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What Shapes Local Innovation Policies?

Empirical Evidence from Japanese Cities

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Abstract:

Increasing attention has been paid to regional innovation systems. However, previous studies have so far only focused on (the regional impact of) national policies or specific regions. To date, no studies have been carried out on the implementation and variety of local research and development (R&D) subsidy programs at the municipality level. Our research fills this gap by using information on R&D subsidy programs from local authorities in Japan collected via websites and our original survey. Our research confirms 151 R&D subsidy programs conducted by 131 cities among all cities in 2015 and investigates the determinants of the implementation and design of local R&D subsidy programs at city level (length and upper limit of subsidies, and flexibility of subsidy conditions) considering both demand- and supply-side factors. The empirical results suggest that, after controlling for city type and population size, supply-side factors including local government conditions significantly affect the implementation of public R&D subsidy programs. In contrast, we find that demand-side factors matter more for the *design* of subsidy programs than supply-side factors.

Keywords: local authority, innovation policy, R&D subsidy, policy design, city

JEL Classification Code: H71, O38, R58

1. Introduction

Generating innovation and new business through R&D is important from the viewpoint of promotion of the regional economy. Accordingly, regional innovation systems have attracted much attention both from academia and practitioners. Whereas firms, universities, and regional governments ought to play important roles in the conceptualization of regional innovation systems, there is not sufficient empirical evidence on the relationship between regional or local governments and the central government in the discussion of regional innovation systems[1]. On the one hand, while the central government is expected to plan national policies considering the general welfare of the nation, local authorities play a complementary role, as they are often required to implement these national policies for local parties. On the other hand, they are also expected to develop original policies that may be better suited to local conditions and needs (Perry and May 2007). We may therefore expect to encounter a large variety of local policies according to different conditions of local authorities and different needs of local firms.

To date, there have been numerous studies on the central government's innovation policies including the promotion of regional clusters. In addition, several studies targeted specific regional policies and provided detailed case studies on these policies. However, despite increasing attention to local policy initiatives, econometric studies on the determinants, contents, and effects of local government policies are scarce, as we discuss in more detail in the next section.

[1] This relationship has been discussed in the literature on regional studies as an important issue with the keyword of multi-level governance (MLG) since the special issue in *Regional Studies* in November 2007, which we will discuss later in more detail.

In Japan, with a traditional centralization of policy-making, national government has always played a major role in promoting regional economies. Even though the promotion of regional innovation has been recognized as an essential policy issue since the beginning of this century under the “Science and Technology Basic Plan”, it was the Ministries of Economy, Trade, and Industry (METI) and of Education, Culture, Sport, Science and Technology (MEXT) that took the initiative in cluster policies (See Kitagawa 2007 and Okamuro and Nishimura 2017 for these innovation policies). However, in 2014, the Japanese government initiated the “Chiho Sosei” (regional revitalization) policy, encouraging local authorities to plan and design their own “General Regional Strategy” considering regional economic conditions and development trends. This new policy trend gives local governments a new, more important position in regional revitalization. However, for the moment, information regarding local authorities’ policies, which is partially available online, is neither widely shared nor accumulated in detail.

It is well known that the structure of public expenditures (the balance between different purposes) varies across local governments. Previous studies in public policy research find that the balance of expenditures depends on economic and institutional constraints, political imperatives, and actual needs (Hajnal and Trounstine 2010). In fact, for a direct and concrete policy targeting local firms, such as an R&D subsidy program, our original survey data found a large variety of program designs among cities regarding volume, conditions, and selection procedures. For example, the upper limit of subsidy per project varies from to less than one million to 50 million yen with a median of two million yen. Subsidy ratio to total project budget varies from 20% to 100% with a median of 50%. Regarding the flexibility of R&D expenses, only 34% of local governments allow public subsidies to be spent on personnel expenses. Thirty percent allow recipients to obtain other public subsidies for the same project. Before estimating the effects of public support with respect to program design, it is important to examine whether such variety is random, and if not, what determines such variations. However, to the best of our knowledge, no previous studies have empirically addressed the determinants of policy design.

Our research will fill this gap by targeting the variety of local innovation policies at city level in Japan directly and empirically. Based on website information of local authorities in the entire country and using original and unique survey data for public officers responsible for local authority R&D subsidy programs, we explore the variety of regional innovation policies. Next, we investigate the determinants local R&D subsidy program implementation and their design at city level using multiple regression analysis. As Tödling and Trippl (2005) argue, no innovation policy can fit all regions because of a wide variety of regional characteristics. Rather, it is important to consider regional variety in the implementation and design of innovation policies by local authorities.

The remainder of this paper is organized as follows: In Section 2, we provide a brief review of the related literature. In Section 3, we provide theoretical background and hypotheses. In Section 4, we explain our sample and data from our original survey for empirical estimations. In Section 5, we elaborate estimation models and report the empirical results. In Section 6, we conclude this paper by presenting some future research agendas.

2. Literature Review

Regional innovation systems comprising local SMEs, research institutes, and local authorities have attracted increasing attention since the seminal works by Cooke et al. (1997) and Cooke (2001), whereas there have been few studies on the innovation policies of local authorities. A special issue in *Regional Studies* focused on the multilevel governance of science (and innovation) policy and provided a comparison of the changing balance between central government and regional governments towards greater decentralization by contrasting centralized countries (England, France, Finland, and Japan) with federal countries (Germany and Canada) (Perry and May 2007). The articles in this special issue provide descriptive studies of science policy in each country with program-level (Salazar and Holbrook (2007) for Canada) or regional case studies (Crespy et al. (2007) for France, Sotarauta, and Kautonen (2007) for Finland, Koschatzky, and Kroll (2007) for Germany) and historical review (Perry (2007) for England, Kitagawa (2007) for Japan). It is also noteworthy that they all target regions or states instead of cities or counties[2].

An OECD report addresses the multilevel governance of innovation policies at different administrative levels (sub-national, national, and supra-national) and refers to some different patterns of governance among member and non-member countries (OECD 2011). There are some conceptual papers on the multilevel policy mix on innovation (Beugelsdijk 2007, Flanagan et al. 2011, Laranja et al. 2008), while Fernandez-Ribas (2009) compares the effects of innovation programs in EU regions between different levels of governments (regional, national, and EU levels), without considering municipality or city level.

