (The latter are of course reported by ECP).

The arithmetic of the adjustments to the ECP data that would meet the third postulate literally is not demanding (conceptually) but it would require the application of the computationally very demanding EKS (Eltető-Köves-Szulc) algorithm. A somewhat lighter approach was taken instead. Because a number of sensitivity test suggest that the eventual biases are very low, the approach seems quite reliable, at least in the concrete context considered.

Specifically, for each of the 25 countries considered (and any year from 1999 through 2008) *calculated (or adjusted) purchasing power parity of consumer services included in the aggregate household final consumption expenditure* (PPP_s) solves the following equation:

$$PPP_h = (Las \cdot Paa)^{1/2} \tag{4}$$

where PPP_h is the (reported) purchasing power parity of household final consumption expenditure and Las , Paa are the binary Laspeyres and Paasche indices for PPP_h defined as follows:

$$Las = PPP_g \cdot W_{EU} + PPP_s \cdot (1 - W_{EU}) \quad Paa = (W/PPP_g + (1 - W)/PPP_s)^{-1}$$

where W is the share of expenditure on goods in household final consumption. This is equal $PPP_g \cdot X_g / PPP_h \cdot X_h$ with PPP_g being the purchasing power parity of consumer goods, X_g the real volume of consumer goods (reported), X_h is the real volume of household final consumption (reported), and W_{EU} is the share of expenditure on goods in household final consumption for the entire EU-27 (this is easily calculated).

Equation (4), which is of course the formula for the binary Fisher PPP_h vs. the average for the EU-27, is quadratic in the single unknown PPP_s . This equation has two solutions of which only the positive one (existing and unique in each and any case) is meaningful. To arrive at the fully multilateral PPPs one would have to replicate the EKS procedure. This would first involve solving, for each country in each year, 25 equations of the type (4) – modifying them suitably (e.g. substituting EU-wide goods' shares W_{EU} with the shares recorded in each of the 25 partner countries) and then properly averaging the resultant 25 solutions for each country in each year. That would be a gargantuan effort. Instead, equation (4) was specified and solved, for each year and the randomly selected samples of the 25 countries five times only - each time substituting the data for the EU-27 averages with the data for Germany, France, the UK, Italy and Spain. On account of their population numbers and the levels of real consumption these countries would dominate the eventual fully multilateral PPP_s anyway. Not surprisingly, the binary PPP_s derived that way do not diverge perceptibly from the ones calculated from (4). (The latter PPP_s are of course closest to the Germany-based solutions to (4)). This justifies assuming the PPP_s solving (4) as acceptable proxies to the fully multilateral purchasing power parities. Finally, it may be observed, that in most cases the adjustments described above did not change the PPPs for services very much. However, in many cases the volumes of real quantities of services have been changed quite substantially. For example, the adjusted German PPP_s for 2005 is 1.0241 rather than the original 1.0333 and the Spain's PPPs for that year are 0.9319 and 0.9262 respectively. But the real adjusted real quantity Q_s for Germany in 2005 is about 7600 euro rather than the original 7200. The respective Q_s quantities for Spain are 6930 and 7700 euro.

5 An Almost-Ideal demand system fits the ECP data remarkably well

With the data on consumption of and purchasing power parities for services made consistent with the data on household final consumption expenditure it is possible to engage into the estimation of the cross-country system of demand function⁷.

⁷ The idea of estimating cross-country systems of consumer demand function with data from international comparison projects is due to the late Professor Henri Theil: see Theil and Suhm (1981), Theil and Clements (1987), Fiebig et al. (1988), Clements and Selvanathan (1994).

After quite extensive, but only moderately successful, experimentation with some popular functional forms for the system of demand function, a simplified version of the ‘classical’ Almost Ideal Demand System AIDS (due to Deaton and Muellbauer, 1980) was eventually selected for the final estimation.

