2012

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doi:10.1111/j.1467-7717.2011.01263.x

Social, not physical, infrastructure: the critical role of civil society after the 1923 Tokyo earthquake

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Despite the tremendous destruction wrought by catastrophes, social science holds few quantitative assessments of explanations for the rate of recovery. This article illuminates four factors—damage, population density, human capital, and economic capital—that are thought to explain the variation in the pace of population recovery following disaster; it also explores the popular but relatively untested factor of social capital. Using time-series, cross-sectional models and propensity score matching, it tests these approaches using new data from the rebuilding of 39 neighbourhoods in Tokyo after its 1923 earthquake. Social capital, more than earthquake damage, population density, human capital, or economic capital, best predicts population recovery in post-earthquake Tokyo. These findings suggest new approaches for research on social capital and disasters as well as public policy avenues for handling catastrophes.

Keywords: disaster recovery, social capital, Tokyo earthquake

Introduction

According to the Emergency Events Database, natural disasters killed 2.5 million people and inflicted billions of dollars in property damage over the past three decades. The 2004 Indian Ocean tsunami devastated the south-east Indian coast of Tamil Nadu; floodwater inundated New Orleans after Hurricane Katrina in 2005; the 2010 Haiti earthquake may have killed 200,000 people. Scientists predict that the global cost of disaster, both in terms of lives lost and property damage, will only increase with the progression of global warming. We have a deep knowledge of what has gone wrong in disasters—for example, the socio-economic, racial, and age-based differences in vulnerability to disaster (Gill, 2007)—but little about what has gone right. Specifically, we often overlook that within disaster-affected regions, certain neighbourhoods and towns recover from catastrophe more quickly than others. For instance, although less than half of New Orleans' residents had returned within two years of Hurricane Katrina, one severely damaged neighbourhood—Village de l'Est—laid claim to a return rate of nearly 90 per cent and a business re-opening rate of 90 per cent (Faciane, 2007).

The fundamental question of which factors facilitate or impede recovery after floods, hurricanes, earthquakes, and similar events remains largely unanswered. Researchers have proposed hypotheses linking the ability of a region, town, or neighbourhood to recover to a number of factors, but few have carried out replicable empirical

Published by Blackwell Publishing, 9600 Garsington Road, Oxford, OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

analyses to test them.[1] Most studies investigating social capital and disaster have relied on qualitative and impressionistic evidence from a few cases (Buckland and Rahman, 1999; Nakagawa and Shaw, 2004; Dynes, 2005) or quantitative evidence from individual-level surveys (Tatsuki and Hayashi, 2002; Tatsuki, 2008); only recently have scholars integrated social capital measures into a quantitative study of rehabilitation (Kage, 2010). This paper builds on these initial findings and uses data on whole neighbourhoods affected by the 1923 Kanto earthquake that leveled 40 per cent of Tokyo to test five factors that may influence the pace of population recovery. It pays particular attention to the role of social capital, namely the 'networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit' (Putnam, 1995, p. 67). This study finds that, controlling for the factors conventionally assumed to be the engines of recovery, the most important predictors of post-disaster population recovery revolve around social capital.

Understanding post-disaster recovery is vital not only for survivors, relief organizations, and governments, but also for social scientists. Catastrophes change participation venues for survivors (Sinclair, Hall, and Alvarez, 2009), increase the likelihood of regime changes (Albala-Bertrand, 1993), and alter legislative priorities (Birkland, 2006), acting as focal points for broader discussions of social and welfare policy. Furthermore, scholars have demonstrated the vital role of social capital in lowering rates of interethnic violence (Varshney, 2001), promoting economic growth (Knack, 2002), improving governance (Putnam, 1993), and providing important policy feedback to governments (Aldrich, 2008). This article adds to the literature on civil society by revealing how social networks can assist residents as they seek to rebuild their lives after disasters. Should social resources prove critical in rebuilding, policymakers may wish to re-allocate resources to at least maintain, if not deepen, social networks among vulnerable populations.

Explanations for recovery rates

Research has uncovered five main factors and resources that may determine the pace of recovery after a disaster: damage, population density, human capital, economic capital, and social capital.[2]

Using the March 1964 Alaskan earthquake as the basis for a far-ranging investigation of the role of federal policy in disaster recovery, Dacy and Kunreuther (1969, p. 72) argued that '[i]t just seems reasonable to assume that the speed of recovery following a disaster will be determined primarily by the magnitude of the physical damage'. Hence the amount of *damage* suffered by a neighbourhood or town may determine the pace of its post-disaster recovery (Haas, Kates, and Bowden, 1977). For example, in analysing Tokyo's recovery following the 1923 earthquake and subsequent fires that devastated nearly half of the city, Tanaka (2006) asserts that downtown areas recovered more slowly than their uptown counterparts due to greater damage.

Rather than damage, some social scientists have argued that *population density*—the population per unit area—alters the rate of recovery. Areas with greater densities may

recover more slowly because of the difficulty in providing temporary and permanent housing during the post-disaster period (Tobin and Montz, 1997, p. 14). For example, after the Indian Ocean tsunami, the densely populated slums near Chennai suffered from slow recovery rates as authorities sought new locations for residents from this very crowded district. Similarly, New Orleans authorities faced criticism for reducing the amount of housing stock in the city through the demolition of high-density, older housing projects flooded after Hurricane Katrina (Nossiter and Eaton, 2007).

Rather than population density, the *human capital* of a neighbourhood—the education, job skills, and employment experience of its residents—may tie directly into its ability to bounce back after tragedy (Wright et al., 1979; Berke, Beatley, and Feagin, 1993). In focusing on the socio-economic conditions in New Orleans, Katz (2006) emphasizes that 'of the 131,000 poor people in the city in 2000, nearly 50,000 (38 percent) lived in those neighbourhoods of extreme poverty'. Alternatively, households with less education and fewer job skills encounter more difficulty securing new livelihoods and the most difficulty in extracting resources from the state and NGOs (Kamel and Loukaitou-Sideris, 2004). More perniciously, where human capital resources are lower, the net benefit of crime rises (Lederman, Loayza, and Menendez, 2002, p. 516), as Becker (1968) and Ehrlich (1973) underscore in their seminal research. Similarly, communities with low human capital suffer from crime and drug abuse and therefore may find it difficult to mobilize their resources into rebuilding (Heath, 2006).

