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Pass-Through of Oil Prices to Japanese Domestic Prices[1]

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Abstract

Recent dramatic surge and fall of crude oil prices have renewed interest in their effects on domestic economies. In this paper, we investigate changes in the influences of world crude oil prices on domestic prices in Japan. We conduct two types of analyses. First, we employ a VAR methodology as well as a time-varying parameter VAR (TVP-VAR) approach to conduct detailed analyses on how the pass-through rate of oil prices has evolved over time. We confirm the declining pattern of the pass-through rate, both at the aggregate and sectoral levels for the period 1980-2000. Second, we study how the declining pass-through during this period is related to the changing cost structure of Japanese firms, by studying predictions from Input-Output Tables. Comparison between the TVP-VAR results and the I-O analysis results indicates that structural changes in cost structure goes a long way toward explaining the decline in the pass-through rate of oil prices. And the main driving force behind these changes, in turn, is the price of oil itself: that is, as oil became cheaper, it became less and less important in the overall cost structure, and thus the pricing behaviors of the firms became less responsive to its prices. The real factor, namely substitution between oil-intensive technology and less oil-intensive one, played a secondary role.

We also study changing influences of oil prices during the period 2000-2007. As one would expect from the above analysis, we find that, as oil prices go through historical surges, pass-through rates of oil prices increase in many instances. However, those increases are muted and delayed in comparison to the drastic increases in oil prices. We present some possible explanations for this fact.

1 Introduction

This paper studies the effects of oil prices on domestic prices using the Japanese data. Recent dramatic surge and fall of crude oil prices have renewed interest in their effects on domestic economies. In the literature, many authors have documented (in many cases using the US data) weakening impacts of oil prices on the domestic economy. For example, Hooker (1996) finds that impacts of oil prices on US GDP and US unemployment have diminished since the mid 1970s. Hooker (2002), which is more relevant for the current analysis, finds that the impact of oil prices on US domestic inflation has been weakened significantly since around 1980. De Gregorio, Landerretche, and Neilson (2007) apply a Hooker-type approach to a number of industrialized as well as developing countries and confirm his findings. They also estimate rolling VARs for those countries and again confirm declines in oil price pass-through. Blanchard and Gali (2007) also estimate rolling VARs for the US. They also estimate regular VARs for the US and other industrialized countries, splitting the sample at 1984. They arrive at similar conclusions as the previous authors[2]. Causes behind these changes have also attracted attention of macroeconomists. As Blinder and Rudd (2009) summarize succinctly, three possible causes have been widely considered. First is increased credibility of monetary policy. Second is greater wage flexibility. Third is the changing industrial structure after the two oil crises: firms have shifted away from energy using technology to energy saving technology[3,4].

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[2] However, they find inexplicable impulse response results for Japan.

[3] Blanchard and Gali (2007) construct a New Keynesian DSGE model that incorporates all three elements. Their simulations show that all three have contributed to declining pass-through of oil prices. Kilian (2007) mentions two other candidates: one is a US specific reason (structure of the automobile industry) which is less relevant here. The other is a difference in the fundamental cause behind the oil price increase. It is hypothesized that the oil price increase in the 2000s was a consequence of a world wide demand increase rather than a supply shock. On the issue of inflation, however, it is not clear if demand-driven oil price increase should have either stronger or weaker effects on domestic prices. De Gregorio et. al. (2007) argue that a positive demand shock would tend to appreciate currencies of commodity importing countries, thus mitigating the effects of higher oil prices. De Gregorio et. al. (2007) also offers an additional candidate for the cause of the pass-through decline: under a low inflation environment, firms change prices less frequently, and, as a consequence, oil price increases are not easily passed through to domestic prices.

[4] Another important hypothesis is that oil prices were not so influential to begin with: it was another shock that occurred around the same time period (the most notable candidate is an excessively tight monetary policy). Refer to, for example, Bernanke, Gertler and Watson (1997). Blinder and Rudd (2008), on the other hand, support the supply-shock view of the "Great Inflation" of the 1970s and the 1980s.

In this paper, we study the Japanese data using time series analysis technique and confirm the tendency toward declining pass-through of oil prices to domestic prices, for the period 1980-2000. We find that the main driving force behind this is the price level of oil itself: investigation of the Japanese Input-Output tables reveals that changes in the cost structure alone goes a long way toward explaining the declining pass-through, and that the main reason behind the changing cost structure is the (relative) price level of oil itself. Put simply, as oil became cheaper, it became less and less important in the overall cost structure (due partially to a relatively low degree of substitution between oil and non-oil inputs), and thus the pricing behaviors of the firms became less responsive to its prices. The real factor, namely the substitution effect mentioned above, did play some role, too, though a secondary one. We also document the importance of taking into account features of the Japanese oil-related taxation system.

This paper is a sequel to Shioji and Uchino (2009). In that paper, we estimate a series of VARs with oil prices, the exchange rate, and various indicators of domestic prices, splitting the entire sample period into two sub-periods: the first is the period January 1975 to December 1989, and the second is from January 1990 to January 2009. It is reported that, as a general tendency, pass-through of both oil prices and the exchange rate tend to decline between the two periods. Then, those results are compared to the results of our study on the Japanese input-output table, though we use only information from the 1980 and 2000 I-O Tables in that paper.

This paper extends the above analysis in three important respects. First, the VAR analysis in the previous paper does not reveal how the pass-through rate evolved over time. Note that, if changes in the cost structure were the main reason behind its decline, we might expect it to happen gradually over time, rather than experiencing a one-time structural break. To pursue this issue further, in this paper, we estimate time-varying parameter (or TVP-) VARs (refer to, for example, Kim and Nelson (1999)). It is expected that this approach will help detect timing of structural changes, and thus give us more hint on the causes behind the decline in the pass-through rate. Like in Shioji and Uchino (2009), we compare the time series estimation results with predictions from the input output table analysis, to see how much of the observed changes in the pass-through rate can be explained by cost structure related reasons. The second feature of this paper is that we conduct a far more detailed analysis of the Japanese input output table. Third, we pay close attention to the late 2000s, i.e., the recent dramatic rise and fall of oil prices and their consequences on the Japanese prices.

The rest of the paper is organized as follows. In section 2, we revisit evidence from the simple VARs with split samples, for the sake of comparison with our TVP-VAR results. Section 3 presents the results based on the TVP-VARs, and, in section 4, we compare them with the results

of the input-output table results for the period 1980-2000. In section 5, we turn our attention to the recent periods of volatile oil price movements. Section 6 concludes.

2 Evidence from regular VARs

Japan imports over 99% of crude oil it uses from abroad, and is thus considered to be vulnerable to its price changes. Figure 1 plots three variables. First is the World Crude Oil Price Index ("OIL" for short). This variable is defined in US dollars. We use IFS's "World Petroleum: Average Crude Price", monthly averages, all the way up to October 2008. As we could not obtain this data for November and December of 2008 as well as for January 2009, we supplement this with the data on North Sea Brent Spot, also monthly averages. Second is the Import Price Index for Crude Oil ("IPI" for short). This variable is denominated in the Japanese yen. It is taken from the Bank of Japan (BOJ)'s *Price Indexes Quarterly*. Third is Japan's Corporate Goods Price Index (overall average, "CGPI" for short), which corresponds to the wholesale price index in many countries. The data source is the same as IPI. The figure spans the entire sample period of our analysis, namely from January 1975 to January 2009. The variables are normalized so that their values in January 1990 are all equal to 100.

Figure 1 Evolution of OIL, IPI and CGPI, January 1990 = 100

Source: Bank of Japan and International Financial Statistics(IFS).
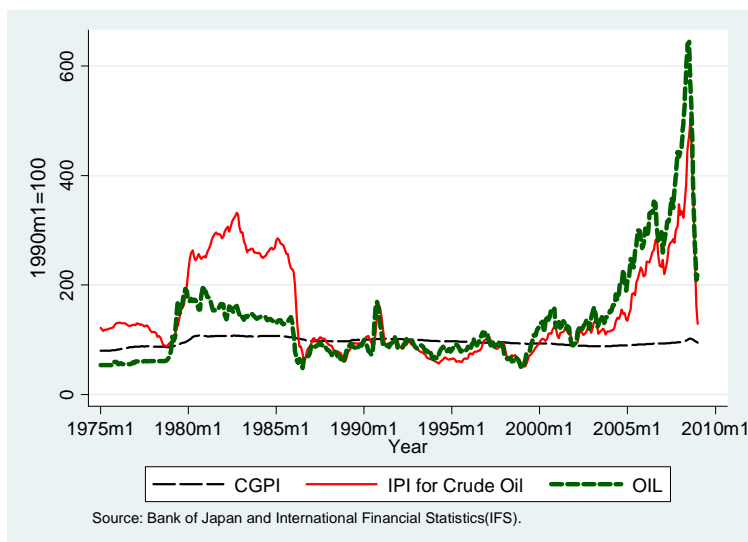
In Figure 1, note that, despite the surge in the US dollar price of crude oil (namely OIL) in the second half of the 2000s, its *yen* price (namely IPI) does not surpass its peak in the 1980s until

late 2007. This is because the dollar-yen exchange rate changed in favor of the yen between those two periods.

