The Evolution of the Exchange Rate Pass-Through in Japan: A Re-evaluation Based on Time-Varying Parameter VARs

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Abstract

This paper re-examines the evolution over time of influences of the Japanese exchange rate on its exports, imports, and domestic prices. By employing the time varying parameter VAR (vector autoregression) method, this study reveals the timings of the pass-through rates changed and by how much. The sample period is January 1980 through January 2010. It shows that the pass-through rates on both import and domestic prices trended down throughout much the sample period. While the pass-through rate on domestic prices experienced a sharp decline during the 1980s and continued to decline gradually afterwards, the rate on import prices went through the second sharp decline in the latter half of the 1990s. In contrast, the pass-through rate on export prices increased, especially during the 1980s.

Key words: exchange rate, pass-through, time varying parameter VAR, export and import prices, domestic prices

JEL classification: F41, E31

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I. Introduction

This paper re-examines the time series evolution of the exchange rate movements on exports, imports, and domestic prices in Japan. In this paper, a pass-through rate is defined as a percentage response of the price of goods in the destination market (i.e., where it is purchased) to a percentage change in the nominal exchange rate. It is well recognized in literature that the degree of pass-through could have an important consequence on the effects of monetary as well as exchange rate policies. One must note that, to have a useful discussion on a reform of the exchange rate regime such as an introduction of a peg to a basket of currencies, we must first have a reliable quantitative assessment of the degree of exchange rate pass-through. In recent years, some studies pointed to a decline in the exchange rate pass-through, especially on import prices, while others have refuted this possibility, and the debate has caught much attention from policy makers as well as from researchers. The first main characteristic of this study is that it employs the time-varying parameter VAR method (TVP-VAR for short), which enables me to investigate how the Japanese pass-through rates have evolved over time. In addition to studies of export and import prices, the second characteristic is that, this paper also examines pass-through on domestic prices. The third distinguishing feature is that, for domestic and export prices, we examine not only the aggregate prices but also carry out goods-type level studies. Herein, “goods-types” refer to such categories as capital goods, consumer durables and non-durable consumption goods. As to be shown later, prices of different goods-types exhibit very distinct time-series movements. It is thus likely that an analysis of goods prices at the disaggregated level will be informative. Indeed, my results will reveal that responses of prices of those different types of goods to the exchange rate have evolved quite differently over time.

The rest of the paper is organized as follows. Section 2 discusses the background of the current paper and the economic significance of the exchange rate pass-through. Section 3 examines the evolution of the pass-through rates on export, import and domestic prices using the aggregate price data. In Section 4, I decompose domestic goods into different goods-types, and re-do the analyses of pass-through. Section 5 does a similar analysis on export prices. Section 6 is for the conclusion.

II. Background

The extent of exchange rate pass-through influences the way the domestic economy responds to fluctuations in the exchange rate. From the import side, when the yen appreciates, if the degree at which it is reflected in prices of imported raw materials, imported intermediate goods and domestic goods that are made from them is low (i.e., the rate of exchange rate pass-through is low), there will be less deflationary pressure on the domestic economy. On the other hand, Japanese households and firms will not be able to benefit from lower prices of goods which
they purchase. This implies that the increase in the amount of imports will be limited. From the export side, if exporting firms cannot pass through the impact of a stronger yen to prices of their exports, as measured in the foreign currency unit (i.e., if the pass-through rate on the export side is low), their profit per unit of exported goods, as measured in the Japanese yen, will be less. On the other hand, the extent of decrease in export volumes from Japan will be limited. That is, while a textbook argument assumes that a monetary tightening, through causing a currency appreciation, lowers domestic prices and worsens the trade account through promoting imports and discouraging exports. Thus, negative effects on output will be weak in a situation of limited exchange rate pass-through.