Arithmetically, the simplified AIDS for the three-commodity economy is compactly represented by three demand equations:

$$\begin{aligned}
 Q_n &= (M/p_n)[\alpha_n + \beta_n(\log (M/M^\circ) - P)] \\
 Q_d &= (M/p_d)[\alpha_d + \beta_d(\log (M/M^\circ) - P)] \\
 \text{and} & \\
 Q_s &= (M/p_s) [\alpha_s + \beta_s(\log (M/M^\circ) - P)]
 \end{aligned}
 \tag{5}$$

Q_n , Q_d and Q_s are real quantities of household-consumed non-durables, durables and services respectively, M is the nominal p.c. household expenditure, M° is the scaling constant identified – in our case – with the average real (which by construction is equal to the nominal) household expenditure for the entire EU-27, p_n , p_d and p_s are the purchasing power parities (playing here the role of prices) for the two consumer goods and services respectively, \log is the natural logarithm, P is the overall (Richard Stone’s) price deflator defined as

$$P = \alpha_n \log(p_n) + \alpha_d \log(p_d) + \alpha_s \log(p_s)$$

Finally, α_n , α_d , α_s , β_n , β_d , β_s are the parameters to estimate.

Table 1 reports the parameter estimates obtained through the application of the non-linear Full Information Maximum Likelihood (FIML) method for consecutive years.

Table 1

	Parameter estimates					
	α_n	α_d	α_s	β_n	β_d	β_s
1999	0.3249	0.2184	0.4567	-0.2067	0.0599	0.1468
2000	0.3236	0.2156	0.4608	-0.1912	0.0557	0.1355
2001	0.3172	0.2166	0.4662	-0.2070	0.0564	0.1506
2002	0.3175	0.2077	0.4748	-0.1992	0.0580	0.1412
2003	0.3163	0.2047	0.4790	-0.2096	0.0559	0.1537
2004	0.3094	0.2085	0.4821	-0.2098	0.0606	0.1492
2005	0.3153	0.1999	0.4848	-0.2149	0.0423	0.1726
2006	0.3120	0.1961	0.4919	-0.2136	0.0321	0.1815
2007	0.3126	0.1943	0.4931	-0.2105	0.0382	0.1723
2008	0.3182	0.1854	0.4964	-0.2239	0.0476	0.1763
Average	0.3155	0.2054	0.4791	-0.2070	0.0499	0.1571
Stand.Dev.	0.0043	0.0083	0.0115	0.0080	0.0107	0.0165

The statistical quality of the estimates turns out to be pretty high. All estimates are highly significant (the significance level is 0.0000 in each case). In most cases the ‘fit’, measured by adjusted R^2 , is fairly high (see Table 2).

Table 2

	Adjusted R2 for equations (5)		
	nondurables	durables	services
1999	0.9226	0.9613	0.9411
2000	0.9196	0.9592	0.9428
2001	0.9044	0.9507	0.9454
2002	0.8939	0.9465	0.9281
2003	0.8779	0.9543	0.9257
2004	0.7930	0.9403	0.8936
2005	0.8010	0.9660	0.9058
2006	0.7560	0.9450	0.8970
2007	0.6964	0.9363	0.8545
2008	0.5846	0.9325	0.8452
Average	0.8303	0.9498	0.9116
Stand.Dev.	0.0806	0.0098	0.0303

Three remarks are not in order. First, the parameters satisfy the adding-up and symmetry conditions, as the theory requires. Statistical tests of these conditions are passed with flying colours.

Second, Negative values of β_n (on average -0.207) indicates that non-durables are ‘necessities’. Similarly as is the case with ‘food’, the share of non-durable goods in total consumer expenditure declines with income level: the Engel’s Law seems to apply to non-durables too. The average β for services is positive and large (0.1571) indicating that services are ‘luxuries’⁸.

Third, although the parameter estimates for consecutive years are on the whole quite similar, they are yet identical. Moreover, they seem to follow some sustained tendencies, especially visible in the case of β_n (generally declining over time) and β_s (generally increasing over time). However, it should be noticed that the parameter estimates for different years cannot be expected to be *precisely* the same. This follows from the fact that the results of ECP (or of any other international comparison project) for various years are not quite comparable. Purchasing power parities and real quantities for a given year and given country cannot be legitimately compared with the same items even for the same country – but for a different year. The same incomparability principle applies to the measures of total real consumption (approximated by $\log(M/M^0)$ -P). In particular, the

⁸ These conclusions, perhaps not quite novel, were also confirmed in the context of research on cross-country systems of demand functions (Podkaminer 1999, 2004, 2010).

