Population Growth, Employment Protection, and Firm-level Distortions

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Cheng Chen and Takahiro Hattori*

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Abstract

Declining population growth and the existence of firm-level distortions are important real-world phenomena. In this paper, we set up a firm dynamics model to study firm-level distortions induced by the firing cost through the lens of population growth. The negative impact of the firing cost on aggregate productivity is larger when the population growth rate declines, since slower population growth leads to fewer entrants and exiting firms which are less troubled by the firing cost. Using Japanese plant-level data, we calibrate the model and implement counterfactual analysis. Importantly, we provide direct evidence on how population growth affects plant-level labor distortions.

Keywords: population growth, employment protection and firing cost, firm-level distortions

JEL Classification: E20, E23, E24, J11, J58.

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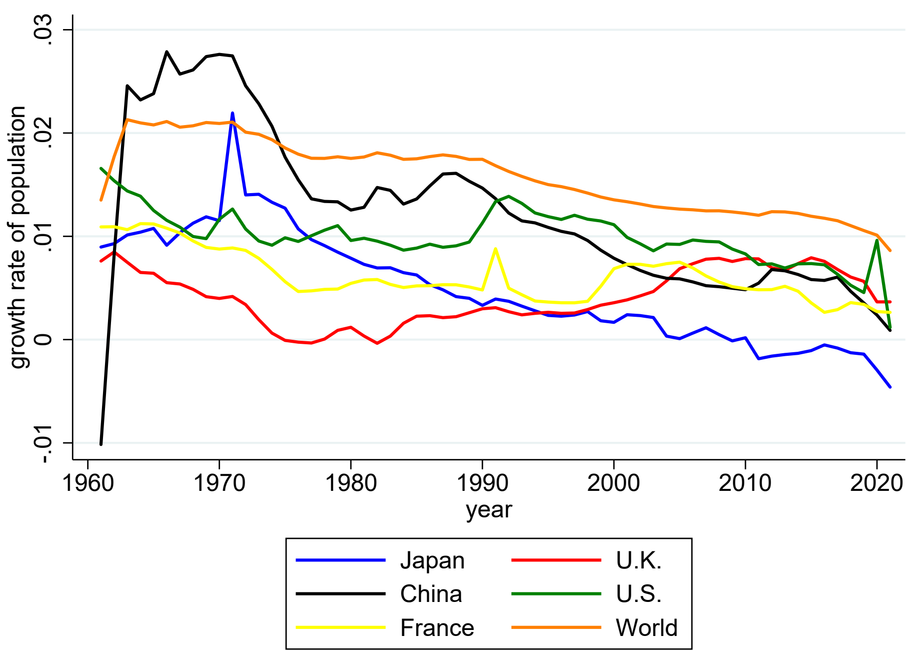
1 Introduction

Almost all economies have been experiencing substantial declines in population growth in recent decades. Figure 1 shows historical population growth rates for a group of economies and the world from 1960 to 2020. As this figure illustrates, the average population growth rate of the world declined from approximately 1.8% in the 1980s to around 0.9% in the 2020s. Additionally, a decline in population growth led to an even sharper decline in the growth rate of working-age population. Figure 2 presents the working-age population growth rates for a group of economies and globally for the same time period and shows that the average growth rate of the working-age population worldwide fell from around 2.4% in 1980 to approximately 0.9% in 2020. In particular, Japan, which is the focus of our paper, stands out in both figures as the above two growth rates have dwindled from approximately 1% (and 2%) to −0.5% (and −1%) over the course of 60 years (1960-2020).

Figure 1: Population growth

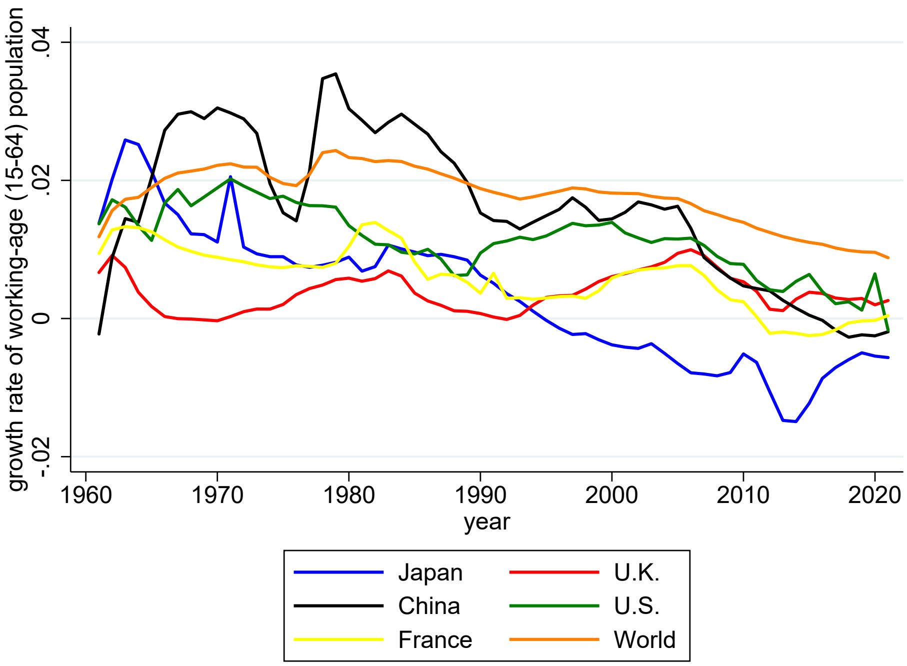


Note: This figure plots the evolution of the population growth rate in five countries and globally. Data source: World Bank.

Declining population growth affects labor supply and hence the labor market, which is governed by many important policies related to employment protection legislation (EPL) including severance pay programs.[1] Holzmann et al. (2011b) document that severance pay

[1]Economists have argued that the existence of a high firing cost is responsible for the high rate of youth unemployment (Kawaguchi and Murao, 2014). Some economists have argued that the rigid labor market

Figure 2: Growth rate of working-age population



Note: This figure plots the evolution of the working-age (15-64) population growth rate in five countries and globally. Data source: World Bank.

programs exist in most countries around the world.[2] Japan is particularly noticeable for several reasons. First, although Japan does not have a demanding severance pay program enforced by the government, court judgments in the case of involuntary separations from the employer have primarily favored workers and demanded large amounts of severance payments from the employers.[3] Second, Japanese workers have longer job tenures compared with their counterparts in the U.S. and Europe.[4] As the dominant factor determining the amount of severance pay is years of service, the amount of severance pay is presumably larger for Japanese firms. In sum, the issue of the firing cost is particularly relevant for Japanese firms and the Japanese economy.

In this paper, we study the impact of the firing cost on firm-level distortions and ag-

is responsible for the slow recovery from the financial crisis in southern European countries (Meghir et al., 2017).

[2]The history of severance pay programs dates back to the nineteenth century during the second Industrial Revolution.

[3]The severance payment is set to be one-month salary under Japan's labor law. However, firms pay substantially more than this in reality. See Katagiri (2023) for a related point.

