Real Exchange Rate Behavior in a Convergence Club

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The paper attempts to reconcile the growing evidence that Purchasing Power Parity (PPP) tends to hold in the long-run with the Balassa-Samuelson model, the most popular of the models that try to rationalize long-term deviations from PPP. It argues that in the very long-run the process of technological diffusion, combined with the forces highlighted by the Balassa-Samuelson model, will tend to lead to real exchange rate convergence towards absolute PPP. Real exchange rate behavior in a group of twenty-four OECD countries that formed a convergence club in the postwar period provides empirical evidence for the argument.

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1. Introduction

The Balassa-Samuelson model (Balassa (1964) and Samuelson (1964)) is the most popular of the models that try to rationalize long-term deviations from Purchasing Power Parity (PPP). It posits that, after adjusting for exchange rates, prices in rich countries will be high relative to those in poor countries, and that prices in fast-growing countries will rise relative to prices in slow-growing countries. In alternative terms, the model states that real exchange rates will be appreciated in rich countries and will appreciate over time in fast-growing countries. The underlying force that drives the Balassa-Samuelson model is cross-country differentials in tradable-sector productivity.

A large body of literature has tested the predictions of the Balassa-Samuelson model.[1] Overall, there is substantial empirical support for the Balassa-Samuelson model, especially in its cross-sectional version. However, in recent years there is increasingly strong evidence supporting the validity of long-run PPP.[2] How can one reconcile the evidence supporting PPP with the Balassa-Samuelson model? Froot and Rogoff (1995, p. 1674) offer the following solution: "Even though technology can differ across countries for extended periods, the free flow of ideas together with human and physical capital produces a tendency towards long-run convergence of incomes."[3] In other words, technological diffusion and the free flow of capital limit potential deviations from PPP in the very long-run.

[1] Froot and Rogoff (1995), Rogoff (1996) and Sarno and Taylor (2002) provide excellent surveys of this literature. Canzoneri, Cumby and Diba (1999), and Chinn (2000) provide recent examples of time-series tests of the Balassa-Samuelson model.

[2] See the surveys mentioned above.

[3] Similar arguments are made by Rogoff (1996, p. 662) and Sarno and Taylor (2002, p. 92).

This paper puts the above argument to an empirical test. A natural environment for application of the test is one in which there is substantial amount of evidence of technological diffusion and capital flows. One such environment is that of a convergence club. A convergence club is a group of countries within which the originally poor grow faster and converge to the rich.[4] Applying the logic of the Balassa-Samuelson model in both its cross-sectional and time-series versions it is straightforward to predict that in a convergence club the initially poor countries will start with depreciated real exchange rates and will undergo real exchange rate appreciation as they catch-up with the rich. The paper demonstrates that this indeed occurred in the postwar OECD convergence club: The process of per-capita income convergence was to a large extent accompanied by convergence of real exchange rates toward absolute PPP.[5]

The next section contains a simple analytical framework that augments the Balassa-Samuelson model with a technological diffusion mechanism to yield convergence in both per-capita incomes and real exchange rates over time. Section 3 describes the data. Empirical testing of the framework's predictions is carried out in section 4. Section 5 concludes.

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[4] This concept is known in the growth literature as unconditional β-convergence. See Sala-i-Martin (1996).

[5] According to absolute PPP the value of the real exchange rate should be one, for all pairs of countries and at all times. According to relative PPP, a weaker form of PPP, the value of the real exchange rate should be constant, but not necessarily one.

2. Analytical Framework

The analytical framework consists of three elements: (1) The Balassa-Samuelson model in its cross-sectional version; (2) The Balassa-Samuelson model in its time-series version; (3) A simple technological diffusion mechanism. The combination of these three elements yields the result of simultaneous convergence: In per-capita incomes and real exchange rates.

Assume a small open economy that takes the world real rate of interest as given and operates under the conditions of perfect competition. Two kinds of goods are produced in the economy, tradables and non-tradables, according to the following constant returns to scale Cobb-Douglas production functions:

$$Y_t^T = \theta_t^T (L_t^T)^{\alpha} (K_t^T)^{1-\alpha} \tag{1}$$

$$Y_t^N = \theta_t^N (L_t^N)^{\beta} (K_t^N)^{1-\beta} \tag{2}$$

where $Y_t^i, \theta_t^i, L_t^i, K_t^i$ are output, level of technology (or productivity), labor input and capital input at time t in sector i (i being T or N), while α and β are production function parameters. Under perfect competition the following optimality conditions must be satisfied:

$$R_t = (1-\alpha)\theta_t^T (k_t^T)^{-\alpha} \tag{3}$$

$$W_t = \alpha\theta_t^T (k_t^T)^{1-\alpha} \tag{4}$$

$$R_t = P_t(1-\beta)\theta_t^N (k_t^N)^{-\beta} \tag{5}$$

$$W_t = P_t\beta\theta_t^N (k_t^N)^{1-\beta} \tag{6}$$

where R_t and W_t are the world real rate of interest and domestic wage rate, respectively, k_t^i is capital per-worker in sector i and P_t is the relative price of non-tradables (i.e.

