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

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Abstract

Conceptually linking product adding and dropping to business cycles goes back to at least Shumpeter. We examine the effects of shocks to aggregate productivity, foreign demand, government expenditures, and demand for foreign liquidity on the dynamics of products of heterogeneous firms. Our structural empirical specifications connecting macroeconomic shocks to product dynamics are based on a neoclassical dynamic general equilibrium model (Dekle, Kiyotaki, and Jeong, 2014). We first construct unique firm level data on products and exports from the Japanese *Census of Manufactures*. The data are more disaggregated than comparable U.S. data and available at the annual frequency (while U.S. product level data are only available at five year intervals), which makes our data more suitable for examining the interaction between the business cycle and firm-product dynamics. We find that positive macroeconomic shocks in foreign demand strongly increase the number of products. The depreciation in real effective exchange rate stimulates the ncrease in number of products of exporters.

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1. **Introduction**

The entry and exit of products are one of the main drivers of productivity growth. The entry of new products can lower prices and spur productivity and real GDP growth. Earlier empirical work have shown that product dynamics are a major source of productivity movements over the medium- and long-runs. [2] There is, however, scant theoretically grounded empirical work on how macroeconomic shocks affect the entry and exit of products at the business cycle frequency.[3] The main concern of this paper is how business cycle shocks such as total factor productivity, foreign demand, and government demand affect product dynamics at the firm level: the entry and exit of firms, and the adding and dropping of products by incumbent firms.

Figure 1-1 shows the movements of shipments in the manufacturing sector in Japan from 1999 to 2009, which are highly cyclical. The first recession which occurred from 2000 to 2002 was affected by the collapse of the IT bubble economy in the U.S. The second recession starting in 2007 was affected by the global financial crisis. We see that during both recessions, the growth in manufacturing shipments was negative (solid line). These movements in total shipments can be decomposed into the following components: new firm entry, firm exit, product adding of incumbent firms, product dropping of incumbent firms, and changes in continuing products by incumbent firms. An exiting firm is defined as a firm that drops from one or more products to zero products.

Focusing on just the two recessionary periods, we find that the movements in the components are much larger than the decline in total shipments. The decline in total shipments was driven by large decreases in continuing products of incumbents, the net dropping of products by incumbents,

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[2] See for example, Aghion et. al. (1992), and Bernard, Redding, and Schott (2010).

[3] There are several studies that relate firm entry and exit to aggregate shocks. See Alessandria and Choi, (2007); Ghironi and Melitz, (2005); Corsetti, Martin, and Pesenti, (2007); and Moreira, (2016) among others.

and the net exit of firms (exit minus entry).

From Figure 1-1, we can see that the contributions of product adding or dropping (or the sum of the contributions of firm entry and exit and the dropping and adding of products by incumbent firms) is much larger than the contributions of simply the entry and exit of firms. Between 00-09, on average, the contributions of entry and exit were 4.5 percent and -7.3 percent, while the contributions of the adding and dropping of products were 13.0 percent and -13.0 percent. Thus, it is important to not only examine the entry and exit of firms, but to focus on the adding and dropping of products by existing incumbent firms.

(Insert Figure 1-1 here)

The key takeaway is that on average between 1999 and 2009 and even just during downturns, firms are entering and adding products at the same time as they are exiting and dropping products. Thus, in analyzing product dynamics at the firm level, we need macroeconomic models that allow for the simultaneous adding and dropping of products of incumbent firms at the business cycle frequency—or of multiproduct firms in dynamic general equilibrium.

In this paper, we empirically relate firm-level product dynamics to macroeconomic shocks such as aggregate productivity, foreign demand, government expenditures and real exchange rates at the business cycle frequency. Our empirical specifications are motivated by the Dekle, Jeong and Kiyotaki (2014) (referred as DJK hereafter) multiproduct firm model. DJK develop a dynamic general equilibrium model in which the products added and dropped at the firm level depends upon aggregate shocks[4] Firms are heterogeneous, facing recurrent firm-product specific shocks and aggregate shocks, such as shocks to aggregate productivity, foreign demand and liquidity preference. Each firm potentially can produce multiple products and decides whether and how

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[4]Bilbie, Ghironi and Melitz (2012) also relate 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.

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 product adding and dropping rates. The authors show that an aggregate productivity improvement lowers the costs of the entry of new establishments and products and raises the total number of products. Shocks to increase foreign demand and government expenditures also encourage entry 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, such as total factor productivity, foreign demand, and government demand. 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 (if the model is true).

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 the short-run or business cycle frequency determinants of the number of new products is scant. In an important paper, Shleifer (1986) developed a model in which in times of high aggregate demand, entrepreneurs innovate and introduce new products. The idea is that only during favorable macroeconomic conditions are implementing new products profitable. In a series of industry level case studies, Schmookler (1966) showed that the more intense the aggregate demand, the more patentable ideas were generated. In this paper, we estimate an empirical specification structurally linked to a conventional business cycle model and show that positive macroeconomic shocks stimulate new product introductions.

We obtain our product level data used in this paper 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 "products"), and the product level shipment data and establishment (and firm) level accounting data are available at the annual frequency, making the data suitable for analysis at the business cycle frequency. Moreover, to use the framework of DJK, we need to aggregate the product level data up to the firm level. *The Census of Manufactures* allows this aggregation. Products can be aggregated into establishments (plants), and plants can be matched to the parent firm using firm identifiers.[5]

An important feature of macroeconomic models with product dynamics such as DJK is that much of the macroeconomic adjustment occurs through the extensive margin at the product level, the entry and exit of products. DJK use this feature to explain the puzzle of why exports at the aggregate level are not significantly correlated with the real exchange rate, while exports at the firm level are correlated (a version of the "exchange rate disconnect" puzzle). Their explanation relies on the heterogeneity of the product mixes of firms with large and small export sales. Because products with large export sales tend to have higher productivity (as in Melitz, 2003), a liquidity shock to appreciate their currency will not induce the dropping of such products from the export market and will not greatly lower their total export sales. Since these high productivity products dominate total exports, total exports become insensitive to real exchange rate fluctuations.[6] On the

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[5] In U.S. Census data, the usual product level data are only available down to the 5-digit level and are not available at the annual frequency (Bernard, Redding, and Schott, 2010). Also, although available at a higher frequency, U.S. store scanner-type product level data as used by Broda and Weinstein (2010) and U.S. Bureau of Labor Statistics individual producer price level data used by Nakamura and Steinsson (2012) need to be first matched to firm level accounting data at the annual frequency before performing the empirical work that we do here.

[6] Berman, Martin, and Meyer (2011) develop a model in which high productivity firms are insensitive to exchange rate fluctuations. In their model, high productivity firms lower price-cost markups, thereby protecting their export market share (quantities). Using Brazilian customs data, Chatterjee, et. al. (2013) also focus on changes in firm-level markups in response to exchange rate fluctuations. In the DJK model, the adjustment in export quantities of high productivity firms are less because high productivity firms drop fewer products when their exchange rate appreciates.

other hand, products with marginal productivities tend to ‘drop like flies’ from the export market with adverse shocks and their export sales tend to be sensitive to the exchange rate appreciation. Since products with marginal productivities are more common than products with very high productivity, firm level exports are more sensitive than aggregate exports to shocks which move the exchange rate.

We find using our firm-product level data that firms with high productivity drop products at a slower rate than firms with lower productivity when the real exchange rate appreciates. We also find that export sales of more highly productive firms are less sensitive to real exchange rate fluctuations, thus lending support to DJK’s explanation of the “exchange rate disconnect puzzle,” that changes in aggregate exports are dominated by large firms.

Our paper is organized as follows. In the next Section, we motivate the empirical specifications in this paper. In Section 3, we explain the construction of our product-firm level dataset. We explain how we construct Total Factor Productivity at the firm and industry levels; and foreign demand, government demand and the real effective exchange rates at the industry levels. In Section 4, using our constructed data set, we 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 exchange rate on the number of products at the firm level.

2. Product Dynamics and Macroeconomic Shocks

Dekle, Jeong, and Kiyotaki (2014) construct a dynamic general equilibrium model of a small open economy with a rich production structure. Firms are heterogeneous and potentially produce many differentiated products. The firm is defined as a collection of differentiated products, each product having heterogeneous productivity.

Their model differs from the usual general equilibrium, dynamic models of firm entry and exit in that their focus is on the addition and deletion of products by incumbent firms. The authors model the product evolution mechanism of both entering and incumbent firms. The product innovation mechanism described below by necessity is highly stylized, to permit clean aggregation into a dynamic general equilibrium model. Here we summarize only the key features of their model relevant for estimating the relationship between aggregate shocks and product dynamics..

