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The Power of People: Social Capital's Role in Recovery from the 1995 Kobe Earthquake

Daniel P Aldrich, *Purdue University*

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The power of people: social capital's role in recovery from the 1995 Kobe earthquake

Daniel P. Aldrich

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Abstract Despite the regularity of disasters, social science has only begun to generate replicable knowledge about the factors which facilitate post-crisis recovery. Building on the broad variation in recovery rates within disaster-affected cities, I investigate the ability of Kobe's nine wards to repopulate after the 1995 Kobe earthquake in Japan. This article uses case studies of neighborhoods in Kobe alongside new time-series, cross-sectional data set to test five variables thought to influence recovery along with the relatively untested factor of social capital. Controlling for damage, population density, economic conditions, inequality and other variables thought important in past research, social capital proves to be the strongest and most robust predictor of population recovery after catastrophe. This has important implications both for public policies focused on reconstruction and for social science more generally.

Keywords Kobe earthquake · Population recovery · Social capital · Disaster · Resilience

Disasters remain among the most critical shocks which impact residents and their neighborhoods around the world. While large-scale crises such as the Indian Ocean tsunami (2004), Hurricane Katrina (2005), and Italy's earthquake (2009) captured media attention, numerous smaller-scale floods, typhoons, earthquakes, and mudslides killed hundreds of thousands of victims around the world and affected far more. Researchers have confirmed an upward trend in the number in the number of disasters, individuals affected by them, and their economic costs over the past two decades (Hoyois et al. 2007). A better understanding of disasters, or more specifically of disaster recovery, will provide policy makers and victims alike with "usable knowledge"—knowledge that is both accurate and politically tractable (Haas 2004: 572).

D. P. Aldrich (✉)
Department of Political Science, Purdue University, 100 N. University Street, West Lafayette, IN 47907, USA
e-mail: daniel.aldrich@gmail.com

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Scholars recognize that the negative effects of disasters are concentrated in the most socially vulnerable populations, which include the poor, minority groups, women, and the elderly (Cutter and Emrich 2006; Cutter and Finch 2008). Yet, we have little replicable, empirical evidence investigating the role of economic capital, damage levels, and social capital—"resources embedded in one's social networks" (Lin 2008: 51)—in facilitating or impeding rebuilding. 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). Building on quantitative evidence that recovery after disasters is not constant across neighborhoods (Rovai 1994; Kamel and Loukaitou-Sideris 2004; Aldrich and Crook 2008; Pais and Elliott 2008), this article incorporates social capital into the potential sources of variation in rates of disaster recovery at the neighborhood level.

This paper uses several case studies along with a new dataset from the 1995 mega disaster in Kobe, Japan, the earthquake known in Japanese as the *Hanshin Awaji Daishinsai*, to investigate the factors which speed up or slow down recovery after a disaster at the neighborhood level.[1] Controlling for a number of factors, including economic status, levels of welfare dependence, damage, socioeconomic inequality, and geographic conditions, the amount of social capital most strongly determines recovery rates. Paired comparisons across neighborhoods in Kobe and three time-series, cross-sectional models confirm these findings. Wards with higher levels of social capital—measured in the time-series, cross-sectional data as the number of new, neighborhood level nonprofit and community-based organizations (NPOs)[2] created per capita—proved more successful at rebuilding population levels controlling for variables thought critical by past research.

Understanding how areas recover following disasters is vital not only for survivors, relief organizations, and governments, but also for social scientists. Catastrophes change participation venues for survivors (Sinclair et al. 2008), 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. This research adds to a growing recognition of the need to take social capital into account both in social science research and public policies (Putnam 2000; Birner and Wittmer 2003; Aldrich 2008). Should social capital prove important in crisis recovery, decision makers should shift resources to strengthen social networks in potentially vulnerable localities before and after disaster (Hattori 2003).

1 The Kobe earthquake

On 17 January 1995 at 5:46 am, a series of shocks measuring 7.3 on the Richter scale struck the densely populated area in and around Kobe City, located in the southern part of Japan's mainland. While the initial tremors caused a great deal of devastation, uncontrollable fires caused additional damage. More than 200 fires broke out across the Hyogo area, with more than 100 in Kobe City itself, and in the 2 days of conflagration that

[1] The data used in this study are available for replication on the author's DataVerse Network homepage.

[2] The term NPO includes groups classified by the Japanese government as nonprofit public-interest entities (*kōeki hōjin*) along with school, religious, medical, and social welfare organizations. Pekkanen points out that in Japan, the borrowed term "NGO" typically refers to organizations involved in international work, while "NPO" involves domestically active groups (2000: 116 fn 12).

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followed, more than 7,000 buildings in the city burned to the ground. The quake and inferno claimed 6,400 lives and injured more than 15,000 in a densely populated urban area which was at the time home to 4 million people. Vibrations and fire destroyed over 110,000 buildings in the area and left 320,000 people homeless, causing close to $64 billion in damage (Horwich 2000). The majority of those killed in the disaster were women and people older than 60 (Yasui 2007: 95; Tajika 2000: 119).

