Understanding Japan's Import Dynamics[*]

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Abstract

Although trade elasticities are fundamental to the analysis of interaction between the economies of a country and the rest of the world, there is substantial uncertainty about the magnitude of the income and price elasticities of Japan's aggregate imports. This paper highlights several economic and statistical problems that render the standard aggregate import equation a poor description of Japan's import dynamics, and develops alternative models that accommodate such difficulties. Our empirical models substantially outperform the conventional model and provide more sensible elasticity estimates, although they are only able to explain a modest part of the sharp import decline between 2008 and 2009.

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1. Introduction

Between the middle of 2008 and early 2009, world trade experienced its steepest contraction in recorded history (Baldwin 2009). Japan was among the most serious casualties in this episode, with its nominal exports and imports falling by 49.2 and 43.0 percent, respectively, during the 12 months ending in February 2009. Although the decline in its imports was marginally milder than that in its exports, and was caused in part by collapsing world commodity prices, the real value of its imports also fell by 23.7 percent – the deepest contraction in its post-war history (Figure 1).

In Japan, while exports attract intense interest from both academic and policy circles, comparatively limited attention is paid to its imports. Nevertheless, the dynamic relationship between the economies of a country and the rest of the world cannot be fully understood without first understanding accurately how the amounts of its exports *and* imports are determined. Moreover, although the dynamics of Japan's exports can be explained reasonably well with conventional models, this is not the case for its imports. In fact, existing estimates of the income and price elasticties of Japan's aggregate imports are so varied and statistically fleeting that it is difficult to judge, for example, whether the recent import contraction was a natural response to its domestic recession or involved any additional factors.

This paper examines why the standard import equation does a poor job of describing Japan's aggregate imports and what should be done to obtain usable elasticity estimates. During the past quarter of a century, the composition of Japan's imports has shifted decisively from primary commodities and lightly manufactured industrial goods and to more advanced products, with several important implications for both short- and long-term relationships between the aggregate import volume and other macroeconomic variables. As will be discussed in this paper, modifying the standard import equation in a manner that accommodates these structural factors, and estimating this modified equation with a carefully constructed dataset, takes us a long way toward understanding the dynamics of

Japan's aggregate imports, although our model still cannot provide a full explanation of the import collapse during 2008–2009.

This paper is organized as follows. The next section reviews the reasoning behind the macroeconomic import demand function and the existing elasticity estimates for Japanese imports. Section 3 discusses issues that need to be considered when estimating Japan's import function, paying particular attention to implications of the increasing importance of manufactured imports. Sections 4 and 5 develop alternative import models and assess their empirical performance. The last section provides a conclusion.

2. Japan's aggregate import function: Theory and literature

2.1 Theoretical consideration

The amount of imports of a country is typically modeled as a function of domestic income and the relative price of imports and domestically produced goods. Let us first consider the following demand and supply schedules:

$$Q^d = Q^d\left(Y, S; Z^d\right), \qquad S = P^m / P, \tag{1}$$

$$Q^s = Q^s\left(R; Z^s\right), \qquad R = P^m / P^w. \tag{2}$$

where Q^d and Q^s represent the demand for and the supply of the real imports of a particular country, respectively. In eq. (1), Y stands for domestic income or absorption, whereas S denotes the real exchange rate defined as the relative price of imports (P^m) and domestically produced goods (P). In eq. (2), R denotes the relative price of imports at home (P^m) and of equivalent goods in other countries (P^w). Lastly, Z^d and Z^s represent (vectors of) other factors that shift the demand and the supply schedules. Although the identities of P^m and P require further elaboration, this discussion will be postponed to Section 3.

If foreign exporters do not engage in pricing to market, P^m always equals P^w and hence $Q^s = Q^s\left(1; Z^s\right) = \tilde{Q}^s\left(Z^s\right)$. Under such circumstances, there are two possibilities concerning how the equilibrium volume of imports is determined:

$$\begin{aligned}
&\text{(A)}\quad Q^d\left(Y,S;Z^d\right)<\tilde{Q}^s\left(Z^s\right) \quad \to \quad Q^*=Q^d\left(Y,S;Z^d\right),\\
&\text{(B)}\quad Q^d\left(Y,S;Z^d\right)\geq\tilde{Q}^s\left(Z^s\right) \quad \to \quad Q^*=\tilde{Q}^s\left(Z^s\right).
\end{aligned}$$

In (A), the equilibrium import volume Q^* is determined by the demand schedule since the supply schedule is not binding at the ongoing values of Y and S. This case is plausible for primary goods and other homogeneous products for which the global supply capacity typically exceeds the demand of any specific country. Meanwhile, in (B) the import volume is constrained by the foreign supply capacity and has no direct bearing on Y and S; this case may be relevant for the type of goods for which taste varies across countries and/or for which the home country has strong technological advantage.

At the level of individual goods both (A) and (B) are equally pertinent, and certain products may even switch between these two cases. Therefore, when considering a model for the *total* import volume of a country, it is natural to combine these two cases and assume the following general function:

$$Q^*=Q^*\left(Y,S;Z\right), \tag{3}$$

where Z^d and Z^s are now merged into a single vector Z to save notations. Note that eq. (3), which describes how the *equilibrium* volume of aggregate imports is determined, is functionally equivalent to eq. (1). This is apparently why most existing studies estimate what corresponds to eq. (3) and call it the import *demand* function. It should be remembered, however, that eq. (3) incorporates supply-side factors as part of Z.

Even if eq. (3) is a correct description of how the equilibrium import volume is determined, the actual volume of imports can deviate from this equilibrium value because of numerous behavioral and institutional rigidities. To the extent that this is the case, it is necessary to distinguish the actual and the equilibrium volumes of imports, and relate the former to the current and past values of Y and S:

$$Q_t=Q\left(Y_t,Y_{t-1},Y_{t-2},..,S_t,S_{t-1},S_{t-2},...;Z_t\right), \tag{4}$$

where all subscripts refer to time. This is the fundamental aggregate import equation that underpins practically all empirical works.

In practice, eq. (4) is manipulated further before subjecting it to empirical analysis. For example, when the variables in eq. (4) are non-stationary and collinear, it may be more desirable to rewrite it in the first-difference form:

$$\Delta Q_t = Q\left(\Delta Y_t, \Delta Y_{t-1}, \Delta Y_{t-2}, .., \Delta S_t, \Delta S_{t-1}, \Delta S_{t-2}, ...; \Delta Z_t\right). \tag{5}$$

Or alternatively, if one wishes to fully utilize the information contained in eq. (3), one may interpret eq. (4) as saying that the observed change in the import volume in each period reflects the contemporaneous and past movements of the explanatory variables, as well as the gap between the actual and the equilibrium levels of imports. Then one may rewrite eq. (4) as follows:

$$\Delta Q_t = Q\left(\Delta Y_t, \Delta Y_{t-1}, \Delta Y_{t-2}, .., \Delta S_t, \Delta S_{t-1}, \Delta S_{t-2}, ..., Q_{t-1} - Q^*_{t-1}\right). \tag{6}$$

The majority of recent studies estimate variants of eqs. (3) and (6), either in sequence or in a single step, using cointegration or other time-series techniques. As discussed below, however, this standard approach does not produce satisfactory results for Japan’s aggregate imports.

2.2 Literature on Japan’s aggregate import function

Table 1 summarizes recent studies on Japan’s aggregate import equations. While both the method of estimation and the result vary from one study to another, there are some recurrent features that are worth noting.

The first and most salient feature of the existing studies is that they often fail to identify the long-run equilibrium relationship in eq. (3). For example, Hamori and Matsubayashi (2001) find no evidence for cointegration among Japan’s real imports, real GDP, and the real exchange rate defined as the ratio of the import and the GDP deflators, even when the possibility of a discrete structural change is taken into account. Similarly, Tang (2008) tests for cointegration among the above three variables, using rolling regression techniques and experimenting with specifications with and without a deterministic time trend. According to his analysis, a unique cointegrating vector is detected only for limited periods, and the estimated vector is sensitive to even a minor change in the estimation period. In an unpublished Appendix to this paper, I update Tang's (2008) analysis using a few alternative datasets. As in Tang (2008), cointegration is only supported for limited cases, and with highly unstable cointegration vectors.

Among other studies, the Economic Planning Agency (EPA) of the Japanese government (2000) experiments with an import equation that has the stock of outward Foreign Direct Investment (FDI) as an additional regressor. The EPA's estimation is motivated by the view that outward FDI represents Japanese firms' external relocation of manufacturing activity, which tends to replace domestic production by imports and serves as a positive shock in eq. (3). While such effects are widely recognized, the EPA's model does not perform well for the 2000s, presumably because of changing purposes of Japanese firms' outward FDI.[1] The above results suggest that Japan's imports are subject to frequent structural shocks that are too complicated to be approximated by discrete regime shifts or a specific variable.

Second, the existing literature is particularly ambiguous about the relationship between imports and the real exchange rate. For example, the estimated long-run price elasticity of imports varies between -2.0 and +0.6. As discussed in the Appendix, this long-run elasticity is in fact extremely sensitive to the choice of the estimation period and often theoretically inconsistent. Furthermore, the short-run elasticties estimated by the existing studies tend to be small and statistically insignificant. While not shown here, some of these studies report much larger price elasticities for Japanese exports, an important asymmetry that begs an explanation.

Third, whereas the existing studies often discuss the method of estimation at length,

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[1] Recent FDI by Japanese firms includes a number of strategic M&A deals that have little to do with imports; see Kumakura (2009) for a further discussion.

they pay relatively little attention to the choice of data used for their empirical analysis. A number of studies build their dataset entirely from the Systems of National Accounts (SNA) statistics, and do not discuss whether doing so is really appropriate. As will be discussed in the next section, however, even a cursory look at this data suggests that this is not the case.

3. Why does the standard equation fail to explain Japan's import dynamics?

This section investigates the source of the apparent difficulty of estimating Japan's import function by examining a series of related statistics. We start with structural factors that influence the long-run relationship between the import volume and other macroeconomic variables, and then proceed to factors that are more relevant to the dynamics of import flows.

3.1 Changing composition of imports

As shown in Figure 2, unprocessed primary commodities accounted for about 80 percent of Japan's imports in the early 1980s. During the following decade and a half, the share of these primary goods fell sharply because of accelerated growth in manufactured imports.[2] Moreover, although Japan's manufactured imports were traditionally dominated by those from the United States and Europe, the rapid increase in manufactured imports during this period has been driven primarily by those from other East Asian countries. In Figure 2, we also notice that the shares of the manufacturing industry in Japan's GDP and employment started falling decisively in the early 1990s.

Figure 3 plots how the relative size of the real imports to GDP has evolved during the past quarter of a century. Although this imports-to-GDP ratio has remained fairly stable for foodstuffs and mineral fuels, it has fallen measurably for raw materials whilst rising rapidly for manufactured goods.[3] The contrasting trends for the latter two product categories clearly reflects the fact that some of the manufactured goods that were traditionally produced at

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[2] The slight decline in the share of manufactured goods during the mid-2000s has been a temporary phenomenon caused by price hikes of petroleum and other commodities.

[3] Manufactured goods in this figure include both final and intermediate products.

home using imported raw materials have been replaced by imported manufactured goods. The rapid increase in the imports-to-GDP ratio for manufactured goods is also reflected in the upward drift of the ratio between aggregate imports and GDP.

In Figure 3, there is also difference in the short-run behavior of the imports-to-GDP ratio among the major product groups. The imports-to-GDP ratios for foodstuffs and mineral fuels are relatively stable both in the short and the long runs, which is remarkable given the enormous volatility of their prices. On the other hand, the imports-to-GDP ratio for manufactured goods has been subject to more pronounced medium-term fluctuations, falling measurably in, for example, the late 1990s and 2002. Moreover, during the recent global trade crisis the manufacturing imports-to-GDP ratio has fallen sharply whilst those for foodstuffs and mineral fuels have remained largely unchanged.

Table 2 shows the evolution of the composition of manufactured imports during the past three decades and its relationship with domestic output and consumption. As shown in the top panel, the shares of resource-intensive goods and industrial semi-manufactures, such as food, fuels and metals, have been in decline whereas those of more advanced products, such as machinery and equipment, have risen measurably. However, even among the latter there are considerable variations, with the share of electronic products having grown particularly rapidly.

The other two panels describe the import penetration ratio (imports/domestic demand) and the export dependency ratio (exports/domestic output) for individual industries and product groups. For the manufacturing industry as a whole, these ratios were low and stable during the 1980s but have since risen noticeably. The magnitudes of these ratios, however, vary considerably among individual industries. Of particular interest is the fact that in some industries, such as electronics, the import penetration and the export propensity ratios have simultaneously increased sharply during the 1990s, which contradicts what one would expect from comparative advantage-based trade theories. This is particularly the case for semiconductor devices and electronic integrated circuits (ICs), whose import penetration and export propensity ratios stand in 2006 at an impressive 78.5 and 85.9 percent, respectively.

