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Abstract

This paper examines the causal effects of population aging on manufacturing activity using municipality- and establishment-level data from Japan. Combining the Census of Manufacture with Population Census data for the 1980-2010 period, we exploit predetermined demographic structure to identify the impact of aging on local manufacturing outcomes. We find that population aging leads to large and statistically significant declines in total manufacturing employment, sales, and value added. These effects operate through both extensive and intensive margins: aging reduces the number of manufacturing establishments and lowers employment and output per establishment. We also document increases in manufacturing labor productivity and wages, driven primarily by the rapid exit of less productive plants in aging regions, with little evidence of changes in entry dynamics.

Keywords: Population aging; manufacturing; Japan
JEL classification: J14

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This study utilizes the micro data of the questionnaire information based on "Census of Manufacture" which is conducted by the Ministry of Economy, Trade and Industry (METI), and the Kogyo Tokei converter, which is provided by RIETI.

1 Introduction

Population aging is one of the most profound demographic transformations confronting advanced economies. Declining fertility rates and rising life expectancy have sharply increased the elderly share in population, reshaping labor markets, consumption patterns, and long-run growth prospects. Among advanced economies, Japan represents the leading case of demographic transition into a super-aging society. The share of the population aged 65 and above is approaching 30 percent in 2025. These demographic changes, particularly accelerated since the 1990s, have coincided with prolonged economic stagnation, weak productivity growth, and a pronounced decline in the share of manufacturing in total employment and output. Despite this temporal overlap, the causal relationship between population aging and the contraction of manufacturing activity remains insufficiently understood.

A large literature examines the macroeconomic consequences of aging, emphasizing its effects on labor supply, savings behavior, productivity growth, and secular stagnation (e.g., Maestas et al., 2023). At the aggregate or regional levels, population aging is widely found to reduce labor force growth and GDP per capita growth, with productivity effects depending on technological adaptation (Acemoglu and Restrepo, 2017). At the sectoral level, several studies argue that aging shifts demand away from manufactured goods toward services (e.g., healthcare and personal services), thereby contributing to long-run deindustrialization (Siliverstovs et al., 2011). On the supply side, manufacturing is often viewed as disproportionately reliant on prime-age workers, whose physical capacity and mobility exceed those of older cohorts. As these cohorts shrink, manufacturing activity may contract relative to services.

This paper contributes to the literature by providing causal evidence on the effects of population aging on manufacturing in Japan. We combine establishment-level panel data and municipality-level aggregates from the Census of Manufacture with Population Census data spanning 1980-2010, a period during which Japan experienced rapid demographic aging alongside a secular contraction of manufacturing. To address endogeneity arising from migration and local economic shocks, we exploit the predetermined nature of local demographic structure and instrument contemporaneous aging with lagged cohort composition. Specifically, we use the population distribution from ten years earlier and age-specific survival rates to construct the predicted population aged 65 and above, as well as the predicted working-age population (aged 20 and above). We then compute the predicted share of the elderly in the working-age population, thereby isolating variation driven by demographic arithmetic rather than contemporaneous economic conditions.[1]

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[1] Our predicted measure is similar to that used by Maestas et al. (2023), who construct changes in the

Our analysis yields three main findings. First, population aging leads to large and statistically significant declines in local manufacturing employment, output, and value added at the municipal level. Second, these effects operate through both extensive and intensive margins: aging reduces the number of manufacturing establishments and lowers employment and output per establishment. Third, we find that aging is not associated with higher labor productivity or wages at the municipality level. To better understand the mechanisms underlying these findings, we use the universe of manufacturing establishments and show that the results are largely driven by two offsetting effects: the exit of less productive plants and declines in within-establishment productivity in aging regions. We also find little evidence of declining entrepreneurship in these regions. Our results highlight the role of population aging in shaping local manufacturing dynamics. While aging substantially reduces the scale of local manufacturing activity, it simultaneously induces productivity-based selection (e.g., Hopenhayn, 1992).

This paper is closely related to the literature exploiting within-country regional variation in population aging. Maestas et al. (2023) use U.S. state-level data and show that local population aging has negative effects on labor productivity. Using prefecture-level data from Japan, Fukuda and Okumura (2021) examine how regional population aging affects saving rates and regional flows of funds. In contrast to these studies, we exploit substantially finer geographic variation (approximately 1,700 municipalities) to examine the effects of exposure to population aging on local manufacturing activity. This rich cross-sectional dimension over decades allows us to isolate demographic effects at a much more granular level and to study how aging reshapes the scale and structure of manufacturing within local economies.

This paper also contributes to the growing literature on the effects of population aging on firm-level and production outcomes. While macroeconomic studies (e.g., Maestas et al. 2023) find that population aging reduces aggregate productivity growth, a growing body of work from firm-level data highlights offsetting mechanisms through which aging may raise labor productivity. In particular, population aging can induce technological adoption, innovation, and capital deepening, suggesting that aging does not necessarily harm firm performance (e.g., Tan et al., 2022; Carta et al., 2021). We extend this literature by jointly examining both exit and entry dynamics. While prior studies typically analyze the effects of aging on entrepreneurship (e.g., Liang et al., 2018) and bankruptcy (e.g., Xu, 2021) separately, we leverage the long-term panel nature of the data to study both entry and exit of manufacturing establishments within a unified framework.

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predicted share of the elderly within the working-age population and apply them to time-differenced state-level data in the United States. It is also important to note that we define the elderly share relative to the working-age population, excluding younger cohorts to isolate the influence of local birth rates on the aging measure.

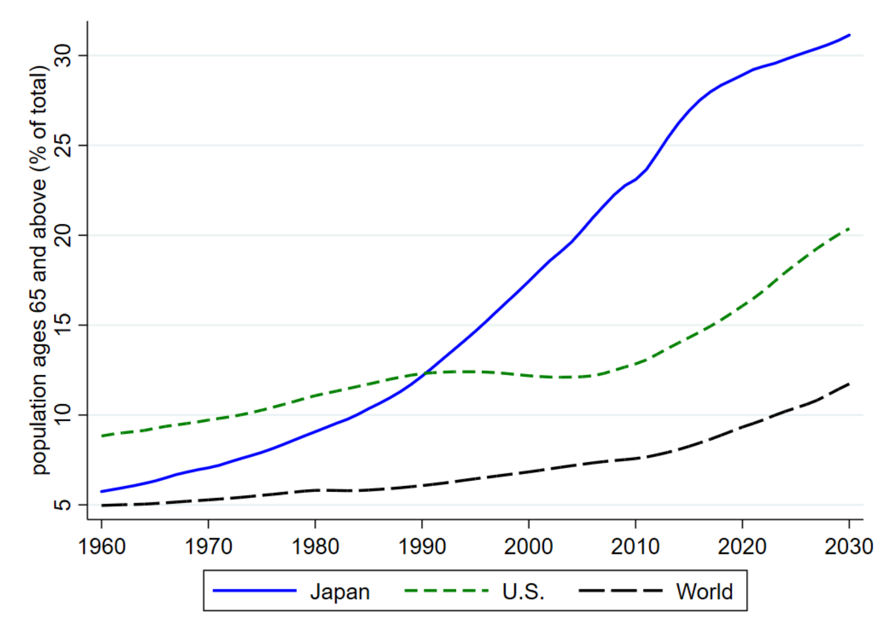
We show that, although population aging substantially reduces manufacturing employment and output at the local level, it is not robustly associated with higher labor productivity and wages within the manufacturing sector. In particular, productivity gains in aging regions are driven primarily by productivity-based selection, which is offset by productivity losses among surviving establishments. We also find that entrepreneurship is not associated with aging, but is positively related to the share of women of childbearing age, which proxies for future population growth.

