Product Dynamics And Aggregate Shocks: Evidence from Japanese Product and Firm Level Data[1]

This version: September 2021

Robert Dekle
USC

Atsushi Kawakami
Toyo University

Nobuhiro Kiyotaki
Princeton University

Tsutomu Miyagawa
Gakushuin University and RIETI

[1] We thank Erick Bartelsman, Joel David, Steven Davis, Masahisa Fujita, Kyoji Fukao, Huiyu Li, Masayuki Morikawa, Shintaro Nishioka, Kozo Kiyota and conference participants at USC, the NBER-Japan Project 2016, Stanford-Juku 2016, ABFER 2016, CAED 2017, Hitotsubashi University, Keio University, Gakushuin University, and APEA 2018 conference for helpful comments on an earlier draft. We also thank Takayuki Ishikawa for an excellent research assistance. This study is conducted as a part of the Project "Study on Productivity Growth at the Firm Level" undertaken at Research Institute of Economy, Trade and Industry (RIETI), and supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology (No. 15H03351 and No. 18H00852) of Japan and the U.S. National Science Foundation.

ABSTRACT

We examine the effects of aggregate shocks on product dynamics and business cycles, by constructing a unique firm level data set on products and exports from the Japanese Census of Manufactures from 1999 to 2010. The data are more disaggregated than comparable US data and available annually (instead of five-year intervals as in the US), which makes our data more suited to examining the interaction between the firm-product dynamics and business cycles. Our data show product adding and dropping by incumbent firms contributing to fluctuations of aggregate shipments more than firm entry and exit. When we divide our dataset into exporters and non-exporters, we find that exporters produce more products and switch their product more actively than non-exporters. Following the Dekle, Jeong, and Kiyotaki (2014) model, we regress the change in the number of products of individual firms on foreign demand, government expenditures, the real exchange rate and aggregate productivity. Consistent with the model, we find that the depreciation of the real exchange rate and the increase of foreign demand, government expenditure and aggregate productivity stimulate the net product adding of firms.

Keywords: Product adding and dropping, Entry and exit, TFP, Foreign demand, Government expenditure, Real exchange rate

JEL classification: E32, F12, F14, F41, L11, L25

1. Introduction

Standard models of firm dynamics which emphasize heterogeneous productivity across firms imply that the entry of new heterogeneous firms and the exit of low productivity firms enhance total factor productivity (TFP) in the aggregate economy. (See Hopenhayn (1992) and Melitz (2003) for example). Empirically, however, the effects of firm entry and exit on aggregate productivity improvements are not very large in the U.S. and in Japan. Hsieh and Klenow (2017) find that most productivity improvements arise from new product introductions by existing firms, not by new firm entry and exit. For Japan, Fukao and Kwon (2006) find that TFP fluctuations by incumbent firms dominate aggregate TFP movements, and the effects on TFP through reallocation effects of the entry and exit of firms are minimal. Aghion et. al. (1992), Bernard, Redding, and Schott (2010), and Garcia-Macia, Hsieh, and Klenow (2019) have also shown that product dynamics of incumbents are a major source of productivity movements over the medium and long runs.[2]

We construct firm-product level data from the Japanese Census of Manufactures. The Japanese Census of Manufactures is unique in that the value of shipments can be obtained all the way down to the 6-digit level (which we define as "products"), and the product level shipment data are available at the annual frequency, making the data suitable for analysis at the business cycle frequency. Products can be aggregated into establishments (plants), and plants can be matched to firms using firm identifiers.[3]

---

[2] See also Kawakami and Miyagawa (2013) who show for Japan that the contribution rate of product adding and dropping to labor productivity growth is large.

[3] In U.S. Census data, the usual product level data are only available down to the 5-digit level and are available only at five-year interval (Bernard, Redding, and Schott, 2010). Although U.S. store scanner product level data used by Broda and Weinstein (2010) and U.S. Bureau of Labor Statistics individual producer price level data used by Nakamura and Steinsson (2012) are available at a higher frequency,

Figure 1 decomposes the movement of total shipments of the Japanese manufacturing sector from 1999 to 2010 into the following components: firm entries and exits, the product adding and product dropping of incumbent firms, and the increase and decrease of shipments of continuing products of incumbent firms. An exiting firm is defined as a firm that drops from one or more products to zero products. From Figure 1, we learn that the contributions of product adding or dropping is much larger than the contributions of entry and exit of firms to the total shipment change. Between 2000 and 2010, on average contributions of the adding and dropping of products were 4.7 percent and -6.0 percent, while the contributions of entry and exit were 3.3 percent and -2.9 percent. There are also large simultaneous increases and decreases in shipments of continuing products by incumbents with average contributions of 15.2 percent and -14.5 percent.

(Insert Figure 1 here)

The first recession from 2000 to 2002 was associated with the collapse of the IT bubble in the U.S. The second recession from 2008 to 2009 is the global financial crisis. We see that during both recessions, the growth in manufacturing shipments was negative (solid line). Focusing on these two recessionary periods, we find that the decline in total shipments was driven by large decreases in excess of increases of shipment of continuing products of incumbents, the net dropping of products by incumbents, and the net exit (exit minus entry) of firms. Notice that, even during downturns, many firms expanded the shipment of continuing products, added products, or newly entered. Figure 1 shows very active gross shipment movements at the product level in both intensive and extensive margins.

The main concern of this paper is how aggregate shocks to total factor productivity, foreign demand, government expenditures and liquidity preferences for net foreign assets affect product dynamics at the

---

they need to be matched to firm level accounting data at the annual frequency before performing the empirical work that we do here.

firm level: the adding and dropping of products by incumbent firms, as well as the entry and exit of firms. Our empirical specifications are motivated by the Dekle, Jeong and Kiyotaki (2014) (referred as DJK (2014) hereafter) multiproduct firm model.[4] DJK (2014) develop a dynamic general equilibrium model of a small open economy in which the firm-product dynamics depends upon aggregate shocks. Firms are heterogeneous, facing recurrent firm-product specific shocks and aggregate shocks. Each firm potentially can produce multiple products and decides whether and how much to produce each product in domestic and export markets. From their model, we can trace how certain macroeconomic shocks can determine product entry and exit, and thus the evolution of the number of products and the adding and dropping rates of products of various firms. The authors show that an aggregate productivity improvement expands the size of market, increases the benefit of the entry of new products and firms and raises the total number of products. Shocks that increase foreign demand and government expenditures and depreciate the real exchange rate also encourage the entry of new products and raise the total number of products.

Our aim is estimating the impact of macroeconomic shocks on product entry and exit at the firm level. To the best of our knowledge, this paper is one of the first to estimate a model of product adding or dropping at the firm level at the business cycle frequency, with well identified macroeconomic shocks. The estimated equations are "structural" in the sense that the specifications are based on a dynamic general equilibrium model, and that the explanatory variables are exogenous or predetermined.[5]

---

[4] Bilbie, Ghironi and Melitz's (2012) model relates product level dynamics to macroeconomic shocks. They do not, however, relate macroeconomic shocks to product adding and dropping at the firm level, since the authors model only single-product firms.

[5] Garcia-Macia, et. al. (2019) use the U.S. Longitudinal database to infer how new products substitute for old products. Since they do not have product level data, they use job flows data from the Longitudinal database and develop a model to relate product turnovers to job turnovers.

While there is a large theoretical and empirical growth literature examining the long-run determinants of innovation and introduction of new products, the literature on product innovations and the business cycle is scant. Shleifer (1986) developed a model in which the benefits of implementing new technology is high when aggregate demand is large while a larger number of implementations increases aggregate demand in equilibrium. In a series of industry level case studies, Schmookler (1966) showed that the larger the aggregate demand was, the more patentable ideas were generated. Our paper is distinct because the empirical estimation of the firm-product dynamics is based on a structural model. On the other hand, our model abstracts from the rich heterogeneity of firm-product productivity dynamics in order to make the model tractable for aggregate dynamics. We focus on examining empirically how the adding and dropping of products and the entry and exit of firms react to macroeconomic shocks, without studying in detail the increases and decreases of shipments of the continuing products of incumbent firms.

Our paper is organized as follows. In the next Section, we motivate the empirical specifications in this paper using an extension of DJK (2014). In Section 3, we explain the construction of our product-firm level dataset, in addition to aggregate variables such as total factor productivity, foreign demand, government demand and the real effective exchange rates at the sector levels. In Section 4, we use our data set to provide an overview of product dynamics and exports in Japanese manufacturing firms. In Section 5, we present our estimates on the effects of shocks to aggregate productivity, foreign demand, government spending, and the real effective exchange rate on the evolution of the number of products at the firm level.

2. Product Dynamics and Macroeconomic Shocks

DJK (2014) construct a dynamic general equilibrium model of a small open economy with a rich production structure. Here we summarize only key features of their model relevant for estimating the relationship between aggregate shocks and product dynamics.

2-1 The Model.

When a new firm or a new product line of an incumbent firm pays a sunk cost κ_{Et} to enter, it draws an opportunity to produce a new differentiated product with a probability λ, or to replace an existing product with probability 1-λ. Sunk costs are positive and an increasing function of the aggregate number of product innovation: N_{Et}

, $\kappa_{Et} = \kappa_E(N_{Et})$, or $\kappa_E(.) > 0$, $\kappa_E{}'(.) > 0$.

Once obtaining a new product or replacing an existing product, the productivity of the product is heterogeneous and is distributed according to a Pareto distribution:

$$Prob(\tilde{a} \leq a) = F(a) = 1 - a^{-\alpha}, \quad \text{where } \alpha > 0.$$

We assume that a fraction ϖ of innovation is done by incumbents and a fraction 1- ϖ by new entrants.

The firm with the production opportunity must pay a fixed cost κ in order to produce the product and maintain productivity for the next period. Once paid the fixed cost for product j at t, the date-t+1 productivity a_{jt+1} will be

$$a_{jt+1} = \begin{cases} a_{jt}\,, & \textit{with probability } 1 - d_t - \zeta \\ 0, & \textit{with probability } d_t \\ \tilde{a}, & \textit{with probability } \zeta \end{cases}$$

The productivity of the next period is maintained as it is with probability $1 - d_t - \zeta$, will be zero with probability d_t, and will receive a new draw from the same Pareto distribution with probability ζ. The probability of dropping product d_t is endogenous as described below.

In addition, the producer of some products obtains another product as a spinout (irrespective to the evolution of their existing products) with probability ν per number of products. The spinout product is a new product with probability λ or replaces an existing product with probability 1-λ.

Although each producer starts with a single product with new entry, each producer (called "firm") may have multiple products as a result of the history of spinouts and the dropping of existing products.

Let N_t be the total number of products of the economy. Define the aggregate innovation rate as $e_t = \frac{N_{Et}}{N_t}$. The probability of dropping an existing product is sum of the probabilities of the exogenous destruction (denoted by δ) and the endogenous replacement of products by innovation and spinouts:

$$d_t = \delta + (1-\lambda)(e_t + \nu). \qquad (1)$$

The second term in the right-hand-side (RHS) says that the destruction rate due to replacement equals the probability of replacing the existing product (1-λ) times the rate of innovations and spinouts per number of existing products. We assume product dropping is iid. across all existing products, irrespective of the productivity of products.