Beyond physical and human capital, scholars and government administrators alike have pointed to *economic capital* as essential for recovery. Communities devastated by disaster require bridge loans and grants as a buffer against these often-unexpected shocks (US SBA, 2006). Neighbourhoods without access to capital will be forced to draw on personal savings; few communities will have sufficient private financial resources to undertake broader recovery schemes. For example, in a study of resilience after the 1995 Kobe earthquake, Tatsuki and Hayashi (2002) use survey data to show that business owners struggled to find capital to rebuild after both homes and businesses were damaged. Even in the 1920s, city officials in post-earthquake Tokyo recognized the urgency of rebuilding pawnbroker shops to provide credit to poor and middle-class residents (Tokyo Municipal Office, 1930).

Social capital and disaster recovery

Beyond these standard resource and damage-based approaches to recovery, a number of qualitative and small-n studies have illuminated the potential role of *social capital*—the resources available to communities that facilitate collective action—in explaining the speed of post-crisis recovery (Nakagawa and Shaw, 2004). Tatsuki (2008, p. 48), for example, shows that individuals who developed deeper ties to and more actively participated in their local communities reported higher levels of personal recovery after the Kobe earthquake. Dynes (2005) has suggested, based on experiences of survivors in a number of disasters, that social capital may be the basis for resilience

as it provides information and resources at a critical moment. In one of the first quantitative tests of civil society's role in regional rehabilitation, Kage (2010) demonstrates that following World War II, Japanese prefectures with more vibrant civil society (measured through higher levels of communication) recovered more quickly.

Three specific mechanisms allow areas with denser social networks to implement a faster recovery following a disaster. First, social ties can serve as 'informal insurance', allowing victims to draw upon ready-made support networks for financial, physical, and logistic guidance (Beggs, Haines, and Hurlbert, 1996). More broadly, signals from civil society—such as 'who is coming back when and what services will be provided'—are critical to decision-making processes of survivors and cannot be replaced by government pronouncements (Chamlee-Wright and Rothschild, 2007, p. 2). Social networks thus provide essential information, financial and administrative support, and guidance through weak and strong ties (Granovetter, 1973).

Second, communities that are more politically active and more connected can better mobilize and overcome barriers to collective action to present their demands to and extract resources from authorities (Olson, 1965). Neighbours with greater levels of trust share information about bureaucratic procedures and upcoming deadlines, monitor public space to prevent dumping, and deter looting in their community. Following the 1995 Kobe earthquake, for example, even as officials sought to clarify rebuilding plans, local residents organized to plan shared, cooperative housing that would pool their resources (Olshansky, Johnson, and Topping, 2005). Higher levels of social capital can assist individuals in attracting and controlling resources (DeFilippis, 2001), as better-coordinated areas can successfully access the loans, supplies, and other resources that may assist their rebuilding (Dow, 1999). Alternatively, citizens bound by fewer ties to their neighbours are more likely to engage in illegal and disruptive acts that can impede recovery efforts (Varshney, 2001; Lee and Bartkowski, 2004).

Finally, embedded networks raise the cost of 'exit' for individuals from a community and increase the probability that residents will use 'voice'; in other words, better-connected survivors are more likely to articulate their demands to authorities and work together to overcome obstacles to recovery (Hirschman, 1970).[3] In an area with high levels of social capital, local residents are more embedded in the locality and have more at stake should the neighbourhood not recover successfully. Deeper social ties act as a barrier to 'exit'—one of the potential responses to a crisis—and make it more likely that residents will work towards a solution. Areas with softer voices that are plagued by low community involvement will rebuild more slowly, if they rebuild at all (Kamel and Loukaitou-Sideris, 2004).

Data

This article relies on a new dataset created by the author and focusing on 39 police precincts within Tokyo over the period 1922–33 to test these explanations.[4] It uses 1920s Tokyo as a tragic 'natural experiment' for testing the influence of various factors

on recovery; Tokyo was highly urbanized and developed, and observers considered it among the top metropolitan areas in the world (Tōkyō shi Kansakyoku, 1936). As an industrialized national capital, Tokyo can provide broad lessons for disasters in other locations and at other times. While politicians and bureaucrats divided the city of Tokyo into wards, the police departments further partitioned the metropolis into jurisdictions. This study uses the police precinct as the unit of analysis; each precinct covered an average area of 1.97 square kilometres. The majority of the data comes from the yearly statistics of the Tokyo Metropolitan Police department, known in Japanese as the Keischichō. The data was recovered by hand from the archives of the Tokyo Metropolitan Police (see below) and remains the best available data at the precinct level (Keishichō Kanbō Bunshoka Tōkei Henshū, 1922–33).

These population, crime, and demographic records are not the off-the-cuff estimates of law enforcement personnel seeking to map their beat. Instead, this data is highly reliable due to the nature of the local police observers who recorded it; they served and lived around the clock in their neighbourhoods in posts now known as *kōban* and had an acute ideological interest in closely monitoring the activities of civil society (Tipton, 1991). Through a centralized command structure, Japanese law enforcement created a broader police state using regular and intrusive surveillance along with 're-education' for those who were seen as disrupting the social order. Even modern Japanese police in Tokyo continue their thorough, biannual surveys of local residents known as *junkai-ren*, which track occupation, household size, vehicle ownership, and other characteristics (Obinata, 2000; Bayley, 1991, ch. 5). These police records are supplemented with data from electoral records and earthquake-related damage published by municipal authorities. The dataset sheds new light on post-disaster recovery not only because of its scope (with demographic, geographic, socio-economic, and social capital measures) and because it has multiple neighbourhoods within the same metropolis, but also because the data begins just before and continues a decade beyond 1923—the year in which Tokyo suffered from a tremendous earthquake.

