Received: 28 February 2022 | Revised: 9 December 2022 | Accepted: 12 January 2023

DOI: 10.1111/ropr.12544

RPR REVIEW OF POLICY RESEARCH

ORIGINAL ARTICLE

Net-zero carbon declarations by Japanese local governments: What caused the domino-like diffusion?

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Funding information
Japan Society for the Promotion of Science, Grant/Award Numbers: 18H00919, 21H00773, 21K13440

Abstract
Sub-national governments are a crucial non-state actor for mitigating climate change. This importance has recently strengthened as increasing numbers of municipalities declare net-zero carbon emission goals to support the Paris Agreement, often well ahead of national governments. In Japan, net-zero declarations have also diffused widely, with nearly 800 declarations appearing in domino-like fashion over 2019–2022. To elucidate the factors that propelled this rapid diffusion, we used an event-history analysis based on data from a survey to develop an integrated statistical model. We then deepen understanding of diffusion mechanisms through seven brief case studies informed by interviews and document analysis. We find that the drivers of policy diffusion varied over time. During the early stage, internal factors drove the spread of declarations; namely participation in transnational city networks, endowed human and financial resources, and political leadership. But in later stages, diffusion was mostly propelled by external factors; namely declarations by neighboring cities and the affiliated prefectural government. Through these

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findings, we contribute to scholarship through two novel perspectives. First, we reveal the factors driving policy diffusion across both early adopters and the ordinary majority. Second, we show how the influence of well-known factors can vary during different stages of policy diffusion.

KEYWORDS
climate change, energy, environment, governance, urban studies

INTRODUCTION

Non-state actors such as NGOs, businesses, research institutions, and local governments are widely recognized as critical for climate change mitigation (Bäckstrand et al., 2017; Hale, 2018). Such actors can potentially fill gaps left by national policies, when ambitious action is stalled or weakened by political deadlocks or the influence of carbon-intensive industries (Jordan & Huitema, 2014). Non-state actors have historically invigorated the dynamics shaping international and national climate policies through varied roles like research, information diffusion, mobilization of other societal sectors, participation in international climate negotiations, lobbying, and policy advocacy (Bäckstrand et al., 2017; Hale, 2018). These activities can be multi-scalar and transnational in nature, leveraging international networks to amplify their effect (Hakelberg, 2014).

Among non-state actors, local governments provide a particularly important driving impetus for climate mitigation (Bulkeley, 2021). This stems from their direct control over local laws, regulations, and planning priorities as well as their ability to mobilize entire cities and towns around particular visions and development agendas (Bulkeley & Broto, 2013; van der Heijden & Hong, 2021). Moreover, cities are major sources of greenhouse gas (GHG) emissions. With more than half of humanity living within and around cities, roughly three-quarters of global CO_2 emissions from fossil fuels originate from urban areas (Seto et al., 2014). Furthermore, this share is rising, as people increasingly migrate to cities, attracted by the concentration of economic activity, culture, infrastructure, and technologies (Truong et al., 2022). But this density makes urban areas highly vulnerable to climate change impacts such as flooding, heatwaves, and sea-level rise, since even localized impacts can disproportionably affect sizable populations and infrastructure (Boland et al., 2021).

Despite this strategic importance of government authorities in urban cities, responses around the world to climate change have been highly heterogenous in terms of ambition and comprehensiveness (Steffen et al., 2019). This prompts the question: under what conditions will local governments adopt ambitious climate policies? Research by climate governance and policy diffusion scholars reveals that ambition is frequently influenced by factors such as endowment with financial and human resources (Fraser et al., 2020; Takao, 2020), participation in transnational networks (Lee & Jung, 2018; Steffen et al., 2019) and strong political leadership (Takao, 2014, 2020; Tatsumi et al., 2021). Additionally, several scholars have developed integrated statistical models to formally test the influence of such factors on policy diffusion and innovation (Abel, 2021; An et al., 2022).

Although this scholarship has generated rich insights into the characteristics that define governments at the forefront of climate action, important knowledge gaps remain. First, scholars have failed to explain why seemingly ordinary governments—which frequently lack the attributes of their progressive counterparts—may also implement pioneering or ambitious policies. Elucidating the factors that incite the "ordinary majority" or laggards to adopt aspiring climate policies is important, since their efforts will determine the success of the global response to climate change just as much as frontrunners. Second, existing studies have not sufficiently considered how the influence of different factors may change over time (Gilardi et al., 2009; Mallinson, 2021). This is despite the literature's emphasis on the temporality of the diffusion process, since it classifies different adopter categories as innovators, early adopters, early majority, late majority, laggards etc. (Rogers, 2003). These knowledge gaps point to a dual challenge for policy diffusion scholars. First, statistical models must be capable of detecting the factors that influence policy diffusion in governments both with and without the attributes known to drive policy innovation and adoption. Second, there is a need to investigate the temporally varying influence of factors during different stages of policy diffusion.

This study, therefore, aims to empirically examine how different determinants of policy adoption can influence the policy diffusion process at different points in time. To fulfill this objective, we focus on the case of Japan. This country provides a compelling example of policy diffusion in the context of climate change mitigation. Concretely, during the 3-year period 2019–2022, nearly 800 local governments announced commitments to reach net-zero carbon emissions by 2050 in rapid, domino-like succession. These declarations support the Paris Agreement's goal of limiting planetary warming to 1.5°C. To examine the factors that drove the diffusion of net-zero declarations across Japan, we couple data from a survey administered to local governments with an event-history analysis. Breaking the policy diffusion period (2019–2022) into four stages, we use a Cox proportional hazards model (Cox, 1972) to investigate the temporally varying influence of factors known to drive adoption of ambitious climate policies. We then verify the model's outcome with evidence from case studies, collected via interviews and documents from seven local governments in Kanagawa Prefecture.

Examining the factors that propelled the spread of net-zero declarations across local governments contributes to increasing international interest on this topic (Davidson et al., 2020; Seto et al., 2021). In parallel, for scholars interested in Japan, our study captures a major paradigm shift within domestic climate governance. Concretely, the wave of net-zero declarations at the sub-national level heavily influenced the national government's decision to follow suite in October 2020 with its own carbon-neutrality target for 2050. Moreover, the adoption of net-zero emission targets for 2050 marks a shift toward backcasting in climate planning. This breaks away from Japan's historical emphasis on feasibility for industry during target setting, which has historically shackled the emergence of ambitious climate policy (Tomozawa, 2016). It also moves beyond the bureaucratic culture of incrementalism, which has previously stifled ambition by prioritizing the fine-tuning of existing policies rather than radical overhauling (Trencher et al., 2020).

More broadly, we advance the literature on urban climate governance and policy diffusion in at least three ways. First, we address a previously stated need for studies that comprehensively assess the influence of diverse factors on policy diffusion (Berry & Berry, 2017), contributing to recent efforts in this area (Abel, 2021; An et al., 2022). Second, we overcome the tendency of previous research to focus exclusively on frontrunners, examining how early policy adopters can exert a domino-like effect on late adopters. Third, by examining both cities and prefectures, we contribute to interest in the mechanisms driving policy diffusion across different levels of government.

This paper's remainder proceeds as follows. The following section summarizes the theoretical basis of policy diffusion and previous discussions about influencing factors and causal directionality. Next, we present our methods and introduce the case of net-zero carbon declarations in Japan. Finally, we present our findings and then conclude by summarizing key findings and implications.

POLICY DIFFUSION AND ITS THEORETICAL BASIS

An extensive body of literature on policy diffusion, urban climate governance, and energy transitions has discussed factors known to influence the adoption of innovative policies by local governments. Following a distinction by Berry and Berry (2017), we categorize these as *internal* (having no diffusion effects) or *external* (also referred to as *policy diffusion*, having diffusion effects). Beginning with the former, we summarize below the factors that we later measure with our statistical model. In highlighting these, we make no claim to have exhaustively covered all known determinants of policy adoption. Rather, our study concentrates on those that surface the most frequently across differing strands of literature.

Internal factors influencing policy adoption

Political leadership

The adoption of ambitious or pioneering climate policies is frequently attributed to the presence of a motivated leader or champion, such as a mayor (Fraser et al., 2020; Ito, 2002; Takao, 2020; van der Heijden & Hong, 2021). Such leaders can perform several important roles. These include conjuring up visions of policy or societal change to inspire or motivate other actors as well as coordinating the varying and sometimes conflicting interests of different stakeholders, such as national government, industry, research institutions, and citizens (Nishida & Hua, 2011; Takao, 2020).

Funding resources

Municipalities endowed with larger budgets may encounter fewer difficulties when introducing and enforcing progressive policies, since funds can alleviate the bureaucratic burden caused by extra efforts (Fraser et al., 2020; Takao, 2014). This reasoning is supported by observations that it is especially governments from prosperous settings like California, Tokyo, and Shenzhen that continuously lead the introduction of progressive environmental policies (de Jong et al., 2013; Matisoff & Edwards, 2014).

Human resources

The human capital comprising the staff of public authorities is another type of endogenous resource that increases the likelihood of taking ambitious climate action (Fraser et al., 2020; Takao, 2020). When human capital is plentiful, productive, or armed with relevant expertise, governments are expected to encounter fewer administrative, technical, or intellectual hurdles when adopting zealous or pioneering climate policies (Altenburg, 2012; Wolfram, 2016).

External factors influencing policy adoption

The above discussion chiefly explained internal conditions that influence the capacity of governments to adopt ambitious environmental policies. However, in some cases, governments poorly endowed with such factors will nevertheless adopt progressive climate policies ahead of their peers. Or alternatively, in a group of local governments sharing roughly equal internal conditions, why is it that some will adopt a policy faster or slower than their peers? This is where external or diffusion factors come into play (Berry & Berry, 2017; Ito, 2002). Policy diffusion is said to occur as a result of "one government's policy choices being influenced by the choices of other governments" (Shipan & Volden, 2012, p. 788). Based on this understanding, below we distinguish diffusion across governments at the same level (*horizontal diffusion*) and different levels (*vertical diffusion*).

Horizontal diffusion

Policy diffusion can occur across jurisdictions at the same level, such as villages, cities, or states/prefectures. Prior studies have shown that such horizontal diffusion tends to occur among peer governments located in geographical proximity to each other (Lee & Koski, 2015; Rai, 2020; Takao, 2014). Not only do geographical neighbors often share similar economic and social characteristics, but they are likely to communicate frequently, which drives mutual learning and emulation (Mooney & Lee, 1995). They are also more likely to feel a stronger sense of competition relative to same-level peers located further away (Berry & Berry, 2017). Although research has demonstrated the mutual influence of geographically proximate peers to be an important determinant of the diffusion process (Shipan & Volden, 2008; Zhou et al., 2019), in aggregate, statistical models have not sufficiently explained the precise mechanisms by which this effect occurs (Boehmke, 2009; but see Zhou et al., 2019 as a recent exception). Notwithstanding, since our primary objective is to identify the differing and time-varying factors that influenced the adoption of net-zero declarations across municipalities, we follow this traditional approach of modeling horizontal diffusion, using geographical neighbors as an aggregated variable of potentially heterogenous mechanisms.

