The Long-Run Socio-Economic Consequences of a Large Disaster: The 1995 Earthquake in Kobe

ONLINE APPENDIX

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Appendix posted at: https://sites.google.com/site/noyeconomics/research/natural-disasters

Abstract

We quantify the ‘permanent’ socio-economic impacts of the Great Hanshin-Awaji (Kobe) earthquake in 1995 by employing a large-scale panel dataset of 1,719 cities, towns, and wards from Japan over three decades. In order to estimate the counterfactual—i.e., the Kobe economy without the earthquake—we use the synthetic control method. Three important empirical patterns emerge: First, the population size and especially the average income level in Kobe have been lower than the counterfactual level without the earthquake for over fifteen years, indicating a permanent negative effect of the earthquake. Such a negative impact can be found especially in the central areas that are closer to the epicenter. Second, the surrounding areas experienced some positive permanent impacts in spite of short-run negative effects of the earthquake. Much of this is associated with movement of people to East Kobe, and consequent movement of jobs to the metropolitan center of Osaka, that is located immediately to the East of Kobe. Third, the furthest areas in the vicinity of Kobe seem to have been insulated from the large direct and indirect impacts of the earthquake.
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Figure 1. A1001 The total number of the population

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).

Figure 2. A1076 More than 65 year-old total population
*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 3. A1352 Population in register – Total

A1352
Deviation from the synthetic result (%)

1995  2000  2010

A1352
Deviation from the synthetic result (%)

1995  2000  2010

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 4. A1353 Population in register – Male

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 5. C1354 Population in register – Female

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan. 1995).

Figure 6. C1495 Day time population
*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan. 1995).
Figure 7. Impact of the Earthquake on Taxpayer Income in Kobe City

Figure 8. Impact of the Earthquake on Taxpayer Income in Nishinomiya City
Figure 9. Impact of the Earthquake on Taxpayer Income in Yokohama City

Figure 10. C1632 Taxable income

C1632
Deviation from the synthetic result (%)
Figure 11.  C1633 Number of taxpayers

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 12.  C1690 Number of the secondary industry business

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 13. Number of tertiary industry business

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 14. C1724 Number of employees in the secondary industry business

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 15. C1725 Number of employees in the tertiary sector

*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 16. F2655 Number of Unemployed in Kobe
*Cities and wards with synthetic results that sufficiently reproduce the actual values prior to the Hanshin Awaji Earthquake (Jan.1995).
Figure 18. Placebos for Registered Population

1352 Registered Population
Kobe - Placebo Test (RMSPE 20x)

1352 Registered Population
Kobe - Placebo Test (RMSPE 5x)

1352 Registered Population
Kobe - Placebo Test (RMSPE 2x)
1352 Registered Population
Himeji - Placebo Test (RMSPE 20x)

% deviation from synthetic control


1352 Registered Population
Himeji - Placebo Test (RMSPE 5x)

% deviation from synthetic control


1352 Registered Population
Himeji - Placebo Test (RMSPE 2x)

% deviation from synthetic control

1352 Registered Population
Amagasaki - Placebo Test (RMSPE 20x)

1352 Registered Population
Amagasaki - Placebo Test (RMSPE 5x)

1352 Registered Population
Amagasaki - Placebo Test (RMSPE 2x)
1352 Registered Population
Nishinomiya - Placebo Test (RMSPE 20x)

1352 Registered Population
Nishinomiya - Placebo Test (RMSPE 5x)

1352 Registered Population
Nishinomiya - Placebo Test (RMSPE 2x)
1352 Registered Population
Kawanishi - Placebo Test (RMSPE 20x)

1352 Registered Population
Kawanishi - Placebo Test (RMSPE 5x)

1352 Registered Population
Kawanishi - Placebo Test (RMSPE 2x)
Figure 19. Placebos for Taxable Income
1632 Taxable Income
Amagasaki - Placebo Test (RMSPE 20x)

% deviation from synthetic control

1632 Taxable Income
Amagasaki - Placebo Test (RMSPE 5x)

% deviation from synthetic control

1632 Taxable Income
Amagasaki - Placebo Test (RMSPE 2x)

% deviation from synthetic control
Table 1: Kobe Population in Register (A1352) Predictor Means