It is often stated that the pass-through rate of oil prices to the domestic prices in Japan has declined in recent years. To see if this claim is verified, we estimate a series of three variable VARs[5], with OIL, IPI and an index of Japanese domestic prices. All the data is monthly. The first sample period is from January 1975 to December 1989 (often referred to as the "first half") and the second sample period is from January 1990 to January 2009 (often referred to as the "second half")[6]. Throughout this paper (including the TVP-VAR part), the lag length is set to equal 12. We take natural logarithms of all the variables and take their first differences. Reported impulse responses are all cumulative responses (that is, they are the responses of the log level of each variable) to one standard deviation shocks. The impulse response calculations are based on Cholesky decomposition, with OIL treated as the "most" predetermined, and IPI as the second. Note that OIL is in US dollars while IPI is in the Japanese yen. Hence, innovations in IPI at least partially reflect unexpected fluctuations in the dollar-yen exchange rate, in addition (possibly) to changes in transportation costs and margins charged by shipping firms. To save space, we report only cases that correspond to an OIL shock, and show its own responses (i.e., responses of OIL to OIL) and responses of IPI and domestic price indices. Figure 2 reports the case in which the domestic price index is CGPI total. In all the panels reported in this section, the left hand side figure is for the first half, and the right hand side is the second half. Also, the shaded areas are the 95 percentile bands. Panel (A) corresponds to the response of OIL to an OIL shock. Panel (B) is the response of IPI to OIL, and (C) is the response of CGPI to OIL. Note that the scales in Panels (B) and (C) are set in the same way as in (A) for the sake of comparison. But this makes the graphs in (C) too small. For that reason, in Panel (D), we present the same graph as in (C) but with a different scale. Note, first, that the sizes of the responses of OIL to an "own shock" are not that different between the first half and the second half (Panel (A)). This means that we can study

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[5] In this paper, we do not try to include more than three variables at a time, as we found that estimating a time varying parameter VAR (TVP-VAR) with more than three variables with 12 lags is too time consuming and, in most cases, we simply run out of computer memories when trying such large scale estimation.

[6] Our choices regarding the beginning of the first half and the last month of the second half are dictated by the data availability (at the time we started this research). The choice of where to break the sample is somewhat arbitrary, except that it roughly corresponds to the beginning of Japan's so-called "lost decade".

changes in the magnitudes of pass-through primarily by looking at the responses of domestic prices[7]. Panel (B) shows that, within six months to one year, changes in the world wide oil prices are passed onto import prices to Japan, almost fully[8]. Panel (C) shows that the response of CGPI to OIL was small compared with the own response, even during the first half and that it declined further in the second half (which is more evident in the magnified graphs in (D)).

One of the possible shortcomings of using the overall CGPI is that it is constructed as the weighted average of prices of goods sold at various stages of production. This means that the same oil can be counted many times: as a raw material, as a part of an intermediate input (such as naphtha, ethylene, and polyethylene), and as a part of a final product (such as plastic hoses). To minimize this problem, we redo the analysis utilizing the information on CGPI "by stage of demand and use" published by the Bank of Japan. First, we use the average CGPI for intermediate products (domestically produced) only, which will be denoted as "CGPI-M". Second, we also use the average CGPI for final products (domestically produced) only, which will be denoted as "CGPI-F". Figure 3 reports the results. We also report the case in which CPI is used in place of CGPI, for the sake of comparison. To save space further, we only report responses of those domestic price indices. We see that the general tendency for declining pass-through applies to those alternative measures of domestic prices as well. We can also see that the pass-through rate tends to decline as we move downstream from CGPI-M to CGPI-F and further to CPI.

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[7] To illustrate this point, consider the following counterfactual example: suppose that the responses of CGPI to OIL are of about the same size between the two periods, but the response of OIL to itself in the second half is twice as large as that in the first half. In such a case, it is reasonable to conclude that the pass-through rate of OIL to CGPI was halved in the second half. This example suggests importance of looking at the sizes of "own responses" in drawing economic conclusions.

[8] It is evident that the second half responses often exhibit oscillatory movements that are difficult to interpret. We have found that this pattern emerges when we extend the sample period beyond September 2008. Some preliminary results indicate that the patterns become "less strange" when we extend the sample further to April 2009.

Figure 2: Regular VAR with CGPI, first half (left) and second half (right)
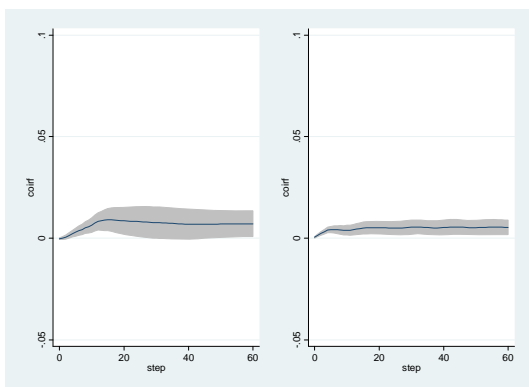
(A) Response of OIL to OIL
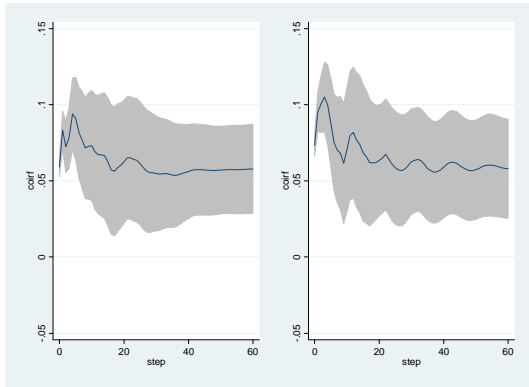
(B) Response of IPI to OIL
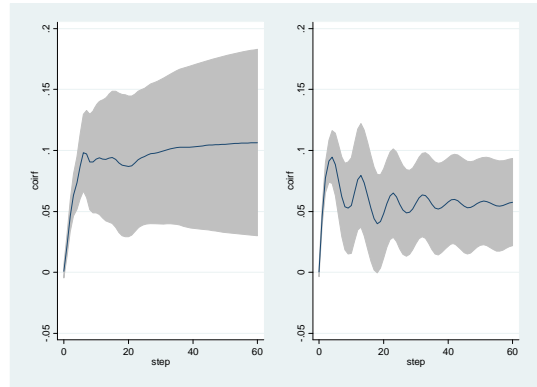
(C) Response of CGPI to OIL
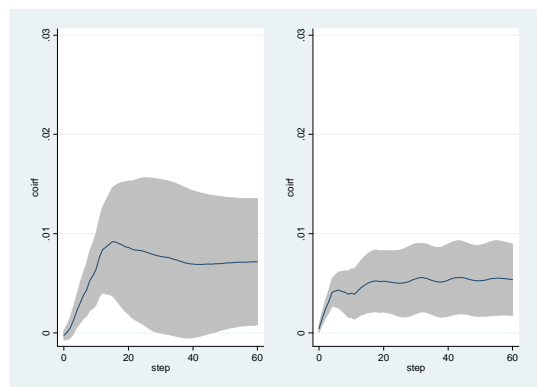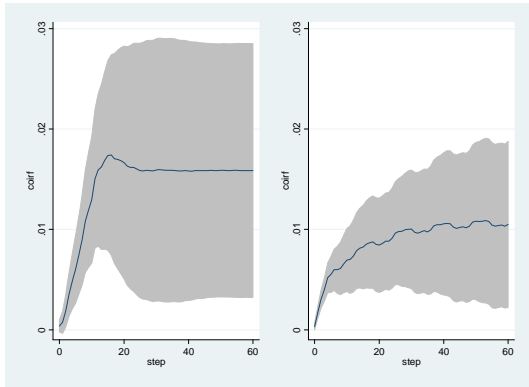

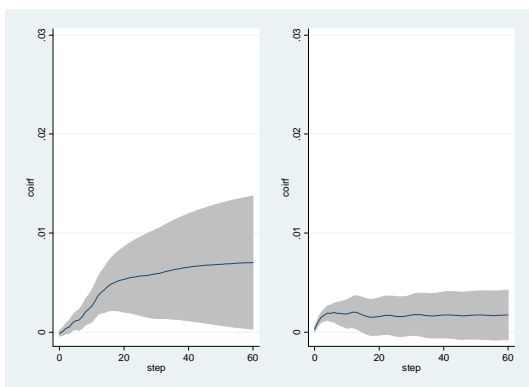(D) Same as (C), magnified

Figure 3: Regular VAR with alternative prices, first half (left) and second half (right)
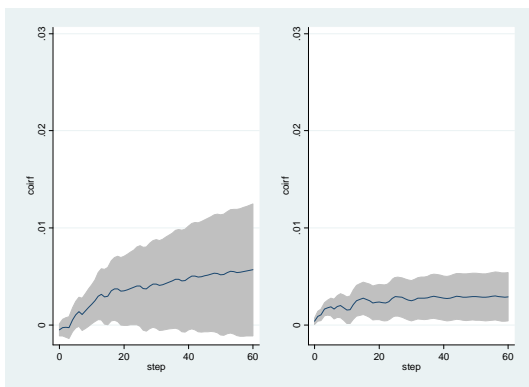
(A) Response of CGPI-M to OIL

(B) Response of CGPI-F to OIL

(C) Response of CPI to OIL

9

3 Evidence from TVP-VARs

3-1 Evidence for aggregate prices

As we have already argued, regular VARs with sub-samples are not necessarily helpful in detecting timing and speed of structural changes. In this section, we employ a time varying parameter VARs (TVP-VARs) to overcome these shortcomings. Refer to Appendix for the details of the empirical method employed here. Very briefly, our method is an application of the Kalman Fliter, and only the reduced form VAR coefficients are allowed to change over time.

In this section, we continue with our study on aggregate domestic prices. As in the previous section, we estimate a series of TVP-VARs with three variables, namely OIL, IIP, and a measure of domestic prices. In Figure 4, we show an example in which we use CGPI as the domestic price index. These are impulse responses, evaluated at January of years 1980, 1985, 1990, 1995, 2000, 2005, and 2009, of each variable to an OIL shock. We can observe that the responses of CGPI shifted upward during the 1980s, moved down sharply at the beginning of the 1990s, and then continued to decline gradually until the mid-2000s. There is a slight shift upward in 2009. While this kind of graph is undoubtedly informative, it is difficult to grasp the big picture from here. This is especially so because we wish to compare the responses of the domestic price index (CGPI here) with the "own responses" at each point in time. Next, we try to summarize the vast information provided by the estimation in a little more succinct way. In Figure 5, we report time series evolution of the estimated "pass-through rates". With respect to an OIL shock, it is defined in the following way:

(Pass-through rate of OIL at time horizon s in period t)

= (impulse response of OIL to an OIL shock at horizon s in period t)

/ (impulse response of domestic price to an OIL shock at horizon s in period t).