$P_t = P_t^N / P_t^T$). From (3) we can solve for the capital stock per-worker in the tradable sector as a function of the interest rate and tradable sector technology. From (5) we can solve for the capital stock per-worker in the non-tradable sector as a function of the interest rate, non-tradable sector technology and the relative price of non-tradables. From (4) and (6) we can solve for the relative price of non-tradables as a function of technology levels and capital stocks per-worker in the two sectors. By combining the above results we obtain the following expression for the relative price of non-tradables as a function of the interest rate and the technology levels in the two sectors:

$$P_t = \left[\frac{\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}}{\beta(1-\beta)^{\frac{1-\beta}{\beta}}} \right]^{\beta} R_t^{\left(1-\frac{\beta}{\alpha}\right)} \left(\theta_t^N\right)^{-1} \left(\theta_t^T\right)^{\frac{\beta}{\alpha}} \equiv \gamma R_t^{\left(1-\frac{\beta}{\alpha}\right)} \left(\theta_t^N\right)^{-1} \left(\theta_t^T\right)^{\frac{\beta}{\alpha}} \tag{7}$$

Note that if α=β then equation (7) simplifies to $P_t = \frac{\theta_t^T}{\theta_t^N}$.

Define the national price level in country i and time t, $NPL_{i,t}$, as a weighted average of prices of tradables and non-tradables. For simplicity we assume that the weights are constant over time and equal across countries.[6] We therefore have for every i and t:

$$NPL_{i,t} = \left(P_{i,t}^N\right)^{\delta} \left(P_{i,t}^T\right)^{1-\delta} \tag{8}$$

where $P_{i,t}^N$ and $P_{i,t}^T$ are the prices of non-tradables and tradables, respectively. The real exchange rate of country i relative to country j at time t is then defined as follows:

[6] This is a conventional assumption made in the literature. The specification of the aggregate price index is based on a Cobb-Douglas utility function with a unit elasticity of substitution.

$$Q_{i,j,t} = \frac{NPL_{j,t}}{NPL_{i,t}} = \left(\frac{P^N_{j,t}}{P^N_{i,t}}\right)^{\delta}\left(\frac{P^T_{j,t}}{P^T_{i,t}}\right)^{1-\delta} \tag{9}$$

Assuming that PPP holds for tradables, i.e. $P^T_{i,t} = P^T_{j,t}$, recalling the definition of the relative price of non-tradables and using (7) we get:

$$Q_{i,j,t} = \left[\frac{\left(\theta^T_{j,t}/\theta^T_{i,t}\right)^{\frac{\beta}{\alpha}}}{\left(\theta^N_{j,t}/\theta^N_{i,t}\right)}\right]^{\delta} \tag{10}$$

According to the Balassa-Samuelson model if j is a richer country than i, we would expect technology levels in j to be higher than in i. Moreover, we would expect the technological gap between the rich and the poor countries to be larger in the tradable sector. This difference is what causes the real exchange rate of i to be depreciated relative to j. Formally: If $\theta^T_{j,t}/\theta^T_{i,t} > \theta^N_{j,t}/\theta^N_{i,t}$ and α=β then $Q_{i,j,t} > 1$. On the other hand, if $\theta^T_{j,t}/\theta^T_{i,t} = \theta^N_{j,t}/\theta^N_{i,t} > 1$ and α<β then we still get $Q_{i,j,t} > 1$.

So far the discussion has concentrated on comparing price level across countries at a given point in time. To see the time-series counterparts of these results we simply take time derivatives of (10) to yield:

$$\frac{\dot{Q}_{i,j,t}}{Q_{i,j,t}} = \delta\left[\frac{\beta}{\alpha}\left(\frac{\dot{\theta}^T_{j,t}}{\theta^T_{j,t}} - \frac{\dot{\theta}^T_{i,t}}{\theta^T_{i,t}}\right) - \left(\frac{\dot{\theta}^N_{j,t}}{\theta^N_{j,t}} - \frac{\dot{\theta}^N_{i,t}}{\theta^N_{i,t}}\right)\right] \equiv \delta\left(a^N_{i,j,t} - \frac{\beta}{\alpha}a^T_{i,j,t}\right) \tag{11}$$

where $a^T_{i,j,t}$ and $a^N_{i,j,t}$ are the differential technological growth rates between countries i and j in the tradable and the non-tradable sectors, respectively. Equation (11) says that, assuming α=β, if the differential technological growth rate is higher in the tradable sector than in the non-tradable sector, country i will experience a real exchange rate appreciation over time relative to country j. If $\alpha<\beta$, then even balanced differential technological growth rates will lead to real exchange rate appreciation.

