Articles

An empirical analysis of a shrinking compact city: The case of Toyama City

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Abstract

This article investigates the compact city policy in Toyama City by examining two considerations. First, we determine the effect of the residence promotion schemes that are an essential factor of Toyama City's compact city policy using push-pull factor analysis. We determine that people may have moved to the residence promotion district because of the lifecycle events of marriage, childbirth, and childcare. Second, considering this assumption, we then calculate the actual effect of the scheme, applying statistical approaches such as difference-in-differences, in particular examining the number of primary and junior high schools. We find that the actual changes in population represent a 12% to 16% increase comparing non-residence promotion and residence promotion districts, both before and after the scheme's implementation. Our results indicate that the compact city policy scheme has a concrete effect in both the short and long term, although some research problems and limitations remain for future investigation. Thus, we conclude that the scheme has succeeded in making Toyama City a compact city, although it does not satisfy the requirements for being a sustainable city.

Keywords: compact city policy, residence promotion scheme, Toyama City, push-pull factor, difference-in-differences approach

1. Introduction

1.1 Background

The United Nations (UN) Sustainable Development Goals (SDGs) are a prominent issue around the world today. The UN 2030 Agenda includes 17 SDGs, the 11th of which is "Sustainable Cities and Communities," whose purpose is to "make cities and human settlements inclusive, safe, resilient, and sustainable." Achieving the SDGs requires the development of sustainable cities from the perspective of urban and regional economics. Compact cities are considered one of the emergent forms of sustainable cities (Guy and Marvin 1999; Kaido 2001; 2007; Hofstad et al. 2012).[1)] The concept of a compact city

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1) I do not intend to imply that only compact cities are a form of sustainable city, as Guy and Marvin (1999) emphasize.

started with the idea of an experimental city proposed by Dantzig and Saaty (1973). Although this idea has not yet been fully realized, a few cities are now attempting to become compact cities. The compact city has various definitions, yet it is generally recognized as a city with a moderately high population density around the city center and adequate mixed use (Thomas and Cousins 1996; Churchman 1999; Neuman 2005 et al.). In Japan, cities, particularly regional cities, are shifting to more compact planning. According to Hattori et al. (2017), the movement toward promoting compact cities in Japan started at the beginning of the 21st century in relation to the problem of shrinking cities.

Compared with compact cities in other countries, those in Japan are different in terms of the population and city size, which is the motivation for examining the case of Toyama City. The Organization for Economic Co-operation and Development (OECD 2012) has identified five cities in the world as notable examples of the compact city model: Portland in the United States; Paris, France; Vancouver, Canada; Melbourne, Australia; and Toyama City in Japan. A key difference between the Japanese city and those in the other four countries immediately emerges. The population in Toyama City is decreasing and the size of the city is quite small, while the populations in the other cities are increasing or have stabilized and are quite large. If the other four cities are defined as "expanding compact cities," Toyama City can be denominated a "shrinking compact city."[2] Because the "shrinking compact city" is in the minority, there is little research on this model. Thus, the paper addresses the gap between expanding and shrinking compact cities and analyzes the latter.

1.2 Issues and Hypothesis

This paper aims to evaluate the compact city policy in Toyama City by comparing the population before and after the residence promotion schemes that began in 2005 and that are one of the main projects of this policy. Fujioka and Sakakibara (2020) examined the population movement in the residence promotion schemes for 13 years after the policy was introduced, concluding that the effect became evident around 2016. However, their analysis only considered the effect of the scheme on the population using descriptive

2) The terms "expanding compact city" and "shrinking compact city" are not officially used in the research of cities, but some research has been conducted on the "shrinking compact city", such as Nakayama (2016) and Morotomi (2018).

statistics. Sakamoto et al. (2021) provided a comparative analysis of compact city policies in Toyama City and Nagano City from the perspective of the degree of crowding and land use, determining that Toyama City has been steadily promoting the policy for 10 years. Toyama City presents investigations on the implemented schemes. As Figure 1 shows, the city experienced population movement in the scheme up until 2019, and also estimates the future population in 2025. Comparing the population in 2005 to that of each year, the population shows an increase of approximately 10%, with the expectation that over 40% of citizens will be living along public transportation lines by 2025.