Each existing product adds a product with innovation done by existing producers and a spinout. The probability of adding a new product to each existing product equals:

$$u_t = \omega e_t + \nu. \qquad (2)$$

The first term in the RHS is a fraction ω innovation rate per number of products done by incumbents and the second term is the spinout rate.

The expected value of the net rate of change of the number of products for each product is

$$u_t - d_t = (\omega + \lambda - 1)e_t - (\delta - \lambda\nu).$$

In our model, we assume the number of existing products is large and that the adding and dropping of products are independent across existing products. Thus the expected value of the change in the number of products for producer i who has N_{it} number of products equals

$$E_t(N_{it+1} - N_{it}) = (u_t - d_t)N_{it}$$

$$= [(\omega + \lambda - 1)e_t - (\delta - \lambda\nu)]N_{it} \quad (3)$$

We assume $\omega + \lambda > 1$. Equation (3) says that if there are favorable aggregate shocks (such as the increase in total factor productivity, foreign demand, government expenditures and the depreciation of the real exchange rate) which stimulates the aggregate innovation rate $e_t = \frac{N_{Et}}{N_t}$, the number of products of existing producers increases in expectation.

In the steady state in which the total number of products is constant, the net adding rate (adding rate minus dropping rate) of an existing product must be balanced by the rate of increase of number of products due to innovations done by new entrants as

$$u - d = -e(1 - \omega) < 0.$$

The second term is the fraction 1-ω of aggregate innovations per number of existing products done by new entrants.[6] Hereafter we consider the dynamics of firms, products and the aggregate economy in the neighborhood of the steady state. Then the expected change in the number of products is a decreasing function of the initial number of products of each firm. Equation (3) is the equation we examine empirically using our firm-product level data set.

The total number of products increases with product innovations and spinouts which yield new products (with probability λ), and decreases with exogenous destruction (at a rate δ)

$$N_{t+1} = N_t + \lambda N_{Et} + \lambda\nu N_t \;\; - \delta N_t. \qquad (4)$$

Product innovations and spinouts which replace existing products (with probability 1-λ), do not change the total number of products.

---

[6] In the steady state, the rate of introduction of new products due to innovation and spinouts equals the exogenous product destruction rate $\lambda(e + \nu) = \delta$. Thus the net adding rate for an existing product is $u - e = -e(1 - \omega) = -\left(\frac{\delta}{\lambda} - \nu\right)(1 - \omega) < 0$.

Comparing equations (3) and (4), the rate of adding and dropping products at the individual product level is higher than at the aggregate level due to replacement. The exogenous shocks to aggregate productivity, government expenditures, foreign demand and the liquidity preference for net foreign assets recursively in general equilibrium determine the endogenous state variables (N_t, D^*_{t-1}) , the firm-product dynamics, and the aggregate variables (which include $N_{Et}, N_{t+1,}$ aggregate output, employment, consumption, export, import, net foreign asset D^*_t and real exchange rate). Please see DJK (2014) for a complete description.

2-2. Estimation Strategy of the Model.

In the estimation, the aggregate shocks that affect the evolution of ΔN_{it} are included at the sector level (two-digit product level) to increase the cross-section variation and the precision of the estimates. Let $g_{kt},\ y^*_{kt}, and\ z_{kt}$ be sector-level government spending, foreign demand and productivity for sector k (such as television and radio receivers). In DJK (2014), shocks to aggregate government spending, foreign demand, and aggregate TFP are modelled as an AR(1) process. In our estimation below, we include the sector-level shocks, $g_{kt},\ y^*_{kt},\ and\ z_{kt}$ directly. The assumption is that the total levels of these variables represent a "shock" or "surprise" to the agents in the model.[7]

2-3. Inclusion of Firm Level TFP

The specification (3) that we estimate is deliberately stylized. This stylized structure was necessary to allow the aggregation of heterogeneous firms with product innovations into a standard

---

[7] Di Giovanni, et. al. (2014) uses sectoral-level shocks to capture the impact of aggregate shocks. We use the narrower measure of industry-level shocks to capture the impact of aggregate shocks. Foerster, et. al. (2011) develops a standard multisectoral neoclassical growth model and shows that the vector of industry output growth rates follows the factor time-series model: $\varepsilon_{kt} = \beta_k S_t + v_{kt}$, where ε_{kt} is the shock to the output industry k, β_k is the matrix of coefficients that reflects how the vector of aggregate shocks S_t affect industry k's output.

stochastic business cycle model. In reality, other variables would influence the product evolution process at the firm-level.

In the growth models such as Acemoglu, Akcigit, and Kerr (2015), and product-level empirical studies such as Kawakami and Miyagawa (2013), firm-level productivity also affects product dynamics. With this empirical result in mind, we modify DJK (2014) to assume the production innovation rate done by each firm depends upon the TFP of that firm, that is

$$\omega_{it} = \omega(TFP_{it}), \qquad \omega' > 0.$$

By this assumption, the change in the number of products in Equation (3) is affected by not only aggregate variables but also firm-level TFP. While the specification including firm-level TFP cannot be as easily and cleanly aggregated into a standard business cycle model, it would be interesting to see whether more productive firms introduce more products at the business cycle frequency.[8]

2-4. Product Dynamics of Exporters.

While the focus of this paper is on the evolution of the total number of products of firm i, the DJK model also has predictions on how macroeconomic shocks impact the number of products that are exported. DJK (2014) show that all products with productivity greater than a certain threshold of idiosyncratic productivity $\underline{a}_t$ are exported. This minimum threshold productivity level for products to be exported is a function of aggregate TFP (Z_t), aggregate number of products (N_t), foreign demand (Y_t^*) and the real exchange rates (ϵ_t).

When aggregate TFP and the number of products are high, the real wage rate is high and

[8] Foster, Haltiwanger, and Syverson (2008) and Syverson (2011) found persistent productivity differences across a cross-section of U.S. firms. The same productivity differences are also found across Japanese firms by Fukao and Kwon (2006) and Kawakami, Miyagawa, and Takizawa (2011).

idiosyncratic productivity has to be high for the product to be exported. Thus the minimum threshold productivity for export $(\underline{a}_t)$ is an increasing function of aggregate TFP and number of products. On the other hand, when foreign demand is large and the real exchange rate is depreciated, it is more profitable to export. Then the minimum threshold productivity for export is a decreasing function of foreign demand and real exchange rates. Please see DJK (2014) for the exact formula.

The structure of our data, the Japanese Census of Manufacturers, does not permit a direct observation of exported products. We only observe whether a firm is an exporter or not and the total number of products produced by the firm. In our estimation below, we form a panel of firms that are only exporters. Firms often produce multiple products, and a firm becomes an exporter if at least one of its products has idiosyncratic productivity which is higher than the minimum threshold for exports. When the firm has a larger number of products (N_{it}) and/or has a high firm-level TFP (TFP_{it}), the firm is more likely to export because at least one of its products is likely to have an idiosyncratic productivity higher than the threshold for exporting. Thus, estimating the model on only the sample of exporters provides another way to see how firm level productivity affects how a firm responds to aggregate shocks.[9]

3. The Japanese Census of Manufacturers Data and the Construction of Explanatory Variables.

We construct our firm-product data using the Census of Manufacturers conducted by the Japanese Ministry of Economy, Trade and Industry. The Census is in principle, a survey of all

---

[9] In Japan, there are only weak correlations among firm-level productivity, total shipments, profitability, export status and the export-shipment ratio across firms. Multi-product firms partly help explain this weak correlation because some firms are large because they have many products even though firm-level productivity is low, while other firms are not large but have a small number of highly productive products to export. See DJK (2014) for more.

establishments (plants) in the Japanese economy. The data are now available annually in the format that we require for 1999-2010. Because we can collect product and establishment level Census data for every year in Japan, it is more conducive to analysis at the business cycle frequency, where peaks to troughs can occur in a period as short as 2 years. We examine versions of the Census that surveys establishments with at least 4 workers, since the data covering establishments below 4 workers are not made publicly available. In 2006, 258,543 establishments have 4 or more employees, representing over 47 percent of all Japanese manufacturing establishments.

We define "Products" as goods at the 6-digit product classification level in the Japanese Census of Manufacturers; "Industries" as goods at the 4-digit product classification level, and "Sectors" as goods at the 2-digit level of product classifications.[10] In the data, each establishment reports the usual accounting data, such as the value of shipments of the different types of "products" that the establishment produces, the number of employees, raw material costs, fuel and electricity costs, and tangible fixed assets. Examples of sector, industry, and product level classifications are shown in Table 1.[11] For example, sector classification number 29 indicates the electric machinery sector. Industry classification number 2951 shows the industry which produces storage batteries. The industry consists of five 6-digit products. AT the 6-digit level, we find not only the usual lead storage battery but also the lithium ion battery which is used for technology products such as mobile phones and personal computers.

---

[10] Industry classifications in the Census of Manufacturers follows the Japan Standard Industry Classification (JSIC) in the case of 2-digit and 4 –digit levels. JSIC started in 1949 is revised every five years. Every version of JSIC is adjusted to adhere to the International Standard Industry Classification (ISIC). However, in the case of the 6-digit classification, the Census of Manufacturers adopts its own classifications. The classifications used in our paper follows the 2008 version of JSIC.

[11] Note that what we call "products" is a much broader category than what are typically called "products" in scanner-type data. For example, in our data, a box of cereal and a bag of rice crackers will be the same product, but in scanner type data, they will be different products. Thus, the introduction of a newer product in our data is a more significant innovation than simply introducing a newer brand of cereal in scanner data.

This means that if we want to examine whether a firm produces new innovative products, we have to capture movements at least at the 6-digit level.

(Insert Table 1 here)

Given that decisions on adding and dropping products and on output volumes of each product are made at the firm level and not at the establishment level, both in reality and in the DJK model, we need to identify the "firm". One problem with the Japanese Census data is that the data do not record a firm level identifier that would allow the grouping of establishments into firms (Bernard and Okubo, 2013). Abe et. al. (2012) develop a procedure to match establishments (plants) to their parents by using information on establishment codes, address codes, and industry classifications. Using their procedure, we aggregate establishment-level data into firm-level data.

Stylized facts of the Census data concerning multiple product firms are documented in Kawakami and Miyagawa (2013). Briefly, according to Kawakami and Miyagawa, in the Japanese Census, the share of multiple product firms in the total number of firms is about 40 percent, and the average multiple-product firm in Japan produces about 3 products (i.e., three different 6-digit JSIC level products). While multiple product firms represent a minority of firms, they account for 78 percent of total shipments by Japanese firms. Average shipments of multiple product firms are 50 percent higher than single product firms; and employment is 28 percent higher, and shipment per worker is 30 percent higher in multiple product firms compared to single product firms.

In the Census, we can also identify whether a particular establishment is an exporter (export value>0) and the total value of their exports in that year. However, export values or quantities are only available at the establishment level and not at the product level. At the product level, only total shipment quantities and values are available and are not broken down into domestic and shipments exports.