This observation suggests that the recent increase in the share of manufactured goods in Japanese imports reflects not only Japanese firms' deteriorating international competitiveness but also increasing specialization *within* individual industries.[4]

3.2 Import competition and the real exchange rate

The increased importance of manufactured imports has implications not only for the relationship between Japan's aggregate imports and domestic absorption but also for the role of the real exchange rate in the import equation. To understand why this is the case, let us return to eqs. (3) and (6) and examine the meaning of S and ΔS in these equations more carefully.

In Section 2, it was merely stated that S was the relative price of imports (P^m) and domestically produced goods (P). Depending on the precise definition of P, however, S can be interpreted in two different ways. First, if we assume that the low of one price (LOOP) holds for all traded goods and define P as the price level in the domestic non-tradable sector, S will represent the relative price of tradable and non-tradable goods. It then follows logically that the coefficient of S in the import demand equation represents the elasticity of substitution between these two mutually exclusive product groups. However, one can also assume that the LOOP does not hold, particularly over relatively short time horizons, because foreign and domestic goods are partially differentiated. Under such circumstances, if P is defined as the price of domestic *tradable* products, S will represent the relative price of foreign and domestic tradables, with its coefficient representing the elasticity of substitution between imported and domestic goods *within* the same tradables sector.

The majority of the existing studies calculate S using one of the following two methods. The first method is to use SNA statistics and to measure P^m and P in terms of its import and GDP deflators, respectively. The other method is to use price indexes compiled by the Bank of Japan (BOJ) and to calculate S as the ratio of its Import Price Index (IMPI) and Domestic

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[4] Recent studies stress that such specialization takes place not only among products and product varieties but also across different *stages* of manufacturing a particular good; see Baldwin (2009).

Corporate Goods Price Index (DCGPI). Since Japan's GDP deflator primarily reflects wages and service prices, there is little doubt that the former real exchange rate represents the relative price of tradables and non-tradables. On the other hand, since DCGPI summarizes the prices of goods traded between domestic firms and in principle excludes services, one would be inclined to interpret the latter exchange rate as an index of the relative price competitiveness of foreign and domestic tradables. Although the existing studies do adopt this interpretation, a closer look at data suggests that it is not appropriate.

IMPI and DCGPI are computed as geometric averages of the prices of hundreds of products, whose list and respective weights in each index are revised every five years. The goods represented in IMPI and DCGPI are by no means identical, since the commodity compositions of Japan's imports and domestic output are very different. To examine how similar their product compositions are, I have made a list of goods that were included in both indexes for all base years after 1980, and have calculated the collective weights of these products in each index. The result is presented in Table 3.

According to Table 3, in 1980 and 1985 the shares of the products represented in both IMPI and DCGPI were fairly small. This is not surprising since, as discussed above, until the mid-1980s Japan's imports were dominated by mineral fuels and primary commodities that were barely produced at home. Although the share of common goods in IMPI has since risen markedly, their share in DCGPI has increased only modestly, reflecting the fact that manufacturing goods produced and traded within Japan are much more varied than those imported from abroad. This observation suggests that the ratio between IMPI and DCGPI does not necessarily provide a good measure of the price competitiveness between imported goods and their domestically produced *substitutes*.

This last point can be ascertained in Figure 4. This figure plots four alternative series of S, of which two are the conventional real exchange rates discussed above. Among the other two series, one is computed as the ratio of IMPI to the BOJ's Corporate Services Prices

Index (CSPI),[5] a more direct measure of the relative price of imported tradables and domestic non-tradables than the ratio of the import and the GDP deflators. The last series, denoted "IMPI/DCGPI (adjusted)", is computed as follows. Since the BOJ provides the time series for the prices of individual products included in IMPI and DCGPI, I have recompiled these two indexes using only the data for goods included in both indexes and taking the weighted average of their prices. The weight of each item is the same for the two recompiled indexes and based on its weight in the original IMPI. "IMPI/DCGPI (adjusted)" is the ratio of the IMPI and the DCPGI that are recompiled in this manner, and aims to represent as closely as possible the relative price of imported goods and *similar* goods produced at home.

In Figure 4, "Import deflator/GDP deflator" and "IMPI/CSPI" are barely distinguishable, confirming our previous reasoning that the former should be regarded as the relative price of imports and domestic non-tradables. More interesting is the fact that the time series of "IMPI/DCGPI" looks much closer to those of "Import deflator/GDP deflator" and "IMPI/CSPI" than to that of "IMPI/DCGPI (adjusted)". This is in part because the numerators of the first three exchange rates are highly sensitive to fluctuations in nominal exchange rates and the international prices of primary commodities, and in part because their denominators, which either represent domestic service prices or are influenced heavily by the prices of manufacturing goods with high service contents, are relatively insensitive to such external developments.

According to the above observation, both "Import deflator/GDP deflator" and "IMPI/DCGPI" are influenced heavily by the yen prices of mineral fuels and other primary commodities. However, the imports-to-GDP ratio for these primary commodities is fairly stable both in the short and the long runs, suggesting that the demand for these goods is not particularly price sensitive (Figure 3). To the extent that this is the case, it is not surprising that the existing literature, which features either of the above two exchange rates, finds little systematic relationship between aggregate imports and the real exchange rate. It should be

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[5] The CSPI used here excludes international transportation so as to exclude price movements originating from abroad.

noted, however, that this does not necessarily mean that relative prices are irrelevant to the dynamics of Japan's aggregate imports. Since commodity overlaps between imported and domestically produced manufactured goods have been growing, the impact of their relative prices on the aggregate import volume may also be rising, an issue that will be investigated in Section 5.

3.3 Dynamics of aggregate and sectoral imports

The existing literature on Japan's import equations leaves considerable uncertainty not only about the long-run equilibrium relationship among the relevant variables but also about their short-run relationships. This subsection discusses some additional issues that need to be addressed when estimating dynamic import equations such as eqs. (5) and (6).

As shown in Table 1, most existing studies conduct their estimation using quarterly (three-monthly) data. When measured in terms of standard statistics, however, the quarterly growth rates of the variables that enter eqs. (5) and (6) are highly volatile. As an illustration, Figure 5[A] plots two series of the (annualized) quarterly growth rates of real imports, computed from seasonally adjusted statistics of the Ministry of Finance (MOF) and the BOJ.[6] As is apparent in this panel, Japan's aggregate imports are subject not only to medium-term swings but also to considerable quarter-by-quarter fluctuations. This appears to reflect the facts that, whereas the composition of Japan's imports has become more varied in recent years, they are still more concentrated in a narrower range of products than are its exports, and that these goods include those whose transactions are particularly volatile.[7] The fact that Japanese imports are more unstable than its exports is also apparent in Figure 1[B].

Figure 5[B] plots the quarterly growth rates of Japan's real GDP and domestic demand,

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[6] The gap between the MOF and BOJ series are due in part to different exchange rates used to calculate yen values of imports, and in part to the manner in which these values are deflated and aggregated into a single volume index.

[7] For example, Japan's exports of transport equipment are composed primarily of automobiles that are shipped in accordance with a regular schedule, whereas its imports include such big-ticket items as aircraft, whose imports tend to be highly irregular.

both calculated from SNA statistics. Their growth rates are also highly irregular on the quarterly basis, so much so that it is difficult to identify more important cyclical components. Although parts of these irregularities may represent genuine macroeconomic fluctuations, this is clearly not the whole reason. As is widely known, the manner in which Japan’s SNA statistics are compiled deviates substantially from the international norm recommended by the United Nations. While the Japanese government has recently expended considerable efforts on improving its statistics, its quarterly GDP data still seems to contain substantial statistical noise, a problem that naturally becomes more serious as we look farther back into the past. This observation raises questions about the accuracy of the existing studies, which often employ unprocessed quarterly data that encompass a long period of time.

Apart from this statistical problem, estimating dynamic import functions raises other more substantive issues. In particular, whereas the standard aggregate import demand function only comprises macroeconomic variables, it is conceivable that the short-run behavior of aggregate imports is influenced by transitory microeconomic factors, such as demand and/or supply shocks that are specific to a particular industry or product. In Japan, this seems to be a genuine possibility since, as noted above, the content of its imports is less varied than its exports.

To examine this possibility, let us consider the following industry-specific import equation:

$$\Delta q_{i,t} = \alpha + \sum_{j=1}^{k} \beta_j \Delta q_{i,t-j} + \sum_{j=0}^{k} \gamma_j \Delta y_{t-j} + \lambda t + \varepsilon_t, \qquad i = 1, 2, \ldots, n, \tag{7}$$

where $q_{i,t}$ stands for the natural logarithm of the real imports of product group or industry *i*, y_i denotes the log of real GDP, and *t* and ε_t are the linear time trend and the error term, respectively. This simplified import equation is estimated to assess the relative importance of the macroeconomic business cycle and other idiosyncratic factors as determinants of the import dynamics of individual industries. Since neither the MOF nor the BOJ provide real import statistics disaggregated for detailed industries, the present equation is conducted with import volume data provided by the Ministry of Economy, Trade and Industry (METI) as part of its *Indices of Industrial Domestic Shipments and Imports*. The period of estimation is 16 years between 1992Q3 and 2008Q2, except for the information and communication equipment industry and the electronic parts and components industry for which the starting period is 1998Q3 due to data limitation.

The result is presented in Table 4.[8] The first line in this table reports the result for all manufactured imports. In this regression, the coefficients of Δy_t and Δy_{t-1} are positive and statistically significant, suggesting that the volume of manufactured imports *as a whole* does respond to the macroeconomic business cycle in the expected manner. Among the two lagged dependent variables, $\Delta q_{i,t-1}$ is not statistically significant but has a negative coefficient, whereas $\Delta q_{i,t-2}$ is significant and has a positive coefficient. This result appears to arise primarily from the high quarterly variability of Japanese imports witnessed in Figure 5[A], which would tend to make the dependent variable negatively correlated to its value in the previous quarter but positively correlated with its value two quarters ago. By looking down Table 4, we find that the negative relationship between the regressand and $\Delta q_{i,t-1}$ is particularly salient for non-ferrous metals and transport equipment, whereas the positive relationship between the regressand and $\Delta q_{i,t-2}$ is most prominent in textiles. While not shown here, the quarterly import growth rates of these industries are particularly erratic, suggesting that the statistical significance of $\Delta q_{i,t-1}$ and/or $\Delta q_{i,t-2}$ in their equations reflects this short-run irregularity rather than economically meaningful industry dynamics.[9]

A closer look at Table 4 also reveals other more interesting information. In the equation for the entire manufacturing sector, the coefficient of $\Delta q_{i,t-1}$ is much smaller in absolute value and estimated less precisely than that of $\Delta q_{i,t-2}$, a puzzling asymmetry if these coefficients merely reflect high quarter-by-quarter fluctuations in the import volume. However, this is not particularly odd if the import dynamics of one or more industries have

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[8] While the regressions in this table limit the lag length to two quarters, adding further lags makes no material difference in the estimation result.

[9] When these equations are estimated with semi-annual data, the majority of the lagged regressands cease to be significant.

large autonomous components that persist for more than three months. Under such circumstances, a negative correlation between $\Delta q_{i,t}$ and $\Delta q_{i,t-1}$ in certain industries would be counteracted by a positive correlation in other industries, making the relationship between these two variables at the aggregate level less straightforward.

In this connection, it is interesting to note that among the 15 manufacturing industries examined here, the result for the electronics parts and components industry differs markedly from those for the other industries. In the equation for the former industry, the coefficient of $\Delta q_{i,t-1}$ is positive and highly significant whereas neither Δy_t nor Δy_{t-1} is significant. Moreover, the fit of this equation is substantially better than those for the other 14 industries, as evidenced by its relatively high R^2. This result suggests that at least over relatively short time horizons, the imports of electronic parts and components are influenced more heavily by factors intrinsic to this industry than from the macroeconomic business cycle. Incidentally, the most volatile segment of the imports of electronic parts and components include such items as semiconductor devices and electronic ICs, whose domestic market is highly exposed to external developments (Table 2).

The peculiarity of the import dynamics of electronic parts and components is also apparent in Figure 6. In this figure, the correlation coefficients for the quarterly growth rates of the real imports and exports of individual industries are plotted against the correlation coefficients for the growth rates of their real imports and domestic shipments. In this figure the electronic parts and components industry is a clear outliner, with the growth rate of its imports highly synchronized with those of its domestic shipments and, in particular, exports. In other industries, the growth correlation between imports and exports is much more tenuous or even negative, as should be the case if the dynamics of imports and exports were governed primarily by domestic and foreign business cycles, respectively. Among the other 14 industries, the correlation between imports and exports is relatively high in the information and communication equipment industry, another important segment of the broader electronics industry that makes intensive use of semiconductor devices and other electronic components. According to Figure 6, the electronic parts and components industry appears to be an important factor behind the positive correlation between the imports and the exports of the whole manufacturing sector.

