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Analysis of the Relative Price of Nontradable Goods in the G7 Countries

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Abstract

To analyze the relative price of nontradable to tradable goods, we build a two-country, two-sector dynamic open macro model that in based on consumers' intertemporal optimizing behavior. The model predicts that the relative price of nontradable goods depends on the cross-sectoral productivity differential, the cumulative current account imbalance, and fiscal expenditure on nontradable goods. Our empirical results using the G7 countries' annual data over the period 1970-1999 support our theoretical predictions. Especially, in Japan, the recent higher relative prices of nontradable goods are explained by sectoral productivity differentials as well as the cumulative current account and the degree of market openness.

Key words : real exchange rate, relative price of nontradable goods, sectoral productivity differential, Balassa-Samuelson hypothesis.

JEL classification : E31, F41

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1 Introduction

The real exchange rate–defined as the nominal exchange rate adjusted for relative national price levels–is one of the most important economic variables for an economy. It measures the degree of deviations from purchasing power parity (PPP) as well as the country's international price competitiveness. The Japanese yen has experienced considerable currency appreciation in both nominal and real terms since the beginning of the generalized floating system in the early 1970s. Indeed the real value of the yen has been overvalued over the past 15 years relative to the norm of the OECD countries.

Persistent currency overvaluation in real terms can be a concern for policymakers. When it reflects a lack of the country's economic integration with the rest of the world – perhaps due to various barriers and other regulatory measures that prohibit competition through import of foreign products or through entry of domestic and foreign firms into the domestic market – the resulting resource allocation is inefficient, and the loss of economic welfare, measured by lost outputs, can be large. Persistent currency overvaluation can also affect patterns of international trade and create trade imbalances through reduced international price competitiveness.

An enormous literature provides some stylized facts about real exchanger rates. First, the real exchange rate has no definitive statistical property; that is, it is either stationary or non-stationary depending on the specific conditions of the country and the specific time periods chosen. Second, when the real exchange rate is stationary and, hence, PPP tends to hold in the long run, the speed of convergence to PPP is often very slow. Third, when the real exchange rate is non-stationary and the long-run convergence to PPP is not observed, the deviation from PPP can often be explained by economic fundamentals, particularly the Balassa-Samuelson factor; that is, cross-country differentials in productivity levels or in cross-sectoral productivity differentials between tradable and nontradable goods sectors within a country.

The Japanese yen's real overvaluation over the past 15 years means that the Japanese price level has been higher than foreign price levels, adjusted for exchange rates. If the yen's overvaluation does not reflect economic fundamentals, a natural adjustment process toward PPP should set in to correct the relatively high price levels in Japan. This process can take the form of either price adjustments, such as price deflation in Japan and foreign inflation, or nominal yen depreciation. The yen's real overvaluation therefore poses two questions. One is whether it is a natural result of economic fundamentals such as cross-country productivity differentials, cross-sectoral productivity differentials, and other pertinent factors. The other is whether effective policy measures exist to correct the relatively high price levels in Japan, or real overvaluation of the yen, without exacerbating the current price deflationary pressure.

The organization of the paper is as follows. Section 2 overviews data, focusing on movements in real exchange rates, the relative price of nontradable to tradable goods, and the cross-sectoral productivity differentials for the G7 countries. Section 3 develops a two-country, two-sector model with intertemporal optimizing consumers, and identifies the theoretical determinants of the relative price of nontradable to tradable goods, an important component of the real exchange rate. The model predicts that the relative price of nontradable goods depends on the cross-sectoral productivity differential, the cumulative current account imbalance, and fiscal spending on nontradable goods. Section 4 empirically tests the theoretical prediction, concerning the determinants of the relative price of nontradable goods by using annual data from national accounts for the G7 countries. Section 5 provides concluding remarks.

2 Overview of Data

International Comparison of Relative Prices. Chart 1 depicts the relationship between per capita GDP and relative price levels for the OECD countries. The horizontal axis indicates per capita GDP expressed at PPP rates, which is standardized by setting the United States' per capita GDP equal to one. The vertical axis indicates the relative price level - the price of all goods and services covered by GDP at home relative to that of the rest of the world, adjusted for the nominal exchange rate, which is also standardized by setting the United States' relative price level equal to one.[1] The chart suggests that for OECD countries there is a positive relationship between per capita GDP and the

[1] These variables are defined by the OECD.

relative price level. If we assume that per capita GDP is a proxy for the country's productivity level, then Chart 1 appears consistent with the Balassa-Samuelson hypothesis for the OECD countries.[2]

Chart 1 indicates that Japan's observation points tend to be above the fitted line relating relative price to per capita GDP for G7 or OECD countries. This means that Japan's relative prices tend to be higher on the average than those in the G7 or other OECD countries for the same per capita GDP level. The chart also indicates that the slope of the fitted line for Japan over the period 1970 to 2001 is steeper than that for the G7 countries, which in turn is steeper than for the OECD countries in general. This means that the response of relative price to per capita GDP in Japan is greater than those in G7 countries and, hence, in OECD countries. One of the questions is why Japan has had persistently high relative price levels among the G7 and, more generally, the OECD countries, beyond what might be explained by the Balassa-Samuelson hypothesis. The other question is why Japan has had a greater response of the relative price to per capita GDP than other G7 and OECD countries.

Real Exchange Rate. Chart 2 depicts movements of the real exchange rates of the G7 currencies vis-*à*-vis the U.S. dollar, expressed in natural logarithms, over the period 1970-1999. The real exchange rate for each country, q, is defined in terms of GDP deflators:

$$q = s + p^* - p, \tag{1}$$

where

s : nominal exchange rate vis-*à*-vis the U.S. dollar,

p, p^* : GDP price deflator in each country and in the United States (a variable with an asterisk is that for the United States).

This chart indicates that the yen's real exchange rate has appreciated the most among the G7

[2] One of the implications of the Balassa-Samuelson hypothesis is that a country with high productivity in the tradable goods sector – relative to the country's nontradable goods sector, or relative to the foreign country's productivity in the tradable goods sector – tends to have a relatively high price level. We will discuss the Balassa-Samuelson hypothesis in more detail below. See Bergstrand (1991) for empirical studies on this type of approach. See Ito (1997), Kawai and Ohara (1997), Ito et al. (1999), and Motonishi (2002) for empirical studies on the Balassa-Samuelson hypothesis using data from Japan and other G7 countries.

countries over the past 30 years. The European currencies, particularly the German mark, the French franc and, to some extent the Italian lire, have moved closely with each other over time. The Canadian dollar is the only currency that has depreciated in real terms vis-à-vis the U.S. dollar.

Assuming that the GDP deflator consists of tradable and nontradable goods prices, it can be written as:

$$p = (1-\gamma)p_T + \gamma \cdot p_N,$$
$$p^* = (1-\gamma^*)p_T^* + \gamma \cdot p_N^*,$$

where γ and γ^* are the weights on nontradable goods prices in the GDP deflators at home and in the United States, respectively. Then, the real exchange rate can be further expressed as:

$$q = (s + p_T^* - p_T) - \gamma(p_N - p_T) + \gamma * (p_N^* - p_T^*). \tag{2}$$

This expression states that the real exchange rate for a country (q) can be decomposed into two factors: the inverse of the terms of trade ($s + p_T^* - p_T$) and the relative price of nontradable to tradable goods at home ($p_N - p_T$) and in the United States ($p_N^* - p_T^*$).

Terms of Trade and Relative Price of Nontradable Goods. Chart 3 plots the inverse of the terms of trade for the G7 countries vis-à-vis the United States in logarithmic form ($s + p_T^* - p_T$) for the period, 1970-1999. The variable is normalized at zero in 1970; that is, its non-logarithmic value is set equal to unity in 1970. The chart indicates the presence of substantial cycles in the terms of trade associated with nominal exchange rate changes. Over the thirty years period, the terms of trade have improved the most for Japan, and more recently for the United Kingdom, while the terms of trade for Italy and Canada have deteriorated the most. The terms of trade for Germany and France have moved in a parallel fashion.

Chart 4 plots the relative price of nontradable to tradable goods for the G7 countries in logarithmic form ($p_N - p_T$) over the period 1970-1999.[3] The chart shows that relative prices of nontradable goods

[3] See Appendix A for our definition of tradable and nontradable goods. Our definition is the same as those of earlier papers, such as Canzoneri, Cumby and Diba (1999).

have risen in all countries, except in Canada, over the past 30 years. Particularly noteworthy is the rapid increase in Italy and Japan, while the United States also saw a relatively high growth in the relative price of nontradable goods.

Sectoral Productivity Differential. Chart 5 plots the sectoral productivity differential for the G7 countries in logarithmic form $(a_T - a_N)$ over the period 1970-1999. The variable is also normalized at zero in 1970, that is, its non-logarithmic value is set equal to unity in 1970. Here, productivity is measured by total factor productivity (TFP). In particular, the sectoral productivity differential is defined as the ratio of tradable goods sector TFP to nontradable goods sector TFP.[4] According to the Balassa-Samuelson hypothesis,[5] this differential should explain the relative price of nontradable goods and, hence, the real exchange rate.

The chart demonstrates that the sectoral productivity differential grew relatively fast in Japan and Italy, which may partly explain the rapid increase in their relative price of nontradable goods. The sectoral productivity differential in the United States, Canada, and the United Kingdom declined relatively sharply in the first half of the 1980s but bounced back in the latter half of the 1980s and in the 1990s.

Chart 6 plots the relative price of nontradable goods in the vertical axis and the sectoral productivity differential in the horizontal axis, both in logarithmic form, for the G7 countries for the period, 1970-99. The chart suggests the presence of a positive correlation between the relative price of nontradable goods and the sectoral productivity differential, which generally supports the Balassa-Samuelson hypothesis. The chart also shows that the slope of the fitted line for Japan relating the two variables is steeper than the average slope for the G7 countries. This suggests that as the sectoral productivity differential widens, the relative price of nontradable goods tends to rise faster in Japan than the average for the G7 countries.

[4]TFP is calculated by the same growth accounting method as adopted by OECD Inter Sectoral Data Base (ISDB), using data from ISDB for the tradable and nontradable goods sectors.

[5]The Balassa-Samuelson hypothesis claims that, holding other factors constant, an increase in the sectoral productivity differential causes the relative price of nontradable goods to rise.

3 The Two-Country, Two-Sector Model with Optimizing Consumers

In this section, we develop a two-country, two-sector model of intertemporally optimizing consumers to obtain the relative price of nontradable goods as a function of the sectoral productivity differential. In addition we also consider the impact of the cumulative current account and the government expenditure on nontradable goods on the relative price of nontradable goods. The model is an extension of those of Froot and Rogoff (1991), Rogoff (1992), and Obstfeld and Rogoff (1996), with modifications tailored to our specific purpose.

3.1 Effects of Productivity Growth

First, we develop the optimization problem of the representative consumer who maximizes the discounted sum of utility defined over the consumption of tradable and nontradable goods subject to her intertemporal budget constraint. Outputs of tradable and nontradable goods are subject to productivity shocks. The representative consumer in the home country solves the following maximization problem:

$$\max_{\{c_{Tt}, c_{Nt}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \delta^t u(c_{Tt}, c_{Nt}), \tag{3}$$

subject to

$$\sum_{t=0}^{\infty} d_t(p_{Tt}c_{Tt} + p_{Nt}c_{Nt}) = \sum_{t=0}^{\infty} d_t[p_{Tt}Q_T + p_{Nt}(Q_N - G_{Nt})] + B_0 \equiv W_0, \tag{4}$$

and

$$\begin{aligned} Q_{Tt} &= A_{Tt}F^T(L_{Tt}, \bar{K}_T), & (5)\\ Q_{Nt} &= A_{Nt}F^N(L_{Nt}, \bar{K}_N), & (6)\\ \bar{L} &= L_{Tt} + L_{Nt}, & (7) \end{aligned}$$

where

c_{Tt}, c_{Nt} : consumption of tradable and nontradable goods at t,

δ : discount factor $1/(1+\rho)$ where ρ is the rate of time preference,

p_{Tt}, p_{Nt} : price of tradable and nontradable goods in the home country,

d_t : discount factor $1/(1+r)^t$,where r is the interest rate,

Q_{Tt}, Q_{Nt} : output of tradable and nontradable goods in the home country,

G_{Nt} : government expenditure on nontradable goods at t,

W_0, B_0 : initial net wealth and initial net external asset in the home country,

A_{Tt}, A_{Nt} : productivity shocks affecting the outputs of tradable and nontradable goods, respectively.

Variables with superscripts $(*)$ indicate foreign country variables, and variables without superscripts $(*)$ indicate home country variables. We assume that government expenditure is financed by a lump sum tax. Furthermore, for simplicity, we assume that in producing tradable and nontradable goods, capital stock in each sector is given while labor can move freely between sectors.

We also assume that the representative consumer in the foreign country solves a similar optimization problem, while allowing the parameters of the utility function and time preference to differ between countries. Because the consumer faces no liquidity constraint, we only have to consider the solvency condition. The initial net wealth position at time 0 is the sum of the discounted present value of output and the initial level of external asset.

Assuming that the consumer's utility function is of a Cobb-Douglas type, i.e.

$$u(c_T, c_N) = c_T^{\alpha_T} c_N^{\alpha_N}, \tag{8}$$

the consumer's total expenditure $Z_t \equiv p_{Tt}c_{Tt} + p_{Nt}c_{Nt}$ at time t turns out to be proportional to the initial level of net wealth:

$$Z_t = (1-\delta)\frac{\delta^t}{d_t}W_0, \tag{9}$$

and consumption demand for tradable and nontradable goods at t are given by

$$c_{Tt} = \alpha_T Z_t / p_T, \tag{10}$$

$$c_{Nt} = \alpha_N Z_t / p_N. \tag{11}$$

In the absence of government spending, the relative price of nontradable goods vis-à-vis tradable goods can be expressed in the following way:

$$\frac{p_{Nt}}{p_{Tt}} = \frac{\alpha_N c_{Tt}}{\alpha_T c_{Nt}} = \frac{A_{Tt} F^T_{L_T}}{A_{Nt} F^N_{L_N}} \tag{12}$$

where $A_{Tt} F^T_{L_T}$ and $A_{Nt} F^N_{L_N}$ are the marginal product of labor in the tradable and nontradable goods sectors, respectively.

Equation (12) indicates that the relative price of nontradable to tradable goods is equal to the marginal rate of consumption substitution between the two goods, which is also equal to the marginal rate of output substitution. Thus, an increase in the sectoral productivity differential between the tradable and nontradable goods sectors leads to an increase in the relative price of nontradable goods.