In responding to the Kobe earthquake, the emergency response teams from police and fire departments and from the Japanese Self Defense Forces mobilized slowly.[3] As a result, neighbors and residents were often first on the scene (Tsuji 2001: 56; Shaw and Goda 2004: 21). Beyond pulling survivors from the rubble and getting neighbors to safety, these "emergent groups" (Stallings and Quarantelli 1985) were the first to encounter the fires. Neighborhood residents responded to the fires in different ways; while some citizens watched in horror as flames consumed their homes and stores, others self-organized into civilian fire fighting corps in attempts to put out the fires (Murosaki 2007).

Following the quake some 236,000 people evacuated to more than 1,000 emergency shelters including elementary schools, junior high schools and temporary housing units (Tajika 2000: 126). Soon afterward, roughly 60% of the households in the area moved into public housing (Nakabayashi and Ichiko 2004: 9). Within 7 months, the emergency shelters were closed but around 4,500 residents remained in temporary housing units (Ikeda 2004: 33). Most residents in temporary housing were from the heavily damaged areas of Nagata, Hyogo, and Nada (Evans 2001: 162).

Building damage from the fire and quake varied across Kobe due to history and geology (Murosaki 2007; Evans 2001), so that areas with fewer old wooden houses and more bedrock suffered less damage. However, recovery rates also varied by location, and these rates were not strongly correlated with damage (Hagiwara and Jinushi 2005; Yasui 2007: 112).[4] One study uncovered housing reconstruction rates of 107% (that is, more houses were in place after reconstruction than before the quake) in Higashi Nada Ward compared with only 44% in Nagata Ward (Evans 2001: 150). By 2007, the overall city population had increased beyond pre-quake levels, but certain wards remain at lower levels of occupation while others have grown substantially (Yasui 2007: 112). This variation in population growth rates across wards provides a "natural experiment" which allows us to test the factors which influence recovery.

2 Factors correlated with recovery

Literature on disasters has identified a number of factors which can accelerate or impede recovery. A number of scholars postulated that the amount of physical *damage* from the disaster best correlates with recovery speed. Using the March 1964 Alaskan earthquake as their core case, Dacy and Kunreuther (1969) 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" (72). Haas et al. (1977) and Yasui (2007: 29) argued

[3] Tierney and Goltz (1997: 6) suggested that the lack of an official request from the governor, devastation of communications networks, logistical problems, the size of the event, and ambivalent attitudes toward the role of military in society were responsible for the SDF's sluggish reaction (see also Yasui 2007: 97).

[4] According to Tsuji (2001: 218, Figures 9–1 and 9–2) the Nagata district had 35% of its population in emergency housing after the earthquake, and it took a full year for them to return to permanent housing. In a similar-sized district of Fukushima, 70% of its population moved into emergency shelters but all had moved out within 100 days.

that more damaged areas will recover more slowly, while those which escaped devastation and suffered only minor devastation require less time to so. More devastated areas require more time for recovery because more repairs are necessary, housing is in shorter supply, and injuries and casualties are higher. Other scholars, such as Murosaki (1996: 55) and Tatsuki (2008: 24), have challenged this logic, arguing that the scale of damage and loss do not necessarily correlate with recovery rates.

Other scholars have sought to connect *population density* in the affected areas with the pace of rebuilding. Haque (2003) for example sought to connect population density with the number of deaths and injuries resulting from disasters. Higher density areas tend to be in metropolitan areas and such areas, if damaged, require more time for 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: 14). High-density slums in India have proved a difficult policy challenge for Indian authorities looking to relocate refugees (Tandon and Mohanty 2000), while the destruction of high-density housing projects in post-Katrina New Orleans triggered strong criticism (Nossiter and Eaton 2007).

Much literature on disasters has focused on the role of *socioeconomic* status in the process of rebuilding. Yasui (2007: 95) demonstrated that welfare recipients died during and after the Kobe earthquake at rates five times higher than those who were not. Sawada and Shimizutani (2008: 465) surveyed households following the Kobe earthquake and found that those families with “collateralizable assets” such as equity in their houses, savings, and jewelry were able maintain their pre-disaster consumption patterns, while families with lower levels of financial capital could not. Aggregating these results to the neighborhood level, communities devastated by disaster require bridge loans and grants as a buffer against these often unexpected shocks (US SBA 2006). At such moments, neighborhoods 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.

Economic *inequality*—the uneven distribution of wealth in a city or town—has been singled out as a cause of delayed post-disaster rebuilding. Cutter and Emrich (2006: 105) have underscored how “inequities in health, well-being, and health care accessibility have now become central issues for many emergency managers.” City planners struggle to create recovery policies which simultaneously can capture the needs of the worse-off neighborhoods alongside better-off ones. Further, research based on individual-level data demonstrated that post-crisis, poorer residents in neighborhoods with more income inequality suffered from depression more than others (Ahern and Galea 2006).