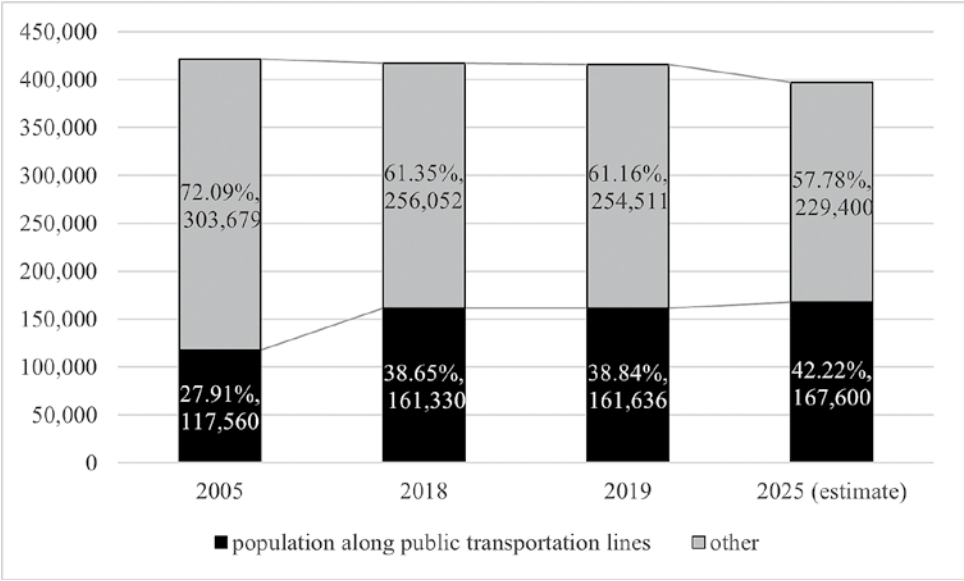

Figure 1. Percentage of citizens living in areas served by public transportation.

Note: The percentage figures indicate the proportion of citizens who live along public transportation lines (black) and other areas (gray); and the figures indicate the number of citizens who live in each area.

Source: *Outline of Urban Improvement Project Toyama City* for 2019 and 2020.

In summary, previous research has only considered population movements after the schemes were put into effect. To estimate the impact of the scheme more precisely, a comparison of the population before and after the scheme's implementation is required. Additionally, previous research has not explored in detail the factors that facilitated the effect of the residence promotion schemes.

We hypothesize that elements in the residence promotion schemes caused citizens to move to the districts. To investigate this, the study conducts a long-term analysis

covering approximately 30 years to compare the periods before and after the policy was implemented and the migration from non-residence promotion districts to residence promotion districts. Thus, by considering these factors, we can predict the future population structure of Toyama City, which will be the outcome of this paper.

We apply a difference-in-differences approach to prove this hypothesis. The approach is normally categorized as a natural or quasi-experiment. Meyer (1995) asserted that, "a natural experiment induced by policy changes, government randomization, or other events may allow a researcher to obtain exogenous variation in the main explanatory variables." This approach is often used within the framework of development economics and related fields in research on migration (Zhao 1999; Imbert and Papp 2020). Regarding research concerning city management, Heckert and Mennis (2012) provided estimations of the impact of an innovative vacant land greening program in the city of Philadelphia in the United States, noting that this approach "investigates whether an intervention influences an outcome over time by comparing observed differences in a case sample that receives the intervention with observed differences in a control sample that does not."

1.3 Structure of the Paper

The remainder of this paper is organized as follows. In section 2, we examine the details of the compact city policy in Toyama City, taking up the residence promotion scheme that is one of the main factors of the policy. Second, we seek to identify the potential factors that caused people to move to other places. In section 3, we estimate how the schemes have impacted migration to Toyama City. Finally, section 4 provides the conclusion and the implications of the study.

2. The Compact City Policy in Toyama City

Toyama City is the capital of Toyama prefecture and has 409,075 inhabitants as of December 2022[3]. It is also designed as one of the core cities in Japan. Similar to the experience of other regional cities in Japan, Toyama City has suffered from a declining population and urban sprawl. These circumstances changed when Masashi Mori became the mayor of Toyama City and adopted the compact city policy as a new strategy to

3）Toyama city (n.d.). *Population in Toyama City*. Retrieved January 7, 2023, from https://www.city.toyama.toyama.jp/kikakukanribu/kikakuchoseika/tokei/jinkosetai/jinkosetai.html (in Japanese).

address the problem of a declining population.