Several previous studies focus on the impact of national cluster policies. Specifically, some empirically investigate local effects of national cluster policies in France (Martin et al. 2011, Fontagné et al. 2013) and

[2] The German study (Koschatzky and Kroll 2007) provides a case study of Bremen, which they do not regard as a city, but as a federal state.

Germany (Engel et al. 2013, Cantner et al. 2015) at firm and local levels. For Japan, Nishimura and Okamuro (2011a, 2011b, 2016) and Okubo et al. (2016) empirically examine the effects of METI's cluster policy at firm level, while Horaguchi (2016) analyses the effects of MEXT's cluster policy at cluster level. Using a unique micro dataset, Okamuro and Nishimura (2017) provide a comparative econometric analysis of the project-level effects of METI's and MEXT's cluster policies that have similar aims but contrasting schemes. However, they do not consider the role of regional or local governments[3].

In other policy fields in which local initiatives and multi-level governance are considered to be essential, such as entrepreneurship and environment protection, some empirical studies have been conducted at various levels of local government. Masuda (2006) explores the determinants of latent entrepreneurship (the ratio of working people who wish to start their own business) at prefecture level in Japan, focusing on the effect of prefecture support policies for start-up and using a cross-section dataset of 47 prefectures. Distinguishing between financial support and business management support, Masuda found that only the former policy significantly encourages latent entrepreneurship. More recently, local governments are increasingly involved in the development of environmental sustainability policies. Accordingly, a couple of empirical studies investigate the determinants of implementation of such policies at city and county levels in the USA, focusing on political factors (Hawkins et al. 2016, Laurian and Crawford 2016 and Laurian et al. 2017).

More generally, Foucault et al. (2008) using a dynamic panel data model of French municipalities,

[3] As an exception, Falck et al. (2010) empirically analyze the firm-level impact of the regional cluster policy of the Federal State of Bavaria in Germany, without considering the roles of cities. Moreover, Okamuro and Nishimura (2015) provide a *descriptive* comparison between Germany, France, and Japan on the role of local cluster management in national cluster policies with case studies of biotechnology cluster areas.

examine interactions between neighboring municipalities regarding primary and investment expenditures.. Hajnal and Trounstine (2010) analyze the effects of economic and institutional constraints, political imperatives, and actual needs on the balance between redistributive, allocational, and developmental spending in the USA at city and county levels.

However, apart from a few recent studies (Lanahan and Feldman 2015; Lanahan 2016) that target state-level small business innovation research (SBIR) programs in the USA, to the best of our knowledge, no empirical studies have so far been carried out on the determinants or effects of regional innovation policies by local authorities with respect to their variety. The 2015 study by Lanahan and Feldman explores the determinants of additional financial support by the states for the recipients of federal SBIR programs, while the latter by Lanahan (2016) examines the effects of additional state support for SBIR recipients. Lanahan and Feldman (2015) use a panel dataset of all states in the USA for the years 1983-2010. They argue that top-down (national policy variables), lateral (neighbor states' policy), and bottom-up (political and scientific environment of the state) factors incur the implementation of additional state-level support for the federal policy and find that most of these variables significantly affect the propensity of state SBIR. However, they do not target any local authorities lower than state-level, nor do they address any variations across state SBIR programs.

This paper will fill this gap by empirically investigating the determinants of both implementation and design of city-level R&D support policies in Japan using original survey data. Focusing on city-level innovation policies, which are independent of national policies, is especially important, because they lack empirical investigation and evidence, despite recent transformation of local governments' roles from passive (regions as stages and implementers) to active (regions as partners and independent policy-makers) (Perry and May 2007), which is striking in the case of Japan. This paper is original in that it targets not only the implementation, but also the variety in the design of R&D support policies by local authorities in Japan, especially in cities, where authorities are smaller and have less administrative power and responsibility than those in federal country states. Due to the cross-section nature of our dataset, we focus on the bottom-up factors used by Lanahan and Feldman (2015) which we reorganize into demand and supply factors.

3. Theoretical Backgrounds and Hypotheses

As previously mentioned, with a traditional centralization of policy-making, central government in Japan always played a major role in promoting regional economies. Even though the promotion of regional innovation has been recognized as an essential policy issue since the beginning of this century, METI and MEXT adopted the initiatives of cluster policies. Local authorities have been gradually acknowledged as partners in cluster policy, but it was not until the introduction of the Regional Revitalization Policy (*Chiho Sosei*) in 2014, that local authorities were encouraged and competitively supported by the central government to plan and design their own development policies with respect to local economic conditions. With this new national policy trend, local governments obtain a new and more important position in regional development.

Perry and May (2007) provide a conceptual framework for the "regional dimension" to science policy. Regions may play passive roles as stages and implementers of national policies and active roles as partners of central government and independent policy-makers. Recent developments in Japan demonstrate that Japanese local authorities (prefectures and cities) are changing rapidly and increasingly from passive to active players with the pressure and support of national policy. However, the extent of such a transformation may vary significantly across local governments. Perry and May (2007) explain the role of regions as independent policy-makers as follows. “Regional authorities and bodies are increasingly devoting their own finance and resources to funding regionally significant scientific investments or projects. The emergence of ‘regional science policies’ may be characterized by independent agenda-setting, institutional creation and new governance arrangements, new mechanisms and policy tools or strategic intelligence and capacity building” (p. 1042). Local authorities may differ regarding their motivation, resources, and capability.

Local government policy decisions are not random, but may be influenced by different factors. As we reported in the previous section, we found at least two empirical studies using US regional data that consider the factors for decision-making by local governments from multiple perspectives. In this section, we first explain the empirical models in these studies in more detail in order to derive our own theoretical basis for the hypotheses, considering the specific Japanese context.

Hajnal and Trounstine (2010) consider four factors for the balance of public expenditures: economic, political, and institutional factors as well as actual needs or local context, and found that each of these factors is important. To elaborate, economic factors include the economic resources of and competition between local governments, for which they use government revenue per capita and the central city dummy as proxies. The political factor refers to local public preference that is represented by share of votes for the Democratic candidate in presidential elections. Institutional factors cover local, state, and federal institutions, among which differences in local administration patterns are regarded as especially important. Actual needs (local context) are measured by regional dummies, poverty rate, unemployment rate, and population size.

