The Impacts of Demand and Productivity Shocks on Product Dynamics: Evidence from Japanese Product and Firm Level Data[1]

This version: March 2026

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, Hidehiko Matsumoto, Naohito Abe and Young Hoo Lee andconference participants at USC, the NBER-Japan Project 2016, Stanford-Juku 2016, ABFER 2016, CAED 2017, Hitotsubashi University, Keio University, Gakushuin University, APEA 2018 conference, Bank of Japan, the Japan Economic Association 2024 Spring Meeting and the IJEE Special Conference held in January, 2026 for helpful comments on an earlier draft. We also thank Takayuki Ishikawa for 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, No. 18H00852 and 22KK0021 and 23K01381) of Japan and the U.S. National Science Foundation.

ABSTRACT

How do the adding of new products and the dropping of old products by incumbent firms interact with aggregate economic activities over the business cycle? This paper empirically examines the effects of demand and supply shocks on product dynamics by constructing an unique firm-product data set from the Japanese Census of Manufactures. The data are available annually and are more disaggregated than comparable US data, showing that product adding and dropping by incumbent firms contributes to fluctuations of aggregate shipments much more than firm entry and exit.

Extending the Dekle, Jeong and Kiyotaki (2015) model, we regress the gross adding rate of new products of individual firms on aggregate shocks to find that shocks that increase foreign demand have positive effects on the gross adding rate of new products. The expansionary foreign demand shocks also increase the gross dropping rate, implying creative destruction. We also find that liquidity facilitates gross product creations for firms with high TFP. Our empirical results shed light on the propagation mechanism of aggregate shocks on the business cycle through intangible capital accumulation of individual firms in the medium run.

Keywords: Product adding and dropping, Firm entry and exit, TFP, Foreign demand, Government expenditures, Business cycle propagation.

JEL classification numbers: E22, E23, E32, O33, O47

1. Introduction

How do the adding of new products and the dropping of old products by incumbent firms interact with aggregate shocks over the business cycle? Traditional general equilibrium models with heterogeneous firms emphasize that the entry of new firms and the exit of low productivity firms enhance total factor productivity (TFP) in the aggregate economy (Hopenhayn (1992), Melitz (2003)). There is a growing literature that investigates how endogenous R&D, technology adoption, and firm entry and exit interact with aggregate production over the business cycle, including Comin and Gertler (2006), Bilbie, Ghironi and Melitz (2012), Anzoategui, Comin, Gertler and Martinez (2019), Moran and Queralto (2018), Bianchi, et. al. (2019), and Fornaro and Wolf (2020).

In this paper, we focus on the under-studied phenomenon of the adding and dropping of products by incumbent firms over the business cycle. For this purpose, we first construct firm-product level data from the Japanese Census of Manufactures from 1999 to 2010. The Japanese Census of Manufactures is unique in that the value of shipments can be obtained down to the six-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 over the business cycle. Products can be aggregated into establishments (plants), and plants can be matched to firm using firm identifiers[2].

---

[2] In U.S. Census data, the usual product level data are only available at the 5-digit level and at five-year intervals (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

Figure 1 decomposes the movement of total shipments of Japanese manufacturing from 1999 to 2010 into six 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. From Figure 1, we learn that the contributions of product adding or dropping to the total shipment change are much larger than the contributions of entry and exit of firms. Between 1999 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 of 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 stock bubble, while the second recession from 2008 to 2009 was the Global Financial Crisis. We see that during both recessions, manufacturing shipments declined (solid line). These declines in total shipments were driven by large decreases over increases in the shipments of continuing products, the significant dropping over adding of products by incumbents, and exits over entries of firms. Notice that, even during downturns, many firms added products, expanded the shipment of continuing products, or newly entered. Figure 1 shows the highly active gross shipment

---

by Nakamura and Steinsson (2012) are available at a higher frequency, they need to be matched to firm level accounting data at the annual frequency before performing the empirical work that we do here.

movements at the product level in both the intensive and extensive margins.

To investigate the relationship between product dynamics and business cycles, we extend the dynamic general equilibrium model of multi-product firms of Dekle, Jeong and Kiyotaki (2015) (referred as DJK (2015) hereafter). Firms are heterogeneous, facing recurrent firm-product specific shocks and aggregate shocks. In addition to endogenous product innovations by new and incumbent firms, incumbent firms have an opportunity to add a new product as a by-product of present production. These product innovations may add to the available variety or replace the existing products. Besides the endogenous product dropping by replacement, there is also an exogenous dropping of existing products. Each firm chooses whether and how much to produce each product in domestic and export markets. Although each firm starts with a single product with new entry, each firm may have multiple products as a result of the history of innovation and spinouts which may outweigh the dropping of the existing products. The DJK model exhibits that shocks to TFP, foreign demand and government purchases have persistence effect on aggregate production, because the number of products is a measure of intangible capital. Intangible capital spins out new products even without explicit innovation (new ideas beget more new ideas), which leads to further increases in output, both at the firm and at the aggregate levels.

As a step towards understanding the interaction between dynamics of firms, products and aggregate production, we examine empirically the effects of aggregate supply and demand shocks on the gross adding rate and gross dropping rate of individual firm using our newly constructed data. Here, the gross adding rate is the ratio of new products added to the number of existing products during the year, while the gross dropping rate is the ratio of the old products discontinued to the existing products. The reason we focus on product dynamics instead of the shipment of continuing products is that we expect product dynamics to be key for understanding the persistent impact of shocks on aggregate production through intangible capital accumulation.

Specifically, we regress the gross adding rate or the gross dropping rate of individual firms on the expected level of foreign demand, government expenditures and TFP at the 2-digit product-level sector, (conditional on the information of the previous year), using Tobit estimations. The results are broadly consistent with the prediction of the DJK model. The positive shocks to the expected values of foreign demand at the sector level have significant expansionary effects on the gross adding rate of products at the firm level. The impact of government expenditures depends on the estimation method. We find significant effects of government expenditures on gross adding behavior in the case of the random effects model. These effects are weaker in the control function approach. Although firm-level TFP does not have positive effects on the gross adding rate, the cross term between firm-level TFP and the ratio of cash flow to total assets show positive and significant signs. This suggests that high productivity firms add products only when they have enough liquidity perhaps because they could not depend much on the financial institutions due to the financial crisis since 1997 in Japan. Although expected sector-level TFP has mixed effects on the gross adding rate of the products of firms, it is consistent with the DJK model because increasing TFP raises the cost of production as well as expands the market size. From these estimates, we learn that expansionary shocks to foreign demand can raise aggregate output persistently through the effects of adding new products. Concerning the gross dropping rate of old products, expansionary foreign demand shocks tend to increase the gross dropping rate. These results imply strong replacement effects by product adding, suggesting creative destruction.

Besides the literature cited above, our paper is related to the literature of multi-product firms and economic growth. 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. Aghion et. al. (1992), Bernard, Redding, and Schott (2010), and Garcia-Macia, Hsieh, and Klenow (2019) have also shown that the product dynamics by incumbents is a major source of productivity movements over the medium and long runs[3],[4].

---

[3] Hsieh and Klenow (2015) and Garcia-Macia, et. al. (2019) develop models to relate product turnovers to job turnovers and use plant-level data of job flows from the US Longitudinal database to infer new products, since they do not have product level data.

[4] Following the seminal paper of Klette and Kortum (2004), Peters and Walsh (2024) examine how population growth rate affects the innovation rate, firm dynamics and aggregate growth in the steady state. Argente, Lee and Moreira (2024) use the detailed scanner data from Nielsen's Retail Measurement Service and the matched firm level data from GS1 US to examine the life cycle of products and firms and then develop a growth model with multi-product firms to explain these life-cycle observations. Using French firm data, Berlingieri et al. (2025) show the possibility that even the single product firms generate many new products. Although these frameworks are richer in describing firm and product dynamics than DJK model, their analysis focus on the steady state of the aggregate economy, not suited for business cycle analysis, which is the focus of this paper.

Our paper is organized as follows. In the next section, we will motivate our empirical specifications by extending the DJK model. In Section 3, we explain the construction of our product-firm level dataset and sector-level foreign demand, government expenditures, and TFP. In Section 4, we use our data set to provide an overview of product dynamics in Japanese manufacturing firms. In Section 5, we present our empirical specifications. In Section 6, we show our estimates on the effects of shocks of sector-level foreign demand, government spending and TFP on the dynamics of products at the firm level.

2. Product Dynamics and Macroeconomic Shocks

DJK (2015) construct a dynamic general equilibrium model of a small open economy with a rich production structure. Here we summarize and extend key features of the model relevant for estimating the relationship between aggregate shocks and product dynamics.

2-1 Model.