The compact city policy in Toyama City has three pillars: the first is the revitalization of public transportation, the second is encouraging residents to relocate to zones along public transportation lines, and the third is the revitalization of the city center[4]. This paper focuses on the second pillar.

2.1 The Residence Promotion Schemes in Toyama City

Toyama City has two residence promotion schemes; the City Center Dwelling Promotion Scheme and a scheme to promote dwelling along the public transport axes. Toyama City has established residence promotion districts for the two schemes, and citizens who live in or who move to these districts receive subsidies. The city center is defined as 436 ha of the center, and the districts along the public transport axes are those located within 500 m of train stations and 300 m of bus stops. The City Center Dwelling Promotion Scheme started in 2005 and a scheme to promote dwelling along the public transport axes began in 2007. More details about each plan are presented in Table 1.

Table 1: Details of Residence Promotion Schemes

Target areas	For whom	Types of schemes
City centers	Citizens	City center housing acquisition support scheme City center renovation assistance scheme City center housing rental subsidy scheme Multi-habitation promotion scheme
	Construction companies	Scheme to promote the construction of apartment blocks in the city center Local excellent rental housing maintenance cost subsidy scheme Scheme to support city center housing conversion Scheme to support stores annexed to housing in the city center City center residential land maintenance promotion scheme Scheme to support and maintain disposal and wastewater treatment system in the city center
Public transport axes	Citizens	Scheme to support public transport axes housing acquisition Rent subsidy scheme for single-parent families Public transport axes renovation assistance scheme
	Construction companies	Scheme to promote the construction of apartment blocks in the public transport axes Local excellent rental housing maintenance cost subsidy scheme Public transport axes residential land maintenance promotion scheme

(Source: Toyama City website)

4）Toyama City（n.d.）. *Toyama's Unique Compact City Management Strategy*. Retrieved January 7, 2023, from https://www.uncrd.or.jp/content/documents/7EST-Keynote2.pdf .

There are various schemes for both citizens and companies, but who uses the residence promotion schemes? Figures 2 and 3 show the details of applicants' ages and household size. Figure 2 indicates that the majority of applicants for both schemes are in their 30s and 40s, which represents more than 80% of applicants for a scheme to promote dwelling along the public transport axes. Figure 3 shows that there are many single applicants to

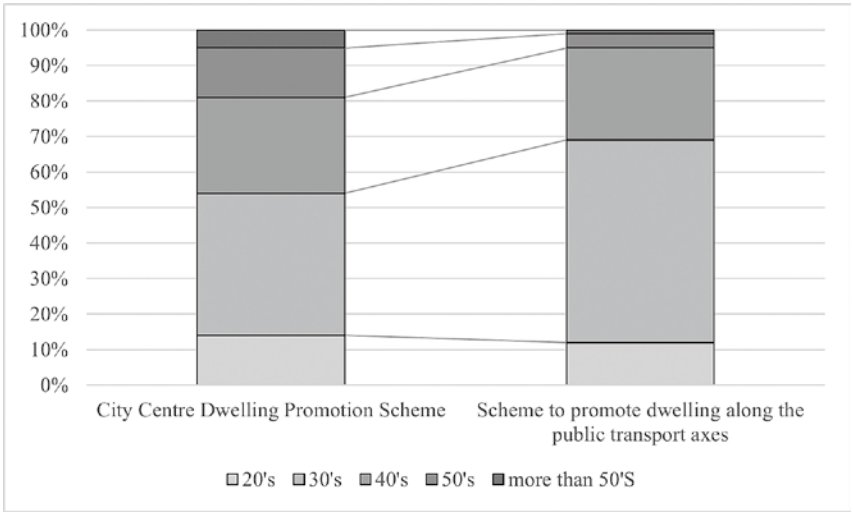

Figure 2. Breakdown of the residence promotion schemes by age (2017).
Source: Document received by the author from Toyama City in 2018.
Composition Ratio %

