

# Direct and non-linear innovation effects of demographic shifts

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## Abstract

A varied set of pressures drive organizational innovation. Among these pressures, demographic shifts seem to boost innovation, as the public sector responds to the arrival of migrants and to community changes in race and ethnic composition. However, we know little about innovation by governments in response to expected population decline. In particular, studies have under-examined how anticipated demographic pressures prompt public organizations to innovate. This study undertakes this task by arguing that innovation is more visible in municipalities facing greater anticipated demographic decline. However, we also argue for a non-linear relationship in which too strong and/or too weak expected demographic declines lead to less visible innovation (inverted U-shape effect). These propositions were tested with a data set of Japanese municipalities and employing a dose–response model. Findings show that anticipated demographic declines directly boost innovation visibility. However, too strong and/or too weak unexpected demographic declines make innovation less visible.

## KEYWORDS

dose–response model, innovation response, Japan, local government, population decline, public sector innovation

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## 1 | INTRODUCTION

According to the World Population Prospect 2019 (United Nations: Department of Economic and Social Affairs Population Division, 2019, p. 12), a growing number of countries are experiencing demographic shifts due to decreasing populations. Between 2019 and 2050, populations are projected to decrease 1% or more in 55 countries or areas, of which 26 may experience at least a 10% reduction. The report highlights that this drop is mainly caused by persistent low fertility levels, which in some areas are reinforced by high rates of emigration due to political or civil conflict and extreme underdeveloped conditions. This shrinking population is compounded by another demographic shift. According to the World Population Prospect 2019, life expectancy is increasing; consequently, the world population is aging.

In response to these trends, governments have started taking action to cope with decreased labour forces and higher demands from senior citizens. Among these actions are adopting innovative administrative structures, governance arrangements, and service provisions. The survival of local governments rests on addressing these demographic pressures. Consequently, innovation should be more noticeable in localities facing greater demographic pressures.

Research has identified various dynamic pressures driving organizational innovation. Scholars have explored the innovation effects of actual and anticipated demographic shifts (Ang & Madsen, 2015; Kohlbacher, Herstatt, & Levsen, 2015). Researchers have investigated public sector responses to the arrival of migrants and resulting changes in the population's race and ethnic composition. However, governmental innovation responses to expected population declines are understudied. We know little about governmental responses to such demographic pressures in an ethnically homogenous country with a restrictive immigration policy. To fill this gap, we examine the association between expected population declines and municipal innovation using Japanese municipalities. Japan is suitable for the present study because it has experienced the most severe demographic pressure in the world. Japan is considered the demographically oldest country among all OECD (Organization for Economic Co-operation and Development) countries (OECD, 2019b). Japan's estimated percentage ratio of old-age (65 and over) to working-age (20–64 years) is 52.0 in 2020, followed by Finland's 40.1 and Italy's 39.5. (This number is defined as 'the number of individuals aged 65 and over per 100 people of working age defined as those at ages 20 to 64'; OECD, 2019b, p. 174). By 2050, this ratio in Japan is expected to reach 80.7, also the highest in the world, followed by South Korea's 78.8 and Greece's 75.0 (OECD, 2019b). From 2010 to 2019, Japan recorded 2.6 million more deaths than births (World Population Prospect, 2019, p. 12). Hence, Japan ranks 24th worldwide in decreased population with  $-0.12$  population growth – meaning the number of deaths exceeding the number of births (Dillinger, 2018).

We hypothesize that expected population decline has a positive association with the visibility of innovation, but that the relationship between demographic pressure and innovation visibility is an inverted U-shape, namely, non-linear. Both low and high levels of estimated population decline may not lead to higher public sector innovation visibility, but moderate levels of such demographic pressure lead to innovation. We examined these propositions using a data set of 647 Japanese municipalities. Our findings suggest expected demographic shifts directly boost municipal innovation, but only at certain levels of population decline. The results provide support for a negative curvilinear relationship; that is, too large and/or too small population declines inhibit local innovation visibility. Our study offers relevant policy implications by suggesting to scholars and practitioners that – at least in an ethnically homogenous country – not all degrees of population decline trigger visible innovation. The findings also offer important observations to the field of public administration by highlighting public organizational inertia when municipalities face strong and weak demographic pressures.

## 2 | DEFINING INNOVATION AND MUNICIPAL INNOVATION

Debates about the definition of innovation go back to 1934. For Joseph Schumpeter, innovations are novel combinations of knowledge, resources, and tools put into commercial practice. Schumpeter labelled this ‘combinatory’ activity as ‘the entrepreneurial function’ and those fulfilling this function are ‘entrepreneurs’. Then, in 1985, Peter Drucker defined ‘innovation’ as ‘the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service’. Starting in the 1990s and beyond, Clayton Christensen wrote extensively on innovation (Christensen, 1997; Christensen & Raynor, 2003; Christensen, Anthony, & Roth, 2004). However, debate also exists about whether the concept of innovation refers to the innovation process or to the outcome of this process (Toivonen & Tuominen, 2009).

Here, we define innovation as adopting an idea, practice, or behaviour new to the adopting organization (Daft, 1978; Damanpour & Evan, 1984). In following Damanpour (1996, p. 694), we conceive of innovation ‘as a process that includes the generation, development, and implementation of new ideas or behaviours’ new to the adopting unit, but these ideas and behaviours may be present in other units. Moreover, although innovation has been studied at the level of the industry, firm, or individual, this study focuses on innovation at the organizational level, specifically at the municipal/local government level. We conceive of innovation as the means of changing a municipality in response to changes in the external environment, specifically in demographic composition. The municipal innovative response may include new services, plans, programs, processes, organizational structures, and/or administrative structures (Damanpour, 1996, p. 694). The definition of service innovation has also been debated. In fact, Witell, Snyder, Gustafsson, Fombelle, and Kristensson (2016) reviews definitions of service innovation and identifies 84 different definitions.