When a new firm or a new product line of an incumbent firm pays a sunk cost κ_{Et} to innovate, it creates a new differentiated product with probability λ, or replaces an existing product with probability 1-λ. Sunk cost is an increasing function of the aggregate measure of product innovations N_{Et} as such,

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

Increasing marginal cost of product innovations reflects the limited supply of human and physical capital for innovations over the business cycle. 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:

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

Each differentiated good j is produced from labor l_{jt} and imported materials m_{jt} for home and foreign markets.

$$q_{jt}^{H} = a_{jt} Z_t \left(l_{jt}^{H}\right)^{\gamma} \left(m_{jt}^{H}\right)^{1-\gamma}$$

$$q_{jt}^{F} = a_{jt} Z_t \left[\left(l_{jt}^{F}\right)^{\gamma} \left(m_{jt}^{F}\right)^{1-\gamma} - \phi\right]$$

where Z_t is aggregate productivity and ϕ is the fixed cost for export. Final goods for home and foreign markets are produced from differentiated goods as

$$Q_t^H = \left[\int_{j \in H_t} \left(q_{jt}^{H}\right)^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}}, \qquad Q_t^F = \left[\int_{j \in F_t} \left(q_{jt}^{F}\right)^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}}$$

where $\theta > 1,$ and H_t and F_t are the sets of differentiated goods produced for home and foreign markets.

2-1-1 Gross Adding and Dropping Rates of Products

The firm with production opportunity must pay a fixed cost κ 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

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

The productivity of the next period will be 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 existing 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, and its productivity is drawn from the same Pareto distribution as the new product. Although each firm starts with a single product, the firm may acquire multiple products through innovations and spinouts which may outweigh the dropping of products. An exiting firm is defined as a firm that drops from one or more products to zero products.

Define the aggregate innovation rate as $e_t = \frac{N_{Et}}{N_{t-1}}$, where N_{t-1} is the total number of existing products in the economy at the *end* of period t-1 or at the *beginning* of period t. In our model, each existing product adds a product with innovation done by incumbent firms as well as a spinout. We assume that a constant fraction ω of innovation is done by incumbents and a fraction $1 - \omega$ by new entrants. We assume that the adding of products is iid. across existing products. Then the expected rate of adding new products per existing products equals:

$$u_t = \omega e_t + \nu. \qquad (1)$$

The first term in the right-hand-side (RHS) is a fraction ω of the innovation rate e_t per number of products done by incumbents and the second term is the spinout rate. In our model, we call u_t the expected gross adding rate of new products.

Any existing product is destroyed either exogenously with rate δ or endogenously with the replacement by the innovation and spinout of the other firms. We assume the fixed cost of producing each differentiated product κ is small enough for the product with the lowest productivity to continue. Thus, we abstract the voluntary discontinuation of existing products. We admit this is a serious limitation of the DJK model, even though it greatly facilitates the aggregation. We assume product dropping is iid. across all existing products, irrespective of the productivity of products. The expected rate of dropping per number of existing products is the sum of the probabilities of the exogenous destruction and the endogenous replacement of products by innovation and spinouts:

$$d_t = \delta + (1-\lambda)(e_t + \nu). \qquad (2)$$

The second term in the RHS says that the dropping rate due to replacement equals the probability of replacing existing products (1-λ) times the rate of innovation and spinouts per number of existing products. From this, we learn that if there are favorable aggregate shocks (such as the increase in foreign demand and government expenditures) which stimulates the aggregate innovation rate e_t, both the expected gross adding rate and gross dropping rate increase due to creative destruction.

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

$$N_t = N_{t-1} + \lambda N_{Et} + \lambda \nu N_{t-1} - \delta N_{t-1}. \qquad (3)$$

Product innovations and spinouts which replace existing products (with probability 1-λ) do not change the total number of products. Comparing equations (1), (2) and (3), the gross rates of adding and dropping of products at the individual firm level are higher than at the aggregate level due to replacement. Since the productivity of the final goods sector is an increasing function of the total number of differentiated products N_{t-1} (in addition to the TFP), we can think of N_{t-1} as a measure of aggregate intangible capital at the beginning of period t.

2-1-2 Effects of Aggregate Shocks on Product Dynamics of Individual Firms

In the home final goods market, final goods produced equals demand –the sum of consumption, government spending, and the gross investment on intangible capital (the maintenance and product innovations) as

$$Q_t^H = C_t + G_t + \kappa N_{t-1} + \kappa_{Et} N_{Et}.$$

In the export market, the production by home producers equals the foreigner's demand for home exportable:

$$Q_t^F = (\varepsilon_t)^{\varphi} Y_t^*.$$

Foreign demand is an increasing function of the real exchange rate ε_t (relative price of foreign produced and home-produced final goods) and foreign income Y_t^* (which is taken as exogenous). For our small open economy, the supply of net foreign assets D_t^* is the cumulative current account surplus. The demand for net foreign assets is an increasing function of the gap between the expected rate of return on foreign bonds and home bonds and the transaction demand (which depend upon final goods consumption and liquidity preferences).

The exogenous shocks to aggregate productivity, government expenditures, foreign demand and the liquidity preference for net foreign assets together with the endogenous state variables (N_{t-1}, D^*_{t-1}) recursively determine the firm-product dynamics and the aggregate variables (which include $N_{Et}, N_{t,}$ aggregate output, employment, consumption, exports, imports, net foreign assets, and the real exchange rate) in general equilibrium. Since the calibration is described in DJK (2015), we do not repeat the quantitative analysis of the model here.

Here we briefly describe the qualitative features of the equilibrium. When demand for final goods expands with an increase in foreign demand or government expenditures, we can show that the real exchange rate appreciates and imported input becomes cheaper in terms of home final goods. This raises value-added productivity, the real wage rate, aggregate output and the expected profitability of each differentiated product. This encourages product innovations by entrants and incumbents, raising both the gross adding rate and gross dropping rate of products, which further expands aggregate production through intangible capital accumulation over time (if the impact on the gross adding rate is larger). When aggregate TFP rises exogenously, aggregate output and consumption expand, which tends to improve the profitability of differentiated products. At the same time, the real exchange rate depreciates, and the real wage rate rises, which tends to worsen profitability. Although the rise in TFP increases the output of existing products at an intensive margin, the effect on the product adding rate and dropping rate at the extensive margin is ambiguous.

2-2. Including Sector-Level Aggregate Variables and Firm TFP

In the estimation, aggregate shocks that affect the dynamics of firm-products are included at the sector level (two-digit product level) to increase the cross-section variation and the precision of the estimates. Let Y_{kt}^{*}、 $G_{kt}, , and$ Z_{kt} be sector level foreign demand, government spending, and productivity for sector k (such as electronic machinery). In DJK (2015), shocks to foreign demand, aggregate government spending, and aggregate TFP are modelled as AR(1) processes[5]. In our estimation below, we use expected values of these sector level variables as explanatory variables to explain the product gross adding and dropping of individual firms.

The specification (1) and (2) above are deliberately stylized. This stylized structure facilitates integrating heterogeneous firms with product innovations into a standard stochastic business cycle model. In reality, other variables would influence the product evolution process at the firm level.

In growth models such as Acemoglu, Akcigit, and Kerr (2016), 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 extend DJK to assume that the product innovation rate done by each firm depends on the TFP of that firm as,

---

[5] 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) develop a standard multisectoral neoclassical growth model and show 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 of industry k, and β_k is the matrix of coefficients that reflects how the vector of aggregate shocks S_t affect industry k's output.

$$\omega_{it} = \omega(TFP_{it}), \quad \omega'(\cdot) > 0. \qquad (4).$$

By this assumption, the adding rate in equation (1) is affected not only by aggregate variables but also by firm-level TFP. While this specification of 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 add more products at the business cycle frequency[6].

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

We construct our firm-product data using the Census of Manufactures conducted by the Japanese Ministry of Economy, Trade and Industry. The Census is a survey of all establishments (plants) in Japan in principle. The data is now available annually in the format that we require for 1999-2010[7]. Because we can collect product and establishment level Census data for every year in Japan, this is more conducive to

---

[6] 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).

[7] Although the product classifications changed three times (1999, 2002 and 2008) in the sample period, we construct time-consistent product classifications during our estimation period as Pierce and Schott (2012) suggested. We explain how to construct these classifications in Appendix 1. The statistical Office of Japan substituted the Census of Manufacture by the Economic Census during 2012 and 2016. Although we obtained the data of the Economic Census, we could not link this data to the data obtained until 2010, because there were many gaps between the Census of Manufacture and the Economic Census. Thus, our analysis focuses on the product dynamics in the 2000s.

analysis at the business cycle frequency, where peaks to troughs can occur within 2 years. We examine versions of the Census that surveys establishments with at least four workers since the data covering establishments with fewer than four are not made publicly available. In 2006, 258,543 establishments had four or more employees, representing over 47 percent of all Japanese manufacturing establishments.

We define "Products" as goods at the six-digit product classification level in the Japanese Census of Manufacture, "Industries" as goods at the four-digit product classification level, and "Sectors" as goods at the two-digit level of product classification. In the data, each establishment reports the accounting information, such as the values 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[8]. For example, sector classification number 27 indicates the business-oriented machinery sector. Industry classification number 2741 shows the industry that produces medical and hospital instruments and parts. This medical and hospital instruments and parts are divided into four categories.