When a new firm or a new establishment of an incumbent firm pays a sunk cost κ_E to enter, it draws an opportunity to produce a new differentiated product with a certain probability of success. The productivity of a new product is heterogeneous and is distributed according to a Pareto distribution with success. The firm with the production opportunity must pay a fixed cost in order to produce the product and maintain the productivity. Firms that pay the maintenance cost may succeed to maintain the productivity of the product with probability 1-δ and lose the productivity of the product completely with probability δ.

In addition, independently from the success or failure of maintaining the existing product, each product that the firm pays the maintenance cost yields an opportunity to produce another new product with certain probability $\lambda\delta,$ and the productivities of new products are distributed according to a similar Pareto distribution,[7] Through these birth and death of differentiated products, the firm may add new products, maintain the existing products, replace the products, or drop the existing products.

We can express this product evolution mechanism in terms of the change in the number of products (ΔN_t) in the following way. Let N_{Et} be the total number of new establishments at time

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[7] The idea here is that new products “spin-out” from old products. Say, Apple is working on the I-pod. Whether the I-pod will continue to be successful or not is stochastic, but only by working on the I-pod will there be a chance that the I-phone will be “spun-out” (they are based on similar technologies).

t. Each new establishment draws the opportunity of producing a new product from date t+1, with probability λ_E. A new establishment can be started by incumbent firms or new firms entering with a new product. Let ω be the exogenously given proportion of new establishments started by newly entering firms (as opposed to incumbent firms). Then the number of new products produced by new firm entrants will be: $(1-\omega)\lambda_E N_{Et}$ (1). Incumbent firms on the other hand will have two means of increasing the number of products: (1) by starting new establishments, $\omega\lambda_E N_{Et}$; and (2) by spinning out new products from existing products, $(\delta\lambda)N_t$. At the same time, incumbent firms will be dropping products through failed maintenance, $\delta(1-\delta\lambda)N_t$ and the closing of existing establishments, reducing the number of their products by: $(-\omega\lambda_E N_{Et})$.

Thus, the total number of products added by incumbent firms are:

$$(1-\delta)[\delta\lambda N_t + \omega\lambda_E N_{Et}] \qquad (2)$$

where 1-δ is the probability that the productivities of the existing products will be maintained. The total number of products dropped by incumbent firms are:

$$(\delta)[(1-\delta\lambda)N_t - \omega\lambda_E N_{Et}], \qquad (3)$$

where δ is the probability that the productivities of the products drop to zero. Thus, the total change in the number of products ΔN_t is the net number of products added by existing firms and the number of products added by the setting up of new establishments by new firm entrants.

Subtracting (3) from the sum of (1) and (2), and collecting terms, we have:

$$\Delta N_{it} = (-\delta + \delta\lambda)N_{it} + \lambda_E N_{Et} \qquad (4)$$

where we subscript by i to denote firm i $(-\delta + \delta\lambda) < 0$.[8] Note that existing firms are

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[8]This assumption is necessary in DJK to guarantee the existence of the steady-state in the model. That is, there are negative scale effects in the introduction of new products by incumbent firms. In fact, this negative scale effect—or decreasing returns to scale at the firm level—is a necessary condition for the DJK model to have a steady-state. Only through the entry of new firms and

heterogeneous, differing by their number of products at time t. This is because each incumbent firm will have a different sequence (history) in the draws of new products and the maintenance of existing products, resulting in different N_{it}.

Aggregate Shocks and New Products.

The entry of new firms and new establishments (of incumbent firms), N_{Et}, depends on the free entry condition of the model, where the firm or establishment enters when the costs of entry are lower than the expected present discounted value of profits:

$$\kappa_{Et} = \lambda_E E_t(\Omega_{t,t+1} V_{t+1}) \tag{5}$$

where κ_{Et} is the sunk cost of entry of the firm; λ_E is the probability of drawing a new product; $\Omega_{t,t+1}$ is the stochastic discount rate of consumers; and V_{t+1} is the value function of firms, or the present discounted value of profits from time t+1 onwards.

Importantly, aggregate shocks affect the evolution of the number of products through the above free-entry condition. These aggregate shocks include aggregate productivity (Z_t), foreign demand (Y_t^*), and government demand (G_t) shocks. Suppose that a positive macroeconomic shock such as Y_t^* hits the firm. The shock raises the present discounted value of profits facing the firm, and the firm opens a new establishment to start a new product line. At the same time, through unsuccessful maintenance, the firm loses products. Thus, as observed in Figure 1-1, we can simultaneously see the adding and dropping of products on average throughout the sample

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establishments will the total number of products be maintained or increasing over time. The DJK model is a neoclassical growth model with a well-defined steady-state. As in such models, the steady-state aggregate number of products, N*, is invariant to business cycle shocks. When a positive macroeconomic shock hits and raises N(t)>N*, over time N(t) decreases from above to return back to steady-state N*. Between the time of the macroeconomic shock and reaching the steady-state, N(t) is higher than at the steady state. There are more products and the level of GDP is higher after the positive macroeconomic shock than in the steady-state.

period and firms are dropping products even in response to a positive macroeconomic shock.

To close the model, consumers supply labor, consume final goods (which is produced from many differentiated intermediate products), and hold home and foreign bonds to maximize expected utility. The state of the economy can then be described by the set of variables $M_t = (N_t, D_t^*, Z_t, G_t, Y_t^*, \zeta_t)$, where N_t is the aggregate number of products, D_t^* is the level of foreign real bonds, and ζ_t is the liquidity shock to holding foreign bonds. The first two are endogenous and the last four are exogenous. The aggregate state variables are respectively, the total number of products in the economy, the aggregate stock of foreign bonds, total factor productivity, foreign demand, and the liquidity shock from holding foreign bonds. All of the other endogenous variables in the model such as aggregate consumption, labor supply, and the exchange rate are functions of M_t through all the equilibrium equations of the DJK model, including the free entry condition (5).

Equation (4) above can be estimated by firm level data with information on the number of products by firms. As summarized in Equation (4), $N_i(t+1) - N_i(t) = \Delta N_i(t)$ depends on the exogenous stochastic shocks that affect the firm's draws of maintenance and spinouts from the existing products, as well as the endogenous choice of the firm to add new establishments. The endogenous choices depend on the entire general equilibrium structure of the DJK model and are driven by macroeconomic shocks such as total factor productivity, government spending and foreign demand shocks. As mentioned, we expect $\Delta N_i(t)$ to be a decreasing function of $N_i(t)$ as existing firms tend to have a smaller number of positive spinouts and innovation than the unsuccessful maintenance of existing products.

Estimation Strategy of the Model.

In the estimation, the aggregate shocks that affect the evolution of ΔN_{it} are included at the *industry level* to increase the cross-section variation and the precision of the estimates. For the two demand shocks, government (G_t) and foreign demand (Y_t^*), let y_{tk}^* and g_{tk} be the industry-level foreign and government demand shocks for industry k (such as television and radio receivers). For the aggregate TFP supply shock (Z_t), let z_{tk} be the k industry-level TFP shock. Assume that the impact of industry level shocks on the dependent variable are proportional to the impact of aggregate level shocks: $g_{tk} = \gamma_{gk} G_t, y^*_{tk} = \gamma_{y*k} Y^*_t, and\ z_{tk} = \gamma_{zk} Z_t$, where the constant of proportionality differs by industry.[9] Then after taking logs of the above expressions of the industry level shocks, we obtain, say for government demand shocks, $lng_{tk} = lnG_t + lnv_{gk}$. Then we can substitute industry-level shocks for aggregate shocks, provided that we also include intercepts that differ by industry (lnv_{gk} or industry level dummy variables) in the estimation.

In DJK, shocks to aggregate government spending, foreign demand, and aggregate TFP are modelled as an AR(1) process. In our estimation below, we include two different industry-level shocks. First, we include the industry-level shocks, $g_{tk},\ y^*_{tk},\ and\ z_{tk}$ by themselves. The assumption is that the total levels of these variables represent a "shock" or "surprise" to the agents in the model. Second, we model the industry-level macroeconomic shock processes as an AR(1) process (following DJK), estimate the process, and use the estimated residuals as the "shock" component. In both cases, the coefficients on the shocks are interpreted as the impact of the particular macroeconomic shock on the evolution of the number of products.