Although the importance of the pass-through issue has long been recognized, recent developments in literature of New Keynesian style open macroeconomic models (or “New Open Economy Macroeconomics”) has renewed the profession’s interest in this subject. Unlike the “International Real Business Cycle” models which had been developed earlier, this type of model is characterized by nominal price rigidities. As a consequence, implications of these models could change substantially depending on the underlying assumptions about the exchange rate pass-through. Most notably, welfare implications on policy effects could be affected. Such welfare analyses became feasible precisely because this type of models start with solid micro-foundations, including an explicit specification of the household utility function. Obstfeld and Rogoff (1995), which pioneered this entire literature, develop a two country model under the assumption of a perfect exchange rate pass-through. They show that, in their model, a monetary easing of one country always improves welfare of the other country. That is, there is no beggar thy neighbor effect. On the other hand, Betts and Devereux (2000) develop a model in which exporting firms, in the short run, fix prices they charge in the destination market in the units of the buyers’ currency. In other words, they assume zero exchange rate pass-through in the short run. The results show that a monetary expansion can be a beggar thy neighbor policy.

Another reason why the issue of exchange rate pass-through has caught much attention in literature of macroeconomic theory is that, depending on what one thinks is the main cause of the reduction in the pass-through rate over time reported by many observers, one might draw very different implications to macroeconomics. For example, Taylor (2000) argues that, in an environment of low inflation, firms become more hesitant to pass through changes in production costs to prices of goods that they supply. Gagnon and Ihrig (2004) advance this argument further. They hypothesize that there was a regime shift in monetary policy, and that the policy stance turned more anti-inflationary. They argue that this change might have caused the reduction in the pass-through rate.

On the side of the empirical analyses, Campa and Goldberg (2005), among others, contributed to a surge of interest in the analysis of exchange rate pass-through. Studies that belong to this strand of literature typically take domestic prices (or export prices or import
prices) as the dependent variable, and employ the exchange rate as well as other possible determinants of those prices, and estimate single equation models. In the US, Marazzi, Sheets, Vigfusson, Faust, Gagnon, Marquez, Martin, Reeve and Rogers (2005) report that the pass-through rate to import prices (i.e., by what percentage import prices increase in reaction to a percentage depreciation in the nominal exchange rate) has come down from around 0.5 during the 1980s to about 0.2. In contrast, Hellerstein, Daly and Marsh (2006) argue that the reduction has been far more modest, coming down from around 0.56 to around 0.51. An example of a study which uses the Japanese data is Parsons and Sato (2008) who utilize a very detailed data set on Japanese exports prices. Also, Otani, Shiratsuka, and Shirota (2003) analyze historical evolution of the pass-through rate to import price indices. In addition, Otani, Shiratsuka, and Shirota (2006) construct an import price index which excludes influences of crude oil and all the other primary products, and reexamine the reduction in the pass-through rate.

Another important empirical approach is estimation of vector-autoregressive models (hereafter VARs), which takes into account a possible bilateral dependence between those price variables and the exchange rate. The current paper also belongs to this second strand of the empirical literature. Within this literature, this paper is closely related to Ito and Sato (2008) who also use data from Asian countries to estimate VARs.

In response to this surge of interests in both theoretical and empirical literatures in the academia, the pass-through issue has come to catch much attention from policy makers since the initiation of the recent monetary easing within the US. As the FRB started to lower its policy rate since mid-2007, some raised a concern that this might cause inflation within the US through a depreciation of the US dollars. This concern was in part based on the increase in the share of both exports and imports in the GDP of the United States. Frederic S. Mishkin, who was a Board Member of FRB at that time, countered this concern in his speech titled "Exchange rate pass-through and monetary policy", on March 7, 2008. He points out that the reduced pass-through rate would weaken the influence of exchange rate fluctuations on domestic prices.