(Insert Table 1 here)

Given that decisions on the adding and dropping of products are made at the firm

---

[8] Note that what we call "products" is a much broader category than in scanner-type data. For example, in our data, a box of cereal and a bag of rice crackers are the same product, while they are different in scanner data. 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. Broda and Weinstein (2006) and Hur and Kwak (2026) examine product churning from the consumption side.

level instead of the establishment level, we need to identify the "firm." One problem with the Japanese Census data is that it does not record a firm-level identifier that would allow the grouping of establishments into firms. Bernard and Okubo (2013, 2015) and 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 method, we aggregate establishment-level data into firm-level data.

Stylized facts of the Census data regarding multiple product firms are documented in Kawakami and Miyagawa (2013). According to their paper, in the Japanese Census, the share of multiple product firms in the total firms is about 40 percent, and the average multiple-product firm in Japan produces about three products (i.e., three different the six-digit JSIC level products). While multiple product firms represent a minority, they account for 78 percent of total shipments by Japanese firms. In multiple product firms, average shipments are 50 percent higher, employment is 28 percent higher, and shipments per worker are 30 percent higher than single-product firms.

For our empirical analysis, we need to construct aggregated variables using both the Census of Manufacture and other, mostly sector level data. We construct sector level foreign demands, Y^*_{kt}, by obtaining the export data in the Input-Output Tables in the Japan Industrial Productivity Database (JIP database). Sector level government expenditures, G_{kt}, are also obtained from the JIP database and the Japanese SNA[9]. We allocate the

---

[9] 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 the EUKLEMS database. The JIP database has several versions, and we 9use the data in the 2021 version in our paper.

aggregate capital formation by the government in the Japanese SNA into each industry using the input ratio of each industry in the total inputs in the civil engineering and construction industries in the JIP database. As there are one hundred sectors in the JIP database, we convert these sector level variables into the two-digit level ones. The concordance table between the two-digit sector classification and the JIP industry classification is shown in Appendix 2.

Applying Good, Nadiri, and Sickles (1997) to the sector level, we measure sector level TFP, Z_{kt}, as follows[10]

$$\ln Z_{kt} = (lnQ_{kt} - \overline{lnQ_t}) - \sum_h \frac{1}{2}(s_{kt}^h + \overline{s_t^h})(lnX_{kt}^h - \overline{\ln X_t^h})$$

$$+ \textstyle\sum_{\tau=1}^{t}(\overline{lnQ_\tau} - \overline{lnQ_{\tau-1}}) - \sum_{\tau=1}^{t}\sum_h \frac{1}{2}(\overline{s_\tau^h} + \overline{s_{\tau-1}^h})(\overline{lnX_\tau^h} - \overline{\ln X_{\tau-1}^h}). \quad (5)$$

In Equation (5), Q_{kt} is output in two-digit sector *k*. X_{kt}^h represents a factor of production h and s_{kt}^h shows the share of the factor of production h in sector *k*, where h is labor, capital, or an intermediate input. $\overline{\ln A_t}$ is the log of the geometric average of A_{kt} across sectors, where A_{kt} is Q_{kt}, s_{kt}^h or X_{kt}^h.

Finally, in some specifications, we add firm-level productivity as another explanatory variable. To obtain the necessary information 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

---

[10] We use the JIP productivity data to obtain the 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 Sickles procedure corrects for this index number problem and allows for interindustry comparisons.

the establishments that the firm manages.[11] We estimate a production function developed by DeLoecker (2011) by the two-digit product classification. Using the estimated coefficients, we measure total factor productivity at the firm level, as described in Appendix 3.

In addition, we make a variable that represents liquidity constraints of a firm, because firms need liquidity for innovation when firms could not depend much on financial institutions especially after the financial crisis deepened in 1997. We choose the ratio of cash and deposit to total assets as a variable of liquidity. The data of this variable is obtained from Financial Statements Statistics of Corporations by industry.

4. Stylized Facts of Japanese Product Dynamics

Using firm-product level data as constructed above, here we provide an overview of product level dynamics in Japan. 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 trillion Japanese Yen worth of goods and has over a million workers.

(Insert Table 2 here)

According to Figure 2 (which follows Figure 1 explained in the Introduction), the average fraction of the contribution of new products added to the total gross increase in

---

[11] When a firm consists of multiple establishments and the headquarters is an independent establishment, the statistical office does not collect the data of this headquarters. Then, the estimated TFP at the firm level is measured by aggregating shipments, capital, and labor in the establishments that the firm owns as production facilities.

shipments during the period of 1999-2010 was 18.4 percent, and the contribution of new firm entry was 4.0 percent. Together 22.4 percent of the gross increase in shipments was the contribution of product innovations, accumulation of intangible capital. The remaining 77.6 percent was the contribution of increases in the shipments of continuing products by incumbents.

Similarly, the average fraction of the contribution of old products dropped was 21.0 percent, and the contribution of firm exit was 7.3 percent. Together 28.3 percent of the gross decrease of shipments was the contribution of the endogenous and exogenous depreciation of the available variety of products, while the remaining 71.7 percent was the contribution of decreases in the shipments of continuing products by incumbents.

Although the contribution of increases and decreases of shipments of continuing products is larger for the total shipment movements, we focus on the adding and dropping of products in the following, partly because they are relatively understudied due to data limitations and partly because they are key factors to understanding why demand and supply shocks have persistent impacts on aggregate output through the fluctuations of intangible capital. The logic is similar to why investment is important for understanding business cycles despite its share of GDP being smaller than consumption.

(Insert Figure 2 here)

Regardless of whether the economy is in a boom or a recession, there are a large number of products simultaneously added and dropped by incumbent firms – in addition to large simultaneous increases of shipment of some continuing products and decreases of shipment of the other continuing products. The contribution of firm entries and exits to gross shipment increases are small in magnitude. The net growth rate of products (products added minus dropped) by incumbent firms is cyclical, while net entry is not very cyclical. These observations argue for the importance of multiproduct firms for analyzing business cycles.

5. Empirical Specifications and Summary Statistics

5-1. **Empirical Specifications**

Let N_{it-1} be the number of the six-digit level products that firm i has at the beginning of year t, or the end of year t-1. To measure the gross adding rate of new products and the gross dropping rate of products during year t, we follow Davis, Haltiwanger and Schuh (1996)

$$Gadd_{it} = Gross\ adding\ rate = \frac{number\ of\ new\ products\ added\ by\ firm\ i\ during\ year\ t}{\frac{N_{it}+N_{it-1}}{2}},$$

$$Gdrop_{it} = Gross\ Dropping\ Rate = \frac{number\ of\ old\ products\ dropped\ by\ firm\ i\ during\ year\ t}{\frac{N_{it}+N_{it-1}}{2}}$$

Although Davis, Haltiwanger and Schuh (1996) define these to include the case of new entry $N_{it-1} = 0$, we focus on the product dynamics of incumbent firms in which both N_{it-1} and N_{it} are positive.

From equation (1), the expected gross additing rate of firm i depends upon the rate of innovation in sector k (which firm i belongs), e_{kt}. The innovation rate of sector k is a function of the expected value of foreign demand, government purchases, and TFP of sector k in period t conditional on period t-1 information as

$$e_{kt} = e(E_{t-1}(lnY^*_{kt}), E_{t-1}(lnG_{kt}), E_{t-1}(lnZ_{kt})) + \epsilon_{kt,} \qquad (6)$$

where $E_{t-1}(lnY^*_{kt})$, $E_{t-1}(lnG_{kt})$ and $E_{t-1}(lnZ_{kt})$ are the expected log levels of foreign demand, government purchases of sector k, and sector level TFPs measured by equation (5) of the year t conditional on year t-1 information, and ϵ_{kt} is the error term.

Here we consider that both incumbent and entrant firms choose their innovation rate during year t based on the expected value of the aggregate variables of year t, based on the information at the beginning of year t, or the end of year t-1. Assuming an AR1 process of the log of foreign demand, government purchase from sector k, and sector level TFP, we construct $E_{t-1}(lnY^*_{kt}), E_{t-1}(lnG_{kt})\ and\ E_{t-1}(lnZ_{kt})$.

5-1-1 Basic Estimation Specifications

Since there are many firms which do not change their product varieties, the dependent variables the (the gross adding and gross dropping rates) include many zeros. Therefore, we choose the Tobit model when we apply equation (1). Equation (7) is the specification for the regression when the dependent variable is the gross adding rate.

$$Gadd_{it} = \begin{pmatrix} Gadd^*_{it} & if\ Gadd^*_{it} > 0 \\ 0 & if\ Gadd^*_{it} \leq 0 \end{pmatrix}$$

$$Gadd^*_{it} = const. + a_1 E_{t-1}(\ln\ Y^*_{kt}) + a_2 E_{t-1}(lnG_{kt}) + a_3\ E_{t-1}(lnZ_{kt})$$

$$+\zeta_i + \mu_{it}, \qquad (7)$$

where ζ_i is the firm level random effect, and μ_{it} is the expectation error for the realization of the gross product adding rate during year t.