3 Social capital

Recently, scholars have sought to link the speed and effectiveness of the process of recovery to levels of trust and social capital—that is, the resources available to individuals through their social networks (Lin 2008). Three specific mechanisms allow areas with denser 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 et al. 1996). Second, more politically active and better connected communities can better mobilize to present their demands to and extract resources from authorities (Olson 1965). Finally, embedded networks raise the cost of “exit” from a community and increase the probability that residents will use "voice;" following a disaster, better connected residents are more likely to articulate their demands to authorities and work together to overcome obstacles to recovery (Hirschman 1970).

Much of the evidence backing the role of social capital post-disaster has come from qualitative and impressionistic studies. Dynes (2005) used his considerable experience in disaster research to posit that social capital worked as the "primary basis for resilience." Nakagawa and Shaw (2004: 18) used case studies from Gujarat and Kobe to argue that social capital proved critical "even in the challenging situation of rehabilitation." Yasui (2007: 43) postulated that areas with established horizontal associations facilitated faster individual recovery of disaster victims and the emergency responses to the quake based on two neighborhoods in Kobe. Quantitative evidence supporting claims for the role of social capital have come primarily from individual, not neighborhood level, research. Tatsuki (2008: 27) and Tatsuki and Hayashi (2002) used surveys of individual victims to argue that citizens in Kobe who had higher levels of community participation and civic trust reported better recovery than those with lower levels. Neighborhood level studies of recovery have rarely included explicit measures for social capital (Rovai 1994; Kamel and Loukaitou-Sideris 2004; Pais and Elliott 2008).

In the Kobe earthquake case, the role of social capital at the ward—not just individual—level became apparent during the creation of neighborhood-based civil society organizations. Following the earthquake, a number of wards within the city of Kobe established new nonprofit organizations to organize and coordinate recovery, neighborhood activities and long-term planning. Mayor Kazutoshi Sasayama had imposed a post-quake moratorium on rebuilding as the Kobe town planning department hastily worked out their reconstruction schemes (Evans 2001: 4), but many residents felt that the city was blocking their participation in land-zoning planning and decided to do it by themselves (Yasui 2007: 230). The city plan categorized areas as black (city-initiated and administered rebuilding zones, 2.9% of total area), gray (eligible for assistance but not administered by the city, 17.9%), and white (citizen-initiated zones, 79.2%) (Olshansky forthcoming). Citizens formed *machizukuri* (town development) organizations to participate in the planning process; these groups were often based in existing civil society organizations such as neighborhood associations (*chōnaikai*) (Nakagawa and Shaw 2004: 7). These NPOs focused on providing assistance solely to individuals within their jurisdiction to develop their ward and serve as a prime example of institutionalized social capital at the neighborhood level.

4 Qualitative data: cases of social capital and recovery

A comparison between two similar neighborhoods within Kobe during and after the quake illustrates how stronger networks accelerate recovery after a disaster. Mano, a mixed residential and industrial zone in the downtown section of Kobe's Nagata-ward, holds within it large factories, workshops, and large numbers of houses (Evans 2001: 177). Like the nearby community of Mikura, Mano faces the problems of "population decline, aging population, fragile old wooden housing, [and] high building density" (Yasui 2007: 15). While physically, demographically, and geographically similar, Mano displayed high levels of social capital while Mikura possessed far lower levels.

In the Mano area, citizens' fire brigades successfully fought the post-quake fires, unlike adjoining neighborhoods—including Chitose and Mikura—facing similar conflagrations. In interviews, Shimizu Mitsuhisa, Secretary General of Mano Town-Building Council,

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argued that citizens in Mano spontaneously organized to form fire bucket lines, not bothering to wait to see if fire trucks would arrive or if they would be able to fight the fires using such primitive techniques which they had rarely practiced (Yasui 2007: 186). Residents coordinated their firefighting efforts, borrowing both hoses and water from nearby shoe manufacturers and other companies while others drew water from the Shin Minato River (Yasui 2008: 188). Residents in Mikura, alternatively, lacked the coordination to do so and stood helplessly as flames consumed their businesses and homes.

Furthermore, the Mano neighborhood undertook a tremendous number of activities after the quake, including the "establishment of Mano Rehabilitation Machizukuri office, construction of Machizukuri center, establishment of 'Manokko (private limited company)' for community development, signature collection campaign for construction of public houses for disaster-affected people, lobbying for special houses for elderly, construction of a model house as collective housing, preparing joint housing project proposals, and running a day-care center" (Nakagawa and Shaw 2004: 8) While critics have argued that even in Mano not all residents participated in community activities (Inui 1998), the neighborhood stands out in comparison with other areas within Kobe for its high levels of social capital. For example, Mikura created only a single organization—Machi Communication (MC)—to coordinate its post disaster recovery (Yasui 2007: 15). The community of Mikura experienced further problems when it was unable to coordinate its recovery; free debris removal sponsored by the city government required written agreement from the property owners, but no one volunteered to organize its signing (Yasui 2007: 227). Mano stands out as a community whose strong social networks facilitated a smoother and faster recovery than similar neighborhoods with weaker ties.