At 11:58 a.m. on 1 September 1923 an enormous earthquake measuring 7.9 on the Richter scale struck the imperial capital along with the nearby city of Yokohama.[5] The combination of strong tremors and widespread fires destroyed close to 40 per cent of Tokyo. The fires in the capital burned for three days (Naimushō Shakaikyoku, 1926, p. 10); the conflagration following the earthquake was far more powerful than well-known, city-wide fires abroad.[6] The earthquake left 60 per cent of the population homeless and 350,000 houses damaged or completely destroyed. About 60,000 residents were confirmed dead, with 11,000 missing. Officials believe that more than 1.6 million residents were negatively affected by the earthquake (Tokyo Municipal Office, 1930, p. 35). As one eyewitness mourned, 'A few seconds sufficed for an overwhelming calamity to bury in ruins and ashes the results of half a century of unremitting labor' (Dahlmann, 1924, p. xiv).

The Kanto earthquake remains the most destructive trembler of the 20th century in Japan, and many groups saw in it important social and professional lessons. The

Japanese government used the earthquake as an opportunity to directly influence the 'moral order' in Japan by promoting various codified stories about heroism and loyalty to the emperor (Borland, 2005; 2006). Japanese engineers and architects employed the earthquake as a chance to evaluate the stability of Western and Japanese building styles (Clancey, 2006a; 2006b). Tokyo officials envisioned the earthquake as a chance to build up a new imperial capital—a modern, global symbol of Japan's economic progress (Hanes, 2000, p. 132; Schencking, 2006, p. 835).

For social scientists interested in crises and reconstruction, the Kanto earthquake provides an ideal test case for investigating the pace of post-disaster recovery. This disaster occurred sufficiently in the past that all relevant data has already been recorded by competent authorities. Importantly, recovery rates varied widely across Tokyo's precincts. One scholar argues that pockets of the city displayed signs of a more active civil society—manifested through neighbourhood associations along with voting and political activities (Hastings, 1995)—which may have accelerated recovery, while others maintains that the degree of damage determined the pace of rehabilitation (Tanaka, 2006). The earthquake provides an excellent opportunity to test various approaches connecting local conditions to population recovery.[7]

Social scientists studying more recent events have more latitude in selecting their proxies; nonetheless, this dataset contains variables that match up well with the core approaches of post-disaster recovery described above. For the purposes of this study, population density is measured as individuals per square kilometre. The role played by human capital is reflected by the number of factory workers per capita (who, on the whole, were uneducated migrants from the countryside) along with the number of commercial cars per capita in the neighbourhood. In the 1920s, the majority of trucks and cars owned by residents in Tokyo were for commercial transportation and delivery, and their numbers reflected the level of capital stock of firms in the area. Another included measure is the per capita cost of crime in the area, based on evidence that individuals with lower human capital—that is, fewer job skills and less education—engage in crimes more often (Becker, 1968; Ehrlich, 1973; Williams and Sickles, 2002). More recently, a number of scholars investigated connections between crime rates and disaster recovery (Mitchell, 2007; Bailey, 2009; Lam et al., 2009); this proxy is included because of its importance in past research. To measure damage levels, the dataset includes the percentage of local residents killed in the earthquake, along with a dummy variable representing location in the Shitamachi district.[8]

As a proxy for economic capital, this study includes observations of per capita pawnbroker lending rates. While most Westerners today may view pawnshops as curios, they were core financial institutions in the 1920s in Tokyo—and they allow the tracking of highly localized assets. Succinctly, 'pawnshops were to the poor of Tokyo what banks are to the rich: the chief source of credit' (Hastings, 1995, p. 47). Pawn shops were seen as such important sources of credit that the Tokyo municipal government itself sought to rebuild pawnshops to replace those that had been destroyed in the earthquake in order to relieve 'the suffering of labouring communities and other poorer classes who had been deprived of their only financial institution' (Tokyo

Municipal Office, 1930, p. 86). The areas with high levels of pawnbroker lending were ones in which people sought to convert household items into cash so that they could purchase food, pay their rent, and carry out other activities.

Given that social capital does not manifest itself in the same form across time and society, measurements of social capital must be sensitive to the historical period and cultural environment under investigation (Krishna, 2007, pp. 944–5). De Hart and Dekker (2003, p. 166) suggest that researchers use 'municipal and police statistics' to capture social capital; this article builds on their advice. Scholarship on social capital has illuminated both its individual and collective features (van Deth, 2008, p. 161); given that the precinct serves as the focus of analysis, this study concentrates on the collective level. Two proxies are used to capture the ability of the precinct to overcome collective action problems (Olson, 1965) and express voice, not exit (Hirschman, 1970). The first proxy is voter turnout at the municipal elections on 16 March 1929 and 1933 (as a percentage); the second proxy is the number of political demonstrations per precinct per year.[9]

Beginning with Verba and Nie (1972), scholars have connected voting with broader engagement in citizen networks; this approach was confirmed by Walsh and Warland (1983) in their study of anti-nuclear activists. Hamilton (1993), Putnam (2000), and Aldrich and Crook (2008) use voter turnout in elections as a proxy for the strength of social capital. More specifically, voting in early 20th century Japan—especially from 1925, when suffrage was extended to all men—similarly reflects mobilization and engagement in voluntary civic activities that required an expenditure of time for little measurable return (and that were therefore 'costly'). One prominent historical study of 1920s Tokyo focuses specifically on voter turnout across the city's neighbourhoods as an indicator of higher levels of voluntary activities among residents (Hastings, 1995, p. 162). These figures are not and need not be representative of the population of Tokyo as a whole—especially as women were excluded from voting—but rather capture the motivation of eligible voters to turn out and vote. In some jurisdictions fewer than half of the eligible voters showed up, while in others more than three-quarters did so. This range indicates that even among qualified men, civic norms varied widely across neighbourhoods.