The author previously examined the historical evolution of the pass-through rate to import prices in Japan in Shioji, Vu and Takeuchi (2007). When we split the entire sample period into half, the post-1990 period has seen a sizable reduction in the pass-through rate, compared to the pre-1990 period. On the other hand, there is no clear difference between the two sub-periods on the export side. Shioji and Uchino (2009, 2010) re-examine robustness of the earlier results by, for example, controlling for the effects of oil prices, but the results remain qualitatively the same. A problem with this VAR sub-sample analysis approach is that it is not possible to know at which point in time a structural change started and how fast it proceeded. To overcome this shortcoming, in this study, we employ the TVP-VAR approach\(^2\). This method allows the

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\(^2\) To the author’s knowledge, a time-varying parameter estimation method has been applied to the issue
(reduced-form) VAR coefficients to change over time. For example, this enables us to draw a graph that depicts evolution of the pass-through rate from the exchange rate to import prices. By examining such a figure, one can know when the pass-through rate started to decline, and if this shift occurred abruptly within a short period of time or it took a long period of time. This paper utilizes this approach and study historical evolution of the pass-through rate, not only to export and import prices but also to domestic prices. The issue of the pass-through to Japanese domestic prices has been studied by Shioji and Uchino (2009) using a VAR approach with split samples, while this paper aims to conduct a more detailed analysis by utilizing the TVP-VAR.

III. Analysis based on the aggregate data

In this section, I conduct the analysis based solely on the aggregate data, not by different sectors. As for domestic prices, this paper uses not the most popular overall average index of DCGPI, but the index for final goods, as will be explained later.

III.1. Estimation method

Estimation method

Here I briefly explain the basic idea behind the TVP-VAR method employed in this paper. A more detailed explanation can be found in the appendix of Shioji and Uchino (2011), and a more precise argument can be found in Kim and Nelson (1999).

For example, a VAR model with two variables and one lag was considered. Denote the values of the two variables in period \( t \) as \( x_t \) and \( y_t \). Then, the reduced form model can be written as:

\[
\begin{pmatrix}
    x_t \\
    y_t
\end{pmatrix} = \begin{pmatrix}
    a_{11} & a_{12} \\
    a_{21} & a_{22}
\end{pmatrix} \begin{pmatrix}
    x_{t-1} \\
    y_{t-1}
\end{pmatrix} + \begin{pmatrix}
    b_1 \\
    b_2
\end{pmatrix} + \begin{pmatrix}
    u_{xt} \\
    u_{yt}
\end{pmatrix}.
\]

(1)

Here, \( a_{ij} (i=1 \text{ or } 2, \ j=1 \text{ or } 2) \), \( b_i (i=1 \text{ or } 2) \) are fixed parameters, and \( u_{xt} \) and \( u_{yt} \) are error terms. Assume that the variance covariance matrix of the error term is time invariant, and write it as follows:

\[
\Sigma \equiv Var \begin{pmatrix}
    u_{xt} \\
    u_{yt}
\end{pmatrix} = \begin{pmatrix}
    \sigma_{ux}^2 & \sigma_{uxy} \\
    \sigma_{yx} & \sigma_{yy}^2
\end{pmatrix}.
\]

(2)

Here, the two error terms are allowed to be correlated with each other. This fact introduces a following difficulty when one tries to draw a policy conclusion from the above analysis. For example, consider a question: when there is a unit exogenous shock to \( x_t \), how will the values of exchange rate pass-through first by Sekine (2006).
xt and yt evolve over time? In such a case, it seems to be inappropriate to assume that there was a shock only to the first error term, ut. As ut and uy are mutually correlated, it seems natural to assume that, whenever there is a change to ut, uy also changes at the same time. However, if that is the case, it becomes impossible to conduct a thought experiment in which only a certain sector of the economy gets hit by a shock. To resolve this problem, it is often assumed that, behind this reduced form model, there is a structural model, in which the two error terms in the reduced form model are determined by two mutually orthogonal structural shocks in the structural model. The following relationship is often assumed:

\[
\begin{pmatrix}
    u_{xt} \\
    u_{yt}
\end{pmatrix} =
\begin{pmatrix}
    c_{11} & 0 \\
    c_{21} & c_{22}
\end{pmatrix}
\begin{pmatrix}
    e_{xt} \\
    e_{yt}
\end{pmatrix}
\]  

and

\[
\text{Var}\begin{pmatrix}
    e_{xt} \\
    e_{yt}
\end{pmatrix} =
\begin{pmatrix}
    \sigma_x^2 & 0 \\
    0 & \sigma_y^2
\end{pmatrix}
\]  

In the above structural models, stochastic variations in the economy are caused by two types of structural shocks, namely e_{xt} and e_{yt}. Equation (3) represents a restriction that, while the “x shock” or e_{xt} affects the variable x contemporaneously, the “y shock” or e_{yt} has no effects. On the other hand, the variable y is allowed to be influenced contemporaneously by both types of shocks. Equation (4) represents the assumption that the two types of structural shocks are uncorrelated with each other. The structural parameters in this model are identified through applying the Cholesky decomposition to the variance covariance matrix of the error terms, \(\Sigma\).