For our empirical analysis, we need to construct some aggregated variables using both the Census of Manufacturers and other, mostly sector level data. Sector-level government expenditures, g_{kt}, are obtained from the Input- Output Tables in the Japan Industrial Productivity Database (JIP database).[12] We use data for only the government's direct demands for sector k. We construct sector level foreign demands, y^*_{kt} , by first obtaining export values in Japanese Yen (JPY) from Japan to four of Japan's main partners, the U.S., China, the European Union, and Russia in each sector. These countries account for about 45 percent of Japan's total exports in 2010. We then obtain the value added in each of Japan's export partners in each sector from the IMF's International Financial Statistics (converted to yen at the prevailing exchange rate). For each sector, we then sum Japan's exports and value added over these four countries and area. Finally, for each sector, we take the ratio of Japan's summed exports to our summed value-added measure, and use this ratio as our sector level foreign demand variable.

Applying Good, Nadiri, and Sickels (1996) to the sector level, we measure sector level TFP, Z_{kt}, as follows[13]

$$\ln Z_{kt} = (lnQ_{kt} - \overline{lnQ_t}) - \sum_h \frac{1}{2}(s^h_{kt} + \overline{s^h_t})(lnX^h_{kt} - \overline{\ln X^h_t})$$

$$+\sum_{\tau=1}^{t}(\overline{lnQ_\tau} - \overline{lnQ_{\tau-1}}) - \sum_{\tau=1}^{t}\sum_h \frac{1}{2}(\overline{s^h_\tau} + \overline{s^h_{\tau-1}})(\overline{lnX^h_\tau} - \overline{\ln X^h_{\tau-1}}). \quad (5)$$

In Equation (5), Q_{kt} is output in sector k. X^h_{kt} represents a production factor h and s^h_{kt} shows share of production factor h in sector k, where h is labor, capital, or intermediate input. $\overline{\ln U_t}$ is a log of geometric average of U_{kt} across sectors (where U_{kt} is $Q_{kt}, or\ X^h_{kt}$).

---

12 Hitotsubashi University and RIETI constructed the JIP database to estimate productivity at the industry level. The construction of this database is consistent with other productivity databases such as Jorgenson, Gollop, and Fraumeni (1987) and EUKLEMS database.

13 We use the JIP productivity data to obtain Good, Nadiri, and Sickles TFP measure, The simple JIP productivity TFP measure is an index and does not allow for inter-sector comparisons of productivity levels. The productivity measures arising from the Good, Nadiri, and Sickels procedure corrects for this index number problem and allows for interindustry comparisons.

In DJK (2014), the real exchange rate depends upon aggregate shocks to productivity, foreign demand, government demand and liquidity preference to net foreign assets. Although liquidity shocks are particularly important, it is difficult to measure them in the data. There is also a tradition in international finance starting from Meese and Rogoff (1981) that include exchange rates as exogenous variables in estimations. Meese and Rogoff justify this practice by pointing out that exchange rates are a random walk process and fundamental variables such as productivity and monetary shocks have little explanatory power in predicting exchange rates. Thus, in our estimations below, we include sector-level real effective exchange rates (ϵ_{tk}) as an additional explanatory variable, being fully aware that this variable could be endogenous.[14]

Finally, in some specifications, we add firm-level productivity as another explanatory variable. We estimate firm-level total factor productivity by using the method of De Loecker (2011) for multiproduct firms. To obtain the necessary accounting data such as the number of employees and the value added at the firm level from the Census data, we simply aggregate the data for all the establishments that the firm manages. Using the estimated coefficients, we measure total factor productivity at the firm level (as described in the Appendix).

---

[14] We obtain the sector-level real effective exchange rates, ϵ_{tk}, from RIETI from 2001 to 2010 (https://www.rieti.go.jp/users/eeri/en/). Since our firm-product database runs from 1999 to 2010, we have to construct real effective exchange rate data ourselves from 1999 and 2000. As for this data from 1999 and 2000, we choose China, EU, Russia, and the US as Japan's trade partners. We obtain trade data from the Trade Statistics published from the Ministry of Finance in Japan. The industry-level output price data are obtained from the World KLEMS database (http://www.worldklems.net/). We use nominal exchange rates from the IMF's *International Financial Statistics*. Our estimates of real effective exchange rates thus constructed runs from 1999 to 2007. We link our constructed data to the RIETI data in 2005. Our measure increases when the Japanese yen depreciates against other currencies.

4. Stylized facts of Japanese Product Dynamics.

4-1. Stylized Facts Using All Samples

Using firm-product level data as constructed above, here we provide an overview of product-level dynamics in Japan. Following Table 1, Table 2 depicts how sectors can be divided into industries and products. For example, the food sector has 40 industries and 121 products, ships 23 billion JPY worth of goods and has over a million workers.

(Insert Tables 2 here)

As shown in the Introduction, Figure 1 depicts the decomposition over time of the total change in shipments (output, solid line). Over the entire period, the biggest contributor to total shipment movements is the fluctuation in continuing products made by incumbent firms. Some continuing products expand their shipments while others contract, and their difference is pro-cyclical.

The second most important contributor to the movement in total shipments is the adding and dropping of products by incumbent firms. Compared to the contribution of products added and dropped by incumbent firms, the contribution of the entry and exit of firms to total shipment fluctuations is small. The shipment of new products by incumbent firms dominates the shipment of new products by new firm entrants. In addition, during booms, product adding dominates product dropping, suggesting that positive macroeconomic shocks stimulate net product adding and increase the number of products. According to Figure 2 during the period of 1999-2010, the average fraction of the contribution of new products added to total gross increase in shipments was 18.4 percent, while the contribution of new firm entry was only 4.0 percent, (while the remaining 77.6% is the contribution of increases in shipment of continuing products by incumbents).

(Insert Figure 2 here)

4-2. Exporting Firms.

In Figure 3, we compare the number of products over time between exporters and non-exporters. It is well-known from earlier work that exporters are larger than non-exporters (Bernard, Eaton, Jenson, and Kortum, 2003). These predictions hold in the data. However, the number of products in export firms has a negative trend and the gap between the number of products in exporters and non-exporters has narrowed. Figure 4 compares the log of sales of exporters and non-exporters. As in DJK (2014), we find that sales of exporting firms are larger on average and more dispersed than non-exporters.

(Insert Figures 3, and 4 here)

Figure 5 shows the average number of added products and dropped products by continuing firms between exporters and non-exporters. We find that exporting firms are more aggressive in product switching than non-exporting firms, because the number of added and dropped products in exporting firms are larger than those in non- exporting firms, even when controlling the number of products. Moreover, the net product adding of exporters appears to be more sensitive to the business-cycle than that of non-exporters.

(Insert Figures 5 here)

To emphasize, regardless of whether the economy is in a boom or a recession, there are simultaneously a large number of products added and dropped by incumbent firms – in addition to large simultaneous increases in shipment of some continuing products and decreases of shipment of the other continuing products in Japan. The contribution of firm entries and exits to gross shipment increases and declines are small in magnitude. The net product adding (products added minus dropped) by existing firms is cyclical, while net entry is not very cyclical. These observations argue for the importance of business cycles models with multiproduct firms as in DJK (2014). Finally, although we do not observe exports at the product level, we find that exporters tend to have a larger number of products and that add and drop of products more actively than non-exporters.[15]

5. Estimation of Product Dynamics

In our estimates below, we focus on the extensive margin of adjustment in the total number of products. The estimated equations are "structural" in the sense that if the DJK model is correct, then the explanatory variables are predetermined (the firm-level variables) or exogenous (the macroeconomic shocks).

5-1. **Empirical Specifications with only Aggregate Explanatory Variables**

Our baseline specification is from (3):

$$\Delta N_{it} = const. + a_1 * lnFD_{kt-1} + a_2 lnGE_{kt-1} + a_3 * lnZ_{kt-1} + a_4 * lnREER_{kt-1} + a_5 * N_{it-1} + \varepsilon_{it} \qquad (6),$$

The dependent variable, the change in the number of products is $\Delta N_{it} = N_{it} - N_{it-1}$. $lnFD_{kt}$ is the log of foreign demand, $\mathrm{l}nGE_{kt}$ is the log of government expenditures, lnZ_{kt} is the log of sectoral TFP, and $lnREER_{kt}$ is the log of the real effective exchange rate in sector k where firm i belongs. While we are fully aware of the endogeneity of the real exchange rate in general equilibrium models, there is enough empirical randomness in the real exchange rate at the yearly frequency that the real exchange rate is effectively divorced from model fundamentals in at least the short-run. Moreover, given the external dependence of Japan's economy, it would be important to estimate the effect of changes in the real exchange rate on new product innovations. N_{it-1} and N_{it} are respectively, the number of products at time t-1 and t for all firms in existence at time t-1 and t. Since

---

15Although not observed at the business cycle frequency, these features are also present in U.S. data (Bernard, Redding, and Schott, 2010).

firms are continuously entering and exiting, the panel is unbalanced. The theory developed above predicts that a_1 , a_2, a_3, and a_4 are positive, and a_5 is negative.

As shown in Section 2, firm-level TFP affects the rate of product innovation of that firm, even though it is endogenous in principle. Many papers in economic growth and industrial organization such as by Acemoglu et al. (2015) stress the role of productivity on product innovation. With this in mind, we estimate the following equation including firm-level TFP as an explanatory variable.

$$\Delta N_{it} = const. + a_1 * lnFD_{jt-1} + a_2 lnGE_{jt-1} + a_3 * lnZ_{jt-1} + a_4 * lnREER_{jt-1}$$

$$+ a_5 * N_{t-1} + a_6 * FTFP_{it-1} + \varepsilon_t \qquad (7)$$

As shown in the Appendix, the measurement of FTFP is based on the estimated parameters of the production function with multiple products (De Loecker, 2011). We expect that a_6 is positive.

The data of all variables used in the following estimations are summarized in Table 3. The average number of products equals 1.749 as 60% of firms have a single product. When a firm exists consecutively in years t-1 and t, the change in the number of products $\Delta N_{it} = N_{it} - N_{it-1}$ has an average of 0.001 and the standard deviation of 0.507. The change in the number of products has a very small mean and a large standard deviation because there are large simultaneous product adding and dropping across firms. Here ΔN_{it} has a positive average while $E_{t-1}(N_{it} - N_{it-1})$ in equation (3) has a negative expected value, because data is conditional on both N_{it-1} and N_{it} being positive while equation (3) is conditional only on $N_{it-1} > 0$ that include $N_{it} = 0$. The number of observations of firm-level TFP is much less than those of other variables because we are not able to obtain capital stock data of firms with less than 30 employees.

(Insert Table 3 here)

5-2. Estimation Results of fixed effects using the change in number of products as a dependent

variable

First, we estimate Equations (6) and (7) by the panel fixed effects regression with firm-specific constant terms. Although we conducted the fixed effects regression with year dummies, the estimation results turn out to be very similar to those without year dummies, (perhaps because we use sector-level aggregate shocks as explanatory variables). We report here the results without year dummies.

Table 4 shows the estimation results using all samples of firms. The dependent variable is the change in the number of products (ΔN_i). The sample size is measured as the sum of the number of firms in each year. Since firms enter and exit from the sample every year, the sample is unbalanced.

For the fixed effects estimation, column (1) is the result for equation (6) without firm-level TFP and column (2) is for equation (7) with firm level TFP with a smaller sample. We find negative and significant coefficients on the lagged number of products. However, as for other variables, we do not have very robust results. Although government spending and aggregate TFP have marginally positive effects on net product adding, when firm-level TFP is included in column (2), the coefficient on firm TFP is negative, which is not consistent with theory.