average EU p.c. household consumption (M°) itself is a *nominal* magnitude. Because of that, the series of M° for the consecutive years reflects *also* the ongoing inflation. For example M° for 2003 is 11800 euro (at purchasing power parities of 2003) while M° for 2004 is 12300 euro (at purchasing power parities of 2004). The implied growth rate of the average p.c. household consumption is 4.24%. But this rate reflects both inflation and the structural change (in both prices and real quantities consumed). The price index P , calculated *separately* for each year, allows cross-country comparisons for the given year only. There is nothing in the definition, or construction, of P which would suggest it could be used to deflate the nominal consumption values for different years – even for the same country. It may be added that even though one does not quite know how to relate the price indices P for consecutive years even at the overall EU level⁹, one may safely assume that in most member states (and at the EU level) the average p.c. *real* consumption kept growing (at least until 2007), even if one does not know precisely how to measure that growth in PPP terms. Given this assumption, one should expect β_s to get larger in absolute terms over time. In other words, even if $(\log(M/M^\circ) - P)$ for a country happens to be the same in two years, its ‘true real’ value is likely to have been larger in the later year. Finally, it is worth adding that large jumps in the parameter estimates occurred only in 2005. This may be due to a change in the Eurostat methodology for the calculation of prices and volumes for education services (which constitute an important part of the service aggregate) which happened in 2005.

6 Solutions to (1)-(2)

For each year the systems of equations (1)-(2) is build, specified (with the ECP data) and solved. The AIDS demand functions specified with the parameters from Table 1 appear on the right-hand sides of these equations. (To safeguard comparability with the original data, the right-hand sides of these equations include, additionally, the values for the residuals the respective regressions).

The systems (1)-(2) are highly non-linear in the unknowns, but obtaining solutions (through repeated iterations) proceeds very quickly.

Table 3 illustrates the character of solutions to the model (1)-(2) for the odd-dated years (this is intended to save on space). The first row reports un-weighted averages of the relative price of tradable goods $\pi = p_d/p_n$ characterizing the original ECP data, the second row the un-weighted coefficients of variation of p_d/p_n . The third row reports the equilibrium value of p_d/p_n – i.e. the effect of the operation of the Law of One Price. The fourth row reports un-weighted averages of pre-trade relative prices of services (in terms of prices of

⁹ Because p_n , p_d and p_s for the whole EU are both 1 by construction, $\log(M/M^\circ) - P$ for the average EU inhabitant is 0 in any year. Correspondingly, Q_s for that inhabitant is estimated as $\alpha_s M^\circ$.

non-durables); the fifth row has the coefficients of variations. The sixth and seventh rows refer to the post-trade relative prices of services. Given the difficulties inherent in comparing the ECP data (and the data derived from them) over time, it is perhaps advisable to comment the contents of Table 3 with some caution. However, it seems fairly correct to notice one fact, namely that in any year the equalization of the prices of tradable goods happens to be associated with the relative prices of services becoming more *dispersed* as compared with the original pre-trade situations. (The coefficients of variations from the seventh row are all larger than those from the fifth row).

Table 3

Characteristics of the original ('pre-trade') and equilibrium ('post-trade') relative prices for a sample of years

	1999	2001	2003	2005	2007
Av. pre-trade π	1.1132	1.079	1.0945	1.096	1.0763
CoV	0.1732	0.138	0.1602	0.1491	0.1317
Post-trade π	0.9687	0.9687	0.9732	0.9722	0.9745
Av. pre-trade P	0.7799	0.7984	0.8505	0.8619	0.8746
CoV	0.3282	0.3164	0.2289	0.2261	0.2125
Av. pre-trade P	0.7728	0.790	0.8419	0.8507	0.8639
CoV	0.3385	0.331	0.2545	0.2463	0.2317

The price solutions to (1)-(2) imply definite reallocations of consumption of the two tradable goods, with some counties exporting 'surpluses' of durables and some exporting 'surpluses' of non-durables. As illustrated by Table 4, in the 'old' EU member states the sizes of these trades are rather small in relation to the domestic consumption levels originally reported. However, these sizes are rather large in the 'new' member states (as well as in Spain, Greece, Ireland and recently Portugal). The interpretation of this fact seems fairly straightforward: the 'old' (and rich) EU member states have been much more mutually integrated through the mutual trade than the 'new' (or 'cohesion') member states. The 'old' countries have had time to integrate and need only marginal additional adjustments (captured by the model) to arrive at the 'optimum'. This is not the case with the 'new' member states, whose consumption patterns still require quite massive adjustments.