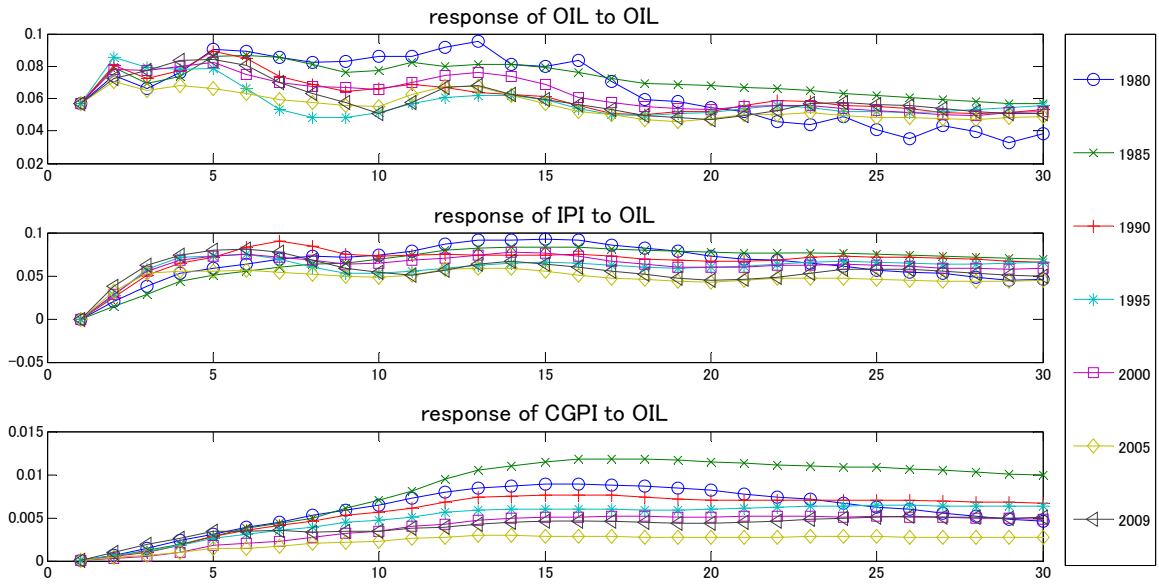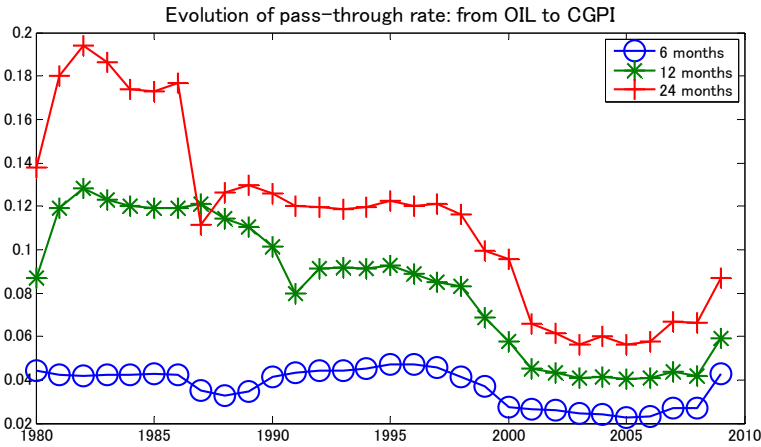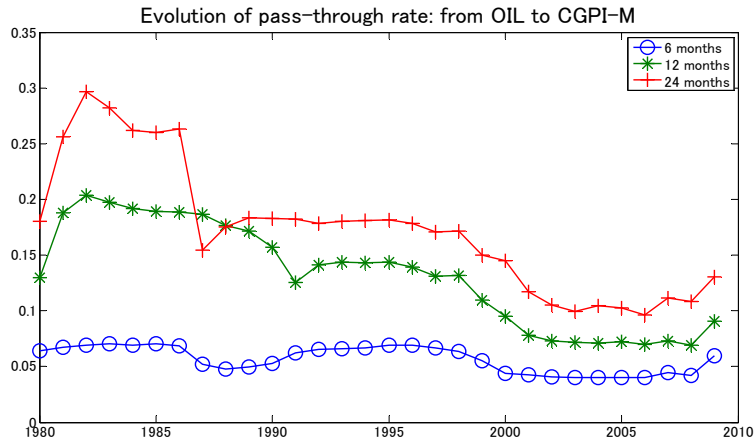Figure 4: TVP-VAR results for CGPI total: Impulse responses to OIL

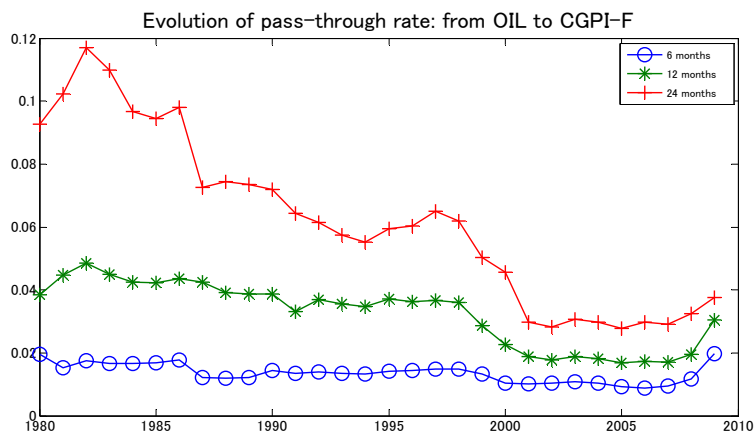Figure 5 Estimated Pass-through rates for aggregate price indices

(A) CGPI total

(B) CGPI-M

Evolution of pass−through rate: from OIL to CGPI−M

(C) CGPI-F

Evolution of pass−through rate: from OIL to CGPI−F

(D) CPI

Evolution of pass−through rate: from OIL to CPI
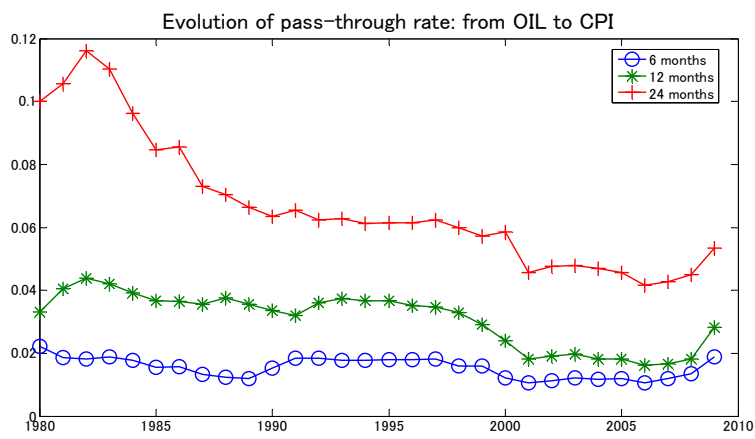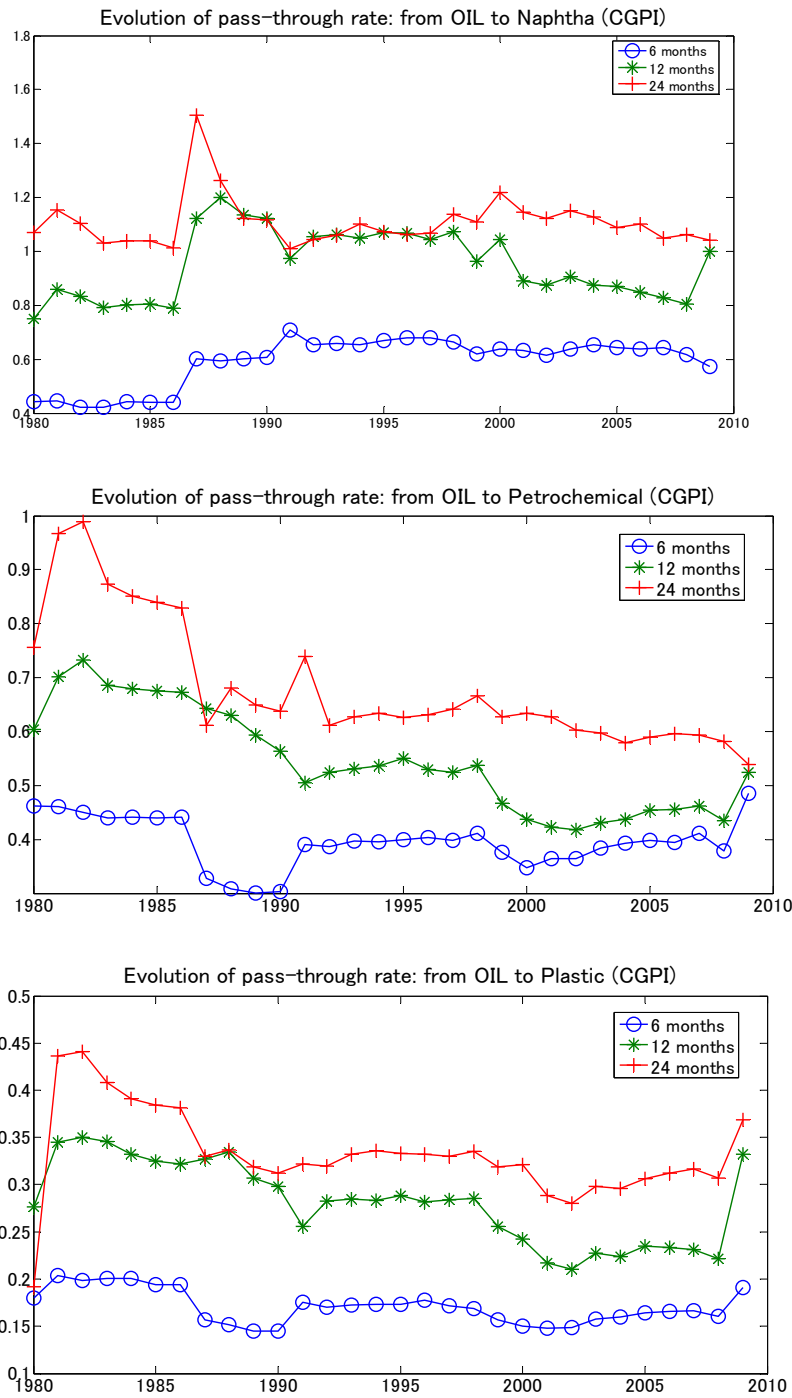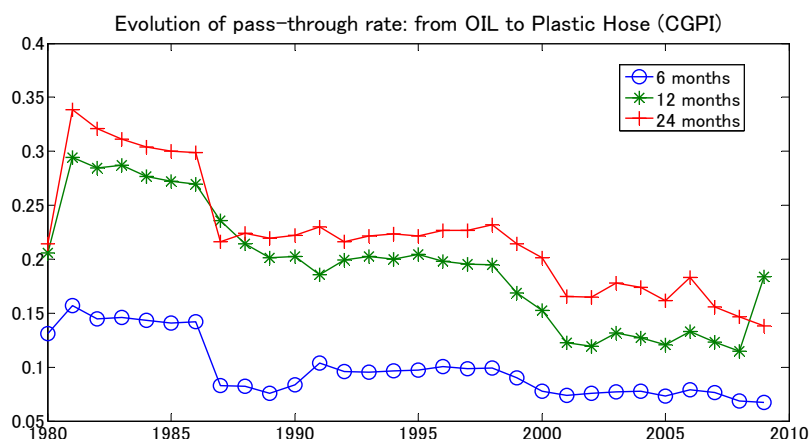
In Figure 5(A), we calculate the estimated pass-through rate of OIL to CGPI total from the impulse responses reported in Figure 4. They are computed for the 6th, 12th, and 24th time horizons, for January of the years 1980-2009. We observe that the pass-through rate goes up sharply at the beginning of the 1980s and comes down gradually but fast in the latter half of the 1980s. It declines further at the end of the 1990s and there is a small increase toward the end of our sample period. In Figure 5(B), (C), and (D), we report the pass-through rates for CGPI-M, CGPI-F, and CPI, from three variable TVP-VARs that incorporate each of those variables in place of CGPI. We find that the basic patterns are similar: pass-through rates for CGPI-M are larger than those for CGPI, while those for CGPI-F and CPI are smaller, with the former slightly larger than the latter.