Vertical diffusion

Diffusion can also occur between different level of governments, such as from a state or prefecture to cities and towns. One of the frequently discussed mechanisms behind such vertical diffusion is coercion from an upper government to lower governments (Shipan & Volden, 2008). Such coercion can be both explicit and hard, for example, through a mandate imposed by a government to the lower levels under its authority (Berry & Berry, 2017). But it can also occur less directly, in softer forms, such as a case where lower-tiered governments are incentivized to pursue a particular agenda through subsidies supplied from above (Ito, 2002; Kim et al., 2018). Lower-level governments can also be motivated to follow the policies of an upper-level authority due to anxieties about being perceived as a laggard or regressive if not adopting a certain policy (Takao, 2014). Again, operationalizing this theory to detect the exact mechanisms by which vertical diffusion takes place has challenged scholars. Consequently, statistical models tend to leverage indirect measures, such as the affiliation groups to which various governments belong (Zhou et al., 2019).

These different drivers of diffusion indicate that governance is a multi-level process (Gupta, 2007). That is, climate change is a "glocal" problem that demands different levels of government to simultaneously plan and implement policies. Climate policy decisions are thus "created, constructed, regulated and contested, between, across and among scales" (Bulkeley, 2005, p. 876). Accordingly, recent studies have started to investigate the communication process of different scales of government in one model (e.g., Di Gregorio et al., 2019). Our paper follows this line of conceptualization by including varying scales of government (cities and prefectures in our case) in a single model. This allows us to explicitly examine and compare the strength of horizontal diffusion across different levels of government.

Global intra-city networks as semi-internal factors

Participation in transnational intra-city networks (hereafter, *transnational networks*) also increases the likelihood of a city government adopting ambitious climate policies (Lee, 2013; Lee & Jung, 2018). Specifically, networks such as the C40 Cities Climate Leadership Group and Local Governments for Sustainability (ICLEI) provide important opportunities for members to learn from peers and adopt innovative or effective practices (Acuto & Rayner, 2016; Castán Broto, 2017; Trencher et al., 2016). Accordingly, the effect of such networks on climate actions by local governments is increasingly studied by diffusion scholars (Hakelberg, 2014; Steffen et al., 2019).

Situating transnational networks into the simplistic distinction between internal and external factors is not straightforward. Such networks can be considered as an external factor, since it can be hypothesized that a declaration by a geographically distant member would influence the choice of other members. However, transnational networks can also be regarded as an internal factor, since they provide a common community, strengthening the intellectual and technical capacity of member governments. Furthermore, the literature generally examines the diffusion process within an explicitly delineated system (Rogers, 2003), which in our case, is declarations made within Japan. Accordingly, we regard participation in transnational networks as a (semi-) internal factor, acknowledging that information resources contained within intra-city communities can diffuse globally.

Temporal variation

When integrating the aforementioned factors as independent variables into regression models, many previous studies aggregate the whole observation period. Although they still succeed in revealing the factors that differentiate adopters from non-adopters, this approach masks the substantial variation that can occur within different categories of adopters (i.e., within early adopters, early majority, laggards, etc.). Cognizing this limitation, recent work (Mallinson, 2021) has underscored the need to consider the temporally varying effect of different variables. Furthermore, the temporal variation of diffusion factors is inevitably connected with broader political forces. Specifically, policy diffusion across local governments does not occur in a closed system, but rather, is driven or hampered by developments at the national level. Based on the varying characteristics of different types of adopters (Rogers, 2003), it is expected that progressive local governments would strive to remain ahead of their national-level counterpart. Meanwhile, the late majority is expected to follow the national government's will. Taking these broader forces into account can thus provide valuable cues for dividing the policy diffusion period to investigate the varying influence of particular variables.[1]

Guided by these insights from the literature on policy diffusion, urban climate governance, and energy transitions, we now examine how the aforementioned factors have influenced the diffusion of net-zero carbon declarations across Japanese local governments.

CASE DESCRIPTION: THE DOMINO-LIKE DIFFUSION OF NET-ZERO CARBON EMISSION DECLARATIONS IN JAPAN

The net-zero objective declared by local governments across Japan aims to eliminate all in-boundary GHG emissions by 2050 in recognition of the globally shared objective under the Paris Agreement to limit post-industrial warming to below 1.5°C. Declarations have been made in various ways. In some cases, governments have stated the target in the statutory municipal plan. In other cases, the political leader has declared the net-zero target at the local assembly or at a press conference (Ministry of Environment, 2022). With political leaders taking the initiative, the process of declaring a net-zero target involves few veto-players (i.e., actors whose agreement is needed for political change) (Tsebelis, 2002). Potentially, however, the cost of declaring is moderately high. This is the case especially in the early stage of implementation, since a government risks losing its reputation if its emissions trajectory in the near term does not follow that needed to reach the long-term net-zero goal.

Figure 1 summarizes the diffusion of net-zero declarations across local governments. Based on the temporal nature of this trend and related political events, the diffusion process can be divided into four periods, shown as T1 to T4.

Period T1 begins in March 2009, when the very first net-zero declaration was made by Yamanashi Prefecture through its *Action Plan for Global Warming Countermeasures*. Being an area blessed with abundant forests, a committee of experts (*Kankyo Yamanashi Sozo Kaigi*) emphasized that this sequestration potential could be levered to reduce carbon emissions to zero. This became the backbone for the subsequent action plan, which marked the first time a local government in Japan officially committed to eliminating all in-boundary GHG emissions on a net-basis by 2050 (Yamanashi Prefecture, 2009). Yet diffusion of net-zero aspirations did not begin until May 2019, when the Mayor of Kyoto City announced his intention to achieve net-zero emissions, also by 2050. By the end of November 2019, this was followed by Tokyo Metropolitan Government, Yokohama City and then by eight other local governments (comprised of four at the prefecture level and four at the city level). In this way, the net-zero declarations spread simultaneously across prefectures and cities. With a 10-year gap between the first declaration in 2009 and later declarations from Kyoto City and elsewhere, Yamanashi's net-zero target was literally years ahead of its time. In contrast, the net-zero targets announced after 2019 were induced by the Paris Agreement, entered into force in 2016, and by the global solidarity emerging after this year around the goal of slashing emissions in a manner consistent with a 1.5°C scenario (Fankhauser et al., 2022). In parallel, as we discuss next, the post-2019 declarations were also triggered by the swelling domestic momentum during Period T2 to support the implementation of the Paris Agreement.

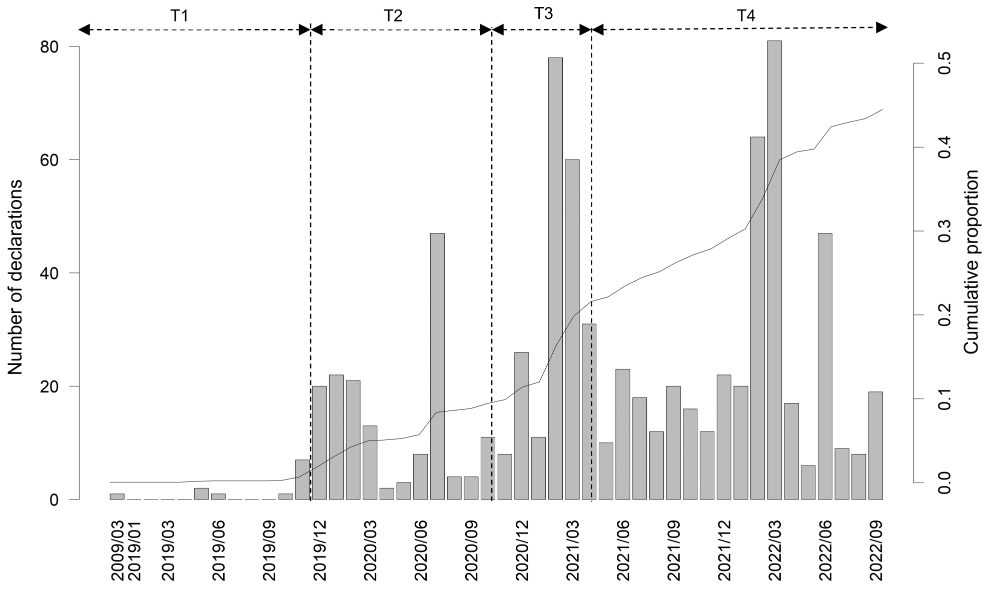

FIGURE 1 The diffusion of net-zero carbon emission declarations by month and period. The bar plot (left axis) shows the number of declarations made during the month. The line plot (right axis) shows the cumulative proportion of declarants among all local governments in Japan (i.e., 1718 cities, 23 wards in Tokyo metropolis, and 47 prefectures). Time periods are as follows: T1 (before December 2019), T2 (December 1, 2019 to October 25, 2020), T3 (October 26, 2020 to April 21, 2021), and T4 (April 22, 2021 to September 30, 2022).

Period T2 begins in December 2019, instigated by the Ministry of Environment's call for local governments to adopt net-zero declarations. The impetus for this initiative from the national-level dates back to around a month earlier, to COP25 held in November 2019. The Japanese government was attracting sharp international criticism at this time for not reconsidering its policies supporting coal-fired power and for failing to set ambitious additional reduction targets under the Paris Agreement (Duygan et al., 2021; Trencher et al., 2020). It was in this context that the Minister of the Environment, Shinjiro Koizumi, attempted to leverage a critical mass of net-zero declarations by local governments as a symbolic demonstration of Japan's ambitious decarbonization efforts.[2] Continuing until the end of October 2020, the 10-month period T2 saw a total of 152 governments adopt the declaration in rapid succession.

The beginning of T3 is marked by the national government's own net-zero target, declared on October 26, 2020. This commitment was institutionalized into national policy in May the following year after the Diet adopted a revision by the Ministry of Environment. This added the net-zero emissions goal into the already scheduled revision of the *Act on Promotion of Global Warming Countermeasures*—a key document guiding national climate policy.[3] Japanese media reports that this decision was influenced by the international spread of net-zero declarations, as more than 120 countries had already declared this goal by October 2020.[4] The adoption of net-zero target peaks during the following 6-month period, with 208 new declarants appearing.

Finally, T4 begins with the national government's announcement on April 22, 2021 to raise Japan's GHG reduction target for the year 2030 to 46% (originally 26%) from 2013 levels. With Prime Minister Suga Yoshihide in office at the time, this announcement from the top propelled a new wave of climate ambition across Japan. As of the end of September 2022 (i.e., the last day of our observation period), a total of 413 local governments adopted the net-zero target during this period.

The cumulative effect of these four periods is remarkable, with diffusion occurring rapidly and in domino-like style. Concretely, by September 2022, 785 local governments had declared a zero emissions goal. According to the Ministry of Environment (2022), these represent 43.9% of all sub-national governments in Japan and cover 94.3% of the country's population.

Incidentally, not all declarations were made individually. In some cases, especially local jurisdictions with smaller populations, multiple local governments cooperated to issue a joint declaration. For instance, in Kumamoto Prefecture, 18 governments declared a net-zero target at the Ministry of Environment's symposium held in Kumamoto City, in January 2020.

DATA AND METHODS

Data and sample

We used both quantitative and qualitative methods to analyze the diffusion of net-zero carbon emission declarations across Japan. The quantitative component used an event-history analysis to detect the influence of the aforementioned internal and external factors during the diffusion process (see Section "Policy Diffusion and its Theoretical Basis"). The qualitative component used data from documents and interviews with local governments to gain contextual details about the influence of these factors.