### 2.1 | Innovation in the public sector

Although innovation studies abound in the private sector, the concept has also gained considerable relevance in the public sector (Berry & Berry, 1990; Damanpour, Walker, & Avellaneda, 2009; Demircioglu, 2019; Demircioglu & Audretsch, 2017, 2018; Teodoro, 2009; Walker, Avellaneda, & Berry, 2011). Studies find evidence that innovation increases performance, so understanding innovation is a central task for governments (Walker, 2005). Given the performance effects of innovation, much research has explored drivers and inhibitors of innovation at the organizational (Berry & Berry 1990), group (Demircioglu & Audretsch, 2018), and individual level (Lapuente, Suzuki, & Van de Walle, 2020). The postulated drivers fall into factors internal and external to organizations.

### 2.2 | Demographic shifts and innovation

Among external factors driving innovation, few scholars have considered the role of demographic shifts/pressures. Kohlbacher et al. (2015) highlight that demographic changes bring about innovation opportunities in terms of managing innovation and product/service development. Moreover, researchers have investigated the public sector’s innovation responses to migrants’ arrival and consequential changes in population race and ethnic composition (see Richter, 2014 for a literature review). A number of these studies have focused on Germany’s demographic changes due to immigration, which has altered the population and triggered social, political, and economic effects. In fact, the German Ministry of Education and Research (BMBF) uses the motto ‘the demographic opportunity’ (Richter, 2014, p. 167) and promotes discovering knowledge of the risks and opportunities of demographic changes in Germany’s economy.

Besides influxes of immigrants due to wars, conflicts, political crises, natural disasters, and extreme underdevelopment conditions, other events lead to demographic changes. However, it is important to highlight that not all environmental shocks lead to innovation. In fact, the aim of this study is discerning why some localities visibly innovate while others do not when facing population declines. This is the case for declining female and total population, particularly in countries with restrictive migration rules. Japan's restricted immigration policy contrasts with Germany's relatively open immigration policy. In 2016, the total number of permanent immigration inflows in Japan was 95,196, which was 0.07% of the population, whereas immigrants in Germany and the United States were 1,051,014 (1.28%) and 1,183,505 (0.37%), respectively (OECD, 2019c). The number covers 'regulated movements of foreigners considered to be settling in the country from the perspective of the destination country' (OECD, 2019c). However, few studies have examined the relationship between demographic pressures and innovative responses in the context of countries such as Japan with high demographic pressure and restricted immigration policy. According to the United Nations Population Division, 'It is estimated that 83 countries are experiencing below-replacement fertility. The 10 most populous countries with fertility rates below two births per woman, by ranking, are as follows: China, the United States, Brazil, Russia, Japan, Vietnam, Germany, Iran, Thailand, and Britain' (Chamie, 2017). In response to this demographic decline, governmental innovation responses in services, programs, policies, planning, and managing and administrative structures vary considerably.

The link between demographic shifts and innovation is well established. The widely accepted notion is that to guarantee the viability of administrative governments, jurisdictions have to innovate in terms of (a) nature and number of services; (b) types of arrangements for service provision (contracting out, collaboration, co-production, privatization, etc.); and (c) different administrative and organizational structures that guarantee cost-efficiency and effectiveness. Kohlbacher et al. (2015) analyse opportunity identification and exploitation in the 'silver' market (targeting older people). In six case studies, Kohlbacher et al. (2015) qualitative analysis reports (a) opportunity recognition and exploitation linked with demographic change, and (b) innovation management and product development for older users. This suggests that the experience of current and expected demographic shifts could potentially trigger governmental innovation across several dimensions. Jurisdictions facing demographic declines are expected to undertake more innovative responses. These innovative actions should, in turn, be visible not only to citizens in the innovative jurisdictions but also to citizens and public officials from other jurisdictions. In fact, the visibility of innovative practices in a particular locality indicates that its innovation is gaining attention and becoming successful. Otherwise, it would not generate visibility. Consequently,

**H1** :The greater the degree of anticipated population decline, the more visible the governmental innovation response.

Conversely, Legge (2016) offers empirical evidence for a negative relationship between a country's demographic shift and its citizens' demands for investment in research and design (R&D). Legge investigates the effects of an aging population on innovation rates and suggests that aging affects the demand for innovative goods. In the overlapping-generations model, individuals are expected to spend time learning how to use new technology. Aging creates age-dependent demand structures because an aging population does not invest in acquiring skills. Within this context, R&D is reduced, as demand falls for innovative goods. Relying on data from OECD countries from 1978 to 2010, Legge (2016) found that countries facing the largest demographic shifts experienced a marked reduction in patent applications.

Despite governmental motivation to respond proactively to current and anticipated population declines, this response may reach a tipping point due to limiting human and financial capabilities. Innovation requires leadership commitment, bureaucratic capacity, and financial resources and it implies a deviation from path dependency, which may be perceived as a burden. In that case, only up to a certain level of current and/or anticipated population decline governments will adopt innovative responses.