3.2 Equilibrium Dynamic Path

Based on Helpman and Razin (1982), we can derive the equilibrium dynamic path of the relative price of nontradable goods, and analyze the effects of the cumulative current account on the relative price.

In this exercise, for simplicity, we assume that output is given. The equilibrium conditions for the world tradable goods market and for the nontradable goods markets at home and abroad at time t can be expressed as follows:

$$Q_{Tt} + Q^*_{Tt} = c_{Tt} + c^*_{Tt}, \tag{13}$$

$$Q_{Nt} - G_{Nt} = c_{Nt}, \tag{14}$$

$$Q^*_{Nt} - G^*_{Nt} = c^*_{Nt}. \tag{15}$$

The equilibrium dynamic path of the relative price of nontradable goods can be obtained from these market-clearing conditions. Thus, given the initial level of wealth W_0, equations (9), (10), (11), (13) and (14), yield the equilibrium relative price of nontradable goods in the home country at t as:

$$\frac{p_{Nt}}{p_{Tt}} = \frac{Q_{Tt} + Q^*_{Tt}}{Q_{Nt} - G_{Nt}} \frac{\alpha_N Z_t}{\alpha_T Z_t + \alpha^*_T Z^*_t}, \tag{16}$$

$$= \frac{Q_{Tt} + Q^*_{Tt}}{Q_{Nt} - G_{Nt}} \frac{\alpha_N (1-\delta)\delta^t W_0}{\alpha_T (1-\delta)\delta^t W_0 + \alpha^*_T (1-\delta^*)\delta^{*t} W^*_0}. \tag{17}$$

Effects of the cumulative current account. Let us express disposable income of the home country at t, Y_t, as

$$Y_t \equiv p_{Tt}Q_{Tt} + p_{Nt}(Q_{Nt} - G_{Nt}). \tag{18}$$

Then, we can rewrite the initial levels of home and foreign wealth, W_0 and W_0^*, as

$$W_0 \equiv \sum_{t=0}^{\infty} d_t Y_t + B_0, \tag{19}$$

$$W_0^* \equiv \sum_{t=0}^{\infty} d_t Y_t^* - B_0. \tag{20}$$

Substituting (18), (19) and (20) into (17), we obtain

$$\frac{p_{Nt}}{p_{Tt}} = \frac{Q_{Tt} + Q_{Tt}^*}{Q_{Nt} - G_{Nt}} \frac{\alpha_N(1-\delta)\delta^t(\sum_{t=0}^{\infty} d_t Y_t + B_0)}{\alpha_T(1-\delta)\delta^t(\sum_{t=0}^{\infty} d_t Y_t + B_0) + \alpha_T^*(1-\delta^*)\delta^{*t}(\sum_{t=0}^{\infty} d_t Y_t^* - B_0)}. \tag{21}$$

The effect of an increase in the initial level of the home country's net external asset B_0 – or the cumulative current account – on the relative price of nontradable goods, that is, $\partial\left(\frac{p_{Nt}}{p_{Tt}}\right)/\partial B_0$, can be given by:

$$\frac{\partial(p_{Nt}/p_{Tt})}{\partial B_0} = \frac{\alpha_N(1-\delta)\delta^t[\alpha_T^*(1-\delta^*)\delta^{*t}W_0^* + \alpha_T(1-\delta)\delta^t W_0]}{[\alpha_T^*(1-\delta^*)\delta^{*t}W_0^* + \alpha_T(1-\delta)\delta^t W_0]^2} > 0. \tag{22}$$

This means that an increase in the home country's net external asset position – or the cumulative current account – in the initial period raises the relative prices of nontradable goods in the initial and subsequent periods.

We can intuitively explain this analytical result: An increase in the initial net external asset position raises net wealth of the home country consumer and, hence, leads to higher consumption demand for both tradable and nontradable goods in the initial and subsequent periods. Higher demand for tradable goods is matched by increased imports, or decreased exports, of tradable goods, while higher demand for nontradable goods is accompanied by higher relative prices of nontradable goods because consumption of nontradable goods is kept constant at a given level of output.[6]

[6]The theoretical prediction that a higher level of the cumulative current account leads to a higher relative price of nontradable goods, thereby causing real currency appreciation is consistent with the alternative approach of explaining the impact of a rising or declining cumulative current account on the real exchange rate through changes in risk premium.

Effects of government spending. We next consider the effects of an increase in the government expenditure on nontradable goods at time t, financed by an increase in the lump sum tax, on the relative price of nontradable goods.[7] From Equation (17) and the definitions of initial wealth for both countries, W_0 and W_0^*, an increase in the government expenditure on nontradable goods would raise its relative price at a given output level of nontradable goods.

4 Empirical Analysis

As mentioned in Section 2, the Balassa-Samuelson hypothesis, which attributes real exchange rate movements to the productivity growth differential between the tradable and nontradable goods sectors, can be divided into the following two components:

- Real exchange rate movements can be explained by changes in the terms of trade and in the relative prices of nontradable to tradable goods at home and abroad.
- The relative price of nontradable goods in each country can be explained by the productivity differential between the tradable and nontradable goods sectors.

While the first component is rather definitional, the second component is the core of the Balassa-Samuelson hypothesis. In this section, we empirically investigate these two components in turn.[8]

4.1 Long-run Stable Relationships: Cointegration Tests

First, we examine whether a long-run stable relationship exists among the variables listed in each component above. The presence of a long-run stable relationship in each component supports the Balassa-Samuelson hypothesis. The presence or absence of such a relationship can be tested by conducting cointegration tests.

[7] Inclusion of the analysis of government expenditure on nontradable goods is based on Rogoff (1992).

[8] In this paper, we do not analyze the determinants of the terms of trade, that is, causes for departures from PPP for tradable goods. See Engel and Rogers (1996), Canzoneri et al. (1999) for empirical studies of PPP for tradable goods. See Engel (1999) for factors that determine changes in real exchange rates.

Real exchange rate, the terms of trade, and relative prices of nontradable goods. Based on Equation (2), we conduct cointegration tests over the real exchange rate, the terms of trade, and the relative prices of nontradable to tradable goods at home and abroad. Equation (2) should represent a stable relationship empirically as long as the shares of the two goods in the GDP price deflator are stable over time, because then this relationship is nothing but a definition. In reality these shares are not stable over time. Here, we test the long-run stability of this relationship by conducting a cointegration analysis over the four variables, q, $s + p_T^* - p_T$, $p_N - p_T$ and $p_N^* - p_T^*$.

The first usual test is a unit root test that is always necessary to conduct a cointegration test. The results of unit root tests for individual country data (Table 1) support the requirement for cointegration analysis; that is, all the relevant variables have unit roots. The same requirement for G7 panel data is also satisfied (Table 3).[9]

Next, we conduct cointegration tests for both individual country data and panel data. The traditional cointegration test using individual country data tends to have the problem of low power. That is, since the distribution under the null hypothesis tends to have a large variance, it is not easy to detect a long-run stable relationship, especially in small sample estimation, even when the underlying relationship is in fact stable. Panel cointegration tests are developed to overcome this problem. Here we adopt "heterogeneous" panel cointegration test procedures, developed by Pedroni (1999), which allow heterogeneous cointegration coefficients across the G7 countries.[10]

The results for individual country data (Table 2) show no evidence of a cointegration relationship among the real exchange rate (vis-à-vis the U.S. dollar), the terms of trade (vis-à-vis the United States), and the relative prices of nontradable goods at home and abroad (the United States). However, the results for G7 panel data (in Table 4) indicate that there is evidence for a cointegrating relationship for panel data.[11] This lends support to the proposition that a long-run stable relationship exists among

[9] Unit root tests for panel data have greater power than the usual unit root tests.

[10] We have conducted heterogeneous cointegration tests for panel data by using the Chiang and Kao (2001) procedure.

[11] We can also detect similar cointegrating relationships in panel data when the reference country is a non-US country, such as Japan and Germany.

the real exchange rate, the terms of trade, the home relative price of nontradable good, and the foreign relative price of nontradable goods.

Relative price of nontradable goods and the sectoral productivity differential. We next examine the second component of the Balassa-Samuelson hypothesis by conducting cointegration tests over the relative price of nontradable to tradable goods and the sectoral productivity differential between the two sectors in each country.

The results of cointegration tests for individual country data are summarized in Table 5, which contains three subsets of tables. Table 5.(1) considers two variables, i.e., the relative price of nontradable goods ($p_N - p_T$) and the sectoral productivity differential ($a_T - a_N$). In addition to these two variables, Table 5.(2) considers the share of government expenditure in GDP ($g - y$). Table 5.(3) further adds the cumulative current account (cca) and the stock of inward foreign direct investment (fdi), both as a ratio of GDP. Following the theoretical results in Section 3, the government expenditure and the cumulative current account are expected to have a positive correlation with the relative price of nontradable goods, while inward foreign direct investment, used as a proxy for market openness, is expected to have a negative correlation with the relative price of nontradable goods.[12] The results indicate no evidence of cointegrating relationships as far as individual country data are concerned.

However, the results of cointegration tests for panel data indicate evidence of cointegrating relations among the variables considered (Table 6). More specifically, Table 6.(1) supports the presence of cointegration among the relative price of nontradable goods, the sectoral productivity differential, and the government expenditure. Finally, Table 6.(2) also finds evidence of cointegration among these variables, the cumulative current account and inward foreign direct investment – as a proxy for market openness.

[12] See Coppel and Durand (1999) and Lane et al. (2001) for previous studies using inward foreign direct investment as a proxy indicating market openness or regulatory tightness in the home market. In addition to measures that restrict market openness, a web of regulatory measures applied to the nontradable goods sector may have negative impact on the sector's productivity. But because of the difficulty of identifying proxy variables that represent such regulatory measures, we have decided to focus only on market openness.

4.2 Empirical Tests on the Determinants of the Relative Price of Nontradable Goods

In this subsection, we focus on the core component of the Balassa-Samuelson hypothesis. That is, we examine the determinants of the relative price of nontradable goods by using error-correction regression analyses. We attempt to explain the relative price of nontradable goods by the error correction term, the sectoral productivity differential, and other relevant variables such as the government expenditure, the cumulative current account, and a market openness proxy. The error correction term confirms or rejects the presence of a long-run, stable relationship among the variables considered. In our estimation, we have adopted an autoregressive distributed lag (hereafter ADL) model, which is a relatively general time series model.[13] Based on the results of ADL estimation, we can confirm the size and significance of both the short-run and long-run effects of the explanatory variables on the relative price of nontradable goods.[14]

Effects of the sectoral productivity differential and government expenditure. Estimation results for individual G7 countries are reported in Table 7, and the estimated coefficients of error correction terms and the long-run coefficients are summarized in Table 8.[15] The results reported in Table 7 generally support our theoretical prediction that the coefficients of the sectoral productivity differential and government expenditures are both expected to be positive. Some exceptions are observed with regard to the sign of government expenditures for Canada, Germany, and the United States.

The long-run coefficients of the sectoral productivity differential, summarized in Table 8, are all positive and statistically significant, except for France and the United States. The coefficients for Italy, Germany, and Japan are relatively large. The long-run coefficients of government expenditures

[13] A typical autoregressive distributed lag model is given by $y_t = \alpha + b(L)y_t + c(L)x_t + \epsilon_t$.

See Hendry, Pagan, and Sagan (1984) for ADL approaches.

[14] See Pesaran and Smith(1999) for our empirical strategy.

[15] See the Appendix B for an explanation of the estimation method adopted and the calculation of long-run coefficients.

are positive and statistically significant for France and Italy, though the coefficients for Canada and Germany are negative (but not statistically significant for Germany). The coefficient of error correction terms, ϕ, is required to be $-1 < \phi < 0$ for the presence of a long-run stable relationship. The estimated coefficient for each G7 country, except the United States, is between -1 and 0, and statistically significant, while the coefficient for the United States is positive (but statistically insignificant).

We have also conducted a likelihood ratio test, with the null hypothesis that the long-run coefficients of the sectoral productivity differential are identical across the G7 countries. The test statistic, summarized in Table 8, indicates rejection of the null hypothesis. Thus, the sectoral productivity differential affects the relative price of nontradable goods differently across the G7 countries.

Effects of the cumulative current account and market openness. Next, we analyze the effects of two additional independent variables on the relative price of nontradable goods: the cumulative current account and the stock of inward foreign direct investment as a proxy for market openness. The coefficient of the cumulative current account is expected to be positive, and the coefficient of market openness is expected to be negative. Table 9 reports the estimation results for individual G7 countries, and Table 10 presents a summary of the estimated coefficients of error correction terms and the long-run coefficients of the explanatory variables included in the equation.

Table 9 largely confirms the theoretical predictions with regard to the signs of the estimated coefficients. Some exceptions are found for the signs of the coefficients on the sectoral productivity differential for France and the United States, the government expenditures for Germany, the United Kingdom, and the United States, the cumulative current account for the United Kingdom and the United States, and the openness proxy for the United States.

Table 10 shows that the long-run coefficients of the sectoral productivity differential are positive and statistically significant for Canada, Italy, Japan, Germany, and the United Kingdom. The coefficient is positive but not statistically significant for the United States, while it is negative for France (but not statistically significant). The long-run coefficients of the cumulative current account are positive for all G7 countries except the United Kingdom, and statistically significant for Canada, Japan, and

Germany. The estimated coefficients of the error correction terms are between -1 and 0 for all G7 countries, except the United Kingdom and the United States, as required for the presence of a long-run stable relationship. Though the estimated coefficients for the United States are positive, it is statistically insignificant. The likelihood ratio test of the null hypothesis that the long-run coefficients of the sectoral productivity differential are identical across the G7 countries yields rejection of the null. Hence a significant difference exists in the estimated coefficients across the G7 countries.

It would be of some interest to compare the results in Table 10 with those of Table 8. For Canada, Germany, Italy and Japan, the coefficients of error correction terms are between -1 and 0, and the long-run coefficients of the sectoral productivity differential are positive and statistically significant in both tables. Based on the likelihood ratio tests of the null of identical long-run coefficients of the sectoral productivity differential across the G7 countries, one finds smaller differences in the coefficients across the G7 countries in Table 10 than in Table 8. The remaining difference across the G7 countries might be due to other factors like differences in time preference, propensity of spending on nontradable goods, demographic conditions, initial endowment, and so on.[16]

Decomposition of factors. Based on the estimation results reported in Table 9, we have decomposed changes in the estimated relative price of nontradable goods into various factors to explain varying degrees of contributions of explanatory variables.[17] Charts 7 to 12 summarize results of such decomposition.[18] Each variable's contribution is normalized by deducting its sample mean from the original value, so that a positive or negative value in the chart does not necessarily mean that the variable makes positive or negative contribution. Because of the unstable estimation nature for France, we do not report its decomposition result.