By focusing on local R&D subsidy programs, which are not essential for local governments, we can more clearly address local economic conditions and distinguish between supply- and demand-side factors than previous studies. Lanahan and Feldman (2015), who estimate fixed-effect models using US state data for 28 years, consider top-down, lateral, and bottom-up factors. Top-down factors (time-series variation in the national policy) consist of the variables of federal R&D funding and industrial specialization in public procurement. Lateral factors reflect policy imitation or bandwagon effects, which are measured as the proportion of neighboring states with policy implementation. Bottom-up factors (regional conditions) are the Democratic governor dummy, its interactive term with early scientific advisory system, fiscal health (state revenue), and the variables of high-tech employment and higher education capacity.

We are more interested in the effects of local (cross-section) variations than time-series variations on public subsidy. Local R&D subsidies at city level are relatively new policy programs in Japan, where most programs have traditionally been centralized and, until recently, there has been very little room for local policy initiatives. In this context, top-down or institutional factors have little importance compared to the US, where institutions and laws differ significantly across federal states. Moreover, in the context of Japanese policy, competition between two major political parties has not functioned well. Most mayors are either "conservative" or "independent," but seldom belong to the opposition party in the central government, in which the conservative Liberal Democratic Party has almost always been the ruling party. Therefore, we concentrate on economic factors and actual needs (Hajnal and Toustine 2010) and in particular, bottom-up factors (Lanahan and Feldman 2015), which we reorganize into demand- and supply-side factors.

Public expenditures by local governments depend on their revenues, which are mainly based on tax and public debt. Therefore, local governments can be viewed as being under fiscal constraints. In light of these constraints, different policy schemes compete for limited budgets, and since it is often difficult to avoid or decrease the expenses of existing policies, launching a new policy program, especially a subsidy program, is a challenge for local governments. Moreover, administrative capabilities regarding R&D support programs may differ significantly across local authorities due to the quantity and quality of available human resources. Therefore, implementation of local R&D support programs depends on supply-side factors including fiscal constraints and the administrative capability of local authorities.

Regarding demand-side factors, actual policy needs of local firms are also important, as argued by Hajnal and Trounstine (2010). Here we argue that not only actual needs, but also potential needs are important. Therefore, the larger the potential local needs for such programs, the more likely local authorities are to implement them. Regarding R&D subsidies for local firms, local needs may be specific in the sense that not every local firm is eligible for the subsidy. It is well known that R&D is concentrated in the manufacturing sector, and more so in some industries within the manufacturing sector. Therefore, agglomeration of manufacturing firms, and specifically high-tech firms in R&D intensive industries, are important demand measures. When considering the competition between different policy purposes, we argue that the *share* of potential firms with R&D investment in each city is an appropriate variable for the demand for R&D subsidy, when controlled for economic size (population size) of the city. Moreover, we propose using average labor productivity of local manufacturing firms as a proxy for potential innovativeness of local firms[4].

The national government promotes collaborative R&D with other firms, universities, or public research institutes through the allocation of specific subsidies. Accordingly, most local R&D support programs target collaborative R&D projects, as we show later in the data section. Therefore, the availability of potential R&D partners in the region may be an essential element of the implementation of local R&D subsidy programs.

As part of the local authority decision-making process when implementing R&D subsidy programs, supply-side factors like fiscal constraints and administrative capability may be considered to be more important than local needs for such programs. However, once the local authorities decide to implement their own R&D subsidy programs, they will also consider local needs as far as possible when designing their programs. Therefore, we expect that supply-side factors of local authorities are more important for *implementing* R&D subsidy programs than demand-side factors, and demand-side factors are more important in *designing* these programs. In the determinants of program design, we pay special attention to the length of subsidy, the upper limit of subsidy ratio, whether the subsidy may cover personnel expenses, and whether multiple subsidization by different levels of governments is permitted. This is because R&D subsidy programs by local authorities considerably differ in these characteristics (See Section 4), which would be substantially affected by local needs of stakeholders.

Based on the aforementioned arguments, we propose the following three hypotheses for the empirical estimations, considering the demand- and supply-side of such subsidy programs.

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[4] Lanahan and Feldman (2015) use only the measures of high-tech employment and higher education capacity as the variables for bottom-up factors on the demand side, and so ignore regional industry characteristics.

Hypothesis 1: in relation to the demand for local R&D support, we suppose that local authorities of regions with higher research potential of local SMEs are more likely to provide R&D subsidy programs in response to higher demand by local firms. Although it can be also argued that local authorities of regions that lag behind in R&D activities are more eager to catch up with subsidies to local firms, as Lanahan and Feldman (2015) point out, we argue that efficient policy measures should consider local needs.

Hypothesis 2: in relation to the demand for local R&D support, we argue that local authorities of regions with more potential R&D partners are more likely to implement subsidy programs in response to higher demand.

Hypothesis 3: in relation to the supply of local R&D support, we hypothesize that local authorities that are financially less constrained and that provide more administrative services, especially for local firms, are more likely to conduct R&D subsidy program.

Hypothesis 4: We expect that supply-side factors matter more than demand-side factors for the implementation of local R&D subsidies, while demand-side factors are more important than supply-side factors in the design of these programs.

4. Sample and Data

We used the website of each prefecture and city in Japan to derive some basic information about public R&D subsidy programs for local SMEs and start-ups, which local authorities (prefecture and city administrations) implemented in 2015. The target projects of these programs include single firm projects, inter-firm collaboration, and university-industry collaboration. We exclude those support programs that ended before 2014 and those in which the maximum amount of subsidy per project is under one million yen in order to select active programs with a substantial amount of subsidy per project. Thus, we confirm that there were 294 local R&D subsidy programs as of 2015 in 47 prefectures and 813 Japanese cities: ninety percent of prefectures (42 of 47) and 19% of cities (158 of 813) conduct their own R&D subsidy programs in 2015, independently of national innovation policies.

Then, we conducted an original online survey of relevant local government officers on the content and strategy of these programs at both the prefecture and city levels[5]. Questionnaire items include 1) program contents (start year, targets and conditions, limit and ratio of subsidies, program budget and expenditure, number of applications, and selected projects), 2) procedures of selection and evaluation (selection method, support for selected projects, progress check, project report, and final inspection), and 3) background of program designs (relatedness to national policy, past programs, self- evaluation, factors for subsidy criteria, and future agenda). After a pre-test with three programs, questionnaires were sent to the relevant government officers of 291 local programs in January 2016. We obtained responses on 247 programs (response rate: 85%). From these, we used data relating to 151 programs in 131 cities for the empirical analysis.