Interestingly, the model suggests that the adjustments needed stipulate that the less affluent countries export significant quantities of durables they consume, in exchange for significant quantities of non-durables.

Table 4

**Exports as percentage of domestic pre-trade availabilities associated
with the solution to (1)-(2), selected years**

	2003		2005		2007	
	Durables	Non-durables	Durables	Non-durables	Durables	Non-durables
Belgium	-0.8	0.4	-0.2	0.1	-0.3	0.1
Bulgaria	23.7	-4.1	26.3	-5.2	13.8	-5.0
Czech R.	29.3	-7.7	21.2	-7.2	19.4	-5.4
Denmark	-5.4	3.5	-0.5	0.6	-3.4	4.1
Germany	-3.6	2.4	-4.2	3.0	-3.2	2.2
Estonia	16.6	-10.4	14.6	-7.5	12.1	-9.3
Ireland	-8.7	6.0	-7.4	6.5	-8.1	6.7
Greece	9.6	-4.8	9.6	-4.4	8.3	-3.4
Spain	14.8	-7.3	11.0	-5.7	9.0	-4.8
France	-3.7	2.0	-1.6	1.1	-1.1	0.6
Italy	-0.2	0.2	-1.3	1.0	-0.7	0.5
Cyprus	7.8	-4.1	5.1	-2.4	1.5	-0.8
Latvia	34.1	-8.3	40.4	-8.5	24.9	-8.5
Lithuania	34.7	-5.5	26.8	-6.2	20.4	-5.8
Hungary	16.1	-7.5	17.5	-6.8	16.5	-4.9
Netherlands	-3.6	2.7	1.0	-0.6	4.1	-2.8
Austria	0.8	-0.6	-1.0	0.6	0.0	0.0
Poland	38.1	-3.7	42.3	-5.6	36.5	-4.4
Portugal	4.2	-4.1	8.3	-7.3	8.2	-6.3
Romania	21.2	-7.0	27.7	-3.9	22.5	-4.0
Slovenia	6.2	-3.2	8.8	-4.4	7.5	-4.0
Slovakia	35.9	-5.2	26.3	-4.3	29.7	-3.6
Finland	-2.6	1.7	0.4	-0.3	1.2	-0.9
Sweden	-5.2	2.7	-4.2	2.5	-3.3	2.1
UK	-2.9	4.1	-3.1	3.8	-4.5	5.7

7 Price equalization affecting the PPP/ER ratios

The solutions to (1)-(2) allow computation of the ratios

$$\frac{PPP_{\text{all consumption}}}{PPP_{\text{tradable goods}}}$$

which are identified as the pure trade theory's equivalents of the PPP/ER ratios. Table 5 reports these ratios for selected years, together with the same ratio calculated for the original data ('pre-trade').

As can be seen, generally the price-equalizing trade moves the PPP/ER ratios closer to unity. However, in each year there are countries whose PPP/ER ratios would – under price equalization – would move away from unity. In 2003 these were Austria, Portugal and the UK, in 2005 Spain, Austria, Portugal, and the UK, in 2007 Denmark, Estonia, Ireland, Spain, Portugal and the UK. In 2006 as many as in 7 countries the PPP/ER would be

moved away from unity (Belgium, Denmark, Ireland, the Netherlands, Austria, Portugal and the UK).