3-2 Evidence from Plastic

The previous sub-section revealed declining tendencies of pass-through of oil prices to Japanese aggregate prices. This, however, could be due to a mixture of two causes: declines in responsiveness of prices of oil-related products to oil prices, and increases in the shares of non-oil-related products (and also services, in the case of CPI). To extract the former effects from the data, we now turn our attention to industry level price data and focus on products that are very oil intensive. In this sub-section, we take up plastic and related products. Distilling crude oil at oil refineries produces "naphtha", among other things, and cracking naphtha in petrochemical steam crackers yields so-called "basic petrochemical products" (ethylene, propylene, benzene, etc.), and they are used to produce various types of "plastic" (polyethylene, polypropylene, etc.). Then plastic is supplied for various purposes, including production of so-called "plastic products" (such as plastic hoses). Here, we study how the pass-through rates of crude oil prices to those products at each of these stages evolved over time.

Figure 6: Estimated pass-through rates for plastic and related products

Evolution of pass–through rate: from OIL to Naphtha (CGPI)

Evolution of pass–through rate: from OIL to Petrochemical (CGPI)

Evolution of pass–through rate: from OIL to Plastic (CGPI)

Evolution of pass-through rate: from OIL to Plastic Hose (CGPI)

In Figure 6, we report results from a series of three variable TVP-VARs, with crude oil (OIL), IPI of Naphtha, and one of the product-level domestic price indices: that is, CGPI of Naphtha, CGPI of Basic Petrochemical Products, CGPI of Plastic, or CGPI of Plastic Hose. The last one is used as a representative of Plastic Products[9]. In this sub-section, we use IPI of Naphtha in place of that of crude oil: this is because domestic prices of naphtha are determined in reference to prices of imported naphtha[10]. First, note that, as we move down the panels, that is, as we move toward downstream of production stages, the estimated pass-through rate tends to decline, as one would expect. Next, we see the same general pattern that we saw in the aggregate prices: the pass-through rate increases sharply at the beginning of the 1980s, declines in the latter half of the 1980s, again toward the end of the 1990s, and we see slight increases in some cases toward the end of the sample period. An exception is naphtha: as the pass-through rate was high to begin with, it does not show an increase at the beginning of the sample. We might be able to argue that there were some declines subsequently.

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[9] It was difficult to find many CGPI series of plastic products that go back all the way to the year 1975: we could identify only four. We use Plastic Hose as a representative example.

[10] To be more precise, this custom started formally in 1982, when the Ministry of International Trade and Industry decided that domestic price of naphtha should be determined by adding certain margin to prices of imported naphtha, and that the price should be revised every quarter (rather than monthly).

3-3 Evidence from Gasoline

Next, we turn to the case of gasoline. Again, we estimate a three variables TVP-VAR, with OIL, IPI of crude oil, and CPI of gasoline. Note that the estimates for the last few months may be contaminated by the temporary reduction in the gasoline tax rate in 2008. We report the estimated pass-through rates in Figure 7. We observe that the level of the pass-through rate is lower compared with, for example, naphtha. It tendency to decline over time, before starting to increase again in the late 2000s, is similar to the previous results.

Figure 7: Estimated pass-through rate for Gasoline
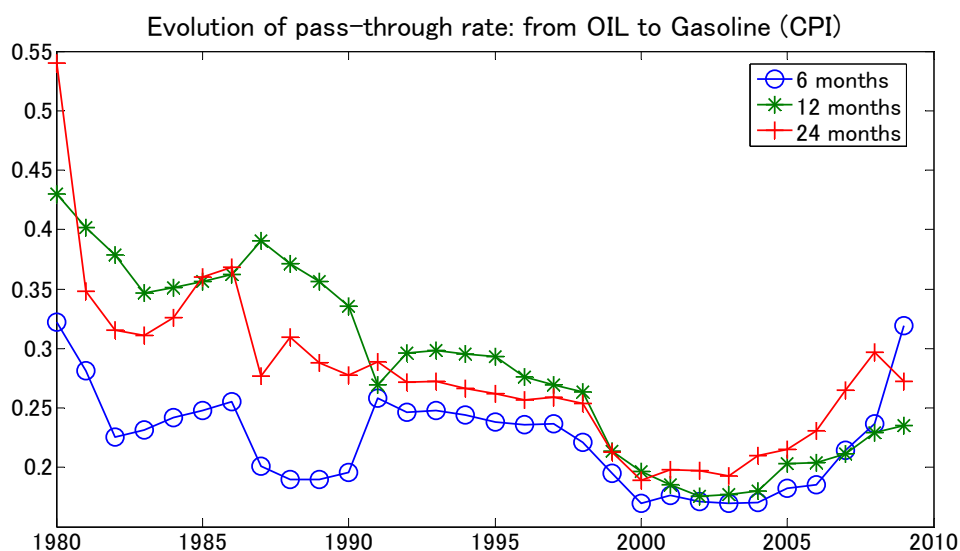
3-4 Evidence from Electricity

Finally, we turn to the case of electricity. In this case, we estimate a three variables TVP-VAR, with OIL, IPI of "crude oil, coal and natural gas", and CGPI of electric power. We include natural gas etc. in our definition of IPI here, because even thermal power plants use not only oil but also coal and natural gas[11]. CGPI of electric power is deseasonalized by the Census X-11 Method. We report the estimated pass-through rates in Figure 8. We can observe continuous declines in the pass-through rate, starting in the early 1980s and lasting throughout much of the sample period, until it starts to increase again toward the end of the sample.

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[11] In fact, oil has come to play a relatively minor role. We shall discuss this matter further in the next section.

Figure 8: Estimated pass-through rate for Electricity
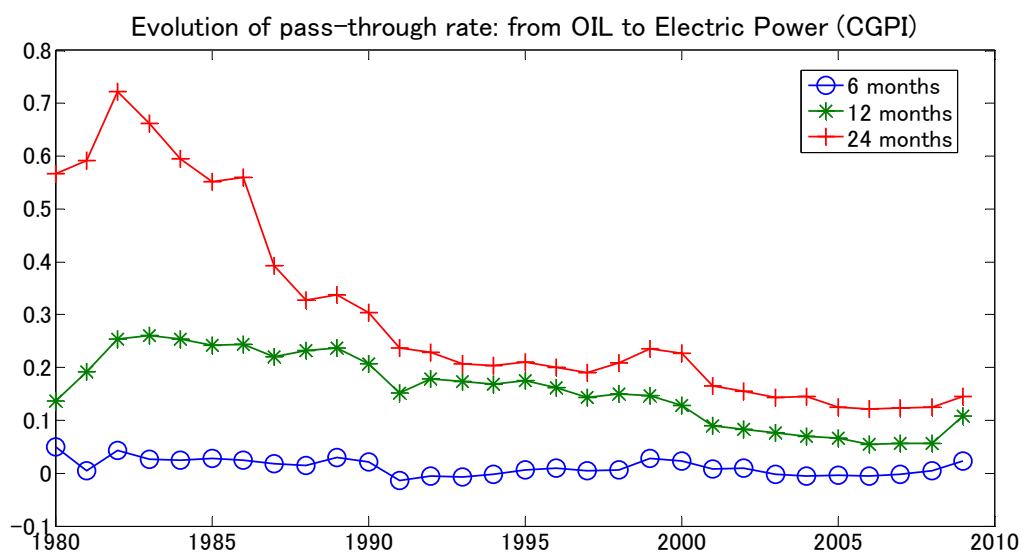
In this section, we have seen that the declines in the pass-through rates at the aggregate level are not simply a result of shrinking shares of oil-related products. Even at the level of those products, we can find declines in the pass-through rates. In the next section, we study implications from the Input-Output Tables to see if this can be explained from changes in the cost structure of oil-related production.