<table>
<thead>
<tr>
<th>Variables</th>
<th>Kobe (Real)</th>
<th>Kobe (Synthetic)</th>
<th>Average of 1641 Control Cities</th>
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Table 1: Kobe Population in Register (A1352) Predictor Means (continued)

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<tr>
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<th>Kobe Real</th>
<th>Kobe Synthetic</th>
<th>Average of 1641 Control Cities</th>
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<td>Employers (F2876)</td>
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All variables are averaged over the pre-treatment period.
Table 2. Data sources

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<td>Total Population</td>
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Table 2. Data sources (continued)

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Abbreviations
GSI: Geospatial Information Authority of Japan
METI: Ministry of Economy, Trade and Industry
MIC: Ministry of Internal Affairs and Communication
MHLW: Ministry of Health, Labor and Welfare
Appendix: Impacts of the Earthquake on Each Variable in Each Ward

Kobe
- Permanent negative impact on total population
  - -1.9% in 2000 (A1001)
  - -2.3% in 2000 (A1352)
  - -1.0% in 2010 (A1001)
  - -1.9% in 2010 (A1352)
- Permanent negative impact on both male and female population
- No impact on 15~29 year old population
- Permanent positive impact on elderly population
  - +7.1% in 2000
  - +15.6% in 2010
- Small Permanent negative impact on daytime population
  - -1% in 2000
  - -1.4% in 2005
- Permanent negative impact on taxpayer income
  - -3.7% in 2000
  - -7.8% in 2010
- Number of taxpayers, however, appears to recover
  - -2.7% in 2000
  - -0.8% in 2010
- Permanent positive impact on the number of unemployed
  - +27% in 2000
  - +29.2% in 2005

Kobe: Higashinada-ku
- Permanent positive impact on total population
  - 1.8% in 2000 (A1001)
  - 10.3% in 2010 (A1001)
- Permanent positive impact on 15~29 population
  - 5.1% in 2000
  - 12.7% in 2010
- Permanent negative impact on elderly population
  - -6.1% in 2000
  - -6.6% in 2010
- No impact on Daytime Population
- Permanent positive impact on Secondary Employees
  - +31.8% in 2001
  - +19.1% in 2006
- Small permanent positive impact on Tertiary Employees
  - +3.8% in 2001
  - +7.8% in 2006
- Permanent increase in the number of unemployed
  - likely due to population increase
  - +2.4% in 2000
  - +25.5% in 2005

Kobe: Nada-ku
- Permanent increase in total population
  - +3% in 2000 (A1001)
- Permanent increase in both male and female population
  - Permanent increase in 15-29 population
    o +12.9% in 2000
    o +16.3% in 2005
  - Permanent increase in Daytime Population
    o +3% in 2000
    o +7.6% in 2005
- No impact on the number of secondary businesses
- Permanent negative impact on the number of tertiary businesses
  o -8.7% in 2001
  o -3.7% in 2006
- Permanent positive impact on the number of unemployed
  o likely due to population increase
    o +20.3% in 2000
    o +11% in 2005

**Kobe: Chuo-ku**
- No permanent impact on total population
- Permanent decrease in Daytime Population
  o -12.6% in 2000
  o -10.9% in 2005

**Kobe: Hyogo-ku**
- Permanent decrease in total population
  o -16% in 2000 (A1001)
  o -15.3% in 2000 (A1352)
  o -20.1% in 2010 (A1001)
  o -18.9% in 2010 (A1352)
- Permanent decrease in both male and female population
- No impact on the number of secondary businesses
- Permanent decrease in the number of tertiary businesses
  o -7.1% in 2001
  o -5.6% in 2006
- Permanent increase in the number of unemployed
  o +17.3% in 2000
  o +40.8% in 2010