The quantitative event-history drew on two data sources. The first consisted of a survey administered to the governmental department in charge of climate and energy policy. Implemented between March and June in 2020, this was distributed via post or email to all 47 prefectural governments in Japan as well as to all cities with a population above 200,000 residents.[5] Not only do these sampling criteria ensure that the majority of GHG emissions in Japan are covered by our data, but they also ensure that sampled municipalities share a common responsibility toward implementing climate policies. This is because the Basic Climate Change Countermeasure Act (*Ondanka taisaku kihon ho*) mandates all jurisdictions with a population above 200,000 to draft a local GHG reduction plan.[6] One hundred and forty-five local governments participated in the survey, giving a response rate of 92.4%. The second data source derives from a list of all local governments with a net-zero goal in place. Compiled by the Ministry of Environment (2022), this provides the names of each government and declaration date along with an overview of the planned policies to achieve the net-zero goal. We used the latest version available at the end of September 2022. We combined these two data sources, limiting our sample to those governments that responded to our survey. It should be noted that our sample includes no cases of joint declarations (a point discussed above).

The dependent variable of our analysis is the date of declaration. Concretely, we calculated the number of days between May 1, 2019 (the start of our observation period) and the declaration date. 85.5% of survey respondents had issued a declaration by the end of the observation period (i.e., September 30, 2022). Note that we treat the exceptional case of Yamanashi Prefecture, which declared in March 2009, as if it had declared on the first day of the observation period.[7]

After setting the dependent variable to the number of days taken to declare, we applied the Cox proportional hazards regression model (hereafter "the Cox regression") (Cox, 1972). With the Cox regression model, we tested how an independent variable contributes to the earlier occurrence of the event of interest; in our case, the net-zero declaration. A larger regression coefficient indicates that an independent variable exerts a stronger effect on the earlier occurrence of the event.

Internal factors

The survey measured internal factors from two perspectives. Each municipality responded about their attitude toward climate policy from the perspective of the governor while data on their organizational situation were completed by the administrative staff in charge of climate policy.[8] To measure the influence of *political leadership* toward climate policy, we used the principal component score of the following three statements about key policy issues (see Appendix A). Opinions were measured with a 5-point Likert scale (5 = strongly agree and 1 = strongly disagree): (1) The Japanese government should set a more ambitious GHG reduction target for 2030 than the current one (at the time of the survey, a conservative target set under national policy aimed to reduce GHG emissions by 26% by 2030 from 2013 levels); (2) Ambitious GHG reduction measures by local governments and business sectors are an effective means of contributing to international climate mitigation; (3) GHG emissions should be reduced to zero in the long term.

We also asked whether the responding government is a member of a major *transnational network* related to climate policy. We listed six networks, and respondents indicated their membership to each as: currently a member (=3), considering becoming a member (=2), not a member (=1). Answers were compiled into a single scale using a categorical factor analysis (see Appendix B).

The survey also obtained data for the following variables:

- *Funding resources*; based on each government's total budget. The answer was log-transformed.
- *Human resources*; based on the number of government staff working with climate policy.[9]

We observed a moderate positive correlation across these factors (Appendix C). Finally, we included a dummy variable for *prefectures* to distinguish them from cities as the control variable. Note that in the main analysis, we treat prefecture and cities uniformly, since both had an equal chance to declare, with sufficient internal capacities to do so.[10] Moreover, including both cities and prefectures in the same sample allowed us to determine how horizontal and vertical diffusion (explained in Section "External Factors as Time-Varying Covariates") contributed to the timing of a particular declaration, after controlling for other factors.

External factors as time-varying covariates

We assume that the aforementioned internal factors remain relatively stable within our 3-year observation period.[11] By contrast, the context of the net-zero emissions goal changed dramatically. As more local governments declared a net-zero target for 2050, such declarations became a new norm. Consequently, the local governments yet to announce a net-zero target faced increased pressure to declare (see also the case studies in Section "Case Study of Kanagawa Prefecture"). Conversely, however, as we explain below, the pace of the contextual change varies among the governments.

To illustrate this, suppose we have two cities L_1 and L_2, each belonging to different prefectures (Figure 2). At the beginning of the first observation period (shown as $t = 1$), neither neighboring cities nor the prefecture of affiliation have declared a net-zero emissions goal (Figure 2a,c). As times goes by, however, the situation begins to vary across cities. At the second point in our illustration ($t = 2$), four neighboring cities in L_1 as well as their affiliated prefecture have now declared the net-zero emissions goal (Figure 2b). In contrast, only one neighboring city in L_2 has

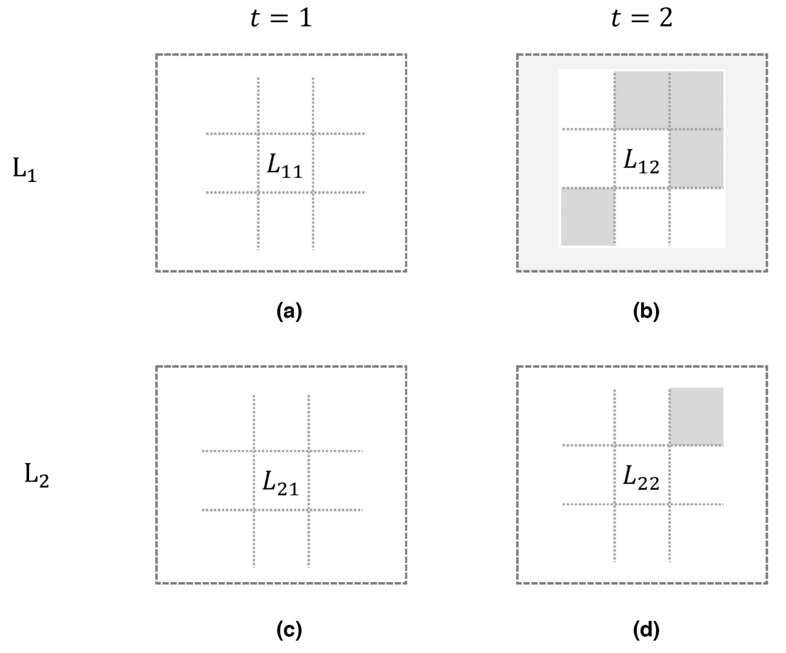

FIGURE 2 Illustration of the time-varying covariates. The smaller squares represent cities and the larger squares show the prefectures of affiliation (i.e., the prefecture within which each city is located). Gray squares indicate cities or prefectures that declared the net-zero emissions goal, and white squares show those that did not. The notation L_{it} indicates a city i at period t.

declared, and its affiliated prefecture has not (Figure 2d). In such a situation, we expect that L_1 in the second point has a greater likelihood of declaring than L_2 because of the greater number of declarants in proximity to which it can refer when considering the adoption of a net-zero policy. Moreover, in the local governments surrounding L_1, declaring net-zero emissions has now become more common than in the neighboring jurisdictions for L_2. Thus, L_1 is exposed to greater pressure to follow this trend to avoid becoming a laggard. A similar logic also applies for prefectures, in that those surrounded by declarants are expected to have a greater likelihood of declaring than other prefectures for which this is not the case.

To take these contextual changes into account, we created two external factors as time-varying independent variables, explained below. Respective values change if the other relevant local governments declare the net-zero emissions goal. We assume that the higher the number of declarants among neighboring governments, the higher the external pressure for a particular local government to follow suite and issue its own declaration.

- *Horizontal diffusion*: This variable indicates the proportion of all neighboring jurisdictions of the same level (i.e., city or prefecture) that declared the net-zero emissions goal.[12] We also include jurisdictions not in our sample. We define "neighboring jurisdictions" as those with which a particular government shares its jurisdictional borders. To account for the possibility that the horizontal diffusion effect might vary between cities and prefectures, we also include a model to which we add an interaction between horizontal diffusion and the prefectural dummy variable.
- *Vertical diffusion*: Each city in Japan belongs to a prefecture, and policies at the prefectural level are known to exert a trickle down influence on the decisions of cities affiliated with that

prefecture (Ito, 2002). Accordingly, we assign a value of "1" if the prefecture (including those not in our sample) to which a city belongs had already declared the zero emission target, and "0" if otherwise.

Time-varying diffusion effect

In the analysis, we firstly show the aggregated results of the Cox model for the entire observation period, following prior studies (Abel, 2021; An et al., 2022). A feature of our study, however, is that we expect the influence of variables to fluctuate during different stages of the diffusion process (see Section "Temporal Variation"). Moreover, we connect this temporal variation of influencing factors to wider political circumstances. That is, over the course of the observation period, the Ministry of Environment and Prime Minister Suga Yoshihide gradually increased the tone of their intention for Japan to announce a more ambitious mitigation target. In parallel, as the net-zero emissions goal diffused rapidly across Japan, it increasingly became a norm, thereby reducing the ability of declaring governments to consider themselves pioneers (see Section "Case Description: The Domino-Like Diffusion of Net-Zero Carbon Emission Declarations in Japan").

To operationalize these ideas, in the latter part of the analysis we calculate time-varying coefficients in the Cox regression (Cox, 1972; Zhang et al., 2018) for each period.[13] For example, while having an ambitious political leader may strongly influence early declarations—especially in the first period—the existence of such leaders could become insignificant for non-declarant cities during the latter periods. Conversely, among these laggard governments, external pressure could be a decisive factor that induces a faster declaration than the other laggards. It should be noted, however, that due to the logic of the algorithm, the later the period, the smaller the remaining sample. Hence, obtaining statistical significance is generally harder during later periods.

The analysis below firstly considers the effect of each factor separately. We then report the full model result, including all independent variables at once to estimate the marginal effect of each by controlling for other variables. As stated above (Section Data and Sample), our sample does not include the thousands of smaller other governments across Japan due to our explicit focus on prefectures and larger cities. Thus, to verify the generalizability of our result, we further tested the diffusion effect for all cities and prefectures in Japan by utilizing the complete list of net-zero declarants (Ministry of Environment, 2022) and population data from the latest national census in 2020 (Statistics Bureau of Japan, 2021) (see Section "Varying Effects in Each Period"). The statistical analysis was carried out with the software *R* (R Core Team, 2021). We used its package *survival* (Therneau, 2021) for the event-history analysis and *mirt* (Chalmers, 2012) for the categorical factor analysis.

Qualitative case studies

Our case studies targeted seven local governments within Kanagawa Prefecture. This step aimed to clarify how the factors identified in the event-history analysis influenced the adoption of a net-zero target in the context of each municipality while verifying the existence of other driving or hampering factors. With a population of over 9 million and located close to Tokyo, Kanagawa Prefecture is one of the largest industrial areas in Japan. As such, this prefecture provides an ideal case study because it provides a contrasting and representative range of various internal and external factors. Concretely, Kanagawa's local governments are characterized by diverse sizes as well as contrasting geographical and socio-economic conditions. These range from the global city Yokohama to smaller governments located in industrial harbor areas, high-density residential zones, and more sparsely populated rural areas. The scale of fiscal budgets and human resources varies widely across these governments. Moreover, the distribution of declaration timings observed in this prefecture largely follows the broader trend observed in the full sample of governments covered by our survey.

We thus selected our cases to include six cities and the prefectural government, ensuring that declaration timings cover the four periods examined (see Table 1). Specifically, Yokohama City and Kanagawa Prefecture declared in T1, the cities of Kawasaki and Sagamihara in T2, Yokosuka and Chigasaki in T3, and Yamato City[14] in T4.

Data were gathered by two means. For secondary data we examined council minutes and policy documents. For primary data we conducted one semi-structured interview with the staff in charge of climate change policy in each government between November and December 2021.

TABLE 1 The status of net-zero emissions declarations in Kanagawa Prefecture (as of end of September 2022).