Other paired comparisons between similar Kobe neighborhoods with high and low levels of social capital have uncovered similar success in recovery efforts. Tsuji (2001: 231, Table 9–3) compared two neighborhoods which he labeled as Nagata A and Fukushima B. Both had similar average ages of residents before the quake (approximately 51 years), similar population levels (around 185 residents), income (4.4 million yen on average), employment (approximately 66 percentage employed) and household leadership (77% headed by men). However, close to three-quarters of the residents of Fukushima B were born there, while fewer than 10% of Nagata A residents were "natives."

Further, nearly double the percentage of Nagata A residents rented their homes—roughly 35%—compared to Fukushima B, where only 16% did. As sociologists have long underscored, long tenure homeowners participate more actively in their neighborhoods and build more connections than short-term renters. Fukushima B employed what Tsuji labeled a "net" support scheme "based on traditional and strong social bonds," while Nagata A relied on a small cadre of leaders. In summarizing the differences after the earthquake, Tsuji (2001: 309) argues that "Nagata A experienced a hollowing out, while B was depopulated." While both neighborhoods lost residents due to the disaster, the stronger bonds in Fukushima B allowed it to hold together. Other evidence from the Kobe earthquake links deeper social capital with stronger recovery.

Collective action and coordination problems proved severe after the earthquake across parts of Kobe; many condominium owners, for example, could not reach agreement on the procedure for rebuilding or repairing damaged their co-owned properties (West 2005). Areas with higher levels of social capital overcame these obstacles not only to repair their own houses, but to design and build new cooperative housing structures. In the Mano neighborhood, survivors organized soon after the quake to discuss the possibility of constructing cooperative housing, known as *kyōdō tatekae*, to replace the older, individual

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family homes which were vulnerable both to fire and quake damage (Yasui 2007: 194). One such project, the Higashi Shiriike Kōtō in Higashi Shiriike 7 chōme involved the "cooperation of the five freehold house-owners and three landowners who owned the land on which were previously eighteen housing units (occupied by five house-owners and thirteen tenants)" (Evans 2001: 223). The tenants worked together to plan their shared housing structures with the help of volunteer architects and engineers and began constructing by August of 1996 on 18 units.

Mano's Shiriike Kōtō project comprised one of many cooperative housing schemes which rose from the ashes of the quake; the City of Kobe reported more than 108 such joint housing projects with more than 4,800 housing units as of 2003. Homeowners could build and sell or rent additional units in the new shared buildings to offset the costs of the project, and many received assistance from city rebuilding schemes (Olshansky forthcoming, Chap. 7, p. 33). Surveys of collective housing members demonstrated that the often lower costs motivated their residence in such projects (Sekikawa et al. 2006: 93), and that respondents for whom *kinjo tsukiai*, or relationships with neighbors, were important were more satisfied with their living arrangements than their less sociable counterparts. Building on these cases connecting social capital to accelerated recovery, the paper now seeks to uncover broader patterns linking recovery not only with civil society but with other potential explanatory factors.

5 Quantitative data

The data for this quantitative analysis come from an original data set developed by the author to follow the economic and demographic development of the nine wards of Kobe between 1990 and 2008 based on multiple sources of data. Kobe's division into wards allows us to trace the effects of different factors, including earthquake damage, population density, social capital, and so on, over time. The data are structured in a time-series, cross-sectional structure because Kobe has nine wards (the units) which are observed over 18 years (periods) with ward-based observations organized by year. The ward thus serves as the unit of analysis within the dataset; the average ward within Kobe is around 60 square kilometers in size. The observations at the ward level match up well with the theoretic

Table 1 Descriptive statistics for selected variables in the dataset

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Population growth rate	153	0.002	0.048	−0.258	0.225
Percentage of population affected by the earthquake	162	0.228	0.151	0.048	0.559
Welfare dependent households per capita	135	0.015	0.012	0.002	0.045
NPOs created per capita	81	0.00004	0.00005	0	0.00025
Population density (people per sq km)	162	5322.6	2870.6	824.4	11923.5
Socioeconomic inequality	126	0.000	0.947	−0.936	1.784

Data from *Kōbe shi Sōmukyoku Tōkeika* (various years), *Kōbe shi Senkyo Kanri Iinkai* (various years), the Kobe City NPO Database, and calculations by the author

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explanations of post-disaster recovery laid out above. Table 1 provides descriptive statistics for the variables used in this article.