[4]The survey of "Basic Survey on Wage Structure", Fujimoto (2017) found that the average job tenure of Japanese workers was 11.9 years in 2016. A recent release from the Bureau of Labor Statistics shows that this number is 4.1 years in 2022 for the U.S. See `https://www.bls.gov/news.release/pdf/tenure.pdf` According to Bussolo et al. (2022), the average job tenure in Europe was approximately 8-10 years during the period 1995-2020.

gregate productivity through the lens of population growth. In Hopenhayn and Rogerson (1993), firms that produce a homogeneous good draw heterogeneous productivities that evolve stochastically over time. Both product and labor markets are perfectly competitive, and the firm-level production function, which uses labor as the only input, features decreasing returns-to-scale. Potential entrants can enter the market by paying a (fixed) sunk entry cost, while operation in the market entails a fixed operation cost each period. In addition to the fixed and variable costs, firms that lay off workers pay a firing cost (i.e., tax) that is proportional to the workers' annual wage.[5] On the consumer side, there is a unit measure of representative households who supply labor inelastically and make the consumption-saving choice. The number of household members grows at a constant rate over time. There is no aggregate uncertainty in the economy, and we study how a change in the growth rate of labor supply affects the productivity gain from eliminating the firing cost in the *steady state*. The introduction of population growth enables us to define variables (e.g., number of firms, entry rate) in per capita terms.

As Hopenhayn and Rogerson (1993) insightfully point out, the output/productivity loss (due to the firing cost) in the model originates from the distortion of allocating labor across firms.[6] While the marginal product of labor (MPL) is equalized in a model without the firing cost, this is not the case in an economy with the firing cost. Firms with a low level of productivity and a high level of employment do not necessarily lay off workers due to the firing cost they would have to pay immediately, leading to a lower MPL. Firms with a high level of productivity and a low level of employment do not necessarily hire enough workers due to the firing cost they might pay in the *future*, which leads to a higher MPL. Consequently, the dispersion of MPL across firms is a crucial measure for the productivity loss that originates from the firing cost.

The key innovation of this paper is that it shows that the degree of firm-level distortions induced by the firing cost interacts with the rate of population growth in an interesting way. As a series of studies (Peters and Walsh, 2021; Hopenhayn et al., 2022; Karahan et al., 2024) have shown, the key impacts of a decline in population growth in firm dynamics models are the declining entry/exit rates. Specifically, entries that bring new firms into the economy decline due to the decreasing supply of workers over time, leading to a positive impact of population growth on the entry rate. The exit rate also decreases as the lower entry rate leads to a bigger share of incumbents among active firms, which are less likely to exit compared to the entrants.

[5] In this paper, we use "firing workers" and "laying off workers" interchangeably.

[6] As labor supply grows exogenously and output is in per capita terms, the productivity loss is equivalent to the output loss in our model.

The entry and exit margins play important roles in our analysis. First, we assume that exiting firms *do not* pay the firing cost (as assumed in Samaniego (2006)) for several reasons. First, labor laws in most countries do not oblige firms to make severance payments to laid-off workers in the case of bankruptcy.[7] Second, exiting firms, which tend to be small, likely lack the financial resources to pay the firing cost as they have to pay debts, unpaid wages, and bonuses first. This assumption is also consistent with the common view that small firms in Japan do not have a lifetime employment system due to the non-existence of severance payments.[8] Next, the data indicate that entrants are less troubled by the firing cost as they tend to either grow or exit (instead of downsizing).[9] Since exiting firms do not pay the firing cost and hiring does not entail any policy-induced cost, the firing cost has a lighter touch on exiting and entering firms compared to incumbent firms. In summary, the effect of the firing cost on incumbents and entrants/exiting firms is *asymmetric*.

The uneven effect of the firing cost on firms leads to the key finding of this paper that the aggregate productivity loss due to the firing cost is larger in economies with slower population growth. Since these economies have fewer entrants/exiting firms and thus more incumbents, there is a higher degree of distortion (measured by the dispersion of the MPL) across firms. Consequently, the productivity gain from eliminating the firing cost is also larger in these economies.

Next, we use a plant-level dataset from Japan (2001-2007) to calibrate our model and quantify the implications of a slow-down in population growth for the (negative) productivity effect of the firing cost. The dataset we use is called the Census of Manufacturers and was obtained from the Japanese Ministry of Economy, Trade, and Industry. It surveys all manufacturing plants with more than three employees every year, generating a panel dataset of seven years with roughly $300,000$-$350,000$ plants per year. Based on this plant-level dataset, we calculate various aggregate moments that we target in the calibration.[10] Overall, our calibrated model well matches not only the targeted moments but also some

[7] According to Holzmann et al. (2011a) and Holzmann et al. (2011b), severance payments are enforced in most countries in two circumstances: separations from employers due to dismissal and redundancy (i.e., the employer lays off worker(s) due to a worsening business environment/product demand or redundant manpower). However, severance payments are enforced in less than 10% of countries that have severance payment programs in the case of bankruptcy. Moreover, the severance payments in such a case are usually made from a government-mandated account, not from the individual firm's account. In summary, firms are unlikely to pay the firing cost (in addition to unpaid wages/bonuses) when they exit in reality.

[8] See Ono (2010) for supporting evidence.

[9] This happens in quantitative models as the calibrated average productivity of entrants is lower than their steady state level and the calibrated dispersion of productivity shocks/innovations is larger among entrants than among incumbents.

[10] Since Japan had experienced several severe recessions in the 1990s and the 2000s, we choose the sample period of 2001-2007. Recessions between 1990 and 2010 include the collapse of the housing bubble (1991-1993), the Asian financial crisis (1997-1999) and the global financial crisis (2008-2009).

key non-targeted moments.

We then implement counterfactual analyses by reducing the firing cost from the calibrated value to zero under different growth rates of the working-age population (from -2% to -3%).[11] We first show that both the entry and exit rates vary positively with the population growth rate. Consequently, we find that the productivity gain from eliminating the firing cost increases when the population growth rate is lower. For instance, the output gain in the case of a -1% (1%) annual growth rate of the labor force is roughly 8.14% (6.83%). When the annual growth rate of the labor force changes from 3% to -2%, the gain in output increases from 6.04% to 9.07%.

To better understand the channel through which the population growth rate affects productivity gains, we show how the dispersion of the MPL varies with the population growth rate in our counterfactual exercises. We find that the (standardized) dispersion of MPL across firms (or plants) declines with the population growth rate conditioning on the firing cost, meaning that the (same) firing cost leads to a lower degree of firm-level distortions when the population growth rate increases. This explains why the productivity gain is larger when the population growth rate is lower. Moreover, the dispersion of the MPL obtained from the data (0.233-0.248) is quantitatively similar to the one generated by our calibrated model (0.202), although we do not target this moment in our calibration. This shows that the quantitative magnitude of the (distortion) channel emphasized by our calibrated model is comparable to that in the data.