Next, we conduct fixed effects estimations using instrumental variables. Instruments are two-year lagged variables of the explanatory variables and the lagged TFP index in the US. We obtain the lagged TFP index in the US from the EUKLEMS database. For the instrumental variable regressions, we did not include firm dummies.

For the instrumental variable estimation, column (3) report the results without firm-level TFP and column (4) with firm-level TFP. We find negative and significant coefficients of the lagged number of products. Although we find positive and significant coefficients of aggregate TFP in column (3), and government expenditures in column (4), these results are not very robust as the sign switches when firm-level TFP is included. The other explanatory variables do not have significant coefficients.

(Insert Tables 4 here)

In Table 5, we focus on exporters. Firms are included in the exporter sample in a given year, only when the firm has exported in that year and in the previous year, in time t and in t-1.[16] Thus, the exporter panel is also unbalanced. Columns (1) and (2) are fixed effect regressions without and with firm TFP respectively. Again, the lagged number of products gives a negative and significant impact on product dynamics.[17] In addition, the increase in government expenditures and aggregate productivity and the depreciation of the real effective exchange rate all significantly increase the number of products at the firm level. These regression results are consistent with Figures 3 and 5 in which exporters tend to have a larger number of products and tend to be more active in product adding and dropping, even after controlling for the number of products. However, the coefficients on foreign demand and firm-level TFP are not significant.

Columns (3) and (4) are the IV estimations without and with firm TFP. Here the real effective exchange rate depreciation continues to significantly increase the number of products at the firm level, with the coefficients larger than the fixed effect regressions. However, the other coefficients are not significant.

(Insert Tables 5 here)

5-3. Results using the Davis =Haltiwanger= Schuh measure

Davis, Haltiwanger, and Schuh (1996) develop a measure of rate of creative destruction of employment. Following their idea, and taking into account the case of N_{it} or N_{it-1} being zero, we

---

[16] To calculate ΔN_{it} in any given year for the exporter sample, we need two consecutive years of N_{it} for exporters, the current and the previous year.

[17] Since the coefficients of the lagged number of products are negative and significant, we focus on the estimation results of other variables in the later sections.

define the alternative rate of net product adding and dropping as

$$\frac{N_{it}-N_{it-1}}{\left(\frac{N_{it}+N_{it-1}}{2}\right)} .$$

We use this measure of net product adding as an alternative dependent variable.

In Table 6, we present the fixed effects estimations in columns (1) and (2) and estimations using instrumental variables in columns (3) and (4) for all samples with the Davis-Haltiwanger-Schuh measure as the new dependent variable. It turns out that, except for the lagged number of products, the coefficients are either insignificant or inconsistent with theory, (except for of course the lagged number of products N_{it}).

(Insert Tables 6 here)

Results using the sample of exporters are shown in Table 7. In the fixed effects estimations of columns (1) and (2), the increase in government expenditures and the depreciation of the real effective exchange rate significantly raise the rate of increase in the number of products of firms. In addition, a higher firm-level TFP significantly raises the rate of increase in the products in column (2). In the IV estimation in columns (3) and (4), we find that the depreciation of the sector-level real effective exchange rate significantly increases the rate of increase of the number of products of exporters, although the effects of firm-level TFP are no longer significant.[18]

(Insert Tables 7 here)

5-4 Estimations results of fixed effects estimation with AR1

---

[18] When we use the lagged Davis=Haltiwanger= Schuh measure instead of the lagged number of products as a dependent variable, the estimation results do not change. The coefficients of lagged Davis=Haltiwanger= Schuh measure are negative and significant and the results of other variables are similar to those in Tables 6 and 7.

In fixed effects regressions, the serial correlations of residuals are high. The errors terms are serially correlated at the annual frequency, possibly because macroeconomic shocks may take more than one year to affect net product adding by each firm. To adjust for this serial correlation, we conduct fixed effects estimation, assuming the estimated residuals follow an AR1 process.

Table 8 shows the fixed effects estimation with AR1 correction with the dependent variable as the change in number of products. Compared to the fixed effects results in Tables 4 and 5, those by fixed effects with AR1 are much better. For all firms, the increase in foreign demand and government expenditures significantly increase the net product adding. The stimulating effect of the real exchange rate depreciation on net products adding is particularly strong. Only the sectoral TFP shock has negative and significant effects on net product adding, but the coefficient becomes insignificant once firm-level TFP is included (which has positive and significant coefficients as expected). Hence, the estimation results almost all support the theoretical predictions of the DJK (2014) model.

Estimation results using the sample of exporters in columns 3 and 4 are also better than those in Table 4. The depreciation of the real exchange rate and the increase in government spending significantly increase the net product adding of firms. Although the coefficient on foreign demand has a negative sign without firm-level TFP, it becomes insignificant once firm level TFP is included (which has significantly positive coefficients).

Table 9 reports similar fixed effect regressions with an AR1 error correction using the Davis=Haltiwanger= Schuh measure of the rate of net product adding as a dependent variable. The results are robust and do not change much from Table 8 (in which the dependent variable is the level of net product adding). The depreciation of the real exchange rate and the increase in government spending and firm-level TFP significantly stimulate the rate of net product adding at the firm level. [19]

---

[19] We also conduct fixed effects estimations with AR1 without outliers for the robustness check. These estimations results are similar to those Tables 8 and 9.

(Insert Tables 8 and 9 here)

To examine the symmetry in the response of aggregate variables to product dynamics, we divide the sample of the change in number of products into two types: the sample without negative changes in the number of products and the sample without positive changes in the number of products. Estimation results of fixed effects with AR1 error correction are shown in Table 10. In the case that focuses on positive changes, the estimation results are similar to those in Table 8, (except that the coefficient on the real effective exchange rate is not significant in column 1). Estimation results using the sample of exporters are also similar to those in Table 8, although the coefficient on foreign demand becomes positive and significant in Table 10-1 (which is consistent with the theory).

In the case that focuses on the negative changes (Table 10-2), the depreciation of the real effective exchange rate and the increase of foreign demand, government expenditures and firm-level TFP all significantly increase the net adding of products, (i.e., reduces the size of the negative changes in the number of products). For exporters, increases in the real effective exchange rate and firm-level TFP both raise net product adding.

Comparing the results of Table 10-1 with Table 10-2, we find that the response of the real effective exchange to positive changes in the number of products is smaller than that to negative change in the number of products. These results show that the effects of the real exchange rate on product net adding are not symmetric, and has more powerful effects on firms that tend to reduce the number of products.

(Insert Tables 10 here)

In our estimation, we confirm that the lagged number of products always gives a negative impact on product dynamics as expected in Equation (3). As for other explanatory variables, aggregate variables except foreign demand give positive impacts on product dynamics for exporters. In fixed effects estimations with AR1 corrections, the results are much better than those without AR1. Almost all variables support the predictions in the DJK model. From these estimation results, we find that exporters which are larger in size than non-exporters are affected by the aggregate variables the most.

6. Concluding remarks

Policy makers in many countries are concerned about promoting product innovation within their borders. For example, the Abe administration in Japan has undertaken expansionary fiscal and monetary policies, partly in the hope of encouraging the introduction of innovative products.[20] The recent expansionary monetary policies in the Euro area is related in part to the desire to stimulate innovation and the introduction of better products (Bergin and Corsetti, 2014).

Conceptually linking business cycles with product adding and dropping behavior at the firm level is not new; the idea goes back at least to Schumpeter. To the best of our knowledge, this paper is one of the first to estimate a model of product adding and dropping behavior for the multiproduct firm at the business cycle frequency. To estimate such a model, we need product level data that can be matched with firms at a minimum at the business cycle or annual frequency.

We construct an unique firm-product database in Japan using the Census of Manufactures. The data are available at the annual frequency and products in our database are classified down to six-digits, which is more detailed than what is available in the U.S. Census of Manufactures.

In Japan, firms change their product compositions quite frequently, although the average number of products per firm is very stable. This stability, however, hides some significant product adding and dropping behavior. The average number of products of exporters is larger and more volatile than non-

---

[20] In addition to improving overall productivity, new products increase consumer utility in a "love of variety" model.

exporting firms. Sales of exporters are larger than the sales of non-exporters. We also find that product adding and dropping are larger and more cyclical than the entry and exit of firms.

In our estimates, we examine whether aggregate variables such as foreign demand, government expenditures and the real effective exchange rate increase product varieties. When we focus on exporters, we find that for many aggregate variables, the depreciation of the real effective exchange rate stimulates product innovations. The effects of a depreciation of the real effective exchange rate on exporters are robust. The depreciation of the real exchange rate and the increase of government expenditures, foreign demand and firm-level TFP all significantly increase the net product adding of firms.[21]

This producer level behavior is consistent not only with the DJK model but also the recent Japanese experiences. As the Japanese population has gradually decreased, foreign demand has become more important in affecting Japanese innovative behavior. Although government spending affects the product dynamics of Japanese firms, the effects are small. Witness the small increase in Japanese growth in the 1990s, when there were large fiscal stimuluses. We also find that the depreciation in real effective exchange rates stimulated the Japanese economy in the Koizumi and the 2nd Abe cabinets, which is consistent with our results for exporters. The low unemployment rate despite the recession induced by the COVID-19 pandemic has been supported by the rapid recovery of exports.

Our empirical results suggest that the creative destruction of the adding of new products and the dropping of old products by incumbent firms is an important contributor to aggregate fluctuations, and much more important than the entry and exit of firms for business cycle fluctuations. This creative destruction of products is more active under favorable macroeconomic conditions of high total factor

---

[21] The results are especially robust when fixed estimation is combined with an AR1 error term.

productivity, government spending and foreign demand, and a depreciated real exchange rate. To revitalize stagnant industrialized countries such as Japan's, it is important for the government to implement policies that raise aggregate productivity, government, and foreign demand, such as improving education, research and development, and stimulating infrastructure and foreign direct investment and trade, in addition to reducing the structural impediments that slow down the product innovation.

Appendix 1. Estimations of Firm level TFP

We estimate a production function with multi products developed by De Loecker (2011) to obtain firm-level TFP. In his paper, the output at firm i (q_i) depends on aggregate demand in industry k (Q_k) and relative price ($\frac{P_i}{P_k}$).

$$q_{it} = Q_{kt} (\frac{P_{it}}{P_{kt}})^{\eta_s} \exp(\xi_{it}) \quad \text{(A-1-1)}$$

In Equation (A-1), ξ_{it} is an unobservable demand shock and η is the elasticity of substitution.

From (A-1), the revenue function in firm i is

$$R_{it} = Q_{it}^{(\eta_s+1)/\eta_s} Q_{kt}^{1/\eta_s} P_{kt} \exp(\xi_{it}))^{-1/\eta_s} \quad \text{(A-1-2).}$$

Assuming a production function of $Q_{it} = L_{it}^{\alpha_l} M_{it}^{\alpha_m} K_{it}^{\alpha_k} \exp(\omega_{it} + u_{it})$ and log-linearizing Equation (A-2), we obtain

$$\bar{r}_{it} (= r_{it} - p_{kt}) = \beta_l l_{it} + \beta_m m_{it} + \beta_k k_{it} + \beta_k q_{kt} + \omega^*_{it} + \xi^*_{it} + u_{it} \quad \text{(A-1-3).}$$

L is labor input, M is intermediate input, and K is capital input. ω is the productivity shock at firm i. Lower case letters represent the log values of upper case letters.