Inclusion of Firm Level TFP

The specification (4) that we estimate is deliberately stylized. This stylized structure was

[9] DiGiovanni, et. al. (2014) use 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) develop a standard multisectoral neoclassical growth model and shows that the vector of industry output growth rates follow the factor time-series model: $\varepsilon_{kt} = \beta_k S_t + v_t$, 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. Thus, in Foerster et. al.'s (2011) real business cycle model, industry level shocks are also proportional to aggregate shocks.

necessary to allow the aggregation of heterogeneous firms with product innovations into a standard stochastic business cycle model. In reality, other variables would certainly influence the product evolution process at the firm level. In our alternate empirical specification (6), we add the ratio of firm level TFP to aggregate (industry) TFP $(Z_t)\ to\ (4)$.

$$\Delta N_{it} = (1 - \delta + \delta\lambda)N_{it} + \frac{TFP_{it}}{TFP_t}\lambda_E N_{Et} \qquad (6)$$

Firm level TFP depends on the entire history of product draws and the successful maintenance of the products of firm i and is predetermined. In the DJK model, N_{it} summarizes this evolution of products; firm level TFP adds no new information, and in theory, should be perfectly correlated with the number of products. In reality, however, the productivity of a firm may depend on other variables than past product draws such as corporate location and physical capital. To capture the effects of these other variables on product dynamics, we include firm-level TFP as an additional explanatory variable in our alternate specification. That is, if firm i has high TFP relative to other firms, then the firm is more likely to maintain its menu of existing products to induce spinouts and give birth to new establishments that can satisfy the free entry condition (5). Although not directly related to this paper, many growth models stress the importance of firm level TFP for product innovation (see Acemoroglu, Akcigit, and Kerr, 2015). While specification (6) cannot be as easily and cleanly aggregated as specification (4) into a standard business cycle model, it would be interesting to see whether more productive firms introduce more products at the business cycle frequency.[10]

Product Dynamics of Exporters.

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[10] 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 (2012).

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. The DJK paper shows that all products with productivity greater than $a_t = [\frac{\alpha(\theta-1)\varphi}{\alpha+1-\theta}\frac{N_t^{\frac{\theta}{\theta}-1}Z_t}{\epsilon_t Y_t^*}]^\gamma$ will be exported. γ is a function of the parameters, θ is the elasticity of substitution of goods (both domestic and foreign), and ε_t is the real exchange rate between foreign and domestic goods. N_t and ε_t are endogenous and are affected by the exogenous shocks, Z_t and Y_t^* in the general equilibrium model.

On impact, a positive shock to Z_t will raise the total number of products in the economy N_t as more establishments are started and will depreciate the real exchange rate, as home goods become cheaper than foreign goods. However, the net effect of a positive shock to Z_t on a_t is ambiguous, and depends on the parameter values and on the general equilibrium effects. We must rely on model simulations to ascertain the general equilibrium effects. Simulations in DJK show that as Z_t rises and a_t increases, the fraction of goods that are exported falls.

A positive shock to foreign demand, Y_t^* raises N_t and appreciates the real exchange rate. Again, the net effect on a_t depends on the parameter values and the general equilibrium effects. Simulations in this case show that in this case, a_t and the fraction of goods that are exported rises.

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 that meet the lower bound of exporting in a given year—exporters--are more productive than the average firm, because of higher N_{it} or higher TFP_{it}. This accords with the well-known empirical finding that exporters tend to be larger and more productive than non-exporters. 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.

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 establishments (plants) in the Japanese economy. The data are now available in the format that we require from 1998-2009 annually. Importantly, unlike in the U.S., where usable product and establishment level data are available for only every 5 years (Bernard, Redding, and Schott, 2010), in Japan, we can collect product and establishment level Census data for every year, which 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 at and above 5 workers, since the data covering establishments below that number of workers are not made publicly available. In 2008 for example, 263,061 establishments of 5 or more employees responded to the Census, representing over 59 percent of all Japanese manufacturing establishments.

We define "Sectors" as goods at the 2-digit Japanese Standard Industry Classification (JSIC) level; "Industries" as goods at the 4-digit JSIC level, and "Products" as goods at the 6-digit JSIC level[11]. In the data, each establishment reports the usual accounting data, such as the number of employees, raw material costs, fuel and electricity costs, tangible fixed assets, and the value of

[11] Industry classification in *the Census of Manufacturers* follows the Japan Standard Industry Classification (JSIC) in the case of 2-digit and 4 –digit levels. JSIC that 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 classification.

shipments (output) of the different types of "products" that the establishment produces. Examples of sector, industry, and product level classifications are shown in Table 1.[12]

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 (2010). 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. The output (shipments) of an average multiple product firm is 50 percent higher than the average single product firm; and average employment is 28 percent higher than a single product firm. Output per worker is 30 percent higher on average in multiple product firms than in 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

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[12] 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.

(not broken down into domestic and export) shipment quantities and values are available.

For our empirical analysis, we need to construct some aggregated variables using both the Census of Manufacturers and other, mostly industry-level data. Industry level government expenditures, g_{tk}, are obtained from the Input- Output Tables in the Japan Industrial Productivity Database (JIP database). [13] We use data for only the government's direct demands for industry k. We construct industry level foreign demands, y_{tk}^{*} , by first obtaining exports from Japan to 4 of Japan's main export partners (in yen), the U.S., China, the European Union, and Russia in each industry (these countries account for over 90 percent of Japan's total exports). We then obtain the value added in each of Japan's export partners in each industry from the IMF's *International Financial Statistics* (converted to yen at the prevailing exchange rate). For each industry, we then sum Japan's exports and value added over the 4 countries. Finally, for each industry, we take the ratio of Japan's summed exports to our summed value added measure, and use this ratio as our industry-level foreign demand variable. Applying Good, Nadiri, and Sickels (1996) to the industry level, we measure industry level TFP, z_{tk}, as follows,

$$\ln TFP_j = (\ln Q_{f,t} - \overline{\ln Q_t}) - \sum_{h=1}^{n}\frac{1}{2}(S_{h,f,t} - \overline{S_{h,t}})(\ln X_{h,f,t} - \overline{\ln X_{h,t}}) + \sum_{s=1}^{t}(\overline{\ln Q_s} - \overline{\ln Q_{s-1}}) - \sum_{s=1}^{t}\sum_{h=1}^{n}\frac{1}{2}(\overline{S_{h,s}} + \overline{S_{h,s-1}})(\overline{\ln X_{h,s}} - \overline{\ln X_{h,s-1}}).$$

[14]

In most general equilibrium models, as in DJK, actual real exchange rate movements are

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[13] 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.

[14] 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 interindustry 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.

dominated by aggregate shocks such as productivity, foreign demand, and government demand. In these models, real exchange rates are endogenous. In particular, in DJK, liquidity shocks importantly drive fluctuations in real exchange rates. However, it is difficult to find variables that capture aggregate exogenous liquidity shocks 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 industry-level real effective exchange rates (ϵ_{tk}) as an additional explanatory variable, being fully aware that this variable could be endogenous.[15]

As mentioned above, instead of the actual levels of the industry variables, we also estimate shocks or "surprises" to the industry-level variables and include these "surprises" as explanatory variables. We assume that the industry-level macroeconomic variables follow AR(1) processes (consistent with the impulse response analysis of DJK). We estimate the processes and take the residuals of the processes as the "shock" components to the industry level variables. We use these

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[15] We obtain the industry-level real effective exchange rates, ϵ_{tk}, from RIETI from 2005 to 2009. Since our firm-product database runs from 1999 to 2009, we have to construct real effective exchange rate data ourselves from 1999 to 2004. As for this data from 1999 to 2004, 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.

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 (2012).

residuals in an alternative set of explanatory variables to capture the "shocks" to the macroeconomic variables (results available from the authors).

Finally, in some specifications, we add the ratio of firm-level productivity to industry-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).

4. Stylized facts of Japanese Product Dynamics.

Using the firm-product level data as constructed above, here we provide an overview of product level dynamics in Japan. Table 1 shows examples of sectors, industries, and products in Japan. Table 2 depicts how sectors can be divided into industries and products. For example, the food sector has 41 industries and 87 products, ships 24 billion yen worth of goods and has over a million workers. We find that the value of shipments (output) per employee is higher in industries with high capital intensity, such as the coal and the petroleum sector.

(Insert Tables 1 and 2 here)

As shown in Introduction, Figure 1-1 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.

(Insert Figure 1-1 here)

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. In accounting for the total change in shipments between 1999-2009, the contribution of new product shipments by incumbent firms was 13.0 percent, while the contribution of new firm entry was only 4.5 percent.

These stylized facts argue for models that allow for the adding of dropping of products of incumbent firms—or of multiproduct firms. In terms of the multiproduct DJK model, this would mean that the entry of new establishments by existing firms and the spinouts from the existing products dominate the entry of new firms in the movement of total shipments.

As further evidence for the importance of multiproduct firms, Figure 1-2 depicts the decomposition over time in the change in the total number of products. The evolution in the total number of products can be decomposed into the addition of new products by incumbent firms, the addition of new products by the entry of new firms (going from 0 to 1 or more products), and the dropping of existing products by incumbent firms, and the exit of incumbent firms (when they drop their last product). Again, the contribution of product adding and dropping dominates the contribution of firm entry and exit for the change in the total number of products.