Importantly, we also provide evidence for the aforementioned channel of our model. Specifically, we exploit differential changes in the growth rate of the working-age population across 47 Japanese prefectures to investigate how this growth rate of a prefecture during a given time period affects the level of labor distortions across plants in that prefecture.[12] Using the plant-level data available to us, we calculate the MPL of plants and find that a decline in the growth rate of the working-age population in a prefecture during a given period increases the standard deviation of the MPL of plants in that prefecture (relative to other prefectures during the same time period). In other words, the data show that a slow-down in the growth rate of working-age population leads to a higher degree of labor distortions across plants in a given prefecture. This empirical finding is new to the literature and directly supports our model's key channel that slower population growth exacerbates firm-level labor distortions.

There are several points worth mentioning before proceeding. First, we allow for job sepa-

[11]This range of population growth rates is consistent with the variation in the (working-age) population growth rates of Japanese prefectures during the period 1980-2020.

[12]We believe our within-country and cross-region analysis can alleviate potential concerns that apply to many cross-country studies (i.e., countries' differing in many dimensions).

rations between workers and firms due to personal reasons in the model to capture the reality that many workers leave their employers due to reasons other than being laid off (e.g., job-to-job/job-to-marriage transitions).[13] Second, as there are several countries that do enforce severance payments in the case of bankruptcy, we extend our baseline model to allow for a *partial* payment of the firing cost in the case of exiting. We show that the model implications under this alternative specification are both qualitatively and quantitatively similar to those obtained from the benchmark model. Third, since the use of dispatched/temporary workers was not an important phenomenon for the manufacturing sector during our sample period (2001-2007), we do not model this worker type.[14] Finally, our model is silent on potential benefits that can arise from the firing cost (e.g., better job security, faster accumulation of firm-specific human capital). Our model shows the interaction between population growth and the impact of the firing cost on *firms*. Therefore, when designing appropriate policies, the results obtained from our study should be combined with those from studies that focus on the positive effect of the firing cost on workers.

Literature Review

To the best of our knowledge, our paper is the first to examine how population growth affects the degree of firm-level distortions and aggregate productivity induced by employment protection. A burgeoning literature has explored the implications of a declining population growth rate for firm entry/exit (Karahan et al., 2024), innovation (Peters and Walsh, 2021; Katagiri, 2023), output and long-run growth (Maestas et al., 2016; Alon et al., 2018; Hayashi, 2023), and the labor share and entrepreneurship (Hopenhayn et al., 2022). We complement this line of research by studying the interaction between population growth and employment protections. We find that the key insight uncovered by the existing research (i.e., the impact of population aging on firm entry/exit) also has important implications for the impact of imposing the firing cost on aggregate productivity.

There has been excellent research that studies the implications of changing population structure (i.e., aging) for various government policies (McGrattan and Prescott, 2018) such as fiscal policy (Carvalho and Ferrero, 2014; Kitao, 2015; İmrohoroğlu et al., 2016), monetary policy (Wong, 2018), tax policy (Ferraro and Fiori, 2020), and pension/health policy (Attanasio et al., 2007; Kitao, 2018; Braun and Joines, 2015). However, few studies have examined how policies that target at firms interact with population aging. Our paper fills

[13]According to the Japanese data, 7.16% of workers in the labor force left their employers due to personal reasons every year during 2001-2007, while 0.86% left their employers involuntarily (i.e., being laid off) every year during that period.

[14]The use of dispatched/temporary workers had become important during and after the global financial crisis.

this gap in the literature.

Finally, there has been a profuse amount of literature that studies implications of the firing cost for various economic outcomes. Bentolila and Bertola (1990) finds that the firing cost has larger effects on a firm's propensity to hire rather than to fire, increasing the average employment of a single firm in a partial equilibrium setting. In a general equilibrium setting, Hopenhayn and Rogerson (1993) find that firing taxes distort firms' hiring and firing decisions, decreasing output and productivity for the aggregate economy. Subsequent research extends Hopenhayn and Rogerson (1993) by introducing capital into the production function (Veracierto, 2001) or search and matching frictions into the labor market (Alvarez and Veracierto, 2001). Our paper emphasizes the assumption that exiting firms do not pay the firing cost, which is related to Samaniego (2006) and Poschke (2009), both of which find that if exiting firms do not pay the firing cost, entry/exit rates will increase in the steady state. Under the same assumption, Samaniego (2006) shows that the negative employment effect of the firing cost is substantially weakened, and Poschke (2009) finds that the negative growth effect of the firing cost is substantially dampened (or even reversed). Our paper presents a complementary view that if exiting firms do not pay the firing cost, population growth matters for productivity gains from eliminating the firing cost.

2 Model

In this section, we first construct and simulate an industry dynamics model with a firing cost and then illustrate how the population growth rate affects the output/productivity gain from eliminating the firing cost. Finally, we show that the entry and exit margins play important roles in generating the interaction between population growth and the gain from eliminating the firing cost.

2.1 Setup

Our discrete-time model economy consists of a continuum of firms that are owned by representative households (with measure one) that inelastically supply labor inputs to firms. Each member of the household is endowed with one unit of labor, and the size of the household (i.e., the number of members), H, grows at rate η. As a result, labor supply grows at the rate of η. There is no aggregate uncertainty, and markets are competitive. There is no friction in the product and labor markets, except for the firing cost that will be introduced later. In what follow, we characterize the balanced growth path (BGP), growing at the same rate as labor supply.[15]

We characterize the household's problem in per capita terms, which we denote with $\bar{x}$, where x is the variable of interest. We use $\bar{W}(\bar{b})$ to represent per capita household value in terms of per capita saving $\bar{b}$:

$$\bar{W}(\bar{b}) = \max_{\bar{c},\bar{b}'}\{\log(\bar{c}) + \beta(1+\eta)\bar{W}(\bar{b}')\}, \tag{1}$$

subject to the budget constraint that

$$P\bar{c} + \bar{b}'(1+\eta) = (1+r)\bar{b} + w + \bar{\pi}^0 + \bar{T}, \tag{2}$$

where r and w are the interest and wage rates, respectively, in the steady state. Per capita saving next period is denoted by $\bar{b}'$, and P is the price of goods. In addition, $\bar{\pi}^0$ is the per capita dividend that comes from aggregate firm profits (excluding the aggregated per capita entry cost). $\bar{T}$ is the (per capita) transfer from the aggregate severance payment to the representative household.

The discount factor is denoted by β. Since the utility function is a logarithm function, the subjective discount factor is

$$DF_{t,t+1} = \beta\frac{\bar{c}_t}{\bar{c}_{t+1}} = \beta,$$

as the per capita consumption is constant in the steady state. This discount factor equals the inverse of the real (gross) interest rate faced by firms in the steady state:

$$\beta = \frac{1}{1+r}.$$

A continuum of firms uses labor as the only input to produce a homogeneous good and sells output in a perfectly competitive market at the price of P. Each firm has decreasing returns-to-scale technology, specified as

$$f(s_t, n) = s_t n^{\nu}, \tag{3}$$

where s_t and n are (labor) productivity and employment, respectively. Firm-level productivity (in log term), $\log(s_t)$, fluctuates stochastically over time according to the following AR(1) process:

$$\log(s_t) = (1-\rho)\bar{s} + \rho\log(s_{t-1}) + \varepsilon_t, \tag{4}$$

[15] BGP prices and firm dynamics are constant and we drop any dependence on time t from the notation.

where ρ is the persistence parameter and ε_t is the productivity innovation in period t. The innovation, ε_t, is drawn from a normal distribution with mean zero and the standard deviation of σ_ε. The initial distribution from which entrants draw their productivities is denoted by Γ_0, which differs from the productivity distribution of active firms in the steady state. Turning to the fixed cost, we assume that there is a per-period fixed cost of operation, f, in terms of labor.