Assuming that production factors are allocated for the production of each product in proportion to the output in each product, De Loecker leads to the following revenue function.

$$\bar{r}_{it} = \beta_n n_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_k k_{it} + \beta_k q_{kt} + \omega^*_{it} + \xi^*_{it} + u_{it} \quad \text{(A-1-4)}$$

In Equation (A-4), n_i is the log of the number of products at firm i.[22]

We estimate Equation (A-4) by using two digit-level industry classifications. [23]Using estimated parameters, we measure productivity as follows,

$$\omega_{it} = (\bar{r}_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_k q_{kt})(\frac{\hat{\eta}_k}{\hat{\eta}_k + 1}) \quad \text{(A-1-5).}$$

The estimation results are shown in the Appendix table 1.

---

[22] In the case that firm i produces multi products where each product belongs to different industries, Equation (A-1-4) becomes more complicated. However, as most Japanese firms produce multi products within one industry (two-digit level), we focus on the estimation of Equation (A-4).

[23] Estimations were conducted by the Levinsohn=Petrin method.

Appendix table 1

	FOOD	BEVERAGES,TOBACCO AND FEED	TEXTILE MILL PRODUCTS	LUMBER AND WOOD PRODUCTS, EXCEPT FOURNITURE	FURNITURE AND FIXTURES	PULP, PAPER AND PAPER PRODUCTS	PRINTING AND ALLIED INDUSTRIES	CHEMICAL AND ALLIED PRODUCTS
l	0.366 ***	0.389 ***	0.643 ***	0.444 ***	0.51 ***	0.501 ***	0.676 ***	0.3 ***
	168.68	11.19	164.68	50.26	38.39	61.76	161.07	24.73
k	0.0991 ***	0.115 ***	0.0831 ***	0.0798 ***	0.0401 **	0.0817 ***	0.0886 ***	0.152 ***
	353.96	19.48	214.58	241.84	3.08	12.79	78.5	9.99
m	0.422 ***	0.415 ***	0.266 ***	0.345 ***	0.377 ***	0.273 ***	0.244 ***	0.359 ***
	65.96	23	32.05	50.22	42.56	60.25	19.4	24.5
q	0.0146 ***	-0.0628 ***	0.0155 ***	0.203 ***	0.0514 **	0.123 ***	-0.545 ***	0.00916
	4.91	-15.26	64.54	6.59	3.29	6.79	-16.29	0.32
n	0.065 ***	0.105 ***	0.0595 ***	0.0596 ***	0.0113	0.0503 ***	0.072 *	0.00505
	22.22	4.74	15.68	19.03	0.99	3.72	2.23	0.14
Yeardummy	No	No	No	No	No	No	No	No
N	119188	12435	70787	18028	18861	25651	59609	18181
N_g	21469	2616	14519	4683	4113	4893	10241	3658
waldT	222.57	7.75	381.63	14.3	0.34	1.32	819.49	501.36
waldP	0	0.01	0	0	0.56	0.25	0	0

	PETROLEUM AND COAL PRODUCTS	PLASTIC PRODUCTS, EXCEPT OTHERWISE CLASSIFIED	RUBBER PRODUCTS	LEATHER TANNING, LEATHER PRODUCTS AND FUR SKINS	CERAMIC, STONE AND CLAY PRODUCTS	IRON AND STEEL	NON-FERROUS METALS AND PRODUCTS	FABRICATED METAL PRODUCTS
l	0.193 ***	0.492 ***	0.524 ***	0.451 ***	0.433 ***	0.451 ***	0.479 ***	0.594 ***
	6.47	67.58	30.65	17.02	140.7	51.72	21.69	667.89
k	0.128 ***	0.0797 ***	0.0749 ***	0.0213	0.0103	0.074 ***	0.191 ***	0.0897 ***
	5.97	172.47	12.46	1.56	0.35	5.31	7.75	275.97
m	0.589 ***	0.324 ***	0.31 ***	0.38 ***	0.378 ***	0.379 ***	0.325 ***	0.324 ***
	10.12	32.8	43.31	26.63	34.38	31.22	24.89	48.02
q	-0.0944 ***	-0.0155	0.123 ***	0.00583	0.201 ***	0.00387	-0.262 ***	0.0364 *
	-4.98	-0.59	6.32	0.32	10.86	0.2	-22.18	2.16
n	-0.0412	0.0436 *	0.0401 *	0.0113	-0.0254	0.0287 ***	0.0146	0.0374 ***
	-0.72	1.98	2.45	1.42	-0.77	69.09	0.54	12.23
Yeardummy	No	No	No	No	No	No	No	No
N	1781	52991	10284	6109	50869	16682	9644	99861
N_g	372	10817	2077	1260	9130	3444	2228	20046
waldT	30.64	259.64	2.82	14.75	0	39.03	171.7	17.06
waldP	0	0	0.09	0	1	0	0	0

	GENERAL-	PRODUCTION	BUSINESS	ELECTRONICPARTS	ELECTRICAL	INFORMATION AND	TRASPORTATION	MISCELLANEOUS
l	0.58 ***	0.639 ***	0.532 ***	0.62 ***	0.542 ***	0.641 ***	0.586 ***	0.556 ***
	60.33	64.84	50.54	72.24	41.12	98.59	62.63	47.82
k	0.0608 ***	0.0701 ***	0.0965 ***	0.126 ***	0.067 ***	0.115 ***	0.119 **	0.0825 ***
	168.48	458.07	184.16	387.98	431.02	211.54	3.17	182.42
m	0.329 ***	0.317 ***	0.3 ***	0.25 ***	0.285 ***	0.241 ***	0.258 ***	0.339 ***
	42.14	92.57	26.8	38.56	92.85	21.25	94.15	36.67
q	0.127 ***	0.223 ***	0.0345 ***	0.457 ***	0.188 ***	0.318 ***	0.00369	0.034 ***
	35.87	142.55	113.73	22.1	8.63	911.55	0.15	8.11
n	0.0255 ***	0.0122 ***	0.0389 ***	-0.0101	-0.0173 ***	0.0404 ***	0.0482	0.0337 ***
	7	7.6	7.65	-0.49	-12.48	7.86	1.24	7.76
Yeardummy	No	No	No	No	No	No	No	No
N	26958	61483	18573	25111	41418	11765	39663	26114
N_g	6663	13764	4643	6308	10018	3620	8761	5453
waldT	156.1	698.23	0.03	4511.83	4.22	2095.41	0.08	14.83
waldP	0	0	0.86	0	0.04	0	0.78	0

The lower cell in each estimation result shows the t-values.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Appendix 2. Estimation Results with Shock Variables

In the DJK model, foreign demand and government expenditures affect the real effective exchange rate. In addition, government expenditures are likely to respond to changes in foreign demand and the real effective exchange rate. To reduce these simultaneities among the aggregate variables, we construct and use aggregate shock variables as is common in the business cycle literature. Assuming that aggregate variables such as foreign demand, government expenditures, the real effective exchange rate, and aggregate TFP follow independent AR1 processes, we regress the aggregate variable at t on its level at period t-1 and take the residuals. Taking this residual as an explanatory variable, we then estimate the two equations as before, corresponding to equations (6) and (7).

$$\Delta N_{it} = const. + b_1 * z_{kt-1} + b_2 * y^*_{kt-1} + b_3 * g_{kt-1} + b_4 * e_{kt-1} + b_5 * N_{it-1} + \varepsilon_{it} \qquad (A-2-1)$$

$$\Delta N_{it} = const. + b_1 * z_{kt-1} + b_2 * y^*_{kt-1} + b_3 * g_{kt-1} + b_4 * e_{kt-1} + b_5 * N_{it-1} + b_6 * FTFP_{it-1} + \varepsilon_{it} \qquad (A-2-2)$$

z_{kt} are log of aggregate TFP shocks in industry k;, $y^*_{kt}$are log of foreign demand shocks in industry k; and g_{kt} are log of government demand shocks in industry k. $e_{kt}$are the log of real effective exchange rate shocks. Like Equations (6) and (7), we expect b_1 , b_2, b_3, b_4 and b_6 are positive, and b_5 is negative. As these expanatory variables are shock variables, we estimate Equations (A-2-1) and (A-2-2) by fixed effects estimations with AR1. The estimation results are shown in the following Appendix table 2.

In Appendix table 2-1, the dependent variable is ΔN_i, we find that firm-level TFP gives a positive impact on product dynamics. However, we do not find robust and significant effects of aggregate variables on product dynamics. Even when we change the dependent variable from the change in number of products to the Davis=Haltiwanger= Schuh measure, the estimation results do not improve. Only the coefficients on firm-level TFP and the lagged number of products show expected signs that are significant.

Appendix table 2-1

	Dependent variable:Δnumber of products			
	All firms(1)	All firms(2)	Exporters(1)	Exporters(2)
y*	0.001	0.028	-0.009 **	-0.022 ***
	1.46	1.60	-2.00	-3.28
g	0.001	-0.002 **	-0.005	0.012 *
	1.02	-0.10	-1.03	1.70
e	-0.041 ***	-0.094 ***	-0.201 ***	-0.191 **
	-6.98	-5.36	-3.25	-2.13
z	-0.002 ***	0.006 **	0.003	0.046 ***
	-2.57	1.98	0.41	3.84
FTFP(t-1)		0.074 ***		0.095 ***
		40.77		11.51
Num of Products(t-1)	-0.932 ***	-0.697 ***	-0.610 ***	-0.443 ***
	-1157.09	-266.22	-125.32	-52.96
Sample Size	1797601	200700	39319	14389
Number of Groups	294443	66075	9205	4478
rho_ar	0.341	0.592	0.250	0.542
R2(within)	0.471	0.345	0.343	0.224
R2(between)	0.009	0.021	0.124	0.125
R2(overall)	0.036	0.028	0.057	0.070
F statistics	334845.88	11827.00	3144.92	476.69
	0.00	0.00	0.00	0.00

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Appendix table 2-2

	Dependent variable:Davis =Hultiwanger=schuh index			
	All firms(1)	All firms(2)	Exporters(1)	Exporters(2)
y*	-0.000	0.000	-0.000	-0.001
	-0.78	1.47	-0.62	-1.16
g	0.000 ***	-0.000	0.000	0.001
	4.54	-0.33	0.54	0.84
e	-0.004 ***	-0.010 ***	-0.013 ***	-0.019 ***
	-6.37	-5.08	-3.00	-2.85
z	-0.000	0.000	0.000	0.001
	-0.74	1.12	0.40	1.18
FTFP(t-1)		0.001 ***		0.004 ***
		31.40		6.68
Num of Products(t-1)	-0.063 ***	-0.056 ***	-0.020 ***	-0.024 ***
	-745.74	-201.60	-65.20	-37.24
Sample Size	1797601	200700	39319	14389
Number of Groups	294443	66075	9205	4478
rho_ar	0.078	0.442	0.130	0.315
R2(within)	0.270	0.232	0.124	0.124
R2(between)	0.001	0.004	0.003	0.006
R2(overall)	0.024	0.012	0.006	0.007
F statistics	111297.35	8890.40	851.82	233.78
	0.00	0.00	0.00	0.00

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

References

Abe, Takeshi, Kazuya Hitomi, Yoko Konishi, Hideaki Tomita and Taisuke Uchino (2012) "A New Converter for Establishments from Japan's Census of Manufactures: 1993-2009," *Policy Discussion Paper*, 12-P-007, RIETI.