The TVP-VAR approach employed in this paper allows the parameters in the “reduced form” model, that corresponds to equation (1), to vary over time. That is, in the current example, coefficients a_{ij} and the intercepts b_{i} are allowed to vary over time. This feature of the methodology permits us to study how the effects of each type of shocks on each variable evolve over time. On the other hand, the variance covariance matrix \(\Sigma\) is assumed to be time invariant. This implies that the coefficient of the contemporaneous relationship, c_{ij} in equation (3), and the variances of the structural shocks, \(\sigma_x^2\) and \(\sigma_y^2\) in equation (4), are constant over time. This in turn implies that, in the analysis that follows, the contemporaneous impact of each type of structural shocks on each variable (i.e., the size of the impulse response function in the first period) is time invariant. On the other hand, impulse responses from the second period onwards are allowed to be time variant, and we shall be focusing on those parts of the impulse

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3 Recent studies have developed a methodology which permits not only the coefficient matrices but also the variance covariance matrix of the error term to be time variant (Primiceri (2005)). In this paper, I use the more conventional approach, as it takes much time to estimate even a single model with the new methodology.
responses below$^{3,4}$. One of the shortcomings of the TVP-VAR approach is that, when one tries to estimate a model that is too large, he/she might face a limitation of the PC’s computing ability. For this reason, this paper tries to limit the number of variables included in a single VAR model by estimating models for the export side and the import side separately. Also, the number of lags is limited to 6, despite that it is more customary to use a larger number like 12 in the case of monthly data. This has made it possible to include five variables or so in a single model.

III.2. Data

Data is monthly throughout the paper, and spans the period from January 1975 to January 2010. The analysis on the import side consists of the following five variables.

- Nominal effective exchange rate (BIS)
- Import Price Index (IPI, Overall, in JPY, Bank of Japan (BOJ))
- Domestic Corporate Goods Price Index, Final Goods (DCGPI, BOJ)
- Real Imports (BOJ)

The first variable, the international price of crude oil, denominated in US dollars, is included to minimize the possibility that reactions of each of the variables in the VAR to oil prices might be mistaken for a response to the exchange rate. As detailed analyses by Shioji and Uchino (2009, 2010) reveal, historically speaking, large swings in oil prices have often coincided with drastic movements in the exchange rate for Japan. If oil prices are not included, we may obtain a conclusion that Japanese prices are reacting very strongly to the exchange rate, when they are actually responding to oil price movements.

Next, the nominal effective exchange rate is the measure of the exchange rate employed in this paper. For the Import Price Index, I use the overall average. In contrast, for domestic prices, instead of using the most popular overall average of DCGPI, I use an index which includes only final goods. This is because, in the overall index, many types of raw materials and intermediate goods are included, and it is possible that the same good is included a number of times as it goes through a multiple layer of production process. This might lead to over-estimation of the impact of price changes in raw materials, such as crude oil, in overall prices. In contrast, in the final goods index, a good is included no more than once, and hence the above bias should not

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$^{3}$ In the estimation of a TVP-VAR model, a researcher needs to set the values of the “hyper-parameters” which represent his or her own judgment on how much time variations in model parameters is allowed. There are criteria on the “optimal” choice of these hyper-parameters based on some definition of optimality, but, in this paper, I set these values based on the author’s subjective judgment. From my experiences, unless I set a very extreme value for a hyper-parameter, the estimation results are not very sensitive to the choice.
be a problem. The last variable, real imports, is included to estimate not only price responses but also responses of trade volumes to the exchange rate. Figure 1 plots all the five variables listed above.