Demographic shifts beyond that level will not be addressed. For instance, research examining individual behavioural responses within an organization has identified curvilinear relationships between conflict at work (Jehn, 1995; Walton, 1969), job demands (Janssen, 2001), work stress (Broadbent, 1972), and employees' responses. Because organizations are managed by individuals, individual responses also may develop into organizational responses. In fact, at the group and organizational level, research on the drivers of innovation has already found evidence of a curvilinear relationship. De Dreu (2006) specifically tests direct and non-linear innovation effects of task conflict at the organizational level. De Dreu's study occurred in the context of an international postal service agency in the Netherlands. Through collaborative problem solving, De Dreu found that task conflict in teams can be positively correlated to innovation but only for teams performing moderately complex tasks, such as product design. That is, both too much and too little conflict hurt innovation (De Dreu, 2006) through collaborative problem solving. The same non-linear innovative effect can be expected from demographic shifts. Small anticipated demographic shifts may lead to organizational inaction, whereas large expected demographic shifts may cause inertia due to limited human and financial resources. Consequently,

**H2** :The relationship between anticipated population decline and visible governmental innovation is non-linear (e.g. inverted-U shape), such that expected population declines that are too strong or weak lead to less visible innovation.

### 3 | METHODOLOGY

#### 3.1 | Case selection: Japanese local governments

Japanese localities are suitable for several reasons. First, Japan is demographically the oldest country among OECD member countries, with low fertility rates and tight immigration policies. In fact, Japan recorded the highest number of elderly population ratio, 25.1%, followed by Germany (21.3%), Italy (20.9%), Sweden (19.9%), and Portugal (19.6%) in 2013 (OECD, 2019a). Japanese local governments are facing fiscal retrenchment, aging populations, and related decreases in the average number of local public servants per 1,000 residents (Suzuki, 2017). The Masuda report predicts that out of 1,741 municipalities, 896 will be extinct by 2040 due to demographic and socioeconomic challenges, causing alarm in rural and small municipalities (Japan Policy Council, 2014a). Second, Japanese municipalities have relatively homogeneous administrative structures, culture, ethnicity, and economic levels, allowing us to control for non-cross-sectional varying factors. Finally, despite a long history of democracy and high economic achievement, scholarly works focusing on Japanese local governments are few compared to studies focusing on other countries. Although Japan records high levels of innovation performance from a cross-national perspective (Cornell University, INSEAD, and WIPO, 2019), few studies exist on public sector innovation and the determinants of innovation in Japanese municipalities. However, several studies examine innovation-related aspects and organizational performances of Japanese municipalities, such as aspirations to be a leading local government (Aoki, 2019), disaster recovery and restoration (Aoki, 2014, 2015, 2018; Dollery, Kinoshita, & Yamazaki, 2019), accrual accounting innovation (Kobayashi, Yamamoto, & Ishikawa, 2016), municipal spending cuts and citizen responses

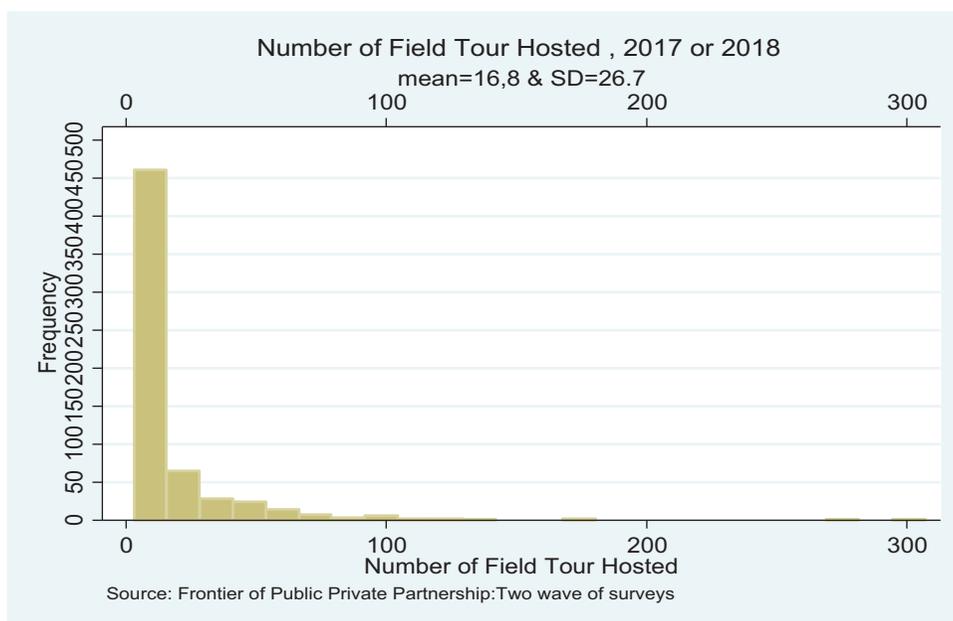
(Suzuki, 2017), citizen participation (Granier & Kudo, 2016; Uddin, Mori, & Adhikari, 2019), gender and risk-taking behaviour in local public finance (Suzuki & Avellaneda, 2018), managerial changes and administrative reforms, including large-scale consolidation of municipalities (Suzuki & Ha, 2018; Suzuki & Sakuwa, 2016; Yamada, 2016, 2018), and New Public Management (Kudo, 2015).

Japan has a two-tier local government system: prefecture as the regional government unit and municipality as the local government unit. Municipalities can be categorized as cities, towns, and villages. As of April 2018, Japan has 47 prefectures and 1,741 municipalities. Of these, 23 are special districts, 772 are cities, 743 are towns, and 183 are villages (Japan Agency for Local Authority Information Systems, 2019). Although some municipalities have additional responsibilities, due to population size, all municipalities have similar powers and responsibilities, such as providing social relief, nursing insurance, national health insurance, and so forth (MIC, 2015).