The second measure—political demonstrations—also captures the ability of local residents to mobilize collectively. Historians have focused on the political activities of neighbourhoods in Tokyo in the 1920s and 1930s; these rallies, marches, and activities of new community social networks indicated broader engagement in the political sphere (Ōoka, 2001; Sakurai, 2002).[10] Reasons for rallies in Tokyo during that time included labour strikes (Large, 1972), tenancy disputes (Smethurst, 1986), pro-suffrage marches, spontaneous riots (Lewis, 1990), anti-Russo–Japanese settlement movements (Matsuo, 1990), and anti-facility demonstrations (Yamada, 1973, pp. 120–3; Tamanoi, 2009). Scholars have regularly used demonstrations and others forms of political engagement as a proxy for social capital in the late 20th century (Putnam, 2000; Krishna, 2007; Grenier and Wright, 2004). So too historians of Japan have envisioned these extensive forms of public collective action during the period

known as the 'Taishō democracy' as indications of cooperative activities that required coordination and mobilization (Kimbara, 1994; Yasuda, 1994). These two proxies measure different aspects of social capital—they have a correlation of less than 0.2 (out of 1)—and hence both are used in this article.[11]

Changes in the per-precinct population are used to measure post-disaster recovery. There are a myriad of ways to measure recovery from disaster, including economic (Albala-Bertrand, 1993), demographic, infrastructure, and transportation metrics (Liu, Fellowes, and Mabanta, 2006). Yet population growth serves as a more realistic proxy for recovery following disaster as it demonstrates whether survivors and newcomers are repopulating what may otherwise become a 'ghost town'. The importance of monitoring how many residents return and newcomers flow into a city following a disaster was underscored by the efforts of US government officials after Hurricane Katrina. They used creative measuring techniques, such as monitoring the US postal system's change of address form filings, to measure population return to New Orleans after the storm (Warner, 2006). Similarly, in their study of the resilience of Japanese cities from 1925 to 1965—a period during which allied forces bombed many of the areas under review—Davis and Weinstein (2002) used population measures to track trends in overall development.

Table 1 Descriptive statistics

Variables		Mean	Standard deviation	Minimum	Maximum
Dependent variable	Population growth rate	0.022	0.187	-0.598	1.088
Area	Area of the precinct (square km)	1.971	0.926	0.763	4.343
Human capital	Crime damage per capita (in yen)	6.808	32.293	0.100	401.417
	Factory workers per capita	0.063	0.090	0.002	0.723
	Number of commercial cars and trucks per capita	0.010	0.047	0.000	0.495
Economic capital	Pawnbroker lending per capita	10.293	6.292	0.000	47.092
Earthquake damage	Percentage of residents killed in the earthquake	0.029	0.062	0.000	0.209
	Shitamachi dummy variable	0.590	0.492	0.000	1.000
Geography and density	Population density (residents per square km)	29,098.280	13,104.350	1,611.553	64,955.900
	Total population	49,745	18,783	3,505	97,036
Social capital	Voter turnout in municipal elections (1929 and 1933)	67.650	6.884	48.700	75.500
	Higher-than-average numbers of political gatherings per year	0.239	0.428	0.000	1.000

This study follows these examples in the literature and measures population recovery through yearly population change—from the last day of year T to the last day of the following year, T+1—to better compare across precincts and cities. Table 1 provides descriptive statistics about the variables used.

Between 1922 and early 1923, the earthquake drove out on average 40 per cent of residents in Tokyo precincts. One scholar documented how many of the people in the city fled when the chance came:

> *Many residents of the ward took advantage of the government's promise of free transportation and left the city […]. When the elementary schools of Honjo reopened on October 15, enrollment was only 26 per cent of the pre-earthquake level* (Hastings, 1995, p. 57).

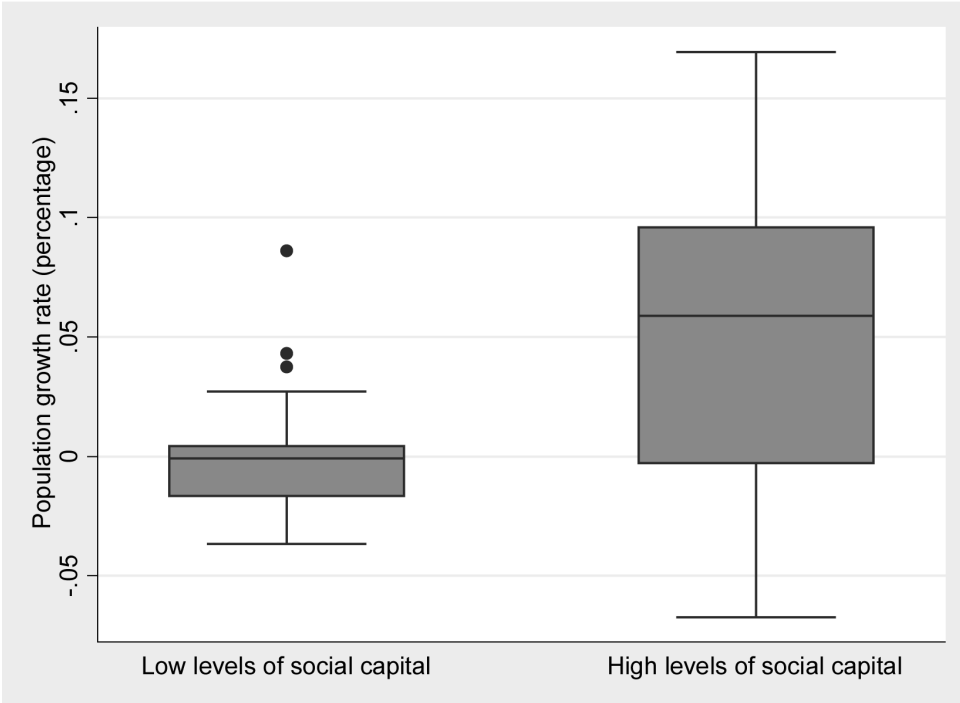
Between 1923 and 1924 the population rebounded from the immediate post-earthquake lows as old residents and newcomers flooded back into the city. Over the next decade or so the rate of growth stayed quite close to zero; on average, few residents departed from or immigrated to these precincts in Tokyo. Across Japan, population growth rates during this period hovered between 1 and 2 per cent. In the major metropolis of Osaka between 1920 and 1935, for instance, the average population growth rate was 1.8 per cent, while for Japan as a whole it was 1.4 per cent. Over the post-earthquake period, however, precincts within Tokyo displayed wide variation in their population growth rates. What accounted for these differences?