4. Estimation strategy

With the above analysis in mind, the rest of this paper formally estimates Japan's aggregate import functions. This section develops our econometric framework and dataset. The estimation result will be presented in Section 5.

4.1 Econometric framework

According to the previous analysis, a key to the successful estimation of Japan's aggregate import equation is to properly control for structural shocks that affect the long-term relationship between the import volume and other macroeconomic variables. While the complexity of these structural shocks and their underlying causes suggests that they are unlikely to be captured by one or two variables, augmenting the estimating equation with a long list of variables would make estimation difficult and diminish the value of the estimated equation as a succinct description of aggregate import dynamics. Therefore, this paper opts to control for these structural factors using the following less conventional method.

Let us first return to the equilibrium relationship in eq. (3). This equation has as its arguments Y, S and Z, of which the last variable is supposed to subsume all relevant structural shocks. As shown in Figure 3, Japan's aggregate imports have grown much faster than its domestic economy, and this upward drift in the aggregate imports-to-GDP ratio has proceed in tandem with changes in the composition of its imports. Moreover, there is little evidence of substitution between imported primary commodities and domestic non-tradables, suggesting that their relative price is not very relevant to the equilibrium equation. While the relative price of imported goods and *similar* domestic goods may be relevant, this price has remained comparatively stable during the past three decades (Figure 4), and is therefore likely to have had at best limited effects on the equilibrium volume of imports.

With the above reasoning in mind, we delete *S* from eq. (3) and rewrite this equation as follows:

$$Q_t^* = Y_t \times \hat{Q}\left(Z_t\right), \tag{8}$$

which states that the *equilibrium* imports-to-GDP ratio, Q_t^* / Y_t, depends solely on structural factors. By inverting $\hat{Q}\left(Z_t\right)$, we can express eq. (8) alternatively as:

$$Z_t = Z\left(\frac{Q_t^*}{Y_t}\right). \tag{9}$$

This equation suggests that Q_t^* / Y_t can be used as a proxy for Z_t, provided that $Z\left(\bullet\right)$ is a monotonic and reasonably well-behaved function.

However, since Q_t^* is an unobservable quantity, Q_t^* / Y_t must be estimated in some way. The *actual* ratio of imports to GDP, Q_t / Y_t, is observable but clearly subject to temporary fluctuations unrelated to structural factors (Figure 3). Therefore, we write the log of Q_t / Y_t as qy_t and assume that the latter comprises the following two components:

$$qy_t = qy_t^T + qy_t^C, \tag{10}$$

where qy_t^T and qy_t^C represent, respectively, the permanent (trend) component and the transitory (cyclical) component of qy_t. If we accept qy_t^T as a proxy for $\ln\left(Q_t^* / Y_t\right)$, the previous reasoning implies that it also serves as a proxy for $z_t = \ln Z_t$. Moreover, if we let $q_t = \ln Q_t$ and $q_t^* = \ln Q_t^*$, it follows that $q_t - q_t^* = qy_t - qy_t^T = qy_t^C$ so that we can approximate the gap between the actual and the equilibrium import volumes by qy_t^C. Doing so obviates the need for explicitly estimating the long-run relationship in eq. (3) and lets us concentrate on investigating the short- to medium-term dynamics of import flows, which tend to be more important for applied research.

We consider two versions of the dynamic import model. Let us modify the logarithmic versions of eqs. (5) and (6) as follows:

$$\Delta q_t = q\left(\Delta y_t, \Delta y_{t-1}, ..., \Delta s_t, \Delta s_{t-1}, ..., \Delta it_t, \Delta it_{t-1}, ..., \Delta qy_t^T\right), \tag{11}$$

$$\Delta q_t = q\left(\Delta y_t, \Delta y_{t-1}, ..., \Delta s_t, \Delta s_{t-1}, ..., \Delta it_t, \Delta it_{t-1}, ..., qy_{t-1}^C\right), \tag{12}$$

where Δz_t and $q_{t-1} - q_{t-1}^*$ are replaced by Δqy_t^T and qy_{t-1}^C, respectively. These equations also include the new explanatory variables Δit_t, $\Delta it_{t-1}, ...$, which control transitory effects arising from the electronics parts and components industry (see below).

Finally, by assuming linearity among the variables in eqs. (11) and (12) and imposing additional restrictions on their relationships, we specify the following empirical models:

$$\Delta q_t = \alpha_0 + \alpha_1 \Delta y_t + \alpha_2 \Delta s_t + \alpha_3 \Delta it_t + \alpha_4 \Delta q_{t-1} + \alpha_5 \Delta qy_t^T + \varepsilon_t, \tag{13}$$

$$\Delta q_t = \alpha + \sum_{j=0}^{k} \beta_j \Delta y_{t-j} + \sum_{j=0}^{k} \gamma_j \Delta s_{t-j} + \sum_{j=0}^{k} \lambda_j \Delta it_{t-j} + \sum_{j=1}^{k} \delta_j \Delta q_{t-j} + \theta qy_{t-1}^C + \varepsilon_t. \tag{14}$$

The first equation is a simple partial adjustment model (PAM) except that it is augmented with Δqy_t^T. The second equation can be regarded as an error correction model (ECM), provided that the coefficient θ is negative and statistically significant.

4.2 Dataset

Since statistics on Japan's quarterly imports and GDP are highly irregular and seem to contain substantial statistical noise, the above equations will be estimated using semi-annual data. Although it is not standard to estimate import equations with six-monthly data, reliable estimates obtained with a semi-annual dataset will be more useful than imprecise estimates based on quarterly statistics.[10] However, even the semi-annual statistics were rather volatile until the 1980s (Figure 5), and using data for overly long periods of time would not be advisable anyway given the continuous structural transformation of Japanese imports. In addition, Japan's imports have experienced a severe contraction between the middle of 2008

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[10] One can alternatively use quarterly statistics from which unimportant irregularities are filtered out. In this case, however, the estimation result will become subject to the filtering method and may prove difficult to interpret.

and early 2009, which may or may not have involved (a) factor(s) specific to this period (Figure 1). Therefore, we estimate our dynamic import equations using data between the first semesters of 1990 and 2008 (1990S1–2008S1), and will investigate later the extent to which the recent import collapse can be explained with the estimated equations.

We now turn to the construction of individual variables. For both eqs. (13) and (14), the dependent variable is computed from the MOF import volume index. While the majority of the existing studies use the real import data obtained from the SNA or the BOJ, their data reflect not only genuine quantity changes but also changing qualities of imported products.[11] Furthermore, although the MOF index is available not only for aggregate imports but also for major product groups, this is not the case for the SNA and the BOJ real imports. Whereas the primary purpose of this paper is to account for the behavior of Japan's imports *as a whole*, there is evidence that the dynamics of manufacturing imports are different from those of more traditional products (Figure 3). Although the next section only reports the equations for aggregate imports, it will also refer to the results obtained for manufactured imports.

As shown in Table 1, the majority of existing studies compute Δy_t in terms of real GDP. However, since this variable is supposed to represent changes in domestic income or absorption, we use the series for real domestic demand. As for the real exchange rate, although the previous analysis suggests that the variables used in the existing studies are inappropriate, this conjecture is worth testing explicitly. Therefore, we estimate our models using the following three real exchange rates interchangeably: S = SNA import deflator/SNA GDP deflator; S^* = IMPI/CGPI; and S^{**} = IMPI/CGPI (adjusted). The series for qy_t^T and qy_t^C were calculated as follows. We first generated a quarterly series of the difference between the logs of the import volume and real domestic demand. This series was decomposed into the permanent and the transitory components using the Hodrick-Prescott (HP) filter with the standard smoothing parameter of 1,600, and then converted into

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[11] This is because the BOJ IMPI, which also constitutes the basis for the SNA import deflator, is adjusted for quality changes. The BOJ's real imports are calculated by deflating nominal imports with its IMPI.

semi-annual series.

Finally, the data for Δit_t is generated in accordance with the following definition:

$$\Delta it_t = \eta_t \times \left(\Delta o_t^{it} - \Delta o_t \right). \tag{15}$$

In this equation, o_t^{it} denotes the log of the gross output of the domestic electronic parts and components industry, whereas o_t represents the equivalent value for all industries in Japan. Accordingly, the value in the parentheses can be regarded as the portion of output fluctuations in the electronics parts and components industry that is not synchronized with the macroeconomic business cycle. The data for o_t^{it} and o_t are obtained from the METI's *Indexes of All Industrial Activity and Industrial Production*. η_t denotes the share of electronic parts and components in the total value of Japanese imports. The value in the parentheses is multiplied by η_t because the importance of electronic parts and components in Japan's imports has changed considerably during the 1990s (Table 2). To avoid simultaneity between Δit_t and the dependent variable, the import share in each period is computed using data for four semesters up to the previous period.

Before estimation, the time-series properties of individual variables have been examined by standard unit root tests. While our data is rather short for these tests to be effective, the result suggests that q_t, y_t, s_t, s_t^*, s_t^{**}, qy_t and it_t, are all $I(1)$ variables. Because of the nature of the HP decomposition, that qy_t is an $I(1)$ variable implies that qy_t^T and qy_t^C are $I(1)$ and $I(0)$, respectively. Detailed results of the unit root tests are provided in the unpublished Appendix.

5. Estimation results

5.1 Partial adjustment model

Table 5 presents the result of our baseline estimation of eq. (13). For the sake of comparison, columns (a.1)–(a.3) report the results for traditional specifications, which include neither Δit_t nor Δqy_t^T. The residuals from these regressions fail the LM test for serial correlation, suggesting that the estimated equations omit (an) important explanatory variable(s). In the first three columns, it is also found that Δs_t and Δs_t^* are not statistically significant while Δs_t^{**} is highly significant and has a theoretically consistent negative coefficient.

The other six columns report the results for models with Δit_t and/or Δqy_t^T. In all columns Δit_t is highly significant, corroborating our previous conjecture that the distinct cyclicality of the market for electronics parts and components exert measurable impact on aggregate import flows. While the relevance of Δq_t^T is less unambiguous, it is significant at the 10 percent level in column (c.3), our most preferred specification in this table. Measured in terms of adjusted R^2, the explanatory power of the model in column (c.3) is roughly twice as large as those of the standard models in (a.1) and (a.2). In column (c.3) the short-run income and price elasticities are estimated at 0.94 and -0.27, respectively.

As discussed in Section 3, however, the structure of Japanese imports has evolved considerably in recent years. Although our estimation only uses data from 1990 onwards, it seems possible that the relationship between aggregate imports and other variables has changed during the period of estimation. To test this conjecture, let us next consider the following augmented version of eq. (13):

$$\begin{aligned}\Delta q_t &= \alpha_0 + \alpha_1 \Delta y_t + \alpha_2 D \times \Delta y_t + \alpha_3 \Delta s_t + \alpha_4 D \times \Delta s_t + \alpha_5 \Delta it_t + \alpha_6 D \times \Delta it_t \\ &\quad + \alpha_7 \Delta q_{t-1} + \alpha_8 \Delta qy_t^T + \varepsilon_t,\end{aligned} \tag{16}$$

where D denotes a dummy variable that takes the value of zero until the second semester of 1997, and one since the first semester of 1998.

Table 6 reports the result for the above model. This table only reports regressions in which the real exchange rate is represented by Δs_t^{**}, since Δs_t and Δs_t^* were never statistically significant. In Table 6 $D \times \Delta y_t$ and $D \times \Delta it_t$ are not statistically significant, indicating that the contemporaneous effects of Δy_t and Δit_t on the dependent variable have not changed materially during the estimation period. On the other hand, $D \times \Delta s_t^{**}$ is significant in all columns although, interestingly, Δs_t^{**} is no longer significant. This result suggests that meaningful price competition between imported and domestic goods has become operative only recently, a finding consistent with the fact that commodity overlaps between imports and domestic output had been limited until the early 1990s (Table 3). According to columns (b.4) and (b.5), a one percent increase in the relative price of imported and domestic substitutes reduces the amount of aggregate imports by roughly 0.5 percent during the same semester, a value that is by no means negligible.

5.2 Error correction model

Estimation results for eq. (14) are presented in Table 7. In all 10 columns qy_{t-1}^{C} is highly significant and has a negative coefficient, indicating that the estimated equations can indeed be interpreted as an ECM. Due to space limitation, this table omits regressions in which the real exchange rate is measured by Δs_t, which consistently underperformed equivalent models with Δs_t^{*} and Δs_t^{**}.

Columns (a.1) and (b.1) report the results for models that include lagged explanatory variables. Given the relatively low frequency and the small size of our dataset, the lag lengths for all variables are set at one. As it turns out, none of these lagged regressors are statistically significant, and this remains the case under a variety of specifications (not shown here). Accordingly, all other columns in Table 7 drop the lagged regressors. The models in columns (a.2) and (b.2) are equivalent to those of (c.2) and (c.3) in Table 5, except the difference between qy_{t-1}^{C} and Δq_t^{T}. The estimation results are also similar, except that the coefficient on Δs_t^{**} is now small and statistically insignificant.