For Japan, the upward trend of the relative price of nontradable goods is mainly explained by

[16] One can also point out differences in lag patterns of the effects of various variables. Analyses of these other factors are the subject of future study.

[17] Effects through lagged dependent variables are also decomposed into factors due to contributions of each explanatory variable. This is the reason why early periods of the estimation period show relatively large errors.

[18] A similar decomposition is made for the real exchange rate and is reported in Appendix Charts 1–6.

the upward movement of the sectoral productivity differential and, partly, by the upward movement of the cumulative current account. The market openness proxy, which has negative effects on the relative price of nontradable goods, is increasing its negative influence in recent years. The government expenditure has small effects, especially in recent years, compared to other factors.

For Canada and the United Kingdom, the relative price of nontradable goods is explained mainly by the sectoral productivity differential and the cumulative current account. For Italy, the relative price of nontradable goods is mostly explained by the sectoral productivity differential. For Germany, the market openness factor and the cumulative current account have large effects on the relative price of nontradable goods, especially in the early 1990s. For the United States, the relative price of nontradable goods is explained mainly by the government expenditure and by the sectoral productivity differential.

5 Policy Implications and Conclusions

Using the annual data for the G7 countries over the period 1970-1999, this paper has shown that the Balassa-Samuelson hypothesis can largely be supported for Canada, Germany, Italy, and Japan. For these countries, the real exchange rate has a stable long-run relationship with the terms of trade and the relative prices of nontradable goods at home and abroad, and that the relative price of nontradable goods at home is positively correlated with the productivity differential between the tradable and nontradable good sectors. But for the United Kingdom and the United States, strong evidence of the latter relationship cannot be found.

In the case of Japan, the significant real appreciation of the yen over the last 30 years has largely been due to an improvement of the terms of trade (see Appendix Chart 4) and the rising relative price of nontradable goods. The real overvaluation of the yen, or the high prices in Japan from international comparative perspectives can be explained by the economic fundamentals, including particularly the sectoral productivity differential, the cumulative current account, and the degree of market openness. If it is important for Japan to correct the real overvaluation of the yen on a sustained basis, it is highly desirable to pursue structural reform measures that would raise productivity in the non tradable goods sector, reduce the savings-investment gap (and, hence, the current account surplus), and increase market access to foreign multinationals through deregulation of the domestic market.

This paper has scope for further extension by examining other bilateral real exchange rates, such as the bilateral yen exchange rates, by increasing the number of countries to be examined, and by extending the observation period. The theoretical part of the paper can be extended by allowing capital stock in each country to be mobile across sectors and across countries. These theoretical extensions may yield somewhat different theoretical predictions of the relevant explanatory variables. This is on our agenda for the extension of our study.

A Data

Sectoral Productivity Differential. We use the OECD Inter Sectoral Data Base (hereafter ISDB) as a basic data source. We adopt the definitions of tradable goods and nontradable goods of Canzoneri, Cumby, and Diba(1999). That is, we define tradable goods as goods produced by the manufacturing industry, agriculture, forest industry, fisheries industry, and mining, and define nontradable goods as goods produced by other industries. The GDP price deflator is defined as the weighted average of the prices of tradable and nontradable goods. TFP is calculated by the same growth accounting method as adopted by ISDB, using data from ISDB for the tradable and nontradable goods sectors. Since ISDB is available only until 1997, we have extended the data set until 1999 by using the OECD STAN Data Base.

Cumulative Current Account. We have calculated the cumulative current account by using the current account data from the IMF's International Financial Statistics (hereafter IFS). The cumulative current account is divided by nominal GDP.

Inward Foreign Direct Investment The stock of inward foreign direct investment as a ratio of GDP is calculated by using IFS data on the stock of inward foreign direct investment and nominal GDP. When the stock of inward foreign direct investment is not available, we have calculated it from the flow data of inward foreign direct investment.

B Pooled Mean Group Estimator

In our likelihood tests of long-run coefficients, we have adopted the pooled mean group estimator (hereafter PMGE) proposed by Pesaran, Shin, and Smith (1999). There are two procedures commonly used for dynamic panel data models. The first method is to estimate separate equations for each group and to examine the distribution of the estimated coefficients, especially the mean of the estimator (MG), across groups. This estimator, however, does not take into account the fact that certain parameters may be the same across groups. The second method is to obtain the traditional pooled estimator, such as the fixed and random effects estimator, where the intercepts are allowed to differ across groups while all other coefficients and error variances are constrained to be the same. The pooled mean group (PMG) estimator is an intermediate estimator. This approach essentially constrains the long-run coefficients to be identical but allows the short-run coefficients and error variances to differ across groups.

Where the number of periods T is small and the number of countries N is large, a cross-section regression based on time-average of the variables will provide consistent estimates of the long-run coefficients. However, this inference requires strong assumptions that the group-specific parameters are distributed independently of regressors, and that the regressors are strictly exogenous. For a large T, Pesaran and Smith (1995) showed that the traditional procedures for estimation of pooled models, such as the fixed effects, instrumental variables, and generalized method-of-moments (GMM) estimators, can produce potentially inconsistent estimates, unless the slope coefficients are in fact identical.

We consider the $ADL(p, q, q, \ldots, q)$ mode. For simplicity, we assume the same lag length of all independent variables.[19]

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij} x_{i,t-j} + \mu_i + \epsilon_{it}. \tag{23}$$

This equation can be transformed as follows:

$$\Delta y_{it} = \phi_i y_{i,t-1} + \beta'_i x_{it} + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta^{*'}_{ij} \Delta x_{i,t-j} + \mu + \epsilon_{it}. \tag{24}$$

where

$$\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij}), \tag{25}$$

$$\beta_i = \sum_{j=0}^{p} \delta_{ij}, \tag{26}$$

[19]This simplicity does not affect our main results.

$$\lambda_{ij}^* = -\sum_{m=j+1}^{p} \lambda_{im}, j = 1, 2, \ldots, p-1, \tag{27}$$

$$\delta_{ij}^* = -\sum_{m=j+1}^{q} \delta_{im}, j = 1, 2, \ldots, q-1. \tag{28}$$

If we assume $\sum_{j=1}^{p} \lambda_{ij} < 1$, that is, $\phi_i < 0$, then we can obtain the following long-run relationship:

$$y_{it} = -(\beta_i'/\phi_i)x_{it} + \eta_{it} \tag{29}$$

If we define $\theta_i \equiv -\beta_i'/\phi_i$, the PMGE approach uses the restriction that ϕ_i are identical, that is,

$$\theta = \theta_i, i = 1, 2, \ldots, N. \tag{30}$$

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Table 1: Unit Root Tests for Individual Country Data

	$s+p^*-p$	$s+p_T^*-p_T$	p_N-p_T	a_T-a_N	$g-y$	cca	fdi
CANADA							
ADF test	-3.116	-3.751**	-2.226	-2.391	-3.074	-2.412	2.288
PP Z test	-8.594	-9.092	-3.705	-2.997	-10.782	-2.252	-1.181
FRANCE							
ADF test	-2.376	-2.288	-2.234	-2.815	-2.400	5.337	1.260
PP Z test	-8.874	-8.493	-5.732	-6.571	-13.666	2.002	8.159
GERMANY							
ADF test	-2.185	-2.161	-3.391*	-2.606	-1.858	0.302	-1.186
PP Z test	-8.606	-8.056	-5.322	-9.416	-6.270	-1.817	-1.186
ITALY							
ADF test	-1.898	-2.016	-2.350	-0.938	-3.053	-1.891	-1.645
PP Z test	-8.734	-8.662	6.125	-5.382	-4.133	0.446	-0.971
JAPAN							
ADF test	-2.454	-2.382	-2.719	-3.297*	-3.053	-3.100	-2.361
PP Z test	-9.170	-9.425	-8.913	-7.688	-7.257	-2.592	-1.577
UK							
ADF test	-2.676	-3.080	-2.013	-1.614	-1.398	-0.945	-3.588**
PP Z test	-9.184	-9.950	-5.153	-3.804	-3.015	-2.310	-3.587
US							
ADF test	—	—	-3.391*	-2.606	-1.858	-0.933	4.130
PP Z test	—	—	-5.322	-9.416	-6.270	-3.455	4.134

Note:

1. Asterisks, ***,** and *, denote statistical significance at the 1%, 5% and 10% levels, respectively.
2. ADF: Augmented Dickey-Fuller test. PP Z: Phillips-Perron (z) test.
3. $s+p^*-p$: Real exchange rate vis-à-vis the US dollar (in log form).
4. $s+p_T^*-p_T$: Terms of trade with the benchmark being the United States (in log form).
5. p_N-p_T : Relative price of nontradable goods (in log form).
6. a_T-a_N : Sectoral productivity differential between the tradable and nontradable goods sectors (in log form).
7. $g-y$: Real government consumption spending as a percentage of real GDP (in log form).
8. cca : Cumulative current account as a ratio of nominal GDP.
9. fdi : Stock of inward foreign direct investment as a ratio of nominal GDP (in log form).
10. Optimal lags are chosen by using the adjusted AIC rule described in Pantula et al. (1994). If j is the number of lags which minimizes AIC, then lag length $j+2$ is used.

Table 2: Cointegration Tests for the Real Exchange Rate, the Terms of Trade, and the Relative Prices of Nontradable Goods – Using Individual Country Data

Dep.Var.	TestStat		Num.lags
CANADA			
$s + p^* - p$	-2.221		3
$s + p_T^* - p_T$	-2.249		3
$p_N - p_T$	-2.236		3
$p_N^* - p_T^*$	-2.257		3
FRANCE			
$s + p^* - p$	-2.458		6
$s + p_T^* - p_T$	-2.452		6
$p_N - p_T$	-2.171		6
$p_N^* - p_T^*$	-2.397		6
GERMANY			
$s + p^* - p$	-0.619		2
$s + p_T^* - p_T$	-0.620		2
$p_N - p_T$	-0.521		2
$p_N^* - p_T^*$	-0.730		2
ITALY			
$s + p^* - p$	-2.391		6
$s + p_T^* - p_T$	-2.390		6
$p_N - p_T$	-2.335		6
$p_N^* - p_T^*$	-2.335		6
JAPAN			
$s + p^* - p$	-2.890		2
$s + p_T^* - p_T$	-2.870		2
$p_N - p_T$	-2.680		2
$p_N^* - p_T^*$	-2.877		2
UK			
$s + p^* - p$	-2.594		5
$s + p_T^* - p_T$	-2.544		5
$p_N - p_T$	-2.613		5
$p_N^* - p_T^*$	-4.231	*	3

Note:

1. Asterisks, ***,** and *, denote statistical significance at the 1%, 5% and 10% levels, respectively.
2. $s + p^* - p$: Real exchange rate vis-à-vis the US dollar (in log form).
3. $s + p_T^* - p_T$: Terms of trade with the benchmark being the United States (in log form). It is the relative price of traded goods between the home country and the US.
4. $p_N - p_T$: Relative price of nontradable goods in the home country (in log form).
5. $p_N^* - p_T^*$: Relative price of nontradable goods in the United States (in log form).
6. Optimal lags are chosen by using the adjusted AIC rule described in Pantula et al.(1994). If j is the number of lags which minimizes AIC, then lag length $j + 2$ is used.

Table 3: Unit Root Tests for Panel Data

	$s+p^{*}-p$	$s+p_T^{*}-p_T$	p_N-p_T	a_T-a_N	$g-y$	cca	fdi
No Time Trend	8.510	6.340	16.198	10.675	3.377	14.438	17.090
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
With Time Trend	95.158	102.957	1949.337	633.275	1152.753	391.252	64527.266
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note:

1. Hadri (2000) test for the null of stationarity applied.
2. P-value in parentheses.
3. $s+p^{*}-p$: Real exchange rate vis-à-vis the US dollar (in log form).
4. $s+p_T^{*}-p_T$: Terms of trade with the benchmark being the United States.
5. p_N-p_T : Relative price of nontradable goods (in log form).
6. a_T-a_N : Sectoral productivity differential between the tradable and nontradable goods sectors (in log form).
7. $g-y$: Real government consumption spending as a ratio of real GDP (in log form).
8. cca : Cumulative current account as a ratio of nominal GDP.
9. fdi : Stock of inward foreign direct investment as a ratio of nominal GDP (in log form).

Table 4: Cointegration Tests for the Real Exchange Rate, the Terms of Trade, and Relative Prices of Nontradable Goods – Panel Data

	Statistics
1. Panel ν-Statistics	11.5939
	(0.121)
2. Panel ρ-Statistics	-18.327
	(0.242)
3. Panel t-Statistics	-5.694
(non-parametric)	(0.358)
4. Panel t-Statistics	-3721.014
(parametric)	(0.000)
5. Group ρ-Statistics	-17.508
	(0.015)
6. Group t-Statistics	-5.509
(non-parametric)	(0.273)
7. Group t-Statistics	-5.691
(parametric)	(0.356)

Note:

1. The table summarizes the results of heterogeneous panel cointegration tests. In these tests, cointegration vectors are permitted to vary across individual members of the panel.
2. Definitions of statistics in the table are given by Pedroni (1999).
3. Statistics 1-4 are within-dimension statistics. The test for the null of no cointegration is implemented as a residual-based test of the null hypothesis $H_0 : \beta_i = \beta = 1$ for all i, versus the alternative hypothesis $H_1 : \beta_i = \beta < 1$ for all i, so that it presumes a common value for $\beta_i = \beta$. (β_i is the autoregressive coefficient of the estimated residuals under the alternative hypothesis of cointegration.)
4. Statistics 5-7 are between-dimension statistics. In this case, The test for the null of no cointegration is implemented as a residual-based test of the null hypothesis $H_0 : \beta_i = 1$ for all i, versus the alternative hypothesis $H_1 : \beta_i = \beta < 1$ for all i, so that it does not presume a common value for $\beta_i = \beta$.
5. P-value in parentheses.