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. Incumbent firms added products especially strongly between 2003 and 2006. In contrast to the pro-cyclical nature of product adding and firm entry, product dropping and firm exit behaviors are relatively noncyclical or even slightly countercyclical.

(Insert Figure 1-2 here)

Exporting Firms.

Since we do not observe exports at the product level in the data, we can only infer the relationship between say macroeconomic shocks and the number of exported products by examining how macroeconomic shocks affect the total number of products by exporting status. In Figure 2, we compare the number of products over time between exporters and non-exporters. It is well-known from earlier work that exporters are larger and more productive than non-exporters (Bernard, Eaton, Jenson, and Kortum, 2003). These predictions hold in the data. Figures 3 show that Japanese exporters produce a larger variety of products than non-exporters and that exporters are larger.

Compared to that of the average Japanese firm, the average number of products of exporting firms fluctuates more pro-cyclically (Figure 4). This is not only because exporting firms on average produce more products. It is also because exporters added products more rapidly over the business cycle than non-exporters. Between 2003 and 2004, exporters on averaged added 0.3 products while non-exporters added essentially none. On average, the number of added products equals to 2 for exporters and 1.4 for non-exporters.

(Insert Figures 2, 3, and 4 here)

We also find that when total exports rise, it is not the increase in the number of firms, but the increase in the number of products that is the driving force. In Figure 5, the share of firms adding products and share of entrants (both weighted by shipments) are positively correlated with movements in average export values by firm. Both shares increased when export growth accelerated in the period from 2002 to 2004, and decreased after 2009, when total Japanese exports collapsed, owing the global financial crisis. However, the fluctuations in the share of firms adding products were much larger than the fluctuations in the share of entrants.

(Insert Figures 5 here)

To summarize, these stylized facts show that a significant adjustment in Japanese output is comprised of the adding of new products, rather than the entry and exit of firms (in addition to the expansion and contraction of the shipments of existing products). This adding of new products appears more pronounced for Japanese exporters.[16] We also find that consistent with DJK, firms add and drop products at all states of the business cycle. These long-run or acyclical features of product adding and dropping are a robust characteristic of the data and capture how firms add and drop products through the normal innovative processes of product “spinouts” and “failed maintenance” that occur in all states of the business cycle.

Finally, although we do not observe exports at the product level, we find that exporters tend to be multiproduct firms and that exporters add products at a much more rapid rate than non-exporters. Product adding rates are highly correlated with average firm exports. Thus, while the total cyclical change in shipments is dominated by the change in continuing products made by incumbent firms, the cyclical change in export sales is highly correlated with the adding of new products, mostly by incumbent firms.

5. Estimation of Product Dynamics

In our estimates below, we focus on the extensive margin of adjustment, of the change 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).

Empirical Specifications

With Only Aggregate Explanatory Variables.

Our baseline specification is adopted from (4):

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

$$\Delta N_{it} = a + b * z_{tk} + c * y_{tk}^{*} + d * g_{tk} + e * N_{it-1} + \varepsilon_{it} \quad (7)$$

where N_{it-1} is the number of products at time t-1 for all firms in existence at time t-1, including firms that exited at time t-1. Since firms are continuously entering and exiting, the panel is unbalanced. N_{it} is the number of products at time t for all firms in existence at time t, including those that entered at time t. The dependent variable, the change in the number of products is $\Delta N_{it} = N_{it} - N_{it-1}$; z_{tk} are log TFP shocks in industry k; y_{k}^{*}, log foreign demand shocks in industry k; and g_{tk} are log government demand shocks in industry k. The fixed effects estimator is used to estimate equation (7), and sectoral dummy variables are included to control for sectoral heterogeneity.[17] The theory developed above predicts that b, c, and d are positive and e is negative. A negative e implies negative scale effects at the firm and aggregate levels.

We measure macroeconomic shocks in two ways. First, we just include the log levels of the macroeconomic variable. This assumes that the entire change in the variable represents an aggregate shock. Second, we estimate an AR(1) process for each macroeconomic variable, and include the residual component of this process as the “surprise” macroeconomic shock component. This assumption that macroeconomic processes follow an AR(1) is usually adopted in DSGE models as in DJK.

The dependent variable in Equation (7), ΔN_{it}, is the change in number of products of firm i, Following Davis, Haltiwanger, and Schuh (1996), we also conduct an alternative estimation

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[17] Instead of industry-level dummy variables to control for industry-level effects, we include sectoral-level dummy variables. Recall that “sectors” are much broader than “industries.” A typical sector contains about 20 industries (In Table 2).

where the dependent variable is instead the rate of change in the number of products:

$$\frac{N_{it}-N_{it-1}}{\frac{N_{it}+N_{it-1}}{2}} = explanatory\ variables \qquad (8)$$

All of the explanatory variables in (8) above are the same as those in (7).

Finally, in a separate set of specifications, we add the industry level log real exchange rate as an additional explanatory variable. 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, so 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.

Estimation Results

In Table 3-1, we depict the estimates from (7), where the dependent variable isΔN_i. "Observations" refer to the sum of the number of firms in each year. Since firms enter and exit from the sample in every year, the sample is unbalanced. We can see that domestic government spending is always insignificant in affecting the number of new products. Foreign demand shocks are always highly significant, suggesting that Japanese firms respond strongly to foreign demand, by entering and introducing new products. A rise in total factor productivity significantly increases the number of products, but only when foreign demand is excluded. As hypothesized, the number of products last period, ΔN_{it}, is negative and highly significant in in each period, implying that the change in the number of products is mean reverting. Recall that a negative coefficient on N_{it-1} is necessary to ensure a stationary steady-state in the model, and implies that absent aggregate shocks, the aggregate number of products in the economy will be declining.

In Table 3-2, we depict the estimates from (7), where the dependent variable is the rate of change in the number of products, $\frac{N_{it}-N_{it-1}}{\frac{N_{it}+N_{it-1}}{2}}$. Again, domestic government spending is always insignificant. Aggregate TFP shocks are significant when foreign demand and government spending are dropped from the estimation; when foreign demand is included, aggregate TFP turns insignificant. Foreign demand shocks are again highly significant in all specifications. The coefficient on N_{it-1} is again negative and highly significant.

Estimation on a Sample of Exporters

We estimate (7) on a sample of 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.[18] Thus, the exporter panel is also unbalanced. Since a minimum level of productivity is required to export in any given year, the sample of exporters has on average higher productivity than the broader sample. In the estimation of (7) using the change in number of products, foreign demand and government demand are generally significant (Table 3-3). The coefficient on aggregate TFP is insignificant, or even becomes negative, when it is included jointly with foreign demand. The coefficient on foreign demand for exporters is almost 6 times as large as the coefficient on foreign demand for the entire sample for firms. As shown in Figures 3-5 above, compared to the average firm, exporters appear to add products much more vigorously in booms. This high elasticity of ΔN_{it} to the business cycle shows up as high values on the coefficients of the macroeconomic variables, mainly foreign demand. In addition, we find that the increase in government spending significantly stimulates product innovation in exporters. In DJK model. the increase in government spending leads to the depreciation in real exchange rate. Responding to this depreciation in exchange rate, the exporters increases number of products.

The estimation on a sample of exporters using Davis and Haltiwanger measure is depicted in Table 3-4. Again, we can see that the coefficient on foreign demand is large and highly significant. However, the increase in government spending does not increase the rate of change in number of products.

Then, we estimate (7) including real effective exchange rate as explanatory variable.

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

When ΔN is a dependent variable, we find the positive and significant coefficients of real effective exchange rate (Table 3-5). This result implies the depreciation in real exchange rate increase in number of products in exporters.[19] Instead, the significant effects of government demand shock disappear. When Davis and Haltiwanger measure in a dependent variable, real effective exchange rate has also positive and significant effects (Table 3-6).

Comparisons with the Results from the Aggregate Impulse Responses

In product level general equilibrium models such as DJK, common macroeconomic shocks such as aggregate productivity, government expenditure, and foreign demand shocks alter product dynamics and export behavior. To analyze their model, DJK shock their model with an AR(1) process of an aggregate shock such as TFP. In their impulse responses, DJK show that a one standard deviation (0.9 percent) increase in aggregate TFP (with auto-correlation of 0.55 in annual data) raises output by 1 percent, and depreciates the real exchange rate by 0.9 percent. Exports increase by 0.7 percent, and correspondingly, the total number of products increases vigorously in 3 to 7 years to 0.4 percent. A 1.4 percent increase in foreign demand (with auto-correlation of 0.94) increases GDP by 0.2 percent and exports by 0.8 percent. The real exchange rate appreciates by 0.8 percent, the number of products increases slowly by 0.15 percent in 7 to 20 years. A 0.8 percent positive government expenditures shock (with auto-correlation of 0.95) raises GDP by 0.15 percent, depreciates the real exchange rate by 0.1 percent, and increases exports by 0.07 percent and the number of products by 0.08 percent. Thus, quantitatively, DJK find that aggregate TFP shocks have the greatest impact on the number of products, followed by foreign demand and government spending shocks.