Columns (a.3)−(a.5) and (b.3)−(b.5) present the results for ECMs that are augmented similarly as in eq. (16). It is found that $D\times\Delta y_t$, $D\times\Delta it_t$ and $D\times\Delta s_t^{*}$ are never statistically significant, whereas $D\times\Delta s_t^{**}$ is highly significant and has the expected sign. The coefficient of $D\times\Delta s_t^{**}$ is estimated at -0.36 when Δs_t^{**} is not included, a value slightly smaller than in Table 6. The coefficient of Δy_t is estimated at around unity, suggesting that fluctuations in real domestic demand alter the import volume by roughly the same proportion during the same semester. Lastly, Δit_t is highly significant, albeit with somewhat smaller coefficients than those found for the PAM. All in all, the results reported in Tables 5−7 support the analysis of Section 3, including the importance of structural and industry-specific shocks, as well as of measuring the real exchange rate using appropriate price indexes. Our estimation also suggests that the price elasticity of Japan's aggregate imports has been rising over time.

5.3 Robustness and predictive power

Although space limitation does not permit detailed discussions, the robustness of the previous results has been examined by a series of auxiliary regressions. To control for potential endogeneity between the lagged dependent variable and the error term, we first conducted two-stage least squares estimation using lagged independent variables as instruments for Δq_{t-1}. While this estimation on occasions altered the coefficient of Δq_{t-1} measurably, there was little difference in the overall results, including the coefficients of Δy_t, Δs_t^{**} and Δit_t. Second, although the previous series for qy_t^T and qy_t^C were generated by decomposing qy_t with the HP filter, the result of this decomposition depends on the value of the smoothing parameter. Therefore, we have reproduced qy_t^T and qy_t^C using two alternative parameter values of 800 and 3,200, and have repeated the same regressions. Although doing so has at times had non-negligible effects on the coefficients of Δq_t^T and q_{t-1}^C, those of the other variables remained largely unaffected. Other regressions include those in which the dependent variable is replaced by the growth rate of *manufactured* imports, which is of interest given their increasing importance and apparently different dynamics from those of non-manufacturing goods. Whilst the qualitative result for this regression is similar to these reported in Table 5−7, the coefficients on Δy_t, Δs_t^{**} and Δit_t are estimated to be marginally larger in absolute values.

Lastly, let us revisit the starting observation in this paper − the severe import slump between 2008 and 2009 − and examine if and how much of this episode can be explained by our import equations. For this purpose, we use the equations reported in columns (b.5) in Tables 6 and 7, which are our preferred PAM and ECM, respectively.

While our dataset terminates in the first semester of 2008, data for additional three semesters is available at the time when this paper is authored. We compute the values of the dependent variable predicted by the above two equations for seven semesters between 2006S2 and 2009S2. The predicted values of Δq_t are then cumulated and converted into the series for Q_t and compared with the actual behavior of the import volume. The result of this exercise is presented in Figure 7, in which both the predicted and the actual volumes of imports are adjusted so that they equal 100 in the first semester of 2008.

According to Figure 7, the actual volume of imports started falling in 2008S2, and dropped by some 15 percent between 2008S2 and 2009S1 before recovering in the next semester by roughly one third of what had been lost in 2008S2−2009S1. On the other hand, the two paths of the predicted values are very similar, remaining more or less stable until 2008S2 but falling measurably thereafter. Although our models correctly predict part of the import collapse during 2008S2−2009S1, the total import declines predicted by the PAM and ECM during these two semesters are 6.6 and 8.5 percent, respectively, whereas the actual decline was 17.5 percent. Moreover, our models predict continued import contraction in 2009S1, although the actual import volume has in fact rebounded rather strongly. While detailed analysis of these discrepancies are beyond the scope of this paper, they suggest that our import equations still leave room for improvement, as well as the possibility that the recent import contraction did involve factors that were unique to this episode.

6. Conclusion

Although aggregate trade equations are used routinely for both short-term macroeconomic forecasting and applied policy analysis, there is evidence that the standard import demand equation does not provide an adequate description of Japan’s import dynamics. The first part of this paper surveyed the existing literature on the subject, and discussed what should be borne in mind when estimating Japan’s import equation. At the center of our analysis is the recognition that the composition of Japan’s imports has shifted decisively during the past two decades from primary commodities to manufacturing products. Not only has this structural shift been the central driving force behind secular upward drifts in the aggregate imports-to-GDP ratio, but it has also given rise to other effects that are potentially relevant to the import equation, including increased product overlaps between imports and domestic output as well as higher susceptibility of aggregate import flows to industry-specific factors. The analysis in Section 3 also suggests that data used in the existing literature is often inappropriate, both for conceptual and statistical reasons.

The second part of the paper has developed two dynamic import equations that accommodate the above difficulties, and estimated these models using a dataset that was built carefully from a variety of statistics. While our empirical models are rather simple, they have clearly outperformed the standard import equation. Of particular interest is the finding that fluctuations in the relative price between imported and domestically produced substitutes exert the theoretically consistent effect on the aggregate import volume, and that the magnitude of this effect seems to have been increasing. To the extent that this is the case, it is conceivable that the effects of exchange rate fluctuations on the volumes of imports and exports become less asymmetric in the future, although this conjecture clearly requires further investigation.

Our import models still leave room for refinement. First, our estimation depends on the assumption that all structural shocks that affect the equilibrium volume of imports can be approximated by long-run drifts in the relative size of imports and domestic demand, an assumption that is rather strong and may need to be investigated further. Second, although we have performed all regressions using semi-annual data, six months is rather long as the time unit for dynamic import models. It is desirable to pursue a more refined description of adjustment mechanism using higher-frequency data, although doing so would require careful screening of official statistics. Lastly, our import models have been able to explain only a limited part of the severe import contraction during 2008–2009. While this may be because of factors that were genuinely unique to this episode, it also suggests the possibility that our model still does not do full justice to the complexity of Japan’s import dynamics. These issues are left for future research.

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Table 1. Literature on Japan’s aggregate import function

Author	Period	Definition of real exchange rate	Estimation method	Income elasticity	Price elasticity	Remark
Economic Planning Agency (2000)	1980Q1−1999Q2	IMPI / DCGPI	OLS	Elasticity rising over time (2.8 for 1992−1999). No distinction between SR and LR.	Elasticity varies over time (-0.3 for 1992−1999). No distinction between SR and LR.	Explanatory variables include the stock of outward FDI in the previous period. The coefficient of the FDI variable is positive and statistically significant.
Hooper et al. (2000)	1970(?)−1994Q4	Import deflator / GDP deflator	VECM	1.0 (SR); 0.9 (LR)	-0.3 (LR). SR coefficients not statistically significant.	Comparison for G7. Japan's income and price elasticities smaller than in most other G7 countries.
Masih and Masih (2000)	1974S1−1989S2	IMPI / DCGPI	DOLS	1.3 (LR)	-1.9 (LR)	Estimation based on semi-annual data. No estimates of contemporaneous elasticities.
Mukunoki (2003)	1990Q1−2001Q4	Import unit value index / DCGPI	PAM, ADLM	0.6−1.2 (SR); 4.4−4.7 (LR). Estimates vary with models.	-0.3 (SR); -2.0 − -1.2 (LR). Estimates vary with models.	Also estimates regional import demand functions. Elasticities largest for imports from East Asia.
Hamori and Matsubayashi (2001)	1973Q1−1998Q1	Import deflator / GDP deflator	VECM	N/A	N/A	No evidence for cointegration even allowing for structural breaks.
Tang (2003)	1973−1997	IMPI / GDP deflator (?)	OLS, ECM, DOLS, VECM	2.8 (SR); 1.0 (LR).	-0.3 (SR); -1.1 (LR).	Cointegration detected only for some models. Estimation based on annual data.
Tang (2008)	1973Q1−2007Q2	IMPI / DCGPI	ECM (rolling regression)	LR elasticity varies between -0.2 and 6.3 depending on the estimation period.	LR elasticity varies between -0.7 and 0.6 depending on the estimation period.	Cointegration detected only for limited periods. Cointegrating vectors highly unstable.
Thorbecke (2008)	1988Q1−2005Q3	Real Y/$ exchange rate deflated by relative CPI	VECM, DOLS, ADLM	0−0.3 (LR); most estimates not statistically insignificant.	-1.4 − -0.3 (LR); most estimates statistically insignificant.	The dependent variable is the import volume from USA. No robust LR equation.
Hida et al. (2008)	1990Q1−2005Q4	Import deflator / GDP deflator	ECM	0.9 (SR); 2.3 (LR).	-0.2 (SR); -0.3 (LR). SR adjustment takes place after six months.	Estimated as part of the Cabinet Office's macroeconomic model. Imports exclude mineral fuels.
Kurita (2010)	1993Q2−2008Q2	Import deflator / GDP deflator	VECM	1.1 (SR); LR elasticity assumed to be unity.	0 (SR); -0.35 (LR).	Linear trend in the cointegrating vector.

(Notes) ADLM (autoregressive distributed lag model); DOLS (dynamic ordinary least squares); ECM (error correction model); OLS (ordinary least squares); PAM (partial adjustment model); VECM (vector error correction model). IMPI (Import Price Index); DCGPI (Domestic Corporate Goods Price Index); CPI (Consumer Price Index); SR (short-run); LR (long-run). SR refers to contemporaneous elasticity unless noted otherwise.

Table 2. Structural evolution of manufacturing trade

[A] Share in total manufacturing imports (%)

Product group / industry	1980	1985	1990	1995	2000	2005	2006
Food and tobacco	18.4	17.3	15.8	18.0	13.7	12.7	11.6
Textiles	7.3	7.0	9.1	10.3	8.9	8.2	8.0
Pulp, paper and paper products	2.9	2.3	2.0	1.9	1.4	1.1	1.0
Chemicals	11.0	12.2	9.5	8.6	8.0	9.1	9.1
Petroleum and coal products	16.9	15.1	8.2	3.9	5.5	6.4	7.1
Ceramics, stone and clay products	0.7	1.2	1.4	1.2	1.2	1.2	1.2
Iron, steel and non-ferrous metals	14.1	14.8	13.0	8.9	7.3	7.7	8.7
Fabricated metal products	0.8	0.9	1.2	1.2	1.1	1.5	1.7
General machinery	4.5	4.2	4.9	4.2	5.8	6.2	6.5
Electrical machinery	2.0	2.8	3.0	4.9	5.9	6.4	6.2
Electronic products	7.5	7.5	10.0	15.9	23.4	21.4	21.3
Computer units & peripherals	1.8	1.9	3.0	5.6	8.7	6.9	6.0
Semiconductor devices & integrated circuits	1.2	1.3	1.8	4.3	6.5	5.4	5.9
Transport equipment	5.2	5.7	7.5	6.2	5.6	6.3	6.4
Other manufacturing	9.0	8.9	14.4	14.7	12.4	11.8	11.2

[B] Import penetration (%)

Product group / industry	1980	1985	1990	1995	2000	2005	2006
Total manufacturing	3.6	4.1	4.7	8.0	10.6	13.8	14.7
Food and tobacco	5.0	4.8	5.8	9.9	9.7	12.4	12.9
Textiles	5.1	5.9	9.0	19.0	29.2	44.8	48.0
Pulp, paper and paper products	2.8	3.0	2.9	4.6	4.9	5.3	5.6
Chemicals	4.6	5.8	5.5	8.2	9.7	13.6	14.2
Petroleum and coal products	6.4	8.8	9.6	7.7	10.8	12.1	13.1
Ceramics, stone and clay products	0.7	1.6	2.1	2.9	4.4	7.0	7.7
Iron, steel and non-ferrous metals	3.2	4.9	5.6	8.0	9.4	10.0	11.6
Fabricated metal products	0.7	0.9	1.1	1.8	2.4	5.0	5.9
General machinery	2.5	2.3	2.5	4.3	7.6	10.4	11.3
Electrical machinery	1.5	2.0	2.3	6.4	11.5	18.4	18.5
Electronic products	5.7	4.3	5.6	13.7	20.8	31.3	32.7
Computer units & peripherals	9.9	5.5	7.8	19.6	35.8	59.5	59.5
Semiconductor devices & integrated circuits	8.8	6.9	8.9	30.5	40.5	67.0	78.5
Transport equipment	2.2	2.3	2.9	4.3	5.1	6.6	7.0
Other manufacturing	2.9	3.5	5.6	9.2	10.8	14.9	15.5

[C] Export propensity (%)

Product group / industry	1980	1985	1990	1995	2000	2005	2006
Total manufacturing	11.5	9.7	9.2	12.7	15.5	19.4	20.3
Food and tobacco	1.1	0.6	0.5	0.5	0.5	0.8	0.9
Textiles	8.8	5.9	4.3	5.6	8.2	13.4	14.1
Pulp, paper and paper products	2.4	1.9	2.1	2.3	2.8	3.3	3.4
Chemicals	8.8	6.2	7.7	11.8	13.7	18.0	18.6
Petroleum and coal products	2.0	1.4	2.7	2.5	2.1	3.8	4.2
Ceramics, stone and clay products	5.5	4.5	3.7	5.5	6.9	10.3	11.0
Iron, steel and non-ferrous metals	10.5	7.5	5.2	8.4	10.3	12.9	14.5
Fabricated metal products	8.8	5.2	2.9	3.4	3.8	5.9	6.3
General machinery	20.5	15.3	14.0	23.1	26.3	30.2	30.8
Electrical machinery	23.8	19.9	16.6	19.6	28.4	34.7	34.6
Electronic products	21.5	18.7	20.2	29.7	31.0	40.5	40.8
Computer units & peripherals	11.6	19.6	27.6	32.8	36.1	54.8	55.8
Semiconductor devices & integrated circuits	26.8	23.1	27.8	56.9	56.7	79.1	85.9
Transport equipment	30.7	24.4	18.8	22.7	27.5	31.5	33.0
Other manufacturing	4.4	3.6	3.2	3.8	5.2	9.3	9.8

(Notes) Import penetration = imports / domestic demand; export propensity = exports / domestic output.
(Source) Author's calculation with data from RIETI JIP Database 2009.