In the empirical estimations, we focus on 813 cities (including special wards in Tokyo) and exclude prefectures, as program characteristics are markedly different between prefectures and cities, and because the variety of local programs appears much larger across cities than prefectures. We matched response data

5 We do not target towns and villages because these municipalities rarely implement their own R&D subsidy programs.

with aggregated regional data from various public statistics including the Economic Census (Statistics Bureau) and the Census of Manufacture (METI). In order to examine the determinants of local R&D subsidy programs among cities, we target all cities in Japan and employ a probit estimation that includes local independent variables on both demand- and supply-sides. These variables include population size, city status, specialization in manufacturing, the ratio of high-tech firms in manufacturing, the number of large manufacturing firms, the number of universities and research institutes, and the scale and structure of public expenditures. Finally, by targeting 129 cities that conducted such programs in 2015, we estimate some other probit models to investigate what characteristics of cities and local authorities may affect the *design* of local R&D subsidy programs.

In the following part, we briefly describe our survey results focusing on 151 city programs regarding the scale, content, conditions, and procedures of the subsidy program. The earliest local policies date back to the 1980s, but the median year of the implementation of the current policy program is 2009, which suggests that most local administration began their own R&D support programs relatively recently. Although there are few R&D subsidy programs that support only single-firm projects (11%), most programs also target single-firm projects. Half of the programs include university-industry collaboration in their targets. Most programs (88%) support only local firms in their own region, but in most programs project partners can be located elsewhere.

Subsidy duration is generally short: Two-thirds (67%) are limited to within one year. The average subsidy ratio to total R&D expenses is 58% (median: 50%). Most programs request partial self-payment of R&D expenditures by subsidy recipients, which may restrain their moral hazard. The average ceiling on R&D subsidy per project is 3.66 million yen (median: two million yen). Personnel expenses are allowed in one-third of the programs (34%), as is the advance payment of the subsidy (36%). The program budget in the fiscal year 2015 is on average 18 million yen (median six million yen) while the actual expenditure is on average 9.6 million yen (median four million yen in median).

Finally, regarding the relatedness to national programs, 67% of city programs do not support projects subsidized by prefecture or national programs in the same year. Thus, city programs are often designed as substitution for prefecture or national ones. The amount and conditions of subsidy are determined considering those of prefecture or national programs in 24% of the cases, while 27% of the programs create rules based on the situation of local firms.

5. Empirical Estimations on Local R&D Subsidy Programs

5.1. Estimation Models

We explain the empirical models to estimate the local authority's propensity to implement its own R&D subsidy program and the determinants of the designs of these programs. We employ a probit model for both estimations because all dependent variables are dummy variables.

In the first estimation, the dependent variable is the dummy variable that takes one if a city implements its own R&D support policy in 2015 and zero otherwise. Seventeen percent of the 772 cities in the sample implemented their own R&D subsidy program in 2015. We use the following city-level independent variables in the estimation: 1) proxies for local R&D capability (the share of manufacturing plants, share of high-tech plants in the manufacturing sector, and average labor productivity in manufacturing), 2) availability of potential partners for R&D collaboration (the number of large manufacturing firms with more than 300 employees, the number of R&D institutes, and the number of universities in the prefecture[6]), and 3) the scale and structure of public expenditures (the number of administrative officers per capita in natural logarithm, the share of industry and commerce expenditures, and the current account[7]).

The variables in groups 1) and 2) represent the demand factors (proxies for policy needs of local firms). We expect that the propensity of implementing R&D support policy may increase with local firms' policy needs (Hajnal and Trounstine 2010). However, if it is a general policy aimed at catching up with other regions, then we may also expect that policy support may be provided in higher propensity in regions with relatively *lower* R&D potential (Lanahan and Feldman 2015). The variables in group 3) indicate the supply factors as the proxies for local authorities' level of administrative services and budget constraints. We hypothesize that these factors affect the probability of local authorities implementing public R&D support programs for local SMEs as economic and institutional factors (Hajnal and Trounstine 2010). We also control for city scale measured as the population size in natural logarithm and the status of the city (the dummy for prefecture capitals)[8]. We assume that cities with a large population and higher administrative centrality in the region may be more likely to implement their own R&D support policies as "leaders" and "role models." In the estimation, we use the data before 2009, the median of the start years of the support policies, in order to consider the time-series consistency.

[6] We use the number of universities in the same prefecture (and not in the same city) because partner universities of private firms are often located outside of the city.
[7] This measure denotes the degree of financial soundness of local authorities. A higher (lower) value of this variable means higher (lower) deficit.
[8] Alternatively, we used the dummy variable for ordinance-designated cities that are empowered to issue their own ordinances. However, estimation results did not change significantly.

In the next estimations of the determinants of program design, we use the following four dummies as the dependent variables: dummies for 1) the length of subsidy, which takes one if public support exceeds one year and zero otherwise, 2) the high ratio of subsidy, which takes one if the upper limit of subsidy ratio is above 50% and zero otherwise, 3) the flexibility in expenses, which takes one if the subsidy is allowed to cover personnel expenses and zero otherwise, and 4) the generosity in receiving public support, which takes one if the same project is allowed to be simultaneously funded by other public subsidies and zero otherwise. We employ probit models again because the dependent variables are dummy variables. For these estimations, we use the same independent variables as the first estimation, except for business field dummies that are not used in the first estimation. We include them as additional control variables in the estimation models of program designs because they may differ across the target business fields of subsidy programs. In the following subsections we conduct these estimations separately and independently, but we will also check possible sample selection bias and the robustness of our estimations.

5.2. Determinants of the Program Implementation

First, we estimate the factors of implementing an R&D subsidy program using a probit model. Our research question is which city (or local authority) provides R&D subsidy programs for local firms. Tables 1 and 2 show the basic statistics and correlation matrix of the variables. The final sample is limited to 773 cities because of some data was missing due to administrative mergers. Table 3 presents the estimation results on the propensity for implementing local R&D support policies. In this table, we also show the marginal effects, and not the coefficients, of each independent variable.