We expect a_1 and a_2 to be positive. The sign of a_3 is ambiguous, because the expected increase of sector level TFP expands the market and raises the innovation costs.

In the case of the gross dropping case, the empirical specification is

$$Gdrop_{it} = \begin{pmatrix} Gdrop_{it}^{*} & if\ Gdrop_{it}^{*} > 0 \\ 0 & if\ Gdrop_{it}^{*} \leq 0 \end{pmatrix}$$

$$Gdrop\ _{it}^{*} = const. + b_1 E_{t-1}(\ln\ Y_{kt}^{*}) + \ b_2 E_{t-1}(lnG_{kt}) + b_3 E_{t-1}(lnZ_{kt})$$

$$+\zeta_i + \mu_{it}, \quad (8)$$

From our theory, we expect that b_1 and b_2 are positive because expansionary demand shocks stimulate innovation and creative destruction. We expect the sign of b_3 to be ambiguous because rising costs tend to offset the market expansion effects of higher sectoral TFP.

5-1-2 Estimation to include Firm Level TFP.

When we consider that more productive firms are more active in product innovation as in equation (4), we need to include firm-level TFP as an explanatory variable for the gross adding rate. As shown in Appendix 3, the measurement of TFP of firm i, TFP_{it}, is based on the estimated parameters of the production function with multiple products which require a minimum investment in the capital stock. Thus, we restrict our sample to firms in which all establishments have more than 30 employees.[12] Because we

---

[12] When a firm consists of two establishments and one has 40 employees and the other has 15,

assume that firms choose their innovations during year t based on the expectation conditional at the beginning of year t, we include the expected value of firm i's TFP conditional on date t-1 information. With this in mind, we add firm level TFP to Equation (7).

$$Gadd_{it} = \begin{pmatrix} Gadd_{it}^{*} & if\ Gadd_{it}^{*} > 0 \\ 0 & if\ Gadd_{it}^{*} \leq 0 \end{pmatrix}$$

$$Gadd_{it}^{*} = const. + a_1 E_{t-1}(\ln Y_{kt}^{*}) + a_2 E_{t-1}(lnG_{kt}) + a_3\ E_{t-1}(lnZ_{kt})$$

$$+a_4 TFP_{it-1} + \zeta_i + \mu_{it} \qquad (9)$$

In equation (9), we expect that a_4 is positive because the product innovation rate of the individual firm is an increasing function of the expected value of TFP of that firm. Because we do not have a long time series of firm level TFP, we use the lagged value of firm level TFP as a proxy of its expected value as $\omega_{it} = \omega(TFP_{it-1}),\ \ \omega'(\cdot) > 0$.

The innovation rate also may depend on financial factors. In particular, during the estimation period, it was difficult for Japanese firms to raise external funds due to the financial crisis from 1997 onwards. Therefore, we conduct the following additional estimations that includethe cross term between the liquidity ratio and firm-level TFP.

$$Gadd_{it}^{*} = const. + a_1 E_{t-1}(\ln Y_{kt}^{*}) + \ a_2 E_{t-1}(lnG_{kt}) + a_3\ E_{t-1}(lnZ_{kt})$$

$$+a_4 TFP_{it-1} + a_5 TFP_{it-1} * LIQ_{kt-1} + \zeta_i + \mu_{it} \qquad (10)$$

In equation (10), LIQ represents the liquidity ratio that is measured as the ratio of cash and deposits to total assets. These data are obtained from the Financial Statements

---

we do not include this firm in our sample for estimating firm-level TFP.

Statistics of Corporations by industry. We also expect $a_5 > 0$, because innovation activities are easier for more productive firms when they have enough liquidity.

In equation (2), the gross dropping rate does not depend upon its own innovation rate (ω_{it}). Therefore, we do not include firm level TFP to explain the gross dropping rate in equation (8).

5-2 Summary Statistics

The summary statistics of all the variables used are presented in Table 3. As for the number of products, we omit outliers in the upper 1% and lower 1% to exclude abnormal values. The log of the average number of products equals 0.387 (the average number of products 1.749) since 60% of firms have a single product. The average gross adding and gross dropping rates are 0.175 and 0.176, respectively which means that many firms do not add new products nor drop old products in a particular year. The number of observations of firm level TFP is much lower than those of other variables, because we are not able to obtain the capital stock data of establishments with fewer than 30 employees. The liquidity ratio is scattered between 2% and 23%. Since firms are continuously entering and exiting, the panel is unbalanced.

(Insert Table 3 here)

6. Estimation Results

6-1 Estimation Strategy

Equations (7) and (8) cannot be estimated by least spares because of the many zeros, and therefore the sample is censored. As it is well-known, even if all of the explanatory variables are exogenous, the presence of censoring induces a dependence between the error term and the explanatory variables, leading to bias in the coefficient estimates. Taking account of the zeros, Hsiao (2003, p. 240) depicts the likelihood function of the panel Tobit model with censored data, which we implement.

6-2 Estimation of the Panel Tobit Model.

We start with our estimation of the Tobit random effects model not considering the endogeneity of government expenditures. In columns (1) and (2) of Table 4, we show the estimation results of equation (7) without firm-level TFP. In the first row, we find positive and significant impacts of the expected values of foreign demand in the two-digit sector level on the gross adding rate of firms in the same sector. In the second row, we find positive and significant impacts of the expected value of sectoral government expenditure on the gross adding rate of firms in that sector. These are consistent with our theoretical predictions. The expansionary effect is much larger for foreign demand than government expenditures. When we include sectoral TFP in column (2), the coefficient is not significant, which is also consistent with the DJK model. Moreover, the regression coefficients of expected foreign demand and government expenditures do not change from column (1).

(Insert Table 4 here)

In columns (3) and (4), we show the estimation results, including firm level TFP in year t-1, following equation (9). Unexpectedly, we find negative and significant effects of lagged firm-level TFP on the gross adding rate. The signs of government expenditures and sector-level TFP turn out to be negative despite the insignificant coefficients.

However, during the estimation period just after the financial crisis in Japan, even highly productive firms might not be able to develop new products due to financing constraints. Therefore, we add the cross term between firm-level TFP and the liquidity ratio represented by the ratio of cash and deposits to total assets as in equation (10). The estimation results provided in columns (5) and (6) show that the sign of the coefficients on the cross terms are positive and significant, although firm-level TFP is still negative and significant. These results suggest that liquidity constraints play an important role in product innovations.

6-3. Estimation Results When Government Expenditures are Endogenous

We now turn to the estimations considering the endogeneity of government expenditures. For example, the dependent variables and government expenditures are all likely to be affected by common exogenous shocks such as earthquakes and typhoons. In Table 5, we show the estimation results following the ”control function” approach, which can be used to control for the potential endogeneity of government expenditures. For example, when the government engages in countercyclical behavior in the event of a negative shock, the shock (the error term) and government spending may be correlated, leading to biased estimates.

The “control function” approach models the endogenous variable’s relationship with the exogenous variables, the instrumental variables, and the error term separately. The approach estimates the “control function,” which is the residual vector from the first stage. For example, when the endogenous variable is government expenditures, the control function measures the part of government spending that is unexplained by the explanatory variables and the instruments.

In the second stage, the control function is included as an additional explanatory variable in the main regression estimating the gross adding or gross dropping rates. The coefficients on the explanatory variables are consistent even when government spending is endogenous because the control function controls for the potentially endogenous, unexplained portion of government expenditures.

It can be shown that while the usual two stage least squares can be applied when the second stage is linear, when the second stage is nonlinear, as in Tobit estimation, two stage least squares fails. For an illustration of the control function approach, see Ichimura (1997).

(Insert Table 5 here)

To conduct the control function approach, we choose three variables as instruments for government expenditures. The first instrument is the government consumption in the Japanese SNA allocated to each industry using the input ratio in each industry to the total inputs in the public service sector. The second instrument is the expenditurefrom the public service sector to the private services sectors allocated to each manufacturing industry using the input ratio of the private service sector to the total inputs in each manufacturing industry. The first and second instruments are constructed from the JIP database. The third instrument is the small and medium enterprise ratio in each manufacturing industry. This ratio is measured by the ratio of number of SME firms and the total number of firms. The SME firm is defined as a firm with less than 300 employees. The third instrument is constructed from the data on employees of firms in Survey of Manufacturers. The correlations between the government expenditures and three instruments are 0.428 (with the first instrument), 0.242 (with the second instrument) and 0.167 (with the third instrument), respectively. The first stage estimations that measures our control functions for use in each of our second stage specifications are shown in the table in Appendix 4.