The remainder of the paper is organized as follows. Section 2 describes the background of population aging in Japan. Section 3 reviews the related literature. Section 4 describes the data. Sections 5 and 6 present the empirical strategy and main results, respectively. Section 7 concludes.

2 Background

Japan is the world's most advanced example of an aging economy. With fertility rates persistently below replacement since the mid-1970s and one of the highest life expectancies globally, Japan has experienced a rapid and sustained shift in its demographic structure. The share of the population aged 65 and above first exceeded that of the United States in 1991, exceeded 20 percent in 2005, and is expected to exceed 30 percent in 2025 (Figure 1). These demographic forces have unfolded faster and earlier in Japan than in any other advanced economy, making it a natural laboratory for studying the economic consequences of population aging.

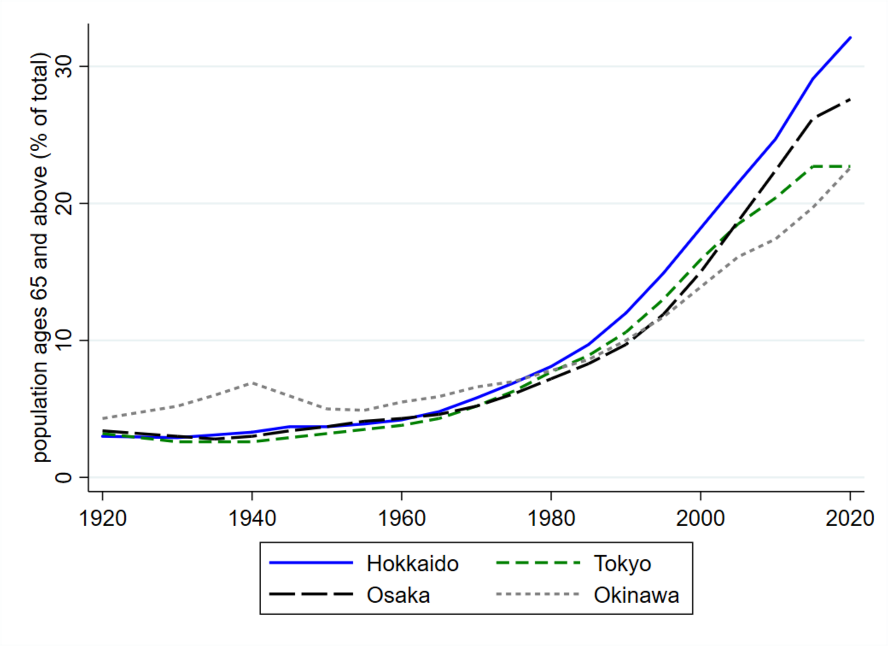
Figure 1: Aging Trend in the World (1960-2030)



Notes. This figure shows the share of the population aged 65 and above from 1960 to 2030, based on World Bank World Development Indicators. Values for the 2020s are projections.

Much of the existing literature examines the effects of population aging on economic outcomes using cross-country data or relatively coarse regional variation within a country. For example, Feyrer (2007) analyzes a country-level sample of 87 countries over the period 1960–1995 and finds a strong association between productivity growth and workforce age composition, especially the proportion of workers aged 40–49. Maestas et al. (2023) use U.S. state-level data to examine the causal relationship between aging and the growth rate of per capita GDP over the 1980-2010 period. Fukuda and Okumura (2021) use Japan's prefecture-level data over the 1975-2019 period and examine the effects of aging on regional saving and the regional flow of funds in Japan. Figure 2 depicts the evolution of the share of the population aged 65 and above from 1920 to 2020 for four prefectures representing different regions of Japan: Hokkaido (north), Tokyo and Osaka (major metropolitan areas), and Okinawa (south). In all prefectures, the elderly population share remains low and relatively stable until the postwar period, followed by a gradual, simultaneous increase beginning in the 1960s and a sharp acceleration after the 1990s. By 2020, the share of individuals aged 65 and above exceeds 20 percent in each prefecture. While the pace of aging differs modestly across regions (aging progresses more rapidly in Hokkaido and more slowly in Okinawa), the timing and overall magnitude of the increase are remarkably similar. Tokyo and Osaka closely track the national pattern. Overall, at the prefecture level, the figure shows that population aging is a pervasive and synchronized phenomenon across Japanese prefectures, with limited cross-regional divergence in long-run trends.

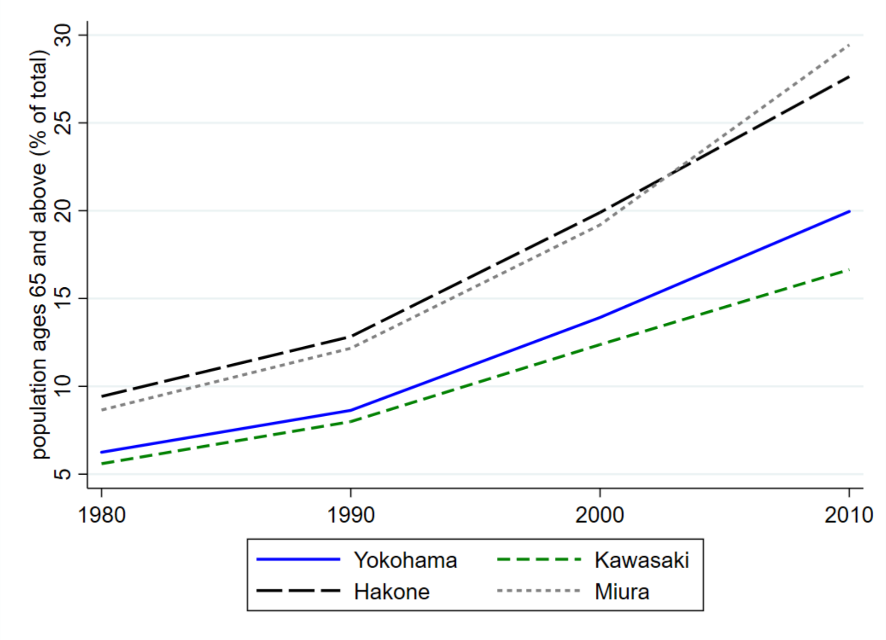
Figure 2: Population Aging in Selected Prefectures (1920-2020)



Notes. This figure shows the share of the population aged 65 and above from 1920 to 2020 for four selected prefectures, based on data from the National Institute of Population and Social Security Research.

Population aging exhibits substantial heterogeneity at finer geographic levels. In Japan, the share of the elderly population varies significantly across municipalities within the same prefecture, reflecting differences in urbanization, industrial structure, and migration patterns. Figure 3 illustrates the evolution of population aging in four municipalities within Kanagawa Prefecture, located south of Tokyo. Kawasaki City and Yokohama City are highly urbanized and closely integrated with Tokyo's labor market, with a large share of residents commuting to firms in Tokyo. In contrast, Miura City and Hakone City are located near the coast and mountainous areas, respectively, and have higher concentrations of employment in agriculture, fishing, and tourism-related activities. In 1980, the share of the population aged 65 and above was substantially lower in Kawasaki and Yokohama than in Miura and Hakone. Although all four cities exhibit a secular rise in population aging, both the initial levels and subsequent changes vary substantially. This heterogeneity indicates that demographic composition is more finely differentiated at the municipality level than at the prefecture level.