### 3.2 | Data collection and variable operationalization

We utilize a unique data set of municipal ranking based on 'study tour hosting' in Japanese municipalities in 2016 (Shin Koumin Renkei Sai Zen Sen, 2017, 2018). In Japan, it is common for local public administrators and councillors to arrange field trips to innovative municipalities to learn about pioneering approaches to municipal policy and administrative work and how to implement them in their municipalities. The data set contains survey responses from municipalities regarding the number of field trips each municipality hosted and brief contents of the trips hosted in previous years. Thus, the data contain information about the field trips from other municipalities that a municipality hosts, not the field trips to other municipalities that a municipality organizes. The survey was conducted by NIKKEI BP Intelligence Group, a research and consulting company. The survey was conducted in 2017, 2018, and 2019. We used the first two survey waves (2017 and 2018). The survey was sent to all 1,741 municipalities in each wave. Response rate for the 2017 survey was 33.4% (582 respondents) and 36.4% for the 2018 survey (634 respondents). The survey asks respondents to name up to three programs or projects that most often hosted visitors from outside of their municipality. For example, if a municipality hosted field tours for five different programs, the municipality can list up to three programs or projects that most often hosted tours. To be included in the survey, a program has to accept at least three tours. Therefore, a program or project that hosted less than two tours is dropped. The data set does not include the number of tour participants. Therefore, we only have information on the number of tours hosted. Respondents are asked not to include visitors from their own municipality, members of the national parliament, national government officials, quasi-governmental organizational officials, or students. Thus, local government officials and councillors from other local governments (including municipal and prefectural level governments) and those from abroad are counted (NIKKEI BP Intelligence Group, 2019; Shin Koumin Renkei Sai Zen Sen, 2017, 2018).

This data set has some limitations. First, it does not contain full information in the responses. The exact number of tours hosted for each program or project is listed for only the top 150 municipalities, ranked by the number of hosted tours and population size. Therefore, the data set does not include the number of tours hosted for municipalities ranked lower than 150. However, to be listed in the data set, at least three tours of programs should be hosted. Each municipality can list up to three programs or projects. For example, if a municipality reports three projects or programs and the municipality's exact number of hosted trip data is not available, we give a value of nine as the number of tours hosted. If a municipality reports two projects or programs, we give a value of six, and three for those who reported only one project. Therefore, depending on the number of projects municipalities reported, we (by assuming municipalities' best innovative efforts) give an estimate value of three, six, or nine as the number of hosted tours for those municipalities ranked lower than 150.



**FIGURE 1** Frequency distribution of total tours hosted [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

Second, some municipalities only participated in one wave of the survey (2017 or 2018). We assume that the municipality's innovative efforts or competence would be lasting and identified by even one point in time. Following this assumption, we use higher values of numbers of hosted tours between the two waves to maximize sample size. We conduct a sensitivity analysis with a different operation on dependent variable (DV) by setting lower values of numbers of hosted tours between two waves. The results are explained in Appendix 2 and displayed in the left column of Appendix 2. Therefore, the data set is cross-sectional data in 2017 or 2018. The unit of analysis is the municipality. The final number of units we cover is 617 municipalities (35.4% of Japanese municipalities). Among these 617 municipalities, 16 are special districts, 432 are cities, 149 are towns, and 20 are villages. Municipalities in Fukushima Prefecture are not included due to the unavailability of population estimates caused by the Great Earthquake in 2011. We used data from the Japan Policy Council (2014b) for our independent variable and MIC (2019) for control variables.

### 3.3 | Dependent variables

We used the total number of field tours hosted in each municipality. Because municipalities reported up to three projects or programs that accept field trip visitors, we calculated the total number of tours hosted for each municipality ranging from three to 307. Figure 1 shows the frequency distribution of total tours hosted. After ranking them, we standardized the variable with Z-score to reduce skewness (from  $-0.514$  to  $10.946$ ). So, the main dependent variable is the total number of tours ranked and Z-score standardized that each municipality hosted in year 2017 or 2018.

### 3.4 | Independent variables: Demographic pressure

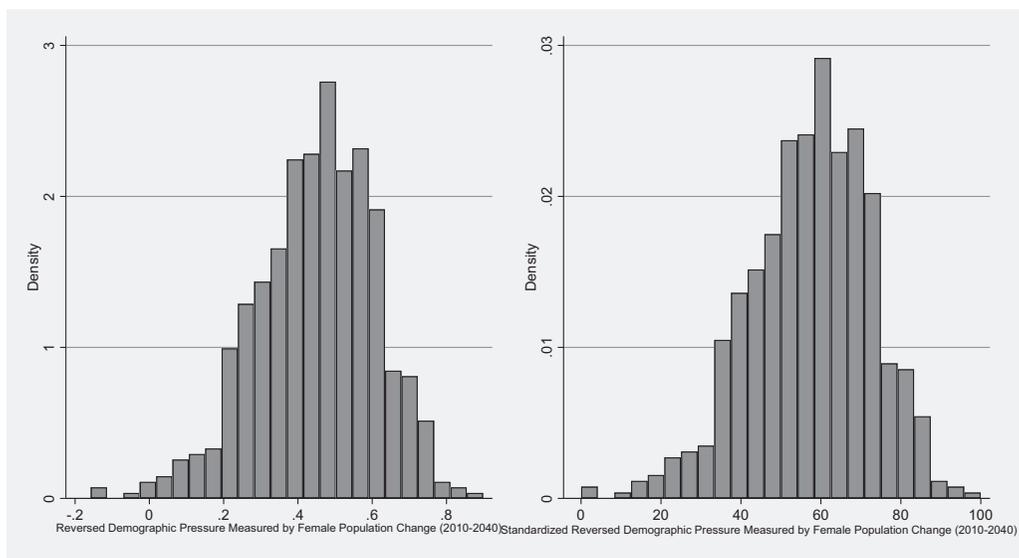
We tested how innovation visibility varies depending on levels of demographic pressure. Demographic pressure is measured by a projected percentage change (growth rate) in female population aged 20–39