The novel element in the analytical framework comes from augmenting it by an exogenous technological diffusion mechanism. Assume the following equations for the rate of growth of technology in the two sectors:[7]

$$\frac{\dot{\theta}^T_{i,t}}{\theta^T_{i,t}} = \phi^T + \left(\frac{\theta^T_{L,t}}{\theta^T_{i,t}} - 1\right) \tag{12}$$

$$\frac{\dot{\theta}^N_{i,t}}{\theta^N_{i,t}} = \phi^N + \left(\frac{\theta^N_{L,t}}{\theta^N_{i,t}} - 1\right) \tag{13}$$

where ϕ^T and ϕ^N are positive parameters, common to all countries, while $\theta^T_{L,t}$ and $\theta^N_{L,t}$ are the time t technology levels in the economy with the highest technology level (we assume for simplicity that the same country is the technology leader in both sectors). Equations (12) and (13) say that the further apart the country is from the technology leader the faster its rate of growth of technology.

Substituting (12) and (13) into (11) yields:

$$\frac{\dot{Q}_{i,L,t}}{Q_{i,L,t}} = \delta\left[\frac{\beta}{\alpha}\left(1 - \frac{\theta^T_{L,t}}{\theta^T_{i,t}}\right) - \left(1 - \frac{\theta^N_{L,t}}{\theta^N_{i,t}}\right)\right] \tag{14}$$

Thus if $\alpha=\beta$ country i will experience real exchange rate appreciation relative to the technology leader as long as it is closer (in ratio terms) to the leader in non-tradable sector technology than in tradable sector technology. When $\alpha<\beta$ country i will experience real exchange rate appreciation even if the technological gap between itself and the leader is the same across the two sectors.

[7] A similar exogenous technological diffusion mechanism is presented in Bernard and Jones (1996).

The analytical framework presented above implies the following process. In the initial period all members of the convergence club have lower per-capita incomes and depreciated real exchange rates relative to the technological leader. Over time these countries are catching-up to the leader in terms of per-capita income and experiencing real exchange rate appreciation. As the members of the convergence club close the technological gap their real exchange rates converge toward absolute PPP.

3. Data

One of the most prominent examples of convergence clubs analyzed in the growth literature is that of the OECD countries in the postwar period and we will therefore focus on that group.[8] The countries examined are Australia, Austria, Belgium, Canada, Denmark, Finland, France, West Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States. These include the twenty original (1961) members plus four members that joined the OECD by 1973. Current OECD members that joined only recently, namely the Czech Republic, Hungary, Korea, Mexico, Poland, and the Slovak Republic are excluded from the analysis.

The database used in the empirical analysis is the Penn World Tables Mark 5.6 (see Summers and Heston (1991)). The Penn World Tables contains a set of national accounts economic time series. Its expenditure entries are denominated in a common set of prices and in a common currency so that real quantity comparisons can be made, both between countries and over time. This database covers the period 1950-92, but because

[8] For analysis of the OECD convergence club see, for example, Dowrick and Nguyen (1989).

Greece has no data for 1992 and Portugal has no data for 1991-2, the period analyzed for all countries is 1950-90.

A direct test of the analytical framework's predictions necessitates use of data on sectoral productivity growth differentials and sectoral price indices. Unfortunately such data is not available for most of the OECD countries prior to 1970. Limiting the analysis to the post-1970 period would not be a good idea because it was the earlier period of the 1950s and 1960s in which most OECD countries exhibited the fastest rates of convergence. Thus the cruder measures of output per-capita and output per-worker will be used in the empirical analysis.

The data from the Penn World Tables is used to construct three variables: Relative GDP per-capita, relative GDP per-worker, and real exchange rate. The first two are obtained by dividing the value of each variable in the domestic economy by the corresponding value in the United States. The real exchange rate of each country relative to the United States is defined as 100/P where P is the price level of GDP.

4. Empirical Analysis

Does the data exhibit the predicted pattern of convergence of per-capita incomes and real exchange rates? This section will try to convince the reader that to a large extent the answer to this question is positive. Within the group of OECD countries examined almost all initially had a low level of GDP per-capita and a depreciated real exchange rate relative to the United States; subsequently a large majority of these countries grew faster than the United States and experienced real exchange rate appreciation. Thus convergence in levels of GDP per-capita was accompanied by convergence towards absolute PPP.