Acemorglu, Daren., Ufuk Akcicgit, and William. Kerr (2015), "The Innovation Network," manuscript, MIT.

Aghion, Philippe, and Peter Howitt (1992) "A Model of Growth through Creative Destruction" *Econometrica* 60, pp. 323-351.

Bergin, P. and G. Corsetti (2014), "International Competitiveness and Monetary Policy," manuscript, Cambridge University.

Bernard, Andrew, B., Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum (2003) "Plant and Productivity in International Trade" *The American Economic Review* 93(4) pp. 1268-1293

Bernard, Andrew, B. and Toshihiro Okubo (2013), "Multi-Product Plants and Product Switching in Japan" *RIETI Discussion Paper Series*, 13-E-069.

Bernard, Andrew, B., Stephen J. Redding, and Peter K. Schott (2010) "Multi-Product Firms and Product Switching," *The American Economic Review*, 100, pp. 70-97

Bilbie, Florin., Fabio Ghironi, and Mark Melitz (2012), "Endogenous Entry, Product Variety, and Business Cycles," *Journal of Political Economy,* 120(2): pp. 304-345.

Broda, Christian and David Weinstein (2010). "Product Creation and Destruction: Evidence and Price Implications," *The American Economic Review*, 100(3), pp. 691-723.

Davis, Steven, John Haltiwanger, and Scott Schuh (1996), *Job Creation and Destruction,* Cambridge, M.A.: MIT Press.

Dekle, Robert, Hyeok Jeong, and Nobuhiro Kiyotaki (2014) "Dynamics of Firms and Trade in General Equilibrium" unpublished manuscript March, 2014," Dekle, Robert, Atsushi Kawakami, Nobuhiro Kiyotaki, and Tsutomu Miyagawa (2015) “Product Dynamics and Aggregate Shocks: Evidence from Japanese Product and Firm Level Data” RIETI Discussion Paper Series 15-E-137.

De Loecker, J. (2011), “Product Differentiation, Multi-product Firms, and the Impact of Trade Liberalization on Productivity, 79(5): pp. 1407-1451.

Di Giovanni, Julian, Andrei A. Levchenko, and Isabelle Méjean (2014) “Firms, Destinations, and Aggregate Fluctuations,” *Econometrica* 82, pp. 1303-1340

Foerster, A., P. Sarte, and M. Watson (2011), “Sectoral versus Aggregate Shocks: A Structural Factor Analysis of Industrial Production,” *Journal of Political Economy*, 119(1), pp.1-38.

Foster, Lucia, John Haltiwanger, and Chad Syverson (2008), “Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?” *The American Economic Review* 98, pp.394-425.

Fukao, Kyoji, and Hyeog Ug Kwon (2006), “Why Did Japan’s TFP Growth Slow Down in the Lost Decade? An Empirical Analysis Based on Firm-Level Data of Manufacturing Firms” *The Japanese Economic Review* 57, pp. 195-228.

Garcia-Macia, G., C-T Hsieh, and Peter Klenow (2019), “How Destructive is Innovation?”, *Econometrica* (87) :1507-1541.

Good, David, Isaq Nadiri, and Robin Sickles (1997) “Index number and Factor Demand Approaches to the Estimation of Productivity”, M. Hashrem Perasan and Peter Schmit eds., *Handbook of Applied Econometrics: Vol. 2, Microeconometrics*, Oxford, England: Basic Blackwell.

Hsieh and Klenow (2017) “the Reallocation Myth” presented at the Federal Reserve of Kansas City Economic Symposium on “Fostering Dynamic Economy”

Jorgenson, Dale, Frank M. Gollop, and Barbara M. Fraimeni (1987) *Productivity and U.S. Economic*

Growth, Harvard Economic Studies Vol. 159.

Kawakami, Atsushi, Tsutomu Miyagawa, and Miho Takziawa (2011) "Revisiting Productivity Differences and Firm Turnover –Evidence for Product-Based TFP Measure in the Japanese Manufacturing Industries" *RIETI Discussion Paper Series* 11-E-064.

Kawakami, Atsushi, and Tsutomu Miyagawa (2013) "Product Switching and Firm Performance in Japan" *Public Policy Review* 9, pp. 287-314, Policy Research Institute, Ministry of Finance.

Meese, R. and K.Rogoff (1983), "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample," *Journal of International Economics*, 14: 3-24.

Melitz, Marc, J., (2003) "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity" *Econometrica* 71, pp. 1695-1725.

Olley, G. Steven and Pakes, Ariel (1996) "The Dynamics of Productivity in the Telecommunications Equipment Industry", *Econometrica*, 64, pp. 1263-1293.

Nakamura, Emi and Jon. Steinnson (2012). "Lost in Transit: Product Replacement Bias and Pricing to Market," *American Economic Review,* 102, 3277-3316.

Schleifer, Andrei. (1986). "Implementation Cycles," *Journal of Political Economy,* 94(6); 1163-1190.

Schmookler, Jacob, (1966). *Innovation and Economic Growth.* Cambridge: Harvard University Press.

Syverson, Chad (2011) "What Determines Productivity?" Journal of Economic Literature 49, pp. 326-365.

Table 1 An example of how products are classified in the Survey of Manufacturers

Sector		Industry		Product	
2-digit classification		4-digit classification		6-digit classification	
29	Elaectirc machineries	2951	Battery	295111	Lead battery
				295112	Alkaline battery
				295113	Lithium ion battery
				295114	Associated parts with batteries

Table 2 The Survey of Manufacturers in Japan

	industry	products	products/ industry	Goods Shipments (million yen)	Number of Employees	Shipments per Employees (million yen)
9 FOOD	40	121	3.0	23473138	1050510	22.3
10 BEVERAGES,TOBACCO AND FEED	12	30	2.5	9420542	89354	105.4
11 TEXTILE MILL PRODUCTS	62	239	3.9	3450657	248209	13.9
12 LUMBER AND WOOD PRODUCTS, EXCEPT FOURNITURE	17	53	3.1	1881095	74158	25.4
13 FURNITURE AND FIXTURES	9	29	3.2	1365973	74349	18.4
14 PULP, PAPER AND PAPER PRODUCTS	15	65	4.3	6945736	173279	40.1
15 PRINTING AND ALLIED INDUSTRIES	7	18	2.6	5647838	256629	22.0
16 CHEMICAL AND ALLIED PRODUCTS	38	181	4.8	26051020	338910	76.9
17 PETROLEUM AND COAL PRODUCTS	5	19	3.8	14772727	22031	670.5
18 PLASTIC PRODUCTS, EXCEPT OTHERWISE CLASSIFIED	25	61	2.4	10531973	386770	27.2
19 RUBBER PRODUCTS	13	51	3.9	2960785	110064	26.9
20 LEATHER TANNING, LEATHER PRODUCTS AND FUR SKINS	10	45	4.5	305900	18992	16.1
21 CERAMIC, STONE AND CLAY PRODUCTS	43	143	3.3	6562749	220025	29.8
22 IRON AND STEEL	22	72	3.3	17887305	210548	85.0
23 NON-FERROUS METALS AND PRODUCTS	18	66	3.7	8819409	137243	64.3
24 FABRICATED METAL PRODUCTS	33	134	4.1	11354599	490041	23.2
25 GENERAL-PURPOSE MACHINERY	19	91	4.8	9867822	304240	32.4
26 PRODUCTION MACHINERY	25	152	6.1	13028847	484356	26.9
27 BUSINESS ORIENTED MACHINERY	22	82	3.7	6742342	201014	33.5
28 ELECTRONICPARTS, DEVICES AND ELECTRONIC CIRCUITS	12	39	3.3	16564505	444281	37.3
29 ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES	23	109	4.7	14909487	463084	32.2
30 INFORMATION AND COMMUNICAION ELECTRONICS EQUIPMET	12	41	3.4	12558964	209837	59.9
31 TRASPORTATION EQUIPMENT	16	80	5.0	53988315	926255	58.3
32 MISCELLANEOUS MANUFACTURING INDUSTRIES	31	130	4.2	3332345	126821	26.3

Note) We take these figures averaging the data from 1999 to 2020 of the Census of Manufacturers

Table 3 Summary of statistics

	Obs	Mean	Std. Dev.	Min	Max
Number of products (N)	3046008	1.749	1.361	1.000	148.000
Change of number of products between t, t-1 (ΔN)	2540245	0.001	0.507	-37.000	27.000
Davis=Haltiwanger= Schuh index	2540425	0.000	0.054	-0.429	0.441
Log of foreign demand (ln FD)	3046008	12.906	1.638	8.673	16.726
Log of government expenditure (ln G)	3046008	10.827	1.183	7.527	13.546
Log of real efective exchange rate (ln REER)	3046008	4.645	0.110	4.402	4.977
Industry-level TFP (Z)	3046008	-0.046	0.819	-3.057	1.650
Firm level relative TFP	465717	3.658	2.569	-14.872	12.255

Table 4 Estimation results for the entire sample

Dependent variable: Δnumber of products

Dependent variable	All firms(1)		All firms(2)		All firms(3)		All firms(4)	
Δ number of products	Fixed effects				IV estimations			
lnFD(t-1)	-0.000		-0.003	**	-0.006	**	0.003	
	-0.37		-1.88		-2.09		0.32	
lnGE(t-1)	-0.001		0.005	**	-0.019	***	0.034	**
	-1.63		2.86		-3.82		2.38	
lnREER(t-1)	-0.015	***	-0.016	**	-0.005		-0.008	
	-5.34		-2.50		-0.64		-0.35	
lnZ(t-1)	-0.001		0.008	**	0.016	***	0.003	
	-0.89		2.61		2.61		0.21	
FTFP(t-1)			-0.004	***			-0.004	**
			-3.61				-2.29	
Num. of Products(t-1)	-0.543	***	-0.432	***	-0.564	***	-0.442	***
	-922.13		-273.78		-836.97		-234.19	
Sample Size	2540245		417521		2092044		266775	
Number of Groups	373826		136511					
rho	0.701		0.763					
R2(within)	0.282		0.211					
R2(between)	0.015		0.025					
R2(overall)	0.040		0.033					
F statistics	353949.22		12535.48					
	0.00		0.00					
Centered R2					0.290		0.220	
Wald F statistics					6764.31		862.26	
Sargan Statistics					5.412		0.092	
(P-value)					(0.020)		(0.762)	

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 5 Estimation results for exporters