years from 2010 to 2040, which is reversed to show a pressure of population decrease, using data from Japan Policy Council (2014b). Demographic pressure =  $(X_{2040} - X_{2010}) / X_{2010} \times (-100)$ , where  $X$  is female population aged 20–39. Note that we reversed the demographic pressure variable by multiplying it by  $-1$ . Therefore, positive values mean higher demographic pressure (i.e. more decline in female population aged 20–39). We used this variable following an influential report for municipal officials, ‘Masuda Report’ (Japan Policy Council, 2014a). The report used this variable as an indicator for the ‘population reproduction power’ (Masuda and the Declining Population Issue Study Group, 2014). The fertility trend is one of the most important determinants in future population projection (KC & Lutz, 2017). Therefore, KC and Lutz (2017) provided population forecasting scenarios by showing the proportion of the female population ages 20–39 in the region by level of education attainment. For a sensitivity analysis, we used the alternative independent variable of population change. Its result is reported in the right column of Appendix 2. A sensitivity analysis can be seen in Table 4. It shows demographic pressures ranged from  $-0.16$  to  $0.90$ , with mean  $0.45$  and standard deviation  $0.16$ , implying positive (negative) means decreasing (increasing) rate of population. In other words, Japanese municipalities expect their local populations to decrease by on average  $45\%$  in year 2040 compared to year 2010.

Dose–Response Function (DRF) model requires both binary treatment variable (Treatment Group) and continuous treatment variable (Treatment Intensity), which allows researchers to analyse varying degrees of effects of intervention (e.g. government policy or external shock) on outcome (e.g. citizen attitudes or behaviour) (Filippetti & Cerulli, 2018). We conduct analysis using the following procedure. First, for the binary treatment variable, we assigned Treatment Group variable with a value of 1 if demographic pressure is more than or equal to zero and 0 otherwise. Municipality was assigned into a treatment group if it is projected to have any increasing demographic pressure due to decreasing female population (Treatment Group variable = 1). Any municipality is assigned into non-treatment group if it is projected to have same or increasing population (Control Group variable = 0). Second, for the continuous treatment variable, we standardized the variable of demographic pressure (inversed percentage changes of female population aged 20–39) to have a value from 0 to 100. Treatment Intensity =  $\frac{X - \min(X)}{\max(X) - \min(X)} \times 100$ , where  $X$  is demographic pressure, which will be helpful in interpreting results. 0 value in the demographic pressure is located on 14.95 when it is standardized between 0 and 100 (Figure 2). This continuous treatment variable is the treatment intensity, implying the larger number means stronger demographic pressure. In sum, we used two independent variables, one for treatment assignment and the other for treatment intensity, which will be used as two independent variables for the DRF model.

### 3.5 | Control variables

The analysis controls for other factors expected to influence a municipality’s innovation visibility. Such factors include (a) number of local government officials per 1,000 residents, (b) percentage of independent revenue sources for total municipal revenue (%), (c) taxable income per capita (in one thousand yen) in logarithmic form, and (d) region dummy. We expected that the size of local government measured by the number of officials should be associated with public sector innovation. Furthermore, we expected that municipalities with more independent revenue sources collected (such as local tax, fees, charges for municipal services, donations, and revenue from municipal property management rather than transfers from the central government) have more resources to invest in innovation than municipalities with limited independent revenues. We also expected that the income levels of municipalities should positively affect public sector innovation. Location of municipalities may also matter. Therefore, we use a region-level dummy to control for this. Region dummy is a categorical variable, dividing Japan



**FIGURE 2** Density of demographic pressure (2010–2040)

into eight regions (Hokkaido (reference group), Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, and Kyushu (including Okinawa)).

Table 1 reports descriptive statistics for the main variables. Units are 617 municipalities, of which 611 (about 99%) belong to the treatment group and six belong to the comparison group. These two groups are compared in Table 2, showing a large difference in mean values of two variables – field tours hosted (ranked and z-score standardized) (DV) and treatment intensity (IV). Table 1 shows no severe multi-collinearities exist among explanatory variables, including controls. The highest value of variance inflation factor (VIF) is 2.48, which is much less than 10, the criteria for serious correlation among variables or multi-collinearity (Hair, Black, Babin, Anderson, & Tatham, 1998; Wooldridge, 2015). Table 3 reports the correlation matrix of all main variables included in the model except for the region dummy variables. Innovation visibility is negatively correlated with demographic pressure and the number of local government officials, whereas it is positively correlated with revenue independence and taxable income per capita (ln) at the 5% level of statistical significance.

### 3.6 | Estimation strategy

When a cause of treatment takes a continuous form, DRF models (Adormo, Bernini, & Pellegrini, 2007; Bia & Mattei, 2008; Cerulli, 2015; Guardabascio & Ventura, 2013; Hirano & Imbens, 2004) are well suited to socio-economic contexts and relatively advantageous compared to traditional regression models (Filippetti & Cerulli, 2018). In considering a policy program or a program evaluation in a socio-economic context, it is important to analyse not only whether treatment is received by a certain group but also the treatment intensity or size.