Table 5: Cointegration Tests Using Individual Country Data

(1) Cointegration Tests for the Relative Price of Nontradable Goods, and the Sectoral Productivity Differential.
(2) Cointegration Tests for the relative Price of Nontradable Goods, the Sectoral Productivity Differential, and the Government Expenditure.
(3) Cointegration Tests for the relative Price of Nontradable Goods, the Sectoral Productivity Differential, the Government Expenditure, Cumulative Current Account and Market Openness Proxy.

	(1)	Test Stat.	No. Lags	(2)	Test Stat.	No. Lags	(3)	Test Stat.	No. Lags
CANADA	$p_N - p_T$	-1.766	11	$p_N - p_T$	-2.023	3	$p_N - p_T$	-2.339	2
	$a_T - a_N$	-0.853	11	$a_T - a_N$	-1.994	2	$a_T - a_N$	-2.633	2
				$g - y$	-2.232	3	$g - y$	-3.070	3
							cca	-2.210	3
							fdi	-2.591	2
FRANCE	$p_N - p_T$	-0.981	11	$p_N - p_T$	-2.374	2	$p_N - p_T$	-2.519	2
	$a_T - a_N$	-2.531	9	$a_T - a_N$	-3.541	3	$a_T - a_N$	-2.310	10
				$g - y$	-2.587	2	$g - y$	-3.074	2
							cca	-2.211	4
							fdi	-2.408	10
GERMANY	$p_N - p_T$	-1.601	9	$p_N - p_T$	-2.648	7	$p_N - p_T$	-2.204	2
	$a_T - a_N$	-2.404	2	$a_T - a_N$	-2.318	2	$a_T - a_N$	-2.504	2
				$g - y$	-3.026	3	$g - y$	-3.371	3
							cca	-2.081	10
							fdi	-2.197	2
ITALY	$p_N - p_T$	-2.611	3	$p_N - p_T$	-1.582	4	$p_N - p_T$	-2.460	2
	$a_T - a_N$	-1.397	5	$a_T - a_N$	-1.432	5	$a_T - a_N$	-1.817	5
				$g - y$	-1.582	5	$g - y$	-1.742	7
							cca	-2.492	6
							fdi	-1.722	8

Table 5: (continued)

	(1)	Test Stat.	No. Lags	(2)	Test Stat.	No. Lags	(3)	Test Stat.	No. Lags
JAPAN	$p_N - p_T$	-1.926	10	$p_N - p_T$	-1.592	6	$p_N - p_T$	-1.401	10
	$a_T - a_N$	-3.441	5	$a_T - a_N$	-3.108	5	$a_T - a_N$	-3.184	5
				$g - y$	-1.412	7	$g - y$	-3.066	2
							cca	-3.321	3
							fdi	-1.517	10
UK	$p_N - p_T$	-4.540**	11	$p_N - p_T$	-2.371	3	$p_N - p_T$	-3.758	5
	$a_T - a_N$	-2.798	3	$a_T - a_N$	-2.270	3	$a_T - a_N$	-2.783	3
				$g - y$	-2.857	2	$g - y$	-3.122	2
							cca	-2.942	3
							fdi	-1.591	8
US	$p_N - p_T$	-3.005	7	$p_N - p_T$	-2.141	2	$p_N - p_T$	-3.435	5
	$a_T - a_N$	-4.606**	11	$a_T - a_N$	-2.121	2	$a_T - a_N$	-1.816	10
				$g - y$	-2.411	8	$g - y$	-3.682	3
							cca	-3.176	3
							fdi	-2.692	5

Note:

1. Asterisks, ***,** and *, denote statistical significance at the 1%, 5% and 10% levels, respectively.
2. $p_N - p_T$: Relative price of nontradable goods (in log form).
3. $a_T - a_N$: Sectoral productivity differential between the tradable and nontradable goods sectors (in log form).
4. $g - y$: Real government consumption spending as a ratio of real GDP (in log form).
5. cca : Cumulative current account as a ratio of nominal GDP .
6. fdi : Stock of inward foreign direct investment as a ratio of nominal GDP (in log form).
7. Optimal lags are chosen by using the adjusted AIC rule described in Pantula et al. (1994). If j is the number of lags which minimizes AIC, then lag length $j + 2$ is used.

Table 6: Panel Cointegration Tests Using Panel Data

(1) Cointegration Tests for the Relative Price of Nontradable Goods, the Sectoral Productivity Differential, and the Government Expenditure	
Statistics	
1. Panel ν-Statistics	-2.051 (0.020)
2. Panel ρ-Statistics	-9.377 (0.000)
3. Panel t-Statistics (non-parametric)	-24.708 (0.000)
4. Panel t-Statistics (parametric)	-486.967 (0.000)
5. Group ρ-Statistics	-10.295 (0.000)
6. Group t-Statistics (non-parametric)	-35.044 (0.000)
7. Group t-Statistics (parametric)	-25.950 (0.000)
(2) Cointegration Tests for the Relative Price of Nontradable Goods, the Sectoral Productivity Differential, the Government Expenditure, the Cumulative Current Account and Market Openness Proxy	
Statistics	
1. Panel ν-Statistics	9.575 (0.019)
2. Panel ρ-Statistics	-10.763 (0.004)
3. Panel t-Statistics (non-parametric)	-4.126 (0.004)
4. Panel t-Statistics (parametric)	-209.726 (0.000)
5. Group ρ-Statistics	-13.460 (0.000)
6. Group t-Statistics (non-parametric)	-4.0647 (0.000)
7. Group t-Statistics (parametric)	-4.279 (0.000)

Note:

1. The table summarizes the results of heterogeneous panel cointegration tests. In these tests, cointegration vectors are permitted to vary across individual members of the panel.
2. See Pedroni (1999) and the footnotes of Table 4 for definitions and properties of statistics in the table.
3. P-value in parentheses.

Table 7: Regression of the Relative Price of Nontradables on the Sectoral Productivity Differential and the Government Expenditure

CANADA	Coef	S.E.	t-value	P-value
C	-0.563	0.219	-2.566	0.03
$(p_N - p_T)_{t-1}$	1.108	0.187	5.937	0.00
$(p_N - p_T)_{t-2}$	-0.980	0.268	-3.657	0.00
$(p_N - p_T)_{t-3}$	0.837	0.253	3.310	0.01
$(p_N - p_T)_{t-4}$	-0.320	0.099	-3.238	0.01
$(a_T^* - a_N)_t$	0.301	0.034	8.732	0.00
$(a_T^* - a_N)_{t-1}$	-0.301	0.060	-5.029	0.00
$(a_T^* - a_N)_{t-2}$	0.188	0.078	2.419	0.03
$(a_T^* - a_N)_{t-3}$	-0.113	0.068	-1.666	0.12
$(g - y)_t$	0.432	0.128	3.384	0.01
$(g - y)_{t-1}$	-0.292	0.149	-1.957	0.08
$(g - y)_{t-2}$	0.085	0.164	0.519	0.61
$(g - y)_{t-3}$	-0.560	0.162	-3.461	0.01
AR(1)-AR(4):LM test	1.627	2.804	12.902	41.09
P-value	0.202	0.246	0.005	0.00
R^2 and Adj-R^2	0.987	0.973		
FRANCE	Coef	S.E.	t-value	P-value
C	0.223	0.099	2.243	0.03
$(p_N - p_T)_{t-1}$	0.820	0.108	7.561	0.00
$(a_T - a_N)_t$	0.011	0.090	0.119	0.91
$(g - y)_t$	0.134	0.065	2.074	0.05
AR(1)-AR(4):LM test	0.648	1.968	3.044	2.18
P-value	0.421	0.374	0.385	0.70
R^2 and Adj-R^2	0.984	0.982		
GERMANY	Coef	S.E.	t-value	P-value
C	-0.098	0.179	-0.550	0.59
$(p_N - p_T)_{t-1}$	1.371	0.204	6.710	0.00
$(p_N - p_T)_{t-2}$	-0.528	0.337	-1.567	0.14
$(p_N - p_T)_{t-3}$	0.188	0.304	0.618	0.55
$(p_N - p_T)_{t-4}$	-0.455	0.237	-1.920	0.07
$(a_T - a_N)_t$	0.237	0.156	1.514	0.15
$(a_T - a_N)_{t-1}$	-0.358	0.147	-2.435	0.03
$(a_T - a_N)_{t-2}$	0.219	0.149	1.472	0.16
$(a_T - a_N)_{t-3}$	0.226	0.118	1.915	0.08
$(g - y)_t$	0.054	0.150	0.362	0.72
$(g - y)_{t-1}$	-0.121	0.105	-1.149	0.27
AR(1)-AR(4):LM test	0.362	3.602	4.981	3.17
P-value	0.547	0.165	0.173	0.53
R^2 and Adj-R^2	0.956	0.926		

Table 7: (continued)

ITALY	Coef	S.E.	t-value	P-value
C	0.223	0.074	3.024	0.01
$(p_N - p_T)_{t-1}$	0.819	0.060	13.615	0.00
$(a_T - a_N)_t$	0.138	0.069	2.007	0.06
$(g - y)_t$	0.122	0.044	2.756	0.01
AR(1)-AR(4):LM test	0.020	0.521	0.543	0.63
P-value	0.887	0.771	0.909	0.96
R^2 and Adj-R^2	0.995	0.995		
JAPAN	Coef	S.E.	t-value	P-value
C	0.222	0.129	1.719	0.10
$(p_N - p_T)_{t-1}$	0.687	0.140	4.910	0.00
$(p_N - p_T)_{t-2}$	0.196	0.148	1.324	0.20
$(a_T - p_N)_t$	0.148	0.079	1.878	0.08
$(a_T - p_N)_{t-1}$	-0.442	0.102	-4.351	0.00
$(a_T - p_N)_{t-2}$	0.372	0.083	4.461	0.00
$(g - y)_t$	0.360	0.099	3.623	0.00
$(g - y)_{t-1}$	-0.459	0.153	-3.002	0.01
$(g - y)_{t-2}$	0.507	0.164	3.092	0.01
$(g - y)_{t-3}$	-0.324	0.092	-3.515	0.00
AR(1)-AR(4):LM test	0.396	0.984	2.455	4.62
P-value	0.529	0.611	0.484	0.33
R^2 and Adj-R^2	0.997	0.995		
UK	Coef	S.E.	t-value	P-value
C	0.196	0.223	0.880	0.39
$(p_N - p_T)_{t-1}$	0.734	0.259	2.836	0.01
$(p_N - p_T)_{t-2}$	-0.536	0.191	-2.813	0.01
$(a_T - a_N)_t$	0.313	0.054	5.785	0.00
$(a_T - a_N)_{t-1}$	-0.268	0.134	-1.997	0.06
$(a_T - a_N)_{t-2}$	0.265	0.101	2.625	0.02
$(g - y)_t$	0.109	0.135	0.805	0.43
AR(1)-AR(4):LM test	0.639	2.579	6.131	11.99
P-value	0.424	0.275	0.105	0.02
R^2 and Adj-R^2	0.972	0.964		

Table 7: (continued)

US	Coef	S.E.	t-value	P-value
C	-0.600	0.296	-2.029	0.06
$(p_N - p_T)_{t-1}$	-0.018	0.253	-0.072	0.94
$(p_N - p_T)_{t-2}$	0.469	0.214	2.196	0.05
$(p_N - p_T)_{t-3}$	0.127	0.243	0.521	0.61
$(p_N - p_T)_{t-4}$	0.462	0.183	2.518	0.03
$(a_T - a_N)_t$	0.358	0.078	4.575	0.00
$(a_T - a_N)_{t-1}$	0.015	0.109	0.136	0.89
$(a_T - a_N)_{t-2}$	-0.068	0.124	-0.547	0.59
$(a_T - a_N)_{t-3}$	-0.339	0.121	-2.793	0.02
$(g - y)_t$	0.333	0.189	1.766	0.10
$(g - y)_{t-1}$	-0.192	0.265	-0.724	0.48
$(g - y)_{t-2}$	-0.237	0.253	-0.935	0.37
$(g - y)_{t-3}$	-0.305	0.266	-1.143	0.27
AR(1)-AR(4):LM test	0.196	0.792	4.216	6.35
P-value	0.658	0.673	0.239	0.17
R^2 and Adj-R^2	0.995	0.990		

Note:

1. Method: ADL.
2. AR(1)-AR(4):LM test: Breusch-Godfrey Test.
3. Dependent variable: Relative Price of Nontradable Goods $(p_N - p_T)$.
4. Explanatory variables: Sectoral productivity differential between tradable and nontradable goods sectors $(a_T - a_N)$ and the government expenditure $(g - y)$.

Table 8: Estimated Long-Run Coefficients: ADL (Group Specific Estimate)

	ECT ϕ	$a_T - a_N$	$g - y$
CANADA	-0.355	0.212	-0.945
	(0.090)	(0.037)	(0.365)
FRANCE	-0.180	0.060	0.746
	(0.108)	(0.476)	(0.157)
GERMANY	-0.424	0.761	-0.156
	(0.253)	(0.238)	(0.303)
ITALY	-0.181	0.764	0.672
	(0.060)	(0.180)	(0.325)
JAPAN	-0.116	0.671	0.710
	(0.075)	(0.091)	(0.496)
UK	-0.802	0.386	0.136
	(0.232)	(0.024)	(0.146)
US	0.039	0.858	10.201
	(0.148)	(1.400)	(42.321)

LR test H_0:the long run coefficients of productivity differential are identical

test statistics	p-value
$\chi^2(6) = 29.656$	(0.000)

Note:

1. Standard errors in parentheses.
2. Estimation Method: Pooled Mean Group Estimate (PMGE).
3. Dependent variable: Relative price of nontradable goods $(p_N - p_T)$.
4. Explanatory variables: Sectoral productivity differential $(a_T - a_N)$ and the government expenditure $(g - y)$.
5. ECT: Error correction term.