Dependent variable: Δnumber of products of exporters

Dependent variable	Exporters(1)		Exporters(2)		Exporters(3)		Exporters(4)	
Δ number of products	Fixed effects				IV estimations			
lnFD(t-1)	-0.025	***	-0.031	***	0.149		0.250	
	-4.22		-3.59		0.30		1.44	
lnGE(t-1)	0.023	***	0.040	***	-0.031		-0.208	
	3.53		4.25		-1.62		-1.47	
lnREER(t-1)	0.215	***	0.131	***	1.083	***	0.694	***
	5.62		2.67		3.51		2.69	
lnZ(t-1)	0.026	**	0.064	***	0.084		-0.312	
	2.69		4.33		0.08		-0.93	
FTFP(t-1)			-0.005				0.012	
			-0.77				0.89	
Num. of Products(t-1)	-0.381	***	-0.394	***	-0.379	***	-0.391	***
	-115.86		-76.48		-104.06		-66.61	
Sample Size	55272		22936		48524		18867	
Number of Groups	13996		7962					
rho	0.760		0.879					
R2(within)	0.246		0.283					
R2(between)	0.044		0.071					
R2(overall)	0.054		0.078					
F statistics	2691.12		982.40					
	0.00		0.00					
Centered R2					0.168		0.212	
Wald F statistics					0.80		6.09	
Sargan Statistics					1.948		0.000	
(P-value)					(0.163)		(0.995)	

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 6 Estimation results for the entire sample

Dependent variable: (N(t)-N(t-1)/(N(T)+N(t-1))/2

Dependent variable	All firms(1)		All firms(2)		All firms(3)		All firms(4)	
Davis=Haltiwanger=Schuh index	Fixed effects				IV estimations			
lnFD(t-1)	-0.000	**	-0.000		-0.000	**	0.000	
	-1.70		-0.61		-2.00		0.38	
lnGE(t-1)	0.000	***	0.001	***	-0.001	*	0.005	***
	3.41		2.86		-1.80		3.00	
lnREER(t-1)	-0.000		-0.003	***	0.001		-0.003	***
	-1.05		-4.04		0.58		-1.42	
lnZ(t-1)	-0.000		-0.000		0.001	**	-0.001	
	-0.77		-0.11		2.23		-0.43	
FTFP(t-1)			-0.000				-0.000	
			-1.52				-0.51	
Num. of Products(t-1)	-0.062	***	-0.038	***	-0.054	***	-0.037	***
	-795.93		-221.74		-720.52		-183.79	
Sample Size	2540245		417521		2092044		266775	
Number of Groups	373826		136511					
rho	0.650		0.710					
R2(within)	0.227		0.150					
R2(between)	0.008		0.012					
R2(overall)	0.027		0.016					
F statistics	126872.52		8231.01					
	0.00		0.00					
Centered R2					0.231		0.147	
Wald F statistics					6764.31		862.36	
Sargan Statistics					2.719		0.099	
(P-value)					(0.100)		(0.753)	

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 7 Estimation results for exporters

Dependent variable: (N(t)-N(t-1)/(N(T)+N(t-1))/2

Dependent variable	Exporters(1)	Exporters(2)	Exporters(3)	Exporters(4)
Davis=Haltiwanger=Schuh index	Fixed effects		IV estimations	
lnFD(t-1)	-0.001 *	-0.001	0.026	-0.001
	-1.74	-0.73	0.73	-0.04
lnGE(t-1)	0.002 ***	0.003 ***	-0.014	-0.005
	3.25	3.66	-1.04	-0.43
lnREER(t-1)	0.011 ***	0.004	0.072 ***	0.04 **
	5.33	1.41	3.29	2.04
lnZ(t-1)	0.001	0.003 **	-0.025	0.016
	1.63	2.09	-0.35	0.61
FTFP(t-1)		0.003 ***		0.000
		3.93		0.38
Num. of Products(t-1)	-0.022 ***	-0.026 ***	-0.016 ***	-0.015 ***
	-68.64	-38.16	-59.29	-34.11
Sample Size	41276	14974	48524	18867
Number of Groups	9702	4653		
rho	0.141	0.322		
R2(within)	0.130	0.130		
R2(between)	0.003	0.005		
R2(overall)	0.006	0.007		
F statistics	945.71	257.48		
	0.00	0.00		
Centered R2			-0.010	0.063
Wald F statistics			0.80	6.09
Sargan Statistics			4.030	3.288
(P-value)			(0.045)	(0.070)

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 8 Fixed effects estimation with an AR1 correction

Dependent variable: Δnumber of products

Dependent variable	All firms(1)		All firms(2)		Exporters(1)		Exporters(2)	
Δ number of products	Fixed effects (AR1)							
lnFD(t-1)	0.016	***	0.019	***	-0.118	**	-0.015	
	23.32		9.23		-1.97		-1.53	
lnGE(t-1)	0.006	***	0.006	**	0.020	***	0.044	***
	8.09		2.50		2.79		4.06	
lnREER(t-1)	0.218	***	0.164	***	0.334	***	0.259	***
	80.93		24.97		12.97		7.47	
lnZ(t-1)	-0.013	***	0.004		0.010		0.062	***
	-10.35		0.94		0.95		3.58	
FTFP(t-1)			0.009	***			0.035	***
			5.89				4.30	
Num. of Products(t-1)	-0.968	***	-0.729	***	-0.633	***	-0.501	***
	-1329.88		-319.32		-131.59		-57.35	
Sample Size	2166419		281810		41276		14974	
Number of Groups	336053		94360		9702		4653	
rho_ar	0.399		0.570		0.262		0.533	
R2(within)	0.492		0.355		0.355		0.247	
R2(between)	0.009		0.019		0.118		0.119	
R2(overall)	0.037		0.030		0.056		0.068	
F statistics	353949.22		17131.98		3468.46		562.26	
	0.00		0.00		0.00		0.00	

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 9 Fixed effects estimation with an AR1 correction

Dependent variable: (N(t)-N(t-1)/(N(T)+N(t-1))/2

Dependent variable	All firms(1)	All firms(2)	Exporters(1)	Exporters(2)
Davis=Haltiwanger=Schuh index	Fixed effects (AR1)			
lnFD(t-1)	0.000 ***	0.002 ***	-0.001 *	-0.001
	4.46	7.51	-1.74	-0.73
lnGE(t-1)	0.001 ***	0.001 **	0.002 ***	0.003 ***
	6.38	2.38	3.25	3.66
lnREER(t-1)	0.002 ***	0.011 ***	0.011 ***	0.004
	6.19	14.87	5.33	1.41
lnZ(t-1)	-0.000 ***	-0.000	0.001	0.003 **
	-2.79	-0.44	1.63	2.09
FTFP(t-1)		0.001 ***		0.003 ***
		6.2		3.93
Num. of Products(t-1)	-0.062 ***	-0.057 ***	-0.022 ***	-0.026 ***
	-811.71	-229.11	-68.64	-38.16
Sample Size	2166419	281010	41276	14974
Number of Groups	336053	94360	9702	4653
rho_ar	0.090	0.403	0.141	0.322
R2(within)	0.265	0.222	0.130	0.130
R2(between)	0.001	0.004	0.003	0.005
R2(overall)	0.025	0.014	0.006	0.007
F statistics	131935.92	8890.40	945.71	257.48
	0.00	0.00	0.00	0.00

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 10-1 Fixed effects estimation with an AR1 correction

Dependent variable: Δnumber of products>=0

Dependent variable	All firms(1)	All firms(2)	Exporters(1)	Exporters(2)
Δ number of products>=0	Fixed effects (AR1)			
lnFD(t-1)	0.009 ***	0.016 ***	0.012 ***	-0.001
	17.44	10.10	3.12	-0.08
lnGE(t-1)	0.002 ***	0.008 **	0.015 ***	0.034 ***
	4.11	4.42	3.29	4.55
lnREER(t-1)	-0.003	0.049 ***	0.049 ***	0.061 ***
	-1.57	9.30	9.30	2.60
lnZ(t-1)	-0.010 ***	-0.008 ***	-0.011	0.004
	-10.59	-2.65	-1.54	0.33
FTFP(t-1)		0.002 *		0.025 ***
		1.80		4.38
Num. of Products(t-1)	-0.625 ***	-0.425 ***	-0.460 ***	-0.348 ***
	-754.86	-171.18	-86.53	-35.39
Sample Size	2002838	266663	36477	13772
Number of Groups	329278	91027	9242	4420
rho_ar	0.507	0.559	0.529	0.542
R2(within)	0.254	0.144	0.217	0.122
R2(between)	0.110	0.048	0.134	0.075
R2(overall)	0.010	0.012	0.040	0.031
F statistics	114223.82	4932.32	1506.23	216.91
	0.00	0.00	0.00	0.00

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 10-2 Fixed effects estimation with an AR1correction

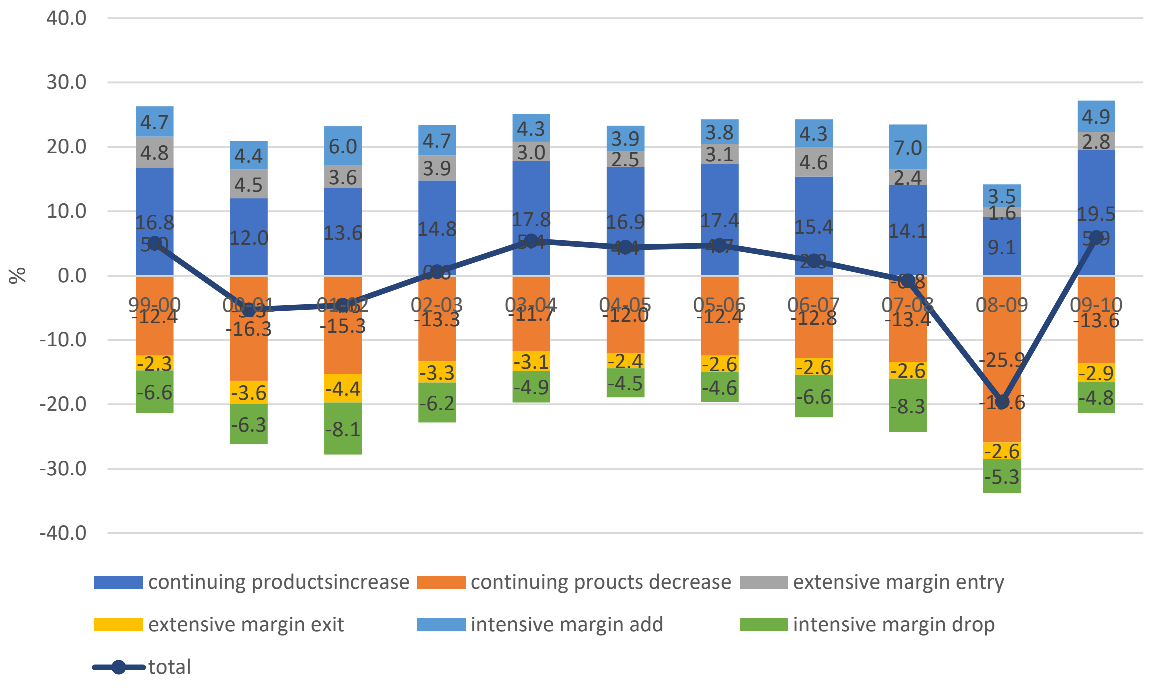
Dependent variable: Δnumber of products<=0

Dependent variable	All firms(1)		All firms(2)		Exporters(1)		Exporters(2)	
Δ number of products<=0	Fixed effects (AR1)							
lnFD(t-1)	0.015	***	0.008	***	-0.001		0.001	
	32.71		6.28		0.25		0.19	
lnGE(t-1)	0.007	***	0.000	**	0.014	***	0.005	
	13.42		-0.06		2.51		0.67	
lnREER(t-1)	0.383	***	0.122	***	0.292	***	0.171	***
	218.94		29.80		15.78		7.28	
lnZ(t-1)	-0.006	***	0.004		0.010		0.138	
	-7.40		1.49		1.21		1.22	
FTFP(t-1)			0.007	***			0.014	**
			7.42				2.46	
Num. of Products(t-1)	-0.622	***	-0.447	***	-0.355	***	-0.302	***
	-964.53		-265.71		-90.65		-44.80	
Sample Size	2003928		261514		36477		13562	
Number of Groups	329507		89193		9207		4344	
rho_ar	0.541		0.670		0.320		0.677	
R2(within)	0.368		0.294		0.233		0.122	
R2(between)	0.232		0.244		0.417		0.075	
R2(overall)	0.134		0.161		0.219		0.031	
F statistics	194647.98		11978.57		1675.48		216.91	
	0.00		0.00		0.00		0.00	

The lower cell in each estimation result shows t-value.