On the import side, the following four variables are included:
- Nominal effective exchange rate (BIS)
- Export Price Index (EPI, overall, in JPY, BOJ)
- DCGPI, final goods (BOJ)
- Real Exports (BOJ)

I have decided to include domestic prices to control for their influences on export prices. Figure 2 plots the two variables that did not appear in Figure 1, namely Export Price Index and Real Exports.

In the VAR estimation, I take natural logs of all the variables, and take first differences. As stated above, the lag length is set at 6, which implies that the actual estimation period starts from August 1975. For the exchange rate, I take the negative of the log of the BIS index, so that an increase in its value signifies a depreciation of the Japanese yen. The Cholesky ordering always assumes that the first one in the list of variables is the “most exogenous”. Therefore, it is not influenced by shocks in the other variables contemporaneously: as we go down the list, the variables become “less exogenous”.

## III.3. Results for the Import Side

This paper defines the “pass-through rate” on import prices and domestic prices in the following way, based on their estimated response to an exchange rate shock and the exchange rate’s own response to an exchange rate shock.\(^5\)

\[
\text{(pass-through rate at the } t\text{-th period horizon (i.e., } t\text{ periods after the shock))} = \left(\frac{\text{cumulative impulse response of a price variable up to } t}{\text{the own response of the exchange rate up to } t}\right)
\]

By tracking changes in the pass-through rate thus defined graphically, one can study its historical evolution.

Figure 3-1 shows the time series evolution of the pass-through rate to import prices using a three dimensional graph. The axis that goes from the center to northwest indicates the number of periods after the shock. The axis that goes from the center to northeast signifies at which point in time the pass-through rate is evaluated. Throughout this paper, pass-through graphs start from January 1980, despite that the estimation period starts from 1975. This is because, in the TVP-VAR, it is known that the estimated impulse responses become sensitive to the set of

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\(^5\) Note that I am taking first differences of the variables prior to the estimation of the VAR. As a consequence, the cumulative impulse responses used in the above definition are responses of the levels of the price variables to an exchange rate shock.
initial values for the VAR parameters chosen by the researcher toward the beginning of the sample period. Accordingly, we are not able to put much trust in earlier estimation results.

Looking at the figure, we can see that the pass-through rate have had a tendency to go down for much of the sample period. A more careful analysis reveals that, during the 1980s, the pass-through rate experienced several ups and downs, and only after the 1990s, it starts to show a clear downward trend. In particular, at the end of the 1990s, we observe a large drop. The value of the estimated pass-through rate almost always exceeds 1. In some periods, it is even close to 2. This implies that a one percentage depreciation in the exchange rate increases import prices by more than one percent, which is counterintuitive. The analysis by Shioji and Uchino (2009, 2010) suggests that this is due to the effects of oil prices, which cannot be controlled for perfectly even with the introduction of the oil price variable into the VAR. Here, we focus on the historical evolution of the estimated pass-through rate, rather than its level per se.

Figure 3-2 depicts an evolution of the pass-through rate to DCGPI, final goods. As expected, the level of the pass-through rate is lower compared with the case of import prices. The historical pattern of the decline is almost the same as in the previous figure, except that we can observe a clear downward trend even during the 1980s, and that the pass-through rate starts to decline once again since the latter half of the 1990s, resulting in a very low value in the most recent years.

Figure 3-3 presents the estimated elasticity of real imports with respect to the exchange rate, that is, by what percentage real imports change in reaction to a percentage depreciation of the yen. Except for the recent years, this elasticity is negative, which is consistent with our prior expectation. The influence of the exchange rate weakens (in the absolute value sense) gradually, and this is consistent with the above result that the pass-through rate has declined over time. We observe particularly sharp declines in the mid 1980s and the late 2000s.

I also tried to control for the effects of domestic business cycles including industrial production of Japan into the VAR model: the results were virtually unchanged.