These estimation results suggest that, even controlling for the size and administrative status of the cities, regional specialization in manufacturing (the share of manufacturing establishments) and active administrative services (number of administrative officers per capita and the share of expenditures for industry and commerce) significantly increase the propensity of implementing R&D support programs. For example, a 1% increase in the number of administrative officers per capita will lead to a 0.216% increase in the propensity of implementing R&D support programs, which suggests a large impact. We also find that the current account has a negative and significant effect on the probability of R&D subsidy programs. As a negative value of current account in this case means budget surplus, this result suggests that the cities with a sound public finance structure are likely to implement R&D support programs.

These findings partially support our first hypothesis that the implementation of local R&D support policies depends on demand-side factors of local economy, but fully support our third hypothesis on the supply-side factors. Moreover, they support the first half of our last hypothesis in that supply-side factors are more important than demand-side factors in implementing local R&D policies. In this regard we may argue that negative effects of demand-side factors (local authorities in the region with weak R&D activity tend to implement these programs for catch-up) offset and thus weaken their positive effects. These results are consistent with those of Lanahan and Feldman (2015), in which state revenue and high-tech employment have positive and significant effects on federal states' propensity to implement their own SBIR subsidy.

Contrary to our expectation, we find that the number of large manufacturing firms in the region *negatively* affect the probability of public R&D subsidy. This result may suggest that cities in which employment relies on large firms find it less necessary to implement support programs for local SMEs. Regarding control variables, the results suggest that larger cities (measured as population size) have significantly higher propensity to implement their own R&D subsidies. A 1% increase in the population leads to a 0.165% increase in the propensity of policy implementation. However, when controlling for population size, prefecture capitals are not significantly different from other cities with regard to the propensity of policy implementation. This may be because prefecture capitals may be expected to play a leadership role in local policies, but may also be more dependent on prefecture's policies in the sense that they do not need their own policies when a similar policy is implemented by their prefecture. Thus, the positive and negative impact may offset each other.

The above estimation results do not significantly change when the upper bound of subsidy per project is changed from one million to two or three million yen, with an exception for the result on the number of large manufacturing firms. Thus, we may regard these estimation results as robust regarding the amount of subsidy per project. Moreover, the results do not considerably change when we use the number of students or only *national* universities instead of the total number universities in the prefecture. From these findings, we may cautiously conclude that the supply-side factors (the conditions of public service of each city administration) are relatively important for the decisions of R&D support programs in relation to local SMEs.

5.3. Determinants of Program Design

In the next step, we examine the determinants of the design (scale, contents, conditions, and procedures) of local R&D subsidy programs. More specifically, we investigate whether and how the local factors used in the estimation in the previous section may affect program features, such as the length of subsidy, the upper limit of subsidy ratio (up to 50%, two-thirds etc.), whether the subsidy may cover personnel expenses, and whether multiple subsidization by different levels of governments is permitted. We focus on these variables because we find that, according to our survey, the features of R&D subsidy programs by local authorities differ considerably. This may also influence the attractiveness and user-friendliness of these programs. For example, a subsidy program for less than one year would be too short to accomplish any fundamental innovation.

Thus, we use the following four dependent variables: 1) subsidy length (dummy variable of whether the program covers a period longer than one year), 2) subsidy ratio (dummy variable of whether the subsidy's upper limit is above half of the total budget), 3) cost coverage (dummy variable of whether the subsidy can be used for personnel expenses), and 4) the relationship with national and prefectural programs (dummy variable of whether an overlapping subsidy with a national or prefectural program is possible). The value one for these variables mean that local R&D subsidy programs provide favorable conditions for the recipients in that 1) the term is longer than one year, 2) more than a half of project budget can be publicly funded, 3) research and support staff may also be employed, and 4) the project can also be supported by prefecture or central government, respectively.

In addition to the independent variables previously used, estimation models in this stage include business field dummies. With these new variables, we control for any unobservable differences in program designs across business fields. We hypothesize that both demand and supply factors matter for the design of local public R&D subsidy programs (H1, H2, and H3), but that program designs depend more on demand-side than supply-side factors.

In this stage, we exclude all cities that did not implement an R&D support policy in 2015. Our sample is therefore limited to 129 cities (including special wards in Tokyo) that conducted at least one R&D support program in 2015. As some cities implemented two or more related policy programs in 2015, in these cases we selected the major program for each city (in terms of total budget size) and excluded others from the sample in order to obtain one-by-one matching between cities and subsidy programs. Table 4 shows basic statistics of this final sample of 120 cities. A correlation matrix of the variables for this sample is provided in Table 5.

In the following estimations, we again employ probit models because all dependent variables are dummy variables. After these basic estimations, we also provide the results of other estimation models (Heckman's two-step estimations, structural estimation modeling, and bivariate probit models) as robustness checks in the following subsection.

Table 6 shows the estimation results of the designs of local R&D subsidy programs. First, regarding subsidy length (dummy for subsidy longer than one year), high-tech ratio, and number of large manufacturing firms have positive and significant effect. Second, the upper limit of subsidy (dummy for upper limit above a half) is positively and significantly affected by manufacturing share, number of large manufacturing firms and universities (in the same prefecture), and the current account of local government. Third, public subsidy may cover personnel expenses in cities where many high-tech firms as well as large manufacturing firms are located. Fourth, double subsidization with prefecture or national government's subsidy is permitted by cities with a higher ratio of high-tech firms but with lower productivity of manufacturing firms. A high-tech ratio in manufacturing firms and number of large manufacturing firms positively and significantly affect subsidy program design in favor of recipient firms. In contrast to the results on the determinants of local R&D subsidy programs, we find that as a whole their designs depend on the demand- rather than on supply-side factors. These results partially support Hypotheses 1 and 2 and are consistent with Hypothesis 4.

Regarding control variables, population size, which is highly significant in the implementation of local R&D support programs, has no significant effects on program designs. Larger cities are more likely to implement their own R&D subsidy programs, but program designs do not depend on city size.

5.4. Sample Selection Models and Other Robustness Checks

We conducted some robustness checks in this stage. First, we estimated Heckman's sample selection models (two-stage probit models) in order to check sample selection bias in the second stage (determinants of program designs). The results are shown in Table 7. We find that the inverse Mill's ratio is statistically not significant and that the error terms of the first and second stage estimations are not significantly correlated. We can reject the null hypothesis that the estimation results on program designs are subject to sample selection bias. These results suggest that the determinants of implementing R&D subsidy programs are not related to those of program features, which is consistent with the results shown in Tables 3 and 6.