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[19] We also estimate (7) including real effective exchange rate on all samples. However, we find negative and significant coefficients on real effective exchange rate, although the foreign demand has positive and significant impacts. The reason of negative impact of real effective exchange rate may be that the depreciation of real exchange rate induce the dropping of home goods, while exporters produce new goods, as our previous empirical studies (Dekle et al, (2015)) showed.

In our estimates above, we have regressed the changes in the number of products (ΔN_{it}) at the firm level on macroeconomic shocks. The estimates above are not identical to what is measured in the impulse responses, where interest lies in how the aggregate number of products (ΔN_t) respond to aggregate shocks. Still, in expectation or on average, changes in ΔN_{it} should correspond to changes in ΔN_t. In our estimates above, we show that the number of products at the firm level responds very strongly to foreign demand shocks, and moderately strongly to aggregate TFP shocks. The response of ΔN_{it} to government demand shocks is more muted.

6. Concluding remarks

Policy makers in many countries are especially concerned about the new products produced 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 policy in Euro area is related in part to the desire to stimulate innovation and 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 (DJK, 2014) 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 a unique firm-product database in Japan using *the Census of Manufacturers*. The 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.

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

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-exporting firms. Sales of exporters are larger than the sales of non-exporters. We also find that product adding and firm entry behavior are highly cyclical.

In our firm level estimates, we find that macroeconomic shocks-- industry level productivity and government demand shocks— increase both the number of products and product adding and dropping behavior. This producer level behavior is consistent with the DJK model.

Our empirical results suggest that creative destruction of adding new products and dropping 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 productivity, government 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 obstacles to slow down the product innovation process.

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Table 1

Sector 2-digit SIC		Industry 4-difgit SIC		Product 6-digit SIC	
30	Information and communication electronics equipment	3011	Communication equipment wired	301111	Telephone sets
				301112	Automatic telephone exchange switchboards
				301113	Auxiliary equipment of telephone exchange switchboards
				301119	Miscellaneous wired telephone sets
				301121	High-speed facsimiles, including ultra-high-speed ones
				301122	Facsimiles, except high-speed ones
				301129	Miscellaneous wired telecommunication equipment
				301131	Digital transmission equipment
				301132	Transmission equipment, except digital transmission equipment
		3012	Mobile phone and PHS	301211	Cellular telephone sets and PHS telephone sets
		3013	Radio communication equipment	301311	Radio and TV broadcasting equipment
				301312	Fixed-station communication equipment
				301313	Miscellaneous mobile-station communication equipment
				301314	Portable communication equipment
				301315	Radio applied equipment
				301319	Miscellaneous radio communication equipment
		3014	Radio and television set receivers	301411	Radio receivers
				301412	Plasma television receivers
				301413	Liquid crystal television receivers
				301419	Miscellaneous television receivers
		3015	Railway signal and safety appliances	301511	Railway signal and safety appliances
				301512	Parts, attachments and accessories of railway signal and safety appliances
		3019	Miscellaneous communication equipment and related products	301911	Fire alarm equipment
				301919	Miscellaneous communication related products
		3021	Video equipment	302111	Recording and duplicating equipment
				302112	Video cameras, except broadcast video cameras
				302113	Parts, attachments and accessories of video recording and duplicating equipment
		3022	Digital camera	302211	Digital cameras
				302212	Parts, attachments and accessories of digital cameras
		3023	Electric audio equipment	302311	Stereo sets
				302312	Car stereo sets
				302313	Tape recorders
				302314	Digital audio disc players
				302315	High fidelity (HI-FI) amplifiers
				302316	Speaker systems for HI-FI and cars
				302317	Hearing aids
				302319	Miscellaneous electric audio equipment
				302321	Finished speaker systems, microphones, earphones, audio pickups, etc.
				302322	Parts, attachments and accessories of electric audio equipment
		3031	Computer, except personal computer	303111	General computers
				303112	Midrange computers
				303113	Parts, attachments and accessories of data processing machines, digital and analog computers and auxiliary equipment
		3032	Personal computer	303211	Personal computers
				303212	Parts, attachments and accessories of Personal computers
		3033	External storages	303311	Magnetic disc equipment
				303312	Optical disc equipment
				303313	Flexible disc equipment
				303319	Miscellaneous external memories
				303321	Parts, attachments and accessories of external memories
		3034	Printer	303411	Printers
				303412	Parts, attachments and accessories of printers
		3035	Display unit	303511	Displays
				303512	Parts, attachments and accessories of displays
		3039	Miscellaneous peripheral equipment	303911	Finance terminal units
				303919	Miscellaneous terminal units
				303929	Miscellaneous input-output systems
				303939	Miscellaneous accessories equipment
				303941	Parts, attachments and accessories of miscellaneous accessories equipment

Table 2

Sector	Industries	Products	Industries/ Products	Goods Shipments (million yen)	Number of Empliyees	Shipments per Employees (million yen)
9 FOOD	41	87	2.1	23784327	1049968	22.7
10 BEVERAGES,TOBACCO AND FEED	13	31	2.4	9802268	91072	107.6
11 TEXTILE MILL PRODUCTS	64	177	2.8	3493573	257219	13.6
12 LUMBER AND WOOD PRODUCTS, EXCEPT FOURNITURE	18	43	2.4	1824205	75766	24.1
13 FURNITURE AND FIXTURES	9	22	2.4	1402558	77669	18.1
14 PULP, PAPER AND PAPER PRODUCTS	15	52	3.5	6895796	177263	38.9
15 PRINTING AND ALLIED INDUSTRIES	7	19	2.7	5724091	262370	21.8
16 CHEMICAL AND ALLIED PRODUCTS	38	160	4.2	24096231	340916	70.7
17 PETROLEUM AND COAL PRODUCTS	5	18	3.6	10241165	21956	466.4
18 PLASTIC PRODUCTS, EXCEPT OTHERWISE CLASSIFIED	25	54	2.2	9669225	383831	25.2
19 RUBBER PRODUCTS	13	40	3.1	2577212	108561	23.7
20 LEATHER TANNING, LEATHER PRODUCTS AND FUR SKINS	9	30	3.3	328166	20288	16.2
21 CERAMIC, STONE AND CLAY PRODUCTS	44	101	2.3	6186607	223326	27.7
22 IRON AND STEEL	22	65	3.0	15751510	210931	74.7
23 NON-FERROUS METALS AND PRODUCTS	17	55	3.2	6847263	136256	50.3
24 FABRICATED METAL PRODUCTS	33	127	3.8	11383456	488184	23.3
25 GENERAL-PURPOSE MACHINERY	19	97	5.1	9604354	301692	31.8
26 PRODUCTION MACHINERY	26	127	4.9	11389401	474074	24.0
27 BUSINESS ORIENTED MACHINERY	23	84	3.7	6951459	206822	33.6
28 ELECTRONIC PARTS, DEVICES AND ELECTRONIC CIRCUITS	15	68	4.5	14819858	453435	32.7
29 ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES	23	111	4.8	13485422	453686	29.7
30 INFORMATION AND COMMUNICAION ELECTRONICS EQUIPMET	15	55	3.7	11427859	214300	53.3
31 TRANSPORTATION EQUIPMENT	16	66	4.1	46946916	923495	50.8
32 MISCELLANEOUS MANUFACTURING INDUSTRIES	32	114	3.6	3521578	132655	26.5

Note) We calculate these values of report by industry of the 2009 census.