III.4. Results on the export side

Figure 4 shows the estimation results for the export side model. Figure 4-1 depicts a historical evolution of the sensitivity (or elasticity) of the Export Price Index to the exchange rate. Note that, as the Export Price Index is evaluated in the JPY unit, a higher value of this sensitivity means a lower value of the pass-through rate to export prices denominated in the units of foreign currencies. Precisely speaking, the pass-through rate in this case is one minus the estimated sensitivity that appears in this figure. The fact that the estimated value in Figure 4-1 shows a downward trend means that the pass-through rate has gradually increased over time. Evaluated at the 24th month horizon, or two years after a depreciation shock hits, the pass-through rate was only around 20% in the 1980s. In recent years, it is close to 40%. On the
other hand, the general tendency that the pass-through rate is more limited on the export side, compared to the import side, is unchanged. Figure 4-2 demonstrates the evolution of the sensitivity of real exports to the exchange rate. It suggests that the export promoting effect of a weak yen has declined over time. Again, evaluating at the 24th month horizon, this elasticity was between around 0.8 and 1.2 during the 1980s, although it has declined to around 0.3 and 0.5 in recent years. It is rather puzzling that, despite that the pass-through rate to export prices has increased, the effect of the exchange rate on export volumes has diminished. One possible interpretation is that, as the share of exports to local subsidiaries has increased in overall exports from Japanese firms, their volumes of exports have become less sensitive to price changes.

I omit the responses of domestic prices as they were virtually the same as in the case of Figure 3. I also added a proxy for world-wide demand (sum of total imports of the US and the EU) to check robustness of the result, but the results remained practically unchanged.

IV. Results from disaggregated prices: domestic prices

Next, I re-do the analysis of pass-through to domestic prices, by using disaggregated data. To be concrete, final goods are classified into three types, namely capital goods, consumer durables, and consumer non-durables. Figure 5 demonstrates that prices of those three types of goods have evolved very differently over time. In particular, they have very distinct trends, with durable goods prices declining steadily over time while non-durable goods prices increasing until the early 1980s. The latter did not show a clear downward trend even in recent deflationary periods. Also, note that production of those different types of goods requires very different proportion of imported raw materials and intermediate goods. This fact suggests that their prices may respond very differently to an exchange rate shock. This section investigates this possibility.

Here, the basic presumption is that the exchange rate affects domestic prices of those goods through the following route;

Exchange rate depreciates.

⇒ Prices of imported raw materials and intermediate goods increase.
⇒ Prices of intermediate goods that are domestically produced out of those imported goods increase.
⇒ This leads to an increase in prices of final goods that are domestically produced out of those intermediate goods.

For example, a weaker yen could raise prices of imported crude oil in JPY, and this could lead to an increase in prices of naphtha that is produced in Japan, and this could eventually lead to an increase in domestic prices of gasoline. This kind of “vertical” linkage of price increases is assumed here. This idea leads to specification of the following three types of VAR models. The first four variables will appear in all the three models:
- Crude oil prices
- Nominal effective exchange rate
- Import Price Index, weighted average of the Raw Materials Index and the Intermediate Goods Price Index (the weights are derived from their shares in the overall Import Price Index)
- Domestic Corporate Goods Price Index (DCGPI), Intermediate Goods

The fifth variable represents prices of domestic final goods, which differs between the three models. Let us call them models (1), (2), and (3). Then, the fifth variable is

- Model (2): DCGPI, Final Goods, Consumer Durables
- Model (3): DCGPI, Final Goods, Consumer Non-durables

As can be seen above, I am analyzing determinants of the three types of final goods prices separately in different models: the purpose is to limit the number of variables included in each estimation.

Also, note that the third variable, an index of import prices, excludes the influences of imported final goods: this reflects the above “vertical route” view. Figure 6 plots historical evolution of the three types of Import Price Indices, namely Raw Materials, Intermediate Goods and Final Goods. The last one shows relatively small variations over time, and appears to be quite different from the other two, which seems to justify the separate treatment. The fourth variable in the list, prices of domestically produced intermediate goods, is included in the hopes for capturing the “vertical rote” more precisely by putting it in between import goods prices and domestic final goods.