4 Cost structure and pass-through rates: what do the Input-Output Tables predict? The 1980-2000 period.

4-1 Data and Methodology

In Japan, frequent changes in rules and methodology (such as grouping of goods and services) make a long run comparison of input-output structure difficult. Fortunately, the Research Institute for Economy, Trade and Industry (RIETI) provide detailed Input-Output Tables for years 1980, 1985, 1990, 1995 and 2000 that are directly comparable between each other. They provide tables in both nominal units and real (constant 1995 price) units. Each of the tables contains 511 rows (industries that provide inputs) and 398 columns (industries that use those

inputs). Most notably, "crude oil" appears as a single row item (though, on the column side, it is combined with natural gas). Also, different types of Petroleum Products, such as "gasoline", "naphtha", "fuel oil A" and "fuel oil B&C", all appear as separate items on the row side (though they are all combined into one on the column side). This is important, as different types of Petroleum Products receive very different tax treatments. We make suitable assumptions to expand the tables into matrices of dimensions 511 times 511[12].

Naturally, we are also interested in the period after 2000. The next section employs more recent I-O tables, which are much smaller than the ones explained above (due to limited data availability), to study the 2000s.

The I-O Tables can be used to derive predictions on a percentage response of the average price of products of a certain sector when the price of imported goods (say) of another sector increases by 1%. The Input-Output analysis with N sectors (with trade) has the following basic structure:

$$x = Ax + d + e - M(Ax + d)$$

where x is the vector of output ($N \times 1$), A is the input coefficient matrix, d is the vector of domestic final demand ($N \times 1$), e is the vector of exports ($N \times 1$), and M is the matrix of import coefficients. The matrix M is a diagonal matrix whose ith diagonal element is the ratio of the imports of the ith sector to the sum of intermediate inputs from the ith sector to all the sectors plus the domestic final demand to this sector's output. From here, it is possible to derive the following pricing equation:

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[12] The numbers of columns and rows do not coincide basically because certain row industries are combined into single column industries. In such cases, in principle, we assume that each column industry that belongs to the same row industry has the same input structure. There are only very minor exceptions in which the correspondence between the row industries and the column industries is not perfect. For Petroleum Products, it is important to consider the fact that different types of products are subject to very different tax schemes. For this reason, we take the following approach. From the input-output table for each year, we obtain the total amount of indirect taxes paid by the whole Petroleum Products sector. From tax revenue statistics of the Ministry of Finance, we obtain the shares of taxes imposed on each type of Petroleum Products. We allocate indirect taxes to each of the sub-sectors according to those shares. The rest of the cost structure is assumed to be the same across those sub-sectors. We consider this to be a reasonable assumption, as all of those products are by-products of a single distillation process.

$$\Delta p = \left[\left(I - \left(I - M \right) A \right)^{-1} \right]' \cdot A' M' \cdot \Delta p^m,$$

where Δp is the vector of the rate of domestic price change in each sector and Δp^m is the vector of the rate of price change of imported goods in each sector. For example, suppose that the crude oil sector is the *J*th sector and that we wish to study the impact of one percentage increase in imported crude oil price. Then we set the *J*th element of the vector Δp^m to be 1 and all the other elements to be 0. Then each element of Δp would indicate the predicted percentage increase in the domestic prices of goods in each sector, under the assumption of flexible prices (complete pass-through at each production stage) and zero substitution.

In this paper, we utilize both nominal and real I-O tables to derive those predictions. The current prices table will predict the impact of an increase in oil prices given the current cost structure of each industry. The constant price table, on the other hand, will give a hypothetical prediction on what would happen if only the real cost structure changed between the current year and the bench-mark year (due to, for example, substitution between oil and other types of materials) while maintaining the same relative price structure. It turns out that differences in predictions from those two types of tables are quite informative.


4-2 Plastic, 1980-2000

We start from product level analysis here. Figure 9(A) uses the *nominal* I-O Tables to derive the predicted responses of Naphtha, Basic Petrochemical Products (ethylene, propylene, benzene, etc.), Thermoplastic Resin (a type of plastic: polyethylene, polypropylene, etc.), and Plastic Products. Red lines with cubes show the predicted percentage responses of those prices when the price of imported crude oil increases by one percent. Blue dashed lines with triangles show the predicted responses when imported prices of both crude oil and petroleum products increase by one percent, simultaneously. This calculation is necessary because currently Japan imports much of naphtha it needs from abroad (which was not the case in 1980). Black lines with circles show what happens when prices of all the imported goods increase simultaneously by one percent. Figure 9(B) performs an analogous study using the *real* I-O Tables (1995 constant prices).

19

The contrast between Figure 9(A) and 9(B) is striking. While the nominal I-O Table predicts sharp declines in the price responsiveness over time, the real I-O Table does not predict any systematic tendency. The fact that the real I-O table does not predict much decline suggests that there was not much of a real substitution away from the use of oil during this period. We had expected a decline in the importance of oil, at the very least in the comparative sense, as we had originally thought the importance of services such as distribution and finance would have increased over time: apparently, that did not happen. Yet the nominal I-O table tells a very different story. The difference comes from the fact that, during this period, there were substantial declines in prices of imported oil, naphtha, and other imports. To summarize, although there were very little substitution between quantities of different types of input, the relative importance of oil still declined substantially basically because it became cheaper. As the lower price of oil reduced its share in overall nominal production costs, prices of those products became much less responsive to fluctuations in oil prices.

How do these predictions in Figure 9(A) compare with the actual estimation results in Figure 6? Comparing the two panel by panel (looking at the long run estimated pass-through rates at the 24 months horizon in each panel of Figure 6), we learn that the cost-related factors that appear in Figure 9(A) are enough (in some cases, more than enough) to explain the declines in the estimated pass-through rates. Our conclusion for these sectors is that the pass-through rates of oil declined because oil became cheaper and thus became less important in overall costs for those sectors.

Figure 9: Predicted responses of Plastic and related products to OIL etc.

(A) Predictions from *NOMINAL* I-O Tables
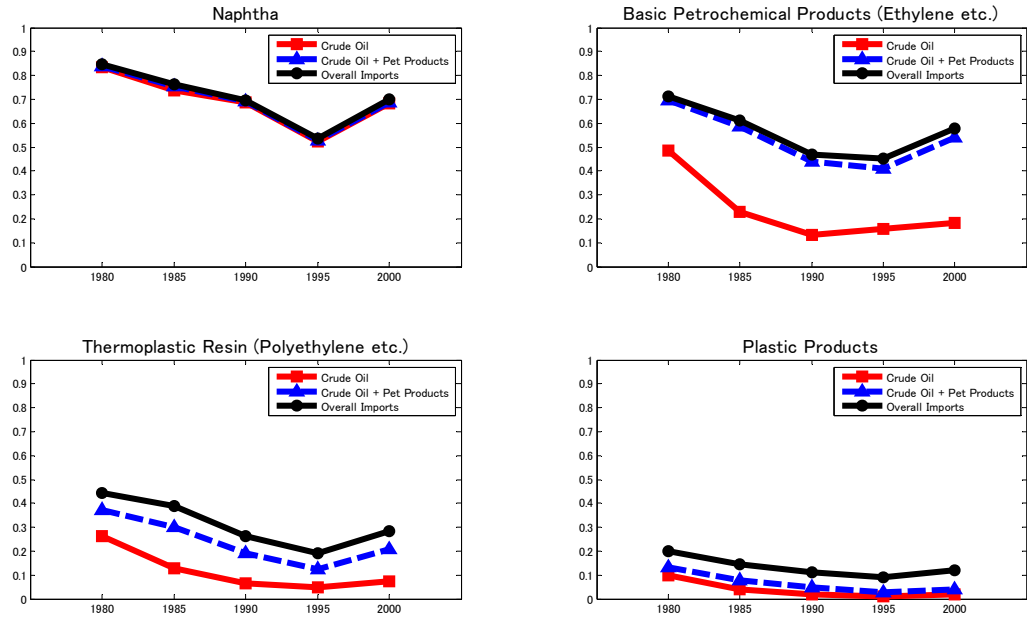
(B) Predictions from *REAL* I-O Tables (1995 constant prices)
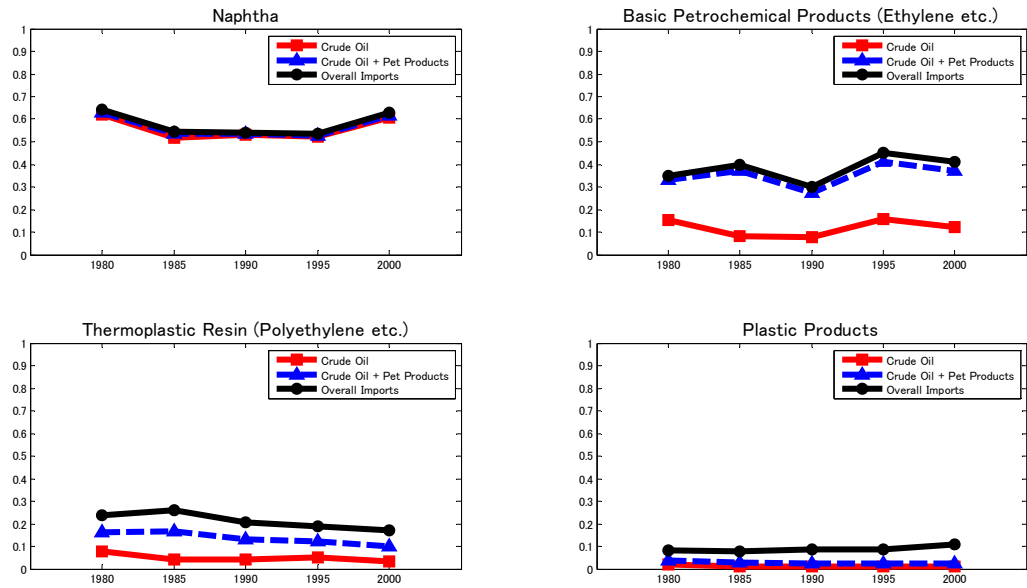
4-3 Gasoline, 1980-2000

Studying the case of gasoline in Japan requires a caution, as it is subject to heavy taxation[13]. What is important is that those taxes are *per-unit* taxes (or specific duties) as opposed to ad valorem taxes. Taxes therefore do not go up when oil prices increase. In the period of high oil prices, the share of those taxes in overall gasoline prices is thus relatively low. Gasoline prices will move nearly one-for-one with oil prices. When oil prices are lower, the share of taxes, the portion that does not respond to oil price fluctuations, in overall gasoline prices is higher. Gasoline prices are thus expected to be less responsive to oil price changes. Pass-through rates of oil prices are thus expected to change endogenously with the level of oil prices. This could at least partially explain the declining pass-through rate we saw in Figure 7.