In Table 5, the control function terms are significant, which suggests the endogeneity of government expenditures. The estimation results in Table 5 are similar to those in Table 4. Although the results of the first two columns are consistent with our theory, the signs of government expenditures are not positive in the remaining columns. It appears that when lagged firm-level TFP is included, the positive effects on government expenditures vanish. Columns (5) and (6) show that high productivity firms add more new products when they have abundant liquidity.

6-4 Estimation Results of the Gross Dropping Rate

As we explained, when firms innovate new products more vigorously under favorable demand conditions, firms are more likely to lose their old products by the replacement with new products. Therefore, we examine how the gross dropping rate reacts to aggregate variables such as the expected values of foreign demand and government expenditures.

Estimation results are shown in Table 6. Columns (1) and (2) show that the expected log level of foreign demand at the 2-digit sector level significantly increases the gross dropping rate of firms. Comparing columns (1) and (2), sector-level TFP does not have significant effect on gross dropping rate of firms. In the second row, we find that expected sector-level government expenditures have significantly positive effects on the gross dropping rate. These results are consistent with our theoretical predictions. In columns (3) and (4), we use the control function approach to take into account the endogeneity of government expenditure at the sector level. The results are similar to the random effect model in columns (1) and (2). Therefore, here we find that replacement effects are important in explaining the dropping of products in incumbent firms as the theory implies.

(Insert Table 6 here)

6-5 Summary of Estimation Results

From Tables 4 to 6, we find that product dynamics in Japan is generally consistent with the predictions of our model. Expected sector-level foreign demand significantly increases both the gross adding and dropping of products of firms. The positive effects of expected government expenditures on the gross adding and dropping rates of products are also significant in the case of the random effects estimations. However, when we take the control function approach, the effects of the government expenditures are mixed, depending on whether firm level TFP is included. These results suggest the endogeneity of sectoral government expenditures or the correlation of these expenditures with other explanatory variables in the regression. We thus believe that our estimation results of government expenditures do not fully support our theory.

The ambiguous effects of sectoral TFP are also consistent with our theory. Although the coefficients of firm-level TFP are negative and significant, the cross term between firm-level TFP and the liquidity ratio are positive and significant, which suggests the importance of liquidity constraints for innovative activities.

7. Concluding Remarks

Policy makers in many countries are concerned about promoting innovation within their borders. For example, the Abe administration in Japan undertook expansionary fiscal and monetary policies, partly in the hope of encouraging the introduction of innovative products during 2010s[13]. The expansionary monetary policies in the Eurozone in the 2010s is related in part to the desire to stimulate innovation and introduction of better products (Bergin and Corsetti, 2014). The present Takaichi cabinet in Japan is also trying to use aggregate demand policies to stimulate innovation.

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, however, this paper is one of the first to estimate a model of product adding and dropping of individual firms at the business cycle frequency within a standard business cycle model. To estimate such a model, we need product level data that are matched with firms at a minimum at the annual frequency. We construct a unique firm-product database in Japan using the Census of Manufacture. The data are available at the annual frequency and products are classified at six-digit level in our sample, which

---

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

is more detailed than what is available in the U.S. Census of Manufactures.

Our study provides important implications for the Japanese economy. Our empirical results suggest that the creative destruction of adding 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 cycles. Our estimation results show that the creations and destructions of products are stimulated by favorable macroeconomic conditions of large foreign demand as the theory implies. Our study suggests that an appropriate combination of aggregate demand management and policies that enhance firm-level productivity and access to liquidity is useful for promoting creative destruction.

In this paper we focus on the gross adding and dropping of products of incumbent firms during business cycles. To better understand aggregate fluctuations, however, we need to examine how the shipment changes of continuing products at the intensive margin interact with the product and firm dynamics at extensive margin over the business cycle. This is a topic for future research.

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”, *RIETI Policy Discussion Paper*, 12-P-007.

Acemoglu, Daren., Ufuk Akeicgit, and William. Kerr (2016). “The innovation network”, Proceedings of the National Academy of Science 113(41), pp. 11483-11488.

Aghion, Philippe, and Peter Howitt (1992) “A model of growth through creative destruction.” *Econometrica* 60(2), pp. 323-351.

Anzoategui, Diego, Diego Comin, Mark Gertler and Joseba Martinez (2019) “Endogenous technology adoption and R&D as sources of business cycle persistence” *American Economic Journal Macroeconomics,* 11(3), 67-110.

Argente, David, Munseob Lee, and Sara Moreir (2024). “The life cycle of products: evidence and implications”, *Journal of Political Economy,* vol. 132(2), pp. 337-390.

Bergin, P. and G. Corsetti (2014). “International competitiveness and monetary policy”, manuscript, Cambridge University.

Berlingieri, G., M. De Ridder, D. Lashkari and D. Rigo (2025), “Creative Destruction through Innovation Bursts” Center for Economic Performance Discussion Paper No, 2095, London School of Economics.

Bernard, Andrew, B., Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum (2003).

"Plant and productivity in international trade", *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. and Toshihiro Okubo (2015). "Product switching and business cycle", *RIETI Discussion Paper Series*, 15-E-103.

Bernard, Andrew, B., Stephen J. Redding, and Peter K. Schott (2010). "Multi-product firms and product switching", *American Economic Review*, 100(1), pp. 70-97

Bianchi, Francesco, Howard Kung and Gonzara Moraleset. (2019) "Growth, slowdowns and recoveries", *Journal of Monetary Economics*, 101(1), pp. 47-63.

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", *American Economic Review*, 100(3), pp. 691-723.

Comin, Diego and Mark Gertler (2006). "Medium-term business cycles", *American Economic Review* 96 (3), pp. 523-551.

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

Dekle, Robert, Hyeok Jeong, and Nobuhiro Kiyotaki (2015). "Dynamics of firms and trade in general equilibrium", USC-INET Research Paper No. 15-12.

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", *Econometrica* 79(5), pp. 1407-1451.

Di Giovanni, Julian, Andrei A. Levchenko, and Isabelle Méjean (2014). "Firms, destinations, and aggregate fluctuations", *Econometrica* 82(4), pp. 1303-1340.

Eaton, Jonathan, and Samuel Kortum (2002). "Technology, geography, and trade", *Econometrica* 70(5), pp. 1741-1779.

Foerster, Andrew, Piere Daniel Sarte and Mark Watson (2011). "Sectoral vs. aggregate shocks: a structural factor analysis of industrial production", *Journal of Political Economy* 119 (1), pp. 1-38.

Fornaro, Luca and Martin Wolf (2020). "The scars of supply shocks: implications for monetary policy", *Journal of Monetary Economics*, 140 (supplement), S18-S36.

Foster, Lucia, John Haltiwanger, and Chad Syverson (2008). "Reallocation, firm turnover, and efficiency: selection on productivity or profitability?", *The American Economic Review* 98(1), 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", *Japanese Economic Review* 57(2), pp. 195-228.

Garcia-Macia, Daniel., C-T Hsieh, and Peter Klenow (2019). "How destructive is innovation?", *Econometrica* 87(5), pp. 1507-1541.

Good, David, Isaq Nadiri, and Robin Sickles (1997). "Index number and factor demand approaches to the estimation of productivity", in M. Hashrem Perasan and Peter Schmit eds., *Handbook of Applied Econometrics: Vol. 2, Microeconometrics*, Oxford, England: Basic Blackwell.

Hsieh and Klenow (2017). "Reallocation myth", Proceeding of the Federal Reserve of Kansas City Economic Symposium on *Fostering Dynamic Economy*.

Hsiao, Cheng (2003). *Analysis of Panel Data (2nd Edition),* Cambridge University Press.

Hopenhayn, Hugo (1992). "Entry and exit in long run equilibria", *Econometrica* 60(5), pp. 1127-1150.

Hur Jung and Hyojin Kwak (2026) "The Impact of E-commerce Competition on New Product Entry in the Manufacturing Sector: Evidence from Korean Manufacturing Establishments' presented at the IJEE Workshop held on January 8th.

Ichimura, Hidehiko (1997). "Semiparametric least squares and weighted SLS estimation of single index models," *Journal of Econometrics,* 50, 1-2, July.

Jorda, Oscar, Sanjay R. Singha, and Alan M. Taylor (2023). "Does monetary policy have long-rum effects?", Federal Reserve Bank of San Franscisco vol. 2023 (23).

Jorgenson, Dale, Frank M. Gollop, and Barbara M. Fraumeni (1987). *Productivity and U.S. Economic Growth*, Harvard Economic Studies Vol. 159.

Kawakami, Atsushi, Tsutomu Miyagawa, and Miho Takizawa (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.

Klette, Tor Jakob, and Samuel Kortum (2004). “Innovating firms and aggregate innovation”, *Journal of Political Economy*, vol. 112(5), pp. 986-1018.

Melitz, Marc, J., (2003). “The impact of trade on intra-industry reallocations and aggregate industry productivity”, *Econometrica* 71(6), pp. 1695-1725.