Table 5

Pre- and post-trade PPP/ER ratios for selected years

	2003		2005		2007	
	pre-trade	post-trade	pre-trade	post-trade	pre-trade	post-trade
Belgium	1.0271	1.0260	1.0182	1.0175	1.0291	1.0282
Bulgaria	0.7125	0.7295	0.7196	0.7383	0.7008	0.7091
Czech R.	0.7490	0.7667	0.7573	0.7703	0.7809	0.7946
Denmark	1.0325	1.0312	1.0350	1.0345	1.0200	1.0241
Germany	1.0092	1.0087	0.9903	0.9907	0.9774	0.9781
Estonia	0.8564	0.8582	0.8642	0.8701	0.9177	0.9155
Ireland	1.0556	1.0541	1.0349	1.0379	1.0644	1.0667
Greece	0.9700	0.9738	0.9650	0.9697	0.9736	0.9783
Spain	0.9943	0.9994	1.0204	1.0231	1.0211	1.0227
France	1.0665	1.0636	1.0818	1.0797	1.0900	1.0876
Italy	0.9714	0.9717	0.9840	0.9844	0.9939	0.9940
Cyprus	0.8881	0.8922	0.8975	0.9016	0.8924	0.8946
Latvia	0.8256	0.8473	0.8342	0.8629	0.8731	0.8875
Lithuania	0.7887	0.8125	0.7977	0.8170	0.8261	0.8407
Hungary	0.8105	0.8178	0.8117	0.8221	0.8145	0.8263
Netherlands	1.0197	1.0197	1.0311	1.0304	1.0194	1.0183
Austria	0.9828	0.9826	0.9969	0.9966	0.9907	0.9907
Poland	0.8436	0.8742	0.8239	0.8575	0.8073	0.8363
Portugal	0.9140	0.9128	0.9179	0.9150	0.9115	0.9102
Romania	0.7947	0.8064	0.7885	0.8109	0.8276	0.8459
Slovenia	0.8806	0.8847	0.8830	0.8879	0.8902	0.8937
Slovakia	0.7503	0.7752	0.7627	0.7840	0.7756	0.7994
Finland	1.0640	1.0624	1.0607	1.0590	1.0470	1.0457
Sweden	1.0155	1.0129	1.0324	1.0307	1.0150	1.0144
UK	1.0197	1.0244	1.0130	1.0173	1.0284	1.0354

8 Concluding remarks

Intuitively, trade among nations – especially if conducted under idealized conditions assumed in pure theory – should reduce the discrepancies between exchange rates and purchasing power parities. However, this intuition would be correct if the equalization of the prices of tradable goods (and the associated trade-induced adjustments in the volumes of consumption of tradable goods) were to leave the prices of non-tradable services intact. In the general equilibrium context such a situation is rather unlikely to occur. Changing relative prices of tradable goods may affect the demand for services – moreover, the changes in the composition and volumes of consumption of tradable goods imply a change in the level of real income. That too may affect the demand for non-tradable services. To bring the demand for services in balance with its fixed supply, the domestic prices of services may have to change in individual countries engaging in trade. The directions and

magnitudes of these changes may be different in individual countries, depending both on the pre-trade availabilities (and prices) obtaining in the given country (and in all of its partners) and on the kinds of preferences underlying 'representative consumers' systems of demand functions of these countries. As shown in Table 5, the general equilibrium adjustments may be such as to push the ratios identified with PPP/ER away from unity in some countries. It is perhaps worth adding that such 'perverse' effects are possible irrespectively of the form of the consumer preferences. In Podkaminer (1999) such effects are shown to occur also under simple Cobb-Douglas and Linear Expenditure (Stone-Geary) demand systems.

Persistence of the PPP/ER discrepancies, also under growing global integration through international trade is therefore not quite surprising. Such persistence – and instances of the discrepancies widening despite the ongoing trade liberalization – can be a normal equilibrium phenomenon even under highly idealized conditions. Needless to say, the imperfections ignored in pure trade theory can only magnify these discrepancies, and make them even more persistent.

One final remark is now in order. The general exchange equilibrium model presented in this Note *forced* the relative prices of tradable goods in the freely trading countries into uniformity – simulating the operation of The Law of One Price. But in reality the relative prices of tradable goods are persistently dispersed. Does this necessarily vitiate the Law of One Price and thus the relevance of the neoclassical 'pure' theory of international trade? Perhaps the answer to this question may be less definitive than often suggested. Prices of tradable goods generally considered (and in particular the prices entering the PPP calculations) are *retail* prices prevailing domestically. As such, they contain a great deal of inputs of *local non-tradable services* (e.g. distribution services). But, as argued in this Note, even under ideal conditions prices of non-tradable services may play various tricks. It cannot be ruled out that the prices of tradable goods *net of costs of domestic services* (unobservable, or at least unobserved) actually tend to obey the Law of One Price. The *observed* prices of tradable goods do not need to show this tendency even under free and competitive foreign trade, precisely because such trade can even widen the gaps between prices of non-tradable services.

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