Methodology and results

To begin analysing the influence of the five factors—damage, population density, human capital, economic capital, and social capital—on population change, a bivariate cross-tabulation is first used to see whether voting and demonstrations can be linked to population change. Then, to establish a causal relationship between these variables, propensity score matching and average treatment effects are used to generate a pre-processed dataset that compares similar neighbourhoods that differ only in terms of their levels of social capital. Finally, time-series, cross-sectional models are applied to demonstrate the significance and magnitude of the effects of social capital in the context of other potential explanations.

First, using the raw data, population growth rates for precincts that had both higher levels of voter turnout and higher levels of demonstrations are compared to those with lower levels of both those proxies. Figure 1 displays the measurably and statistically significant difference in population growth between the two types of neighbourhoods using this bivariate analysis. The figure shows the full spread of values within the precincts, with the individual dots representing outliers beyond the standard minimum and maximum values. While the results show a clear gap in population growth rates between high and low social capital neighbourhoods, this analysis does not take into account potential confounding or control variables. The next step, then, is to evaluate these proxies using propensity score matching.

Figure 1 Population change in low and high social capital precincts



Note: Precincts that exhibit low levels of social capital had below-average voter turnout and numbers of demonstrations, while those with high levels of social capital had above-average voter turnout and numbers of demonstrations. Chi-squared value (for a tab test of below-average/above-average social capital with below-average/above-average growth rates) = 0.001.

Propensity score matching tests causal inference with fewer assumptions than typical regression models, using a smaller, pre-processed dataset (see Rosenbaum and Rubin, 1983).[12] Matching takes observational datasets—such as the one created here—and prunes away dissimilar observations to create two groups of data: a control and a treatment group, which are as alike as possible in all measurable ways except for their exposure to the 'treatment'. The treatment being investigated in this paper is the amount of social capital in the precinct, so the data is divided into neighbourhoods with higher and lower levels of social capital (using mean-dichotomized measures of voter turnout and number of demonstrations). In essence, this technique builds a 'twins study', analogous to a test of a new drug through an experiment in which twins—alike in all obvious ways—are exposed to different medical treatments. One twin (the control) receives no intervention while the other (the treated one) receives a vaccine. In such studies, any difference in the health outcome of a twin is assumed to come from the vaccine, as the twins share the same age, body type, genetics, overall health, and so on.

Propensity score matching pre-processes the existing data into a smaller, but more similarly matched dataset split into two groups, simulating the randomization done in randomized control trials.[13] A propensity score—which is the likelihood that the precinct will have high levels of social capital—is used to match neighbourhoods on

all of the non-social capital variables from the time-series, cross-sectional analysis: area of the precinct (square km), crime damage per capita (in yen), factory workers per capita, number of commercial cars and trucks per capita, pawnbroker lending per capita, percentage of residents killed in the earthquake, and Shitamachi dummy variable. This involves dropping observations that are not on common support—that is, that are statistically unlike the treatment group—to build a smaller, but much more balanced, dataset with one group of observations having low levels of voter turnout or demonstrations and the other having high social capital (though the two groups are similar in all other measurable aspects).

Five different methods of matching on propensity scores have been used, four of them without replacement (meaning that each control is used as a match only once): kernel, radius, nearest neighbour, and Mahalanobis matching techniques, and one with replacement (nearest neighbour with replacement). Matching reduces the bias—that is, the difference between the means for the treated and control groups—significantly for all matched variables but one: 43 per cent reduction for the variable measuring area, 97 per cent for crime damage, 90 per cent for factory workers per capita, 99 per cent for the number of commercial cars and trucks per capita, 76 per cent for pawnbroker lending per capita, and 85 per cent for residents killed in the earthquake. For the Shitamachi dummy variable, matching slightly worsens bias, by around 10 per cent. The strong reduction in bias indicates that matching creates two parallel groups for comparison. Once the balance is assessed using distributions of baseline characteristics and propensity score histograms, the differences between the two groups can be studied using the average treatment effect. The average treatment effect compares the outcome of the control and treated groups to highlight any disparities, which are assumed to be a result of the treatment (for example, having higher levels of social capital). In this case, the outcome of interest is the population growth rate.

This process reveals substantial evidence that for both measures of social capital, higher levels of social capital resulted in a stronger population recovery. Neighbourhoods that had higher-than-average numbers of political demonstrations had—across all five types of matching—a 2 per cent higher level of population return than very similar neighbourhoods (in terms of earthquake damage, economic and human capital, area, and so forth), with lower-than-average numbers of rallies, marches, and protests. Given that the average growth rate in the city of Tokyo over the post-quake decade was just under zero, this 2 per cent increase in the population growth rate is actually quite large. In addition, this rate of population increase for more mobilized precincts is higher than the national average at the time—approximately 1.4 per cent. For precincts with higher-than-average voter turnout, the results of average treatment effect on the matched data are more impressive: an average—across all five types of matching—of close to 3 per cent higher population growth rate than similar neighbourhoods with lower-than-average voter turnout.