Table 3. Product overlaps between IMPI and DCGPI

Price index	1980	1985	1990	1995	2000	2005
Import price index	28.6	35.0	54.6	64.1	64.4	60.2
Domestic corporate goods price index	17.2	18.6	25.0	31.8	38.8	37.8

(Note) Product overlaps refer to the sum of the weights of common goods in IMPI and DCGPI in each index. The weights are revised every five years.
(Source) Author's calculation with data from the Bank of Japan website (http://www.boj.or.jp/type/exp/stat/pi/excgpi02.htm).

Table 4. Estimation of industry import equations

Industry / product category	$\Delta q_i(-1)$	$\Delta q_i(-2)$	Δy	$\Delta y(-1)$	$\Delta y(-2)$	*const.*	t	R^2 (adj.)
Total manufacturing	-0.107	0.348	***0.918***	***0.868***	-0.204	0.016	0.000	0.182
	(0.125)	(0.119)***	**(0.422)****	**(0.440)***	(0.452)	(0.012)	(0.000)	
Iron and steel	0.144	0.032	0.184	1.740	0.722	0.002	0.000	-0.038
	(0.137)	(0130)	(1.458)	(1.475)	(1.473)	(0.042)	(0.001)	
Non-ferrous metals	-0.525	-0.148	1.403	2.400	1.811	-0.012	0.000	0.157
	(0.132)***	(0.131)	(2.088)	(2.151)	(2.170)	((0.061)	(0.001)	
Fabricated metal products	0.082	0.227	0.378	0.264	0.646	0.029	0.000	0.025
	(0.126)	(0.128)	(0.698)	(0.706)	(0.696)	(0.020)	(0.000)	
General machinery	-0.046	-0.083	3.111	0.655	2.619	0.037	0.000	0.003
	(0.129)	(0129)	(1.762)*	(1.844)	(1.846)	(0.052)	(0.001)	
Electrical machinery	0.114	0.088	1.483	0.131	0.921	0.086	-0.001	0.154
	(0.126)	(0.125)	(0.863)*	(0.894)	(0.893)	(0.029)***	(0.000)**	
Information & communication equipment	-0.117	-0.009	1.751	1.288	-0.429	0.011	-0.001	-0.004
	(0.178)	(0.174)	(1.036)	(1.150)	(1.171)	(0.065)*	(0.001)	
Electronic parts & components	***0.800***	-0.378	0.172	0.610	-0.133	0.089	-0.001	0.350
	(0.191)***	(0.179)**	(1.298)	(1.370)	(1.303)	(0.066)	(0.001)	
Transport equipment	-0.376	-0.073	0.251	2.673	-1.135	0.010	0.000	0.103
	(0.132)***	(0.129)	(1.557)	(1.591)*	(1.629)	(0.045)	(0.001)	
Precision instruments	-0.138	-0.095	1.089	5.977	-0.145	0.029	0.000	0.045
	(0.134)	(0.130)	(2.173)	(2.177)***	(2.252)	(0.061)	(0.001)	
Ceramics, stone and clay products	0.144	0.046	0.699	1.548	-0.349	0.019	0.000	0.011
	(0.132)	(0.132)	(0.913)	(0.921)*	(0.914)	(0.025)	(0.000)	
Chemicals	-0.250	-0.114	0.610	1.305	1.072	0.019	0.000	0.012
	(0.131)*	(0.130)	(0.915)	(0.928)	(0.942)	(0.027)	(0.000)	
Petroleum & coal products	-0.279	-0.134	-0.070	1.250	-0.235	0.022	0.000	0.004
	(0.132)**	(0.131)	(1.208)	(1.236)	(1.235)	(0.035)	(0.000)	
Plastic products	-0.301	0.008	1.395	0.160	-0.283	0.108	-0.001	0.144
	(0.131)**	(0.133)	(0.801)*	(0.828)	(0.817)	(0.028)***	(0.000)***	
Pulp, paper & paper products	-0.117	-0.225	-1.168	0.432	1.544	0.043	-0.001	0.088
	(0.125)	(0.120)*	(0.940)	(1.001)	(0.976)	(0.028)	(0.000)*	
Textiles	-0.148	0.375	-0.084	-0.467	-0.492	0.029	0.000	0.129
	(0.125)	(0.125)***	(0.674)	(0.690)	(0.678)	(0.021)	(0.000)	

(Notes) Regressions are performed with quarterly statistics for 1992Q3−2008Q2, except for the information and communication equipment and the electronic parts and devices industries for which the starting period is 1998Q3. Values in parentheses are robust standard errors. *, **, *** denote significance at 10, 5 and 1 percent levels, respectively.

Table 5. Estimation of the partial adjustment model

Independent variable	(a.1)	(a.2)	(a.3)	(b.1)	(b.2)	(b.3)	(c.1)	(c.2)	(c.3)
Const.	0.008 (0.005)	0.008 (0.005)	0.009 (0.005)*	0.004 (0.004)	0.005 (0.004)	0.006 (0.004)	-0.004 (0.011)	-0.005 (0.011)	-0.006 (0.010)
Δy	0.966 (0.467)**	1.030 (0.465)**	1.068 (0.390)***	0.835 (0.413)*	0.875 (0.416)**	0.886 (0.373)**	0.828 (0.431)*	0.867 (0.437)*	0.942 (0.376)**
Δs	-0.135 (0.097)			-0.142 (0.085)			-0.090 (0.083)		
Δs^{*}		-0.181 (0.113)			-0.162 (0.095)*			-0.113 (0.091)	
Δs^{**}			-0.388 (0.139)***			-0.271 (0.115)**			-0.265 (0.110)**
Δit				4.252 (0.700)***	4.106 (0.675)***	3.373 (0.717)***	4.338 (0.686)***	4.242 (0.653)***	3.523 (0.628)***
Δqy^{T}							0.694 (0.660)	0.718 (0.656)	0.917 (0.554)*
Δq (-1)	0.403 (0.130)***	0.402 (0.130)***	0.337 (0.129)**	0.364 (0.111)***	0.361 (0.110)***	0.317 (0.108)***	0.285 (0.102)***	0.282 (0.099)***	0.227 (0.096)**
R^2 (adj.)	0.314	0.333	0.458	0.555	0.556	0.588	0.567	0.573	0.634
SER	0.024	0.024	0.022	0.020	0.020	0.019	0.019	0.019	0.018
LM(2)	10.813 [0.005]***	9.715 [0.008]***	5.383 [0.068]*	1.538 [0.464]	1.630 [0.443]	2.105 [0.349]	0.561 [0.755]	0.581 [0.748]	0.522 [0.770]
N	37	37	37	37	37	37	37	37	37

(Notes) All regressions are based on semi-annual data for 1990S1−2008S1. Values in ( ) are robust standard errors. *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively. SER = standard error of regression. LM(2) = Breusch-Godfrey test for second-order serial correlation (p-value in [ ]). N = number of observations.

Table 6. Estimation of the partial adjustment model (continued)

Independent variable	(a.1)	(a.2)	(a.3)	(a.4)	(a.5)	(b.1)	(b.2)	(b.3)	(b.4)	(b.5)
Const.	0.008 (0.003)**	0.008 (0.003)**	0.008 (0.003)**	0.008 (0.003)**	0.008 (0.003)**	-0.002 (0.009)	-0.003 (0.009)	-0.002 (0.009)	-0.003 (0.009)	-0.002 (0.008)
Δy	0.760 (0.308)**	0.765 (0.294)**	0.874 (0.342)**	0.830 (0.334)**	0.764 (0.320)**	0.773 (0.262)***	0.777 (0.249)***	0.904 (0.347)**	0.886 (0.340)**	0.812 (0.327)**
$D \times \Delta y$	0.276 (0.508)	0.150 (0.507)				0.320 (0.494)	0.260 (0.481)			
Δs^{**}	-0.073 (0.148)	-0.105 (0.120)	-0.086 (0.141)	-0.111 (0.118)		-0.096 (0.131)	-0.115 (0.106)	-0.111 (0.127)	-0.124 (0.107)	
$D \times \Delta s^{**}$	-0.487 (0.236)**	-0.436 (0.208)**	-0.454 (0.201)**	-0.421 (0.179)**	-0.526 (0.156)***	-0.430 (0.234)*	-0.399 (0.206)*	-0.393 (0.204)*	-0.373 (0.184)*	-0.492 (0.162)***
Δit	6.457 (3.694)*	2.745 (0.924)***	6.311 (3.486)*	2.850 (0.782)***	2.939 (0.724)***	4.886 (3.418)	2.868 (0.768)***	4.738 (3.223)	3.043 (0.660)***	3.138 (0.617)***
$D \times \Delta it$	-3.992 (3.853)		-3.638 (3.558)			-2.181 (3.635)		-1.795 (3.346)		
Δqy^{T}						0.775 (0.526)	0.843 (0.513)	0.765 (0.516)	0.824 (0.501)	0.802 (0.492)
Δq (-1)	0.268 (0.115)**	0.304 (0.119)**	0.278 (0.111)**	0.305 (0.115)**	0.306 (0.115)**	0.209 (0.109)*	0.222 (0.106)**	0.215 (0.102)**	0.225 (0.100)**	0.229 (0.097)**
R^2 (adj.)	0.620	0.618	0.630	0.629	0.632	0.649	0.656	0.657	0.665	0.664
SER	0.018	0.018	0.018	0.018	0.018	0.017	0.017	0.017	0.017	0.017
LM(2)	2.038 [0.361]	3.868 [0.145]	2.223 [0.329]	3.581 [0.167]	4.537 [0.103]	1.066 [0.587]	1.587 [0.452]	1.286 [0.526]	1.563 [0.458]	2.745 [0.253]
N	37	37	37	37	37	37	37	37	37	37

(Note) See Table 5. *D* refers to a dummy variable whose value is 0 until 1997S2 and 1 thereafter.