Figure 8 presents the estimated pass-through rates and other related results. Figure 8-1 shows the pass-through rate to Import Prices, Raw Materials + Intermediate Goods, while Figure 8-2 corresponds to DCGPI, Intermediate Goods. Those results are based on model (1), but the results are basically the same in models (2) and (3). Figure 8-1 reconfirms the earlier results that the pass-through rate to import prices is high and it is declining over time, though we again find the rather uncomfortable result that the pass-through rate is above one. Again, the extent of the decline is the largest during the 1990s. According to Figure 8-2, evaluated at one and a half years after a shock, the pass-through rate to domestic intermediate goods was nearly 80% at the beginning of the 1980s but declined throughout the 1980s, and experiences a large decline one more time at the end of the 1990s. In the end, this rate goes down to about 20 to 30%.

Figure 8-3, based on the results from model (1), presents the pass-through rate to domestic capital goods prices. Likewise, Figure 8-4 shows the result for domestic consumer durables based on model (2), while Figure 8-5 used the results from model (3) to produce a similar graph for domestic consumer non-durables. Starting with the comparison of the levels of the pass-through rate, that to consumer durables is very low, never surpassing 10%. The case for capital goods is somewhere in the middle: in the early 1980s, when its level was the highest, the
pass-through rate in the medium to long runs was over 20%. Compared to those two, the pass-through rate to consumer non-durables has been relatively high, and its medium to long run values at the beginning of the 1980s were close to 40%. This has been expected, to some extent, as consumer non-durables include such items as gasoline. Still, its level is about a half, compared with the pass-through rate to domestic intermediate goods.

Moving on to the analysis of historical evolutions, all three types show declining tendencies. Looking more closely, consumer durables go through a steady decline throughout the sample while capital goods and consumer non-durables experience sharp declines in the 1980s. Those discrepancies across goods-types, not only in terms of the levels of the pass-through rates but also their historical evolutions, indicate merits of studying disaggregated data. It should be noted that, in recent years, the pass-through rates are at very low levels for all three types. For capital goods and consumer non-durables, their levels are about 5% or lower. As for consumer durables, the estimates have turned negative. It is possible to conclude from those results that, independent of the goods-types, prices of domestically produced final goods in Japan have become quite insensitive to the exchange rate movements.

V. Results from disaggregated prices: export prices

Finally, I conduct a similar analysis for export prices. Again, I will focus on export prices of final goods, and decompose them into capital goods, consumer durables, and consumer non-durables. As Figure 7 shows, those three have exhibited very different historical patterns of variations. It is particularly notable that prices of consumer non-durables are more volatile than the other two. Again, I set up three types of VAR models that correspond to each of those types of goods.

Concretely, I estimate three types of four variable VARs which consist of the following variables:

- Nominal effective exchange rate
- Import Price Index (Capital Goods for model (1), Consumer Durables for model (2), and Consumer Non-durables for model (3))
- DCGPI, Final Goods (again, Capital Goods for model (1), Consumer Durables for model (2), and Consumer Non-durables for model (3))
- Export Price Index (once again, Capital Goods for model (1), Consumer Durables for model (2), and Consumer Non-durables for model (3))

As can be seen above, those models incorporate import prices and domestic final goods prices that are of the same category as the last variable in the list, namely export prices. Import prices of the same category are included as they are thought to represent prices of rival products for Japanese firms in the international competition. Domestic prices of the same category are included as they capture production cost changes in producing those types of goods. Thus, the
modeling strategy for export prices emphasizes “horizontal” links. Results are summarized in Figure 9. Figure 9-1 depicts the elasticity of capital goods export prices to the exchange rate based on the results from model (1). As discussed earlier, the pass-through rate is one minus the elasticity shown here. Figure 9-2 and 9-3 corresponding results for consumer durables (based on model (2)), and consumer non-durables (based on model (3)), respectively.

The results emphasize differences across goods-types. Starting with the levels of the pass-through rates that for capital goods is relatively high, averaging around 50%. The pass-through rate to consumer durables is around 25% in the short run and around 50% in the medium to long runs. That for consumer non-durables is historically very low. In fact, in some parts of the sample, the value turns negative. Even recently, the value is 20 to 30%. This may reflect the fact that Japanese firms do not have much pricing power in the international market for consumer non-durables.