Declarants at end of September 2022			Non-declarants at end of September 2022
	Location	**Date**	**Location**
T1	Yokohama City #	2019/6/17	Ebina City
	Odawara City	2019/11/22	Oiso Town
	Kanagawa Prefecture #	2019/11/28	Ninomiya Town
T2	Kamakura City	2020/2/7	Nakai Town
	Kawasaki City #	2020/2/17	Yamakita Town
	Kaisei Town	2020/3/5	Hakone Town
	Miura City	2020/5/7	Yugawara Town
	Sagamihara City #	2020/9/30	Aikawa Town
T3	Yokosuka City #	2021/1/29	Kiyokawa Village
	Fujisawa City	2021/2/15	
	Atsugi City	2021/2/22	
	Hadano City	2021/2/26	
	Hayama Town	2021/3/18	
	Chigasaki City #	2021/4/1	
	Samukawa Town	2021/4/1	
	Manazuru Town	2021/4/14	
	Matsuda Town	2021/4/20	
T4	Isehara City	2021/10/22	
	Zushi City	2022/1/31	
	Zama City	2022/2/14	
	Oi Town	2022/3/4	
	Ayase City	2022/3/15	
	Hiratsuka City	2022/3/24	
	Yamato City #	2022/4/1	
	Minami Ashigara City	2022/6/22	

Note: Cities targeted for investigation in the case studies are marked with "#".

Our seven interviews each lasted around 60-minutes. All were recorded and transcribed before analysis.

RESULTS

Determinants for all periods combined

What factors explain the domino-like effect where nearly 800 local governments declared a net-zero emissions goal in such a short space of time? Table 2 shows the average difference between declarants and non-declarants for each period. Results show, for example, that the political leadership score for declarants during T1 are on average 1.47 points higher than for non-declarants. Overall, the results indicate that the earlier declarants tend to be endowed with favorable internal factors, having more ambitious political leaders, larger budgets and human resources, and more connections with transnational networks.

Table 3 tests these observations statistically, measuring the influence of each factor for the four declaration periods combined. We find that the internal factors—leadership (see model 1 in

TABLE 2 Difference in values for declarants and non-declarants ($n = 145$).

	T1	T2	T3	T4
Descriptive statistics				
N	9	32	48	34
Share of prefectures among all declaring governments during this period	0.56	0.47	0.31	0.06
Mean value of difference between those declared and not declared at the point of declaration (standard deviation in parenthesis)				
Political leadership (principal component score)	1.47	0.99	0.17	−0.20
	(0.46)	(0.91)	(0.81)	(0.78)
Funding resources (log)	1.94	1.57	0.90	0.29
	(1.64)	(1.69)	(3.36)	(2.89)
Human resources	9.54	2.59	0.04	0.75
	(21.25)	(7.58)	(5.79)	(5.01)
Transnational networks (factor score)	1.18	0.39	0.11	0.08
	(0.97)	(0.80)	(0.52)	(0.39)
Horizontal diffusion[a] (proportion)	0.06	0.05	0.03	0.01
	(0.18)	(0.21)	(0.31)	(0.25)
Horizontal diffusion[a] (proportion): prefecture level	0.07	0.06	0.08	−0.11
	(0.18)	(0.23)	(0.34)	(0.21)
Horizontal diffusion[a] (proportion): city level	0.00	0.00	−0.04	0.12
	(0.00)	(0.05)	(0.15)	(0.27)
Vertical diffusion (dummy)[a]	−0.15	−0.11	−0.09	0.12
	(0.08)	(0.43)	(0.50)	(0.39)

Note: 21 respondents (17 cities and 4 prefectures) did not declare during the observation period.

[a]This variable is time-varying.

TABLE 3 Results of Cox regression analysis for all periods combined ($n = 145$).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Prefecture (dummy)[b]	0.23	0.28	0.41**	0.55***	0.66**	1.13****	0.27	0.88**
	(0.21)	(0.22)	(0.20)	(0.20)	(0.31)	(0.34)	(0.33)	(0.35)
Political leadership	0.45****						0.31***	0.30***
	(0.09)						(0.10)	(0.10)
Funding resources		0.30***					0.21**	0.25**
		(0.11)					(0.11)	(0.11)
Human resources			0.25***				0.05	0.11
			(0.09)				(0.10)	(0.10)
Transnational network				0.45****			0.35****	0.38****
				(0.07)			(0.08)	(0.08)
Horizontal diffusion[a,b]					−0.03	0.98*	−0.15	1.34**
					(0.45)	(0.58)	(0.48)	(0.60)
Vertical diffusion (dummy)[a,b]					0.16	0.05	0.14	−0.00
					(0.25)	(0.26)	(0.26)	(0.26)
Horizontal diffusion × prefecture[a,b]						−1.70**		−2.43****
						(0.68)		(0.68)
AIC	1044.93	1057.11	1059.69	1032.38	1067.79	1063.62	1025.66	1015.26
Concordance	0.670	0.653	0.621	0.670	0.565	0.577	0.730	0.722
	(0.029)	(0.027)	(0.028)	(0.025)	(0.029)	(0.029)	(0.025)	(0.027)
Number of events	124	124	124	124	124	124	124	124

Note: The result shows the standardized regression coefficients except those of dummy variables. Standard errors are shown in parenthesis.

[a]This variable is time-varying.

[b]This variable is not standardized.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.

Table 3), funding resources (model 2), human resources (model 3), and transnational networks (model 4)—are positively associated with an earlier declaration.

The horizontal diffusion effect (i.e., a declaration by a neighboring jurisdiction) is not significant (model 5) if the level of jurisdictions is not differentiated. However, once differentiated between cities and prefectures through the interaction term in the regression model (model 6), horizontal diffusion effect is statistically significant among cities but not among prefectures (the regression coefficient of horizontal diffusion among prefectures is 0.98 – 1.70 = −0.72)[15] (Note that by the logic of interaction with dummy variables, the row of horizontal diffusion in the original model 6 and model 8 in Table 3 shows the effect of horizontal diffusion among cities). Model 6 also indicates that the diffusion effect at the prefecture level is significantly lower than at the city level.

This result can be interpreted in tandem with the result of the prefecture dummy variable, which is statistically significant in most of the models. This indicates that declarations are faster at the prefectural level than at the city level, even when jurisdictions are endowed with other factors equally. This tendency can be also seen in the proportion of prefectures making up the total declarants in each period in Table 2. In T1, more than half of declarants were prefectures, while in T4, this dropped to below one tenth. Across all periods, declarations at the prefecture level occurred regardless of their geographical proximity to other declarants.

The last model, model 8, show that political leadership, funding resources, participation in transnational networks, and the horizontal diffusion effect among neighboring cities exert the statistically significant influence, when all other effects remain equal.[16]

Varying effects in each period

The results in the previous section provide insights into what factors, in general, contributed to an earlier declaration. However, following arguments in our literature review, we expect some factors to be more relevant during the earlier stage of diffusion and others to exert a stronger influence later on.

To clarify further this temporal dimension, we first come back to Table 2. This time, we compare the values between adjacent groups (e.g., declarants in T1 and T2 or those in T2 and T3). We find that some effects do not differ greatly between the two groups. For example, the funding resources of declarants in T2 are on average 1.57 points higher than non-declarants while in T3 it is only 0.9 points higher. This implies that funding resources are no longer a decisive factor for declarations made from T3 onwards. In contrast, the proportion of declarants among neighboring cities is particularly high for declarants in T4 when compared to non-declarants. This suggests that the horizontal diffusion effect is important during this period.

Table 4 statistically tests this idea by utilizing the time-varying Cox regression to analyze how the magnitude of each factor varies over time.[17] Note that due to the small number of declarations in T1, we combine T1 and T2 for the sake of model convergence. Results demonstrate that the effects of different factors do indeed vary considerably across the different stages of diffusion. Overall, we find that the internal factors are more relevant during the earlier stage of policy diffusion. Concretely, the effect of political leadership (model 1), funding resources (model 2), human resources (model 3), and transnational networks (model 4) is strong during T1 and T2, but this effect attenuates during later periods.[18]

Conversely, we find that external diffusion factors matter more in the later phases. Horizontal diffusion effect among cities has no statistically significant effect during T1 and T2, even exerting

TABLE 4 Results of Cox regression analysis by period ($n = 145$).

		Model 1		**Model 2**		**Model 3**		**Model 4**	
Prefecture[b]		0.39*	(0.21)	0.09	(0.24)	0.47**	(0.21)	0.62***	(0.20)
Political leadership[a]	T1 & T2	1.04****	(0.16)						
	T3	0.20	(0.16)						
	T4	−0.37	(0.23)						
Funding resources	T1 & T2			1.31***	(0.43)				
	T3			0.27	(0.17)				
	T4			0.11	(0.16)				
Human resources	T1 & T2					0.44****	(0.11)		
	T3					−0.04	(0.19)		
	T4					0.08	(0.19)		
Transnational network	T1 & T2							0.59****	(0.09)
	T3							0.29**	(0.14)
	T4							0.22	(0.20)
Horizontal diffusion[a,b]	T1 & T2								
	T3								
	T4								
Vertical diffusion[a,b]	T1 & T2								
	T3								
	T4								
Horizontal diffusion × prefecture[a,b]	T1 & T2								
	T3								
	T4								
AIC		1015.55		1051.07		1057.55		1031.43	
Concordance		0.693	(0.028)	0.659	(0.028)	0.609	(0.030)	0.666	(0.026)

(Continues)

TABLE 4 (Continued)

		Model 1		Model 2		Model 3		Model 4	
Number of events	T1 & T2	41		41		41		41	
	T3	48		48		48		48	
	T4	34		34		34		34	
		Model 5		**Model 6**		**Model 7**		**Model 8**	
Prefecture[b]		0.73**	(0.31)	0.94***	(0.36)	0.26	(0.34)	0.55	(0.40)
Political leadership[a]	T1 & T2					0.92****	(0.18)	0.91****	(0.18)
	T3					0.15	(0.16)	0.13	(0.16)
	T4					−0.31	(0.24)	−0.14	(0.24)
Funding resources	T1 & T2					0.29	(0.34)	0.30	(0.34)
	T3					0.22	(0.16)	0.17	(0.16)
	T4					0.15	(0.18)	0.27	(0.19)
Human resources	T1 & T2					0.10	(0.14)	0.10	(0.13)
	T3					−0.15	(0.21)	−0.17	(0.21)
	T4					0.16	(0.24)	0.31	(0.24)
Transnational network	T1 & T2					0.42****	(0.10)	0.44****	(0.10)
	T3					0.27*	(0.15)	0.24	(0.15)
	T4					0.30	(0.22)	0.44*	(0.23)
Horizontal diffusion[a,b]	T1 & T2	0.15	(0.82)	1.15	(2.53)	0.29	(0.87)	3.51	(2.88)
	T3	−0.36	(0.59)	−1.25	(1.15)	−0.03	(0.65)	−1.11	(1.20)
	T4	0.80	(0.77)	1.56**	(0.78)	0.86	(0.88)	1.48*	(0.86)
Vertical diffusion[a,b]	T1 & T2	−0.29	(0.43)	−0.27	(0.45)	−0.69	(0.47)	−0.72	(0.48)
	T3	−0.07	(0.36)	0.15	(0.39)	−0.15	(0.36)	0.10	(0.40)
	T4	1.35**	(0.57)	0.21	(0.55)	1.22**	(0.61)	0.30	(0.54)

TABLE 4 (Continued)

		Model 5		Model 6		Model 7		Model 8	
Horizontal diffusion × prefecture[a,b]	T1 & T2			−1.29	(2.58)			−3.58	(2.95)
	T3			0.85	(1.21)			1.06	(1.26)
	T4			−2.61**	(1.02)			−3.06***	(1.16)
AIC		1067.65		1051.07		1006.8		1003.27	
Concordance		0.617	(0.027)	0.659	(0.028)	0.750	(0.026)	0.752	(0.025)
Number of events	T1 & T2	41		41		41		41	
	T3	48		48		48		48	
	T4	34		34		34		34	

Note: The result shows the standardized regression coefficients except those of dummy variables.