The main relative advantage of DRF models is they allow researchers to graphically identify the entire pattern or distribution of the effects of treatments by estimating effects (response) in the form of a function defined along the values taken by the treatment (dose) variable (Cerulli, 2015; Filippetti & Cerulli, 2018). We follow Cerulli's (2015) DRF model, which does not require the full normality assumption that Hirano and Imbens (2004) and Bia and Mattei (2008) assume. Cerulli's DRF model

**TABLE 1** Descriptive statistics with multi-collinearity test

Variable	Obs.	Mean	STD	Min	Max	VIF
Number of field tours hosted (#)	617	16.81	26.77	3.00	307.00	
DV: Number of field tours hosted (ranked & z-scored)	617	0.01	1.00	-1.37	1.79	
Demographic pressure	617	0.45	0.16	-0.16	0.90	
IV: Treatment assignment	617	0.99	0.10	0.00	1.00	
Treatment intensity	617	57.38	15.23	0.00	100.00	1.80
Controls: local Gov. officials (per 1,000 residents)	617	7.05	4.42	3.09	42.93	1.54
Revenue independence (%)	617	41.90	13.70	11.61	90.92	2.48
Income capita (1,000 Yen) (ln)	617	7.97	0.17	7.60	9.05	1.81
Region						
Tohoku	617	0.09	0.29	0.00	1.00	
Kanto	617	0.25	0.43	0.00	1.00	
Chubu	617	0.20	0.40	0.00	1.00	
Kinki	617	0.14	0.35	0.00	1.00	
Chugoku	617	0.06	0.23	0.00	1.00	
Shikoku	617	0.04	0.19	0.00	1.00	
Kyushu	617	0.12	0.33	0.00	1.00	
Population size = 1 ( $\leq 100,000$ )	617	0.68	0.47	0	1	
Population	617	121,185	196,953	629	1,952,356	

Obs., observation; STD, standard deviation; VIF, variance inflation factor; DV, dependent variable; IV, independent variable.

**TABLE 2** Descriptive statistics by treatment

Variable	Untreated ( $n = 6$ )				Treated ( $n = 611$ )			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Number of field tours hosted (ranked & z-scored)	-1.11	0.65	-1.37	0.22	0.02	1.00	-1.37	1.79
Treatment intensity	8.32	6.54	0.00	14.17	57.86	14.49	17.20	100.00
Local gov. officials (per 1,000 residents)	8.11	4.30	4.17	14.15	7.04	4.42	3.09	42.93
Revenue independence (%)	54.33	13.84	33.51	73.72	41.77	13.65	11.61	90.92
Income capita (1,000 Yen) (ln)	8.06	0.15	7.92	8.33	7.97	0.17	7.60	9.05

allows a zero-treatment probability mass (i.e., many units having a treatment level of 0) and accounts for treatment that is endogenous as well as exogenous.

We are interested in estimating effects of the treatment variable (the demographic pressure,  $t$ ) on the outcome (innovation output visibility measured by the number of visits hosted,  $y$ ) in Japanese municipalities, assuming that treated and untreated units ( $w$ ) may respond differently to specific observable confounders or controls (a vector of  $X$ ) and to the intensity of treatment ( $t$ ). We wanted to estimate a DRF of a municipality's innovation visibility ( $y$ ) by demographic pressure ( $t$ ) when the treatment is assumed to be exogenous, namely, selection into treatment ( $w$ ) depends only on observable factors ( $X$ ). See Appendix I for explanation of the model estimations.

**TABLE 3** Correlation

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Number of field tours hosted (#) (1)	1.000							
Number of field tours hosted (ranked & z-scored) (2)	.633 <sup>*</sup>	1.000						
Treatment assignment (3)	.047	0.110	1.000					
Demographic pressure (4)	-.122	-.173 <sup>*</sup>	.320 <sup>*</sup>	1.000				
Treatment intensity (5)	-.122	-.173 <sup>*</sup>	.320 <sup>*</sup>	1.000 <sup>*</sup>	1.000			
Local gov. official (per 1,000 residents) (6)	-.137 <sup>*</sup>	-.263 <sup>*</sup>	-.024	.381 <sup>*</sup>	.381 <sup>*</sup>	1.000		
Revenue independence (%) (7)	.108	.228 <sup>*</sup>	-.090	-.611 <sup>*</sup>	-.611 <sup>*</sup>	-.571 <sup>*</sup>	1.000	
Income capita (1,000 Yen) (ln) (8)	.114	.173 <sup>*</sup>	-.050	-.569 <sup>*</sup>	-.569 <sup>*</sup>	-.239 <sup>*</sup>	.603 <sup>*</sup>	1.000

<sup>\*</sup> $p < .05$

## 4 | RESULTS

In this section, we present the main results of the DRF, using CTREATREG STATA command (Cerulli, 2015). Results showed whether or not (a) H1: a demographic pressure (ID) is positively associated with innovation visibility (DV), and (b) H2: the demographic pressure–innovation visibility relationship is curvilinear or inverted U-shaped. The main summary is as follows: innovation visibility (DV) is measured by total number of field tour visits hosted by a municipality, which is ranked and standardized by Z-score; demographic pressure (IV) generates two main explanatory variables of interest, treatment assignment and treatment intensity. The treatment assignment variable assigns a municipality to a group: it is assigned to the treatment group if its population projection is expected to be decreased, or it is assigned to the control group otherwise. So, the treatment assignment variable is binary: 1 if it is assigned to the treatment group or 0 otherwise. Next, the treatment intensity variable shows how severely a municipality's population in the treatment group will be decreased, which is standardized from 0 to 100. Variables that might affect a municipality's innovation visibility are controlled by the number of local government officials, revenue independence, taxable income, and regional dummy.