Figure 1 is a scatter diagram of all (943) observations on the natural logarithm of relative GDP per-capita and the natural logarithm of the real exchange rate for the twenty-three OECD countries during the 1950-90 period. Visual inspection indicates a strong negative relationship between the real exchange rate and relative GDP per-capita. The argument that this paper makes can be visualized as a rightward and downward movement inside the cluster of points in Figure 1. A typical country in our sample was represented in 1950 by a point in the second quadrant. In 1990 the same country was represented by a point located close to the origin (0,0), which represents the combination of full convergence in GDP per-capita and real exchange rate (absolute PPP). Figure 2 plots the time series of the natural logarithm of relative GDP per-capita and the natural logarithm of the real exchange rate for each of the twenty-three countries included in the sample. For the majority of the countries a negative relationship between the two variables is again apparent.

Table 1 establishes that the OECD countries indeed formed a convergence club during the period 1950-90. The table is divided into two parts, the first focuses on the behavior of relative GDP per-capita, the second on the behavior of relative GDP per-worker. In order to establish the existence of a convergence club we have to examine both the initial values of the variables and their rate of growth over time. An ordinary least squares regression of the natural logarithm of each variable against a constant and a linear time trend was used to estimate this rate of growth. A member of the convergence club has to have both lower GDP per-capita (and per-worker) than the United States in

1950 and a positive rate of growth of relative GDP per-capita (or per-worker) over the period 1950-90. Table 1 demonstrates that all countries started out in 1950 with lower GDP per-capita and lower GDP per-worker than the United States and all, except for New Zealand, grew faster than the United States during the following four decades.[9] The members of the convergence club had in 1950 on average only forty-six percent of the United States' level of GDP per-capita. Subsequently their annual rates of growth of GDP per-capita were on average 1.25 percent faster than that of the United States. The corresponding figures for GDP per-worker were forty-five percent and 1.62 percent, respectively.

What happened to the real exchange rate of the OECD countries during the period 1950-90? Table 2 answers this question. The table is again divided into two parts. The first focuses on the behavior of the GDP deflator based real exchange rate series. This part of the table displays first the initial value of the real exchange rate. It then displays the trend change in the real exchange rate.[10] The table provides support for the second part of the convergence hypothesis: Eighteen out of twenty-two countries that were initially poorer and subsequently grew faster than the United States had in 1950 a depreciated real exchange rate and subsequently experienced a trend of real exchange rate appreciation. In 1950 the real exchange rate of the OECD countries was depreciated relative to the United States by forty-seven percent on average. Subsequently these

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[9] In 1950 New Zealand had the third highest relative GDP per-capita and the highest relative GDP per-worker in the sample. Thus its lack of convergence is not surprising.

[10] The trend variable is the slope coefficient from an ordinary least squares regression of the natural logarithm of the real exchange rate on a linear time trend and a constant.

countries experienced an annual rate of real exchange rate appreciation of 1.06 percent on average.

The second part of Table 2 focuses on the behavior of the consumer price index (CPI) based real exchange rate. Studying the behavior of CPI based real exchange rate series will serve to check the sensitivity of the results. The data used to construct the CPI based real exchange rate series come from the International Financial Statistics CD-ROM. The real exchange rate was obtained by multiplying the nominal exchange rate of the domestic currency against the United States dollar by the United States' CPI and then dividing by the domestic CPI.[11]

Table 2 clearly shows that the results obtained using the two sets of real exchange rate series are quite similar. For all countries the sign of the trend in two series is the same. Moreover, the magnitudes of the trends reported in the two parts of the table are similar. The simple correlation coefficient between the trend coefficients from the two sets of series is 0.95. It is therefore fair to conclude that the results exhibit very little sensitivity to the choice of deflator.

The next step in the analysis is to examine whether the OECD countries were converging to absolute PPP as implied by the analytical framework. Table 3 reports the results of ordinary least squares regressions of the natural logarithm of the real exchange rate (q) on the natural logarithm of relative GDP per-capita (y) and a constant for each country separately and then when all observations are pooled together. The first part of the table focuses on the slope coefficient, the second on the intercept. In sixteen out of

[11] The nominal exchange rate used here is the period average (AE line in the International Financial Statistics CD-ROM).

twenty-three cases the slope coefficient has the expected negative sign and is statistically significant. In only three cases there is a statistically significant positive slope coefficient. The four cases with a statistically insignificant slope coefficient are split evenly between negative and positive slopes.

The results reported in the second part of Table 3 allow testing the hypothesis of convergence to absolute PPP. Convergence to absolute PPP means that if a country's GDP per-capita were to be equal to that of the United States then its same currency prices should also equal those in the United States. This implies that in a regression of the natural logarithm of relative GDP per-capita on the natural logarithm of the real exchange rate and a constant the intercept coefficient should be zero. In nineteen cases there is a rejection of the hypothesis of convergence to absolute PPP. However, the average value of the intercept coefficient in the individual regressions is quite small: –0.12. This implies that full convergence in GDP per-capita leads on average to a twelve percent deviation from absolute PPP.