Table 3-1

Dependent variable: Δ number of products

	All firms	All firms	All firms	All firms	All firms	All firms	All firms
GNSTFP(t-1)	0.021 ***			0.008	0.021 ***		0.008
	3.03			1.08	3.12		1.13
lnFD(t-1)		0.016 ***		0.016 ***		0.017 ***	0.016 ***
		8.18		7.67		8.31	7.79
lnG(t-1)			0.000		0.000	0.000	0.000
			-0.13		0.11	-0.02	0.06
Num of Products(t-1)	-0.972 ***	-0.972 ***	-0.970 ***	-0.972 ***	-0.970 ***	-0.970 ***	-0.970 ***
	-1259.60	-1259.63	-1256.51	-1259.58	-1256.43	-1256.48	-1256.41
constant	1.673 ***	1.450 ***	1.673 ***	1.456 ***	1.669 ***	1.443 ***	1.449 ***
	1343.35	78.48	1291.76	77.21	1066.76	77.46	76.28
N	1947121	1947121	1946761	1947121	1946761	1946761	1946761
N_g	310357	310357	310315	310357	310315	310315	310315
r2_w	0.492	0.492	0.491	0.492	0.491	0.491	0.491
r2_b	0.007	0.007	0.007	0.007	0.007	0.007	0.007
r2_o	0.050	0.050	0.050	0.050	0.050	0.050	0.050
F	793357.80	793345.90	789479.80	528890.50	526301.20	526294.80	394717.20
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Panel Fixed Firm-level Estimations with AR(1)

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 3-2

Dependent variable: Δ number of products =(N(t)-N(t-1)/(N(T)+N(t-1))/2

	All firms	All firms	All firms	All firms	All firms	All firms	All firms
GNSTFP(t-1)	0.004 *			-0.001	0.004		-0.002
	1.67			-0.55	1.57		-0.63
lnFD(t-1)		0.006 ***		0.006 ***		0.006 ***	0.006 ***
		6.85		6.66		6.85	6.70
lnG(t-1)			0.000		0.000	0.000	0.000
			-1.34		-1.16	-0.90	-0.96
Num of Products(t-1)	-0.240 ***	-0.240 ***	-0.241 ***	-0.240 ***	-0.241 ***	-0.241 ***	-0.241 ***
	-766.92	-766.99	-768.91	-766.96	-768.87	-768.94	-768.90
constant	0.413 ***	0.327 ***	0.416 ***	0.325 ***	0.415 ***	0.329 ***	0.327 ***
	601.86	26.99	567.63	25.68	473.78	27.01	25.76
N	1947121	1947121	1946761	1947121	1946761	1946761	1946761
N_g	310357	310357	310315	310357	310315	310315	310315
r2_w	0.264	0.264	0.265	0.264	0.265	0.265	0.265
r2_b	0.002	0.002	0.002	0.002	0.002	0.002	0.002
r2_o	0.036	0.036	0.036	0.036	0.036	0.036	0.036
F	294112.80	294139.50	295640.40	196093.70	197095.30	197113.40	147835.60
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Panel Fixed Firm-level Estimations with AR(1)

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 3-3

Dependent variable: Δ number of products

	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters
GNSTFP(t-1)	0.074			−0.221 **	0.092		−0.208 **
	0.87			−2.55	1.07		−2.40
lnFD(t-1)		0.175 ***		0.182 ***		0.173 ***	0.180 ***
		15.21		15.40		14.95	15.11
lnG(t-1)			0.012 ***		0.012 ***	0.007 *	0.006 *
			3.39		3.45	1.93	1.73
Num of Products(t-1)	−1.041 ***	−1.049 ***	−1.042 ***	−1.050 ***	−1.042 ***	−1.050 ***	−1.050 ***
	−161.35	−162.72	−161.40	−162.76	−161.37	−162.71	−162.74
constant	2.930 ***	0.506 ***	2.884 ***	0.475 ***	2.857 ***	0.498 ***	0.470 ***
	141.35	4.66	154.31	4.36	113.92	4.58	4.31
N	31780	31780	31780	31780	31780	31780	31780
N_g	8559	8559	8559	8559	8559	8559	8559
r2_w	0.529	0.533	0.529	0.533	0.529	0.533	0.533
r2_b	0.090	0.090	0.090	0.090	0.090	0.090	0.090
r2_o	0.058	0.058	0.058	0.058	0.058	0.058	0.058
F	13018.00	13239.50	13029.40	8830.70	8684.00	8828.00	6623.80
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Panel Fixed Firm-level Estimations with AR1

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 3-4

Dependent variable: Δ number of products =(N(t)-N(t-1)/(N(T)+N(t-1))/2

	Exporters		Exporters		Exporters		Exporters		Exporters		Exporters		Exporters	
GNSTFP(t-1)	-0.036	*					-0.030		-0.028				-0.024	
	-1.76						-1.40		-1.38				-1.12	
lnFD(t-1)					0.003	***			0.003	***	0.003	***	0.003	***
					3.87				3.72		3.77		3.67	
lnG(t-1)			-0.011				-0.007				-0.008		-0.005	
			-1.40				-0.90				-1.05		-0.67	
Num of Products(t-1)	-0.136	***	-0.136	***	-0.136	***	-0.136	***	-0.136	***	-0.136	***	-0.136	***
	-82.01		-81.95		-82.13		-81.96		-82.12		-82.08		-82.08	
constant	0.392	***	0.533	***	0.363	***	0.493	***	0.372	***	0.477	***	0.446	***
	56.55		5.31		55.45		4.74		42.78		4.72		4.27	
N	31780		31780		31780		31780		31780		31780		31780	
N_g	8559		8559		8559		8559		8559		8559		8559	
r2_w	0.225		0.224		0.225		0.224		0.225		0.225		0.225	
r2_b	0.006		0.006		0.006		0.006		0.006		0.006		0.006	
r2_o	0.016		0.016		0.016		0.016		0.016		0.016		0.016	
F	3362.50		3358.60		3372.60		2239.80		2248.10		2246.00		1684.80	
p	0.00		0.00		0.00		0.00		0.00		0.00		0.00	

Panel Fixed Firm-level Estimations with AR1

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 3-5

Dependent variable: Δ number of products

	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters
GNSTFP(t-1)	0.119			0.023	0.132		0.037
	1.18			0.21	1.30		0.34
lnREER(t-1)	0.503 ***	0.402 ***	0.494 ***	0.405 ***	0.497 ***	0.395 ***	0.401 ***
	11.74	7.08	11.48	6.82	11.54	6.95	6.74
lnFD(t-1)		0.053 ***		0.051 **		0.053 ***	0.050 **
		2.63		2.36		2.63	2.31
lnG(t-1)			0.005		0.006	0.005	0.005
			1.34		1.45	1.36	1.38
Num of Products(t-1)	-1.049 ***	-1.050 ***	-1.050 ***	-1.050 ***	-1.050 ***	-1.050 ***	-1.050 ***
	-148.84	-148.81	-148.75	-148.80	-148.77	-148.75	-148.74
constant	0.682 ***	0.436 ***	0.726 ***	0.437 ***	0.675 ***	0.432 ***	0.433 ***
	4.85	2.74	5.26	2.74	4.79	2.71	2.72
N	25837	25837	25837	25837	25837	25837	25837
N_g	7439	7439	7439	7439	7439	7439	7439
r2_w	0.546	0.546	0.546	0.546	0.546	0.546	0.546
r2_b	0.087	0.087	0.087	0.087	0.087	0.087	0.087
r2_o	0.059	0.059	0.059	0.059	0.059	0.059	0.059
F	7385.20	7384.40	7383.70	5537.70	5538.70	5538.90	4430.60
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Panel Fixed Firm-level Estimations with AR1

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 3-6

Dependent variable: Δ number of products =(N(t)-N(t-1)/(N(T)+N(t-1))/2

	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters
GNSTFP(t-1)	0.013			0.022	0.021		0.029
	0.48			0.81	0.79		1.04
lnREER(t-1)	0.039 **	0.030 *	0.033 *	0.034 *	0.038 **	0.029	0.034 *
	2.17	1.67	1.96	1.83	2.11	1.60	1.81
lnFD(t-1)		-0.010		-0.012		-0.008	-0.010
		-1.07		-1.25		-0.82	-1.07
lnG(t-1)			0.003 ***		0.003 ***	0.003 ***	0.003 ***
			2.72		2.79	2.63	2.71
Num of Products(t-1)	-0.140 ***	-0.140 ***	-0.140 ***	-0.140 ***	-0.140 ***	-0.140 ***	-0.140 ***
	-75.53	-75.53	-75.60	-75.52	-75.59	-75.59	-75.58
constant	0.216 ***	0.399 **	0.231 ***	0.405 **	0.203 **	0.358 **	0.365 **
	2.74	2.49	3.21	2.52	2.58	2.23	2.27
N	25837	25837	25837	25837	25837	25837	25837
N_g	7439	7439	7439	7439	7439	7439	7439
r2_w	0.237	0.237	0.237	0.237	0.237	0.237	0.237
r2_b	0.006	0.006	0.006	0.006	0.006	0.006	0.006
r2_o	0.016	0.016	0.016	0.016	0.016	0.016	0.016
F	1902.40	1902.50	1905.60	1427.00	1429.30	1429.20	1143.60
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Panel Fixed Firm-level Estimations with AR1

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.