Moran, Patrick and Albert Queralto (2018). “Innovation, productivity and monetary policy”, *Journal of Monetary Economics*, 93, pp. 24-41.

Olley, G. Steven and Pakes, Ariel (1996). “The dynamics of productivity in the telecommunications equipment industry”, *Econometrica*, 64(6), pp. 1263-1293.

Nakamura, Emi and Jon. Steinnson (2012). “Lost in transit: product replacement bias and pricing to market”, *American Economic Review,* 102(7), pp. 3277-3316.

Peters, Michael, and Conor Walsh (2024). “Population growth and firm dynamics”, mimeo, Yale University.

Piearce, Justin, R. and Peter K. Schott (2012). “Concording U.S. harmonized system codes over time”, *Journal of Official Statistics*, Vol. 28(1), pp. 53-68.

Schleifer, Andrei. (1986). “Implementation cycles”, *Journal of Political Economy,* 94(6), pp. 1163-1190.

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

Shimer, Robert. (2005). “Cyclical behavior of equilibrium unemployment and vacancy”, *American Economic Review* 5(1), pp. 25-49.

Syverson, Chad (2011). “What determines productivity?”, *Journal of Economic Literature* 49(2), pp. 326-365.

Table 1 An Example of How Products are Classified in the Census of Manufacturers

Sector		Industry		Product															
2-digit classification		4-digit classification		6-digit classification				Number of establishments											
2008 version		2008 version		2008 version	2002 version	1999 version	name of products	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
27	Bussiness oriented machinery	2741	Medical and hospital instruments and prats	274111	323111	313111	Medical instruments, apparatus and equipment	369	392	362	361	362	357	350	337	349	351	343	323
				274112	323112	313112	Hospital instruments, apparatus	164	156	159	148	149	135	137	126	125	125	111	119
				274113	323113	313113	Parts, attachments and accessories fo medical instruments and apparatus	538	545	527	508	518	514	507	511	536	568	567	563
				274191	323191	313191	Medical instruments and appratus and parts, attachments and accessories (piecework)	290	303	281	273	302	284	308	267	273	280	251	263

Table 2 The Outline of the Survey of Manufacturers in Japan

	industry	products	products/ industry	Goods Shipments (million JPY)	Number of Employees	Shipments per Employees (million JPY)
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
Log of number of products (lnNi)	**3,046,008**	**0.387**	**0.526**	**0.000**	**4.997**
Gross adding rate (Gaddi)	**2,507,665**	**0.175**	**0.407**	**0 (0.839)**	**5.000**
Gross dropping rate (Gdropi)	**2,507,876**	**0.176**	**0.408**	**0 (0.837)**	**5.000**
Log of expected foreign demand/shipment/shupment (Et-1Y*t))	**3,046,008**	**13.321**	**1.611**	**9.217**	**16.895**
Log of expected government expendityre/shipment (Et-1Gt)	**3,046,008**	**5.320**	**2.939**	**-1.996**	**12.108**
Log of expected sector-level TFP (Et-1Zt)	**3,046,008**	**0.008**	**0.196**	**-1.324**	**0.721**
Log of firm-level TFP (TFP)	**465,717**	**3.658**	**2.569**	**-14.872**	**12.255**
Liquidity ratio (LIQ)	**3,046,008**	**0.122**	**0.032**	**0.020**	**0.233**

***The parenthsis in the column *Min* show the share of samples of minimum value (0) in the total samples.**

Table 4 Estimation Results for Gross adding Rate (1) : The RE estimation

Dependent variable	Gross adding rate of products					
	(1)	(2)	(3)	(4)	(5)	(6)
Expected foreign demand (Et-1Y*t)	0.077 ***	0.077 ***	0.060 ***	0.062 ***	0.063 ***	0.064 ***
	72.46	72.45	11.54	11.78	11.84	11.96
Expected government expenditure (Et-1Gt)	0.018 ***	0.018 ***	0.013 ***	0.011 ***	0.012 ***	0.010 ***
	29.90	28.99	5.00	3.96	4.33	3.56
Expected sector-level TFP (Et-1Zt)		-0.013		-0.125 ***		-0.110 **
		-1.34		-3.14		-2.71
Lagged firm-level TFP(TFP(t-1))			-0.035 ***	-0.031 ***	-0.054 ***	-0.047 ***
			-9.99	-8.09	-6.96	-5.70
Lagged cross term between firm-level TFP and cash flow					0.158 ***	0.130 **
					2.96	2.18
Constant	-2.077 ***	-2.077 ***	-3.028 ***	-3.063 ***	-3.054 ***	-3.080 ***
	-239.14	-238.88	-63.68	-62.54	-62.82	-62.02
Year dummy	yes	yes	yes	yes	yes	yes
Sample Size (uncensored)	403,807	403,807	19,341	19,341	19,341	19,341
Log likelihood	-1412367.4	-1412366.5	-84666.4	-84661.5	-84662.8	-84659.1

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

*, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Table 5 Estimation Results for Gross adding Rate (2): Control function approach

Dependent variable	**Gross adding rate of products**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Expected foreign demand (Et-1Y*t)	**0.084 *****	**0.083 *****	**0.074 *****	**0.074 *****	**0.125 *****	**0.103 *****
	65.72	**64.58**	**11.11**	**10.32**	**12.61**	**10.99**
Expected government expenditure (Et-1Gt)	**0.000**	**0.003**	**-0.167 ***	**-0.013**	**-0.098 *****	**-0.059 *****
	0.15	**1.48**	**-1.83**	**-1.35**	**-6.51**	**-4.26**
Expected sector-level TFP (Et-1Zt)		**-0.047 *****		**-0.215 *****		**-0.323 *****
		-4.44		**-4.02**		**-5.54**
Lagged firm-level TFP(TFP(t-1))			**-0.033 *****	**-0.026 *****	**-0.113 *****	**-0.068 *****
			-9.29	**-6.13**	**-10.15**	**-7.38**
Lagged cross term between firm-level TFP and cash flow (LIQ(t-1))					**0.726 *****	**0.410 *****
					7.51	**5.04**
Residual of the 1st step	**0.020 *****	**0.017 *****	**0.032 *****	**0.026 ****	**0.112 *****	**0.071 ****
	10.15	**8.22**	**3.40**	**2.51**	**7.40**	**5.07**
Constant	**-2.178 *****	**-2.161 *****	**-3.256 *****	**-3.263 *****	**-3.928 *****	**-3.660 *****
	-164.03	**-160.87**	**-39.39**	**-34.82**	**-30.49**	**-29.19**
Year dummy	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
Sample Size (uncensored)	**403,807**	**403,807**	**19,341**	**19,341**	**19,341**	**19,341**
Log likelihood	**-1412315.9**	**-1412332.8**	**-84660.6**	**-84658.3**	**-84635.4**	**-84646.3**

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

*, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

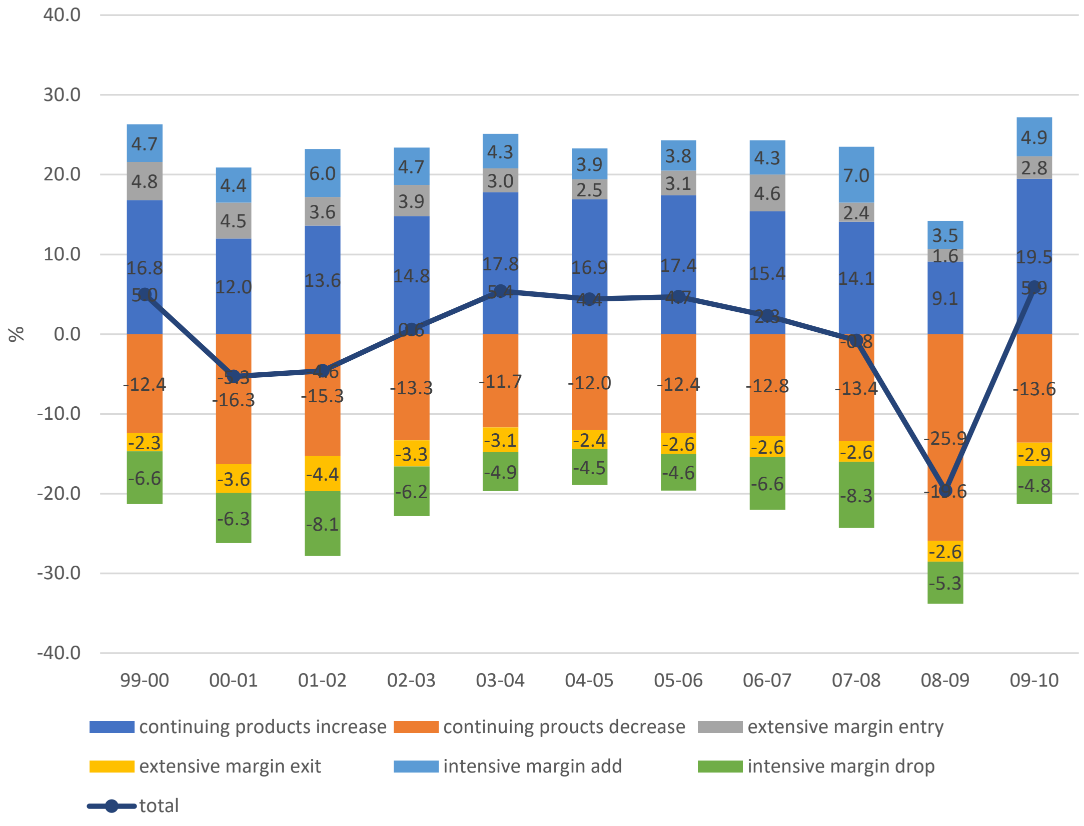
Table 6 Estimation Results for Gross Dropping Rate