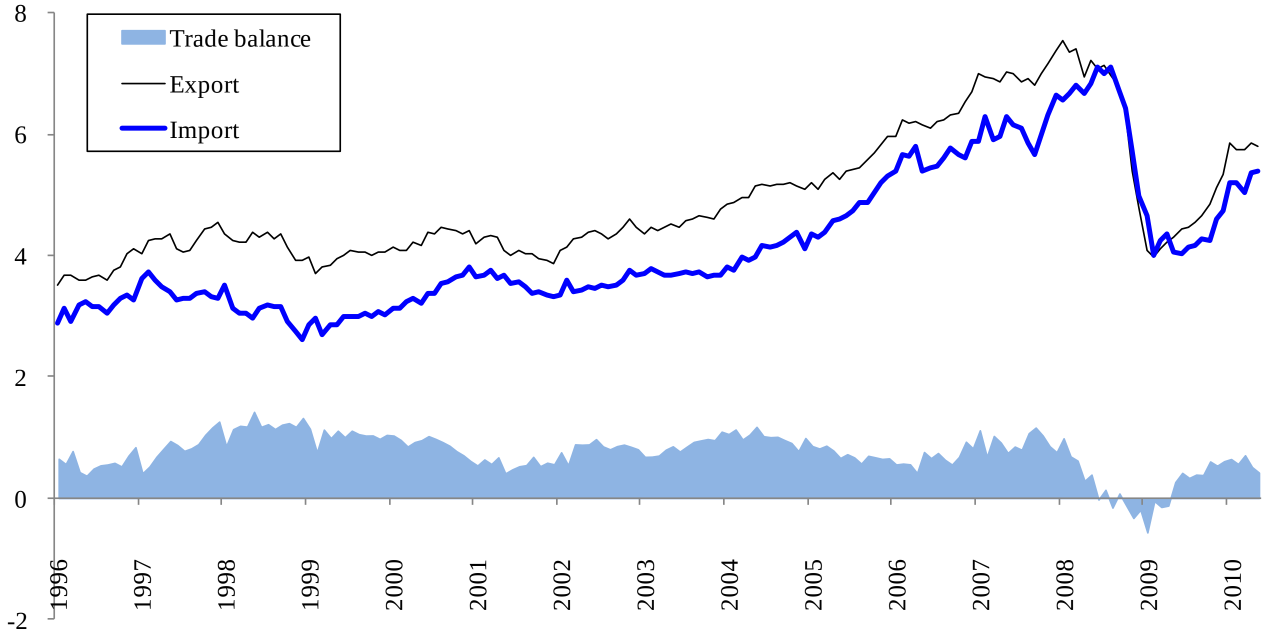
Table 7. Estimation of the error correction model

Independent variable	(a.1)	(a.2)	(a.3)	(a.4)	(a.5)	(b.1)	(b.2)	(b.3)	(b.4)	(b.5)
Const.	-0.001 (0.006)	0.000 (0.005)	0.001 (0.004)	0.001 (0.005)	0.001 (0.005)	0.000 (0.007)	0.001 (0.005)	0.003 (0.005)	0.003 (0.005)	0.003 (0.004)
Δy	1.091 (0.333)***	1.062 (0.368)***	0.973 (0.325)***	0.987 (0.406)**	1.056 (0.372)***	1.140 (0.340)***	1.086 (0.351)***	0.981 (0.267)***	1.033 (0.308)***	1.057 (0.300)***
$D\times\Delta y$			0.093 (0.590)					0.218 (0.409)		
Δy (-1)	-0.187 (0.334)					-0.185 (0.351)				
Δs^{*}	0.022 (0.088)	0.045 (0.091)	0.146 (0.124)	0.130 (0.104)						
$D\times\Delta s^{*}$			-0.200 (0.166)	-0.190 (0.123)	-0.096 (0.101)					
Δs^{*}(-1)	0.101 (0.095)									
Δs^{**}						-0.086 (0.141)	-0.052 (0.152)	0.151 (0.149)	0.121 (0.129)	
$D\times\Delta s^{**}$								-0.498 (0.207)**	-0.442 (0.165)***	-0.355 (0.164)**
Δs^{**}(-1)						0.094 (0.112)				
Δit	2.203 (0.849)**	2.411 (0.811)***	4.790 (3.402)	2.476 (0.698)***	2.685 (0.691)***	2.348 (0.716)***	2.500 (0.726)***	5.228 (3.583)	1.927 (0.714)**	1.982 (0.731)***
$D\times\Delta it$			-2.490 (3.508)					-3.615 (3.653)		
Δit (-1)	-0.297 (0.998)					-0.242 (0.782)				
Δq (-1)	0.654 (0.186)***	0.558 (0.114)***	0.550 (0.112)***	0.572 (0.115)***	0.541 (0.110)***	0.611 (0.217)***	0.526 (0.147)***	0.484 (0.141)***	0.519 (0.143)***	0.488 (0.129)***
qy^{C}(-1)	-0.579 (0.184)***	-0.519 (0.145)***	-0.519 (0.127)***	-0.517 (0.136)***	-0.433 (0.110)***	-0.451 (0.224)**	-0.439 (0.187)**	-0.445 (0.156)***	-0.451 (0.160)***	-0.389 (0.119)***
R^{2} (adj.)	0.663	0.684	0.677	0.693	0.688	0.659	0.683	0.729	0.734	0.735
SER	0.017	0.016	0.017	0.016	0.016	0.017	0.016	0.015	0.015	0.015
LM(2)	0.233 [0.890]	0.776 [0.678]	1.463 [0.481]	1.030 [0.597]	0.464 [0.793]	0.573 [0.751]	0.670 [0.715]	0.635 [0.728]	1.423 [0.491]	1.679 [0.432]
N	37	37	37	37	37	37	37	37	37	37

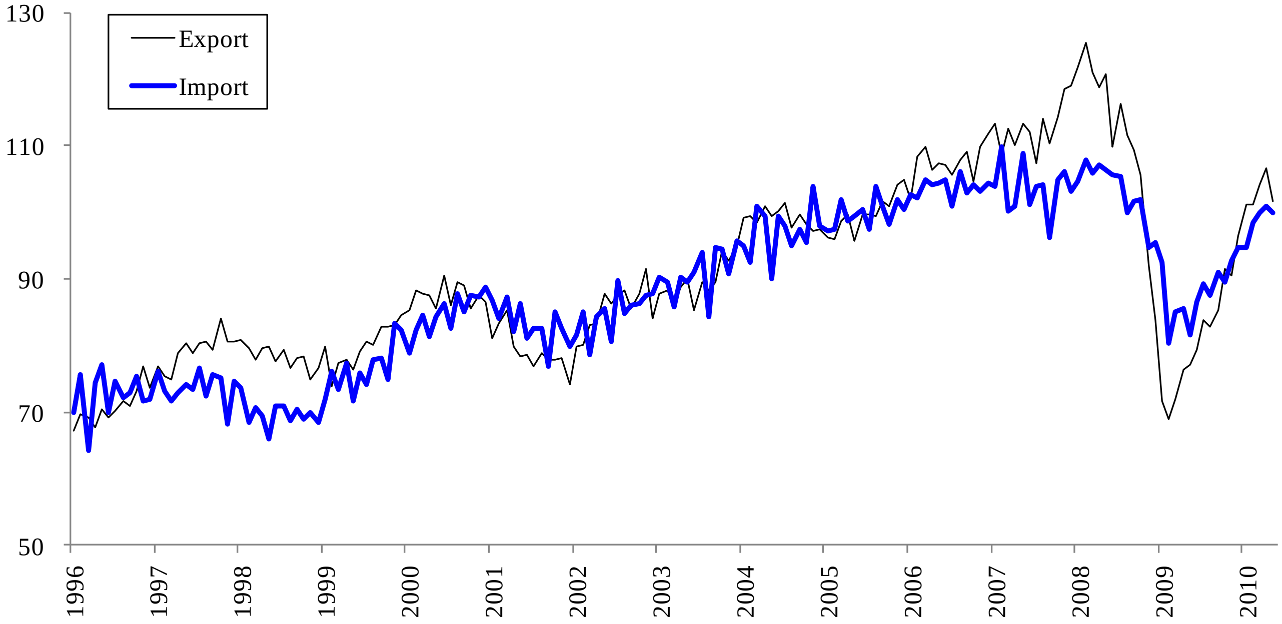
(Note) See Tables 5 and 6.

Figure 1. Evolution of Japan’s nominal and real trade

(A) Nominal (trillion yen)

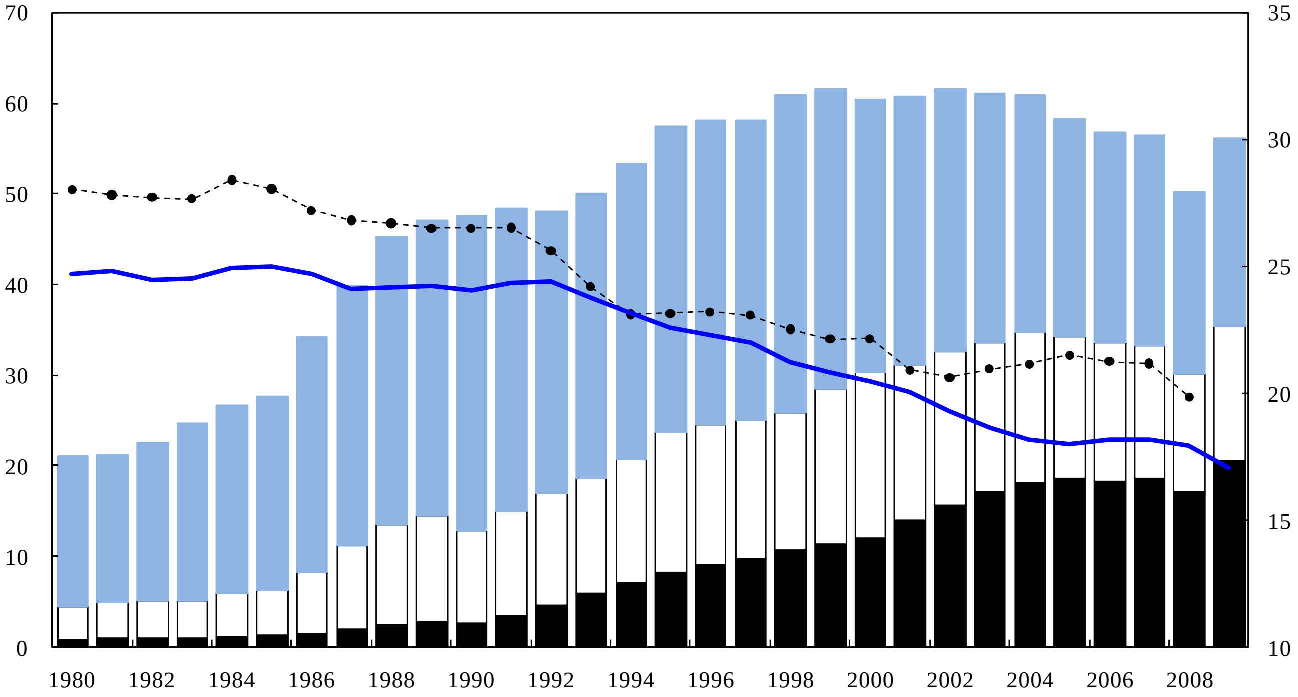


(B) Real (2005=100)



(Note) All series are seasonally adjusted and exclude service trade.
(Source) Ministry of Finance, *Trade Statistics of Japan*.

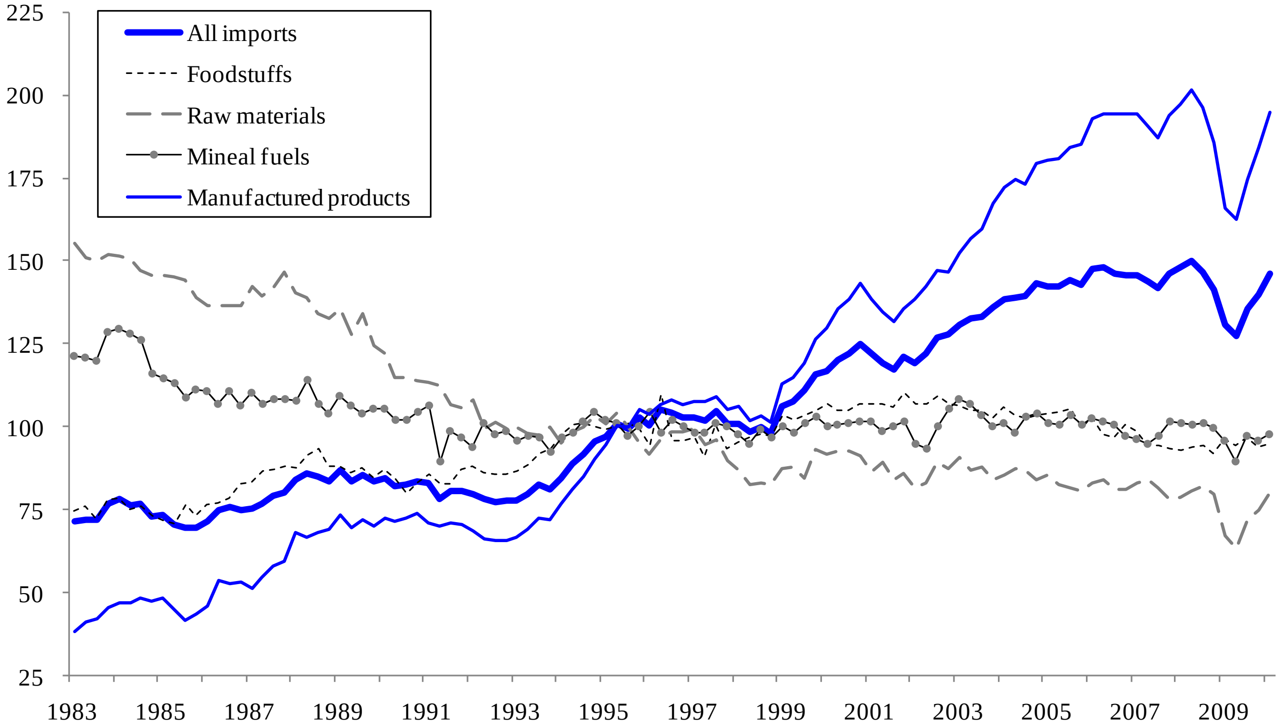
Figure 2. Structural evolution of Japanese imports (%)



(Notes) "Other Asia" includes Indonesia, Hong Kong, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand.