To capture the damage done to each ward, the dataset measures the percentage of individuals in the ward directly impacted by quake through deaths and injuries. The average neighborhood in Kobe had approximately 1 in 5 residents either wounded or killed by the quake, but some had more than half of their residents affected while a few had only 1 in 20 hurt or killed. The measure of households in the ward on welfare per capita serves as a proxy for economic conditions. On average, the Kobe wards had only 2 households per 100 people on welfare, while the most poverty stricken had close to 5 in 100 and the wealthiest fewer than 2 households per 1,000 people. Population density is measured as people per square kilometer, with an average of 5,300 people per square kilometer and a maximum density of close to 12,000 people per square kilometer. To measure socioeconomic inequality, I created a Z-score measure that measures the gap between the economic conditions in each ward in each year and other wards through the equation $Z_{t,i} = \frac{x_{i,t}-\mu_t}{\sigma_t}$.

This provides a relative measure of inequality by subtracting the mean level of socioeconomic conditions (across all wards) from the observed level in each ward (for each year) and dividing the result by the standard deviation. In this case, I have constructed the measure so that higher values of this score indicate higher levels of inequality compared to other neighborhoods and lagged it by 1 year to better capture any causal effects. This measure is set with its mean at zero and a maximum of 1.7 (the highest concentration of poverty) and a minimum of −0.93 (the lowest).

Given the complexity involved in measuring social capital, social scientists have regularly employed proxies to capture it quantitatively (cf. Putnam 2000). Measures of social capital need to be sensitive to the cultural and historical environment of the case under investigation (Krishna 2007: 944–945). Scholarship has illuminated the measures of social resources available at the individual, community, and national levels (Van Deth 2008: 161), and here, because of my use of the ward as the unit of analysis, I focus on the community level. To measure the amount of social capital at the community level, the dataset measures the number of nonprofit organizations (NPOs) created per capita per ward. These NPOs were created to assist the redevelopment and reconstruction of the ward in which they were established, and as mutual aid organizations concerned with helping members, they serve as examples of institutionalized social capital (Nakagawa and Shaw 2004). Small (2009) has demonstrated how the individuals embedded within such organizations benefit from the formal and informal social resources that they provide. It is certainly accurate that not all communities will form NPOs and local community groups despite having higher levels of social capital. However, these organizations formed solely from internal, and not external resources, and in interviews local leaders often commented on mobilization ability as an indicator of social capital and coordination capacity. Because this dataset captures the year of creation of the new NPOs, I include a lagged measure (by 2 years) of NPO creation to allow time for this institutionalized social capital to impact the residents and their communities based on research showing it takes time for social resources and networks to diffuse through the community (Krishna 2007). The most active neighborhoods created roughly 3 new nonprofit organizations per 10,000 residents, while the least mobilized created only 5 per 100,000 people.

There are a myriad of ways to measure recovery from disaster including economic (Albala-Bertrand 1993), demographic, infrastructure, and transportation metrics (Liu et al. 2006). However, population growth serves as a more realistic proxy for recovery following disaster as it demonstrates whether or not survivors and newcomers are repopulating what

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may otherwise be a "ghost town." (Horwich 2000: 523). Yasui (2007: 319) argues that population recovery has proved to be "one of the essential parts of disaster recovery." Scholars investigating the recovery of New Orleans from Hurricane Katrina have used innovative techniques for measuring population return, including tallying mail-forwarding orders used by the United States Post Office (Warner 2006). Similarly, in studies of recovery from World War II, Davis and Weinstein (2002) measured population growth rates as their proxy for resilience following the bombings of Japanese cities. I follow this scholarship and use population growth rates as a proxy for post disaster recovery. I define population growth through the intuitive measure of $\Delta_{\text{population}} = \frac{(Y_{i,t} - Y_{i,t-1})}{Y_{i,t-1}}$, which provides a way of comparing population change across neighborhoods. Growth rates ranged tremendously across wards; in some neighborhoods, it reached -0.26, meaning that the area lost one-fourth of its population, while in other wards, it was as high as 0.23, meaning that it gained roughly one-fourth over that year. The mean across all observations for population growth rate is quite close to zero (0.002).

Figure 1 displays the raw population levels for the 9 wards over time. Note that certain wards, such as Kita and Nishi, had populations that were growing before the earthquake struck in 1995; for these wards the quake was merely a downward blip on the radar screen in terms of their overall patterns of growth. For others, such as Suma, Hyogo, Nagata, and Tarumi, the earthquake accelerated or catalyzed a loss of population. For Higashinada, Nada, and Chuo, the earthquake stopped a downward trend.

Explaining the variation in these levels of population growth is a critical task for social science. To analyze the factors responsible for accelerating or slowing population growth rates, I developed three different models to test the effects of the variables.