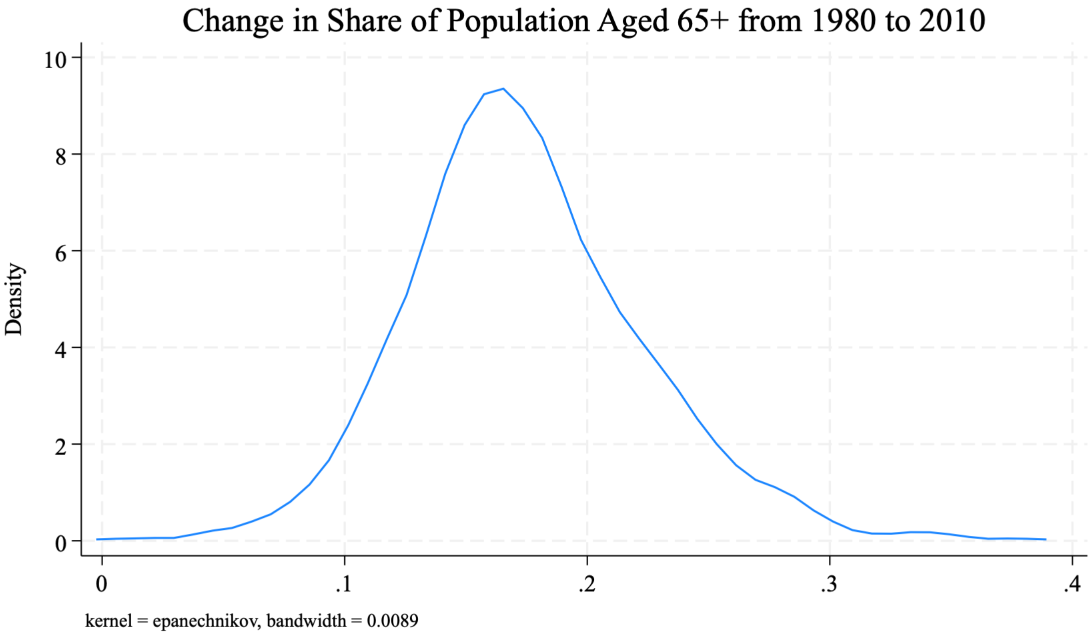
Figure 3: Population Aging in Selected Cities (1920-2020)



Notes. This figure shows the share of population aged 65 or above from 1980 to 2010 for four selected cities from the Population Census in Kanagawa Prefecture.

To highlight the extent of population aging at the municipality level, Figure 4 presents the distribution of changes in the share of the population aged 65 or older between 1980 and 2010. The figure shows that fewer than one percent of municipalities experienced a decline in the elderly population share. The median increase is 17.0 percentage points, the mean increase is 17.5 percentage points, and the standard deviation is 4.85 percentage points.

Figure 4: Distribution of Change in Aging (1980-2010)



Notes. This figure shows the distribution of the change in the share of population aged 65 or above from 1980 to 2010, measured in each municipality.

3 Literature Review

A growing literature examines how population aging shapes economic growth, productivity, firm dynamics, and macroeconomic outcomes. This literature collectively documents that aging affects the economy through multiple, sometimes offsetting, channels operating at the worker, firm, and aggregate levels.

3.1 Aging and Economic Outcomes in the World

Early work emphasizes the relationship between workforce age composition and aggregate productivity. Feyrer (2007) provides one of the first systematic cross-country analyses showing that changes in workforce age structure are strongly correlated with labor productivity growth, with prime-age cohorts (i.e., the share of workers aged 40 to 49) contributing disproportionately to aggregate performance. This demographic mechanism can account for a nontrivial share of cross-country labor productivity gaps.[2] More recent contributions revisit this relationship using richer data and refined identification strategies. Maestas et al. (2023)

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[2] The demographic structure can explain almost one-quarter of the productivity gap between the OECD and low-income countries.

exploit predetermined demographic variation across U.S. states and find that population aging significantly reduces GDP per capita growth, largely through slower labor productivity growth rather than employment declines.

Acemoglu and Restrepo (2017) argue that aging need not depress productivity in normal times, as labor scarcity can induce capital deepening and technological adaptation. However, Eggertsson et al. (2019) show that this positive relationship breaks down after the Great Financial Crisis, when interest rates are constrained by the zero lower bound. Jones (2023) develops a model that incorporates demographics, monetary shocks, and an occasionally binding zero lower bound on nominal interest rates and shows that demographic forces generate slow-moving trends in interest rates, employment, and productivity. Demographic dynamics alone can account for roughly 40 percent of the deviation of log output per capita from its linear trend by 2019. There is a broad consensus that U.S. productivity started slowing down around 2004. Goldin et al. (2024) examine demographic change as one of several secular forces contributing to the productivity slowdown, alongside declining capital deepening, weaker allocative efficiency, and reduced spillovers from intangible capital. They conclude that slow secular developments, such as aging, are unlikely to provide a complete explanation on the productivity slowdown. Park et al. (2021) examine the role of automation and robotics in moderating the productivity effects of aging in South Korea. They document that increases in the share of older workers are generally associated with lower labor productivity and total factor productivity growth. However, robot adoption attenuates these negative effects, particularly for total factor productivity. While the paper finds limited evidence that more rapidly aging industries adopt robots faster, the results suggest that automation enables older workers to remain productive by reducing the physical and cognitive demands of certain tasks.

A second strand of the literature focuses on how aging affects firm entry, exit, and reallocation. Engbom (2019) develops a theory of firm and worker dynamics in which aging reduces entrepreneurship and job mobility through compositional effects. Empirically, aging explains a substantial share of the long-run decline in firm entry and worker mobility in the United States. Liang et al. (2018) provide complementary evidence using cross-country data, showing that older societies exhibit systematically lower rates of entrepreneurship. They emphasize a rank effect, where older workers occupy key positions and slow the acquisition of entrepreneurial skills by younger cohorts. Decker et al. (2014) further show the macroeconomic importance of startups and young firms for job creation and economic dynamism, reinforcing the link between demographics, entry rates, and aggregate outcomes. The aging also alters the structure of local economies. Silverstovs et al. (2011) document a shift in employment shares away from agriculture and manufacturing toward personal services and the financial sector, driven by an aging population. Moreno-Galbis and Sopraseuth (2014) identify that the shift toward personal services due to aging is also responsible for job polarization, since these services require low-paid labor.

Beyond entry and reallocation, several papers examine how aging affects firm behavior and innovation. Tan et al. (2022) show that population aging in China is associated with higher firm-level innovation. This effect is stronger for firms facing higher labor costs, state-owned enterprises, and R&D-intensive sectors, consistent with the idea that labor scarcity can induce technological adaptation. Carta et al. (2021) examine the effects of workforce aging induced by pension reforms in Italy. Using matched employer-employee data, they find that increases in older workers raise employment and value added without reducing labor productivity, suggesting complementarity between older and younger workers at the firm level. These findings challenge the view that aging necessarily imposes productivity costs on firms. Related work by Cooley and Henriksen (2018) and Brakman et al. (2025) highlights how demographic change can alter firm incentives, regional economic structure, and capital allocation, further shaping productivity outcomes through spatial and sectoral channels.