Now, we discuss the separation between workers and firms. First, a randomly selected λ fraction of all firms' incumbent workers are separated from their employers every period, reflecting the fact that workers sometimes leave their jobs due to personal reasons such as job-to-job/job-to-marriage transitions. We further assume that the firm does not know which worker(s) would be separated from the firm exogenously when it makes firing and hiring decisions.[16] Second, we assume that the firm has to pay a firing cost for every laid-off worker who is *not* separated from its employer exogenously. Specifically, the firing cost appears in the form of severance payments:

$$g(n_t, n_{t-1}) = \tau(1-\lambda)w_t \max\left[0, n_{t-1} - n_t\right], \tag{5}$$

where τ denotes the fraction of monthly or annual wage payments that the firm has to pay to the laid-off worker. When $\tau = 0$, the firing cost is zero. As the firm does not pay the firing cost to the exogenously separated worker, the *expected* firing cost the firm pays is the full firing cost (in the case without exogenous separations) multiplied by $1 - \lambda$ (i.e., the fraction of laid-off workers who are not exogenously separated). As all households are homogeneous, we assume that the aggregated severance pay is transferred to all households equally.

The timing of events is specified as follows. At the beginning of each period, the population (labor force) increases by a fraction of η. Potential entrants draw productivities from the distribution, Γ_0, by paying the fixed entry cost, f_e, in terms of labor. If the productivity draw is too low and the firm value associated with it is negative, the potential entrant simply "exits" the market immediately after paying the entry cost. For incumbents, a δ fraction randomly exit the market due to the death shock. The remaining incumbents receive contemporaneous productivity innovations and are able to observe their productivities in the current period. They decide whether to exit the market by comparing the continuation value and the cost of exiting (which is zero in the benchmark model). Both entrants and incumbents that choose to stay in the market adjust employment and produce (and sell) output in the perfectly competitive market. New entrants do not pay the firing cost as they have

[16] In reality, workers who choose to leave their employers are probably not the type of workers firms want to lay off. In particular, those departing workers usually move to better jobs (i.e., job-to-job transitions) or quit their jobs due to non-performance related reasons (e.g., marriage, having babies).

no existing workers carried over from the previous period. After the incumbents choose the number of workers to lay off (and to retain), a random λ fraction of workers from each group is exogenously separated from the employment. As a result, the incumbents only pay the firing cost to a $1-\lambda$ fraction of the laid-off workers.

Next, we discuss the value functions. There are two aggregate state variables (P and w) and two firm-level states (s_t and n_{t-1}) for incumbents. Thanks to the Walras's law, we choose the wage rate as the numeraire. Therefore, the value function of an incumbent at the beginning of the period is

$$V^{inc}(s_t, n_{t-1}; P) = \max\left[-\kappa g(0, n_{t-1}), \max_{n_t}\left(s_t n_t^{\nu} - n_t - g(n_t, n_{t-1}) - f + \frac{1-\delta}{1+r} E_{\varepsilon_{t+1}} V^{inc}(s_{t+1}, n_t; P)\right)\right], \tag{6}$$

where the last part is the continuation value from next period. Note that we assume $\kappa = 0$ in the benchmark model (i.e., exiting firms do not make severance pays to laid-off workers).[17] We use the indicator functions $X(s_t, n_{t-1})$ and $h(s_t, n_{t-1})$ to denote the exit choice and employment choices of the incumbent, respectively. For an entrant with the productivity draw of s_0, the value function is

$$V^{ent}(s_0; P) = \max\left[0, \max_{n_0}\left(s_0 n_0^{\nu} - n_0 - f + \frac{1-\delta}{1+r} E_{\varepsilon_1} V^{inc}(s_1, n_0; P)\right)\right]. \tag{7}$$

We use the indicator functions $X_0(s_0)$ and $h_0(s_0)$ to denote the exit choice and employment choices of the entrant, respectively.

2.2 Equilibrium conditions

We now specify equilibrium conditions. First, the supply of potential entrants is perfectly elastic, and each of them can enter the economy by paying an entry cost, f_e, specified in units of labor. Based on the value functions defined above, the free-entry condition can be written as

$$f_e \geq \int_{s_0} V^{ent}(s_0; P) d\Gamma_0(s_0), \tag{8}$$

where the inequality is strict in an equilibrium without entry. The free-entry condition has to be an equality for a BGP with constant prices when the labor supply is growing.[18] The free-entry condition pins down the mass of potential entrants, while the zero-payoff-condition implied by equations (6) and (7) pins down the exit cutoff on realized productivity for the

[17] We do allow for a positive (but small) κ in our additional numerical exercises.

[18] Note that if there were no entry, clearing the labor market through only incumbent firms' labor demand would require a continuously declining real wage which is impossible.

incumbents and entrants.

Next, we study the law of motion for firm-level productivities. We use M to denote the measure of (potential) entrants, and $\mu(s_t, n_t)$ to denote the measure of all firms (entrants and incumbents) with current productivity s_t and current employment n_t at the end of each period. We define the per capita versions of these two variables as $\bar{M} = M/H$ and $\bar{\mu} = \mu/H$, respectively. Then, we can state the evolution of firm-level state variables from the current period to the next period as

$$\begin{aligned}\bar{\mu}(s_{t+1}, n_{t+1}) \quad = \quad & \int_{s_t}\int_{n_t} \mathit{1}\left[h(s_{t+1}, n_t) \equiv n_{t+1}\right]\left[1 - X(s_{t+1}, n_t)\right](1-\delta) f(s_{t+1}|s_t)\frac{\bar{\mu}(ds_t, dn_t)}{1+\eta} \\ & + \mathit{1}\left[h_0(s_{t+1}) \equiv n_{t+1}\right] \bar{M}'\left[1 - X_0(s_{t+1})\right]\gamma_0(s_{t+1}), \qquad (9)\end{aligned}$$

where $\gamma_0(s_{t+1})$ is the probability density function (PDF) of entrants' productivities in period $t+1$, and $f(s_{t+1}|s_t)$ is the transition productivity from productivity s_t to productivity s_{t+1}. Both $\mathit{1}\left[h(s_{t+1}, n_t) \equiv n_{t+1}\right]$ and $X(s_{t+1}, n_t)$ are indicator functions of the employment choice and the exit choice for incumbents. Similarly, we can define these two functions for entrants as $\mathit{1}\left[h_0(s_{t+1}) \equiv n_{t+1}\right]$ and $X_0(s_{t+1})$.