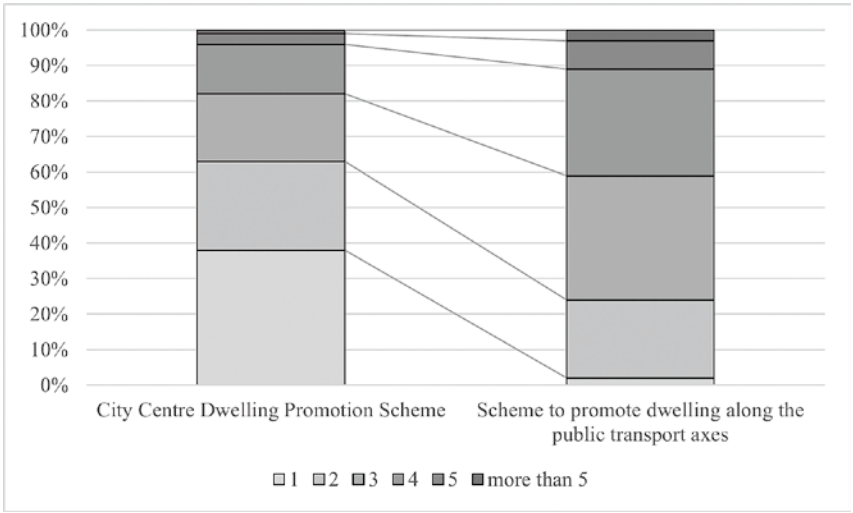

Figure 3. Breakdown of the residence promotion schemes by household size (2017).
Source: Document received by the author from Toyama City in 2018.
Composition Ratio %

the City Center Dwelling Promotion Scheme. Households comprising two to four people account for about 90% of the applications, and there are few single applicants to a scheme to promote dwelling along the public transport axes. These data indicate that a variety of citizens use the City Center Dwelling Promotion Scheme, while a scheme to promote dwelling along the public transport axes is largely used by families with young children.

2.2 Identifying the Push and Pull Factors of the Residence Promotion Schemes in Toyama City

Considering the discussion in section 2.1, in this section we attempt to determine the control variables using push-pull factor analysis. Push-pull factor analysis is a framework that is still used today in fields of development economics and economic geography. Lee (1966) is considered the classic study of push-pull factor analysis, and Van et al. (2018) further developed the research model.

According to Lee (1966), there are four factors of migration associated with the area of origin (push factors), factors associated with the area of destination (pull factors), intervening obstacles, and personal factors. Applying this notion to the residence promotion schemes in Toyama City, the first two factors are associated with the non-residence promotion districts and the residence promotion districts.

Van et al. (2018) refined the framework, arguing that there are five drivers of migration, namely, locality, scale, duration, selectivity, and tractability. He posited that these dimensions are often combined in particular cases of immigration, forming "driver complexes," to use the author's phrase.

Let us consider what may affect these two push and pull factors. Lee (1966) stated, "Another important difference between the factors associated with area of origin and area of destination is related to stages of the lifecycle." Thus, Figure 4 describes the dynamics of migration in the case of Toyama City as reflecting the particular factors that acted to pull and push the population to migrate.

In the case of the City Center Dwelling Promotion Scheme and a scheme to promote dwelling along the public transport axes in Toyama City examined in section 2.1, the majority of users are families with young children. Accordingly, it is possible that people relocate from non-residence promotion districts to residence promotion districts, seeking an environment that suits childcare needs or where children can be easily provided an

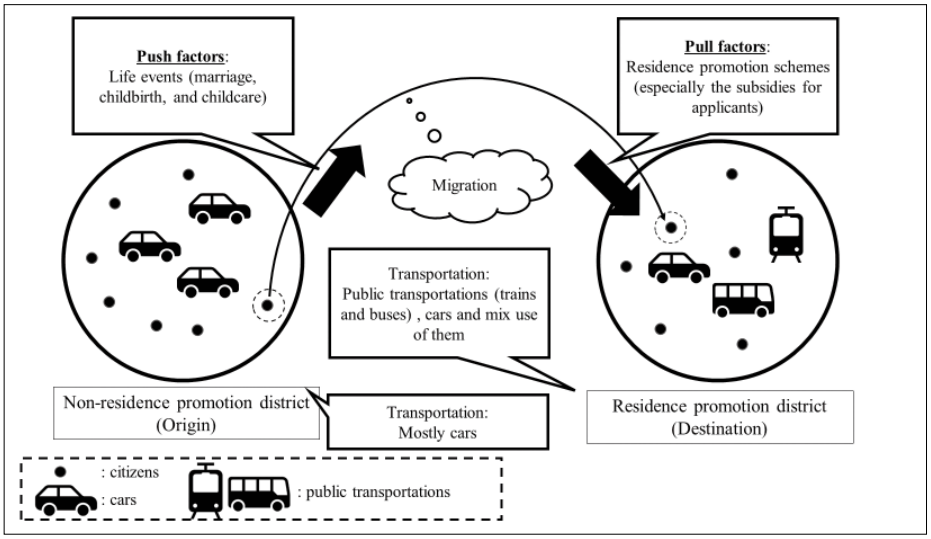

Figure 4. The dynamics of migration considering push and pull factors in the case of Toyama City.