Table 9: Regression of the Relative Price of Nontradables on the Sectoral Productivity Differential, the Government Expenditure, the Cumulative Current Account, and an Market Openness Proxy

CANADA	Coef	S.E.	t-value	P-value
C	0.671	0.363	1.850	0.09
$(p_N - p_T)_{t-1}$	1.278	0.200	6.387	0.00
$(p_N - p_T)_{t-2}$	-0.834	0.301	-2.770	0.02
$(p_N - p_T)_{t-3}$	0.215	0.236	0.910	0.38
$(a_T - a_N)_t$	0.239	0.047	5.118	0.00
$(a_T - a_N)_{t-1}$	-0.295	0.074	-3.999	0.00
$(a_T - a_N)_{t-2}$	0.176	0.095	1.863	0.08
$(a_T - a_N)_{t-3}$	0.051	0.091	0.566	0.58
$(g - y)_t$	0.261	0.192	1.361	0.20
cca_t	0.517	0.220	2.347	0.03
fdi_t	-0.449	0.533	-0.842	0.41
AR(1)-AR(4):LM test	0.199	0.323	0.417	6.44
P-value	0.655	0.851	0.937	0.17
R^2 and Adj-R^2	0.964	0.939		
FRNACE	Coef	S.E.	t-value	P-value
C	0.329	0.139	2.372	0.03
$(p_N - p_T)_{t-1}$	0.984	0.247	3.990	0.00
$(p_N - p_T)_{t-2}$	-0.050	0.222	-0.225	0.82
$(a_T - a_N)_t$	-0.248	0.144	-1.725	0.10
$(a_T - a_N)_{t-1}$	0.279	0.156	1.792	0.09
$(a_T - a_N)_{t-2}$	-0.236	0.134	-1.763	0.09
$(g - y)_t$	0.181	0.085	2.131	0.05
cca_t	0.414	0.230	1.799	0.09
fdi_t	-0.368	0.347	-1.061	0.30
AR(1)-AR(4):LM test	0.005	1.248	2.323	1.95
P-value	0.946	0.536	0.508	0.75
R^2 and Adj-R^2	0.987	0.982		

Table 9: (continued)

GERMANY	Coef	S.E.	t-value	P-value
C	-0.069	0.175	-0.398	0.697
$(p_N - p_T)_{t-1}$	0.310	0.244	1.268	0.225
$(p_N - p_T)_{t-2}$	-0.258	0.252	-1.024	0.323
$(p_N - p_T)_{t-3}$	0.299	0.216	1.384	0.188
$(a_T - a_N)_t$	0.505	0.172	2.927	0.011
$(g - y)_t$	-0.078	0.156	-0.503	0.623
$(g - y)_{t-1}$	0.166	0.164	1.014	0.328
$(g - y)_{t-2}$	-0.158	0.109	-1.453	0.168
cca_t	-0.519	0.195	-2.656	0.019
cca_{t-1}	0.446	0.322	1.388	0.187
cca_{t-2}	-0.477	0.308	-1.551	0.143
cca_{t-3}	0.635	0.220	2.893	0.012
fdi_t	-0.694	0.203	-3.425	0.004
AR(1)-AR(4):LM test	0.302	1.930	1.942	1.954
P-value	0.583	0.381	0.584	0.744
R^2 and $Adj - R^2$	0.968	0.940		
ITALY	Coef	S.E.	t-value	P-value
C	0.273	0.113	2.417	0.04
$(p_N - p_N)_{t-1}$	0.817	0.077	10.639	0.00
$(a_T - a_N)_t$	0.085	0.196	0.432	0.68
$(a_T - a_N)_{t-1}$	0.046	0.224	0.206	0.84
$(g - y)_t$	0.172	0.116	1.483	0.17
$(g - y)_{t-1}$	-0.024	0.127	-0.192	0.85
cca_t	0.261	0.243	1.071	0.31
cca_{t-1}	-0.214	0.222	-0.964	0.36
fdi_t	-0.743	0.500	-1.486	0.17
fdi_{t-1}	0.698	0.590	1.184	0.26
AR(1)-AR(4):LM test	0.006	1.990	1.495	2.93
P-value	0.938	0.370	0.683	0.57
R^2 and Adj-R^2	0.996	0.994		
JAPAN	Coef	S.E.	t-value	P-value
C	0.553	0.184	3.006	0.01
$(p_N - p_T)_{t-1}$	0.241	0.175	1.380	0.19
$(p_N - p_T)_{t-2}$	0.395	0.159	2.482	0.02
$(a_T - a_N)_t$	0.372	0.098	3.774	0.00
$(a_T - a_N)_{t-1}$	-0.222	0.082	-2.708	0.02
$(g - y)_t$	0.348	0.108	3.224	0.01
$(g - y)_{t-1}$	-0.113	0.108	-1.052	0.31
cca_t	-0.332	0.244	-1.359	0.19
cca_{t-1}	0.619	0.270	2.295	0.04
fdi_t	-7.850	3.382	-2.321	0.03
fdi_{t-1}	0.517	4.236	0.122	0.90
AR(1)-AR(4):LM test	0.220	0.920	0.153	3.45
P-value	0.639	0.631	0.985	0.49
R^2 and Adj-R^2	0.996	0.994		

Table 9: (continued)

UK	Coef	S.E.	t-value	P-value
C	-0.313	0.295	-1.059	0.30
$(p_N - p_T)_{t-1}$	0.480	0.265	1.812	0.09
$(p_N - p_T)_{t-2}$	-0.238	0.169	-1.402	0.18
$(p_N - p_T)_{t-3}$	-0.335	0.173	-1.944	0.07
$(a_T - a_N)_t$	0.320	0.054	5.942	0.00
$(a_T - a_N)_{t-1}$	-0.128	0.132	-0.968	0.35
$(g - y)_t$	-0.175	0.170	-1.033	0.32
cca_t	-0.215	0.527	-0.407	0.69
cca_{t-1}	-1.036	0.587	-1.764	0.10
fdi_t	-0.331	0.178	-1.854	0.08
AR(1)-AR(4):LM test	3.999	9.068	9.199	11.42
P-value	0.046	0.011	0.027	0.02
R^2 and Adj-R^2	0.978	0.966		
US	Coef	S.E.	t-value	P-value
C	-0.056	0.235	-0.239	0.81
$(p_N - p_T)_{t-1}$	0.389	0.310	1.257	0.23
$(p_N - p_T)_{t-2}$	0.249	0.290	0.859	0.40
$(p_N - p_T)_{t-3}$	0.428	0.358	1.197	0.25
$(a_T - a_N)_t$	0.251	0.085	2.936	0.01
$(a_T - a_N)_{t-1}$	-0.036	0.121	-0.296	0.77
$(a_T - a_N)_{t-2}$	-0.205	0.121	-1.694	0.11
$(a_T - a_N)_{t-3}$	-0.129	0.125	-1.031	0.32
$(g - y)_t$	-0.039	0.139	-0.280	0.78
cca_t	0.295	1.000	0.295	0.77
cca_{t-1}	-0.388	1.011	-0.384	0.71
fdi_t	0.100	0.378	0.265	0.80
AR(1)-AR(4):LM test	0.816	1.757	16.467	19.98
P-value	0.366	0.415	0.001	0.00
R^2 and Adj-R^2	0.989	0.981		

Note:

1. Method: ADL.
2. AR(1)-AR(4):LM test: Breusch-Godfrey Test.
3. Dependent variable: Relative price of nontradable goods $(p_N - p_T)$.
4. Explanatory variables: Sectoral productivity differential between tradable and non-tradable goods sectors $(a_T - a_N)$, the government expenditure $(g-y)$, the cumulative current account as a ratio of nominal GDP (cca), and the stock of inward foreign direct investment as a ratio of nominal GDP (fdi) as a proxy for market openness.

Table 10: Estimated Long-Run Coefficients: ADL (Group Specific Estimate)

	ECT ϕ	$a_T - a_N$	$g - y$	cca	fdi
Canada	-0.341	0.505	0.765	1.517	-1.316
	(0.143)	(0.162)	(0.700)	(0.882)	(1.827)
France	-0.066	-3.12	2.752	6.308	-5.609
	(0.189)	(11.147)	(7.282)	(19.976)	(20.140)
Germany	-0.649	0.777	-0.108	0.131	-1.069
	(0.194)	(0.140)	(0.189)	(0.064)	(0.464)
Italy	-0.143	0.696	1.146	1.182	-2.219
	(0.099)	(0.318)	(0.858)	(1.825)	(4.842)
Japan	-0.363	0.413	0.645	0.792	-20.197
	(0.144)	(0.140)	(0.168)	(0.210)	(12.423)
U.K.	-1.093	0.176	-0.16	-1.145	-0.303
	(0.288)	(0.076)	(0.169)	(0.324)	(0.145)
U.S.	0.066	1.787	0.588	1.397	-1.507
	(0.528)	(11.747)	(5.243)	(15.618)	(16.692)

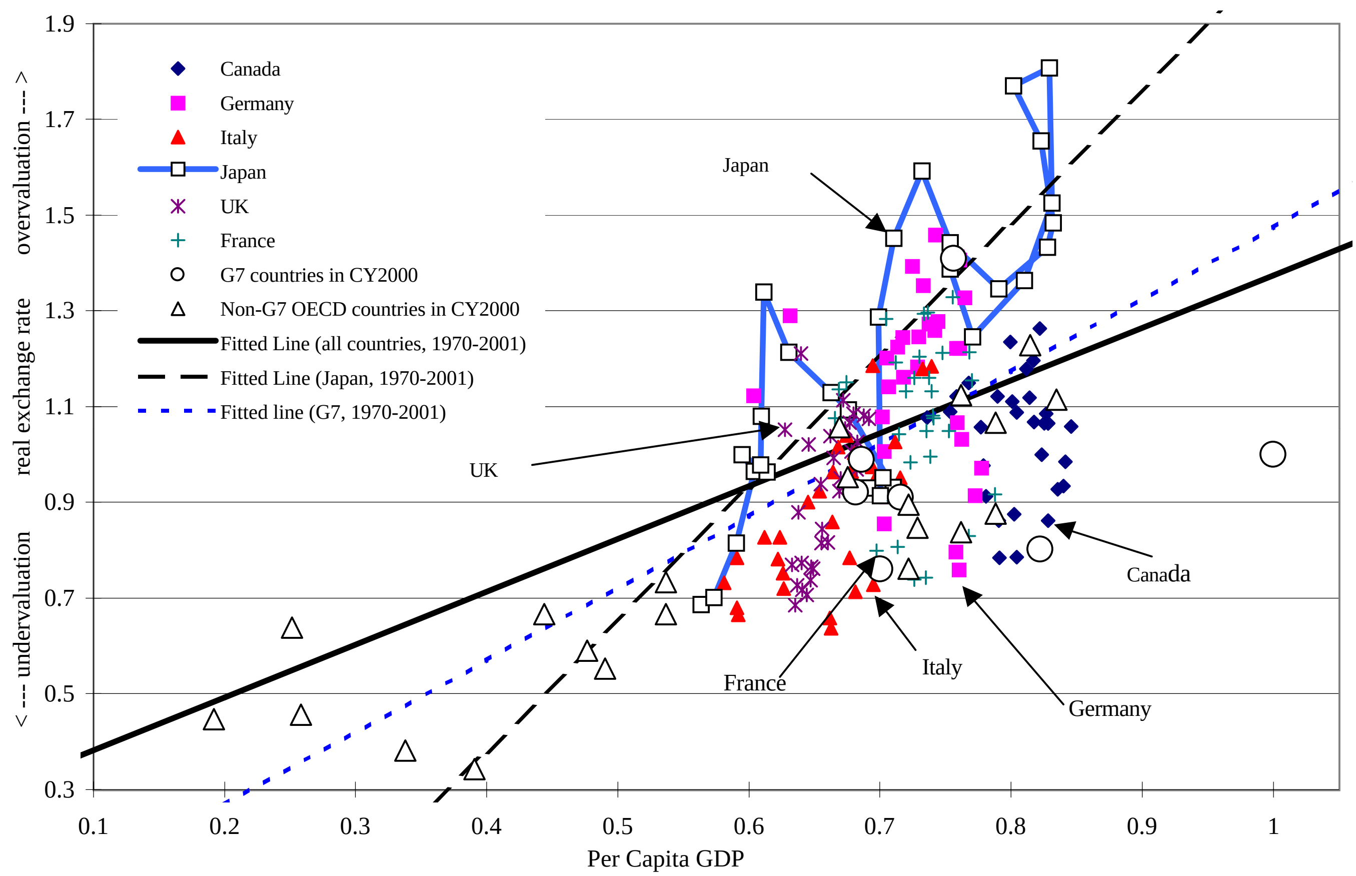
LR test H_0:the long run coefficients of productivity differential are identical

Test Statistics	p-value
$\chi^2(6) = 18.9205$	(0.000)

Note:

1. Standard errors in parentheses.
2. Estimation Method: Pooled Mean Group Estimate (PMGE).
3. Dependent Variable: Relative price of nontradables goods ($p_N - p_T$).
4. Explanatory variables: Sectoral productivity differential ($a_T - a_N$), the government expenditure as a ratio of GDP ($g - y$), the cumulative current account (cca), and the stock of inward foreign direct investment (fdi) as a proxy for market openness.
5. ECT: error correction term.