Standard errors are expressed in parentheses. *, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Figure 1 Decomposition of shipment change



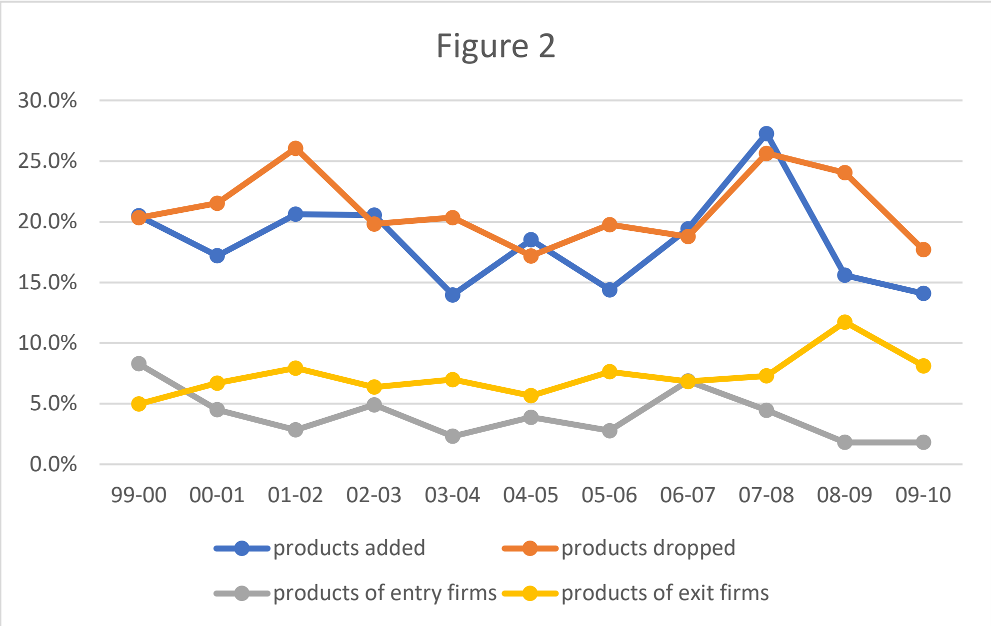


Figure 2
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
09-10
products added
products dropped
products of entry firms
products of exit firms

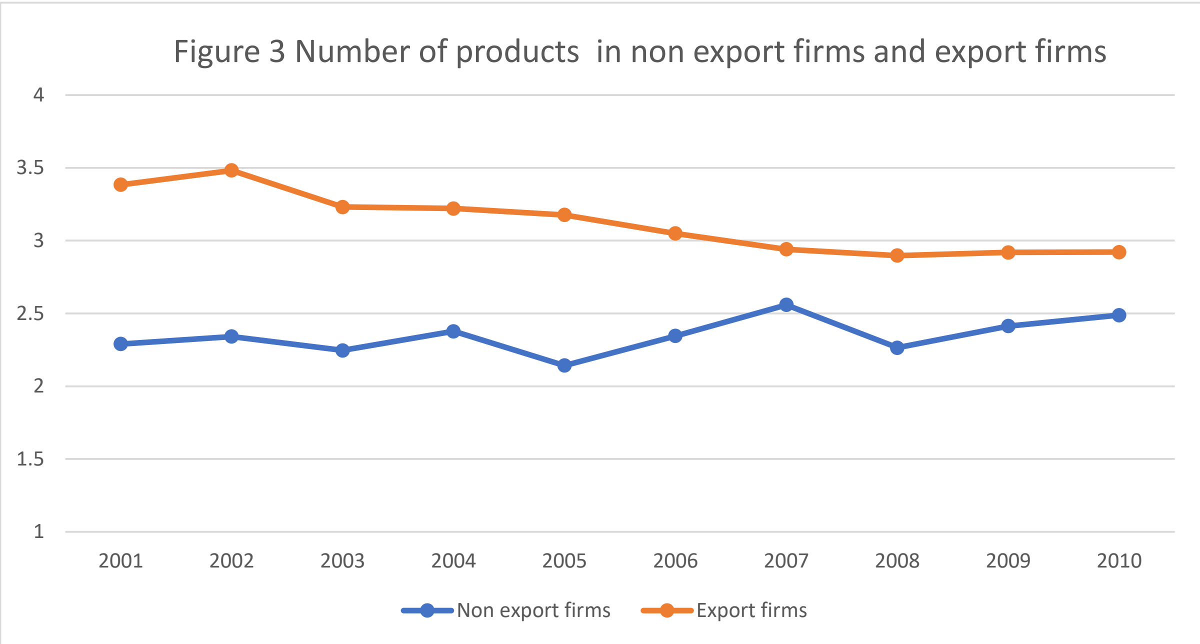
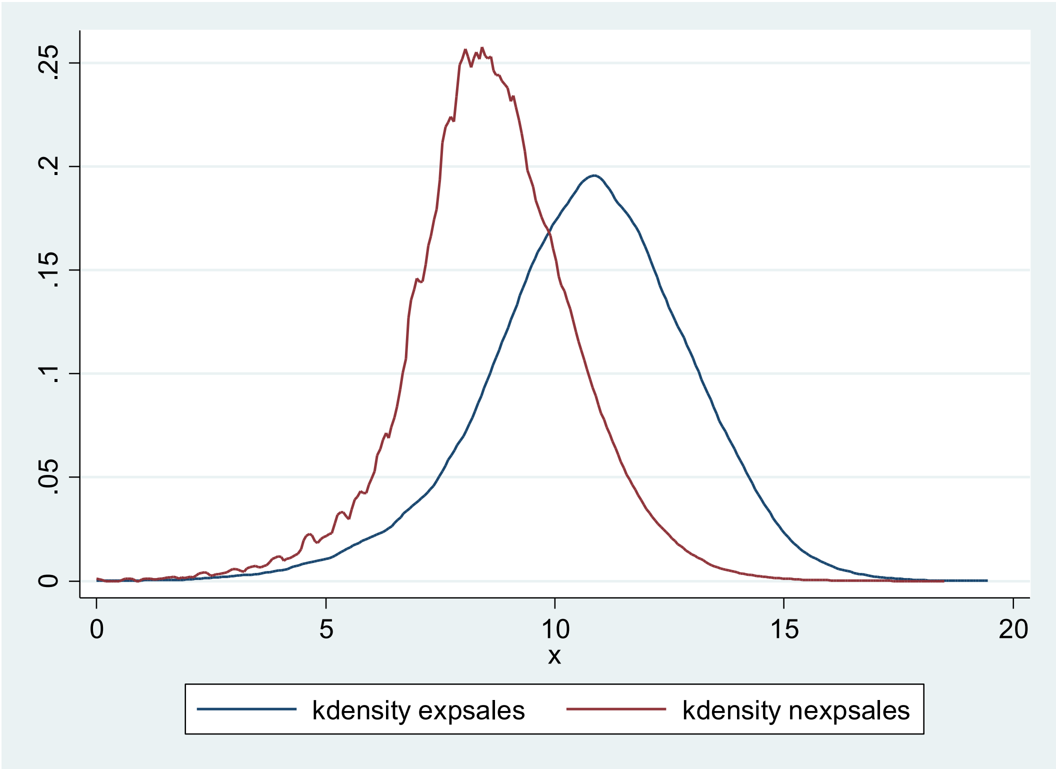


Figure 3 Number of products in non export firms and export firms
4
3.5
3
2.5
2
1.5
1
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Non export firms
Export firms

Figure 4



.25
.2
.15
.1
.05
0
0
5
10
15
20
x
kdensity expsales
kdensity nexpsales

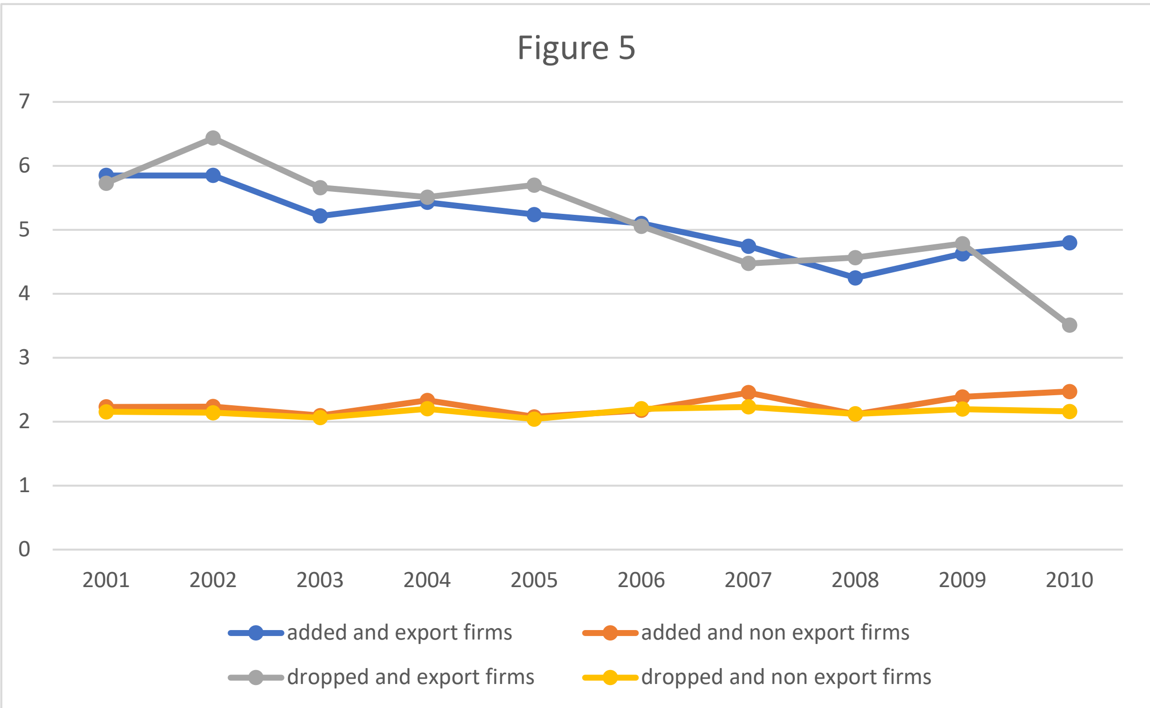


Figure 5
7
6
5
4
3
2
1
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
added and export firms
added and non export firms
dropped and export firms
dropped and non export firms