Source: Author's construction.

education. Under this assumption, push factors could entail life events such as marriage, childbirth, and childcare, while pull factors could be residence promotion schemes or the subsidies described in Table 1.

3. Empirical Analysis of the Residence Promotion Schemes

We have presented the details of the residence promotion schemes in Toyama City, particularly the types of schemes and the applicants' ages and household size. We also found that the push factors of migration were life events and the pull factors were the residence promotion scheme itself or the related subsidies. Based on these findings in section 2, we next carry out the empirical analysis of the residence promotion schemes employing a difference-in-differences approach. It is key to identify the years of analysis before and after the schemes were implemented. We establish the border based on the City Center Dwelling Promotion Scheme; that is, the years before the scheme are 1988 to 2004, and after the scheme are 2005 to 2021.

3.1 Variables and Data

Before discussing the data used in the analysis, the appropriate variables must be identified. In section 2, we determined that push factors include life events such as

marriage, childbirth, and childcare, and pull factors are residence promotion schemes and subsidies. We will first focus on the push factors. If an applicant to a particular scheme departs from their place of origin, what are they seeking in a new destination? If they are looking for an environment for educational purposes, as suggested in section 2, the number of primary or junior high schools in each region could be a possible push factor. These factors become the control variables in the estimation models.

For the empirical analysis of the Toyama City residence promotion schemes, we use panel data constructed by the author, which includes a logarithm of the number of residences and the number of public primary and junior high schools in 80-82 regions[5] from 1988 to 2021. The data for the number of residences were obtained from the *Books of Toyama City Statistics* (Toyama City each year). The author also requested actual numbers from Toyama City, as some of them were not available in the books. Both data points were then combined in the panel data. Data for primary and junior high schools are based on *A Memorial Magazine for the 70th Anniversary* (Association of Primary Schools Principals in Toyama Prefecture 2018) and an interview with Toyama City Board of Education. The descriptive statistics are presented below (Table 2).

Table 2: Descriptive Statistics

Variable	Variable description	Mean	Std. Dev.	Min	Max
$Y_{i,t}$	Number of residences in region i in year t	5,126.959	4,200.156	11	22,573
$\ln Y_{i,t}$	Logarithm of $Y_{i,t}$	8.066	1.199	2.398	10.025
$Primary_{i,t}$	Number of public primary schools in region i in year t	0.863	0.371	0	2
$Junior.high_{i,t}$	Number of public junior high schools in region i in year t	0.327	0.495	0	2

Number of samples 2,752/Number of regions (i) 80 (1988-2001); 81 (2002-2009); and 82 (2010-2021)/ Number of times (t) 34 (1988-2021)

Source: Author's construction.

To advance the research, we identify which regions out of 80-82 overlap residence promotion districts. However, the categorization of residence promotion districts or non-residence promotion districts does not correspond to the 80-82 regions. Comparing the map of residence promotion districts with the Toyama City map, if each region overlaps

5) Due to local reorganization in 2002 and 2010, two new regions were established as independent from other regions.

by at least approximately 10%, it is categorized as a residence promotion area.

What are the correlations between the chosen variables? Table 3 presents the correlation coefficients. Table 3 demonstrates the correlations between D_i, dummy variables indicating whether a region overlaps with residence promotion districts, which equals 1 when a region overlaps and 0 when it does not; A_t, another binary variable, equals 1 for dates after the scheme was implemented (t = 2005, 2006, ⋯, 2021) and 0 before the scheme was implemented (t = 1988, 1989, ⋯, 2004); and D_iA_t, multiplied D_i by A_t are a bit high, as the highlighted numbers in Table 3 shows, although the other correlations are minimal.

Table 3: Correlation coefficients

	D_i	A_t	D_iA_t	Primary	Junior high
D_i	1				
A_t	0.010058	1			
D_iA_t	0.596765	0.555292	1		
Primary	0.19093	-0.17101	0.028453	1	
Junior high	0.178265	-0.018	0.097821	0.246928	1

Source: Author's construction based on calculations.