Next, we describe the labor and product market clearing conditions. First, since there is no capital and we have representative households, we have $\bar{b}' = \bar{b} = 0$. As a result, the budget constraint can be rewritten as

$$P\bar{c} = H + \bar{\pi} + \bar{T}, \qquad (10)$$

where we have assumed that the wage rate is the numeraire. The firm's per-period profit is

$$\pi(s_t, n_{t-1}, n_t) = Pf(s_t, n_t) - n_t - f - \tau g(n_t, n_{t-1}), \qquad (11)$$

where $n_t \equiv h(s_t, n_{t-1})$ or $n_t \equiv h_0(s_t)$. Aggregate profits plus the aggregate amount of severance pays (in per capita terms) are

$$\begin{aligned}\bar{\pi} + \bar{T} &= \int \pi(s_t, n_t) d\bar{\mu}(s_t, n_t) \\ &= \int \left[Pf(s_t, n_t) - n_t - f\right] d\bar{\mu}(s_t, n_t), \qquad (12)\end{aligned}$$

where $\bar{\mu}(s_t, n_t) \equiv \frac{\mu(s_t, n_t)}{H_t}$ is the steady state distribution of firm-level states for all firms (at the end of the period) in per capita terms. Goods market clearing requires

$$\bar{Y} = \int f_t(s_t, n_t) d\bar{\mu}(s_t, n_t) = \bar{c} = \frac{H + \left(\bar{T} + \bar{\pi} - f_e \bar{M}\right)}{P}, \tag{13}$$

where $\bar{M}$ is the number of entrants per capita in the current period. Note that the mass of incumbents is proportional to the number of entrants (i.e., the entry rate is constant). Labor market clearing requires

$$H = \int_{s_t} \int_{n_t} (n_t + f) d\bar{\mu}(s_t, n_t) + \bar{M} f_e. \tag{14}$$

Walras's law implies that as long as one of the above two equations holds, the economy is in equilibrium.

We define the BGP as follows. A BGP equilibrium growing at rate η consists of the constant price of the goods P, real wage rate w (normalized to one), interest rate r, savings $\bar{b}$, consumption $\bar{c}$, profits $\bar{\pi}$, and the aggregate firing cost $\bar{T}$ (all in per-capita terms), labor demand functions and exit policy functions (for the incumbents and the entrants) $h(s_t, n_{t-1})$, $h_0(s_0)$, $X(s_t, n_{t-1})$ and $X_0(s_0)$, an invariant distribution of incumbent firms $\bar{\mu}(s_t, n_t)$ and the mass of potential entrants $\bar{M} > 0$ (all in per-capita terms) such that: (i) given P, w, r, $\bar{\pi}$ and $\bar{T}$ that $\bar{c}$ and $\bar{b}$ solve equation (1); ii) firm-level labor demands, $h(s_t, n_{t-1})$ and $h_0(s_0)$, and exit choices, $X(s_t, n_{t-1})$ and $X_0(s_0)$, solve equations (6) and (7); iii) free-entry condition in equation (8) is satisfied with equality; iv) the distribution of incumbent firms, $\bar{\mu}(s_t, n_t)$, and the mass of potential entrants, $\bar{M}$, satisfy the law of motion in equation (9); and v) markets clear so that equations (13)-(14) are satisfied.

3 Quantitative Analysis

In this section, we quantitatively assess how population growth interacts with the firing cost in terms of resource allocation and aggregate productivity. First, we introduce the plant-level data we use. Then we describe our calibration procedure and show the mapping from model parameters to empirical moments obtained from the plant-level data. Using the calibrated model, we conduct counterfactual analyses and show that a decline in the population growth rate has a quantitatively sizable impact on how the firing cost affects aggregate productivity. Furthermore, we provide direct evidence for our model's key channel that is related to how population growth affects plant-level labor distortions.

3.1 Data

We use a plant-level dataset called the "Census of Manufacture" from Japan for the period 2001-2007 to calibrate our model. This dataset is an annual survey conducted by the Ministry of Economy, Trade, and Industry (METI). The data consist of two layers: plant and product level. Plant-level variables (e.g., revenues, employment, wage bills, spending on intermediate inputs, and investments) are from the plant-level data, and product-level variables (e.g., shipments and physical quantities) are from the product-level data. In this analysis, we only use the plant-level information. The annual census data cover all manufacturing plants with four or more employees as plants employing fewer than four employees are not surveyed every year.[19]

3.2 Calibration

We first describe model parameters that we set/calibrate externally. First, we follow Hopenhayn et al. (2022) to set the curvature of the production function, ν, to 0.64 and the annual discount factor, β, to 0.96. Next, the separation rate between firms and workers due to personal reasons (e.g., job-to-job/job-to-marriage transitions) is set to 7.16%, which is consistent with the statistics from the Ministry of Health, Labor, and Welfare (MHLW) of Japan. Third, data from the Ministry of Internal Affairs and Communications of Japan show that the average labor force growth rate in the 2000s-2010s was roughly -1%. Fourth, we set the exogenous death rate of firms in the model to the annual exit rate of the largest 5% plants, which is 2.8% in the data. Finally, the long-run mean of the AR(1) process of firm productivity is normalized to zero as it is unidentifiable in the calibration.[20] All externally set/calibrated parameter values are reported in Table 1.

Table 1: Parameter Values: calibrated externally

Parameters	Description	Value	Source
ν	curvature of revenue function	0.64	Hopenhayn et al. (2022)
β	discount factor	0.96	Hopenhayn et al. (2022)
λ	exogenous separation rate	7.16%	40 years of working
$\eta_{2000-2010}$	labor force growth rate in 2000s and 2010s	-1%	Japan government
δ	exogenous death rate	2.8%	death rate of top 5% firms (in terms of employment)
$\log(\bar{s})$	long-run mean of AR(1) process	0	normalization

Time period: 2001-2007. Data: Census of Manufacturers.

Now we turn to the parameters calibrated inside the model. In total, we need to calibrate seven parameters ($\bar{s}_{ent}$, ρ, σ_{ε}, σ_{ent}, f, f_e, and τ) to match eight empirical moments

[19]Those plants are only surveyed in years ending with 0, 3, 5 and 8.

[20]What the model can identify is the productivity difference between entrants and incumbents.

that are frequently used by firm dynamics models. We minimize the sum of the squared difference between the model moments and the data moments. Table 2 presents the calibrated parameters as well as the corresponding moments.

We describe how each moment helps us calibrate its corresponding parameter.[21] First, we use the size ratio of incumbents to entrants to identify the difference in the average productivity between entrants and incumbents as an increase in $\frac{\bar{s}}{\bar{s}_{ent}}$ raises this ratio. Second, we use the serial correlation of (log) employment to pin down ρ (the persistence of the productivity shock). Third, we use the average exit rate of plants to calibrate σ_ε as a larger variance of productivity innovation leads to more exits (conditioned on the mean). Fourth, the standard deviation of plants' productivity draws, σ_{ent}, is calibrated using the standard deviation of the (log) employment distribution of entrants. Fifth, we use the entry rate to pin down the entry cost, f_e. Sixth, the fixed operation cost, f, is calibrated using the employment shares of the top 5% and 10% incumbent plants (among all incumbents), as a higher fixed cost implies tougher selection and thus a smaller employment share of top plants.