The results of the pooled regression on all 943 observations are reported in the bottom of Table 3. They are broadly similar to those presented above. The statistically very significant slope coefficient in the regression implies that an increase of one percent in relative GDP per-capita is associated with an appreciation of 0.39 percent in the real exchange rate. The intercept coefficient implies that in this sample complete convergence in GDP per-capita leads to only a six-percent deviation from absolute PPP.

Table 4 reports the results of ordinary least squares regressions of the natural logarithm of the real exchange rate (q) on the natural logarithm of relative GDP per-worker (y) and a constant for each country separately and then for the pooled data. These results are somewhat more favorable to the analytical framework's predictions than those reported in Table 4. In eighteen out of twenty-three cases the slope coefficient has the expected negative sign and is statistically significant. In three cases the slope coefficient is positive and statistically significant and in the other two cases the slope coefficient is positive but insignificant. The average deviation from absolute PPP implied by the intercept coefficients in the individual regressions is eleven percent. The results of the pooled regression are again similar to those reported in Table 3. The slope coefficient in the regression implies that an increase of one percent in relative GDP per-worker is associated with an appreciation of 0.36 percent in the real exchange rate; the implied deviation from absolute PPP is only four percents.

5. Conclusion

The Balassa-Samuelson model is considered the most important alternative to PPP as a model of long-run real exchange rate behavior. This article has essentially argued that these two models do not necessarily generate different predictions about real exchange rate behavior in the very long-run. The process of technological diffusion can lead to convergence in real exchange rates in the very long-run. Put differently, deviations from absolute PPP cannot be very large if technology tends to diffuse over time.

The empirical part of the paper has established that for twenty-four OECD countries in the period 1950-90 this was not just a theoretical possibility. Almost all of these countries grew faster than the United States and experienced real exchange rate appreciation, converging toward parity with the United States in both per-capita incomes and real exchange rates. Results from pooled regressions imply that an increase in relative GDP per-capita (per-worker) of one percent is associated with a real exchange rate appreciation of 0.39 (0.36) percent. The implied long-run deviations from absolute PPP estimated in these regressions are rather small, only six (four) percents.

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Table 1
The OECD Convergence Club, 1950-90

	Relative GDP Per-Capita				Relative GDP Per-Worker			
Country	Initial[1]	Trend[2]	t-Statistic[3]	Reject[4]	Initial[1]	Trend[2]	t-Statistic[3]	Reject[4]
Australia	0.76	0.32	7.22	***	0.78	0.41	9.71	***
Austria	0.33	1.76	15.72	***	0.29	2.48	18.56	***
Belgium	0.51	1.01	18.17	***	0.53	1.41	19.72	***
Canada	0.73	0.85	17.02	***	0.79	0.51	13.07	***
Denmark	0.60	0.78	10.61	***	0.53	0.84	11.51	***
Finland	0.40	1.56	24.41	***	0.34	1.91	28.75	***
France	0.46	1.30	15.52	***	0.43	1.81	19.85	***
Germany	0.39	1.32	10.28	***	0.36	1.96	16.12	***
Greece	0.16	2.45	17.09	***	0.17	3.21	22.47	***
Iceland	0.43	1.65	19.19	***	0.42	1.41	16.14	***
Ireland	0.31	1.21	22.75	***	0.31	2.04	27.36	***
Italy	0.31	1.89	19.54	***	0.31	2.66	26.19	***
Japan	0.16	3.92	22.10	***	0.13	4.15	32.57	***
Luxembourg	0.74	0.33	3.70	***	0.69	0.99	13.43	***
Netherlands	0.52	0.91	10.58	***	0.56	1.21	11.27	***
New Zealand	0.76	-0.22	-2.71	**	0.85	-0.16	-2.11	**
Norway	0.50	1.46	29.40	***	0.50	1.36	27.05	***
Portugal	0.14	2.48	22.96	***	0.14	2.63	23.33	***
Spain	0.22	1.93	12.81	***	0.24	2.73	18.07	***
Sweden	0.66	0.48	7.33	***	0.65	0.52	10.44	***
Switzerland	0.78	0.19	2.09	**	0.73	0.49	8.08	***
Turkey	0.12	0.84	9.04	***	0.09	2.12	20.45	***
United Kingdom	0.62	0.25	5.85	***	0.57	0.62	17.72	***
Average	0.46	1.25			0.45	1.62		

Source: Penn World Tables Mark 5.6 and author's calculations.

Notes:
1. Value of the variable in 1950.
2. (100x) Slope coefficient from an OLS regression of the natural logarithm of the variable on a constant and a linear time trend.
3. Value of the t-statistic for the slope coefficient in the regression.
4. Rejection at the 10% (*), 5% (**), 1% (***) levels of significance in a two sided t-test.