**Kobe: Nagata-ku**
- Permanent decrease in total population
  o -20.9% in 2000 (A1001)
  o -22.1% in 2000 (A1352)
  o -25.2% in 2010 (A1001)
  o -25.7% in 2010 (A1352)
- Permanent negative impact on both male and female population
- Permanent decrease in 15-29 population
  o -23.6% in 2000
  o -28.7% in 2005
- Permanent decrease in Daytime Population
- Permanent decrease in the number of Tertiary Businesses
  - 13.9% in 2001
  - 11.9% in 2006

Kobe: Suma-ku
- Permanent decrease in total population
  - 8.4% in 2000 (A1001)
  - 9.3% in 2000 (A1352)
  - 12.9% in 2010 (A1001)
  - 13.8% in 2010 (A1352)
- Permanent decrease in total population
  - 6.4% in 2000
  - 9.6% in 2005
- Permanent decrease in 15–29 population
  - 8.3% in 2000
  - 10.7% in 2005
- Permanent decrease in the number of Secondary Businesses
  - 29.6% in 2001
  - 32.8% in 2006
- Permanent increase in the number of unemployed
  - +16% in 2000
  - +11.6% in 2005

Kobe: Tarumi-ku
- Permanent increase in total population
  - Seems to have started prior to the earthquake
  - +19.2% in 2000 (A1001)
  - +19.7% in 2000 (A1352)
  - +16.2% in 2010 (A1001)
  - +17.2% in 2010 (A1352)
- Permanent increase in total population
  - +19.2%
  - +16.5%
- Permanent increase in the number of unemployed
  - likely due to population increase
  - +30.9% in 2000
  - +25.9% in 2005

Kobe: Kita-ku
- Permanent increase in total population
  - May have started prior to the earthquake
  - +11.7% in 2000 (A1001)
  - +12% in 2000 (A1352)
- Permanent positive impact on both male and female population
- No impact on 15~29 population
- Permanent increase in the number of unemployed
  - likely due to increase in population
  - +29.3% in 2000
  - +15.7% in 2005

Kobe: Nishi-ku
- Permanent increase in total population
  - May have started prior to the earthquake
  - +41.7% in 2000 (A1001)
  - +39.4% in 2000 (A1352)
  - +46.6% in 2010 (A1001)
  - +44.3% in 2010 (A1352)
- Permanent positive impact on male and female population
- Permanent increase in 15~29 population
  - +45.9% in 2000
  - +61.1% in 2005
- Permanent increase in elderly population
  - +16.6% in 2000
  - +21.1% in 2010
- Permanent increase in Daytime population
  - +44.8% in 2000
  - +46.9% in 2005
- Permanent increase in the number of secondary businesses
  - +27.8% in 2001
  - +25.2% in 2006
- Permanent increase in the number of secondary employees
  - +55% in 2001
  - +55.6% in 2006
- Permanent increase in the number of unemployed
  - likely due to population increase
  - +40.3% in 2000
  - +48.3% in 2005

Nishinomiya
- Short-term decline, but permanent increase in total population
  - +4% in 2000 (A1001)
  - +3.75 in 2000 (A1352)
  - +9.1% in 2010 (A1001)
  - +8.9% in 2010 (A1352)
- Permanent positive impact on both male and female population
- Permanent increase in 15~29 population
  - +5.2% in 2000
  - +5.8% in 2005
- Permanent decrease in elderly population
  - -4.7% in 2000
  - -3.3% in 2010
- Permanent decrease in daytime population
Short-run impact on taxpayer income, but fully recovers
- Permanent decrease in the number of tertiary businesses
  o -5.4% in 2000
  o -3.5% in 2005
- Large temporary spike in government expenditure
- Mixed impact on the number of unemployed

**Himeji**
- No impact on population, taxpayer income, government expenditure, and the number of unemployed

**OTHER SURROUNDING TOWNS**

**Amagasaki**
- Bad fit with total population
- Permanent decrease in 15~29 population
  o -16.1% in 2000
  o -24.3% in 2005
- No impact on elderly population
- No impact on the number of secondary businesses
- Permanent decrease in the number of tertiary businesses
  o -15.7% in 2001
  o -21.8% in 2006
- No impact on the number of unemployed