The firing cost (as a fraction of the annual wage), τ, is a crucial parameter for our quantitative analyses. The MHLW of Japan has been surveying plants for job separations annually. As a result, the Survey on Employment Trends provided by the MHLW includes a breakdown of job separations based on various reasons (e.g., layoffs, job-to-job transitions, job-to-marriage transitions). We use the fraction of workers being laid off to calibrate τ. Intuitively, a higher firing cost disincentivizes firms to lay off workers and leads to a smaller fraction of workers being fired. Our calibrated τ is 1.312, which implies a firing cost that approximately equals wage payments in 15 months.

Table 2: Parameter Values: calibrated inside the model

Parameter	Description	Value	Moment	Data	Model
$\log(\bar{s}_{ent})$	mean of log prod. dist. of entrants	-3.469	size ratio of incumbents to entrants (value-added)	2.66	2.66
ρ	persistence of AR(1) process	0.971	corr. of log employment in two consecutive years	0.983	0.982
σ_ε	s.d. of inno. to incumbent's prod.	0.188	exit rate	10.2%	9.93%
σ_{ent}	s.d. of entrants' productivity draws	1.819	s.d. of log employment distribution of entrants	0.90	0.869
f_e	sunk entry cost	0.195	entry rate	8.7%	9.02%
f	per-period fixed operation cost	2.168	employment shares of top 5% incumbents	49.8%	50.37%
-	per-period fixed operation cost	2.168	employment shares of top 10% incumbents	62.2%	62.71%
τ	firing cost (percentage of annual salary)	1.312	fraction of workers being fired	0.86%	0.85%

Time period: 2001-2007. Most data moments are obtained from the Census of Manufacturers, while the fraction of workers being fired among all workers is obtained from the Survey on Employment Trends produced by the Ministry of Health, Labor and Welfare (MHLW) of Japan. Notations: s.d.: standard deviation; corr. : correlation coefficient; inno. : productivity innovation; prod.: productivity.

Since we use eight moments to calibrate seven parameters, our calibrated model cannot

[21] Our identification strategies follow Hopenhayn et al. (2022) closely.

perfectly match the data moments. However, Table 2 shows that the moments generated by our model are very close to their empirical counterparts. Moreover, Table 3 shows that our calibrated model matches several key non-targeted moments reasonably well.

Table 3: Non-targeted Moments

Moment	Data	Model
s.d. of log employment distribution of incumbents	0.97	1.08
vol. of (log) employment growth	0.166	0.217
average sales growth	3.93%	4.29%
average value-added growth	3.41%	4.29%
3-year exit rate	24.7%	26.0%
5-year exit rate	35.7%	38.6%

Time period: 2001-2007. Data: Census of Manufacturers. Notations: s.d.: standard deviation; vol.: volatility.

3.3 Counterfactual Analyses

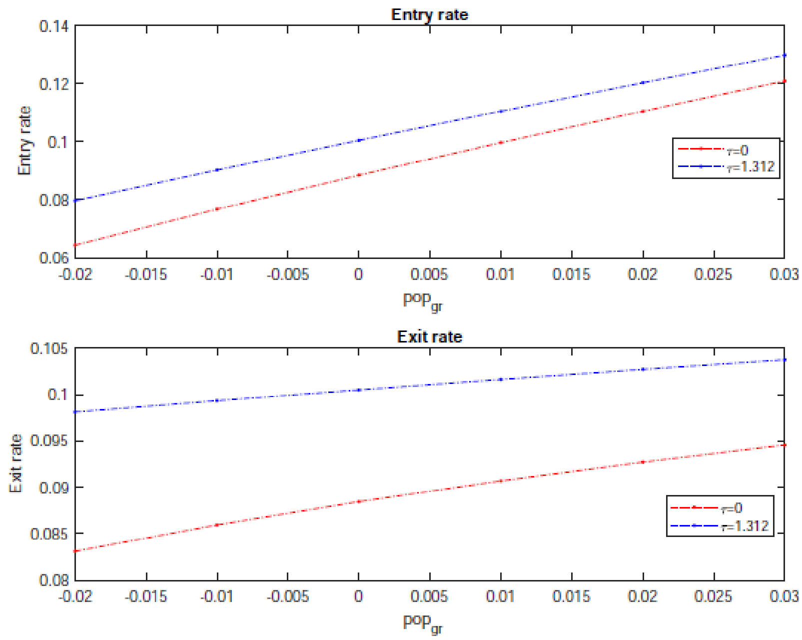
Having calibrated our model, we conduct counterfactual analyses by reducing the firing cost, τ, to zero under different population (i.e., working-age population) growth rates. We start our analyses by studying how population growth affects firm entry/exit. Figure 3 shows that both the entry and exit rates vary positively with the population growth rate, which is consistent with the findings in Hopenhayn et al. (2022) and Karahan et al. (2024). Note that the output price increases when we increase τ from 0 to 1.312 as a higher firing cost makes the market less competitive. However, it does not vary with the population growth rate.[22] Thus, the exit rate *conditioning* on age does not change with the population growth rate. As the entry rate drops with the decline of the population growth rate, the average age of firms increases. Thus, the average exit rate also falls as older firms are less likely to exit. Owing to the increasing exit rate, the entry rate moves *more than* one-to-one with respect to the population growth rate.[23]

Next, we turn to the output gain from eliminating the firing cost. The data show that the annual growth rates of the working-age population in 47 Japanese prefectures during 1980-2020 range from roughly -2% to 3%. Therefore, we set the range of population growth to -2% to 3%. Figure 4 shows that the output/productivity gain increases when the population growth rate is lower. For instance, when $\tau = 1.312$, the output gain (by eliminating the firing cost) in the case of a -1% (1%) annual growth rate of labor force is 8.14% (6.83%). In other words, the gain in output increases by approximately 19% ($= (8.14\% - 6.83\%)/6.83\%$) when

[22]The population growth rate affects endogenous variables only at the extensive margin (e.g., entry/exit rates, number of firms) when the aggregate entry cost varies *linearly* with the number of potential entrants.

[23]Note that we analyze the steady state; thus, average firm size in unchanged over time.

Figure 3: Population growth and firm entry/exit



Note: This figure plots how the entry and exit rates vary with the population growth rate.

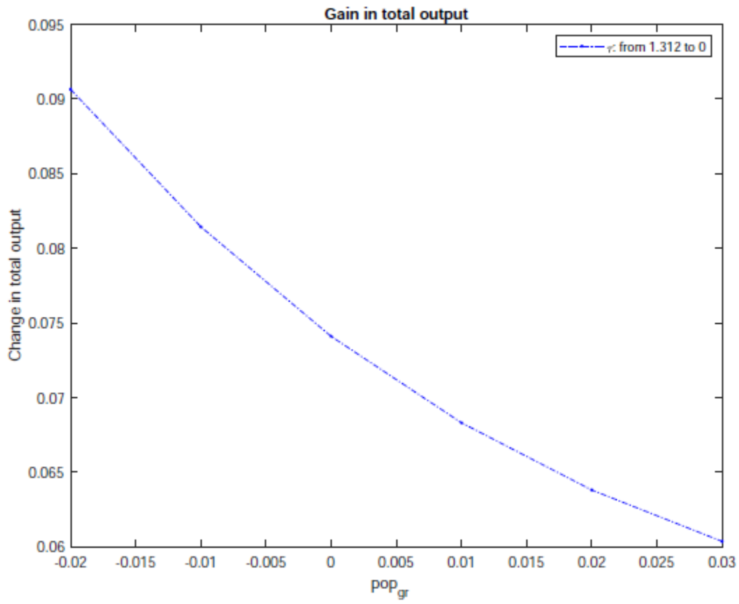
the annual growth rate of the labor force drops from 1% (Japan in 1980s) to −1% (Japan in late 2000s and early 2010s). When the annual growth rate of the labor force drops from 3% to −2%, the gain in output increases from 6.04% to 9.07%, which is substantial.