3.2 Analysis

In this study, we apply a difference-in-differences approach, but the applications of this approach vary. Therefore, we use the approach by estimating a log regression using ordinary least squares (OLS). The first empirical model used for analysis is the most basic difference-in-differences approach:

$$lnY_{i,t} = \beta_0 + \beta_1 D_i + \beta_2 A_t + \beta_3 D_i A_t + u_{it} \cdots (1)$$

where $lnY_{i,t}$ is a logarithm of $Y_{i,t}$, which is the number of residences in region i in year t. Thus, β_3, the coefficient of D_iA_t, indicates the effect of the scheme, which also means the pull factor by the difference-in-differences approach. Table 4 presents how it is calculated.

Table 4: The Process of Calculating the Difference-in-Differences on Formula (1)

	$A_t = 0$	$A_t = 1$	Difference	Difference-in-Differences
$D_i = 1$	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_2 + \beta_3$	β_3
$D_i = 0$	β_0	$\beta_0 + \beta_2$	β_2	

Source: Author's construction.

Formula (1) can be expanded by adding control variables. We make three other log regression models whose control variables are $Primary_{i,t}$, representing the number of primary schools in region i in year t (Formula 2), $Junior.high_{i,t}$, representing the number of junior high schools in region i in year t (Formula 3), and both $Primary_{i,t}$ and $Junior.high_{i,t}$ (Formula 4):

$$lnY_{i,t} = \beta_0 + \beta_1 D_i + \beta_2 A_t + \beta_3 D_i A_t + \beta_4 Primary_{i,t} + u_{i,t} \cdots (2)$$
$$lnY_{i,t} = \beta_0 + \beta_1 D_i + \beta_2 A_t + \beta_3 D_i A_t + \beta_4 Junior.high_{i,t} + u_{i,t} \cdots (3)$$
$$lnY_{i,t} = \beta_0 + \beta_1 D_i + \beta_2 A_t + \beta_3 D_i A_t + \beta_4 Primary_{i,t} + \beta_5 Junior.high_{i,t} + u_{i,t} \cdots (4).$$

What we can understand from Formula (2) to (4) is that β_4 and β_5, the coefficients of $Primary_{i,t}$ and $Junior.high_{i,t}$, indicating the effect of life events on citizens; that is, the impact of the push factor.

3.3 Estimation Results

The results of the regression model estimation are shown in Table 5. As described in section 3.2, the coefficients of $D_i A_t$ indicate the effect of the scheme as well as the pull factor by the difference-in-differences approach and those of $Primary_{i,t}$ and $Junior.high_{i,t}$ indicate the effect of life events and the push factor.

Overall, the $D_i A_t$s of models (1)-(4) show the effect of the scheme was significant at a 5% level, indicating that there is a positive effect of the residence promotion schemes on migrants in Toyama City. If we resolve the effect of the scheme into each factor of D_i and A_t as shown in Table 4 in the case of model (1), this can be described in Table 6.

First, we will discuss model (1), which is the simplest OLS model without control variables. The coefficient of $D_i A_t$ is 0.160, indicating that the actual effect of the scheme is about a 16% population increase in the regions that overlap the residence promotion districts after 2005. The adjusted R-squared indicates a linear relationship of 0.350, which is somewhat weak.

Second, models (2) and (3), which are controlled considering the push and pull factors indicate coefficients of $D_i A_t$ of 0.121 and 0.155, respectively, which is modest compared with model (1). What about the number of primary and junior high schools? $Primary_{i,t}$ shows a significant effect at the 0.1% level with a coefficient of 1.626 in model (2), and $Junior.high_{i,t}$

Table 5: Estimation Results

Regressor	(1)	(2)	(3)	(4)
D_i	1.337***	1.124***	1.219***	1.065***
	(0.052)	(0.042)	(0.050)	(0.041)
	[1.233, 1.440]	[1.041, 1.207]	[1.121, 1.316]	[0.985, 1.145]
A_t	-0.176***	0.051	-0.160***	0.043
	(0.051)	(0.041)	(0.047)	(0.039)
	[-0.275, -0.77]	[-0.029, 0.131]	[-0.253, -0.067]	[-0.034, 0.120]
D_iA_t	0.160*	0.121*	0.155*	0.120*
	(0.074)	(0.059)	(0.069)	(0.057)
	[0.015, 0.305]	[0.005, 0.236]	[0.019, 0.291]	[0.009, 0.232]
Primary		1.626***		1.494***
		(0.041)		(0.040)
		[1.546, 1.707]		[1.414, 1.573]
Junior high			0.685***	0.443***
			(0.036)	(0.030)
			[0.616, 0.755]	[0.385, 0.501]
Intercept	7.490*	6.081***	7.315***	6.083***
	(0.036)	(0.046)	(0.035)	(0.044)
	[7.420, 7.560]	[5.992, 6.171]	[7.246, 7.383]	[5.997, 6.169]
Adj. R-squared	0.3502	0.5864	0.4275	0.6171