With both the bivariate analysis and propensity score matching indicating that social capital and positive growth rates are strongly connected, the focus now shifts

to time-series, cross-sectional models. As the data contains information on both time (as it was recorded yearly, when possible, between 1922 and 1933) and location (with 39 precincts), time-series, cross-sectional approaches capture both the within- and across-precinct influence of the variables under study. The process begins with a generalized least-squares model with random effects, without inclusion of the measure of voter turnout (as it reduces the overall number of observations due to the infrequent occurrence of municipal elections), labelled Model 1 in Table 2. Two of the estimated coefficients—both of which are positive, meaning that an increase in these two variables increases the dependent variable of population growth rate—are

Table 2 Estimated variable impact on population growth rate

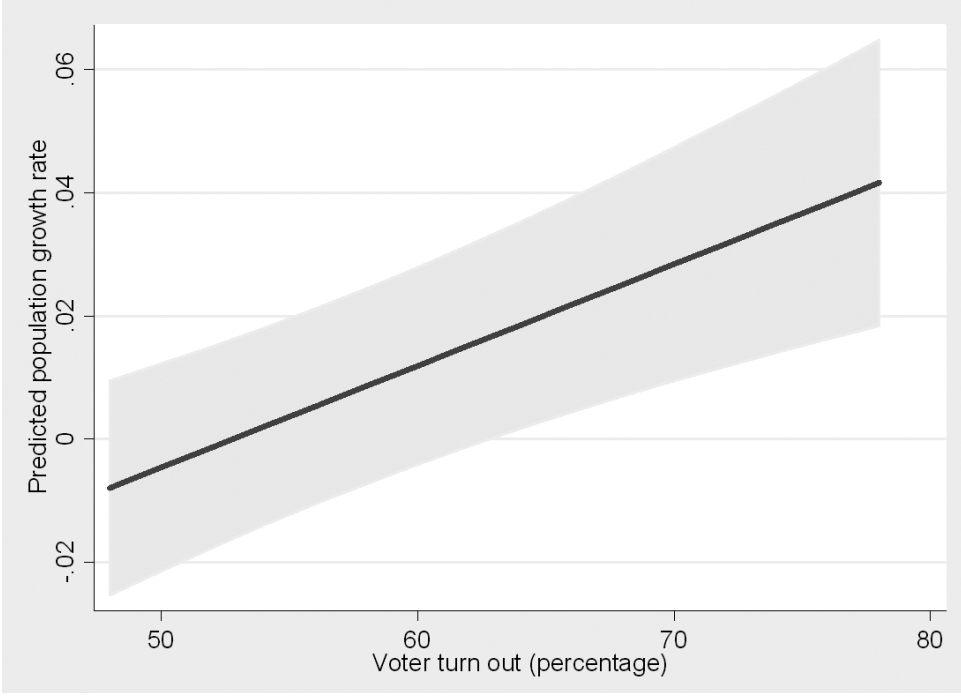
Variables	Coefficients from time-series, cross-sectional models			
	Model 1 (random effects, generalized least-squares)	**Model 2 (random effects, generalized least-squares)**	**Model 3 (fixed effects)**	**Model 4 (panel-corrected standard errors)**
Area of the precinct (square km)	0.00306 (0.0045)	0.00126 (0.0075)	…	0.00126 (0.0029)
Crime damage per capita (in yen)	-0.00014 (0.0003)	-0.00026 (0.0013)	-0.000143 (0.0004)	-0.00026 (0.0016)
Factory workers per capita	-0.0424 (0.073)	-0.0451 (0.126)	-0.928 (0.35)	-0.045 (0.093)
Number of commercial cars and trucks per capita	-0.0552 (0.245)	-0.00835 (1.08)	-0.243 (0.335)	-0.00835 (1.39)
Pawnbroker lending per capita	-0.00079 (0.00093)	-0.00059 (0.0015)	-0.003 (0.001)	-0.00059 (0.001)
Percentage of residents killed in the earthquake	0.0876 (0.0611306)	0.0889 (0.0979)	…	0.0889 (0.056)
Shitamachi dummy variable	0.0208** (0.0098)	0.0363** (0.0176)	…	0.0363 (0.029)
Voter turnout in municipal elections (1929 and 1933)	…	0.00165* (0.00094)	…	0.00165*** (0.0004)
Higher-than-average numbers of political gatherings per year dummy	0.0181** (0.0083)	0.0209** (0.011)	0.0440*** (0.012)	0.0209*** (0.0085)
_cons	0.0055	-0.11	0.104	-0.11
sigma_u	0.0000	0.0000		
sigma_e	0.0490	0.0470		
Observations	234	78	234	78

Notes: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. Standard errors are provided after the estimated coefficients.

significant regardless of whether the precinct was in the Shitamachi section or had higher-than-average numbers of political gatherings. Model 2 adds voter turnout, and despite the smaller number of observations (as only two of the years in the dataset had municipal elections), both of the measures of social capital—voter turnout and higher-than-average number of demonstrations—remain significant, as is the location of the district in Shitamachi. The two estimated coefficients for social capital remain positive, meaning that an increase in voter turnout or an above-average number of demonstrations resulted in a measurable population increase.

However, a Hausman test indicates that a fixed-effects model might be more appropriate than random effects, so Model 3 carries out a fixed-effects time-series, cross-sectional analysis. Due to the structural nature of fixed-effects models, the factors in the data that remain unchanging over time—such as the area of the precinct, the percentage of residents killed, and the location of the precinct—drop out of the equation. Even with the fixed-effects model, however, the social capital variable of political demonstrations remains significant at the $p<0.01$ level. To ensure that these findings are not artefacts of the models, a final model (Model 4) is tested, involving panel-corrected standard errors, which Beck and Katz (2004, p. 4) argue are better for handling the problems of 'groupwise heteroskedasticity and contemporaneous

Figure 2 Predicted population growth rate per precinct based on voter turnout



Note: Figure based on time-series, cross-sectional, panel-corrected standard errors; all dependent variables (area of the precinct in square km, crime damage per capita in yen, factory workers per capita, number of commercial cars and trucks per capita, pawnbroker lending per capita, percentage of residents killed in the earthquake, number of political gatherings, and Shitamachi dummy variable) held at their means except for voter turnout. The grey band indicates the 95 per cent confidence interval for these predicted values.

correlation of the errors'. While the Shitamachi dummy variable is no longer significant, the social capital indicators remain both positive and significant (at p values smaller than 0.01).