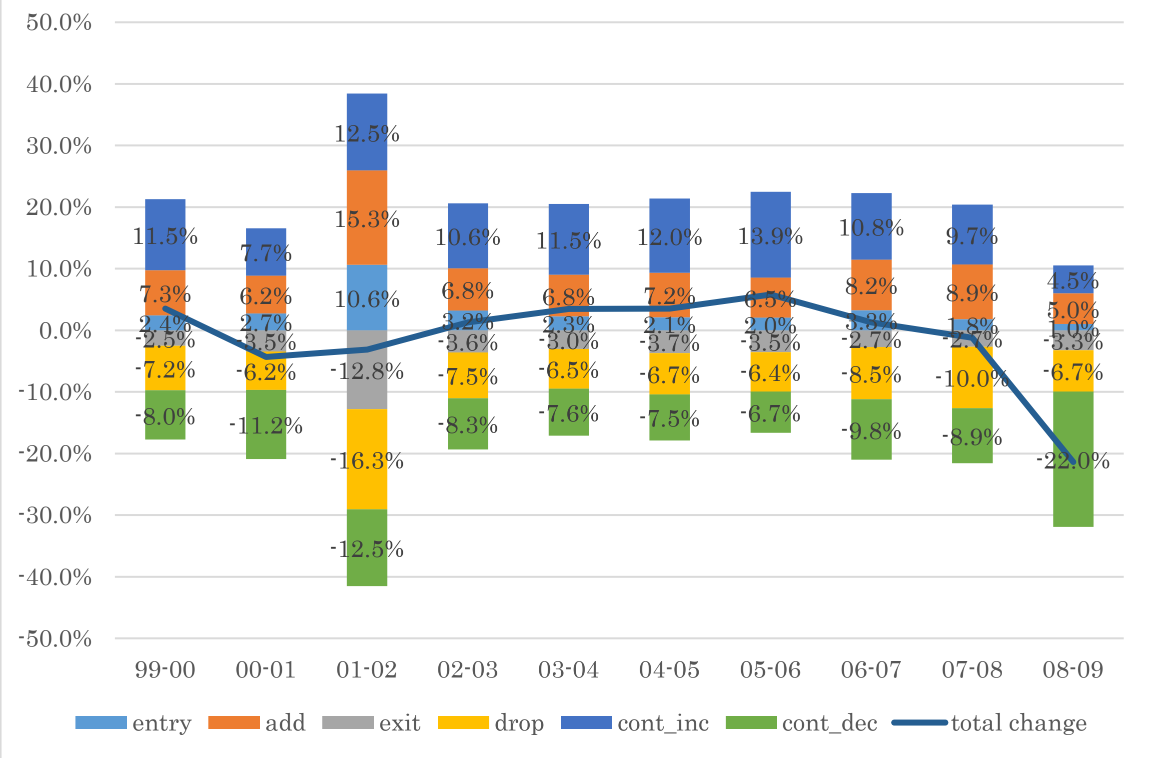


Figure 1-1. Decomposition of shipment changes

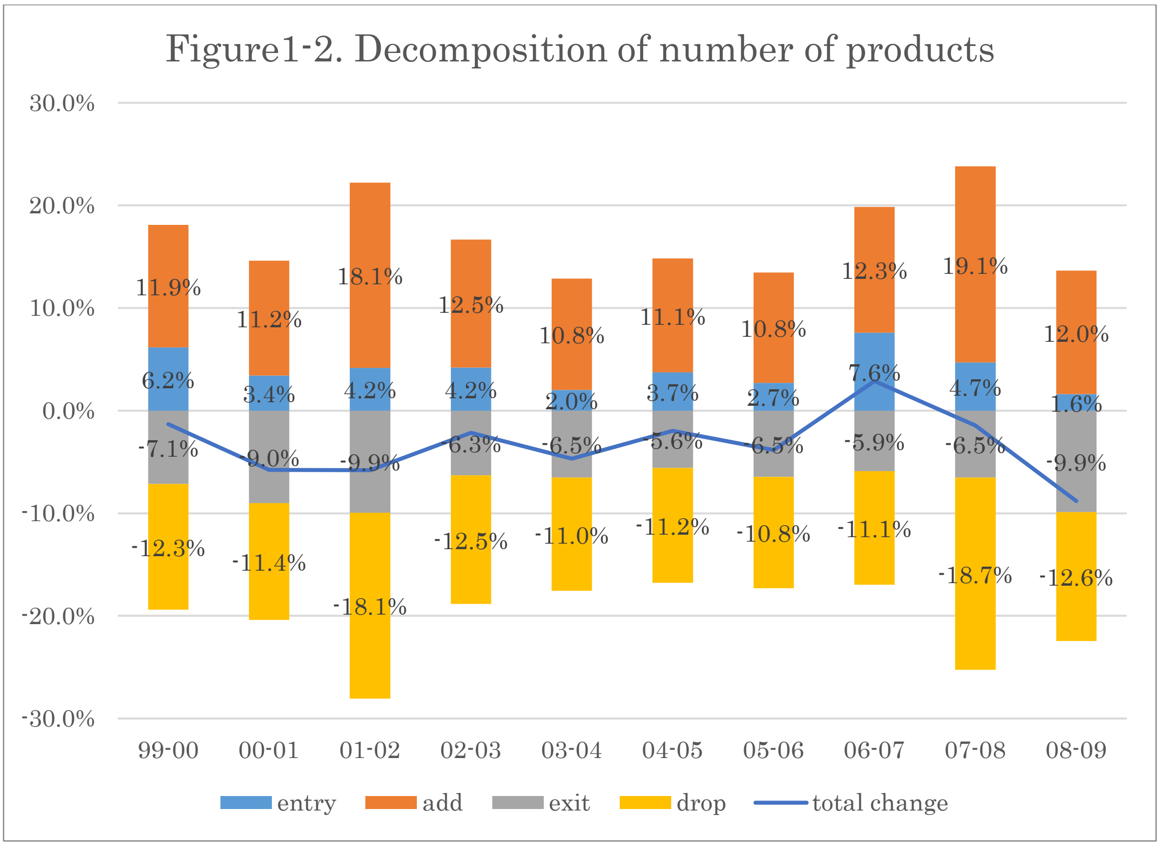
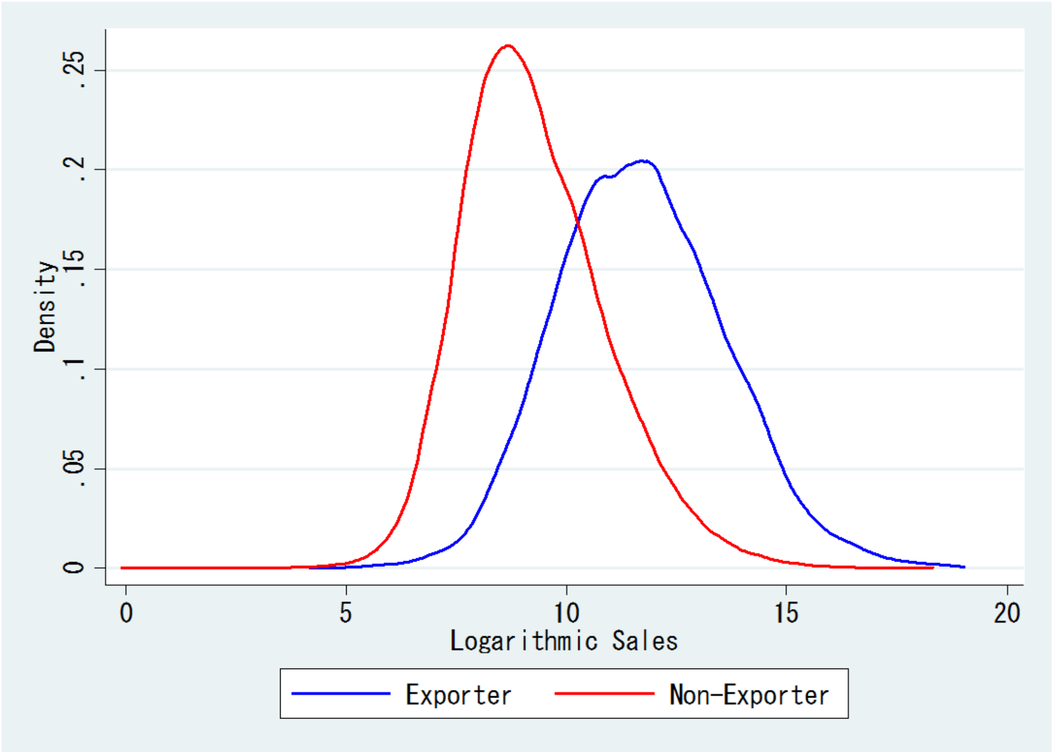