(Chart 1) Real Exchange Rate and Per Capita GDP for OECD Countries



Notes

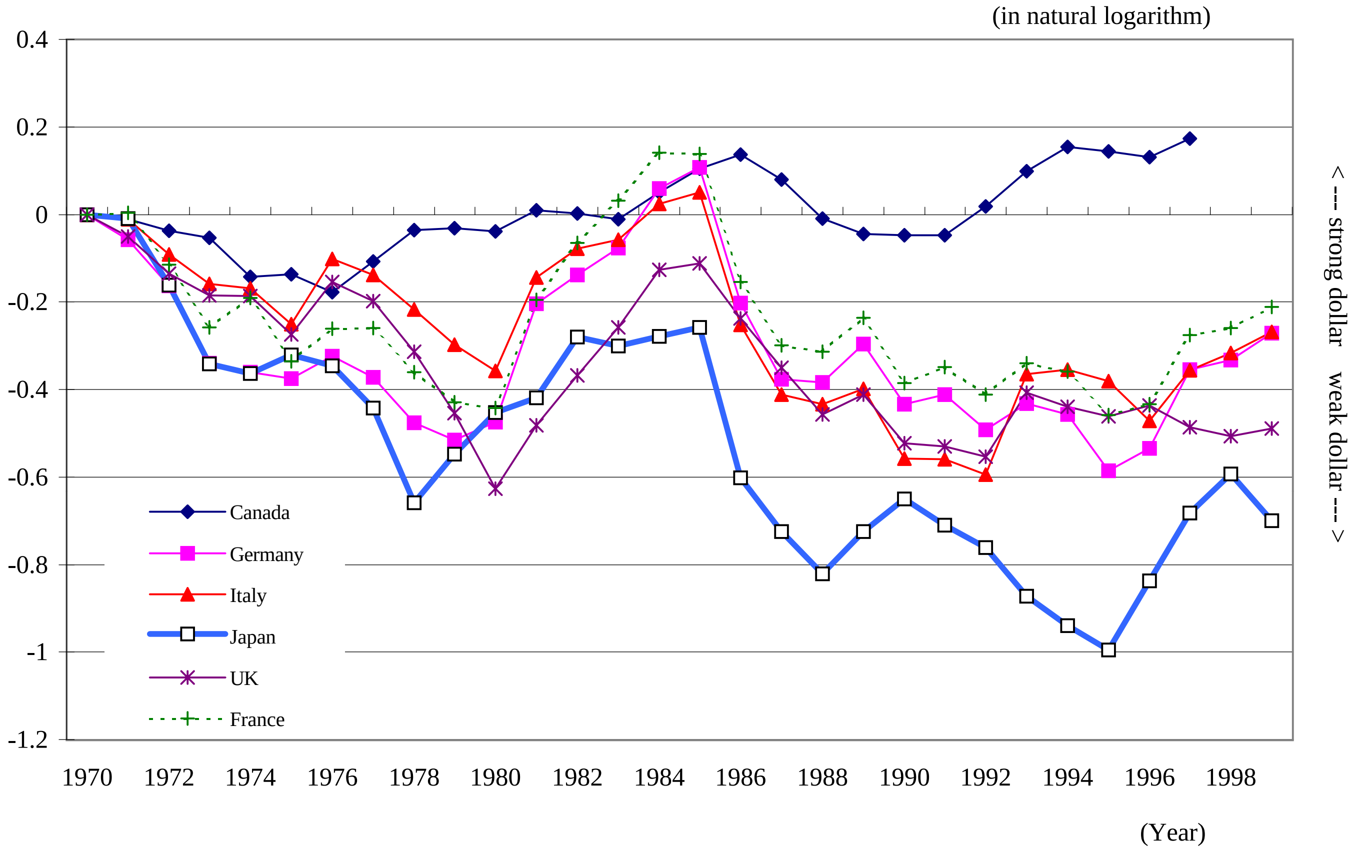
1. The real exchange rate is defined in terms of the relative prices of all goods and services covered by GDP, between home and the United States.

2. Per capita GDP is defined at PPP rates.

3. Both axes are standardized so that the values for the United States are set equal to one.

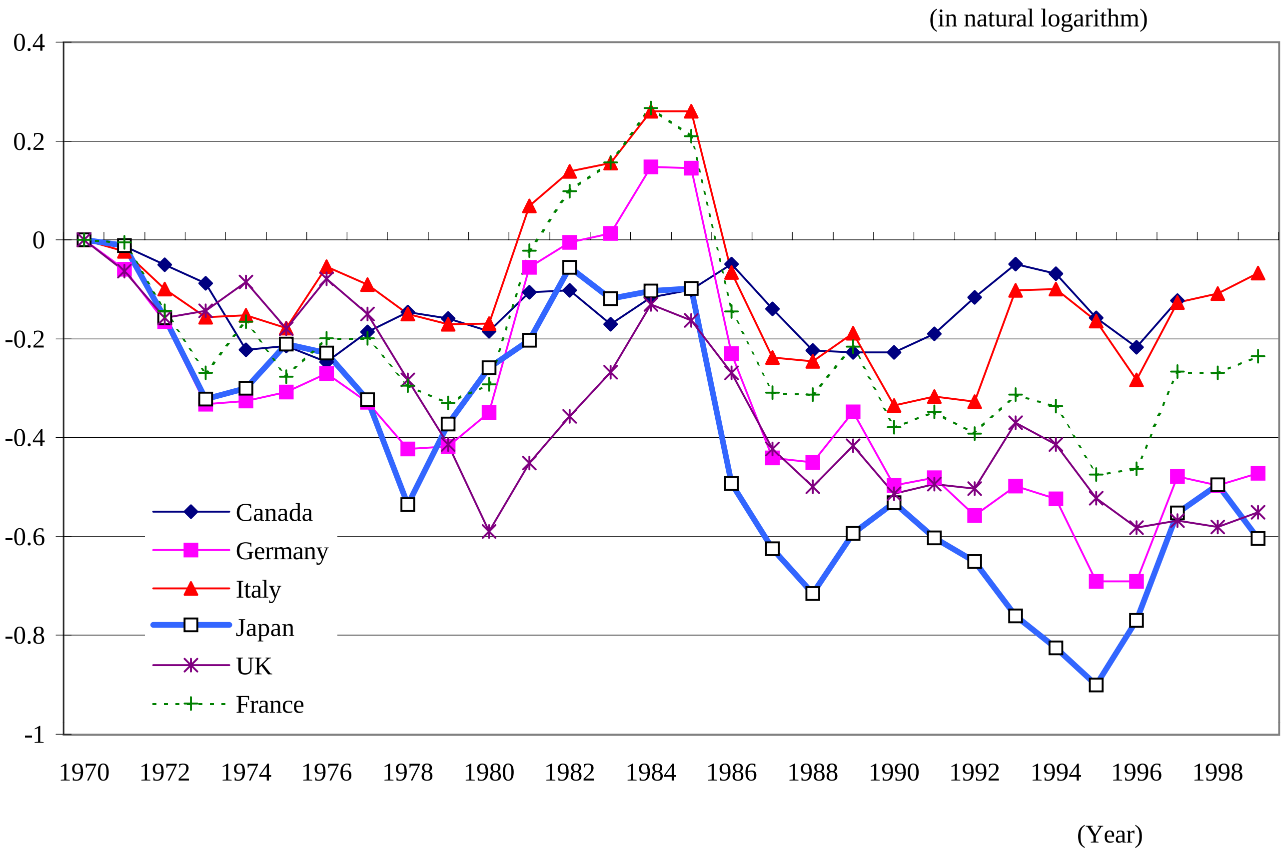
Source: OECD "Main Economic Indicators."

(Chart 2) Real Exchange Rates vis-à-vis the U.S. Dollar for G7 countries



(Definition)
The real exchange rate vis-à-vis the U.S. dollar: $q=s+p^*-p$
where
s: nominal exchange rate (home currency / U. S. dollar),
p*: US GDP deflator,
p: home country GDP deflator.

(Chart 3) Terms of Trade for G7 Countries vis-à-vis the U.S.



(Definition)

Terms of trade: $s+p^*_T-p_T$

where

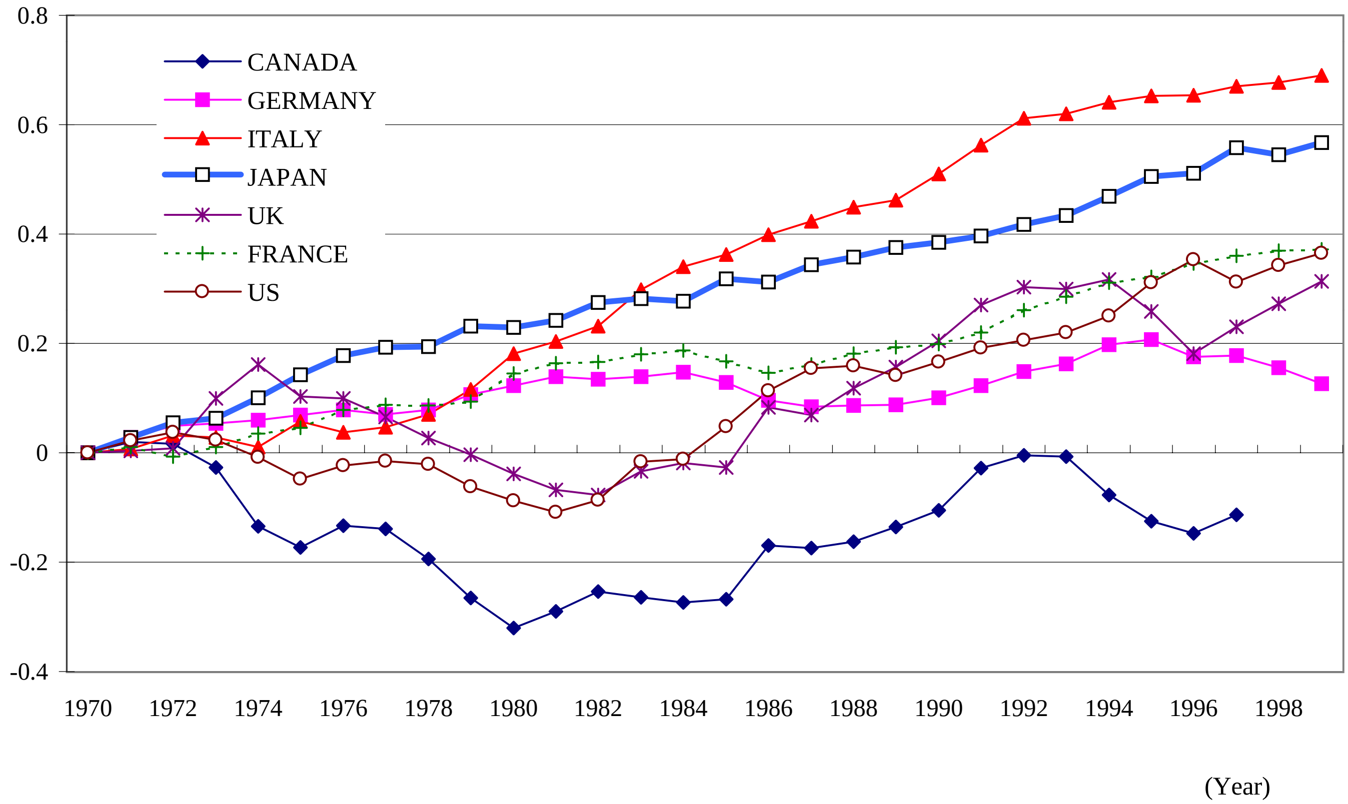
s: nominal exchange rate (home currency/U.S. dollar),

p^*_T: US price of tradable goods,

p_T : home countries' price of tradable goods.

(Chart 4) Relative Prices of Nontradable to Tradable Goods for G7 Countries

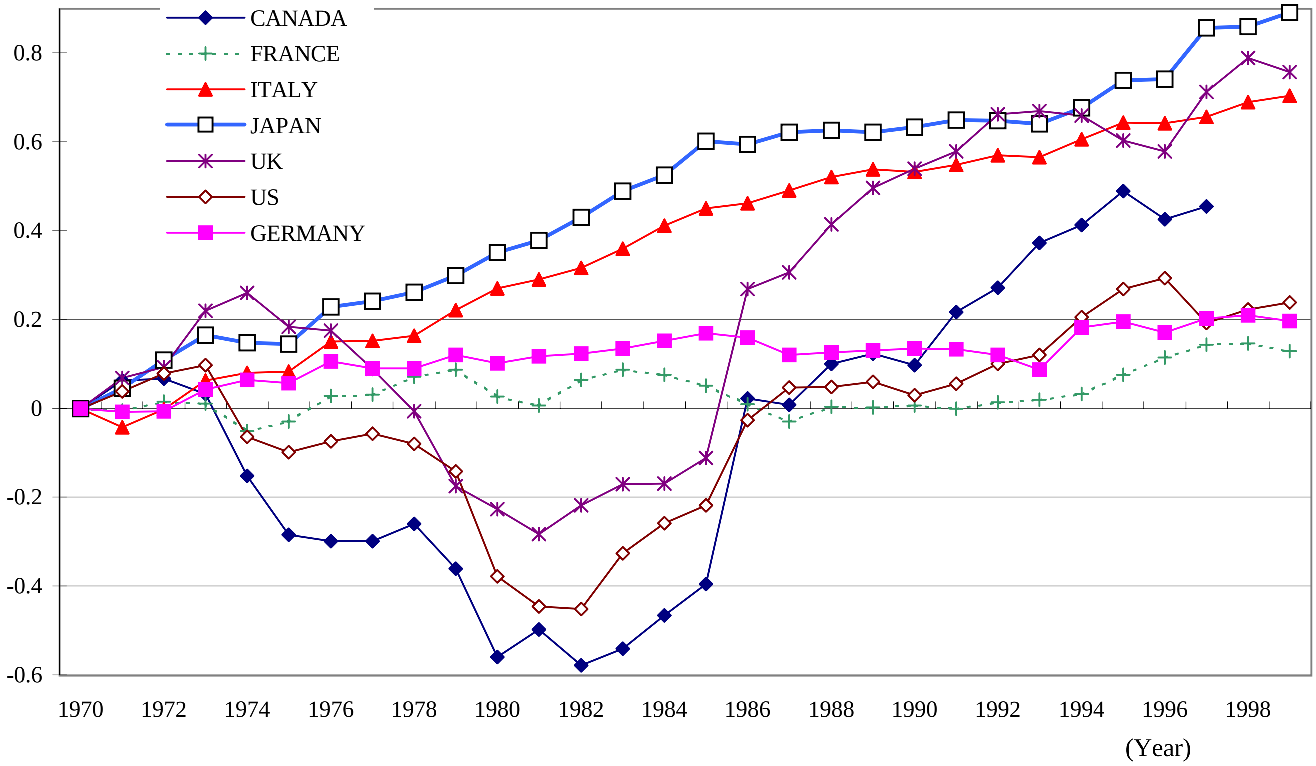
(in natural logarithm)



(Definition)
Relative price of nontradable goods: p_N-p_T
where
p_N: price of nontradable goods,
p_T: price of tradable goods.