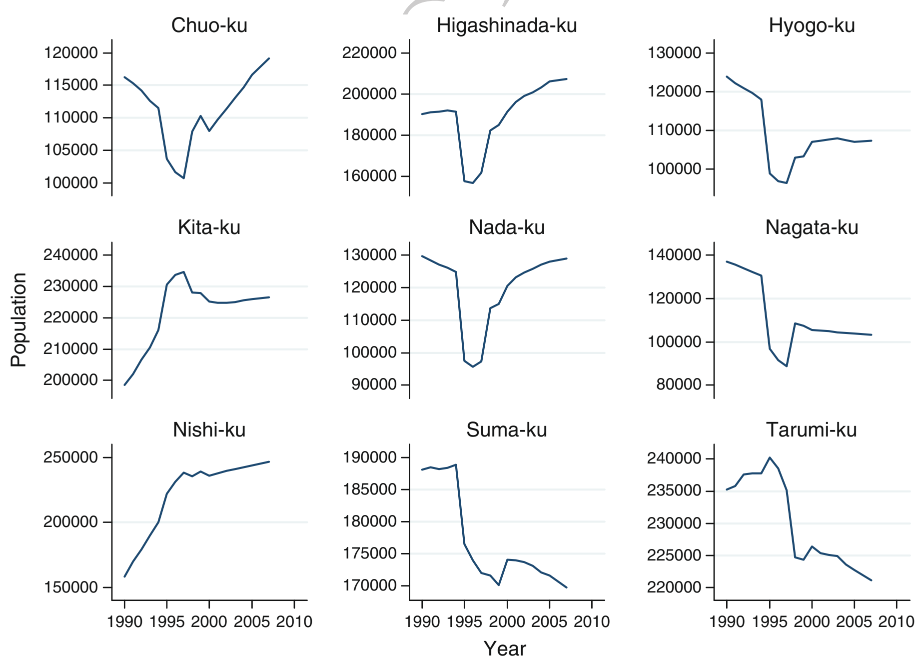

Fig. 1 Population change per ward over time

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6 Methods and results

The autoregressive distributed lag (ADL) model incorporates important time and unit information for both the independent and dependent variables, as displayed below.

$$y_{i,t} = \alpha_1 Y_{i,t-1} + \beta_0 X_{i,t} + \beta_1 X_{i,t-1} + \varepsilon_{i,t}$$

Known as the "workhorse" of time-series models (Keele and Kelly 2005), this model can adopt values of i (the unit) from 1 to 9 (for the 9 wards within Kobe) and values of t (time, measured in years) from 2 to 18 (as the dataset contains 18 years of measurements). The model is known as "autoregressive" because it contains a lagged Y (the dependent variable, a feature which leads many to call this a "dynamic model"), and "distributed" because of the presence of lagged X variables (the independent variables) (Beck and Katz 2009). This model controls for at least some of potential endogeneity between variable X and outcome Y at time T—known as the instantaneous or contemporaneous effect—through the use of lagged variables as explanatory factors. It allows researchers to make stronger causal claims about the direction of causality between lagged independent and dependent variables because of the chronology of the effect—the system is structured to test the influence of earlier values of X on later values of Y. As the past values of X predict current values of Y, it cannot be claimed that Y in period T simultaneously or endogenously influenced X in period T-1 or T-2, as X occurred in an earlier period.[5]

Table 2 displays the estimated coefficients for the three models tested on the data set.

Model 1 used the standard fixed effects (FE) time-series cross-section model which controls for variables which differ between cases but remain the same over time. As a result, time-invariant factors—including the area and the percentage of residents impacted by the quake—drop out of the fixed-effects models (as indicated in the table). In model 1, the lagged dependent variable (of the previous year's growth rates) proved highly significant, meaning that past growth rates within the ward measurably influenced current growth rates. The estimated coefficient for the lagged number of NPOs created per capita is positive and significant, indicating than an increase in this proxy for civil society correlates with an increase in the population growth rate two years later. As explained earlier, social capital's effects are not immediate; rather, their influence is felt at a later time. Welfare dependence within the ward—which measures socioeconomic conditions—proved significant, so that as the number of families per capita on welfare increased, the growth rate in that ward decreased.

To ensure that these findings—which support theories connecting stronger social capital to recovery and find little evidence for other explanations—were not an artifact of the fixed effects model, I next used panel-corrected standard error (PCSE) time-series models which Beck and Katz (2004: 4) believe better handle the problems of "groupwise heteroscedasticity and contemporaneous correlation of the errors." Model 2 uses panel-corrected standard errors, while Model 3 uses the Prais–Weinstein regression (which adds first order

[5] As autoregressive distributed lag models often create high levels of multicollinearity, I tested the data for multicollinearity using the Variance Inflation Factor (VIF) approach, and found relatively low levels of interaction among the variables (with a VIF of less than 7 for all models) (Rabe-Hesketh and Everitt 2007: 69). A second concern for ADLs is that variables within them remain strictly stationary. A multivariate augmented Dickey-Fuller test indicated that we can reject the null hypothesis that the processes for 1, 2, and 3 period lags are nonstationary (that is, lack equilibrium). Further, the Hausman specification test determines whether a fixed or random effects model is most appropriate when using time-series data, and it indicated in this case that a fixed effects model fit more closely (Chi square value of 0.0001).