[a]This variable is time-varying.

[b]This variable is not standardized.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.

a negative effect during T3 (although not statistically significant). However, this factor yields an effect during T4 (model 6). Note that the horizontal diffusion effect is not significant in T4 if the diffusion effect is not differentiated between cities and prefectures (model 5). This finding corroborates what we observed in the previous analysis in Table 3. This is due to the fact that the horizontal diffusion effect at the prefecture level is significantly lower than at the city level (model 6).

The temporal variation observed in the fluctuating strength of influencing factors across cities can be further teased out if considering the vertical diffusion effect exerted by the prefecture of affiliation. During T1 and T2, many declaring cities share the common feature of belonging to a prefecture that had not declared beforehand. Conversely, during T4, laggard cities tend to declare if their prefecture of affiliation had already declared (model 5). This trend, however, is not statistically significant in the model where the horizontal diffusion effect is differentiated between cities and prefectures (model 6). This latter model indicates that while city-level declarations tend to occur in the declarant prefectures in T4, this effect is most pronounced among those cities whose neighboring cities had already declared. Thus, for this period, horizontal diffusion exerts a direct effect across cities, while the influence of vertical diffusion is indirect.

This result suggests that the context of declaring a net-zero emissions goal for cities changed dramatically. During T1 and T2, many non-declarant governments appear to have seen the net-zero target as mostly relevant for prefectures or a handful of large, ambitious cities. During T4, however, the net-zero goal become a “standard” policy that laggard cities were then expected to follow.

As shown in the full model (model 8), when all other factors are kept constant, the marginal effect of political leadership and transnational networks becomes strong and statistically significant in T1 and T2. Meanwhile, horizontal diffusion among cities becomes significant in T4. Interestingly, the effect of transnational networks is also significant in T4 in the full model. This result suggests that participation in transnational networks remains an important factor for earlier declarations across our observation periods, if other factors are controlled.

Figure 3 summarizes the varying influence of each factor by period. To make comparison easier, the figure shows the *z*-score of the regression coefficients in model 8. As the regression coefficient become larger and the standard error shrinks, the *z*-score increases. The size of the *z*-score reflects the strength of the marginal effect of variables and is roughly comparable across periods and variables (Allison, 2014). Results show that during T1 and T2, it is endowed governments (i.e., those with strong leadership), also connected with transnational networks, that tend to declare a net-zero target ahead of their peers. In T3, however, declarants are not as endowed as the early adopters in T1 and T2; indicated by a smaller *z*-score. Then, by the end of T3, the majority of large governments had declared a net-zero emissions goal. Finally, during T4, the remaining local governments, (this time, mainly cities) then followed suited and issued a declaration, influenced by the horizontal diffusion effect.

Figure 3 also exhibits temporal variation among the internal factors. All leadership, budget, and human resources follow a similar trend in the models where these factors were analyzed separately (see models 1 to 3 in Table 4). Recall that these three variables are moderately correlated with each other. When the effects of each of these internal factors are controlled for in the full model (depicted in Figure 3), the latter two remain relatively stable throughout all periods. This finding may reflect the nature of the policy analyzed in this study. That is, we find that it is attitudinal aspects rather than technical aspects that primarily matter when issuing a net-zero declaration. Hence, attitudinal factors, such as ambitious leadership by political leaders, come into play mostly during the earlier period.

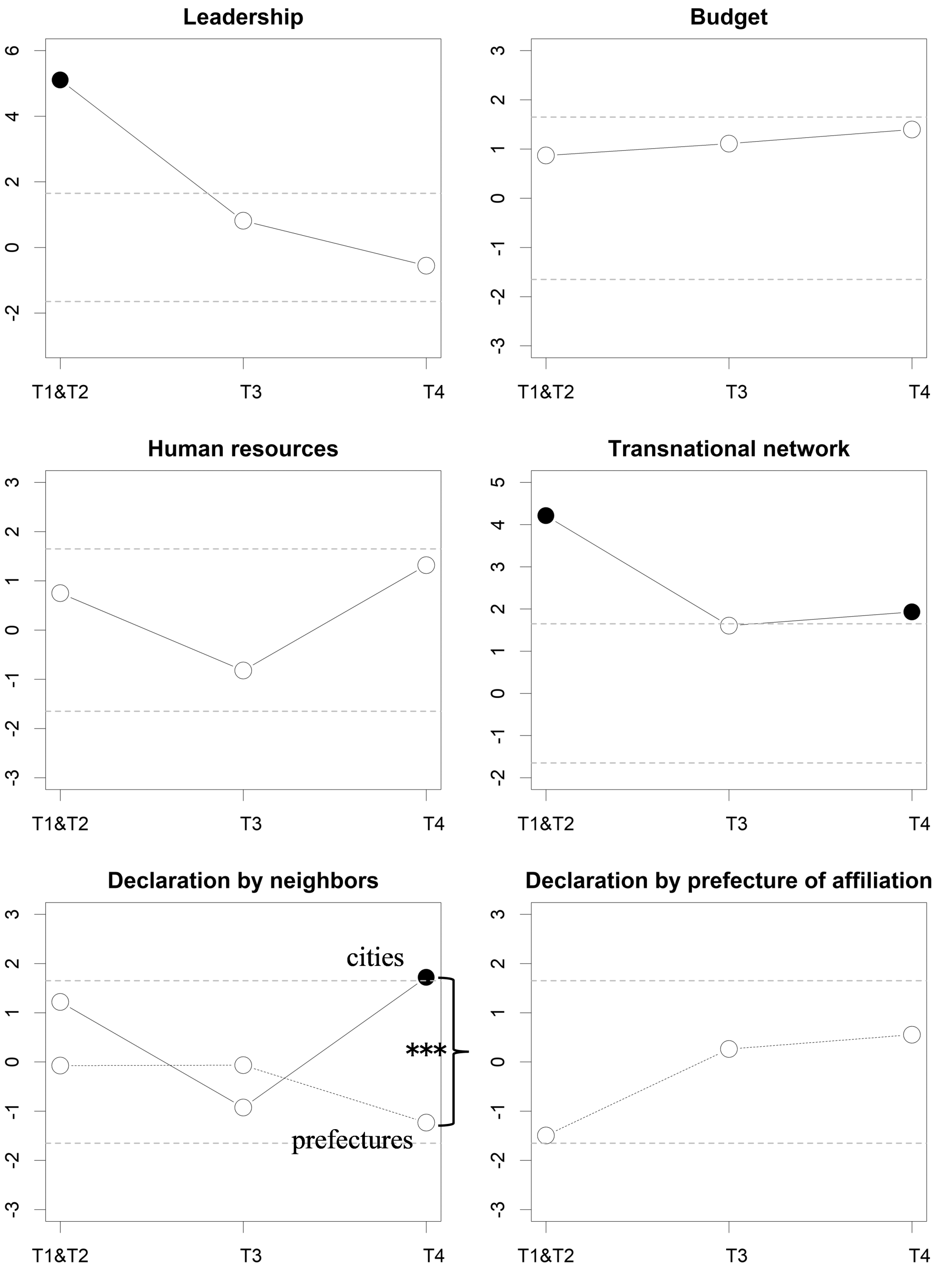

FIGURE 3 The changing marginal effect of factors by period. *Y*-axis values show the *z*-score of the regression coefficients for model 8 in Table 4. Black dots indicate statistical significance while white dots indicate the absence of statistical significance. Dotted lines indicate the reference for judging statistical significance (based on the Wald test). If *z*-score exceeds this line, the relevant effect is judged as statistically significant at $p < .10$.

Figure 3 also depicts the consistently important influence of transnational networks on net-zero declarations, demonstrating how global policy trends can diffuse to the context of local governments. Earlier studies (e.g., Lee & Jung, 2018; Steffen et al., 2019) have already pointed out the importance of transnational networks as a mechanism of climate policy diffusion. Supporting this, we find the effect of transnational networks remains relatively high, suggesting those cities even weakly connected to a transnational network share a higher likelihood of declaring than if otherwise. However, the proportion of local governments affiliated with transnational networks is low (see Appendix B). Accordingly, the influence of transnational networks alone cannot explain the widespread and rapid diffusion of net-zero declarations.

Hence, instead of revealing a single factor that can explain the entire diffusion process, our results point clearly to the importance of understanding the changing relevance of factors over time. Furthermore, findings indicate the existence of different types of local governments in the diffusion process. That is, early adopters tend to consist of local governments with ambitious leadership, backed by budget and human resources, and affiliated with transnational networks. Policy adoption by these early adopters then exerts a horizontal and vertical diffusion effect for other local governments to follow suite with their own net-zero declaration. In aggregate, our results demonstrate how different local governments—with varying degrees of embeddedness in transnational networks, political leadership, and endowment with human and financial resources—played a key role in driving the domino-like diffusion of net-zero declarations in Japan.

Last, we further tested the timing of the diffusion effect for all cities and prefectures in Japan (Table 5). The result generally supports our arguments above, showing a particularly strong effect for horizontal diffusion in the last period (see z-scores in model 2 in Table 5). However, contrary to our main result, the vertical diffusion effect is also strong in the first period, then remaining statistically significant until T3, before disappearing in T4. It should be noted that this variation in the vertical diffusion effect was identified by including all the smaller cities in Japan. This finding thus suggests that while the effect of vertical diffusion may be stronger for smaller cities, for large cities this effect may be limited, because the latter decide their climate policy more autonomously.[19]

CASE STUDY OF KANAGAWA PREFECTURE

Influence of internal factors

The quantitative analysis above revealed that internal factors (namely, participation in transnational networks and political leadership, along with funding and human resources) were important, especially during the earlier periods of the policy diffusion process. We now turn to our seven case studies carried out in Kanagawa Prefecture to learn about how these factors influenced declarations in practice.

During the early adopter stage (T1), the influence of connections with transnational networks was particularly strong for the case of Yokohama City. Being the first local government in Kanagawa Prefecture to declare a net-zero emissions target (declared on June 17, 2019), Yokohama City is a member of the C40 Cities Climate Leadership Group and had been keeping an eye on the trends of European cities such as Paris and Frankfurt, which had already declared by that time. Interviews with officials[20] and records of parliamentary discussions indicate that Yokohama was in close collaboration with its European peers in the C40 network through activities

TABLE 5 Results of Cox regression analysis by period for all cities and prefectures in Japan ($n = 1674$).

		Model 1			Model 2		
		Coef.	SE	z-score	Coef.	SE	z-score
Prefecture		−0.05	(0.23)	−0.22	1.52****	(0.30)	5.00
Population (log)		0.41****	(0.03)	14.24	0.41****	(0.03)	14.07
Horizontal diffusion[a,b]	T1 and T2	1.48**	(0.59)	2.53	1.57*	(0.93)	1.69
	T3	0.99***	(0.33)	3.00	0.84**	(0.40)	2.10
	T4	0.58***	(0.20)	2.95	0.92****	(0.20)	4.69
Vertical diffusion[a,b]	T1 and T2	0.52**	(0.21)	2.43	0.67***	(0.23)	2.96
	T3	0.33*	(0.17)	1.91	0.49***	(0.19)	2.60
	T4	0.34**	(0.15)	2.35	0.08	(1.19)	0.59
Horizontal diffusion × prefecture[a,b]	T1 and T2				−2.58**	(0.08)	−2.16
	T3				−1.40**	(0.63)	−2.22
	T4				−4.25****	(0.74)	−5.71
AIC		8614.6			8569.08		
Concordance		0.718	(0.011)		0.720	(0.011)	
Number of events	T1 and T2	102			102		
	T3	166			166		
	T4	396			396		

Note: The result shows the standardized regression coefficients except those of dummy variables. The cities that declared jointly are treated as a single case.