A literature examines the macro-financial consequences of aging. Doerr et al. (2024) show that banks exposed to aging regions increase risk-taking, driven by higher deposit inflows from older households and weaker local credit demand. Auclert et al. (2025) provide a framework quantifying how population aging affects wealth accumulation, rates of return, and global imbalances. They show that the compositional effect of aging (i.e., older cohorts holding disproportionate wealth) predicts declining returns to wealth, rising wealth-to-GDP ratios, and widening international capital flows. Their results underscore the persistent macroeconomic effects of aging.

Finally, demographic change operates through human capital decisions. Borsch-Supan (2003) provides an earlier synthesis of labor market and macroeconomic adjustments to aging, emphasizing the need for productivity-enhancing human capital accumulation and labor mobility to offset declining labor force growth. Hansen and Strulik (2017) exploit the cardiovascular mortality decline in the United States and show that increases in adult life expectancy lead to higher tertiary education enrollment. This mechanism links aging and longevity to human capital accumulation, providing an offsetting channel through which demographic change may raise productivity over the long run.

3.2 Aging in Japan

Japan has served as the leading empirical laboratory for studying the macroeconomic consequences of population aging, given its early and rapid transition into an aged society. A central strand of the literature examines how demographic shifts affect savings, investment, output growth, and external balances over long horizons. Early macroeconomic studies of Japan emphasize the aggregate consequences of aging. Kitao (2016) develops a general equilibrium life-cycle model calibrated to Japan and shows that aging substantially reduces labor supply and output while increasing fiscal pressure through pension and tax systems. Using a time-series cointegration framework for Japan over 1960–2015, Goh et al. (2020) show that changes in population age shares exert statistically significant long-run effects on domestic saving, investment, real GDP, inflation, fiscal balances, and the current account. Their results emphasize that demographic forces generate non-monotonic macroeconomic dynamics, characterized by alternating periods of moderate growth and stagnation, rather than a simple secular decline. This evidence highlights the importance of explicitly modeling demographic structure when assessing Japan's long-run macroeconomic performance. Fukuda and Okamura (2021) examine the impact of population aging on regional savings rates in Japan. Population aging has a positive impact on the average savings rate when the working-age population is large; however, it has a negative impact when the working-age population decreases. Their study suggests that, in prefectures where deposits exceeded loans in the past, bank deposits are expected to decline as society ages, leading to a shortage of local deposits in the near future.

At the firm level, a growing literature studies how aging affects exit, succession, and reallocation. Xu (2021) provides an analysis of small business exits in Japan, distinguishing between voluntary closures, bankruptcies, and mergers and acquisitions. Xu (2021) shows that population aging increases exits via acquisitions while reducing forced exits such as bankruptcies. Population aging does not significantly increase voluntary closures among firms operated by elderly CEOs, suggesting that aging affects exit primarily through macroeconomic and market-wide channels rather than individual retirement decisions. Miyakawa et al. (2025) shift the focus from exit to business succession as a central mechanism linking aging to firm dynamics. Using matched firm-manager data, they document an inverted U-shaped relationship between managerial age and firm performance, with productivity peaking around age 60. Building on these facts, they develop a general equilibrium model with life-cycle managerial ability and endogenous succession. Declining population growth reduces the pool of potential successors, increasing firm closures without succession. At the same time, aging strengthens firm selection by disproportionately eliminating low-productivity firms. Quantitatively, their model predicts that population decline can raise output per capita, highlighting a selection channel that is largely absent from standard macro models of aging.

Taken together, the literature suggests that population aging has complex and heterogeneous effects on economic performance. Aging tends to reduce labor force growth, entrepreneurship, and reallocation, while its effects on productivity and innovation depend on institutional settings, capital market conditions, and firms' and workers' ability to adapt through technology and organization. At the macro level, aging reshapes savings behavior, asset markets, and global capital flows, with some implications for secular stagnation.

4 Data

Population aging reduces labor supply growth, weakens aggregate demand and investment, and places increasing pressure on public finances through pension and healthcare systems. In Japan, these demographic forces have coincided with persistently low interest rates, weak productivity growth, and prolonged economic stagnation. Since the early 1990s, the Japanese economy has experienced an extended period of stagnation, often referred to as the "lost two decades." The existing literature typically attributes this stagnation to the collapse of the asset price bubble (e.g., Caballero et al., 2008; Giannetti and Simonov, 2013) and a slowdown in productivity growth (Fukao, 2013). Nonetheless, the temporal coincidence between the rapid increase in the aging population, the slowdown in per capita GDP growth, and the decline in the share of manufacturing has not yet been systematically examined.

To investigate the causal effects of population aging on economic outcomes, with a focus on the manufacturing sector, we begin by using confidential administrative data from the Census of Manufacture (Kogyo Tokei), administered by the Ministry of Economy, Trade and Industry. The Census of Manufacture covers all manufacturing plants with more than four regular employees and is conducted annually. The data report, among other variables, the number of regular employees, output, and value added. Plant-level data are available from 1980 onward; however, time-consistent plant identifiers that allow the construction of panel data are only available after 1986. Given this limitation and the objectives of our study, we first use data aggregated from plants to the municipality level and then rely on plant-level data when examining entry and exit dynamics later in the paper. In our analysis, employment is measured as the number of regular employees (in persons) and output as total shipments or sales (in ten thousand yen).[3] Labor productivity is approximated by value added per employee (in ten thousand yen), calculated as total sales minus spending on intermediate inputs, divided by the number of regular employees.

Our second data source is the Population Census from the Ministry of Internal Affairs and Communications. The Population Census, which is conducted every five years for the

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[3] The Census of Manufactures reports data on shipments. In this paper, following the literature, we use the terms sales and output throughout the paper.

Table 1: Summary Statistics (Municipality-level Data)

	mean	s.d.	min	max
Share of population aged 65+	0.28	0.11	0.06	1.00
Predicted share of population aged 65+	0.27	0.10	0.06	0.65
Number of establishments	186.9	535.8	0	20,395
Employees (total at municipality)	5,273	11,933	0	355,918
Output (total at municipality, million yen)	166,373	465,025	0	14,697,849
Value added (total at municipality, million yen)	64,984	163,113	-32,992	4,066,764
Employment per establishment	29.4	21.5	0	416
Output per establishment (million yen)	917.8	2,804	0	182,692
Value added per establishment (million yen)	352.9	756.4	-824.8	36,118
Output per worker (million yen)	23.7	22.3	0	779
Value added per worker (million yen)	9.53	7.01	-16	175
Fertility rate	0.32	0.07	0.00	0.88
Share of women of childbearing age	0.14	0.03	0.00	0.24

Source. The Census of Manufacture, the Ministry of Economy, Trade and Industry.

entire population of Japan, reports population data by age and gender at the municipal level. Using the data, we construct the predicted share of the population aged 65 and above within the working-age population (aged 20 and above), based on the population distribution from ten years earlier and national age-specific survival rates.[4] For example, Haltiwanger et al. (1999) construct firm-level measures of workforce age composition, including the shares of workers under age 30, between ages 30 and 55, and over age 55. In contrast, we do not observe establishment-level age structure in our data.

In the municipality-level analysis, we use data at five-year intervals from 1980 to 2010, combining manufacturing data from the Census of Manufacture with the predicted share of the population aged 65 and above from the Population Census. Over this period, many municipalities were merged, particularly after 2000 as part of Japan's local government reforms (the number of municipalities declined from 3,257 in 1975 to 3,218 in 2002, and to 1,727 in 2010). Using the latest municipality codes, we construct a balanced panel dataset at the municipality level.