Table 2
Real Exchange Rate Behavior in the OECD, 1950-90

	GDP Deflator Based Real Exchange Rate				Consumer Price Index Based Real Exchange Rate		
Country	Initial[1]	Trend[2]	t-Statistic[3]	Reject[4]	Trend[2]	t-Statistic[3]	Reject[4]
Australia	1.57	-1.16	-7.02	***	-0.75	-4.71	***
Austria	1.65	-1.86	-10.06	***	-1.80	-8.69	***
Belgium	1.27	-0.95	-4.38	***	-0.95	-4.17	***
Canada	1.03	0.28	3.19	***	0.34	4.46	***
Denmark	1.56	-2.13	-10.27	***	-2.03	-10.01	***
Finland	1.21	-1.10	-6.11	***	-0.81	-4.25	***
France	1.26	-0.65	-3.77	***	-0.53	-2.75	***
Germany	1.42	-1.65	-8.56	***	-1.37	-6.53	***
Greece	0.98	0.38	2.04	**	0.47	2.32	**
Iceland	0.73	0.42	1.57		1.23	3.76	***
Ireland	1.68	-1.26	-10.17	***	-1.26	-9.69	***
Italy	1.64	-1.32	-10.05	***	-0.85	-5.42	***
Japan	2.28	-2.97	-19.98	***	-3.49	-19.81	***
Luxembourg	1.39	-1.20	-5.95	***	-0.53	-2.42	**
Netherlands	1.88	-2.17	-10.07	***	-2.10	-9.36	***
New Zealand	1.43	-0.30	-2.12	**	-0.55	-3.20	***
Norway	1.43	-1.83	-10.98	***	-1.94	-11.23	***
Portugal	1.68	-0.26	-1.49		-1.20	-5.77	***
Spain	1.82	-1.40	-6.11	***	-1.80	-8.18	***
Sweden	1.40	-1.43	-7.85	***	-1.09	-5.23	***
Switzerland	1.52	-2.59	-12.49	***	-2.26	-9.71	***
Turkey[5]	1.45	1.68	5.17	***	2.92	8.74	***
United Kingdom	1.56	-0.96	-7.17	***	-0.86	-5.51	***
Average	1.47	-1.06			-0.92		

Source: Penn World Tables Mark 5.6, International Financial Statistics CD-ROM and author's calculations.

Notes:
1. Value of the variable in 1950.
2. (100x) Slope coefficient from an OLS regression of the natural logarithm of the variable on a constant and a linear time trend.
3. Value of the t-statistic for the slope coefficient in the regression.
4. Rejection at the 10% (*), 5% (**), 1% (***) levels of significance in a two sided t-test. Turkish consumer price index is unavailable for 1950-2.
5. Turkish consumer price index is unavailable for 1950-2.

Table 3

Relationship between Real Exchange Rate and Relative GDP Per-Capita

$$q_t = \alpha + \beta y_t + \varepsilon_t$$

Country	β	t-Statistic	Reject[1]	α	t-Statistic	Reject[1]
Australia	-2.16	-4.53	***	-0.36	-3.07	***
Austria	-0.87	-7.00	***	-0.31	-3.96	***
Belgium	-1.01	-5.38	***	-0.39	-4.21	***
Canada	0.28	2.76	***	0.01	0.50	
Denmark	-1.94	-6.17	***	-0.62	-5.29	***
Finland	-0.62	-5.06	***	-0.31	-4.52	***
France	-0.40	-3.17	***	-0.13	-2.18	**
Germany	-0.89	-5.78	***	-0.27	-3.95	***
Greece	0.11	1.47		0.40	4.19	***
Iceland	0.11	0.68		-0.23	-2.53	**
Ireland	-1.00	-9.76	***	-0.71	-7.12	***
Italy	-0.61	-7.74	***	-0.11	-2.10	**
Japan	-0.69	-13.39	***	-0.33	-6.71	***
Luxembourg	-0.50	-1.19		0.01	0.05	
Netherlands	-2.05	-9.88	***	-0.68	-7.22	***
New Zealand	0.66	2.52	**	0.51	5.77	**
Norway	-1.18	-9.41	***	-0.54	-9.35	***
Portugal	-0.16	-2.46	**	0.37	3.91	**
Spain	-0.52	-4.23	***	-0.01	-0.12	
Sweden	-1.86	-5.28	***	-0.50	-5.45	***
Switzerland	-0.35	-0.45		0.08	0.87	
Turkey	0.83	2.10	**	2.07	3.00	**
United Kingdom	-2.00	-4.46	***	-0.58	-3.14	***
Average	-0.73			-0.12		
Pooled	-0.39	-22.04	***	-0.06	-4.60	***

Source: Penn World Tables Mark 5.6 and author's calculations.

Notes: 1. Rejection at the 10% (*), 5% (**), 1% (***) levels of significance in a two sided t-test.