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Table 2 Coefficients for three models of population growth rate

Dependent variable: population growth rate	Model 1: fixed effects	Model 2: panel-corrected standard errors	Model 3: Prais–Winstein regression (panel-corrected standard errors with first-order autocorrelation)
Population growth rate (lagged)	0.131***	0.267***	0.230***
	0.042	0.063	0.059
Percentage of population affected by the earthquake	(dropped)	0.011**	0.011**
		0.004	0.005
Welfare dependent households per capita	−0.983***	−1.73***	−1.69***
	0.334	0.388	0.414
NPOs created per capita (lagged)	43.01**	90.1***	84.7***
	20.950	27.700	28.00
Population density	−0.00001	−0.000008***	0.00***
	0.000	0.000	0.000
Socioeconomic inequality (lagged)	0.027	0.022***	0.021***
	0.018	0.006	0.005
_cons	0.074	0.035	0.035
	0.059	0.006	0.007
sigma_u	0.024		
sigma_e	0.003		
rho	0.989		0.215

Standard errors are underneath the estimated coefficients

** $p < 0.05$; *** $p < 0.01$

autocorrelation to the PCSE model). As in the fixed effects model, the lagged independent variable (of past growth rates) remained positive and significant—showing that the "shadow of the past" for growth rates influences current outcomes. Similarly, in both models 2 and 3 the proxy for social capital—that is, the lagged number of NPOs created per capita—remained significant at the 0.01 level.

In these models, as in model 1, the estimated coefficient for NPO creation is positive, meaning that the more NPOs created per capita, the higher the population growth rate in the ward later in time. Because these are lagged independent variables, we can more strongly make a causal claim about the impact of social capital on growth rates—as endogeneity and simultaneity are eliminated through the use of past values. In these two PCSE models, four other variable coefficients proved statistically significant: percentage of the population affected by the quake, population density, socioeconomic inequality, and welfare dependent households per capita. The coefficients for welfare dependent households per capita were negative in all three models—meaning wards which had higher levels of dependence on local government assistance had negative growth rates. This discovery meshes well with standard arguments about the role that financial capital plays in

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the rebuilding process; households seeking government assistance lack a buffer against shocks and are more vulnerable to disasters (Yasui 2007).

Higher population density neighborhoods recovered more quickly, but the measured coefficient was quite small (with more than 7 zeroes in front of it) and was only significant in the two panel corrected standard error models. The measure of socioeconomic inequality showed that areas with greater concentrations of poverty actually had higher growth rates, while the measure for quake damage showed that more heavily damaged areas bounced back more quickly than less damaged ones—but only in models two and three. These nonrobust findings run counter to standard assumptions made about damage and inequality.

As it is difficult to comprehend the magnitude of effect of the independent factors on the dependent variable of population recovery solely from their coefficients, I provide a more intuitive way of interpreting this relationship. Figure 2 uses simulation techniques and confidence intervals to predict the population recovery rate, holding all other factors at their means, for various (lagged) numbers of NPOs created per capita. Based on this model, a ward in Kobe after the earthquake which mobilized to create three new NPOs per 1,000 residents would show close to 1.5% growth rate—a figure which sounds quite low, but is far higher than the average city-wide level of growth (hovering just above zero percent per year). Alternatively, a similar damaged, wealthy, and welfare-dependent ward which was only able of organizing 1 NPO per 1,000 residents would have around a 0.05% growth rate, and a neighborhood unable to create any civil society organizations would demonstrate close to zero population growth.

Through an analysis of the most common explanations for post-disaster recovery, this paper revealed that social capital—more than economic conditions, earthquake damage, population density, inequality, or geography—proved critical over the long term. Areas which could self-organize not only immediately following the quake to fight fires but also over the rehabilitation period to set up ward associations better recovered in terms of

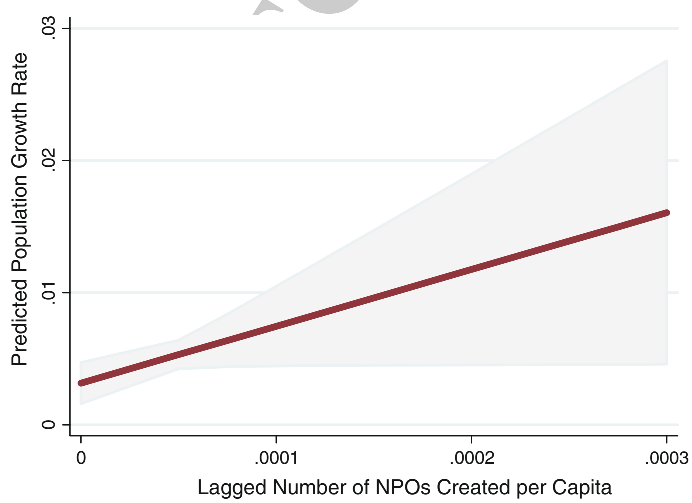

Fig. 2 Predicted population growth rate as a function of social capital. *Note* All variables (percentage of ward population affected by the earthquake, welfare dependent households per capita, socioeconomic inequality, and population density) were held at their means except for the lagged number of NPOs created per capita. The *gray shaded area* indicates the 95% confidence interval around the predicted value of population growth rate