Table 1 reports substantial variation in demographic and economic characteristics across municipalities. On average, the share of the population aged 65 and above within the working-age population (aged 20 and above) is 0.28, with a wide range from 0.06 to 1.00, indicating significant heterogeneity in population aging. The predicted elderly share, constructed from data ten years earlier, closely tracks the actual share (mean of 0.27), suggesting that the measure captures meaningful variation in aging (see also Figure 5 below).

Manufacturing activity is highly skewed across municipalities. The average municipality

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[4] When using ten-year differenced data, we follow Maestas et al. (2023) and construct the change in the predicted elderly population share in the workforce by combining population distributions from ten and twenty years earlier with the corresponding national age-specific survival rates.

has about 187 establishments and 5,274 employees, but the large standard deviations and high maximum values indicate substantial concentration in a small number of municipalities. Similar dispersion is observed for sales and value added, reflecting differences in local industrial scale. Productivity measures also exhibit notable variation. Both sales per worker and value added per worker vary substantially across municipalities, indicating heterogeneity in firm performance and efficiency.

Finally, demographic variables related to fertility show meaningful variation. The total fertility rate averages 0.32, while the predicted share of mothers averages 0.14, suggesting differences in future population growth potential across municipalities.

5 Empirical Strategy

A key concern in estimating the effect of population aging on manufacturing outcomes is endogeneity. Aging may be jointly determined with the local economic environment. In particular, the out-migration of young working-age individuals is likely to respond to municipal economic conditions.[5] As a result, even after controlling for municipality fixed effects, unobserved negative productivity shocks may simultaneously induce the outflow of younger cohorts, thereby increasing the local share of older residents, and directly reduce manufacturing firm performance.[6] This simultaneity would bias ordinary least squares estimates.

To address this concern, we adopt an instrumental variables strategy that exploits predetermined demographic structure. Specifically, we use the predicted elderly share within the working-age population, constructed from data ten years earlier, as an instrument for contemporaneous aging:[7]

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[5] Siliverstovs et al. (2011), for example, examine both the share of the elderly population and the share of the young population, recognizing that the size and composition of the working-age population depend on changes at both ends of the age distribution. Fukuda and Okumura (2021) explicitly analyze interregional migration and its interaction with aging at the prefecture level.

[6] For example, some municipalities in Fukushima Prefecture were affected by the Great Tōhoku Earthquake and the nuclear accident. Younger populations were forced to relocate out of the region, while some older residents chose not to evacuate. At the same time, the shock disrupted manufacturing activity. Thus, such negative shocks may simultaneously affect both population aging and manufacturing outcomes, posing a challenge for causal identification. Natural disasters are relatively frequent in Japan. See also Cole et al. (2019), who show that the Kobe earthquake induced plant exit, particularly among more vulnerable small establishments.

[7] We follow Maestas et al. (2023), who exploit the fact that population aging is largely predetermined by past fertility decisions and cohort sizes, and construct a shift-share (Bartik, 1991) instrument to identify the causal effects of aging on economic growth. States that happened to have larger cohorts several decades earlier mechanically experienced faster population aging later on, largely independent of contemporaneous economic conditions. This predictable demographic transition provides plausibly exogenous variation in population aging. Specifically, their state-level instrumental variable for population aging combines lagged age-level population shares (the exposure) with national age-level survival rates (the shock). Aggregating the interaction of these two components yields a predicted elderly population share that reflects demographic

$$AgingPred_{it} = \frac{\sum_{i,a>=65} suv_{ta} \times pop_{i,t-10,a-10}}{\sum_{i,a>=20} suv_{ta} \times pop_{i,t-10,a-10}} \tag{1}$$

where $pop_{i,t-10,a-10}$ denotes the population in municipality i in age group $a-10$ in year $t-10$, and suv_{ta} represents the survival rate of age group $a-10$ in $t-10$ at the national level from year $t-10$ to t.

The intuition is that the share of older individuals today is strongly predicted by the size of cohorts approaching old age in the past, while being plausibly exogenous to current economic shocks affecting manufacturing performance.

Our main estimating equation is:

$$Y_{it} = \beta Aging_{it} + \alpha_i + f_t + \phi X_{it} + \epsilon_{it} \tag{2}$$

where i indexes municipalities and t indexes years.

Y_{it} is a measure of manufacturing sector performance in municipality i in year t. We use total employment (the number of regular employees), total sales (total output) and value added per employee (total value added per employee). $Aging_{it}$ denotes the share of the population aged 65 or above in the working population in municipality i in year t.

We instrument for $Aging_{it}$ using $AgingPred_{it}$, defined in equation (1). To alleviate concerns about omitted variable bias, we include a rich set of fixed effects. The baseline specification includes municipality fixed effects α_i and year fixed effects f_t to account for unobserved local economic conditions. The vector X_{it} includes additional control variables: prefecture-by-year fixed effects to flexibly absorb prefecture-level economic shocks,[8] and the logarithm of the initial population interacted with a linear time trend to account for potentially differential trends in outcome variables by initial municipality sizes.

Figure 5 presents a binned scatter plot illustrating the relationship between the 5-year change in the instrumental variable $AgingPred_{it}$, measured approximately ten years prior to year t, and the 5-year change in the treatment variable $Aging_{it}$. The strong positive correlation between these variables indicates a powerful first-stage relationship. As shown in the following tables, the Kleibergen–Paap (2006) Wald F test rejects the null hypothesis that the instrument is weak.

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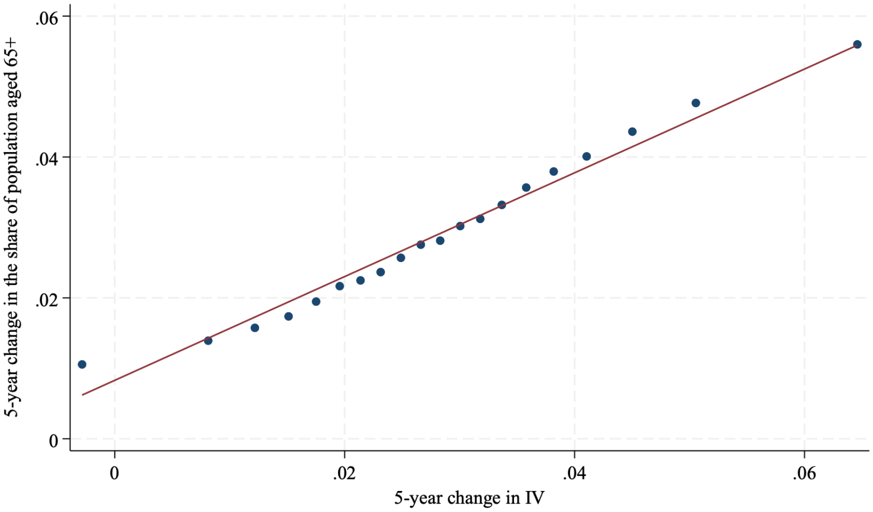
arithmetic rather than endogenous migration or economic shocks. Our instrumental variable aligns closely with this insight. Given the substantial cross-sectional variation in our municipality-level data, we expect our identification to rely primarily on the exposure component (e.g., Goldsmith-Pinkham et al., 2020).

[8] Japan consists of 47 prefectures, which are broadly analogous to states in the United States.

Figure 5: Five-Year Changes in Aging and the Instrumental Variable



Notes. This figure shows a binned scatter plot of the relationship between changes in our instrumental variable and changes in the share of the population aged 65 and above at the municipality level, both measured over five-year intervals (i.e., in first differences).