[a]This variable is time-varying.

[b]This variable is not standardized.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.

such as knowledge and best-practice sharing. In addition, Yokohama is a member of the international Carbon Neutral Cities Alliance (CNCA), which includes among its members environmentally progressive cities such as Vancouver and Stockholm. Not only has this network provided Yokohama with multiple opportunities to learn from peers around the world, but it also created a need to demonstrate environmental leadership. Likewise, interviewed officials explained that decarbonization and net-zero aspirations in Yokohama were strengthened by other international influences, such as the IPCC's Fifth Assessment Report and the Paris Agreement.

Besides Yokohama City, interviews with other local governments across Kanagawa Prefecture did not identify other cases where transnational networks exerted a strong influence during the early diffusion stages. A notable example is Kanagawa's prefectural government. Although a member of one network, the Climate Ambition Alliance, officials did not emphasize this as a driver behind their net-zero declaration.[21] Evidence thus suggests that while participation in transnational networks may be especially influential for a global city such as Yokohama, this is not necessarily the case for smaller cities or prefectural governments that are comparatively less active in such networks.

The characteristics of the case studies also support the earlier observation about the driving influence of endowment with funding and human resources. For instance, early declarants from

T1 and T2 (i.e., Yokohama, Kawasaki, and Sagamihara) have the largest fiscal resources in the prefecture due to their large population. Moreover, they are “ordinance-designated cities” within the classification system defined by the national government. This system grants them the autonomy to carry out certain public services and governance functions normally performed by prefectural governments. Hence, given their larger budget and institutional importance within Japan, they are blessed with superior budgets and human resources compared to other cities.

Also supporting the model's results, we found evidence of strong political leadership influencing early adopters. This was noted especially in endowed cities. Specifically, three cities along with Kanagawa Prefecture share the status of an “SDGs Future City.”[22] Run by the national government, this program recognizes and supports outstanding initiatives across local municipalities toward realization of the UN Sustainable Development Goals. By participating in this program, SDGs Future Cities share a prior commitment to actively pursuing sustainable development. Engagement with this program thus reflects a strong degree of political ambition to seize occasions to raise the environmental profile of that city. In addition, status as an SDG Future City also reflects endowment with other internal factors, since these governments have developed a suite of progressive environmental policies, which are typically underpinned with supporting resources. Yokohama City, also designated as an SDGs Future City, has equally displayed the ambition to strengthen its environmental leadership. When debating the benefits of declaring a net-zero target, council minutes reveal that the mayor expressed a strong desire to utilize the net-zero target as a strategic way to strengthen Yokohama's profile as an international climate leader. This ambition was notably described as a way to attract private investments from overseas firms looking for low-carbon business locations.

Influence of external factors

The statistical analysis revealed the influence of external factors to be relatively weak during the two early diffusion phases, but stronger during the later phases.

Evidence from at least three cases confirms that external factors had a comparatively weak influence on early adopters: namely Kanagawa Prefecture along with the cities of Yokohama and Kawasaki (declarants during T1 and T2). Officials interviewed in these locations asserted that their declarations and respective timings were not directly affected by the trends of other local governments.[23]

An exception to this general tendency was observed in the case of Sagamihara City, an early adopter that declared in T2. Officials in this location described a particularly strong influence from other cities in the prefecture.[24] Concretely, as net-zero targets spread across Japan, Sagamihara City was initially hesitant to follow suite with its own declaration. A key reason was that in the first half of 2020 it had reinforced its historical commitment to an 80% emissions reduction target by 2050 in its flagship climate policy, the “Second Global Warming Prevention Plan.” Declaring net-zero emissions would thus be inconsistent with this target. Nonetheless, this city eventually succumbed to the influence of declarations by the prefecture's other two ordinance-designated cities (i.e., Yokohama City and Kawasaki City), issuing its own in late September, 2020.

On the other hand, we found evidence that declarations made by other cities influenced decisions to issue net-zero targets for two later adopters, Chigasaki City and Yokosuka City. However, this occurred during T3, differing to the model, which indicates the strongest influence during T4. The case of Chigasaki City, declared in T3, provides a case in point. Officials in this location[25] explained that the national government's declaration in October 2020 immediately prompted them to begin exchanging information with neighboring cities to mutually check the status of intentions to declare a net-zero target. Since it turned out that several cities were planning to declare, Chigasaki was incited to follow suite. The influence of neighboring cities then increased further when Fujisawa City, a neighboring city that had previously collaborated with Chigasaki City in various projects, declared in February 2021. These forces eventually compounded, inducing Chigasaki to follow suite with its own declaration, in April 2021. Similarly, Yokosuka City had also been closely monitoring the trends of other municipalities.[26] Declarations made among these neighbors were then cited during requests for Yokosuka to also follow suite during council deliberations.

The above-described slight inconsistency between our model and the cases might be related to the nature of municipalities that a local government refers to. Our interviews within Kanagawa Prefecture revealed that a local government does not necessarily pay close attention to its direct neighbors, but rather, to cities of a similar size to its own.[27] Furthermore, as the case of Chigasaki illustrates, neighboring municipalities—especially those sharing a previously established collaborative relationship—may exert a strong influence on ambitions to declare. The complex nature of such emulation may therefore explain why declarations in neighboring municipalities exerted a driving influence earlier (i.e., in T3) than found in the model (i.e., T4).

Finally, while the statistical model found that a declaration by the prefectural government tends to work positively during T4 (although not statistically significant), our case studies did not produce direct evidence of a declaration at the prefectural level affecting lower levels of government. Although the Kanagawa prefectural government and its cities involved exchanged information and held meetings, an interviewee stated that Kanagawa Prefecture did not particularly encourage its municipalities to declare.[28] Furthermore, officials of the other six cities in our case study did not cite Kanagawa Prefecture's declaration as a particularly strong influence either. As noted above, we speculate that this inconsistency can be partially explained by the comparatively large size of the six cities studied, which may reduce tendencies to follow the prefectural government in many areas of policy making.

Other factors found influential

The case studies also revealed contextual factors that influenced the timing of declarations. In September and October 2019, two powerful typhoons hit the Japanese archipelago (Typhoon Fakusai and Typhoon Hagibis). Kanagawa Prefecture suffered from extensive damage due to overflowing rivers and landslides, which left nine people dead or missing.[29] Interviewed officials cited this back-to-back damage as a key driver behind the declarations. This impetus came from finding themselves with a sudden need to demonstrate strengthened engagement with climate change mitigation. This was observed at the prefectural level (Kanagawa Prefecture) as well as in Kawasaki City and Sagamihara City,[30] where Typhoon Hagibis caused the most damage in the prefecture. We thus found that an extreme weather event, in this case typhoons, served as an important trigger for local governments to increase their decarbonization ambition. This evidence suggests that the first peak in declaration numbers over November 2019 to March 2020 can be at least partially attributed to the typhoon disasters in late 2019, since these created widespread damage across Japan.

The case studies also revealed factors that prevented or delayed declarations. First, we found that the perceived difficulty of achieving the net-zero emissions target made some cities wary of declaring. For instance, Yamato City, a late adopter, issued a net-zero emissions goal only in

April 2022. Although paying close attention to the national government's policy (like most local governments), Yamato City reported a more cautious stance regarding the feasibility of eliminating all carbon emissions by 2050. Interviewed officials stated a sentiment that it was easy to make a declaration, but this should be accompanied with a concrete and effective plan. Moreover, in the case of their city, they expressed a view that unless broader structural changes occurred first in the power companies and the automobile industry, it would be impossible to achieve net-zero emissions by 2050 within their city boundaries.[31] It was not until the national government announced concrete policies toward carbon neutrality that Yamato City made a declaration.

Second, we also found a case where unique local circumstances made it structurally and politically difficult to issue a net-zero declaration. Concretely, Yokosuka City—also a late adopter—is currently home to a large coal-fired power plant with two units totaling 1.3 GW, still under construction at the time of writing. Although carbon emissions will be attributed to the out-of-boundary area consuming the electricity, this project is seen domestically and internationally as a symbol of Japan's regressive climate policies and ongoing dependence on coal (Tabuchi, 2020). Moreover, construction of this coal-fired power plant prevented the adoption of a net-zero commitment by the local government,[32] since its carbon-intensive nature compromised any societal legitimacy and feasibility of reaching zero carbon emissions. This hurdle was cleared in October 2020, when the electricity utility JERA announced a roadmap to achieve zero emissions by 2050. This prompted the City of Yokosuka to relaunch consideration of its own net-zero target, subsequently declared in January 2021.[33]

CONCLUSION

This study examined the factors that influenced the domino-like spread of net-zero carbon emission declarations across nearly 800 local governments in Japan over 2019–2022. To this end, we built an event-history analysis using quantitative data collected from surveys and public sources before contextualizing the findings of our statistical model with qualitative evidence from interviews and document analysis.

Findings revealed that for early adopters it was especially *internal* factors—namely, participation in transnational networks, endowed financial and human resources, and political leadership—that drove uptake of net-zero declarations. But these internal factors alone did not directly influence the timing of declarations for all local governments. Rather, as declarations spread across Japan, it was *external* factors that incited policy adoption during later stages of diffusion. Furthermore, as an aggregate trend, we found that declarations tended to occur firstly mostly in larger municipalities and prefectures. This was then followed by diffusion across smaller cities in later stages. The speed of diffusion also varied across periods. Thus, the domino-effect was initiated by larger and endowed frontrunners before spreading rapidly to the late-adopting majority, mostly concentrated in smaller jurisdictions.

Evidence from the case studies reveals important contextual details that further influenced the timing of declarations. These both drove and inhibited declarations. For instance, extensive damage from consecutive typhoons in Kanagawa Prefecture incited the earlier adoption of net-zero targets by some local governments. Conversely, structural factors like the construction of a large coal-fired power plant or the inability to control the carbon intensity of electricity sources and industrial emissions have suppressed ambitions to declare for some governments. Although these cases are not necessarily representative of the entire country, these findings complement the quantitative results.

These results provide important contributions to the policy innovation and diffusion literature. The most important finding revealed by our statistical model is that the influence of factors varied considerably across the different stages of policy diffusion. Earlier studies have tended to study the determinants of policy diffusion across the entire observation period. In this study, however, after briefly considering aggregate trends, we focused on detecting the changing influence of different factors during each period, utilizing time-varying coefficients in the Cox regression. Not only did considering these temporal dynamics allow us to identify the characteristics of different categories of adopters during the diffusion process, moreover, this revealed how early adopters influenced late adopters, both vertically and horizontally.

Importantly, in our chosen case of net-zero targets, both prefectures and cities had the chance to declare. (Recall that after the declaration by Yamanashi Prefecture in 2009, it was two cities, Kyoto and Yokohama, and one prefectural government, Tokyo Metropolitan, that initiated the spread of declarations since 2019). However, the strength of horizontal diffusion varied across different levels of government, mainly effecting cities rather than prefectures. It is beyond the scope of our paper to examine reasons for this in detail. However, one possible explanation would be that many prefectures declared in the earlier stages, leaving only reluctant prefectures before diffusion factors came into play at the prefectural level. Another plausible explanation is that cities have more opportunities than prefectures to collaborate with neighboring municipalities in conducting administrative projects, which often include waste disposal and firefighting.