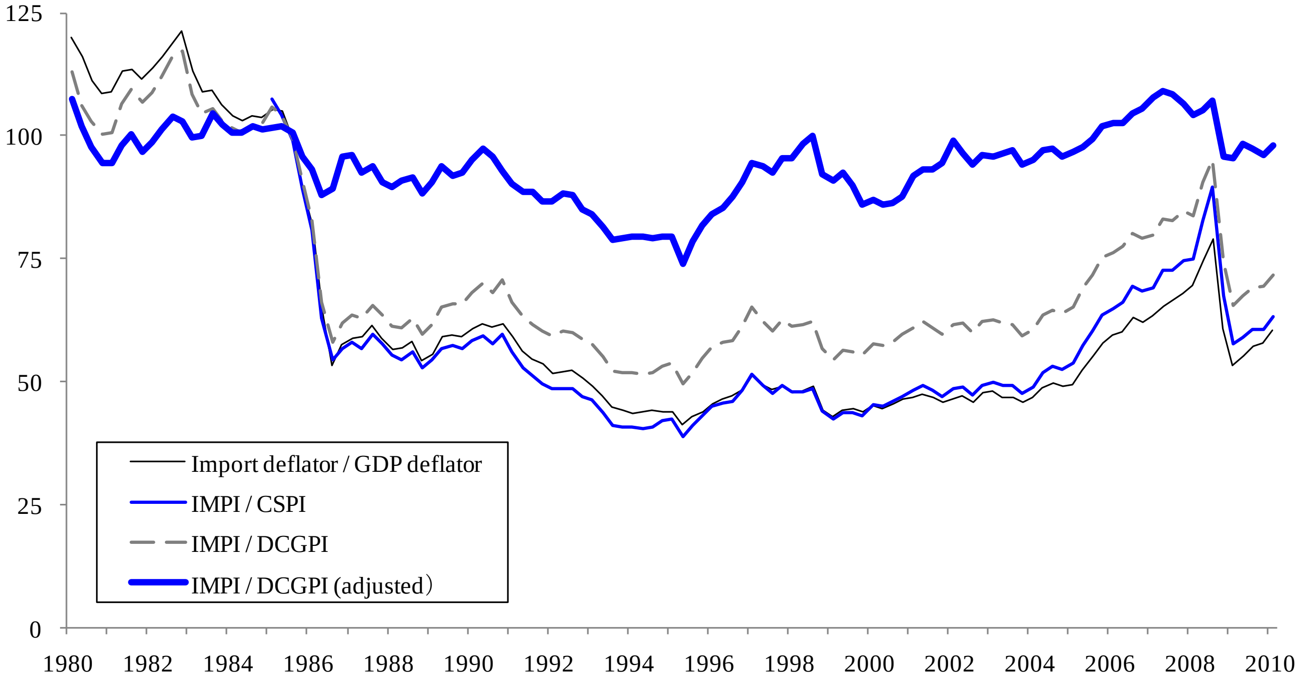
(Source) Author's calculation with data from Cabinet Office, Minstry of Finance and Ministy of Internal Affairs and Communications.

Figure 3. Real imports-to-GDP ratio by product group (1995=100)



(Notes) Product classification follows that of customs statistics. For detailed definition of individual product categories, see Japan Tariff Association, *Summary Report on Trade of Japan*.
(Source) Author's calculation with data from Ministry of Finance and Cabinet Office.

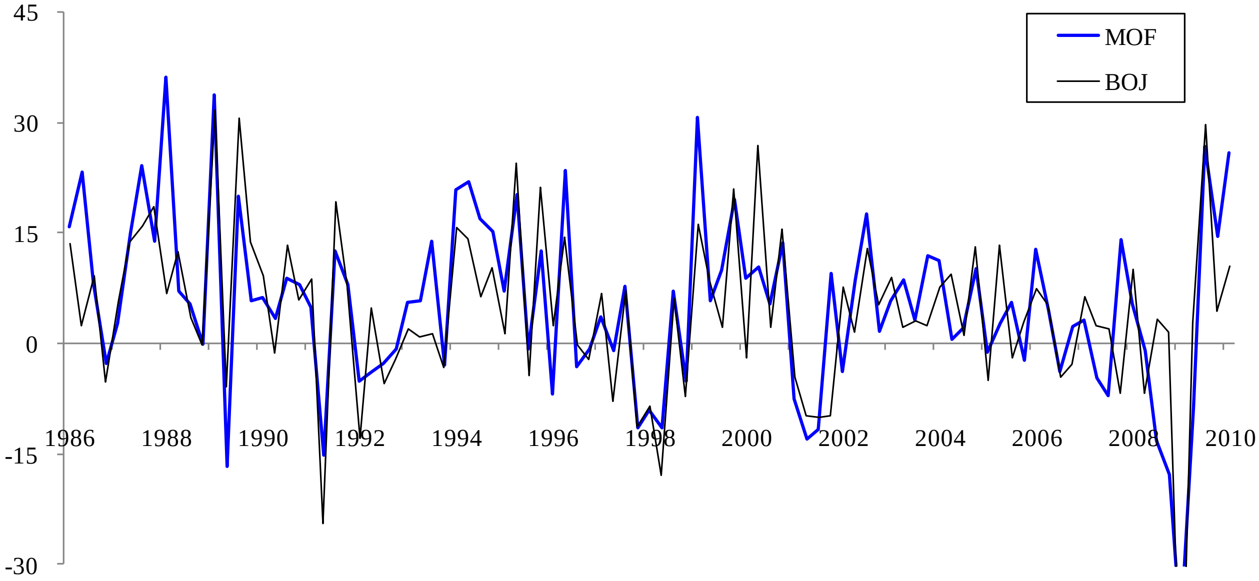
Figure 4. Alternative real exchange rates (1985=100)



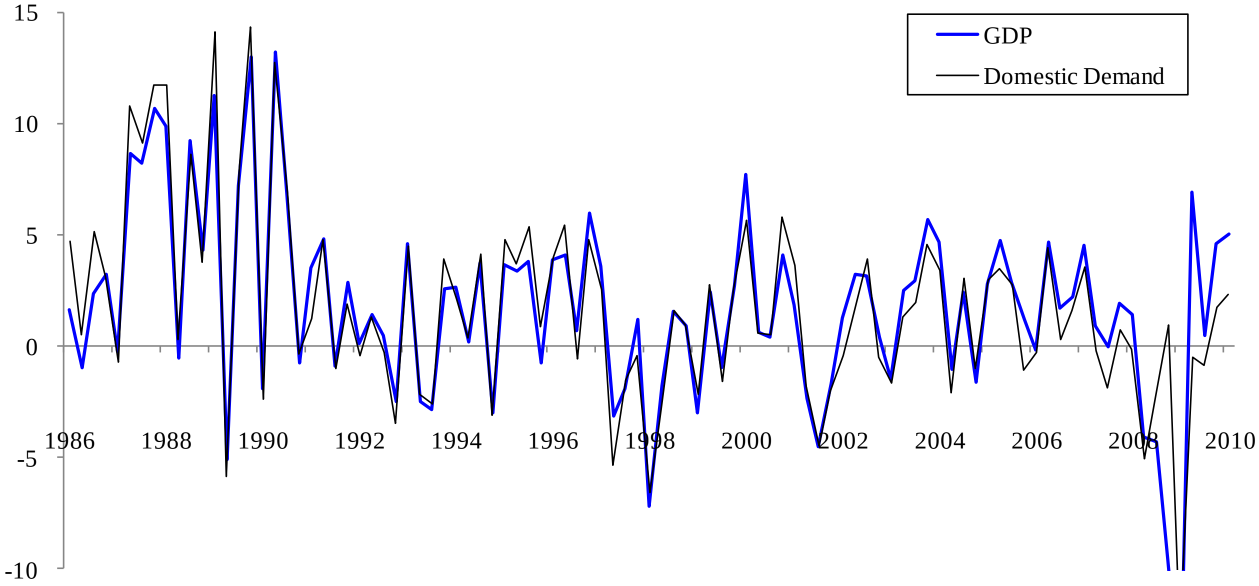
(Source) Author's calculation with data from Bank of Japan and Cabinet Office.