6 Empirical Results

6.1 Manufacturing Employment and Output

We begin by examining the effect of population aging on total manufacturing employment, sales, and value added at the municipality level. Table 2 reports the IV estimates of equation (2) for log manufacturing employment (Panel A), log sales (Panel B), and log value added (Panel C). Each panel reports three specifications. The first column presents baseline results with municipality and year fixed effects. The second column adds prefecture-by-year fixed effects. The third column further includes interactions between initial population shares and linear time trends. Throughout the paper, we report standard errors that are clustered at the municipality level. We also report only the second-stage IV estimates.

The results indicate that an increase in the population share aged 65 or above leads to statistically significant reductions in employment, sales, and value added in manufacturing. The magnitudes of the estimated coefficients are substantial. Specifically, the estimates reported in the first column imply that the average increase in the elderly population share over the twenty-year period from 1980 to 2000 (0.072) is associated with a 33.7 percent decline in local sales, a 31.0 percent decline in value added, and a 35.5 percent decline in local employment. Additionally, controlling for prefecture-by-year fixed effects and a linear time trend interacted with initial log population size does not alter the qualitative implications of the results. If anything, the estimated coefficients tend to increase in magnitude.

Siliverstovs et al. (2011) emphasize that demographic change is a key driver of the long-run decline in the manufacturing share, operating primarily through demand-side and labor-supply channels rather than short-run relative price movements. Their central argument is that population aging systematically shifts consumption away from manufactured goods toward services, especially health, personal, and social services. This reallocation of demand translates into a secular decline in manufacturing value added and employment, even in the absence of trade shocks or technological displacement. On the supply side, they note that aging alters sectoral labor allocation. Manufacturing tends to rely more on prime-age workers, who exhibit higher physical capacity and mobility. As the share of these cohorts shrinks, manufacturing contracts relative to services, which are better able to absorb older workers.

By exploiting original plant-level data, we take a different approach from Siliverstovs et al. (2011). The aggregate effects reported in Table 2 can operate through two distinct channels: extensive and intensive margins. First, population aging may reduce overall manufacturing activity by decreasing the number of establishments (the extensive margin). Second, it may reduce average establishment size (the intensive margin), thereby lowering employment and output per establishment. To explore these channels, we next examine the effects of population aging on the number of establishments and on average employment and output per establishment.

In Table 3, we examine the effects of population aging on the log of the total number of manufacturing establishments (Panel A), as well as on the log of sales, value added, and employment per establishment (Panels B–D, respectively). The results indicate that population aging leads to statistically significant and economically substantial reductions in the number of manufacturing establishments. The estimate in the first column of Panel A implies that the average increase in the elderly population share between 1980 and 2000 (0.072) is associated with an 18.4 percent decline in the number of manufacturing establishments.

Panel B–D in the table report the effects of population aging on average employment, sales, value added per establishment, and employment per establishment at the municipality level. The results indicate that these per-establishment outcomes also decline substantially as population aging increases in municipalities. For example, the estimate reported in the first column of Panel A in Table 2 indicates that the average increase in the elderly population share over the twenty-year period is associated with a 31.5 percent decline in local sales. Panels A and B of Table 3 further decompose this effect into an 18.4 percent decline in the number of manufacturing establishments and a 16.2 percent decline in sales per establish-

Table 2: Aging and Manufacturing Activities (Municipality, IV)

Panel A: Sales				
	Ln Sales			
Share of Population Aged 65+	-4.681***	-5.538***	-5.413***	-5.392***
	(0.370)	(0.468)	(0.461)	(0.525)
Observations	11879	11879	11879	11879
Kleibergen-Paap rk Wald F	11285	6261	7415	6236
Panel B: Value Added				
	Ln Value Added			
Share of Population Aged 65+	-4.305***	-4.993***	-4.988***	-5.288***
	(0.378)	(0.494)	(0.492)	(0.546)
Observations	10171	10171	10171	10171
Kleibergen-Paap rk Wald F	8126	4590	5287	4782
Panel C: Employment				
	Ln Employment			
Share of Population Aged 65+	-4.930***	-5.912***	-5.804***	-6.136***
	(0.263)	(0.338)	(0.333)	(0.384)
Observations	11956	11956	11956	11956
Kleibergen-Paap rk Wald F	10040	5734	6563	5389
Municipality FE, Year FE	Yes	Yes	Yes	Yes
Pref x Year FE	No	Yes	Yes	Yes
TFR Control	No	No	Yes	No
Mother Share Control	No	No	No	Yes
Balanced Panel	Yes	Yes	Yes	Yes

Source. The Census of Manufacture, the Ministry of Economy, Trade and Industry.

Table 3: Extensive and Intensive Margins (Municipality, IV)

Panel A: Number of Establishment				
	Ln Num. Establishments			
Share of Population Aged 65+	-2.554***	-3.303***	-3.236***	-3.559***
	(0.197)	(0.248)	(0.245)	(0.289)
Observations	12063	12063	12063	12063
Kleibergen-Paap rk Wald F	10034	5732	6391	5467
Panel B: Sales per Establishment				
	Ln (Sales per Establishment)			
Share of Population Aged 65+	-2.245***	-2.365***	-2.324***	-1.950***
	(0.332)	(0.402)	(0.398)	(0.451)
Observations	11879	11879	11879	11879
Kleibergen-Paap rk Wald F	11285	6261	7415	6236
Panel C: Value Added per Establishment				
	Ln (Value Added per Establishment)			
Share of Population Aged 65+	-1.946***	-1.896***	-1.895***	-1.926***
	(0.343)	(0.428)	(0.427)	(0.478)
Observations	10171	10171	10171	10171
Kleibergen-Paap rk Wald F	8126	4590	5287	4782
Panel D: Employment per Establishment				
	Ln (Emp. per Establishment)			
Share of Population Aged 65+	-2.304***	-2.540***	-2.505***	-2.470***
	(0.188)	(0.238)	(0.234)	(0.270)
Observations	11956	11956	11956	11956
Kleibergen-Paap rk Wald F	10040	5734	6563	5389
Municipality FE, Year FE	Yes	Yes	Yes	Yes
Pref x Year FE	No	Yes	Yes	Yes
TFR Control	No	No	Yes	No
Mother Share Control	No	No	No	Yes
Balanced Panel	Yes	Yes	Yes	Yes

Source. The Census of Manufacture, the Ministry of Economy, Trade and Industry.

ment. These results suggest that the exit and entry of establishments in aging regions plays a larger role in driving the overall decline in sales. Results using value added per employee and employee per establishment are similar to those using sales per employee.

Overall, the results indicate that population aging substantially reduces total manufacturing sales, value added, and employment through both the extensive and intensive margins by lowering the number of establishments and reducing outcomes per establishment.

6.2 Aging and Productivity

In this section, we follow the literature (e.g., Maestas et al., 2023; Goldin et al., 2024) and examine the effects of population aging on labor productivity (sales per worker) and wages (value added per worker).

Table 4 reports the IV estimates of equation (2) for the log of average sales per worker and log of value added per worker. The estimates indicate that aging has no statistically significant effect on labor productivity or wages.