Table 4
Relationship between Real Exchange Rate and Relative GDP Per-Worker

$$q_t = \alpha + \beta y_t + \varepsilon_t$$

Country	β	t-Statistic	Reject[1]	α	t-Statistic	Reject[1]
Australia	-2.17	-5.80	***	-0.32	-3.72	***
Austria	-0.66	-8.06	***	-0.22	-3.70	***
Belgium	-0.74	-5.60	***	-0.18	-3.30	***
Canada	0.39	2.40	**	0.02	0.72	
Denmark	-1.91	-6.71	***	-0.83	-5.99	***
Finland	-0.53	-5.38	***	-0.31	-4.79	***
France	-0.33	-3.58	***	-0.09	-2.11	**
Germany	-0.78	-8.36	***	-0.25	-5.29	***
Greece	0.08	1.37		0.35	5.07	***
Iceland	0.13	0.72		-0.22	-1.98	*
Ireland	-0.60	-10.16	***	-0.25	-4.87	***
Italy	-0.45	-8.33	***	0.03	0.88	
Japan	-0.69	-16.26	***	-0.54	-10.34	***
Luxembourg	-0.94	-4.54	***	-0.06	-1.13	
Netherlands	-1.59	-10.75	***	-0.23	-4.76	***
New Zealand	0.60	2.15	**	0.43	6.40	***
Norway	-1.24	-9.26	***	-0.55	-9.23	***
Portugal	-0.15	-2.44	**	0.39	4.65	***
Spain	-0.45	-5.27	***	0.14	2.10	**
Sweden	-2.11	-6.01	***	-0.69	-6.19	***
Switzerland	-2.95	-5.03	***	-0.38	-3.56	***
Turkey	0.58	3.52	***	1.68	5.55	***
United Kingdom	-1.49	-7.45	***	-0.46	-4.86	***
Average	-0.78			-0.11		
Pooled	-0.36	-20.75	***	-0.04	-2.87	***

Source: Penn World Tables Mark 5.6 and author's calculations.
Notes: 1. Rejection at the 10% (*), 5% (**), 1% (***) levels of significance in a two sided t-test.