Second, we simultaneously estimated four models of program design in Table 6 using structural equation modeling. The results are presented in Table 8. We find statistically significant correlations between the error terms between Models 1 and 2, Models 1 and 4, and Models 3 and 4, but do not observe significant changes in the estimated results from those in Table 6. Finally, we conducted bivariate probit estimations with Models 1 and 2, Models 1 and 4, and Models 3 and 4, in order to take correlations between the error terms of estimation models into consideration (Table 9). The estimated results did not change significantly from those in Table 6. The results of these additional estimations suggest that our findings are robust to possible biases.

6. Concluding Remarks

For several years, regional innovation systems and multilevel governance of innovation policies have attracted much attention. Local authorities are now expected to play a more active and independent role in regional development, including innovation policies for local SMEs in Japan, where regional and innovation policies have traditionally been strongly centralized. However, despite these new policy trends of regional decentralization, few empirical studies have so far been conducted on innovation policies by local authorities. In this sense, as far as we know, this paper is a pioneering empirical study on this research topic.

This paper paid particular attention to local R&D subsidy policies in Japan and, based on our original survey data on local governments, investigated the factors of implementation and design of local innovation policies. The results of the empirical estimation on the determinants of local R&D support programs show that both demand-side and supply-side factors are important in the decisions of local authorities to implement local R&D support program, but that supply-side factors seem to be more important. Further empirical estimations on the determinants of program design suggest that demand factors, especially the presence of high-tech firms and large firms in the manufacturing sector, are correlated with subsidy designs that are favorable for local recipients. These results as a whole support our hypotheses.

A major limitation of this study is its static nature due to cross-section data. It is not possible to obtain information about the start year of each local R&D support program from the websites. Moreover, we cannot collect information about local R&D support programs that ended before 2015. In the questionnaire survey, we asked for the start year of the *current* program, but 30% reported that they implemented another R&D support program prior to the current one. In some cases, nobody was able to identify the start year partly because some programs remain live with modifications to titles, targets, and contents. Therefore, it is often difficult to identify when R&D subsidy programs *really* began. With a more dynamic setting with a panel dataset, in which start years of each program could be clearly identified, we would quantitatively examine the effects of national policy schemes and decisions of neighboring local governments as considered by Lanahan and Feldman (2015).

According to the results of our original survey, in only a few cases local authorities started R&D subsidy programs because neighboring cities started similar programs. In contrast, however, 23% and 22% of the respondents report that they determined the design of subsidy programs by considering neighboring cities' programs or considering the relationship with national and prefectural government, respectively. Hence, the bandwagon effect in local innovation policies may be more than negligible.

A major academic implication of this study is that we obtained clear empirical evidence for the endogeneity of local innovation policies. Based on our estimation results, it is advised that future empirical studies on the effects of innovation policies are undertaken to consider this endogeneity issue. Moreover, from a practical point of view, the findings of this study may be considered when designing local public policies and the relationship between public policies at different levels.

Major policy implications may also be derived from this study. National government should consider the existing conditions of local economies and authorities in encouraging and evaluating policy initiatives by local authorities. Local authorities should consider local conditions (demand-side factors) more seriously in order to provide original local policies. We hope our paper may encourage empirical studies on the roles and strategies of local authorities in regional innovation systems and the multilevel policy mix in innovation policy.

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Table 1: Basic statistics of all cities (including Tokyo Wards) in Japan

Variables	Obs	Mean	Std. Dev.	Min	Max
d_subsidy	772	0.17	0.37	0	1
share of manufacturing	772	9.40	5.10	2.08	36.36
high-tech ratio	772	29.24	12.87	0	67.86
ln (manufacturing productivity)	772	6.95	0.47	5.03	8.85
# large manufacturing firms	772	15.23	63.12	0	945
# research institutes	772	8.11	19.54	0	211
# universities in prefecture	772	26.24	31.33	2	132
ln (# officers per capita)	772	-5.25	0.32	-5.95	-4.26
share of industry expend.	772	2.56	2.54	0.16	25.58
current account	772	91.36	6.40	58.63	106.6
ln (population size)	772	11.33	0.89	8.56	15.09
prefecture capital	772	0.05	0.22	0	1

Table 2: Correlation matrix of variables used in the first empirical analysis

	Obs=772	1	2	3	4	5	6
1	d_subsidy	1					
2	share of manufacturing	0.06	1				
3	high-tech ratio	0.05	0.18	1			
4	ln (manufacturing productivity)	0.06	0.07	0.38	1		
5	# large manufacturing firms	0.08	-0.07	-0.01	0.04	1	
6	# research institutes	0.17	-0.11	0.06	0.10	0.81	1
7	# universities in prefecture	0.04	-0.01	0.30	0.03	0.31	0.24
8	ln (# officers per capita)	-0.09	-0.10	-0.48	-0.30	-0.10	-0.21
9	share of industry expend.	0.17	0.05	-0.11	-0.02	0.11	0.13
10	current account	-0.12	-0.10	-0.17	-0.16	-0.23	-0.19
11	ln (population size)	0.27	-0.07	0.31	0.28	0.40	0.56
12	prefecture capital	0.10	-0.16	-0.03	0.06	0.33	0.47
		7	8	9	10	11	12
7	# universities in prefecture	1					
8	ln (# officers per capita)	-0.34	1				
9	share of industry expend.	-0.21	0.11	1			
10	current account	-0.27	0.19	0.01	1		
11	ln (population size)	0.33	-0.67	0.01	-0.21	1	
12	prefecture capital	-0.09	-0.22	0.14	0.02	0.49	1

Table 3: Estimation results on the propensity of the R&D subsidy program (probit model)

	R&D subsidy program	
variables	marginal effect	Robust S.E.
share of manufacturing	0.006**	0.002
high-tech ratio	－0.000	0.001
ln (manufacturing productivity)	－0.009	0.029
# large manufacturing firms	－0.001**	0.000
# research institutes	0.001	0.001
# universities in prefecture	－0.000	0.000
ln (# officers per capita)	0.216***	0.061
share of industry expend.	0.019***	0.005
current account	－0.005***	0.002
ln (population size)	0.165***	0.023
prefecture capital	－0.082	0.038
N	772	
Wald chi2	102.15***	
Log pseudolikelihood	－298.456	
Pseudo R2	0.143	

1) This table shows marginal effects instead of coefficients.