A variance inflation factor test produces a mean result of 3.64, which is slightly high—indicating some collinearity—but acceptable (Rabe-Hesketh and Everitt, 2007, p. 69). Even controlling for factors commonly thought critical in the recovery period, social capital remains the most important variable for growth.

Next, to provide a visual representation of the influence of voter turnout and of higher or lower numbers of political demonstrations on precinct-level population recovery, all controlling variables are set at their means to generate predictions for different levels of these proxies. The results are displayed in Figure 2. Holding everything else constant, a neighbourhood that had only half of its eligible voters participate in municipal elections would see a slightly negative population growth rate. On the other hand, a precinct in which more than three-quarters of voters carried out their civic duty would see a population growth rate of close to 4 per cent—higher than both national and urban levels.

In Tokyo neighbourhoods where citizens rallied together for a common cause—overcoming the typical barriers to collective action that often block voting and demonstrations—they built up informal and formal networks and relationships. Through repeated meetings—whether at local bars, the houses of prominent activists, or protests against unwanted projects (Tamanoi, 2009)—these residents established expectations of reciprocity and assistance (Small, 2009). While survivors could choose to relocate to new areas or leave Tokyo completely, bonds drew them back to their neighbourhoods and allowed them to work together to clear debris, erect neighbourhood bulletin boards to transmit information (Hastings, 1995), and rebuild homes. Ties between neighbours provided information and other types of informal insurance, such as tips on inexpensive places to sleep and eat, suggestions for rebuilding damaged houses, and early insight about new job openings. Where these bonds and ties between residents were weak—that is, where trust had not been established—residents could easily contemplate moving elsewhere and seeking new neighbours, practicing exit, not voice (Hirschman, 1970). In post-earthquake Tokyo, precincts with higher levels of social capital had measurably and statistically significant higher levels of population than those with lower levels of social capital.

Conclusions

Focusing on the potential of a popular (Putnam 1993; 1995; 2000) but relatively untested factor of social capital, this article seeks to demonstrate that more than damage levels, physical, human, or economic capital, social capital best explains why communities rebuild quickly or fail to do so. Using bivariate analysis, propensity score matching, and time-series, cross-sectional models, this article underscores that Tokyo precincts that were better able to mobilize and coordinate their activities showed higher population growth rates after the devastating 1923 earthquake. This analysis

finds little evidence supporting claims about the standard factors said to alter the pace of recovery—such as levels of damage, financial and human capital, area, or population density.

Three important policy implications arise from these findings. First, areas that can strengthen their social networks before or after disasters stand a better chance of recovering, at least in terms of population (Aldrich, 2010). Nascent research suggests that organizational structures (Small, 2009) and public policy frameworks, such as community currency programmes (Doteuchi, 2002), can increase reservoirs of social capital in neighbourhoods. Through activities that connect residents to each other and to extra-neighbourhood resources, organizations and policy frameworks can develop communities with deeper and stronger social networks (Richey, 2007).

Second, disaster managers should seek to evacuate victims in socially intact groups or reassemble evacuees as closely as possible with members of their original communities. In many recent disasters, including the 1995 Kobe earthquake, the Indian Ocean tsunami in 2005, and Hurricane Katrina in 2005, a desire to rapidly evacuate local residents led them to be separated from their social support networks. This separation resulted in the documented 'lonely deaths' of many survivors who were cut off from friends and family (Suga, 2007).

Finally, the vast majority of aid provided to communities following disaster is material and focused on infrastructure rehabilitation, such as repairing and rebuilding homes, roads, bridges, and sidewalks. If social networks prove to be an important part of the rebuilding process, then aid givers should reallocate resources to ensure that social structures are not damaged in the evacuation and resettlement processes. Rather, they should seek to nurture existing social networks, ensure their continuity during the evacuation process, and then further develop reservoirs of trust and interconnectedness during the long period of recovery.

To apply these findings to more recent disasters, it is instructive to return to the resilient community of Village de l'Est in New Orleans. The community's Father Vien Nguyen and other activists drove to temporary evacuation shelters in Texas, Arkansas, and Louisiana to meet with their neighbours and community members who had left the city with the arrival of Hurricane Katrina. While other communities found their residents often alone and isolated in temporary locations in Houston, Dallas, or other far-flung cities, members of this community did everything they could to maintain their connections. When New Orleans allowed residents to return in October 2005, Village de l'Est residents did so *en masse*, with the parish providing necessities ranging from bleach to food to building supplies. When 500 signatures were needed to prompt Entergy—the local utility—to restore electrical power to the neighbourhood, more than 1,000 residents signed by the end of the day. Village de l'Est displayed its ability to overcome barriers to collective action and to draw upon informal insurance; it remains an emblem of resilience in a still struggling New Orleans (LaRose, 2006).

As observed through neighbourhoods in New Orleans in 1995 and Tokyo in 1923, strong connections and trust among residents assist them in overcoming collective action problems that may prevent other neighbourhoods from rebounding effectively.

For citizens and decision-makers concerned with disasters, social networks are a resource that should not be overlooked.