**Akashi**
- Permanent increase in total population
  o +8.5% in 2000
  o +6.1% in 2010
- No impact on 15~29 Population
- No impact on elderly population
- Permanent increase in daytime population
  o +9.2% in 2000
  o +7.5% in 2005
- Short-run negative impact on taxpayer income, but fully recovers
- Short-run negative impact on # of taxpayers but fully recovers
- No impact on the number of tertiary businesses
- No impact on the number of tertiary employees
- Permanent increase in government expenditure
- Permanent increase in the number of unemployed
  o +15.4% in 2000
  o +7% in 2005

**Sumoto**
- No impact on population
- Temporary increase in taxpayer income in the late ‘90’s.
  o Returns to normal by 2005
- No impact on the number of secondary businesses
- Temporary increase in Tertiary Businesses prior to the quake
  o Bridge related?
  o Permanent Increase in the number of secondary employees
    - +27.4% in 2001
    - +21.8% in 2006
  o Small permanent increase in tertiary employees
    - +3.5% in 2001
    - +8.3% in 2006
  o Large increase in government expenditure
  o No impact on the number of unemployed

Ashiya
- Note Ashiya is very difficult to match
  o this is likely due to its Beverly Hills esque nature.
- Temporary decline in total population
  o -7.1% in 2000 (A1001)
  o -2.7% in 2010 (A1001)
- Permanent decline in the elderly population
  o -7.3% in 2000
  o -4.9% in 2010
- Temporary decline in the number of unemployed
  o -14.8% in 2000
  o +3.3% in 2005

Itami
- Small impacts related to the construction of the Kansai airport?
- No impact on population
- Temporary Increase in the number of secondary employees
  o +12.3% in 2001
  o -1% in 2006
- Permanent decline in the number of tertiary employees
  o -14.6% in 2001
  o -10.9% in 2006
- Short-run increase in government expenditure following the quake
- Permanent increase in the number of unemployed?
  o +11.1% in 2000
  o 10.1% in 2005

Takarazuka
- Permanent increase in the total population
  o +2.5% in 2000 (A1001)
  o +4.4% in 2000 (A1352)
  o +6.9% in 2010 (A1001)
  o +9.1% in 2010 (A1352)
- Permanent increase in both the male and female population
- Permanent decrease in 15–29 population
  o -7.4% in 2000
  o -9.8% in 2005
- No impact on elderly population
- Temporary decline in taxpayer income, but fully recovered
- Temporary decline in the number of taxpayers, but fully recovered
- Temporary spike in government expenditure
  - Permanent increase in the number of unemployed.
    o +10.2% in 2000
    o +7.6% in 2005

**Miki**
- Permanent decline in total population
  o -5.7% in 2000 (A1001)
  o -6.3% in 2000 (A1352)
  o -11.4% in 2010 (A1001)
  o -11.6% in 2010 (A1352)
- Permanent decline in both the male and female population
- Permanent decline in 15~29 population
  o -4.5% in 2000
  o -5.5% in 2005
- No impact on the elderly population
- No impact on daytime population
- Permanent decline in taxpayer income
  o -6.6% in 2000
  o -15.5% in 2010
- Permanent decline in the number of taxpayers
  o -7.2% in 2000
  o -11.7% in 2010
- Permanent increase in the number of secondary businesses
  o +31.9% in 2001
  o +27.1% in 2006
- No impact on the number of tertiary businesses
- Permanent increase in the number of secondary employees
  o +15.6% in 2001
  o +18.7% in 2006
- No impact on the number of tertiary employees
- Temporary increase in government expenditure
- Little impact on the number of unemployed

**Kawanishi**
- No impact on total population
- Permanent decrease in 15~29 population
  o -11.5% in 2000
  o -16.5% in 2005
- Permanent increase in elderly population
  o +9.1% in 2000
  o +9.9% in 2010
- Permanent decline in taxpayer income
  o -5.8% in 2000
  o -13.5% in 2010
- Permanent decline in the number of taxpayers
  o -4% in 2000
  o -8.4% in 2010
- Permanent increase in the number of unemployed
  o +2.6% in 2000
  o +7.3% in 2010