To better understand the channel through which the population growth rate affects the output gain, we plot how the variance of the marginal productivity of labor (MPL) changes with the population growth rate in Figure 5. While the MPL is equalized in the case without the firing cost (i.e., zero variance), it is not equalized in the current model. As Hopenhayn and Rogerson (1993) insightfully point out, the output loss stems from the distortion of allocating labor across firms, as exemplified by the dispersion of the MPL across firms. Figure 5 shows that the (standardized) dispersion of MPL declines with the population growth rate, meaning that the firing cost creates a lower level of labor distortion when the population growth rate is higher. This explains why the output gain is larger when the population growth rate is lower.

The distortion channel generated by our calibrated model is quantitatively comparable to that in the data. Specifically, we calculate the dispersion of (the standardized) MPL across plants using our data.[24] Interestingly, the dispersion of the MPL calculated from the data (0.233-0.248) is quantitatively similar to the one generated by our calibrated model (0.201),

[24] Section 3.4 discusses how we construct the measure of MPL using our plant-level data.

Figure 4: Population growth, the firing cost, and output gains



Note: This figure plots how the change in output (after the firing cost's being eliminated) varies with the population growth rate.

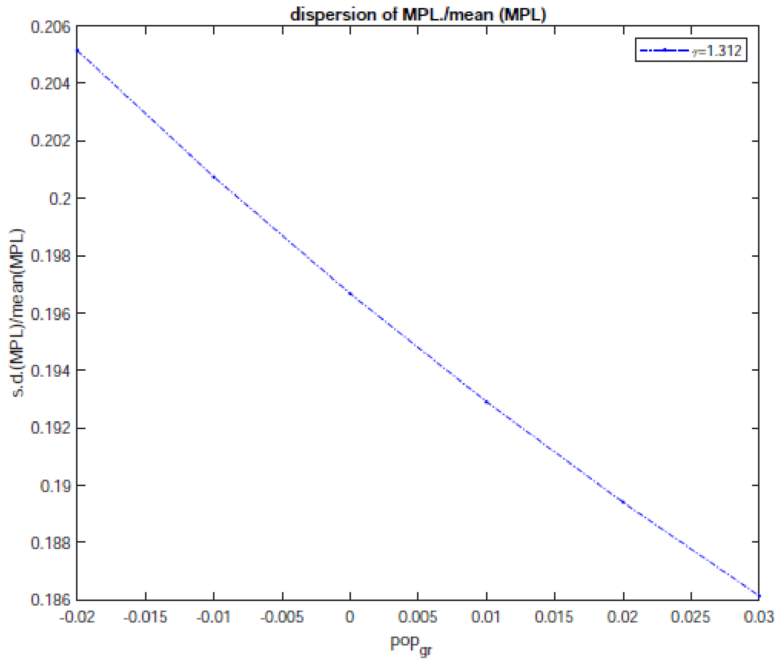
although we do not target this moment in the calibration. This shows that the quantitative magnitude of the distortion channel generated by our model is comparable to that in the data.

Next, we analyze the output gain by focusing on how the aggregate (real) profits vary with the firing cost and the population growth rate. The aggregate (real) profits in the model are aggregated firm profits plus the aggregate firing cost and minus the aggregate entry cost (divided by the output price).[25] Note that the aggregate output equals the total wage payment plus the aggregate profits and divided by the output price (see equation (13)). The total wage payment (in per capita terms) is a constant in the steady state as the labor supply (in per capita terms) and the wage rate are normalized to one in the steady state. Moreover, population growth does not impact the output price for a given τ. Therefore, the reason the output gain varies with the population growth rate must come from differential changes in the (real) aggregate profits (after the firing cost is eliminated).

Figure 6 presents that when the population growth rate is higher (above 2%), eliminating the firing cost actually leads to a reduction in the (real) aggregate profits and vice versa. Imposing a firing cost has offsetting effects on the aggregate profits. First, imposing a firing cost reduces market competition. Subsequently, firms earn more profits. Second, the firing cost distorts firms' labor choices, thus reducing aggregate firm profits. In total, the former

[25] It is the term of $\frac{\bar{T}+\bar{\pi}-f_e\bar{M}}{P}$ in equation (13).

Figure 5: Population growth, the firing cost, and productivity



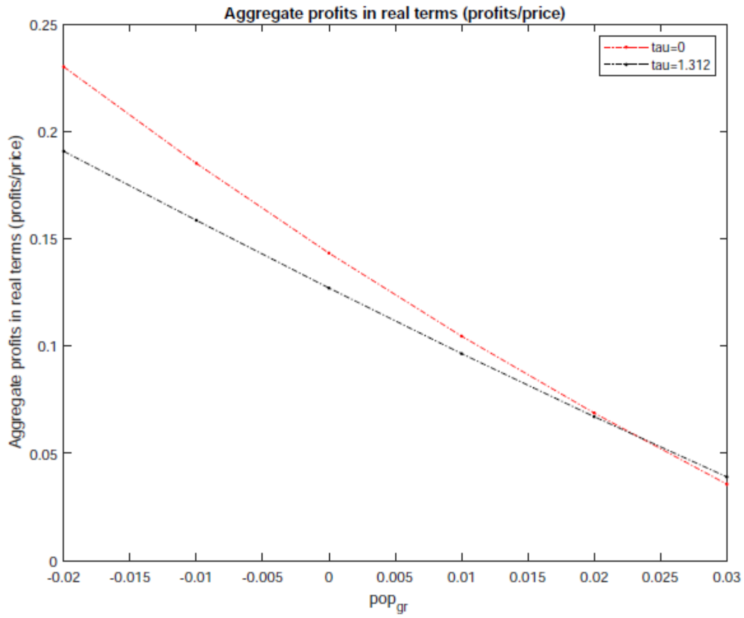
Note: This figure plots how the dispersion of the MPL varies with the population growth rate.

effect dominates the latter when population growth is higher. Intuitively, more firms enter and exit (and suffer less from the labor distortion) when the firing cost is in place, *and* the population growth rate is higher. In total, the output gain is larger in the case of a lower population growth rate as the aggregated profits increase (more) after the firing cost is removed.