To study the magnitude of this effect, in Figure 10(A), we first compute predicted response of gasoline prices to oil prices from the nominal I-O tables, under the actual cost structure (red line with cubes). Note that those predictions are fairly close to the actual estimated pass-through rates, that are reported in Figure 7, for the medium and long runs. Next, we redo the calculation under the counterfactual assumption that the indirect taxes did not exist (or the taxes move proportionately with prices), and the results appear in blue dashed line with triangles. Lastly, we redo the analysis by assuming that not only domestic taxes but also tariffs did not exist (or they also move proportionately with prices), and the results appear in black lines with circles. Comparing those lines reveals that the presence of those taxes is greatly mitigating the responsiveness of gasoline prices to oil prices. More importantly, the presence of those taxes made the responsiveness to decline substantially between 1980 and 2000. Without those taxes and tariffs, the responsiveness would have decreased by relatively small percentages. Figure 10(B) does analogous calculation based on the real I-O table. We see that, without the effects of nominal price levels and taxes and tariffs, the responsiveness would have remained nearly constant, and high. We conclude that the declining pass-through rates in Figure 7 could possibly be explained entirely by those two effects.

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[13] Also, diesel and jet fuel are heavily taxed in Japan. On the other hand, naphtha and heavy fuel oil are, relatively speaking, lightly taxed. This necessitates careful treatment of indirect taxes that we explained in the previous section.

Figure 10: Predicted responses of Gasoline to OIL

(A) Predictions from *NOMINAL* I-O Tables

Gasoline

(B) Predictions from *REAL* I-O Tables (1995 constant prices)

Gasoline
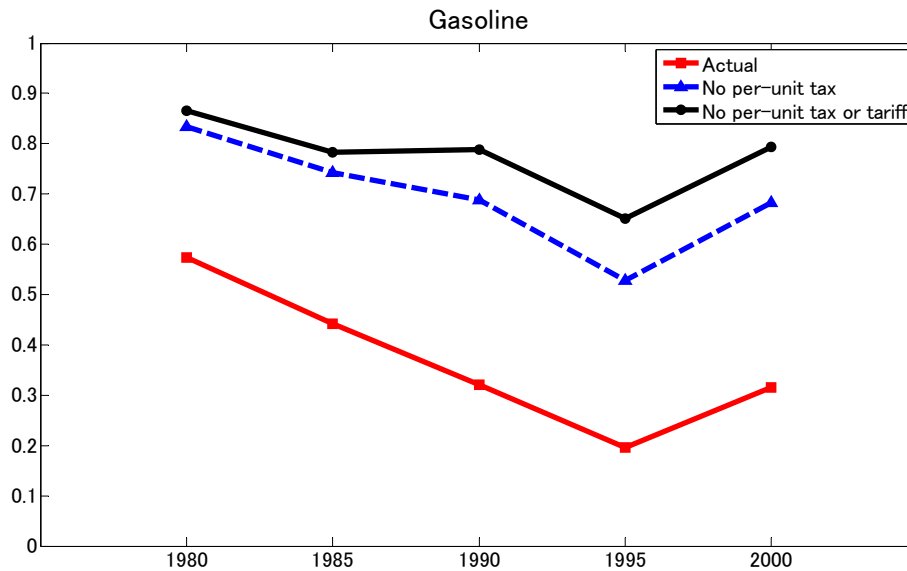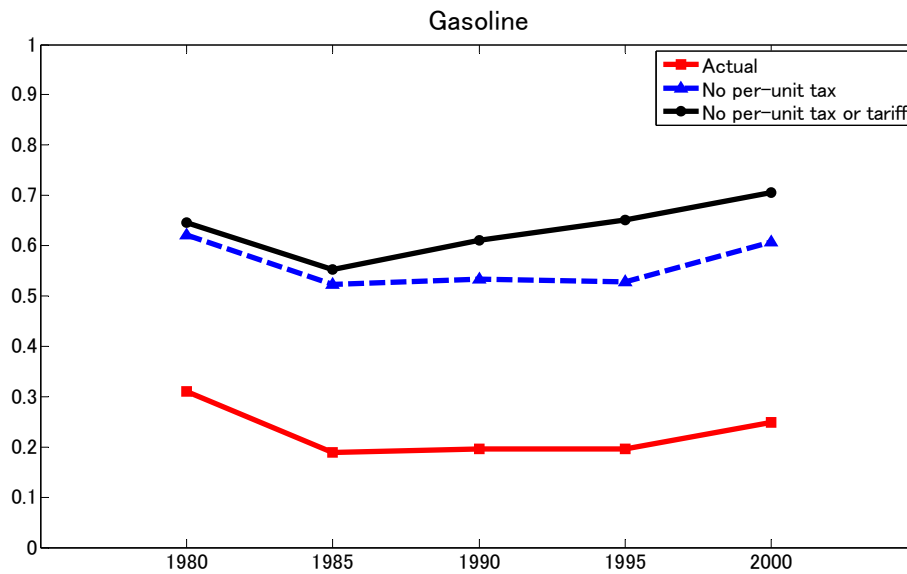
4-4 Electricity, 1980-2000

We next turn to the case of electricity. There are two electricity-related entries in the I-O table, namely electricity for business uses and self uses. We derive the predicted responses for both of them, and the results are shown in Figure 11(A) for the nominal table and Figure 11(B) for the real table. We study the case in which only crude oil prices increase (red lines), the case in which oil and natural gas prices increase simultaneously by one percent (blue lines) and the case in which prices of all the imported goods increase at the same time (black lines). The nominal tables predict substantial declines in pass-through rates of oil. The estimated pass-through rates in Figure 8 are close to predictions that appear in the black line in the electricity for self use case. What is noteworthy about this sector is that, even in the predictions from the real tables, we observe some declines in the predicted responsiveness, though the declines are much smaller compared with the predictions from the nominal tables. The decline is most evident for "crude oil" in the "electricity for self use" case. It is also likely that increasing use of imported coal and construction of nuclear power plants have contributed to the general tendency. Evidently, some part of this decline, since 1990, is the emergence of natural gas as an alternative to using oil. Hence, we conclude that, for this sector, real substitution played a minor but non-negligible role.

Another feature of the electricity industry is that prices were under strict regulations previously, but a series of deregulation took place during our sample period. This would have contributed to increase the pass-through rate. But such an increase does not seem to show up in a noticeable manner either in Figure 8 or in 11.
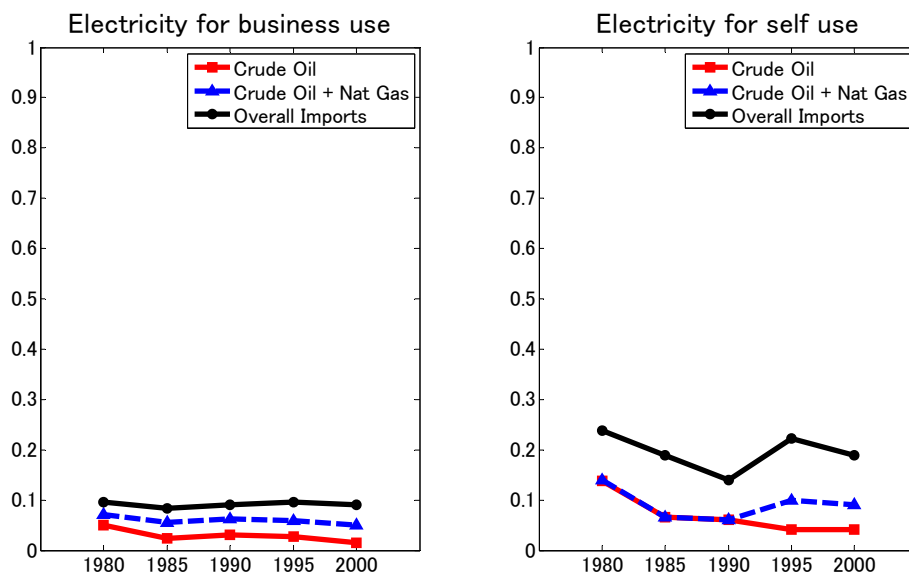
Figure 11: Predicted responses of Electricity to OIL etc.