To test the hypotheses, we ran the contingent estimator (equation 5 in Appendix 1) to estimate the parameters of interest consistently and calculated Average Treatment Estimates (equation 6 in Appendix 1) to get DRF ( $t$ ) over  $t$  changing from 0 to 100 if  $t > 0$ . In addition to the dose–response model, we also ran the OLS (ordinary least squares) model to see if the polynomials showed an inverse U-shape. Table 4 reports results of the OLS and dose–response models. Table 4 shows the effects of demographic pressure (treatment intensity) are inverted U-shape, as the coefficients of treatment intensity and treatment intensity squared are significantly positive and negative, respectively, in the OLS model. Next, we set the dose–response model to be a second degree polynomial of treatment intensity ( $t$ ) such as  $h(t_i) = a^*t_i + b^*t_i^2$  in order to reflect the OLS result that shows significant first and second degrees of Treatment Intensity, implying the inverted-U shape. The results from full units of 617 municipalities are displayed in the second column of Table 4.

The main result from the dose–response model shows that treatment assignment indicates positive coefficient ( $p < .01$ ). This means that municipalities getting a treatment of demographic shock or expecting any population decrease make more visible innovative projects or plans by 1.253 units more than those that do not. On average, a 1 percentage point decrease in population induces 1.253 units of visible innovation conditional on the covariates above. The advantage from the DRF model, compared to the traditional regression models, is that it displays graphically the entire pattern or distribution of

TABLE 4 Estimation (OLS or DRF model)

	Full model		Small municipality model (pop. size < 100,000)	
	OLS model	DRF model	OLS model	DRF model
Treatment assignment		1.253**		0.970*
		(3.19)		(2.44)
Local gov. officials (per 1,000 residents)	-0.037**	-0.036**	-0.020	-0.020
	(-3.20)	(-3.20)	(-1.68)	(-1.66)
Revenue independence (2015) (%)	0.008	0.008	0.009	0.009
	(1.66)	(1.69)	(1.47)	(1.48)
Income capita (2015) (ln)	0.824*	0.744*	-0.238	-0.337
	(2.38)	(2.14)	(-0.54)	(-0.75)
Region Dummy Tohoku	0.273	0.275	0.283	0.278
	(1.47)	(1.48)	(1.35)	(1.33)
Kanto	-0.13	-0.128	-0.087	-0.076
	(-0.78)	(-0.78)	(-0.44)	(-0.38)
Chubu	0.028	0.023	0.037	0.028
	(0.17)	(0.14)	(0.20)	(0.14)
Kinki	0.105	0.102	0.196	0.195
	(0.62)	(0.60)	(1.01)	(1.00)
Chugoku	0.459*	0.477*	0.609*	0.630*
	(2.23)	(2.32)	(2.41)	(2.50)
Shikoku	0.244	0.252	0.165	0.171
	(1.01)	(1.05)	(0.58)	(0.60)
Kyushu	0.334	0.32	0.368	0.351
	(1.90)	(1.83)	(1.88)	(1.79)
Treatment intensity	0.034**		0.030*	
	(2.68)		(2.19)	
Treatment intensity <sup>2</sup>	-0.0003**		-0.0003*	
	(-2.64)		(-2.20)	
Constant	-7.579**	-7.342**	0.622	1.161
	(-2.73)	(-2.66)	(0.17)	(0.33)
Polynomial degree 1 (Tw_1)		0.0125		0.0072
		(0.76)		(0.39)
Polynomial degree 2 (Tw_2)		-0.0001		-0.0001
		(-0.97)		(-0.63)
test_b[Tw_1] = _b[Tw_2] = 0		Prob > F = .466		Prob > F = .535
N	617	617	419	419
Adj. R-squared	.102	.108	.048	.052
AIC	1,698.8	1,695.9	1,151.9	1,150.9
BIC	1,756.3	1,757.9	1,204.4	1,207.4

Note. *t*-statistics in parentheses.