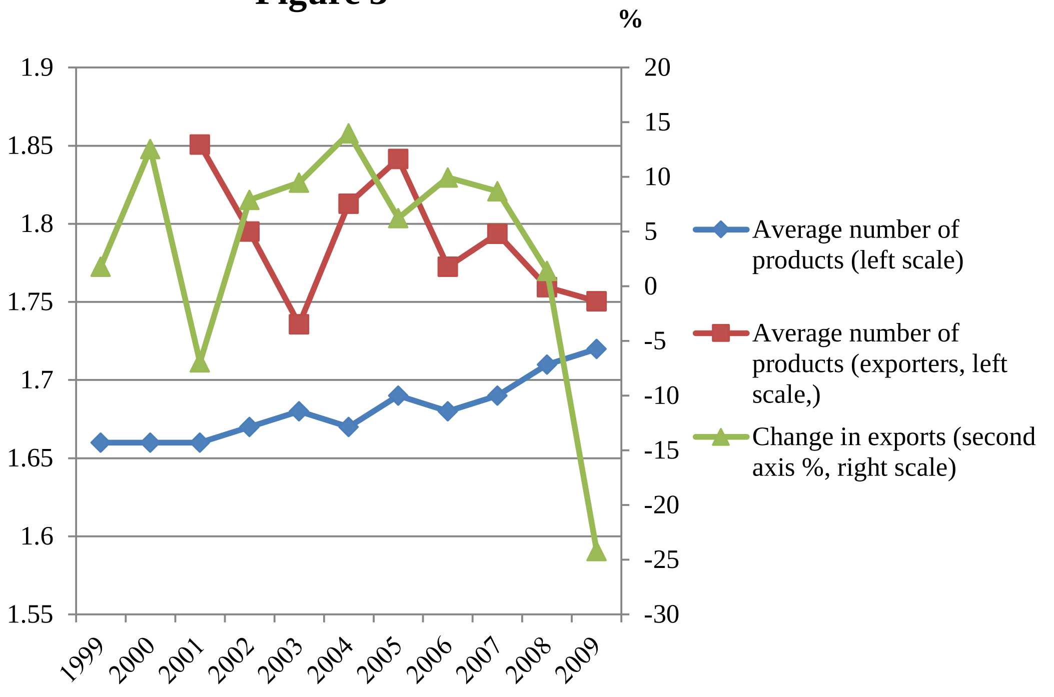
Figure1-2. Decomposition of number of products
30.0%
20.0%
10.0%
0.0%
-10.0%
-20.0%
-30.0%
11.9%
6.2%
-7.1%
-12.3%
11.2%
3.4%
-9.0%
-11.4%
18.1%
4.2%
-9.9%
-18.1%
12.5%
4.2%
-6.3%
-12.5%
10.8%
2.0%
-6.5%
-11.0%
11.1%
3.7%
-5.6%
-11.2%
10.8%
2.7%
-6.5%
-10.8%
12.3%
7.6%
-5.9%
-11.1%
19.1%
4.7%
-6.5%
-18.7%
12.0%
1.6%
-9.9%
-12.6%
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
entry
add
exit
drop
total change

Figure 2



Density
0
.05
.1
.15
.2
.25
0
5
10
15
20
Logarithmic Sales
Exporter
Non-Exporter

Figure 3


%
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Average number of products (left scale)
Average number of products (exporters, left scale,)
Change in exports (second axis %, right scale)

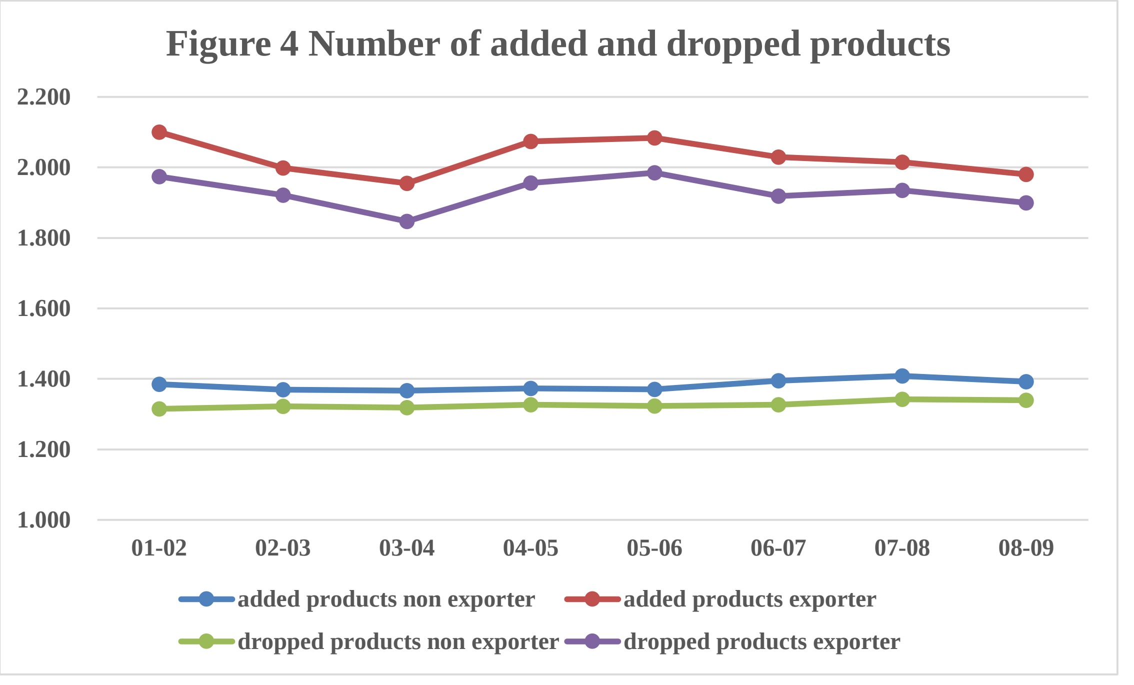
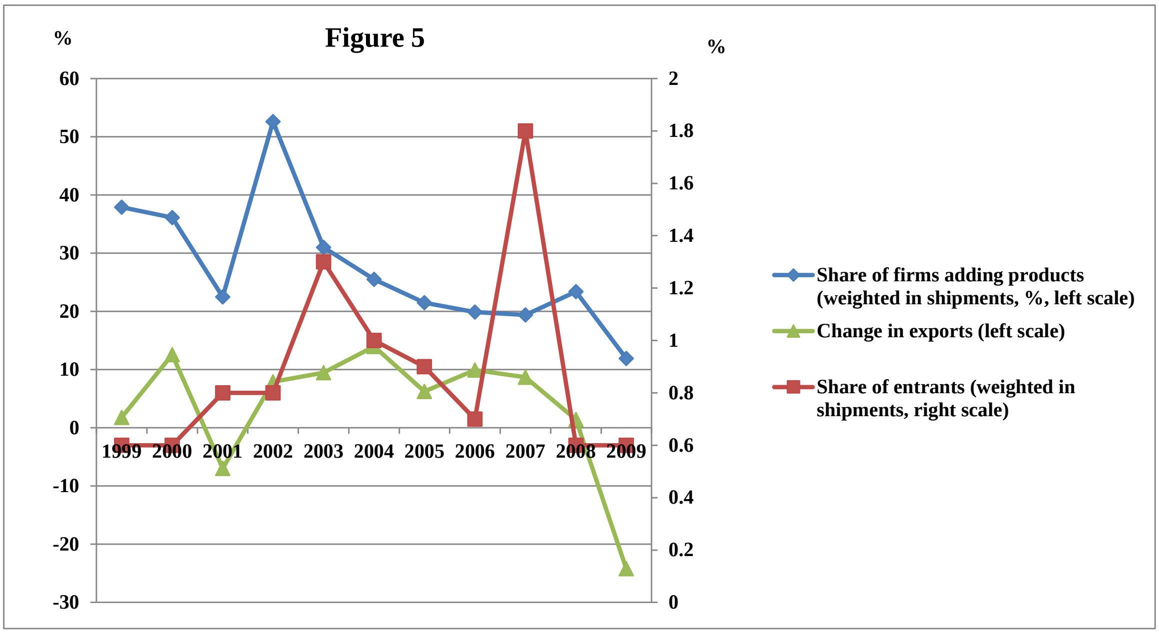


Figure 4 Number of added and dropped products
2.200
2.000
1.800
1.600
1.400
1.200
1.000
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
added products non exporter
added products exporter
dropped products non exporter
dropped products exporter



%
Figure 5
%
60
50
40
30
20
10
0
-10
-20
-30
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Share of firms adding products (weighted in shipments, %, left scale)
Change in exports (left scale)
Share of entrants (weighted in shipments, right scale)