(A) Predictions from *NOMINAL* I-O Tables
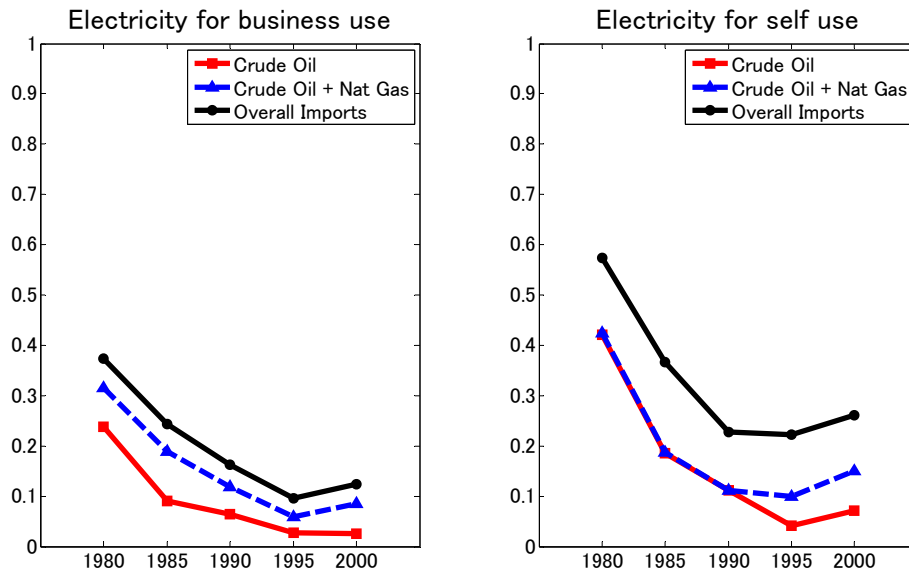
(B) Predictions from *REAL* I-O Tables (1995 constant prices)

4-5 Overall Prices, 1980-2000

Through the I-O analysis in this section, we have found some important elements that could explain declining pass-through of oil prices. The most notable factor has been the price level of oil itself. Input substitution showed up as a minor (but non-negligible) factor for electricity. Also, the analysis for gasoline has pointed out importance of the tax structure. Are they important in accounting for declines in pass-through rates in overall prices as well? To answer this question, we apply procedures analogous to the ones that we have seen to all the sectors simultaneously. Then we average them, weighting each sector's predicted price increase by the sector's output[14]. The results are in Figure 12. Panel (A) uses the nominal tables. Panel (B) uses the real tables. Panel (C) uses the nominal tables, under the hypothetical assumption that there are no per-unit taxes on Petroleum Products (such as gasoline, diesel, and jet fuel).

Predictions from Panel (A) fit very well with the evolution of the estimated pass-through rates for CGPI total, that appears in Figure 5(A). This means that changing cost structure goes a long way toward explaining observed declines in pass-through between 1980 and 2000. Comparison between Panels (A) and (B) indicates that the real side story plays only a minor role in the structural change that lowered pass-through during this period: we observe only slight declines in the predicted responsiveness to imported oil, petroleum products (basically naphtha), and natural gas. Again, the main factor behind the change was the price level of oil itself: as oil became cheaper, it became less relevant in the cost structure. Finally, Panel (C) is almost indistinguishable from Panel (A), except that the declines in the predicted responsiveness for the 1990s are slightly milder. This suggests that, although the tax structure mattered a lot in certain sectors, it was not such an important factor at the aggregate level.

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[14] Note that the "multiple count" problem for fuels and materials that we discussed about CGPI also applies here. We might be able to obtain more meaningful predictions by focusing on, for example, final goods sectors only.

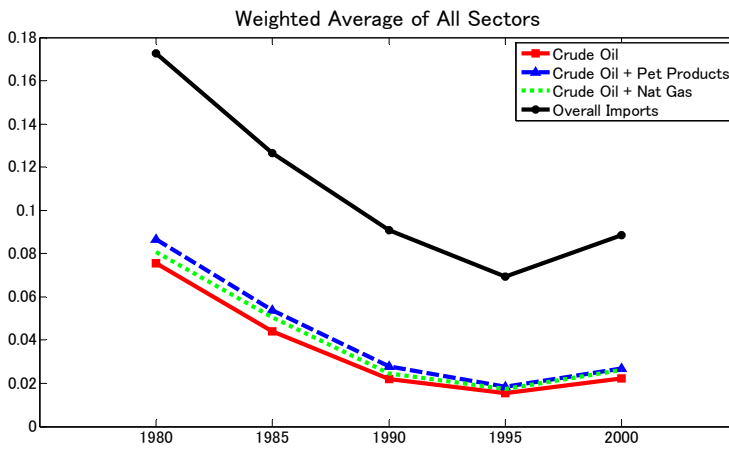Figure 12: Predicted responses of Weighted Average of All Sectors to OIL etc.

(A) Predictions from *NOMINAL* I-O Tables
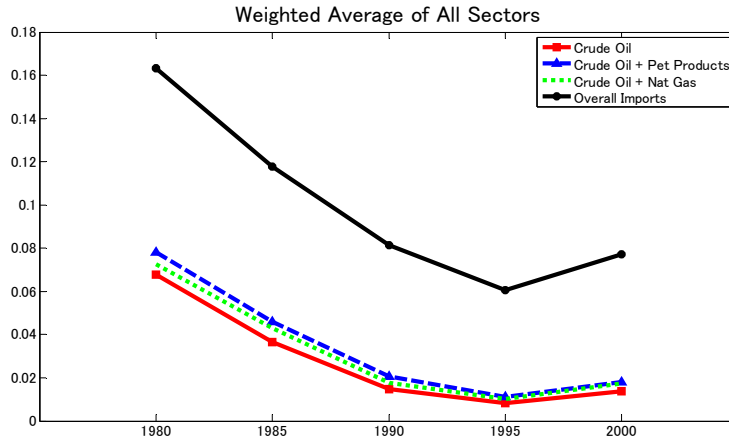
(B) Predictions from *REAL* I-O Tables
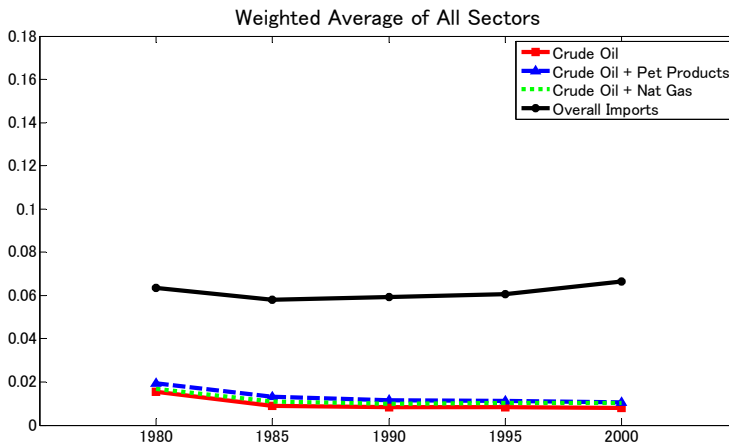
(C) Predictions from *NOMINAL* I-O Tables with no taxes or tariffs on petroleum products

5 Predictions from the I-O Tables, 2000-2007

In this section, we shift our focus to the 2000s, especially toward the end of this period. At the time of this writing, detailed Input-Output Tables were available only up to the year 2006, which is not sufficient for our purpose. We have decided to employ basic Input-Output Tables provided on the Ministry of Economy, Trade, and Industry, with only 73 sectors, which were available for years 2000 and 2003-2007. In these tables, "crude oil" is no longer a separate sector but is combined with natural gas. Also, all the Petroleum Products sub-sectors are merged into one. We expand them by making suitable assumptions to decompose a single Petroleum Products sector into nine sub-sectors[15]. As in the previous section, we compute predicted responsiveness of sectoral prices to prices of imported oil and natural gas. To save space, we present results from *nominal* I-O tables only. The predicted responsiveness from real I-O tables was mostly close to constant over this short time period.

Figure 13 presents the results. Panel (A) is for plastic and related products, (B) is for gasoline, (C) is for electricity and (D) is for the weighted average of all the sectoral prices. Note that, in all cases with the exception of gasoline[16], the I-O tables predict increases in the responsiveness. This is natural: as oil prices increase, the share of oil and related products in overall production cost returns to be large, and thus their prices are expected to become more sensitive to oil prices. Going back to the TVP-VAR results, in many cases, we observed increases in the estimated pass-through rates of oil, so, in terms of directions of changes, they support the predictions from the I-O tables. However, the magnitudes are very different. While I-O tables predict swift and sharp increases in oil price sensitivities, the estimated pass-through rates from actual data start increasing slowly and only gradually (if at all).

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[15] On the row side, for years 2004-2006, we have information from detailed I-O Tables with 511 row sectors, and we can directly utilize information provided by these tables to decompose a single row into nine separate ones. For year 2003, we assume that the shares of each sub-product of Petroleum Products used in different sectors, in *real* units, were the same as in year 2004. We then use deflators provided for 511 sectors in each year's I-O Table to convert them into nominal units. For year 2007 we utilize information from the 2006 detailed table to conduct a similar approximation. On the column side, we apply a procedure analogous to the one explained in the previous section.
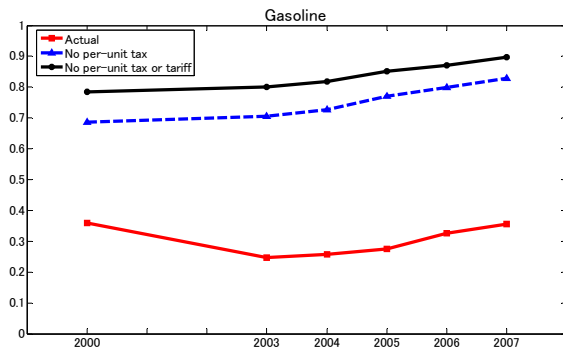
[16] The predicted responsiveness of gasoline is large in 2000 because our estimated tax revenue from gasoline tax for this year was small. We will investigate this matter further in near future.