3.4 Evidence on how Population Aging Affects the Level of Distortions

In this subsection, we use our plant-level data for 1985-2018 to provide evidence on how population aging affects the level of distortions exemplified by the standard deviation of the normalized MPL. We calculate the MPL using the several steps. First, we assume that the production function takes the Cobb-Douglas form (in terms of capital and labor) and is (2-digit) industry-year specific. We then back out the labor share for industry-year pairs using information on the value added and total wage bill. Next, we define the MPL as the value-added divided by employment and multiplied by the labor share parameter, which is how we calculate the MPL in the Cobb-Douglas case. Finally, we winsorize the calculated MPLs and tease out the industry-year level components from the originally calculated MPLs and

Figure 6: Population growth and aggregate profits



Note: This figure plots how the aggregate profits (plus the transfer) vary with the population growth rate.

obtain the residual MPL.[26] Starting from the residual MPL, we obtain its standard deviation across plants in each prefecture-year cell and treat this variable as the dependent variable in our regression analysis.

We exploit differential changes in the growth rate of the working-age population across 47 Japanese prefectures to investigate how this growth rate during a given time period affects the level of labor distortions across plants in that prefecture. We choose this approach for several reasons. First, the labor market institutions and regulations are primarily determined at the national level in Japan. As a result, there is little variation in the firing cost across regions in Japan. However, there are substantial differences in the growth rate of the working-age population across Japanese prefectures during our sample period.[27] Finally, we believe that this within-country and cross-region analysis can alleviate potential concerns that apply to cross-country studies, as different regions within the same country (especially in Japan) are

[26]We choose to do so, since we want to eliminate the potential composition effect (from the calculation of the dispersion of MPL at the prefecture-year level) caused by different industrial structures held by various prefectures during different time periods.

[27]The average growth rate of working-age population across Japanese prefectures had dwindled from 0.7% in 1985 to -1.3% in 2018, while its standard deviation had only decreased from 0.8% in 1985 to 0.6% in 2018. In particular, places like Tokyo had had little reduction in the annual growth rate of working-age population during 1985-2018 (0.3%), while other places such as Saitama prefecture and Nara prefecture had had substantial reductions in the annual growth rate of working-age population during same period (over 3%).

largely subject to the same government policies, institutions and culture. Specifically, the regression we run is

$$s.d.(MPL)p,y = \beta_0 + \beta_1 working\ gr_{p,y} + \delta_p + \delta_y + \epsilon_{p,y}, \tag{15}$$

where $s.d.(normalized\ MPL)p,y$ is the standard deviation of the residual MPL. The variable of $working\ gr_{p,y}$ is the annual growth rate of the working age population at the prefecture-year level. Next, we always include the prefecture fixed effects δ_p and the year fixed effects δ_y to in the regression. Consequently, we are comparing prefectures with different growth rates of the working age population in the same time period in the regression analysis.

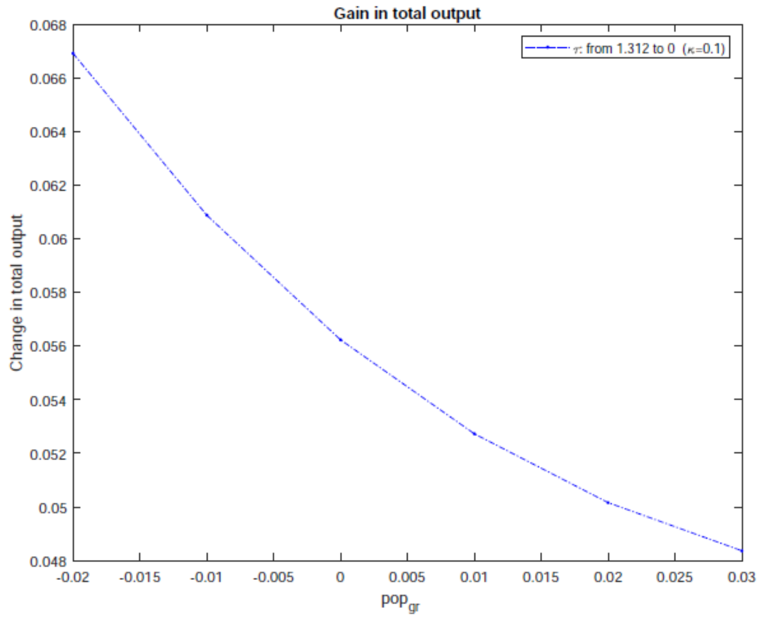
The regression result reported in Table 4 supports our model's key channel. Specifically, the coefficient of β_1 is estimated to be negatively significant, suggesting that the dispersion of the MPL across plants within a prefecture increases more when the growth rate of the working-age population drops more (compared to other prefectures). In other words, a slow-down in the growth rate of working-age population leads to a higher degree of labor distortions across plants in a given prefecture. This finding is robust to the level of trimming the MPL (when calculating the standard deviation of the MPL). Moreover, the quantitative magnitude is sizable. The last column of Table 4 implies that a 0.8% decline in the growth rate of the working-age population (which is roughly its standard deviation in our sample) leads to roughly a 0.0011 increase in the dispersion of the MPL across plants within a prefecture (standard deviation of the MPL: 0.014). In summary, this empirical finding is new and supports our model's key channel that slower population growth exacerbates firm-level labor distortions.

Table 4: Population aging and Prefecture-level Distortions

	$s.d.(MPL)p,y$ (trimmed)			
$working\ gr_{p,y}$	-0.0921** (0.0412)	-0.104** (0.0469)	-0.120** (0.0553)	-0.134** (0.0631)
level of trimming	top and bottom 3%	top and bottom 2%	top and bottom 1%	top and bottom 0.5%
Prefecture Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
N	1598	1598	1598	1598
adj. R^2	0.978	0.975	0.974	0.971

Time period: 1985-2018. The estimate of the constant is suppressed. Standard errors are clustered at the prefecture level, and there are 47 prefectures. * 0.10 ** 0.05 *** 0.01

Figure 7: Population growth, the firing cost, and output gains ($\kappa = 0.1$)



Note: This figure plots how the change in output (after the firing cost's being eliminated) varies with the population growth rate.

3.5 Partial Payment of the Firing Cost in the Case of Exiting

In the final part of this section, we check whether our quantitative result is sensitive to the assumption that exiting firms do not pay the firing cost at all. Specifically, we assume that the exiting firm pays 10% (denoted by κ) of the firing cost that a downsizing (but non-exiting) firm pays. Figure 7 shows that our results presented in the benchmark model are barely changed, both qualitatively and quantitatively.

4 Conclusion

This study examines the impact of the firing cost on firm-level distortion and aggregate productivity through the lens of population growth. The key finding is that the negative impact of the firing cost on output (and aggregate productivity) is larger when the (working-age) population growth rate declines. A lower population growth rate leads to fewer entrants and exiting firms, which barely pay the firing cost, and makes a larger fraction of firms (i.e., incumbents) suffer from the firing cost. Using plant-level data from Japan, we calibrate the model and find a quantitatively sizable impact of a decline in the population growth rate on the negative output/productivity effect of imposing the firing cost. Moreover, our calibrated model generates a distortion channel that gains empirical supports in the case of Japan and is quantitatively similar to that obtained from our Japanese plant-level data.

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