\* $p < 0.05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

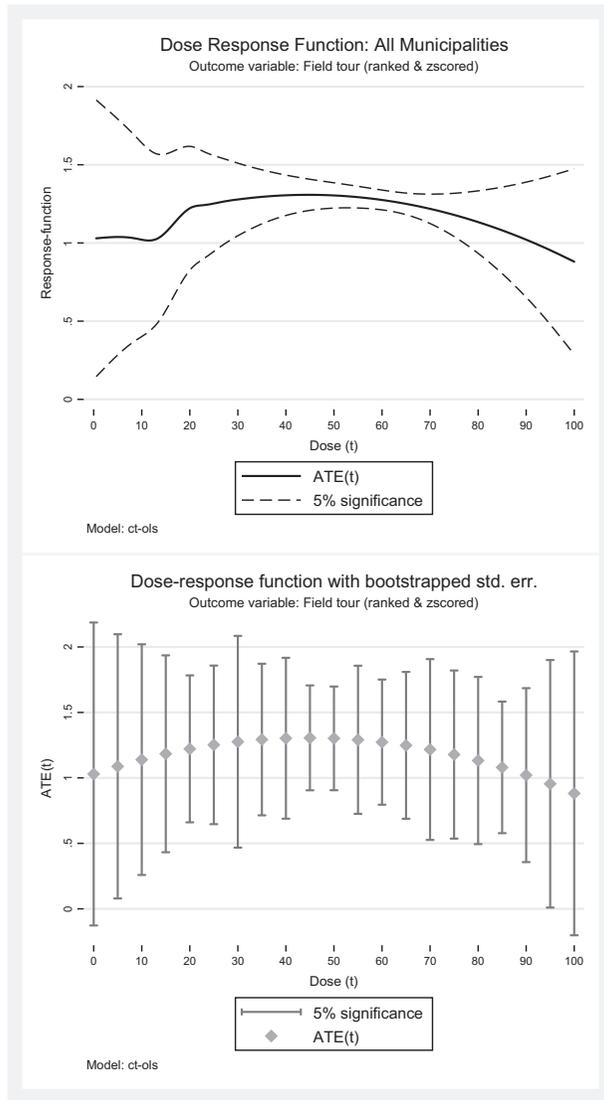


FIGURE 3 DRFs with 95% confidence interval

the effects of treatment intensity ( $t$ ), shown at the top of Figure 3. Even though the joint F-test on the second polynomial is not significant in Table 4 ( $p$ -value  $>$   $F$ -test value = .466), the DRF graph with 95% confidence interval (CI) shows the ATE has a roughly inverse U-shape over dose ( $t$ ) ranging from 0 to 100. The plot of DRF on the first graph in Figure 3 shows that the low and high values on treatment intensity ( $t$ ) are estimated less precisely than the middle ones because their 95% CIs are thicker than the middle ones. We graphed the DRF with 95% CIs through the bootstrap estimation on the standard errors at the bottom of Figure 3. The DRF is increasing as the treatment intensity increases. It is highest at the value of about 50 in the treatment intensity ( $t$ ) and decreasing as  $t$  is bigger than 50. All are significant because their lower CIs are bigger than 0. On average, over all values taken by treatment intensity, the effect of demographic pressure on innovation visibility is positive and curvilinear. This result provides empirical support for hypotheses 1 and 2.



## 5 | DISCUSSION

This research examines whether demographic pressures are linked to the visibility of public sector innovation outputs. We hypothesized that demographic pressure has a direct relationship with the visibility of innovation outputs. In line with existing studies (e.g. Kohlbacher et al., 2015), findings suggest that demographic changes bring about innovation. Those municipalities under higher demographic pressures are likely to score high in terms of visibility of innovation outputs, attracting more visitors from outside of their municipalities than those under lower demographic pressure. Therefore, demographic pressure has a direct positive relationship with innovation visibility, controlling for other factors. Furthermore, we hypothesized that such a positive relationship is not linear but curvilinear or an inverted U-shape. As the demographic pressure of a decreasing population becomes severe, a municipality's visible efforts toward innovation increase but in a decreasing way. In other words, too little or too much demographic pressure hampers municipalities' innovation efforts. The non-linear relationship found here goes in line with De Dreu's (2006) findings in which task complexity is non-linearly correlated to innovation. We employed a dose-response model and OLS regression model to examine these hypotheses. Results showed demographic pressure has a positive effect on innovation visibility, but the effect is inverted U-shaped. Therefore, our two hypotheses received empirical support. Furthermore, these results add an empirical evidence on demographic change or pressure's effect on innovation (Islam & Taslim, 1996; Kohlbacher et al., 2015; Richter, 2014).

Our study has some limitations. First, the original data set does not disclose full information regarding tours hosted, including actual numbers of field tours hosted in lower-ranking municipalities, intentions of tours, and size of tours. Second, we did not treat the endogeneity issue of the treatment variable (i.e. demographic pressure) in our analysis. Municipalities suffering from high demographic pressure may be inherently different from those municipalities experiencing less demographic pressure. Such differences may be related to the variations in innovation visibility. A valid and strong instrumental variable may solve this issue (Cerulli, 2015; Cerulli & Potì, 2014). Third, we focus on innovation visibility as our dependent variable. This measurement is different from actual innovation outputs, local government performance, or socioeconomic outcomes. These data impede us from examining if high visibility of innovation improved the performance of municipal governments or living conditions. Such endeavour is beyond the scope of this paper. Fourth, we focused on Japan, which has experienced one of the highest levels of demographic pressure in the world. The suggested relationships need to be tested in other countries experiencing moderate levels of population decline. Thus, we caution readers about the generalizability of the study's results.

Our study calls for further research. First, current municipal-level data for public sector innovation in Japanese municipalities are very limited; scholars need more data collection efforts. Second, in order to solve an endogeneity problem, we could apply instrument variable DRF techniques (Cerulli & Potì, 2014). Third, future studies should explore whether contextual factors moderate municipal innovative response to demographic changes. Hence, 'the concept of innovation is influenced by the context and the context always matters' (Demircioglu and Audretsch, 2017, p. 1682). Finally, future research could explore whether similar innovation effects occur in more ethnically heterogeneous countries.

## 6 | CONCLUSION

Our results suggest demographic changes may bring about innovation. That is, adversity has the potential to boost public sector innovation, which offers practical implications for policy makers and practitioners. Despite fears of anticipated population declines, Japanese municipalities seem to respond

proactively, making themselves more visible by attracting more visitors eager to emulate their innovative efforts. For not all jurisdictions respond proactively to challenges, it is important to identify the inhibiting factors preventing Japanese municipalities from responding to demographic shifts. Hence, only moderate levels of anticipated population decline make innovation visible; for neither too strong nor too weak anticipated population declines boost the visibility of innovation. Municipal innovation is expected to trigger economic benefits, and municipal tours boost networking, which, in turn, should enhance intergovernmental relations. Intergovernmental connectivity allows for more information sharing, further emulation of practices, and diffusion of ideas. We hope our study triggers further research on the demographic pressure–innovation relationship, for there is still a shortage of scholarly work on public sector innovation compared to work on private sector innovation (Demircioglu and Audretsch (2017)).

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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