2) Level of significance: *** 1%, ** 5%, * 10%.

3) Robust standard errors of coefficients in italics under marginal effects.

Table 4: Basic statistics of cities that implemented R&D subsidy programs in 2015

Variables	Obs	Mean	Std. Dev.	Min	Max
subsidy longer than 1 year	120	0.34	0.48	0	1
upper limit of subsidy ratio above 1/2	117	0.43	0.50	0	1
personnel expenses covered	118	0.38	0.49	0	1
overlap with other subsidy programs possible	115	0.37	0.48	0	1
share of manufacturing	120	10.09	5.26	3.72	36.36
high-tech ratio	120	30.51	12.43	3.88	55.43
ln (manufacturing productivity)	120	7.02	0.43	5.92	8.22
# large manufacturing firms	120	27.54	55.37	0	353
# research institutes	120	15.80	30.09	0	211
# universities in prefecture	120	28.31	34.67	2	132
ln (# officers per capita)	120	-5.31	0.34	-5.86	-4.52
share of industry expend.	120	3.53	2.74	0.24	13.56
current account	120	89.41	7.36	61.07	105.40
ln (population size)	120	11.87	1.09	9.58	15.09
prefecture capital	120	0.11	0.31	0	1

Table 5: Correlation matrix of variables used in the second empirical analysis

	Obs=110	1	2	3	4	5	6	7	8
1	subsidy longer than 1 year	1							
2	upper limit of subsidy ratio above 1/2	0.15	1						
3	personnel expenses covered	0.09	-0.05	1					
4	overlap with other subsidy programs possible	0.23	-0.10	0.15	1				
5	share of manufacturing	0.00	0.08	0.13	0.08	1			
6	high-tech ratio	0.16	-0.12	0.21	0.07	0.15	1		
7	ln (manufacturing productivity)	-0.08	-0.06	0.04	-0.12	-0.06	0.52	1	
8	# large manufacturing firms	0.09	0.25	0.19	-0.14	-0.07	0.12	0.12	1
9	# research institutes	0.03	0.11	0.27	-0.15	-0.16	0.20	0.17	0.73
10	# universities in prefecture	-0.08	0.25	0.09	-0.05	0.20	0.10	-0.02	0.48
11	ln (# officers per capita)	-0.07	-0.10	-0.17	0.09	-0.07	-0.51	-0.54	-0.35
12	share of industry expend.	0.08	0.11	0.05	-0.12	0.19	-0.11	-0.14	0.00
13	current account	-0.02	0.00	-0.04	0.04	-0.28	-0.30	-0.11	-0.28
14	ln (population size)	0.06	0.18	0.23	-0.18	-0.13	0.40	0.44	0.59
15	prefecture capital	0.13	0.08	0.00	-0.15	-0.23	-0.02	0.07	0.29

		9	10	11	12	13	14	15
9	# research institutes	1						
10	# universities in prefecture	0.18	1					
11	ln (# officers per capita)	-0.36	-0.30	1				
12	share of industry expend.	0.03	-0.24	0.15	1			
13	current account	-0.04	-0.58	0.38	0.24	1		
14	ln (population size)	0.61	0.36	-0.76	-0.11	-0.25	1	
15	prefecture capital	0.38	-0.17	-0.25	0.05	0.13	0.43	1

Table 6: Estimation results on the design of R&D subsidy programs

	Model 1	Model 2	Model 3	Model 4
Variables	subsidy longer than 1 year	upper limit of subsidy ratio above 1/2	personnel expenses covered	overlap with other subsidy programs possible
share of manufacturing	−0.009	0.024**	0.008	−0.003
	0.009	*0.009*	*0.010*	*0.011*
high-tech ratio	0.014***	−0.008	0.009**	0.008*
	0.004	*0.005*	*0.004*	*0.005*
ln (manufacturing productivity)	−0.418***	−0.112	−0.209	−0.236*
	0.143	*0.175*	*0.173*	*0.138*
# large manufacturing firms	0.003**	0.004**	0.002*	0.000
	0.001	*0.002*	*0.001*	*0.001*
# research institutes	−0.004**	−0.005	0.004	−0.003
	0.002	*0.004*	*0.003*	*0.003*
# universities in prefecture	−0.003	0.006**	−0.002	−0.000
	0.002	*0.003*	*0.002*	*0.002*
ln (# officers per capita)	−0.167	−0.031	0.032	−0.096
	0.255	*0.297*	*0.253*	*0.251*
share of industry expend.	0.014	0.018	0.012	−0.026
	0.016	*0.021*	*0.019*	*0.019*
current account	−0.006	0.027**	−0.004	0.001
	0.009	*0.011*	*0.009*	*0.009*
ln (population size)	−0.006	0.085	0.143	−0.045
	0.094	*0.113*	*0.104*	*0.090*
prefecture capital	0.231	0.239	−0.262	−0.192
	0.203	*0.202*	*0.139*	*0.140*
business field dummies	yes	yes	yes	yes
N	120	117	118	115
Wald chi2	28.47**	31.95**	29.39**	25.78*
Log pseudolikelihood	−64.849	−58.548	−64.689	−65.208
Pseudo R2	0.160	0.267	0.175	0.146

1) This table shows marginal effects instead of coefficients.

2) Level of significance: *** 1%, ** 5%, * 10%.

3) Robust standard errors of coefficients in italics under marginal effects.