population than more fragmented neighborhoods. Such communities overcame collective action problems (Olson 1965), demonstrated their "voice" and not "exit" (Hirschman 1970) and worked to improve the lives of the citizens within their neighborhood. These wards cleaned up debris, organized anti-looting patrols (Olshansky forthcoming), cooperated and structured aid so that all residents had sufficient food to eat, and kept up morale and motivation to rebuild through regular social interaction. Neighborhoods in which citizens were less connected to each other and had lower levels could not regain their population following the disaster.

7 Conclusions

Using both mini-case studies of neighborhood level, paired-comparisons within Kobe and quantitative data from all nine Kobe wards measured over 18 years, this article underscored the important role played by social capital in post-disaster recovery. While past growth rates proved important across all model specifications and welfare dependence had a measurable effect on population growth, no other variables had social capital's robust, measurable influence across all three models. Horwich (2000: 522) argued that "A fundamental factor is that in most economies physical capital, although the most visible, is not the dominant economic resource—human capital is." Despite this understanding of the power of social infrastructure, decision makers continue to focus resources on standard physical infrastructure targets—roads, bridges, and house rebuilding—often ignoring the role of social capital. Tatsuki and Hayashi (2002: 19) argued that "more policy concerns should be paid to assist family systems and to facilitate more active community participation."

Given the importance of social capital in bringing back residents and new migrants, NGO and government decision makers should take it more seriously as they develop recovery plans. Disasters themselves may disrupt existing social networks as West (2005: 128) demonstrated: "while 100% of the previous condominium owners' voting patterns had been made unanimously, only 12% of those following the Kobe earthquake were unanimous." Further, policies put in place to help with rebuilding themselves may be responsible for slower recovery due to the breaking apart of communities. The often random assignment of displaced survivors to temporary housing post-quake disrupted existing social ties (Tsuji 2001: 59). Many of the new housing complex were immense—with as many as 1,000 living units in the buildings similar to *danchi*, or large scale, Soviet Union-style public housing blocks—so that elderly and disabled residents felt isolated and unable to establish new friendships (Yasui 2007: 110). Scholars and the news media in Japan reported that more than 120 people had died "lonely deaths," or *kodoku shi* in Japanese, while living in such conditions (*Mainichi Shinbun* 17 January 1997: 4; Suga 2007). Upon resettlement, areas like Rokkomochi were populated primarily by newcomers—only a third of the original community remained geographically together (Horne 2005). Grouping survivors from the same area together in temporary shelters and in long-term housing can ensure that existing stocks of social capital are not damaged by the move.

Further, various public policy programs can build up stores of trust and interaction within neighborhoods (see Aldrich forthcoming). After the 1995 earthquake, for example, the city of Kobe itself sought to create stronger solidarity among survivors through programs targeted at increasing trust and participation (Hattori 2003), and such programs could be duplicated elsewhere. Small (2009) demonstrated that individuals who regularly interact with local organizations benefit from their unplanned introduction into broader social networks, and decision makers could seek to increase the density of organizations—whether day care, *jidōkan* (children's halls), senior care, or communal use halls—across cities.

Many scholars have understood that disasters can motivate survivors to participate in civil society organizations and governance structures for at least short periods of time (Tatsuki and Hayashi 2002: 2; Tatsuki 2008: 14; Sorensen 2007: 78). Sorensen (2007: 63) observed the same phenomenon almost 100 years ago: neighborhood associations spread throughout Tokyo following the 1923 Kanto earthquake. Many saw the Kobe earthquake as a similar catalyst for both growth in civil society and public policies designed to facilitate its institutionalization. Authorities estimated that between 630,000 and 1 million volunteers streamed into the area to assist in rebuilding (Tierney and Goltz 1997: 2; Shaw and Goda 2004: 19). This paper has sought to demonstrate that more than a short-lived phenomenon involving outsiders, the social capital among residents of disaster struck communities is a critical component of the post-disaster recovery process.

8 Issues for future research

Using neighborhood (ward) level data, this article has connected social capital to post-disaster recovery through time-series cross-sectional data and mini case-studies. Future research could combine individual level data—from surveys, focus groups, and survivors' diaries and blogs—to see exactly how social networks and ties worked to assist them in the rebuilding process. Scholars such as Shigeo Tatsuki (2002, 2008) have worked to collect and analyze longitudinal, individual data since the immediate post-disaster recovery, and a fruitful avenue for further investigation would be to mesh individual and communal level studies to gain a deeper understanding of the power of people in rebuilding. Furthermore, this article has used ward-level creation of NPOs and community groups as a proxy for social capital; future studies should seek to broaden the instruments used for capturing this critical resource to ensure these findings are robust.

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