Next, consider the historical evolution of the pass-through rate, focusing on its value two years after the shock. For capital goods, its value was around 30% in the early 1980s, but has risen to 50-60% in recent years. For consumer durables, starting from a negative value as indicated above, the pass-through rate goes up to around 30%. In contrast, the pass-through rate to consumer durables fluctuates between 40 to 50%, showing no clear trend either downward or upward.

To summarize, pass-through is incomplete on the export side, but we observe an upward trend historically. In recent years, evaluated at the 2 year horizon, it is between 30 to 50%. We must note, however, that there are substantial differences in those patterns across goods-types.

VI. Conclusions

This paper has utilized the TVP-VAR method to examine the evolution of the exchange rate pass-through rates to export, import and domestic prices in Japan. It has been found that, while the pass-through rates have declined for import and domestic prices, that for export prices have increased. As for real trade volumes, influences of the exchange rate have declined on both export and import sides.

A major characteristic of this paper approach is the use of disaggregated data. Capital goods, consumer durables and consumer non-durables appear to differ not only in terms of the levels of the pass-through rates, but also with respect to their historical patterns.

I list four subjects for the future researches. First, analyses at more disaggregated levels of goods are in order. There is substantial within-goods-type heterogeneity in the three categories of goods used here. It is worthwhile considering analyses at more disaggregated level as in Shioji and Uchino (2009, 2010). Second, effects of the exchange rate on consumer prices, especially service prices, need to be analyzed. Third, reasons for the elasticity of prices of certain types of goods (mainly consumer non-durables) with respect to the exchange rate
exceeding one need to be investigated. Fourth, on the methodological issue, introduction of a new TVP-VAR method which allows the contemporaneous variance covariance matrix to change over time is worth considering.
References

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Primiceri, G. E. “Time Varying Structural Vector Autoregressions and Monetary Policy”,


Figure 1 Data for the analysis of aggregate data, import side

Figure 2 Data for the analysis of aggregate data, export side (excluding those variables that already appeared in Figure 1)
Figure 3-1 Analysis of aggregate data, import side
Evolution of the pass-through rate from the exchange rate to IPI (overall)

Figure 3-2 Analysis of aggregate data, import side
Evolution of the pass-through rate from the exchange rate to DCGPI, final goods
Figure 3-3 Analysis of aggregate data, import side  
Evolution of the elasticity of real imports to the exchange rate

Figure 4-1 Analysis of aggregate data, export side  
Evolution of (1- pas-through rate) from the exchange rate to EPI (overall)
Figure 4-2 Analysis of aggregate data, import side
Evolution of the elasticity of real exports to the exchange rate

Figure 5 DCGPI, Final Goods, by goods-types
Figure 6 Import Prices, by stages of demand

![Import Prices Graph](image1)

Figure 7 Export Price Index, by goods-types

![Export Price Index Graph](image2)
Figure 8-1 Analysis of disaggregated data import and domestic side
Pass-through rate from the exchange rate to IPI (raw materials and intermediate goods)

Figure 8-2 Analysis of disaggregated data import and domestic side
Pass-through rate from the exchange rate to DCGPI, intermediate goods
Figure 8-3 Analysis of disaggregated data import and domestic side
Pass-through rate from the exchange rate to DCGPI, capital goods

Figure 8-4 Analysis of disaggregated data import and domestic side
Pass-through rate from the exchange rate to DCGPI, consumer durables
Figure 8-5 Analysis of disaggregated data import and domestic side
Pass-through rate from the exchange rate to DCGPI, consumer non-durables

Figure 9-1 Analysis of disaggregated data, export side
(1-pass-through rate) from the exchange rate to EPI, capital goods
Figure 9-2 Analysis of disaggregated data, export side
(1-pass-through rate) from the exchange rate to EPI, consumer durables

Figure 9-3 Analysis of disaggregated data, export side
(1-pass-through rate) from the exchange rate to EPI, consumer non-durables