In this study, participation in transnational networks exerted a particularly important influence during the early adoption of net-zero declarations. Existing research (e.g., Lee & Jung, 2018; Steffen et al., 2019) has previously shown that transnational networks are playing an important role in driving the development of ambitious climate policies across the globe. Yet, by focusing on frontrunner governments, the scholarship has not been explicitly attentive to the influence of city networks for the late-adopting majority. In our research, however, by breaking down the diffusion process into four periods, we revealed both direct and indirect pathways by which transnational networks can drive the adoption of ambitious climate policies. That is, our findings suggest that many early declarants of the net-zero target were directly influenced by their participation in inter-city networks. In addition, these transnational networks have exerted a subtle and indirect influence on net-zero declarations in Japan. Concretely, this occurred as early adopters contributed to the formation of a critical mass of net-zero declarants, which subsequently incited the late majority to follow suite and issue their own declaration.

Limitations to our unit of analysis suggest opportunities for future research. For example, the presence of a net-zero declaration does not necessarily guarantee that climate policies and urban planning will be subsequently overhauled or strengthened. For some local governments, it might be that net-zero declarations remain a political gesture that carries little impact in terms of lowering emissions at the speed required to attain such a target. Investigating the influence of declarations on emissions and climate policies is thus an important topic for future research.

Nonetheless, our choice to focus on net-zero declarations is justified by the symbolic importance of this policy in Japan. As explained in the introduction, by setting a goal to eliminate all carbon emissions by 2050, the rapid spread of net-zero declarations signifies a paradigm shift in Japanese policy making. That is, by declaring a net-zero goal, local governments have signaled a willingness to move away from incrementalism. Policy makers in this former paradigm have historically emphasized feasibility over ambition, adhering to and building on the legacy of historical commitments. Yet by formalizing a commitment to eliminate all carbon emissions irrespective of existing policy commitments and mitigation capacities, meeting the net-zero target will require increased reliance on backcasting approaches to climate policy formulation. Moreover, the rapid spread of declarations by frontrunners at the local level induced the adoption of a net-zero goal by the national government. Furthermore, the magnitude of emission cuts required to achieve this goal has influenced the raising of reduction pledges for 2030 at both the local and national level.

The significance of these shifts in policy-making practices is far from trivial if recalling that NGOs and researchers within and outside Japan have long criticized the unambitious nature of national climate policy (Moe, 2012; Trencher et al., 2020). Furthermore, backcasting-based policies are also attracting increasing attention within Japan in the context of setting measures to achieve the U.N. Sustainable Development Goals. Climate policy in Japan, which has historically prioritized feasibility and consensus building with industry, is hence currently undergoing a major paradigm shift. The policy changes that will ensue from this shift toward backcasting-style planning suggest ample opportunities to explore new research topics for policy innovation and urban climate governance.

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ENDNOTES

[1] Due to this assumption, we do not divide adopters in accord with the timing of adoption (which is determined by groups reflecting a cumulative proportion of total adoption); a canonical procedure suggested by Rogers (2003).

[2] Mainichi Shimbun (December 13, 2019) "COP25 Datsu-tanso syakai e: Kankyo-sho, kantei settoku dekizu enzetsu de datsu-sekitan miokuri" (Towards a decarbonized society: Minister of Environment unable to persuade the Cabinet and declare "coal-free" in his COP25 speech), available at https://mainichi.jp/articles/20191213/ddm/012/040/027000c. Accessed February 24, 2022.

[3] Asahi Shimbun (December 17, 2020) "50 nen jisshitsu zero, horitsu ni meiki e. Kankyo-sho houshin" (Ministry of Environment decided to include a net-zero provision), available at https://digital.asahi.com/articles/ASNDP6GJHNDPUBQU002.html. Accessed January 17, 2022.

[4] Asahi Shimbun (October 28, 2020) "Datsu tanso, Nihon mo youyaku. Naze zero, gutaisaku wa, sekai dewa" (Japan finally declared net-zero emissions. Why zero? What is the concrete plan? How is the global trend?), available at https://digital.asahi.com/articles/DA3S14672861.html. Accessed January 17, 2022.

[5] Concretely, these cities include "core cities" (*chukaku-shi*), "designated cities" (*seirei shitei toshi*), and "wards" (*tokubetsu-ku*). Also, since all local governments in our sample share a large urban population, we sometimes refer to them as "cities."

[6] Except for 23 wards in Tokyo metropolis.

[7] We set May 1, 2019 as the start of the observation period even though Yamanashi Prefecture had declared in 2009. We opted for this treatment because diffusion occurred from this month (see Section "Case Description: The Domino-Like Diffusion of Net-Zero Carbon Emission Declarations in Japan"). Moreover, we confirmed that this treatment does not affect the results greatly. This is because the Cox regression places importance on the order of the cases that experience the event (Allison, 2014).

[8] In some cases, local governments had already declared a net-zero goal at the time when the survey was administered (namely those declarants in T1 and some declarants in T2; totaling 30 cases or 25.6% of the sample) while some others had not. We acknowledge this causal ambiguity due to our method, which relies on survey responses.

[9] The human resources variable was found to strongly correlate with the population of each jurisdiction ($r = .59$, $p < .001$). This is not surprising given that jurisdictions with larger populations may require more staff for planning and implementing climate policies than those with smaller populations. Furthermore, larger jurisdictions may also take advantage of their scale by differentiating the competencies of their staff, being able to afford to allocate staff in charge of climate policy. By contrast, funding resources correlate only moderately with population ($r = .34$; $p < .001$). This may be because local governments in Japan obtain on average 44% of their budget from the revenues of the national government (Ministry of Internal Affairs and Communications, 2022). Hence, the budget size is not always proportional to the population of a jurisdiction.

[10] As described above, our sampled cities have considerable autonomy to decide their own GHG emissions reduction plan. It is also worth mentioning that some cities (particularly those in Tokyo) have a larger population than smaller prefectures, hence their administrative capacities are comparable with smaller prefectures.

[11] Among the internal factors, political leadership has the greatest short-term variability. Among our sample, 16 local governments experienced a change of heads after the time of our survey. However, only three cities (Nagano, Kashiwa, and Takarazuka Cities) had a different mayor when they declared from the time of the survey, and only one undeclared city (Kumagaya City) has a different mayor from the time of the survey. As a robustness check, we ran the Cox regression for these four cities excluded (see Appendix D) and confirmed that the result does not change greatly.

[12] This specification implies that the pressure from neighboring jurisdictions may be equivalent across all jurisdictions, which is a conventional assumption in the literature. We recognize that some literature (e.g., Mistur et al., 2022; Shipan & Volden, 2008; Zhou et al., 2019) differentiates the effect of peers in accord with the type of relationship shared. This aspect is not covered in our quantitative analysis, but considered in our case studies section.

[13] In a nutshell, calculating the time-varying coefficient is similar to running the Cox regression period by period. However, in contrast to simply conducting a separate regression for each period, using time-varying covariates allows us to simply run the Cox regression once and then calculate the concordance for all periods combined.

[14] At the time interviews were conducted, Yamato City had not declared.

[15] Formally, this was tested by running the same model but setting cities instead of prefectures as the dummy variable and viewing the effect of the horizontal diffusion.

[16] Appendix E provides the result calculated by separating cities and prefectures into two separate samples.

[17] Appendix F provides the result in that city sample and prefecture sample are separated.

[18] It should be noted that because the timing of the T1 declarants is ahead of the survey (see also endnote 8), we cannot exclude the possibility that the effect of the budget and human resources for T1 is overestimated. By contrast, we think the effect of T2 would not be overestimated, because these governments declared only shortly before the survey.

[19] Appendix G shows the result with the sample that only includes all cities in Japan (i.e., the sample that excludes prefectures).

[20] Interview with officials of Yokohama City on December 7, 2021.

[21] Interview with officials of Kanagawa Prefecture on December 7, 2021.

[22] Six of the eight local governments in Kanagawa Prefecture which issued a net-zero declaration before the Suga administration's declaration in October 2020 were an SDGs Future City.

[23] Interviews with officials of Yokohama City, Kanagawa Prefecture on December 7, 2021, Kawasaki City on December 23, 2021, and Sagamihara City on November 29, 2021.

[24] Interview with officials of Sagamihara City on November 29, 2021.

[25] Interview with officials of Chigasaki City on December 3, 2021.

[26] Interview with officials of Yokosuka City on December 1, 2021.

[27] Appendix H formally tests this diffusion mechanism (model 5). This result indicated that model 5 (i.e., a declaration by a neighboring city with a similar population size in the same prefecture) can fit our dataset slightly

better than the main model (model 1). However, since we could not decisively observe a strong effect for this mechanism, we opted to retain our use of the current model, due to its consistency with well accepted theory.

[28] Interview with officials of Kanagawa Prefecture on December 7, 2021.

[29] Kanagawa Prefecture (2019) "Reiwa gannen Taifu 19 gou niyoru kennai higai jyokyo (Dai 21-hou) 15ji 00 fun happyo" (Damage in the prefecture by the 19th Typhoon of 2019, the 21th report), available at https://www.bousai.pref.kanagawa.jp/PUB_VF_Detail_KisyaHappyo?oid=a3w7F000001EWG1QAO. Accessed on January 19, 2022.

[30] Interviews with officials of Sagamihara City on November 29, 2021, and Kawasaki City on December 23, 2021.

[31] Interview with officials of Yamato City on November 30, 2021.

[32] Interview with officials of Yokosuka City on December 1, 2021

[33] Yokosuka City (2021) "Shicho messe-ji (Yokosuka-shi zeroka-bonshithi sengen 2021 nen 1 gatsu 29 nichi)" (Message from the Mayor, Yokosuka City's zero-carbon city declaration, January 29, 2021), available at https://www.city.yokosuka.kanagawa.jp/0520/movie_channel/gyousei/message_27.html. Accessed on January 19, 2022.

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How to cite this article: Nakazawa, T., Satoh, K., Trencher, G., Tatsumi, T., & Hasegawa, K. (2023). Net-zero carbon declarations by Japanese local governments: What caused the domino-like diffusion? *Review of Policy Research*, *00*, 1–41. https://doi.org/10.1111/ropr.12544

APPENDIX A

DESCRIPTIVE STATISTICS OF AMBITIOUS LEADERSHIP TOWARD CLIMATE POLICY AND ITS PRINCIPAL COMPONENT ANALYSIS

	Descriptive statistics		Principal component analysis	
	Mean	Standard deviation	Loadings	Communality
The Japanese government should set a more ambitious GHG reduction target for 2030 than the current one	3.36	0.88	0.84	0.70
Ambitious GHG reduction measures by local governments and business sectors are an effective means of contributing to international climate mitigation	4.10	0.73	0.72	0.52
GHG emissions should be reduced to zero in the long-term	4.12	0.85	0.76	0.57
SS loadings				1.80
Proportion explained				0.60

Note: $n = 145$.