Figure 5. Volatility of growth rates of real imports and GDP

[A] Real imports

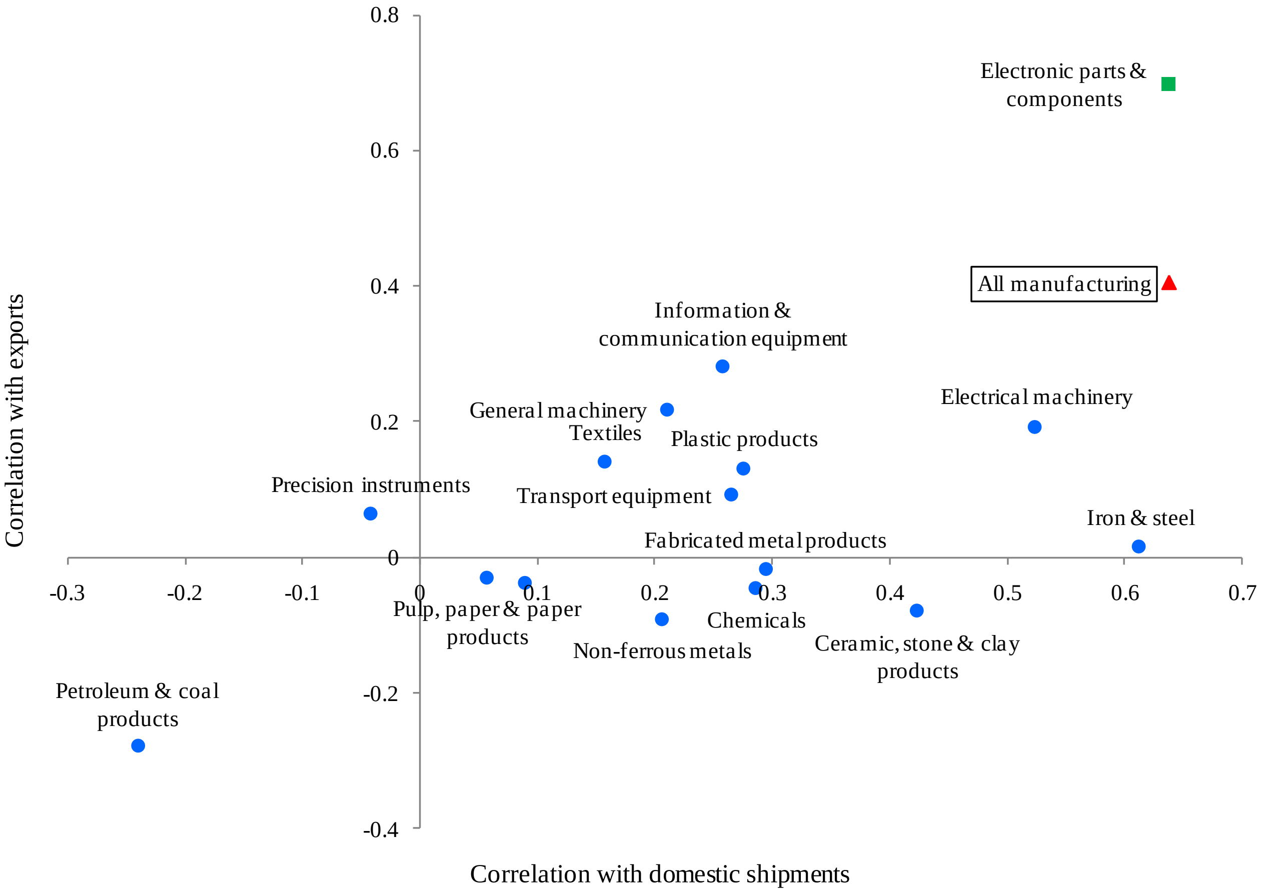


[B] Real GDP



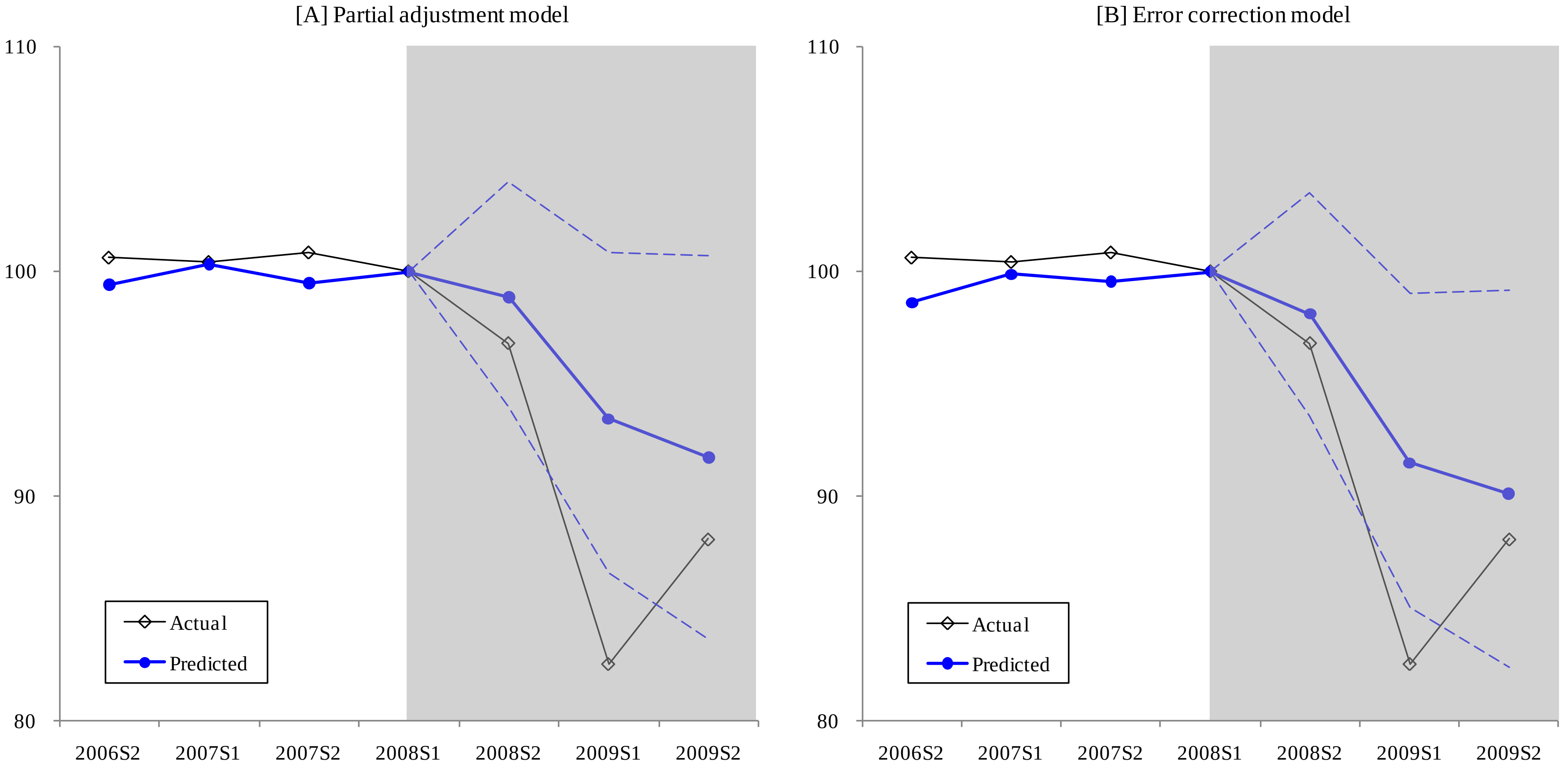
(Notes) All plots describe annualized quarter-on-quarter growth rates computed from seasonally adjusted data.
(Source) Author’s calculation with data from Ministry of Finance, Bank of Japan and Cabinet Office.

Figure 6. Growth correlations of real imports with exports and domestic shipments



(Notes) Correlation coefficients are computed using quarterly data for 1992Q3−2008Q2, except for the information and communication equipment and the electronics marks and components industries, for which the starting period is 1998Q3.
(Source) Author’s calculation with data from Ministry of Economy, Trade and Industry, *Indices of Industrial Domestic Shipments and Imports* and *Indices of Industrial Domestic Shipments and Exports*.

Figure 7. Actual and predicted volumes of imports (2008S1=100)



(Notes) The predicted paths are based on the models of Table 6 (b.5) and Table 7 (b.5). All data on the explanatory variables used for prediction are actual observations. The dotted lines indicate the confidence intervals defined as the antilog of the cumulative values of the predicted value ± 2 * standard error of regression from 2008S2 onwards.

Appendix to *Understanding Japan's Import Dynamics*

(Not intended for publication)

A1. Stability of standard import functions

As noted in Section 2, a number of existing studies find no stable long-run relationship among Japan's real imports, real GDP, and the relative price of imports and domestic goods, although a few studies claim that such a relationship does exist (e.g., Kurita 2010). This appendix updates and extends Tan (2008), who tested for cointegration among the above three variables using a rolling regression technique.

We consider the following two versions of the standard import models:

$$\begin{aligned}&\text{Model A:}\quad q_t = \alpha_0 + \alpha_1 y_t + \alpha_2 s_t\\ &\text{Model B:}\quad q_t = \alpha_0 + \alpha_1 y_t + \alpha_2 s_t + \alpha_3 t,\end{aligned}$$

where, as discussed in Section 2, the deterministic time trend t is meant to subsume all structural (persistent) shocks. The existence of a unique cointegrating vector is tested using the standard maximum eigenvalue and the trace tests (Johansen 1996). We also assess the stability of the cointegrating vector by performing these tests for overlapping periods. More specifically, we start with 60 quarterly observations for 1984Q1−1998Q4 and repeat the same tests, each time shifting the estimation period forward by eight quarters. Since Section 5 makes use of three versions of s_t, this test is also performed for all of these variables.

The result is summarized in Table A1. As in Tan (2008), the hypothesis of a unique cointegrating relationship is rejected fairly frequently. Even when the tests indicate the existence of a single cointegrating vector, the implied import equation is highly unstable and often counter-intuitive. In particular, the coefficient of the real exchange rate (α_2) is often positive, which suggests that an increase in import prices relative to domestic prices encourages imports. Moreover, the inclusion of the trend variable completely alters the estimated coefficients of y_t and s_t, while the coefficient of t itself is highly sensitive to minor differences in the estimation period.

All in all, the results in Table A1 suggest that the standard cointegration techniques lack power to determine the genuine cointegrating rank for the dataset under investigation, and that the estimated cointegrating vectors are unlikely to represent a meaningful economic relationship. To the extent that this is the case, they should not be used as a basis for further analysis.

Table A1. Johansen cointegration tests for conventional import functions

Sample period (sample size)	Trace test	Max. eigenvalue test	Cointegrating vector					
			q	*y*	*s*	s^*	s^{**}	*t*
Model A								
1984Q1-1998Q4 (60)	No	No				-	-	-
1986Q1-2000Q4 (60)	No	No				-	-	-
1988Q1-2002Q4 (60)	No	No				-	-	-
1990Q1-2004Q4 (60)	No	Yes	1.000	-10.575	4.923	-	-	-
1992Q1-2006Q4 (60)	No	No				-	-	-
1994Q1-2008Q4 (60)	No	Yes	1.000	-8.278	0.507	-	-	-
1984Q1-1998Q4 (60)	Yes	Yes	1.000	-19.630	-	-11.320	-	-
1986Q1-2000Q4 (60)	No	No			-		-	-
1988Q1-2002Q4 (60)	No	No			-		-	-
1990Q1-2004Q4 (60)	No	No			-		-	-
1992Q1-2006Q4 (60)	No	No			-		-	-
1994Q1-2008Q4 (60)	Yes	Yes	1.000	-9.577	-	0.886	-	-
1984Q1-1998Q4 (60)	Yes	Yes	1.000	-1.732	-	-	-1.496	-
1986Q1-2000Q4 (60)	Yes	Yes	1.000	-2.000	-	-	-1.926	-
1988Q1-2002Q4 (60)	Yes	No	1.000	-2.653	-	-	-1.997	-
1990Q1-2004Q4 (60)	Yes	Yes	1.000	-4.710	-	-	-1.058	-
1992Q1-2006Q4 (60)	No	No			-	-		-
1994Q1-2008Q4 (60)	Yes	Yes	1.000	-23.326	-	-	9.824	-
Model B								
1984Q1-1998Q4 (60)	No	Yes	1.000	-1.881	-0.907	-	-	-0.018
1986Q1-2000Q4 (60)	No	No				-	-	
1988Q1-2002Q4 (60)	No	No				-	-	
1990Q1-2004Q4 (60)	No	Yes	1.000	-2.883	0.500	-	-	-0.008
1992Q1-2006Q4 (60)	No	Yes	1.000	-4.678	0.232	-	-	-0.004
1994Q1-2008Q4 (60)	No	No				-	-	
1984Q1-1998Q4 (60)	No	Yes	1.000	-2.015	-	-1.099	-	-0.013
1986Q1-2000Q4 (60)	No	No			-		-	
1988Q1-2002Q4 (60)	No	No			-		-	
1990Q1-2004Q4 (60)	No	No			-		-	
1992Q1-2006Q4 (60)	No	No			-		-	
1994Q1-2008Q4 (60)	No	No			-		-	
1984Q1-1998Q4 (60)	Yes	Yes	1.000	-1.599	-	-	-1.435	-0.002
1986Q1-2000Q4 (60)	No	No			-	-		
1988Q1-2002Q4 (60)	No	Yes	1.000	-1.788	-	-	-0.944	-0.006
1990Q1-2004Q4 (60)	No	Yes	1.000	-3.692	-	-	-0.825	-0.003
1992Q1-2006Q4 (60)	No	Yes	1.000	-2.595	-	-	-3.342	0.006
1994Q1-2008Q4 (60)	Yes	Yes	1.000	-0.215	-	-	-0.651	-0.010

(Note) *q* = real imports; *y* = real GDP; *s* =import deflator/GDP deflator; s^* = IMPI/DCGPI; s^{**} = IMPI/SCGPI (adjusted); *t* = trend. "Yes" refers to cases in which the hypothesis of a unique cointegrating vector is supported at the 5 percent level. Shading indicates that the sign of the estimated coefficient is not consistent with prior expectation.

A2. Unit root tests

Prior to the econometric analysis of this paper, the time-series properties of individual variables were investigated. Table A2 reports the result of the standard Phillips-Perron (PP) and the Augmented Dickey-Fuller (ADF) tests that were conducted on these variables. While these tests are asymptotically equivalent, the PP test is more general in the sense that it does not assume that error terms are serially uncorrelated and have a constant variance, assumptions that do not seem to hold for some of our variables (e.g., it_t). Since our datasets are semi-annual and contain too few data points for these tests to be reliable, we also conducted the same tests using equivalent data series recorded at the quarterly frequency. The results are summarized in Table A2.

Table A2. Unit root tests

Variable	Phillips-Perron Test				Augmented Dickey-Fuller Test			
	Level		First difference		Level		First difference	
	Constant	Const. + trend	Constant	Const. + trend	Constant	Const. + trend	Constant	Const. + trend
[A] Semi-annual series (1990S1-2008S1)								
q	-0.901	-2.140	-2.996 **	-2.910	-0.970	-3.924 **	-4.134 ***	-4.122 **
y	-1.597	-3.039	-4.749 ***	-4.654 ***	-0.755	-2.928	-4.740 ***	-4.642 ***
qy	-0.733	-1.732	-2.918 **	-2.764	-0.951	-3.871 **	-4.126 ***	-4.105 **
s	-0.477	-1.081	-2.876 **	-4.311 ***	0.681	-1.844	-2.920 *	-4.311 ***
s^{*}	-0.207	-1.512	-3.386 **	-4.376 ***	0.692	-1.853	-3.386 **	-4.376 ***
s^{**}	-1.171	-2.779	-3.452 **	-3.420 *	-1.620	-3.219 *	-2.887 *	-2.878
it	1.792	-2.086	-4.671 ***	-6.000 ***	1.185	-3.233 *	-5.363 ***	-5.735 ***
[B] Quarterly series (1990Q1-2008Q2)								
q	-0.932	-2.335	-7.748 ***	-7.733 ***	-0.944	-2.684	-4.483 ***	-7.619 ***
y	-2.122	-3.668 **	-7.659 ***	-7.641 ***	-2.256	-3.262 *	-7.661 ***	-7.641 ***
qy	-0.610	-2.563	-8.890 ***	-8.845 ***	-0.585	-2.160	-5.042 ***	-8.850 ***
s	0.251	-0.686	-6.636 ***	-7.755 ***	0.866	-0.650	-6.432 ***	-7.750 ***
s^{*}	0.281	-1.187	-7.214 ***	-7.984 ***	0.634	-1.160	-7.111 ***	-7.980 ***
s^{**}	-1.058	-2.578	-7.237 ***	-7.403 ***	-0.770	-2.516	-7.228 ***	-7.408 ***
it	0.048	-2.620	-3.733 ***	-3.715 **	-0.055	-4.754 ***	-5.449 ***	-5.505 ***

(Note) *, ** and *** denote rejection of the unit root hypothesis at 10, 5 and 1 percent, respectively.

According to Table A2, all variables seem to be non-stationary when they are measured in levels. Although the ADF test indicates the possibility of a few variables being trend-stationary, this result is contradicted by the PP test and does not seem to be robust. Interestingly, although s^{**} looks fairly stable in Figure 4, both tests designate this variable to be non-stationary. Meanwhile, all variables are clearly I(0) when measured in terms of first differences, suggesting that the original level series are I(1). As noted in Section 4, that qy_t is I(1) implies that qy_t^T and qy_t^C are I(1) and I(0), respectively, because of the nature of the HP decomposition.

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