Table 7: Heckman's Sample Selection Model

	Model 1	Model 2	Model 3	Model 4
variables	subsidy longer than 1 year	upper limit of subsidy ratio above 1/2	personnel expenses covered	overlap with other subsidy programs possible
share of manufacturing	0.016	0.021	0.073	0.013
	0.042	*0.026*	*0.116*	*0.025*
high-tech ratio	0.013*	−0.006	0.004	0.005
	0.007	*0.004*	*0.019*	*0.006*
ln (manufacturing productivity)	−0.379*	−0.098	−0.251	−0.196*
	0.204	*0.127*	*0.550*	*0.111*
# large manufacturing firms	0.000	0.002	−0.006	0.002
	0.005	*0.003*	*0.014*	*0.004*
# research institutes	−0.000	−0.002	0.010	0.002
	0.007	*0.004*	*0.019*	*0.005*
# universities in prefecture	−0.004	0.005**	−0.005	−0.001
	0.004	*0.002*	*0.011*	*0.003*
ln (# officers per capita)	0.706	0.029	2.392	0.561
	1.519	*0.984*	*4.110*	*1.080*
share of industry expend.	0.076	0.014	0.176	0.029
	0.112	*0.072*	*0.295*	*0.089*
current account	−0.028	0.016	−0.062	−0.018
	0.041	*0.028*	*0.109*	*0.034*
ln (population size)	0.607	0.094	1.783	0.435
	1.054	*0.679*	*2.811*	*0.822*
prefecture capital	−0.094	0.202	−1.037	−0.432
	0.620	*0.354*	*1.558*	*0.512*
business field dummies	yes	yes	yes	yes
N	120	117	118	115
Wald chi2	28.45**	51.27***	2.17	25.13*
Mills lambda	1.095	0.027	2.865	0.829
	1.804	*1.226*	*4.796*	*1.361*

1) We show only the estimation results in the second stage.

2) This table shows marginal effects instead of coefficients.

3) Level of significance: *** 1%, ** 5%, * 10%.

4) Robust standard errors of coefficients in italic under marginal effects.

Table 8: Structural Estimation Modeling

	Model 1	Model 2	Model 3	Model 4
variables	subsidy longer than 1 year	upper limit of subsidy ratio above 1/2	personnel expenses covered	overlap with other subsidy programs possible
share of manufacturing	−0.003	0.020***	0.015*	0.005
	0.009	*0.007*	*0.009*	*0.009*
high-tech ratio	0.012***	−0.006	0.008**	0.009**
	0.004	*0.004*	*0.004*	*0.004*
ln (manufacturing productivity)	−0.362***	−0.139	−0.246*	−0.218*
	0.124	*0.130*	*0.145*	*0.123*
# large manufacturing firms	0.002**	0.002**	0.001	−0.000
	0.001	*0.001*	*0.001*	*0.001*
# research institutes	−0.004**	−0.001	0.000	−0.001
	0.002	*0.002*	*0.002*	*0.002*
# universities in prefecture	−0.002	0.004***	−0.001	−0.000
	0.002	*0.001*	*0.002*	*0.002*
ln (# officers per capita)	−0.191	−0.040	−0.071	−0.042
	0.235	*0.229*	*0.227*	*0.206*
share of industry expend.	0.008	0.012	0.006	−0.028
	0.014	*0.016*	*0.018*	*0.016*
current account	−0.002	0.016**	0.003	0.006
	0.010	*0.007*	*0.007*	*0.008*
ln (population size)	−0.011	0.083	0.064	−0.064
	0.079	*0.080*	*0.091*	*0.084*
prefecture capital	0.284*	0.237	−0.024	−0.096
	0.161	*0.158*	*0.164*	*0.139*
business field dummies	yes	yes	yes	yes
N		110		
Log pseudolikelihood		−3854.191		
	cov (e1, e2) =	0.024*	cov (e2, e3) =	−0.023
	cov (e1, e3) =	0.009	cov (e2, e4) =	−0.017
	cov (e1, e4) =	0.036**	cov (e3, e4) =	0.034**

1) This table shows marginal effects instead of coefficients.

2) Level of significance: *** 1%, ** 5%, * 10%.

3) Robust standard errors of coefficients in italics under marginal effects.

Table 9: Bivariate Probit Estimations

	Model 1		Model 2		Model 3	
variables	subsidy longer than 1 year	upper limit of subsidy ratio above 1/2	subsidy longer than 1 year	overlap with other subsidy programs possible	personnel expenses covered	overlap with other subsidy programs possible
share of manufacturing	−0.017	0.065***	−0.021	−0.009	0.024	−0.010
	0.026	*0.024*	*0.026*	*0.030*	*0.028*	*0.030*
high-tech ratio	0.040***	−0.020	0.038***	0.025**	0.025**	0.026**
	0.013	*0.012*	*0.013*	*0.012*	*0.012*	*0.013*
ln (manufacturing productivity)	−1.345***	−0.332	−1.128***	−0.608*	−0.696*	−0.640*
	0.408	*0.439*	*0.402*	*0.367*	*0.404*	*0.384*
# large manufacturing firms	0.008**	0.008*	0.008**	0.000	0.003	−0.001
	0.004	*0.005*	*0.004*	*0.003*	*0.003*	*0.003*
# research institutes	−0.014**	−0.009	−0.013**	−0.009	−0.001	−0.009
	0.006	*0.009*	*0.006*	*0.007*	*0.006*	*0.006*
# universities in prefecture	−0.007	0.014**	−0.007	−0.001	−0.003	0.000
	0.006	*0.006*	*0.006*	*0.005*	*0.005*	*0.005*
ln (# officers per capita)	−0.655	−0.144	−0.529	−0.332	−0.471	−0.322
	0.699	*0.760*	*0.701*	*0.645*	*0.687*	*0.672*
share of industry expend.	0.026	0.039	0.033	−0.067	0.032	−0.066
	0.046	*0.053*	*0.047*	*0.052*	*0.053*	*0.050*
current account	−0.008	0.064**	−0.011	0.006	−0.000	0.012
	0.029	*0.026*	*0.028*	*0.023*	*0.023*	*0.025*
ln (population size)	0.007	0.221	−0.069	−0.147	0.123	−0.164
	0.253	*0.284*	*0.254*	*0.234*	*0.259*	*0.241*
prefecture capital	0.769	0.669	0.836*	−0.539	−0.157	−0.566
	0.506	*0.496*	*0.498*	*0.521*	*0.496*	*0.533*
business field dummies	yes	yes	yes	yes	yes	yes
N	117		115		113	
Wald chi2	81.82***		62.51***		59.24***	
Log pseudolikelihood	−128.208		−133.215		−135.106	
Wald test of rho=0	1.892		4.098**		5.739**	

1) This table shows marginal effects instead of coefficients.

2) Level of significance: *** 1%, ** 5%, * 10%.

3) Robust standard errors of coefficients in italics under marginal effects.