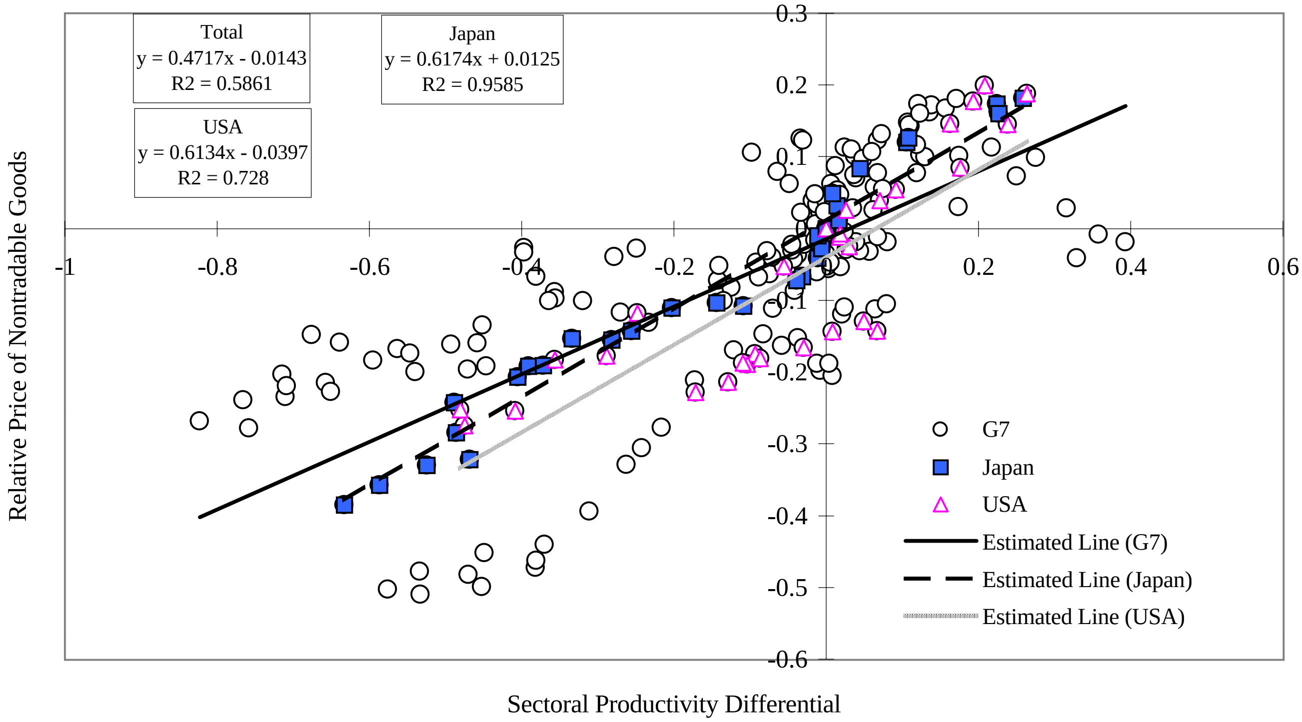
(Chart 5) Sectoral Productivity Differential for G7 countries

(in natural logarithm)



Note: The sectoral productivity differential is defined as the natural logarithm of tradable goods sector TFP (total factor productivity) relative to nontradable goods sector TFP.

(Chart 6) Relative Price of Nontradable Goods and Sectoral Productivity Differential for G7 Countries



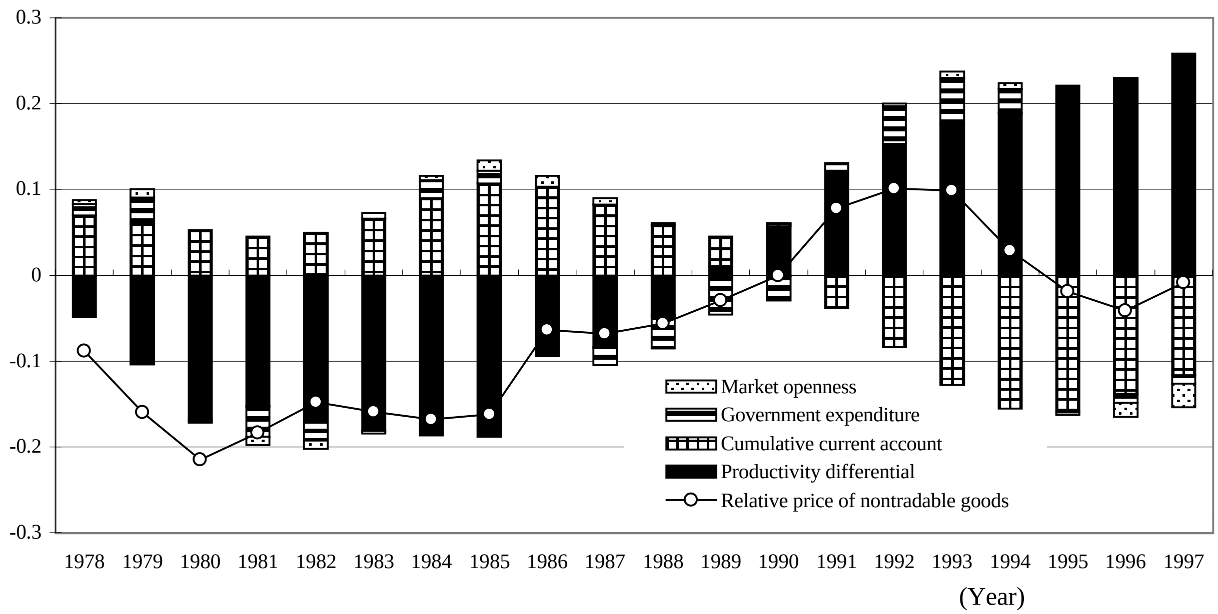
Notes:

(1) The relative price of nontradable goods is the natural logarithm of the nontradable goods price relative to the tradable goods price (p_N-p_T).

(2) The sectoral productivity differential is the natural logarithm of tradable goods sector TFP relative to nontradable goods sector TFP (a_T-a_N).

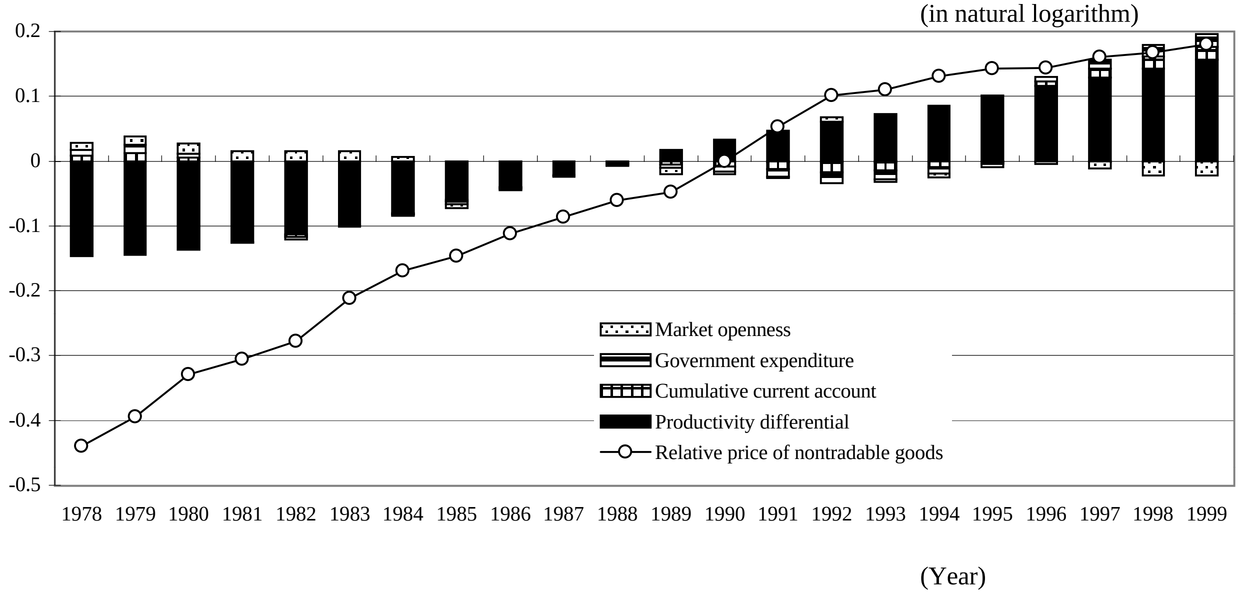
(Chart 7) Estimated Decomposition of the Relative Price of Nontradable Goods: Canada

(in natural logarithm)



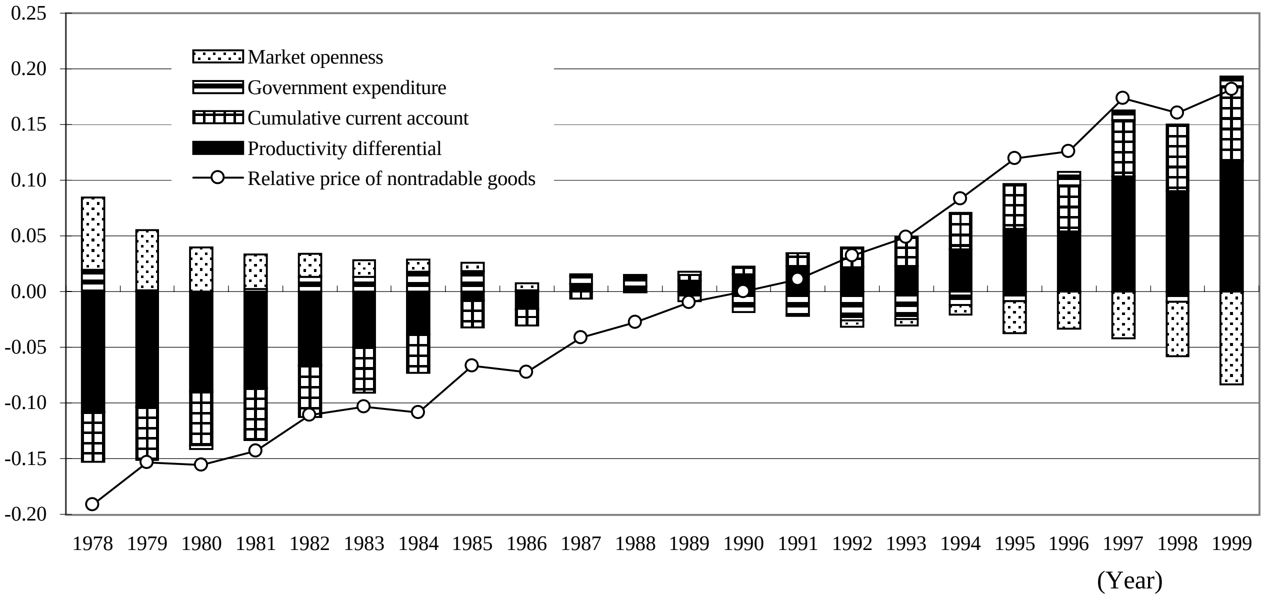
(Chart 8) Estimated Decomposition of the Relative Price of Nontradable Goods: Italy

(in natural logarithm)



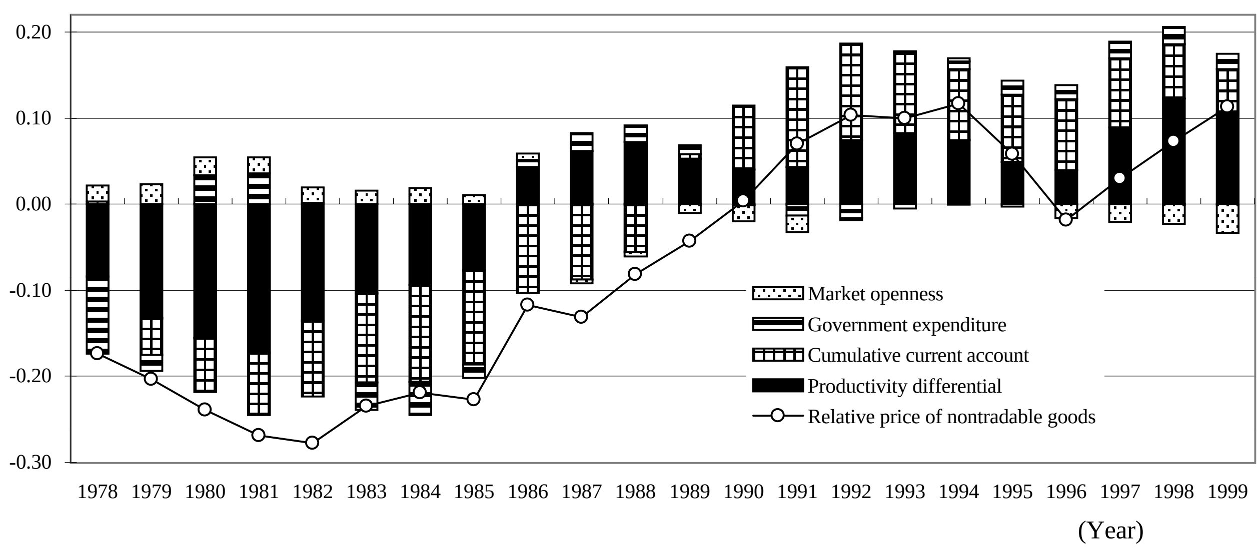
(Chart 9) Estimate Decomposition of the Relative Price of Nontradable Goods: Japan

(in natural logarithm)



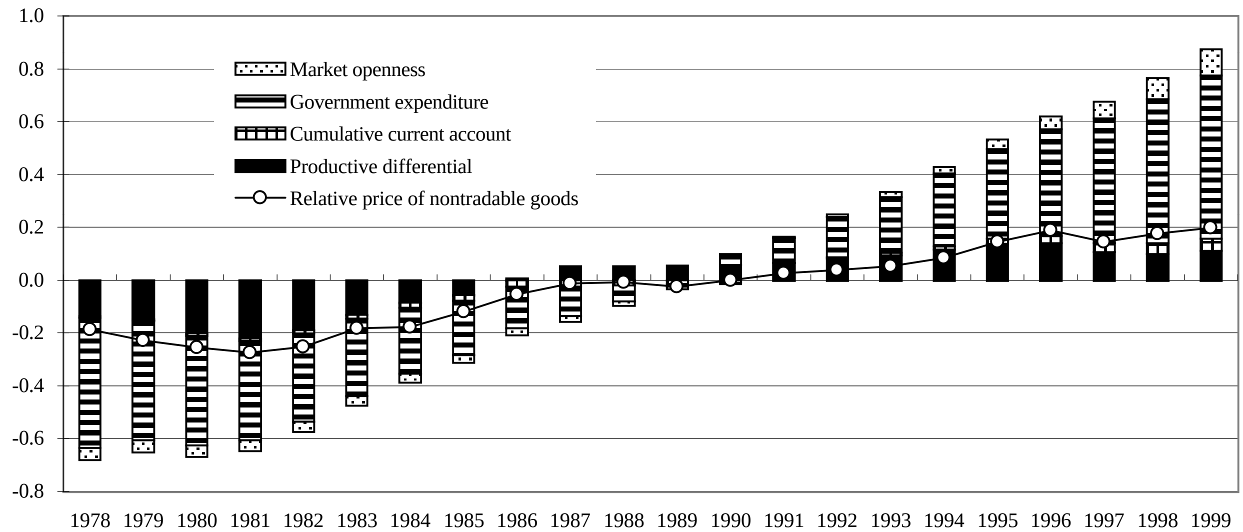
(Chart 10) Estimated Decomposition of the Relative Price of Nontradable Goods: UK