Note 1: * = 5% significance; ** = 1% significance; *** = 0.1% significance

Note 2: Standard errors are given in parentheses under the coefficients, and 95% confidence intervals are given in square brackets under the coefficients.

Source: Author's construction based on estimation results

Table 6: The Process of Resolving the Effect in Model (1)

	$A_t = 0$	$A_t = 1$	Difference	Difference-in-Differences
$D_i = 1$	7.490 + 1.337	7.490 + 1.337 - 0.176 + 0.160	-0.176 + 0.160	0.160
$D_i = 0$	7.490	7.490 - 0.176	-0.176	

(Source: Author's construction.)

is significant at the 0.1 level, with a coefficient of 0.685 in model (3). As both coefficients are positive, the finding here is that increasing the number of primary and junior high schools has the effect of increasing the population in each region.

Finally, model (4) considers both of the control variables. The coefficient of D_iA_t is 0.120, which is smaller than in model (1). $Primary_{i,t}$ and $Junior.high_{i,t}$ are again significant at the 0.1% level, with coefficients of 1.494 and 0.443, respectively. The adjusted R-squared is 0.6171, indicating the strongest linear relationship among the four models.

4. Conclusion

The aim of this paper was to evaluate the compact city policy in Toyama City. Limited research has applied a long-term analysis to the evaluation of compact city policies. Additionally, compared with the extensive number of cases and research studies on expanding compact cities, the research on shrinking compact cities has been minimal. We conducted an evaluation of the residence promotion schemes of Toyama City considering the push and pull factors of migration, observing an approximately 12%-16% population increase that could be explained by the number of schools affecting migration to Toyama City. Considering the findings of this study and Fujioka and Sakakibara (2020), the policy thus far can be positively evaluated from the perspective of migration in both the short and long term.

An important implication of this research related to the issue of reorganizing public primary schools and junior high schools. According to the Toyama City Board of Education (2022), Toyama City plans to reorganize its public primary and junior high schools. Twenty-five out of 65 primary schools and 2 out of 26 junior high schools (as of 2022) are subject to reorganization, which will involve a decrease in the number of regions that have schools and a focus on particular regions. As shown in the study, increasing the number of schools in each region leads to a growth in the number of people in each region. Thus, the population gap between regions which have public transportation and schools and those that do not is going to continue to grow. From an efficiency standpoint of compact cities, this is desirable because more people are going to come to particular regions, increasing the density of the city center. In other words, from the perspective of compact cities, the scheme has succeeded so far. However, from the perspective of sustainable cities, this outcome is not necessarily desirable because it lacks equity[6)].

We should also mention the research limitations of this paper. First, this research presents a simplified case that considers a limited number of factors related to migration, only focusing on push and pull factors, yet other variables could also have possible effects. Second, we ignored migrants' origins in the analysis, whether inside or outside of the city, because the data were limited. This consideration is necessary to advance the research on

6）Elkin et.al. (1991) presents the four underlying principles of sustainable urban development as futurity, environment, equity, and participation.

regional economics, and future research should focus on this point. Third, the problem of simultaneous variable selection remains in the controlled model. Normally, instrumental variables are one solution and some research uses the same control variables in the previous year $(t-1)$ as instrumental variables in the regression using panel data. In this paper, they could be the numbers of primary and junior high schools in region i in year $(t-1)$. However, this may not satisfy instrument exogeneity. Further consideration about the appropriate variable is needed in the future. Finally, the method used for sorting whether regions overlap with the promotion districts is imperfect because the author merely compared the map of residence promotion districts with the Toyama City map analogically. Although digital data, such as that produced by geographic information systems for over 30 years, was not available at the time of this study, the research could be updated in a more digitally systematic manner in the future.

Acknowledgments

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