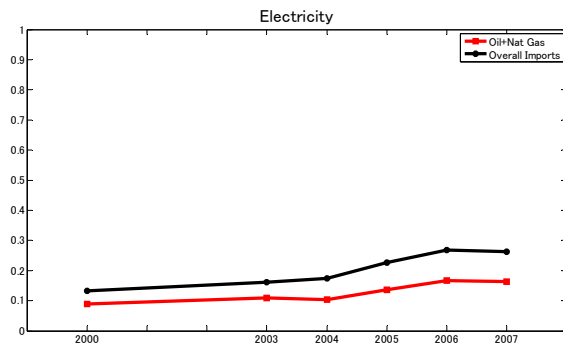Figure 13: Predicted responses for the 2000s, based on NOMINAL I-O Tables
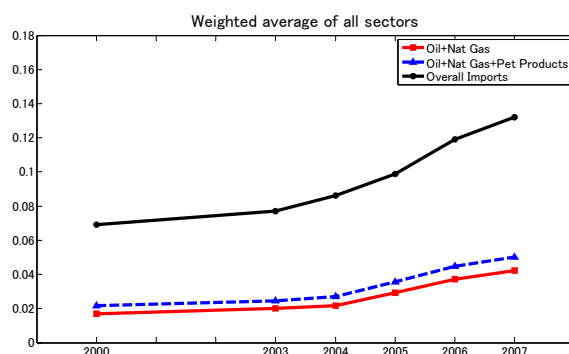
(A) Plastic and related products
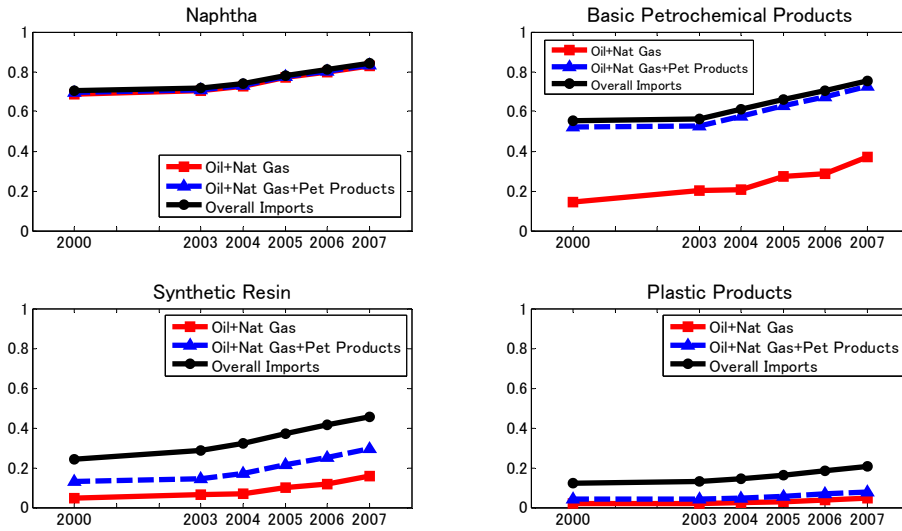
(B) Gasoline, under actual and hypothetical tax systems

(C) Electricity

(D) Weighted average of all sectors

Weighted average of all sectors

Hence, the increases in the estimated pass-through rates during the 2000s that we reported in section 4 are too late and too little, from the viewpoint of the I-O table analysis. What accounts for the difference? We can think of several possible explanations. First, our TVP-VAR estimation uses data on fixed weight Laspeyres price indices[17], and the data for the post 2005 period uses the 2005 weights: the rapidly increasing nominal weights of oil related products after 2005 are not reflected in those indices. Thus, our estimation could have underestimated the true extent of the increase in the pass-through rate which was caused by the oil price increase in this period. Second, firms might have perceived the oil price increase during this period to be very temporary (which turned out to be the case), thus did not wish to respond to such a shock. At this point, these hypotheses are mere speculations, and further analyses of this period would be needed to truly understand what was going on in this period.

6 Conclusions

In this paper, we have investigated factors behind the declining pass-through rate of oil prices to Japanese domestic prices. We have found that, for the period 1980-2000, the main driving force behind the decline is the price level of oil itself. As oil became a less important cost item for firms, they naturally decided to respond less to its price changes. Consistently with this view, we find increasing pass-through rates in many of our TVP-VAR results for the 2000s, when oil prices were on the rise. However, at this point, those increases seem a little muted and delayed

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[17] Chained price indices were not available for long enough time periods.

compared to the sharp increase in oil prices during this period. Investigating this matter further once more data becomes available for this period will be an important topic for future research.

Reference

Bernanke, Ben S., Mark Gertler, and Mark Watson. 1997. Systematic monetary policy and the effects of oil price shocks. *Brookings Papers on Economic Activity* 1: 91-142.

Blanchard, Olivier J., and Jordi Gali. 2007. The macroeconomic effects of oil shocks: Why are the 2000s so different from the 1970s? NBER Working Paper no. 13368, September.

Blinder, Alan S., and Jeremy B. Rudd. 2008. The supply-shock explanation of the Great Stagflation revisited. NBER Working Paper no. 14563, December.

Blinder, Alan S., and Jeremy B. Rudd. 2009. Oil Shocks Redux. VOX Website,
http://www.voxeu.org/index.php?q=node/2786

De Gregorio, José, Oscar Landerretche, and Christopher Neilson. 2007. Another Pass-through Bites the Dust? Oil Prices and Inflation. Bank of Chile Working Paper 417.

Hooker, Mark A. 1996. What happened to the oil price-macroeconomy relationship? *Journal of Monetary Economics* 38 (October): 195-213

Hooker, Mark A. 2002. Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. *Journal of Money, Credit, and Banking* 34 (May): 540-561.

Kilian, Lutz. 2007. The economic effects of energy price shocks. University of Michigan, October. Mimeo.

Kim, Chang-Jin, and Charles R. Nelson. 1999. *State-Space Models with Regime-Switching: Classical and Gibbs-Sampling Approaches with Applications*. MIT Press.

Shioji, Etsuro and Taisuke Uchino. 2009. Kawase reto to genyu kakaku hendo no pasu suru ha henka shitaka (Have pass-through of the exchange rate and oil prices changed?). In Japanese. Mimeo (Bank of Japan).

Appendix on TVP-VAR

In this Appendix, we explain our time varying parameter (TVP-) VAR methodology based on Kim and Nelson (1999). Consider the following VAR model with *K* variables and *L* lags, in which the coefficients are varying over time with a specific dynamic structure.

$$y_t = x_t \beta_t + e_t, \quad t = 1, 2, 3, ..., T ,\qquad\qquad (A1)$$

$$\beta_t = \beta_{t-1} + \upsilon_t ,\qquad\qquad (A2)$$

$$e_t \sim i.i.d.N(0, R) ,\qquad\qquad (A3)$$

and $\quad \upsilon_t \sim i.i.d.N(0, Q) ,\qquad\qquad (A4)$

where the vector x_t consists of lagged dependent variables. In this specification, we assume that the coefficient vector follows a random walk, but Kim and Nelson (1999) allow a more general VAR(1) specification. The dimensions of the vectors and matrices are as follows:

$x_t : (K \times (K \times L + 1))$, $\;\; y_t : (K \times 1)$, $\;\; \beta_t : ((K \times L + 1) \times 1)$, $\;\; R : (K \times K)$, and $Q : ((K \times L + 1) \times (K \times L + 1))$.

We consider estimating this model by Kalman Filter. Note that, in implementing this estimation, we need to specify the matrices Q and R, known as "hyper-parameters". Define the following notations.

$\beta_{t|s}$: expectation of $\;\beta_t\;$ conditional on information up to s,

$P_{t|s}$: variance-covariance matrix of $\;\beta_t\;$ conditional on information up to s,

$y_{t|s} = E(y_t \mid \Psi_s) = x_t \beta_{t|s}\;$: forecast of $\;y_t\;$ given information up to time s,

$\eta_{t|s} = y_t - y_{t|t-1}$: prediction error,

and $\quad f_{t|s} = E(\eta_{t|s}^2)\;$: conditional variance of prediction error.

Given the information set up to period t-1, the prediction rules for period t are written as follows:

$$\beta_{t|t-1} = \beta_{t-1|t-1}, \;\; P_{t|t-1} = P_{t-1|t-1} + Q , \text{ and } \; f_{t|t-1} = x_t P_{t|t-1} x_t' + R .$$

Define the prediction errors in period t as:

$$\eta_{t|t-1} = y_t - y_{t|t-1} = y_t - x_t \beta_{t|t-1} .$$

Then the updating rules are given by

$$\beta_{t|t} = \beta_{t|t-1} + K_t \eta_{t|t-1} ,\qquad\qquad (A5)$$

and $\qquad P_{t|t} = P_{t|t-1} - K_t x_t P_{t|t-1}$ $\hfill$ (A6)

where $\qquad K_t = P_{t|t-1} x'_t f_{t|t-1}^{-1}$ (Kalman gain). $\hfill$ (A7)

In our estimation, the initial values $\beta_{0|0}$ and $P_{0|0}$, as well as the hyper-parameters Q and R are chosen in the following manner. We first estimate a reduced form VAR using the entire sample. The initial coefficient vector $\beta_{0|0}$ is set to be equal to the estimated coefficient vector from this estimation, and $P_{0|0}$ is set to be equal to h_0 times the estimated variance covariance matrix of the coefficients. Denote the variance covariance matrix of the estimated coefficients as $\hat{Q}$ and the residual variance covariance matrix as $\hat{R}$. Then we impose the following relationships:

$$Q = h_Q \cdot \hat{Q},$$ $\hfill$ (A8)

and $\qquad R = h_R \cdot \hat{R},$ $\hfill$ (A9)

where both h_Q and h_R are positive constants. This restriction greatly reduces the number of parameters to be chosen by the researcher.

We set $h_0 = 10$ in all the estimations reported in the text[18]. For h_Q and h_R, we try several different values and choose a combination that minimized the likelihood:

$$l(\theta) = -\tfrac{1}{2} \sum_{t=1}^{T} \ln((2\pi)^n \mid f_{t|t-1} \mid) - \tfrac{1}{2} \sum_{t=1}^{T} \eta'_{t|t-1} f_{t|t-1}^{-1} \eta_{t|t-1}.$$ $\hfill$ (A10)

In practice, we tried four different values, (0.1, 0.05, 0.025, 0.01), for h_Q, and three different values, (1.1, 1, 0.9) for h_R (for the latter, the value of 1 was usually preferred by the likelihood criterion).

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[18] It is customary to choose a relatively large number for this parameter, so that the results are not very sensitive to the initial values. We avoid reporting results for the first five years of the sample, namely 1975-1979, in an effort to further minimize the effects of those initial values.