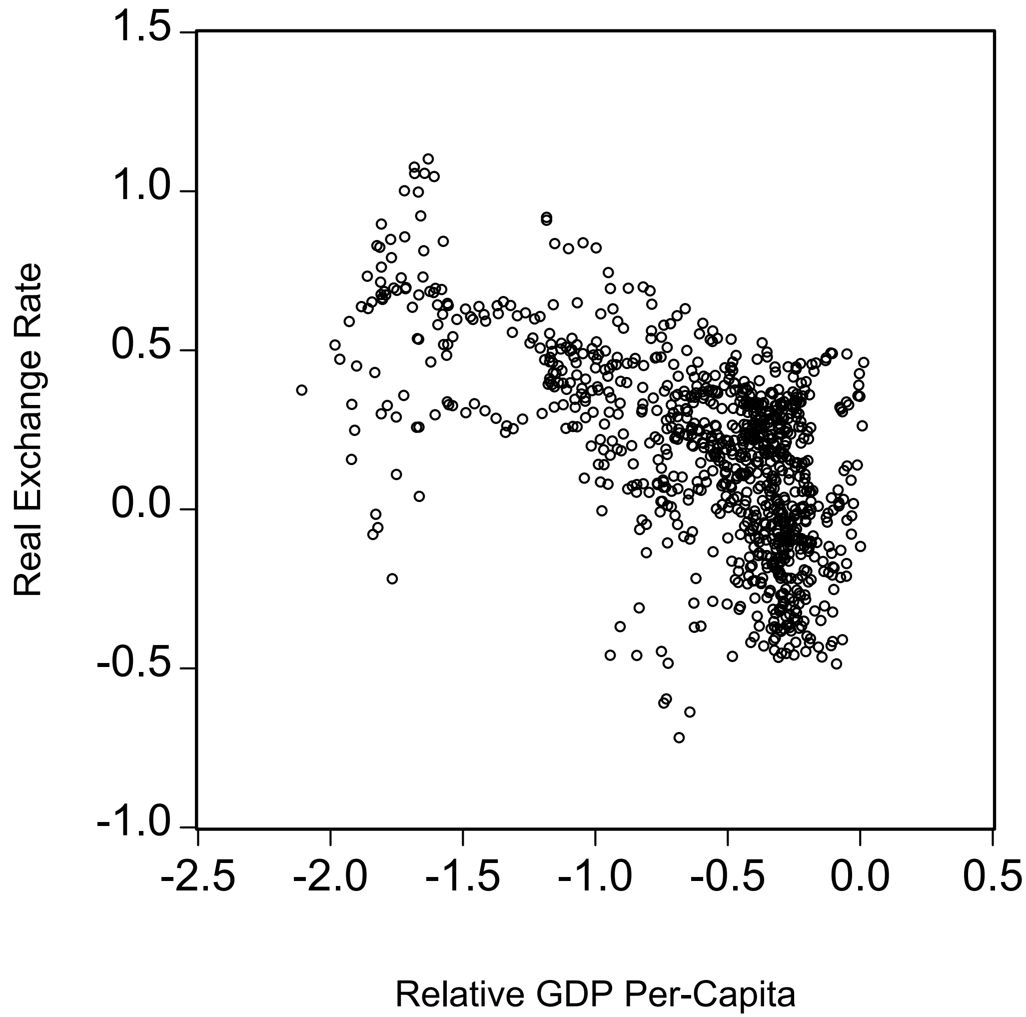

Figure 1
Relative GDP Per-Capita and Real Exchange Rate, OECD 1950-90

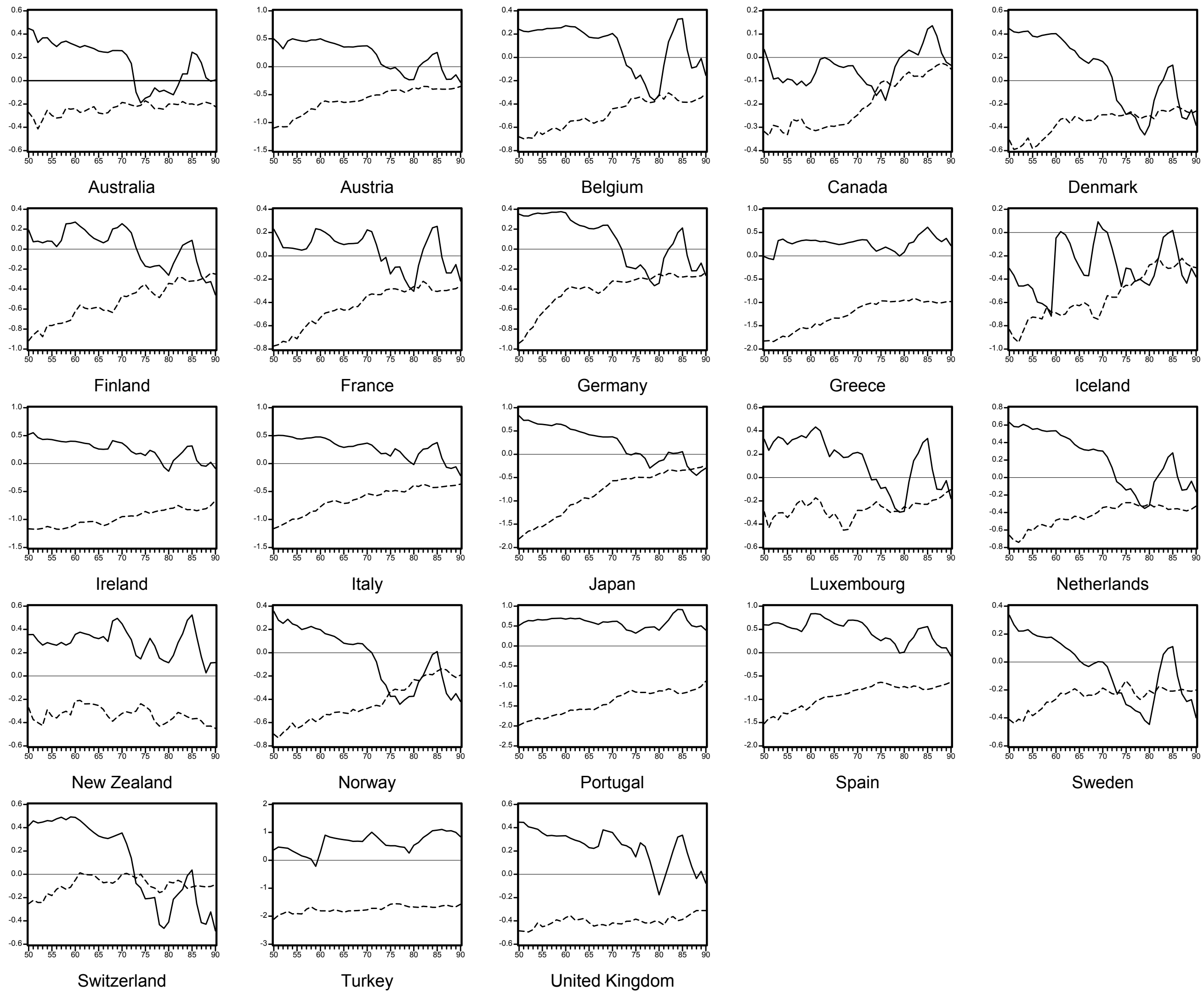

Figure 2
Relative GDP Per-Capita (dashed line) and Real Exchange Rate (solid line), OECD 1950-90