(in natural logarithm)



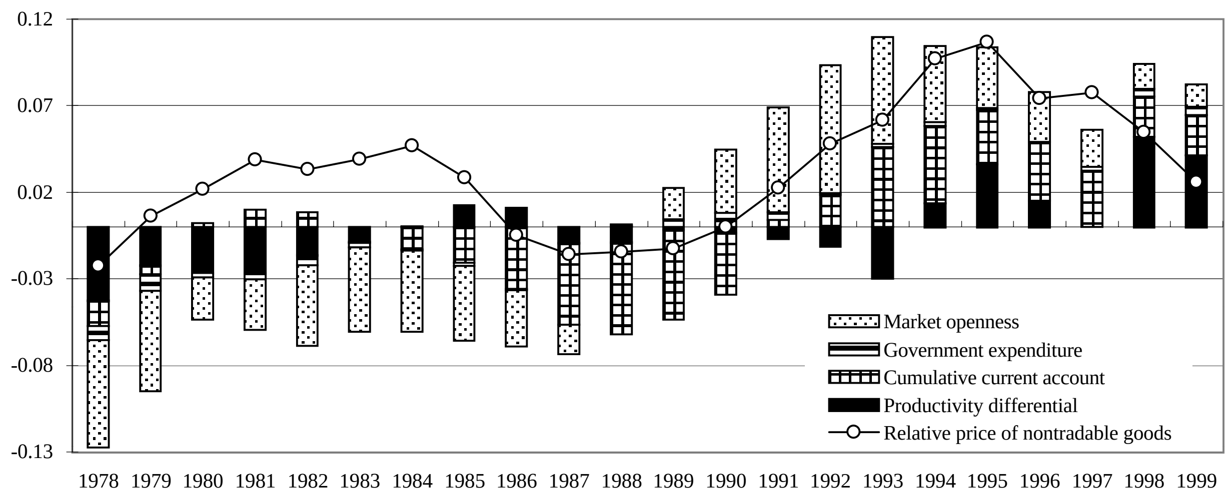
(Chart 11) Estimated Decomposition of the Relative Price of Nontradable Goods: US

(in natural logarithm)



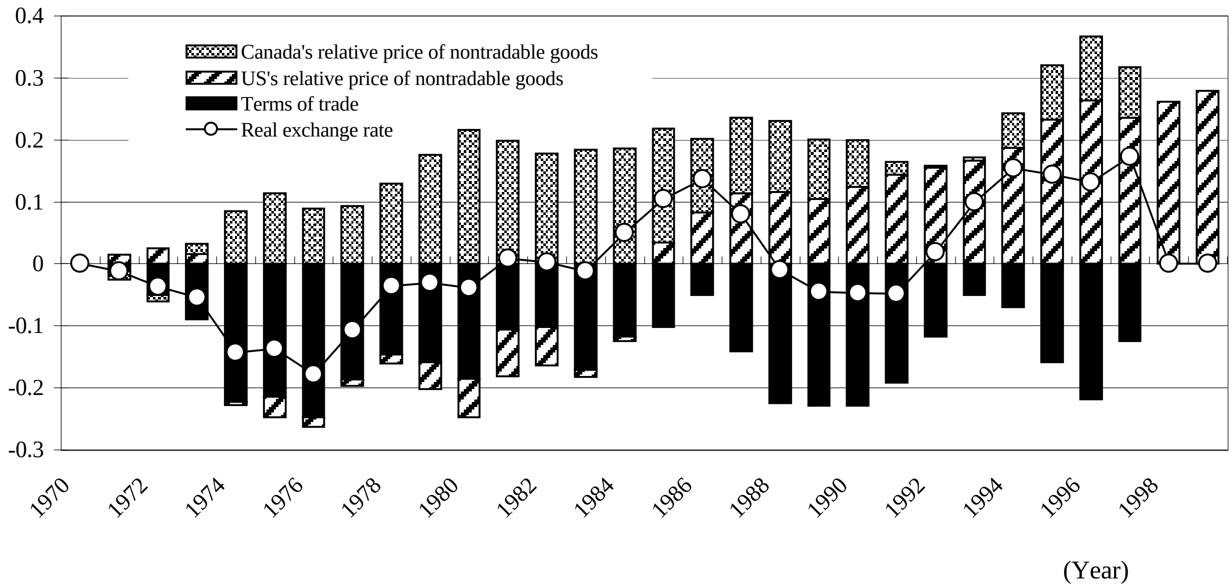
(Chart 12) Estimated Decomposition of the Relative Price of Nontradable Goods: Germany

(in natural logarithm)



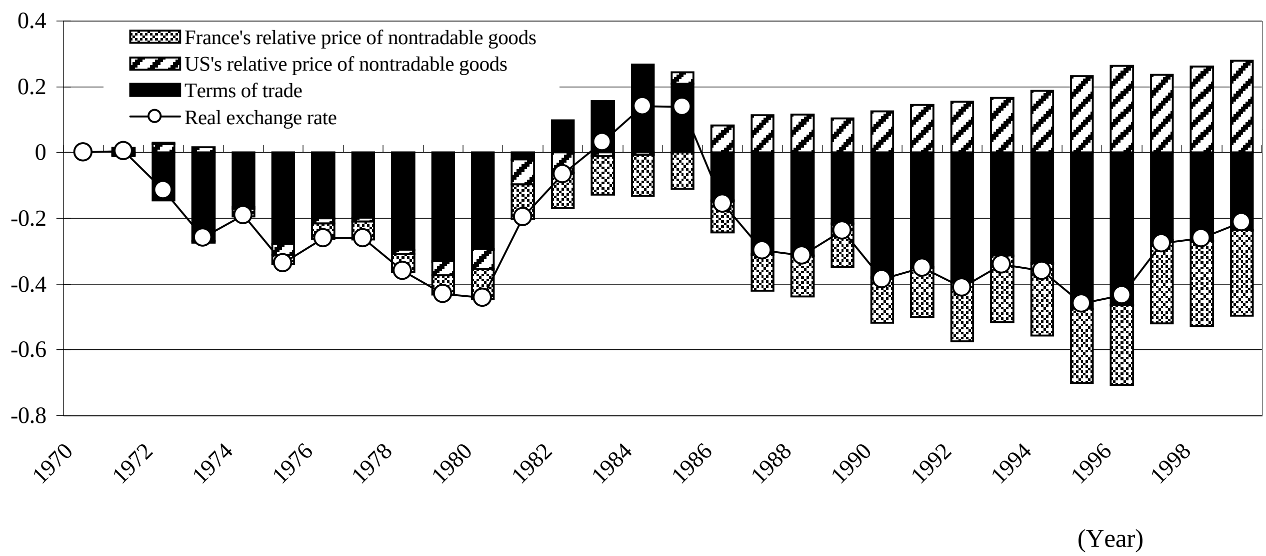
(Appendix Chart 1) Estimated Decomposition of the Real Exchange Rate: Canada

(Canadian-dollar/US dollar in natural logarithm)



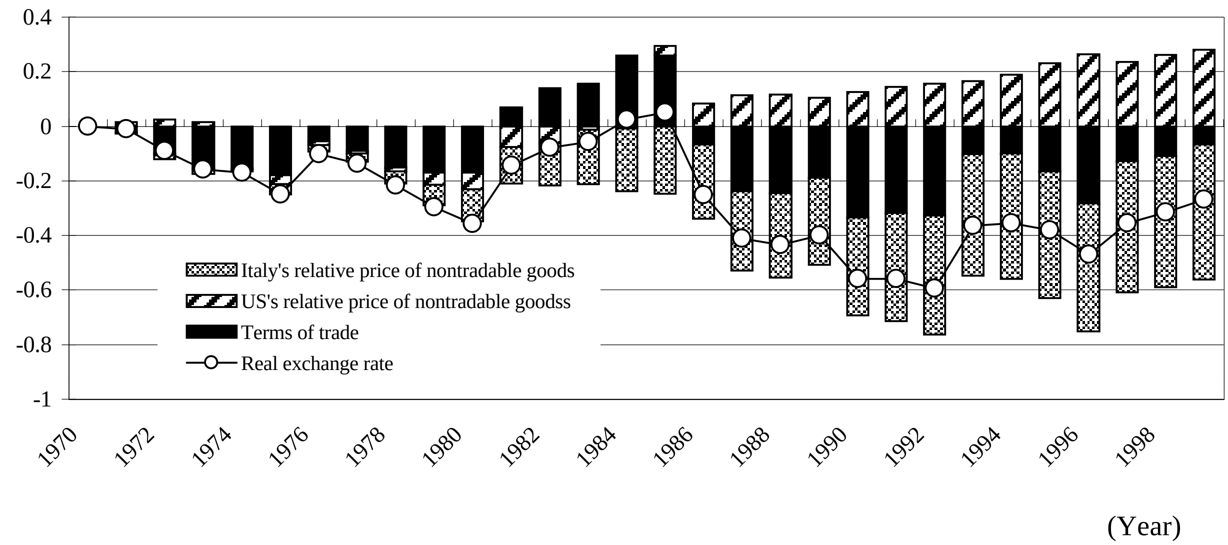
(Appendix Chart 2) Estimated Decomposition of the Real Exchange Rate: France

(French-franc/US-dollar in natural logarithm)



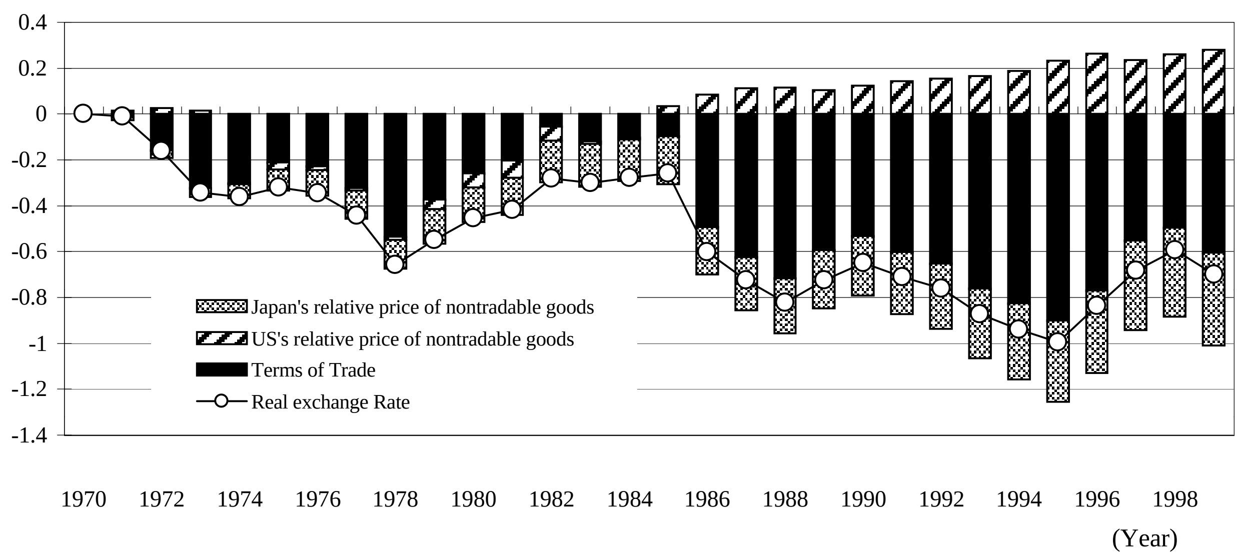
(Appendix Chart 3) Estimated Decomposition of the Real Exchange Rate: Italy

(Italian-lira/US-dollar in natural logarithm)



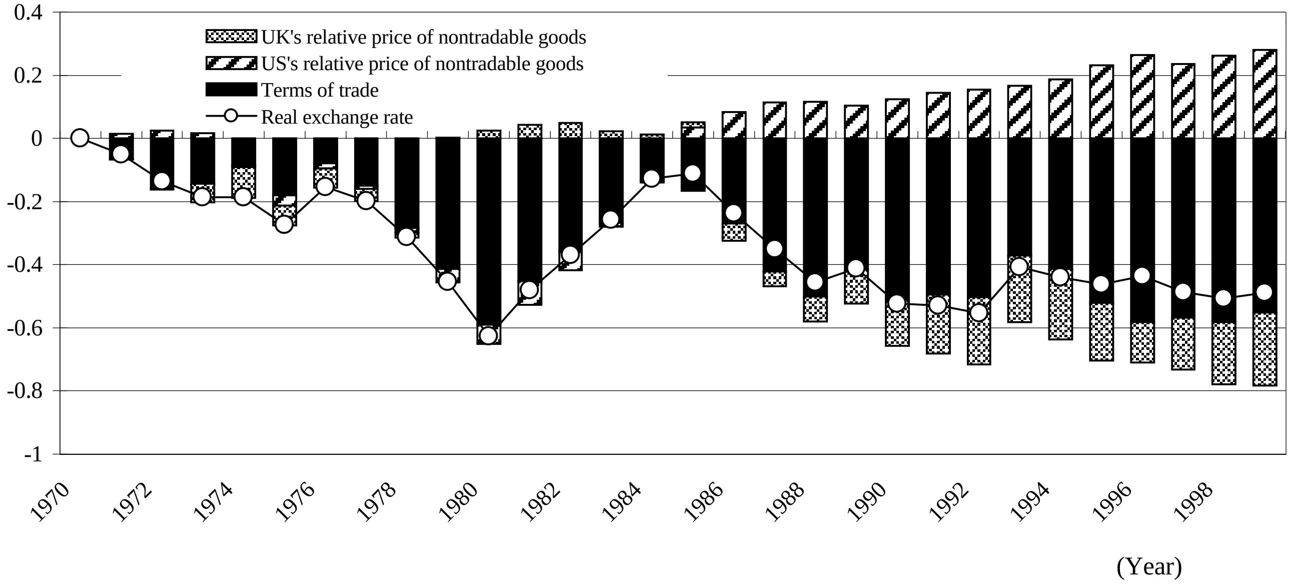
(Appendix Chart 4) Estimated Decomposition of the Real Exchange Rate: Japan

(Japanese-yen/US-dollar in natural logarithm)



(Appendix Chart 5) Estimated Decomposition of the Real Exchange Rate: UK

(UK pound/US-dollar in natural logarithm)



(Appendix Chart 6) Estimated Decomposition of the Real Exchange Rate: Germany

(Deutschemark/US-dollar in natural logarithm)