Dependent variable	Gross dropping rate of products			
	(1)	(2)	(3)	(4)
Expected foreign demand (Et-1Y*t)	0.073 ***	0.073 ***	0.082 ***	0.081 ***
	69.48	69.47	64.82	63.65
Expected government expenditure (Et-1Gt)	0.017 ***	0.017 ***	-0.006 ***	-0.003
	28.70	27.80	-3.07	-1.59
Expected sector-level TFP (Et-1Zt)		-0.014		-0.060 *
		-1.42		-5.62
Residual of the 1st step			0.026 ***	0.022 ***
			13.04	11.66
Constant	-2.050 ***	-2.050 ***	-2.179 ***	-2.163 ***
	-237.30	-237.05	-164.70	-161.55
Year dummy	yes	yes	yes	yes
Sample Size (uncensored)	406,887	406,887	406,887	406,887
Log likelihood	-1419903.3	-1419902.3	-1419818.3	-1419841.2
Estimation method	Random effects model		Control function approach	

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

*, **, and *** show significance at 10%, 5%, and 1% levels, respectively.

Figure 1 Decomposition of Shipment Change



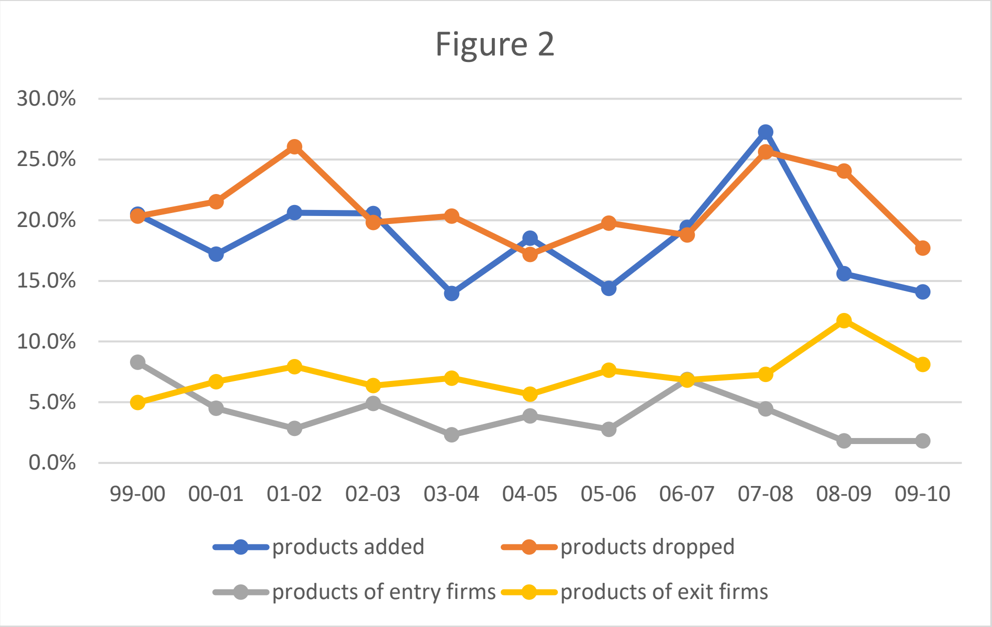


Figure 2
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
09-10
products added
products dropped
products of entry firms
products of exit firms

Appendix 1 On the Construction of Firm Product-Level Data in Japan

We use the Census of Manufacture conducted by the Japanese Ministry of Economy, Trade and Industry (METI) to construct firm product-level data in the Japanese manufacturing sector. We are able to count the number of products at the establishment level and consolidate numbers of products at the firm level because this survey records shipments by product at an establishment. When an establishment increases the number of products, we recognize that this firm is generating a new type of product.

Industry classification in the Census of Manufacturers follows the Japan Standard Industry Classification (JSIC) at the two and four–digit levels. JSIC, that was first created in 1949, is revised every five years. Every version of JSIC is adjusted to adhere to the International Standard Industry Classification (ISIC). However, for the six-digit classifications, the Census of Manufactures uses its own distinct classifications. This product classification changed three times (1999, 2002 and 2008) during our estimation period. In the 1999 classification, the number of products is 1,806 but in the 2008 classification it is 2,351. Suppose product A in the 1999 version is divided into two products in the 2002 version, product A and product B, and the name of the product that an establishment produces is changed from product A to product B. In this case, we may consider this to be the establishment changing products although it is actually the same product. At the same time, some products that were distinct in 1999 may be combined in 2002. This applies to changes that occurred between the 2002 and 2008 classifications.

To avoid miscounting the number of products in these ways, we construct a time-consistent product classification as Pierce and Schott (2012) suggested. That is, we keep a single product classification through 1999 to 2010. When the product classification changed, the METI published a classification converter from the old product classification to the new combined ones. In addition, we separated combined product classifications back to their old classifications manually by checking for changes in the tables because the METI did not provide the converter for this. Through these methods, we constructed a time-consistent product classification.

To count the number of products at the firm level, we have to integrate the number of products at the establishment level into those at the firm level. A firm that an establishment belongs to is identified from the address and phone number of the firm's headquarters. We identified establishments with the same address and phone number as those in the same firm and count the number of products in this firm.

Appendix Table 1. The Movements of Product Classification in the Census of Manufacture

	1999 version	2002 version	2008 version
Two-digit sector	**23**	**24**	**24**
Four-digit industry	**547**	**562**	**546**
Six-digit product	**1806**	**2408**	**2351**

Source: *The Census of Manufacture classification related materials*, Ministry of Economy Trade and Industry, Japan.

Note: The numbers exclude products from services, electrics, scraps and wastes.

Appendix 2 The Concordance Table between the Two-digit Sector-level Classification and the JIP Industry Classification

Usually, the product classification is different from the industry classification. However, using the Supply-Use table, we created the following concordance table. Some industries such as production machinery and office and service industry machines are classified into multiple product categories. For those instances, we divided aggregate variables of such industries into multiple product categories by using the concordance table between the two-digit industry classification and the JIP industry classification.

2-digit product classification		JIP classifications	
9	FOOD	6	Livestock products
		7	Seafood products
		8	Flour and grain mill products
		9	Miscellaneous foods and related products
10	BEVERAGES,TOBACCO AND FEED	10	Beverages
		11	Prepared animal foods and organic fertilizers
		12	Tobacco
11	TEXTILE MILL PRODUCTS*	13	Textile products (except chemical fibers)
		14	Chemical fibers
12	LUMBER AND WOOD PRODUCTS, EXCEPT FOURNITURE	53	Lumber and wood products
		16	Paper products
13	FURNITURE AND FIXTURES	54	Furniture and fixtures
14	PULP, PAPER AND PAPER PRODUCTS	15	Pulp, paper, and coated and glazed paper
		16	Paper products
15	PRINTING AND ALLIED INDUSTRIES	52	Printing
16	CHEMICAL AND ALLIED PRODUCTS	17	Chemical fertilizers
		18	Basic inorganic chemicals
		19	Basic organic chemicals
		20	Organic chemicals
		21	Pharmaceutical products
		22	Miscellaneous chemical products
17	PETROLEUM AND COAL PRODUCTS	23	Petroleum products
		24	Coal products
18	PLASTIC PRODUCTS, EXCEPT OTHERWISE CLASSIFIED	55	Plastic products
19	RUBBER PRODUCTS	56	Rubber products
20	LEATHER TANNING, LEATHER PRODUCTS AND FUR SKINS	57	Leather and leather products
21	CERAMIC, STONE AND CLAY PRODUCTS	25	Glass and its products
		26	Cement and its products
		27	Pottery
		28	Miscellaneous ceramic, stone and clay products