Issues for future research

These findings illuminate two potential avenues for future research. First, historians focusing on post-earthquake mob behaviour in Tokyo have described the tragic attacks against Koreans who were falsely accused of various crimes—such as poisoning wells and setting fires—in the aftermath of the disaster. While the exact number of victims is still contested, between 2,000 and 5,000 Korean residents were slaughtered with at least complicit police support (Yamada, 1993). One potential explanation for this behaviour revolves around the role of social capital—in which bonding social capital solidifies ties between similar individuals but exacerbates differences with others. If bonding social capital was quite strong in certain neighbourhoods, but bridging social capital was lacking, the panic in response to the fires and earthquakes, combined with existing prejudices and rumours of poisoning, may have inflamed local residents who sought to attack those 'outside' their groups (see Varshney, 2001). Scholars could seek to correlate the locations of such attacks with neighbourhood-level measures of social capital to test whether there are measurable connections. Such investigations would further our understanding of the 'dark side' of social capital (Putnam, 1995).

Finally, scholars should analyse these arguments against different units of analysis to see whether these relationships can be confirmed at the micro and macro levels. A number of scholars are using data from recent disasters to investigate which factors best improve the rates of *individual* recovery (Weil, Shihadeh, and Lee, 2006; Tatsuki and Hayashi, 2002). Future work should combine measures of aggregate, objective neighbourhood recovery with individual surveys to see whether social networks are indeed crucial components in resilience. Importantly, a recent wave of cross-national empirical research has opened up new directions in the field of disaster research (Shaw and Goda, 2004; Vale and Campanella, 2005; Özerdem and Jacoby, 2006). Given the likelihood of disasters in the future, and their importance for both scholars and survivors, researchers should seek to turn their skills to sharpening our understanding of these events. It may be that social, not physical, infrastructure proves the most important for recovery.

Acknowledgments

Thanks to Christian Brunelli, Erik Cleven, Paul Danyi, Leigh Raymond, and John Sides for their close readings and suggestions and to members of the Contemporary Japan Group at the University of Tokyo's Institute of Social Science and participants in Purdue University's Public Policy and Political Theory workshop for their comments. Edwin Leuven provided coding assistance and Takahiro Yamamoto provided research assistance. This research was underwritten by the Abe Fellowship

Program, which is supported by the Japan Foundation through the Center for Global Partnership, the Social Science Research Council, and the American Council of Learned Societies.

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Endnotes

1 Most papers linking potential factors to post-disaster conditions have been based on single events (Dacy and Kunreuther, 1969) or on qualitative evidence (Nakagawa and Shaw, 2004). Exceptions include Zhao and Dalen (2006) and Aldrich and Crook (2008).

2 While economists distinguish between human and physical capital, social scientists introduced the concept of social capital, beginning with Coleman (1988; 1990) and Putnam (1993; 1995; 2000). This paper includes an additional category of economic capital to reflect the financial resources available to communities.

3 More 'voice' does not necessarily result in better policy outcomes for recovering cities as a whole, as Aldrich and Crook (2008) demonstrate. In the context of this study, however, the point is that individuals who have more at stake commit themselves and their resources more fully to recovery than those with fewer ties to the area. Hirschman defines voice as 'any attempt at all to change, rather than to escape from, an objectionable state of affairs' (Hirschman, 1970, p. 30); this desire to alter unwanted conditions stems from rootedness and deep connection. Individuals less tied to the area are more likely to respond with exit.

4 The dataset and code book for this cross-sectional, time-series data will be available for replication on the author's website.

5 For technical details on the seismicity and geographic efforts of these massive tremors, see Takemura (2003); for a pictorial atlas of the scope of destruction, see Ogawa (1973).

6 The London fire of September 1666, for example, burnt only 1.8 million square metres, while that of Chicago's 1871 fire covered 8.6 million, and San Francisco's 1906 fire destroyed 12.1 million. Tokyo's fires burnt nearly 33.5 million square metres (Tokyo Municipal Office, 1930).

7 In the same way that studies of historical events across time and space provided social scientists with better models and hypotheses for understanding revolution (Skocpol, 1979) and social capital (Putnam, 1993), so too this study seeks to use the recovery processes from early 20th-century Japan as an exploration of broader post-disaster resilience.

8 This variable is used as a test for Tanaka's (2006) argument that the Yamanote (high city) areas of western Tokyo near Shinjuku recovered more rapidly than the downtown section of Shitamachi (low city) because they were less damaged by fire; each of the 39 jurisdictions can be mapped to one of these sections.

9 Given the extreme kurtosis in the distribution of the number of political gatherings per precinct per year—with many having none and others having hundreds—this study dichotomizes this measure at its mean of 67 demonstrations to measure whether having larger than average numbers of rallies, marches, and demonstrations has an effect on population change. Roughly three-quarters of observed precincts over time had fewer than 67 demonstrations per year.

[10] Observers may wonder if the rallies and marches in a community were in fact made up principally of local residents or outsiders; perhaps certain neighbourhoods, such as Hibiya, served as focal points for protest during this period. In fact, historical studies show that during the 1920s and 1930s many neighbourhoods actively protested local decisions—such as the plans by city authorities to place an incinerator in their backyard (Yamada, 1973). Furthermore, tests of Hibiya and other popular gathering spots show that, in fact, overall population growth in these areas was negative, not positive; hence, this independent variable cannot bias estimates.

[11] An alternative interpretation of these two proxies would be to envision voter turnout as a measure of individual social capital and political demonstrations as a measure for collective social capital; voting allows individuals to mobilize for collective goods, while demonstrations show the neighbourhood levels of political and social organization. Both measure the potential for collective action.

[12] Additional merits of matching methods are their transparency in statistical identification, fewer assumptions about model fit, less model dependence, less bias (Ho et al., 2007), and the observation that non-technical audiences often find it 'a persuasive method of adjusting for imbalances in observed covariates' (Rosenbaum and Rubin, 1985, p. 33).

[13] For technical details of the mathematics of matching, see Ho et al. (2007).

[14] Nearest neighbour matching chooses the observation with the closest propensity score as a match; radius matching sets a limit on the gap distance between the matched propensity scores; kernel matching uses the averages of observations in the control group to create a match; and Mahalanobis matching randomly orders the observations and determines the propensity score gap between treated and control groups Allowing replacement in matching means that an observation can be matched more than once.

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