APPENDIX B

DESCRIPTIVE STATISTICS OF TRANSNATIONAL CITY NETWORKS AND ITS FACTOR ANALYSIS

	Descriptive statistics (%)			Factor analysis	
	Not a member	Considering becoming a member	Already a member	Loadings	Communality
ICLEI	89.7	0.7	9.7	0.86	0.74
Covenant of mayors for climate and energy	91.0	2.8	6.2	0.73	0.54
Climate ambition alliance	94.5	2.1	3.4	0.83	0.68
JCI	86.9	0.0	13.1	0.81	0.65
C40	98.6	0.0	1.4	1.00	1.00
RE100	98.6	0.0	1.4	0.42	0.18
RE action	95.2	1.4	3.4	0.87	0.75
SS loadings					4.53
Proportion explained					0.65

Note: $n = 145$.

APPENDIX C

CORRELATION MATRIX OF THE NON-TIME-VARYING VARIABLES

		I	II	III	IV
I	Political leadership				
II	Budget	0.24			
III	Human resources	0.23	0.23		
IV	Transnational networks	0.32	0.18	0.42	

Note: $n = 145$.

APPENDIX D

COX REGRESSION IN THAT THE FOUR CASES THAT EXPERIENCED THE CHANGE IN GOVERNOR WERE EXCLUDED

For the robustness check, we excluded the cases that experienced a change of governor during the observation period (i.e., Nagano, Kashiwa, Takarazuka, and Kumagaya; see endnote 11).

	Model 1	Model 2
(a) Result for all periods combined		
Prefecture (dummy)[b]	0.21	0.75**
	(0.21)	(0.35)
Political leadership[a]	0.46****	0.32***
	(0.09)	(0.10)
Funding resources		0.26**
		(0.11)
Human resources		0.10
		(0.10)
Transnational network		0.38****
		(0.08)
Horizontal diffusion[a,b]		1.58***
		(0.61)
Vertical diffusion[a,b] (dummy)[a,b]		−0.16
		(0.27)
Horizontal diffusion × prefecture[a,b]		−2.61****
		(0.69)
AIC	1011.15	981.93
Concordance	0.672	0.727
	(0.029)	(0.027)
Number of events	121	121

APPENDIX D (Continued)

(b) Result for separate periods					
Prefecture[b]		0.42**	(0.21)	0.52	(0.40)
Political leadership[a]	T1 and T2	1.03****	(0.16)	0.92****	(0.18)
	T3	0.20	(0.16)	0.13	(0.16)
	T4	−0.50**	(0.24)	−0.23	(0.25)
Funding resources	T1 and T2			0.30	(0.34)
	T3			0.18	(0.16)
	T4			0.26	(0.19)
Human resources	T1 and T2			0.10	(0.13)
	T3			−0.14	(0.20)
	T4			0.31	(0.24)
Transnational network	T1 and T2			0.44****	(0.11)
	T3			0.24	(0.15)
	T4			0.47**	(0.23)
Horizontal diffusion[a,b]	T1 and T2			3.53	(2.87)
	T3			−1.07	(1.19)
	T4			1.39	(0.88)
Vertical diffusion[a,b]	T1 and T2			−0.74	(0.48)
	T3			0.04	(0.40)
	T4			0.40	(0.61)
Horizontal diffusion × prefecture[a,b]	T1 and T2			−3.58	(2.94)
	T3			1.02	(1.26)
	T4			−2.81**	(1.19)
AIC		1000.86		990.5	
Concordance		0.699		0.754	
Number of events	T1 and T2	41		41	
	T3	48		48	
	T4	34		34	

[a]This variable is time-varying.

[b]This variable is not standardized.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.

APPENDIX E

COX REGRESSION FOR ALL PERIODS CALCULATED FOR SAMPLED CITIES AND PREFECTURES SEPARATELY

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(a) Results with sampled cities only (n = 99)						
Political leadership	0.52****					0.29***
	(0.12)					(0.11)
Funding resources		0.33**				0.29**
		(0.14)				(0.14)
Human resources			0.34****			0.24**
			(0.10)			(0.10)
Transnational network				0.62****		0.52****
				(0.10)		(0.10)
Horizontal diffusion[a,b]					0.71	0.84
					(0.62)	(0.64)
Vertical diffusion (dummy)[a,b]					−0.02	−0.15
					(0.26)	(0.26)
AIC	671.3	683.66	680.38	655.54	690.94	644.93
Concordance	0.642	0.639	0.578	0.632	0.529	0.715
	(0.037)	(0.036)	(0.034)	(0.030)	(0.030)	(0.034)
Number of events	82	82	82	82	82	82
(b) Results with sampled prefectures only (n = 42)						
Political leadership	0.39**					0.37**
	(0.16)					(0.17)
Funding resources		0.34				0.27
		(0.27)				(0.29)
Human resources			0.13			−0.13
			(0.15)			(0.19)
Transnational network				0.62****		0.26*
				(0.10)		(0.14)
Horizontal diffusion[a,b]					−0.09	0.10
					(0.64)	(0.67)
AIC	225.26	228.71	230.45	655.54	231.17	228.07
Concordance	0.666	0.574	0.556	0.632	0.488	0.680
	(0.050)	(0.056)	(0.055)	(0.030)	(0.052)	(0.053)
Number of events	37	37	37	37	37	37

Note: The result shows the standardized regression coefficients except those of dummy variables. Standard errors are shown in parenthesis.

[a]This variable is time-varying.

[b]This variable is not standardized.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.

APPENDIX F

COX REGRESSION BY PERIODS CALCULATED FOR SAMPLED CITIES AND PREFECTURE SAMPLES SEPARATELY

		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
(a) Results only with the city sample (n = 99)													
Political leadership[a]	T1 and T2	1.12****	(0.20)									0.99****	(0.25)
	T3	0.32*	(0.18)									0.21	(0.17)
	T4	−0.19	(0.25)									−0.19	(0.22)
Funding resources	T1 and T2			1.94**	(0.91)							0.32	(0.48)
	T3			0.16	(0.19)							0.15	(0.19)
	T4			0.24	(0.22)							0.34	(0.23)
Human resources	T1 and T2					0.38***	(0.13)					0.09	(0.17)
	T3					0.14	(0.18)					0.11	(0.19)
	T4					0.46**	(0.18)					0.41**	(0.21)
Transnational network	T1 and T2							0.72****	(0.14)			0.48***	(0.16)
	T3							0.46***	(0.16)			0.39**	(0.17)
	T4							0.53**	(0.23)			0.71***	(0.25)
Horizontal diffusion[a,b]	T1 and T2									1.07	(2.62)	3.43	(3.15)
	T3									−1.19	(1.19)	−1.03	(1.26)
	T4									1.68**	(0.81)	1.45	(0.91)
Vertical diffusion[a,b]	T1 and T2									−0.26	(0.46)	−0.87	(0.54)
	T3									0.07	(0.41)	−0.10	(0.42)
	T4									0.16	(0.54)	0.34	(0.54)
AIC		655.32		681.06		682.49		657.77		694.31		646.51	
Concordance		0.651	(0.037)	0.639	(0.036)	0.578	(0.034)	0.632	(0.030)	0.546	(0.029)	0.722	(0.035)
Number of events	T1 and T2	21		21		21		21		21		21	
	T3	33		33		33		33		33		33	
	T4	32		32		32		32		32		32	

APPENDIX F (Continued)

		Model 1		Model 2		Model 3		Model 4		Model 5	
(b) Results for sampled prefectures only (n = 42)											
Political leadership[a]	T1 and T2	0.76****	(0.23)								
	T3	−0.24	(0.32)								
	T4	0.31	(0.59)								
Funding resources	T1 and T2			0.42	(0.49)						
	T3			0.39	(0.43)						
	T4			0.18	(0.44)						
Human resources	T1 and T2					0.37**	(0.15)				
	T3					−0.50	(0.38)				
	T4					−0.33	(0.60)				
Transnational network	T1 and T2							0.51****	(0.14)		
	T3							−0.29	(0.42)		
	T4							−6.08	(1650.09)		
Horizontal diffusion[a,b]	T1 and T2									0.07	(1.04)
	T3									−0.21	(0.81)
	T4									0.93	(5.34)
AIC		221.99		232.56		227.98		222.1		235.09	
Concordance		0.683	(0.049)	0.574	(0.056)	0.608	(0.053)	0.621	(0.043)	0.506	(0.052)
Number of events	T1 and T2	20		21		21		21		21	
	T3	15		33		33		33		33	
	T4	2		32		32		32		32	

Note: The result shows the standardized regression coefficients except some variables with the standard error in parenthesis. The full model was not calculated because the model was not converged due to the small sample size and small number of events.

[a]This variable is time-varying.

[b]This variable is not standardized.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.

APPENDIX G

COX REGRESSION BY PERIODS FOR ALL CITIES IN JAPAN (NOT INCLUDING PREFECTURES)

		Model 1		
		Coef.	SE	*z*-score
Population (log)		0.42****	(0.03)	14.25
Horizontal diffusion[a,b]	T1 and T2	1.55*	(0.94)	1.65
	T3	0.83**	(0.40)	1.65
	T4	0.92****	(0.20)	4.67
Vertical diffusion[a,b]	T1 and T2	0.65***	(0.23)	2.81
	T3	0.47**	(0.19)	2.45
	T4	0.08	(0.14)	0.60
AIC		8045.36		
Concordance		0.703	(0.012)	
Number of events	T1 and T2	80		
	T3	148		
	T4	393		

Note: $n = 1627$. The result shows the standardized regression coefficients except those of dummy variables.

[a]This variable is time-varying.

[b]This variable is not standardized.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.

APPENDIX H

COMPARISON OF DIFFERENT SPECIFICATIONS FOR DIFFUSION FACTORS

		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Horizontal diffusion[a]	T1 and T2	1.07	(2.62)	2.03	(1.36)	0.74	(5.02)	3.94	(3.05)	2.53**	(1.20)	1.79	(9.31)
	T3	−1.19	(1.19)	−0.62	(1.14)	−0.02	(1.99)	−2.42	(1.57)	−2.16	(1.50)	0.37	(2.77)
	T4	1.68**	(0.81)	1.35*	(0.72)	1.67	(1.39)	1.91**	(0.83)	1.27*	(0.68)	3.34*	(1.72)
Vertical diffusion	T1 and T2	−0.26	(0.46)	−0.31	(0.47)	−0.25	(0.48)	−0.31	(0.47)	−0.32	(0.47)	−0.25	(0.47)
	T3	0.07	(0.41)	0.10	(0.41)	0.08	(0.42)	0.14	(0.41)	0.18	(0.42)	0.07	(0.42)
	T4	0.16	(0.54)	0.03	(0.54)	0.08	(0.54)	−0.13	(0.55)	−0.06	(0.55)	0.09	(0.54)
AIC		694.31		694.60		698.40		690.60		691.42		695.95	
Concordance		0.546	(0.029)	0.539	(0.031)	0.510	(0.035)	0.596	(0.028)	0.574	(0.030)	0.527	(0.033)
Number of events	T1 and T2	21		21		21		21		21		21	
	T3	33		33		33		33		33		33	
	T4	32		32		32		32		32		32	

Note: $n = 99$. The result shows the regression coefficients with the standard error in parenthesis. Calculated based on the city sample in our main dataset.

[a]The specification of the horizontal diffusion is as follows: Model 1: declaration by neighboring cities (same as the main results). Model 2: declaration by those neighboring cities that belong to the same prefecture. Model 3: declaration by cities that belong to the same prefecture. Model 4: declaration by neighboring cities that share the similar population size. Model 5: declaration by those neighboring cities that belong to the same prefecture and share the similar population size. Model 6: declaration by cities that belong to the same prefecture and share the similar population size.

****$p < .001$.

***$p < .01$.

**$p < .05$.

*$p < .10$.