2-digit product classification		JIP classifications	
22	IRON AND STEEL	29	Pig iron and crude steel
		30	Miscellaneous iron and steel
23	NON-FERROUS METALS AND PRODUCTS	31	Smelting and refining of non-ferrous metals
		32	Non-ferrous metal products
24	FABRICATED METAL PRODUCTS	32	Non-ferrous metal products
		33	Fabricated constructional and architectural metal products
		34	Miscellaneous fabricated metal products
25	GENERAL-PURPOSE MACHINERY	35	General-purpose machinery
		36	Production machinery
		37	Office and service industry machines
26	PRODUCTION MACHINERY	36	Production machinery
27	BUSINESS ORIENTED MACHINERY	37	Office and service industry machines
		38	Miscellaneous business oriented machinery
		39	Ordnance
28	ELECTRONICPARTS, DEVICES AND ELECTRONIC CIRCUITS	40	Semiconductor devices and integrated circuits
		41	Miscellaneous electronic components and devices
29	ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES*	42	Electrical devices and parts
		43	Household electric appliances
		44	Electronic equipment and electric measuring instruments
		45	Miscellaneous electrical machinery equipment
		38	Miscellaneous business oriented machinery
30	INFORMATION AND COMMUNICAION ELECTRONICS EQUIPMET	44	Electronic equipment and electric measuring instruments
		45	Miscellaneous electrical machinery equipment
		46	Image and audio equipment
		47	Communication equipment
		48	Electronic data processing machines, digital and analog computer equipment and accessories
31	TRASPORTATION EQUIPMENT	49	Motor vehicles (including motor vehicles bodies)
		50	Motor vehicle parts and accessories
		51	Other transportation equipment
32	MISCELLANEOUS MANUFACTURING INDUSTRIES	58	Watches and clocks
		59	Miscellaneous manufacturing industries

Appendix 3. Estimations of Firm-level TFP

We estimate a production function for the multi-product firm developed by De Loecker (2011) to obtain firm-level TFP. In his paper, the output of product *j* at firm i, Q_{ijt}, depends on aggregate demand in industry k, Q_{kt}, and relative price, $\frac{P_{ijt}}{P_{kt}}$, as

$$Q_{ijt} = \left(\frac{P_{ijt}}{P_{kt}}\right)^{-\eta} Q_{kt} \exp(\xi_{it}). \qquad \text{(A-1)}$$

Here ξ_{it} is an unobservable demand shock to firm i and $\eta > 1$ is the elasticity of substitution.

From (A-1), the revenue function of product *j* by firm *i* is

$$R_{ijt} = P_{ijt}Q_{ijt} = Q_{ijt}^{\frac{\eta-1}{\eta}} Q_{kt}^{\frac{1}{\eta}} P_{kt} \left[\exp(\xi_{it})\right]^{\frac{1}{\eta}}. \quad \text{(A-2)}$$

Assume that the production function of each product is given by

$$Q_{ijt} = L_{ijt}^{\alpha_l} M_{ijt}^{\alpha_m} K_{ijt}^{\alpha_k} exp(\omega_{it} + u_{it})$$

for all products produced by firm *i*, where *j*=1,2,...N_{it}. Denote the total revenue of firm *i* as $R_{it} = \sum_{j=1}^{N_{it}} R_{ijt}$, and the total use of labor, material and capital as $L_{it} = \sum_{j=1}^{N_i} L_{ijt}, M_{it} = \sum_{j=1}^{N_i} M_{ijt}$, and $K_{it} = \sum_{j=1}^{N_i} K_{ijt}$. Assuming that the input is used equally across products within the firm, $X_{ijt} = \frac{X_{it}}{N_{it}}$, for $X = L, M, and\ K$. we define the log level of real revenue of firm i using the sector-level price level as $\tilde{r}_{it} = lnR_{it} - lnP_{kt}$. From Equation (A-2), we obtain

$$\tilde{r}_{it} = \frac{\eta-1}{\eta}(\alpha_l l_{it} + \alpha_m m_{it} + \alpha_k k_{it}) + \left[1 - \frac{\eta-1}{\eta}(\alpha_l + \alpha_m + \alpha_k)\right] n_{it}$$

$$+\frac{1}{\eta}q_{kt}+\frac{\eta-1}{\eta}(\omega_{it}+u_{it})+\frac{1}{\eta}\xi_{it}. \qquad \text{(A3)}$$

Here lower-case letters represent the log values of the variables represented by their upper-case letters.

We estimate Equation (A-3) by using the two digit-level industry classifications as [14], [15].

$$\tilde{r}_{it} = \beta_l l_{it}+\beta_m m_{it}+\beta_k k_{it}+\beta_n n_{it}+\beta_q q_{kt}+\omega_{it}^{*}+\xi_{it}^{*}+u_{it}^{*}, \qquad \text{(A4)}$$

Using estimated parameters, we measure productivity as

$$\hat{\omega}_{it} = \left(\tilde{r}_{it}-\hat{\beta}_l l_{it}-\hat{\beta}_m m_{it}-\hat{\beta}_k k_{it}-\hat{\beta}_n n_{it}-\hat{\beta}_q q_{kt}\right)\frac{\eta}{\eta-1}. \qquad (A5)$$

The estimation results are shown in the Appendix Table 3.

---

[14] If firm *i* produces multiple products across different industries, Equation (A-4) becomes more complicated. However, as most Japanese firms produce multiple products within one industry at the two-digit level, we focus on the estimation of Equation (A-4).

[15] Estimations were conducted by the Levinsohn-Petrin method.

Appendix table 3 Estimation Results of Production Functions

	FOOD	BEVERAGES, TOBACCO AND FEED	TEXTILE MILL PRODUCTS	LUMBER AND WOOD PRODUCTS, EXCEPT FURNITURE	FURNITURE AND FIXTURES	PULP, PAPER AND PAPER PRODUCTS	PRINTING AND ALLIED INDUSTRIES	CHEMICAL AND ALLIED PRODUCTS
lnL	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
lnK	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
lnM	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
industry-level demand	0.0146 ***	-0.0628 ***	0.0155 ***	0.203 ***	0.0514 **	0.123 ***	-0.545 ***	0.0092
	4.91	-15.26	64.54	6.59	3.29	6.79	-16.29	0.32
number of products	0.065 ***	0.105 ***	0.0595 ***	0.0596 ***	0.0113	0.0503 ***	0.072 *	0.0051
	22.22	4.74	15.68	19.03	0.99	3.72	2.23	0.14
Year dummy	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
lnL	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
lnK	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
lnM	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
industry-level demand	-0.0944 ***	-0.0155	0.123 ***	0.0058	0.201 ***	0.00387	-0.262 ***	0.0364 *
	-4.98	-0.59	6.32	0.32	10.86	0.2	-22.18	2.16
number of products	-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
Year dummy	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-PURPOSE MACHINERY	PRODUCTION MACHINERY	BUSINESS ORIENTED MACHINERY	ELECTRONIC PARTS, DEVICES AND ELECTRONIC CIRCUITS	ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES	INFORMATION AND COMMUNICAION ELECTRONICS EQUIPMENT	TRASPORTATION EQUIPMENT	MISCELLANEOUS MANUFACTURING INDUSTRIES
lnL	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
lnK	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
lnM	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
industry-level demand	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
number of product	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
Year dummy	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	4511.8	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 4 The First Step Estimations in the Control Function Approach

Dependent variable=Expected government expenditure (Et-1Gt)	Columns (1) in Table 5 and Column (3) in Table 6		Columns (2) in Table 5 and Column (4) in Table 6		Columns (3) in Table 5		Columns (4) Table 5		Column (5) in Tsble 5		Column (6) in Table 5	
Government consumption allocated to each industry using the input raito in each industry to the total inputs in the public service sector (FEGY(t-1))	0.594	***	0.508	***	0.582	***	0.332	***	0.441	***	0.289	***
	407.98		343.61		110.77		60.33		70.42		46.27	
Expenditures from the public service sector to the private services sectors allocated to each manufacturing sindustry (LGIV(t-1))	-0.130	***	-0.138	***	-0.151	***	-0.163	***	-0.086	***	-0.139	***
	-90.69		-98.03		-28.77		-31.85		-15.79		-25.99	
SME ratio (SME(t-1))	8.502	***	10.566	***	7.081	***	10.943	***	5.480	***	10.255	***
	214.28		264.02		62.38		95.29		45.83		82.80	
Expected foreign demand (Et-1Y*t)	0.202	***	0.262	***	0.250	***	0.471	***	0.329	***	0.493	***
	150.01		194.33		48.69		88.65		60.26		89.40	
Expected sector-level TFP (Et-1Zt)			-2.491	***			-3.920	***			-3.805	***
			-253.85				-120.61				-113.96	
Firm-level TFP(TFPt-1)					-0.818	***	0.077	***	-0.309	***	-0.009	
					-28.52		25.09		-49.81		-1.35	
									2.217	***	0.797	***
									41.26		14.81	
Constant	-13.413	***	-15.389	***	-12.685	***	-17.419	***	-11.615	***	-16.896	***
	-346.04		-393.97		-115.61		-153.32		-103.36		-142.08	
Sample Size (left-censored)	2,540,337		2,540,337		245,887		245,887		245,887		245,887	
Adj R-squared	0.193		9.213		0.159		0.206		0.164		0.206	

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.