While most representative studies (e.g., Feyrer 2007; Maestas et al. 2023) find that population aging reduces aggregate productivity growth, a growing literature shows that aging can increase labor productivity through induced technological adoption and stronger firm selection (e.g., Tan et al. 2022; Carta et al. 2021; Miyakawa et al. 2025). Tan et al. (2022) show that population aging increases firm-level labor productivity in China. They argue that aging tightens local labor markets and raises labor costs, which induces firms to adopt labor-saving technologies and increase innovation, consistent with the automation mechanism emphasized by Acemoglu and Restrepo (2017). Importantly, these productivity gains arise from firms' endogenous technological and organizational responses rather than from higher individual productivity of older workers. Similarly, Carta et al. (2021) find that workforce aging does not reduce firm-level labor productivity in Italy. Exploiting pension reforms as an exogenous source of workforce aging, they show that firms adjust task allocation and organizational structure in ways that mitigate potential age-related productivity losses. Finally, using Japanese data, Miyakawa et al. (2025) demonstrate that population aging can raise average productivity through a firm-selection channel. In an aging economy, succession constraints disproportionately eliminate low-productivity firms, while high-productivity firms are more likely to survive, thereby strengthening selection and raising average productivity.

6.3 Exit and Entry

The empirical findings thus far indicate that population aging contributed to a contraction in the manufacturing sector without reducing labor productivity or wages, suggesting a

Table 4: Aging and Productivity (Municipality, IV)

Panel A: Sales per Worker				
	Ln (Sales per Worker)			
Share of Population Aged 65+	-0.016	0.100	0.104	0.453
	(0.248)	(0.304)	(0.299)	(0.340)
Observations	11878	11878	11878	11878
Kleibergen-Paap rk Wald F	11284	6261	7415	6236
Panel B: Value Added per Worker				
	Ln (Value Added per Worker)			
Share of Population Aged 65+	0.312	0.441	0.437	0.449
	(0.250)	(0.308)	(0.308)	(0.345)
Observations	10164	10164	10164	10164
Kleibergen-Paap rk Wald F	8104	4583	5290	4762
Municipality FE, Year FE	Yes	Yes	Yes	Yes
Pref x Year FE	No	Yes	Yes	Yes
TFR Control	No	No	Yes	No
Mother Share Control	No	No	No	Yes
Balanced Panel	Yes	Yes	Yes	Yes

Source. The Census of Manufacture, the Ministry of Economy, Trade and Industry.

systematic selection of plants based on productivity differences. To better understand the mechanisms underlying these trends, we use establishment-level data from the Census of Manufacture to examine how local population aging affects entry and exit dynamics. The survey consists of two types: one covering establishments with more than 30 employees and another covering those with 4–29 employees. We use both types to ensure that small establishments are included in the analysis. Including these establishments helps us avoid misclassifying survey attrition as exit, which can occur when an establishment's employment falls below the reporting threshold. However, because the survey for establishments with 4–29 employees does not report tangible capital stock or investment, we are unable to construct capital stock measures for these firms. As a result, we use labor productivity as a proxy for total factor productivity.

To capture exit and entry dynamics, it is crucial to define the first and last year of production for each manufacturing establishment. We begin by constructing establishment-level operational spells using the annual panel data from 1986 to 2017,[9] where an establishment is classified as active in any year it reports production. Based on these spells, we define the first year of operation as the entry year and the last year as the exit year.

To reduce noise from year-to-year fluctuations and align outcomes with medium-run changes, we aggregate these annual measures into non-overlapping five-year windows. Specifically, we partition the sample period into seven windows: 1986-1987, 1988–1992, 1993–1997, 1998–2002, 2003–2007, 2008–2012, and 2013–2017. For each window, we construct an entry indicator that takes the value one if an establishment's first year of observation falls within that window, and an exit indicator that takes the value one if its last year of observation falls within the window. In the main analysis, we focus on the five middle windows, 1988–1992, 1993–1997, 1998–2002, 2003–2007, and 2008–2012, to avoid artificial entry and exit induced by sample boundaries. In particular, establishments first observed in 1986 may have entered before the panel begins, while establishments last observed in 2017 may continue operating after the panel ends. Following the recent literature (e.g., Bandick and Gorg, 2010; Guariglia et al., 2016; D'Costa et al., 2024), this spell-based definition of entry and exit allows us to incorporate key time-varying variables into our regression models while capturing establishment turnover at a medium-run frequency.

Table 5 presents the shares of manufacturing establishments that operated continuously, entered, and exited in each time window. On average, the exit rate ranges from 18–25%, while the entry rate ranges from 10–25%. The exit rate exceeds the entry rate throughout most of the period, particularly following the collapse of Japan's bubble economy in the early 1990s. While the existing literature typically focuses on Kaplan–Meier survival rates,

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[9] We cannot track establishments using consistent identifiers prior to the 1986 survey.

Table 5: Summary Statistics (Establishment-level Data)

	1988–1992	1993–1997	1998–2002	2003–2007	2008–2012
Observations	641889	563623	515170	429363	395762
Number of survivors	641714	596034	569013	462144	433721
Number of exits	160090	113896	119204	77394	90735
Number of entries	160265	81485	65361	44613	52776
Exit rate	0.249	0.202	0.231	0.180	0.229
Entry rate	0.250	0.145	0.127	0.104	0.133
Employment	25.626	26.618	26.899	29.461	34.152
Sales (million yen)	702.30	749.68	83959	102239	116681
Value added (million yen)	268.71	309.09	342.45	390.13	363.24
Sales per worker (million yen)	11.95	12.08	12.72	13.59	14.07
Value added per worker (million yen)	4.49	4.94	5.39	5.58	4.89

Notes: This table reports summary statistics based on establishment-level data. For each five-year window (1988–1992, 1993–1997, 1998–2002, 2003–2007, and 2008–2012), the number of observations, exits, and entries correspond to the number of establishments observed at least once during the window, the number whose last observed year falls within the window (i.e., exited during the window), and the number whose first observed year falls within the window (i.e., entered during the window), respectively. Exit and entry rates represent the share of establishments that exit or enter within each window. For each establishment, employment, sales, value added, sales per worker, and value added per worker are first averaged within each window; the table then reports the mean of these establishment-level averages. Source: The Census of Manufacture, the Ministry of Economy, Trade and Industry.

we instead examine both entry and exit rates to better understand how local population aging affects firm turnover and survival. The table also reports the average characteristics of establishments observed within each time window.

To guide the analysis, we draw on a heterogeneous firm framework (e.g., Hopenhayn, 1992) and apply it to the empirical study of firm turnover (e.g., Foster et al., 2008). We focus on two main questions. First, we examine whether establishments located in areas with a higher degree of population aging are more likely to exit. Second, conditional on local demographic conditions, we investigate whether more productive firms have a survival advantage over less productive firms in aging regions. Since productivity is not directly observable ex ante, our analysis of entry focuses only on the empirical relationship between establishment entry and local population aging.

We use the linear probabilistic model (LPM) and estimate the probability of survival at the establishment level:[10]

$$Y_{jt} = F(Aging_{it}, \ln(LP_{jt}), X_{jt}, \mu_j, \lambda_t)., \tag{3}$$

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[10] The literature cited above (e.g., Bandick and Gorg, 2010; Guariglia et al., 2016; D'Costa et al., 2024) employs the complementary log-log (cloglog) model. While this approach is suited for rare binary outcomes, we instead use ordinary least squares (OLS) and two-stage least squares (2SLS) models to accommodate our IV framework and incorporate high-dimensional fixed effects to control for unobserved heterogeneity. Results from cloglog models are available upon request.

Table 6: Entry

	Establishment Entry			
	(1) Reduced Form	(2) IV	(3) IV + Mothers	(4) IV + Fertility
Predicted aging (IV)	-0.0447			
	(0.0797)			
Aging		-0.0536	0.0292	-0.0518
		(0.0954)	(0.1013)	(0.0949)
Share of mothers			1.0828***	
			(0.2264)	
Fertility rate				-0.0452
				(0.0588)
Observations	2265928	2265919	2265919	2265919
Municipality clusters	1739	1739	1739	1739
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
R-squared	0.3857	—	—	—
First-stage KP F	—	1447.511	2569.046	1664.608

Notes: The dependent variable is an indicator equal to one if an establishment enters at any point within a given five-year window. Column (1) reports reduced-form estimates of the relationship between predicted aging (instrument) and entry. Column (2) reports two-stage least squares (2SLS) estimates of the effect of aging (share of population aged 65 or above), instrumented by predicted aging. Columns (3) and (4) extend the IV specification by including the share of mothers and the fertility rate, respectively, as additional controls. All specifications include year and establishment fixed effects. Standard errors are clustered at the municipality level.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: The Census of Manufacture, the Ministry of Economy, Trade and Industry.

where j indexes establishments, t indexes five-year time windows, and i indexes municipalities. $Aging_{it}$ denotes the share of the population aged 65 or above in municipality i during period t, and $\ln(LP_{jt})$ denotes establishment-level labor productivity (measured by sales or value added per worker). Our dependent variable Y_jt is the entry indicator variable ($enter_{jt}$) or the exit indicator variable ($exit_{jt}$). X_{it} includes additional controls, and μ_j and λ_t denote establishment and time fixed effects, respectively. We use high-dimensional fixed effects to control for unobserved local market conditions and firm-level heterogeneity. Table 6 reports the results of entry, and Tables 7 and 8 report the results of exit. As in the previous sections, we use the predicted share of the population aged 65 or above as an instrument for the realized share of the population aged 65 or above.

Table 6 shows little evidence that population aging affects establishment entry. Across specifications, the estimated coefficients on aging are small and statistically insignificant, including in the IV specification. This suggests that aging does not materially reduce en-

Table 7: Exit

	Establishment Exit			
	(1) Reduced Form	(2) IV	(3) IV + Mothers	(4) IV + Fertility
Predicted aging (IV)	0.6151***			
	(0.0477)			
Aging		0.7414***	0.8405***	0.7413***
		(0.0608)	(0.0659)	(0.0601)
Share of mothers			1.2960***	
			(0.1967)	
Fertility rate				0.0045
				(0.0492)
Observations	2265928	2265919	2265919	2265919
Municipality clusters	1739	1739	1739	1739
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
First-stage KP F	—	1447.511	2569.046	1664.608

Notes: The dependent variable is an indicator equal to one if an establishment exits at any point within a given five-year window. Column (1) reports reduced-form estimates using predicted aging (instrument). Column (2) reports 2SLS estimates of the effect of aging (share of population aged 65 or above), instrumented by predicted aging. Columns (3) and (4) augment the IV specification by including the share of mothers and the fertility rate, respectively. All specifications include year and establishment (ID) fixed effects. Standard errors are clustered at the municipality level municipality level.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: The Census of Manufacture, the Ministry of Economy, Trade and Industry.

Table 8: Exit: Heterogeneity by Labor Productivity Level

	Establishment Exit			
	(1) Sales/Worker	(2) VA/Worker	(3) Above Median (Sales)	(4) Above Median (VA)
Predicted aging (IV)	5.3182***	5.0911***	1.5499***	1.4785***
	(0.1470)	(0.1625)	(0.0970)	(0.0974)
Interaction (IV × Productivity)	-0.6451***	-0.6813***	-1.2390***	-1.1421***
	(0.0165)	(0.0204)	(0.0351)	(0.0342)
Productivity	0.0933***	0.1149***	0.2423***	0.2273***
	(0.0042)	(0.0051)	(0.0086)	(0.0082)
Observations	1373349	1332791	1373349	1332791
Municipality clusters	1737	1737	1737	1737
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
R-squared	0.4146	0.4135	0.4119	0.4117

Notes: The dependent variable is an indicator equal to one if an establishment exits at any point within a given five-year window. All columns report fixed-effects regressions including year and establishment fixed effects. The key independent variable is predicted aging (instrument), interacted with measures of establishment-level labor productivity. Column (1) uses labor productivity measured by sales per worker, and column (2) uses value added per worker. Columns (3) and (4) use indicator variables for whether an establishment's productivity is above the median within its municipality-year, based on sales per worker and value added per worker, respectively. Each specification includes the main effects of predicted aging and the corresponding productivity measure. Standard errors are clustered at the municipality level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: The Census of Manufacture, the Ministry of Economy, Trade and Industry.

trepreneurial activity or the creation of new manufacturing establishments. Column (3) reports the results when we include the share of potential mothers, which proxies for future local population growth. The coefficient on this variable is positive and statistically significant at the 1% confidence level, suggesting that expected population growth plays an important role in shaping entrepreneurship.

In contrast, Table 7 indicates a strong and robust positive effect of aging on establishment exit. The IV estimate in column (2) suggests that a 10 percentage point increase in the elderly share is associated with roughly a 0.074 (7.4 percentage point) increase in the probability of exit. This magnitude is economically large, given that exit rates range from 18–25%. The estimates in columns (1) through (4) are statistically significant across all specifications.

Table 8 reports the results when we include productivity and its interaction with aging. Consistent with the firm heterogeneity literature, productivity (proxied by labor productivity or value added per employee) is a statistically significant positive determinant of exit, increasing the probability of plant exit. The interaction term is also negative and statistically significant, indicating that the effect of aging on exit is stronger for less productive plants. In other words, less productive plants in aging regions are more likely to exit. These results remain robust when we restrict the sample to relatively larger establishments (see columns (3) and (4)).

Taken together, these results suggest that the impact of population aging on manufacturing dynamics operates primarily through the exit margin rather than the entry margin.

The findings are consistent with a productivity-based selection mechanism, whereby less productive establishments are more likely to exit, while entry remains largely unaffected by aging.

This pattern is consistent with the spatial selection mechanism emphasized by Baldwin and Okubo (2006), whereby less productive firms are more likely to exit from less favorable locations. In our context, population aging may reduce the attractiveness of a location through tighter labor supply and weaker local demand, thereby increasing the likelihood that less productive establishments exit.

7 Conclusion

This paper examined the causal effects of population aging on manufacturing activity using municipality-level data from Japan. Exploiting predetermined demographic structure to identify exogenous variation in local aging, we showed that population aging led to large and economically meaningful declines in manufacturing employment, sales, and the number of establishments. These effects operated through both extensive and intensive margins, with aging regions experiencing fewer plants and lower employment and output per establishment. At the same time, we found that population aging was associated with higher labor productivity and wages.

We also show that aging affects local economies primarily through plant exit rather than entry. Exit dynamics are systematically associated with productivity-based selection, indicating that less productive plants in aging regions are more likely to exit. Overall, our results suggest that population aging contracts local manufacturing activity while strengthening productivity-based selection among plants.

The findings contributed to the growing literature on the regional and sectoral consequences of demographic change and underscored the importance of aging as a driver of structural transformation in advanced economies. As many countries were expected to follow Japan's demographic trajectory, understanding how population aging affected manufacturing dynamics was essential for assessing long-run growth prospects and designing policies aimed at sustaining economic activity in aging societies.

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