

An Empirical Analysis of Disasters on Regional Economy

Case Study of 2000 Flood Disaster in Japan by use of regional GDP data

Naoyuki Yoshino, Ph.D

Dean, Asian Development Bank Institute (ADBI)

Professor Emeritus, Keio University, Japan

Umid Abidhadjaev, Ph.D

Research Consultant on Infrastructure, ADBInstitute

Economic Effects of disaster

(1) Effects on Supply Side (Production)

L = Labor

K_p = Private Capital

K_g = Infrastructure

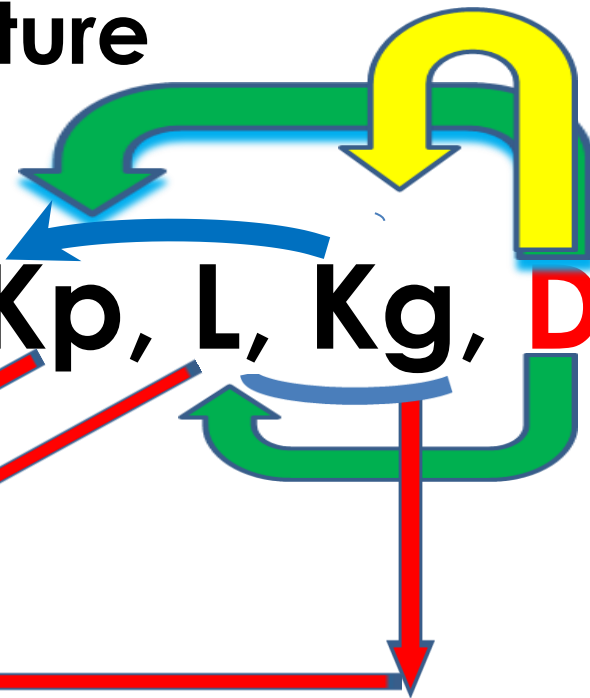
D = Disaster

Agriculture

Manufacture

Service

$$\text{(GDP) } Y = F(K_p, L, K_g, D)$$



(2) Effect of Disaster on Demand Side

Aggregate Demand of the Region

$$Y = C + I + G + EXP - IMP$$

Transmission of Natural Disaster

→ **Decline in consumption (C)**

→ **Decline in Investment (I)**

→ **Decline in Exports (EXP)**

→→→ **Overall Decline in GDP**

Trans-log Production Function

$$\begin{aligned}
 (\ln Y_t - \ln \bar{Y}) - (\ln L_t - \ln \bar{L}) &= a_K [(\ln K_{P,t} - \ln \bar{K}_P) - (\ln L_t - \ln \bar{L})] \\
 &+ a_G (\ln K_{G,t} - \ln \bar{K}_G) + \beta_{KL} [(\ln K_{P,t} - \ln \bar{K}_P) (\ln L_t - \ln \bar{L}) \\
 &- \frac{1}{2} (\ln K_{P,t} - \ln \bar{K}_P)^2 - \frac{1}{2} (\ln L_t - \ln \bar{L})^2] \\
 &+ \beta_{KG} (\ln K_{G,t} - \ln \bar{K}_G) [(\ln K_{P,t} - \ln \bar{K}_P) - (\ln L_t - \ln \bar{L})] \\
 &+ \frac{1}{2} \beta_{GG} (\ln K_{G,t} - \ln \bar{K}_G)^2 + \varepsilon_{P,t}
 \end{aligned} \tag{2}$$

$$S_{L,t} = 1 - a_K + \beta_{KL} [(\ln K_{P,t} - \ln \bar{K}_P) - (\ln L_t - \ln \bar{L})] + \beta_{KG} (\ln K_{G,t} - \ln \bar{K}_G) + \varepsilon_{S,t} \tag{3}$$

Yoshino, Nakajima and Nakahigashi (1999) and Nakahigashi (2003). Our marginal productivity of public capital from equation (2) is as follows:²

$$\frac{dY}{dK_G} = \eta_{K_G} \frac{Y}{K_G} + \eta_{K_P} \frac{\eta_{K_G} \eta_{K_P} + \beta_{KG}}{\eta_{K_P} (1 - \eta_{K_P}) + \beta_{KL}} \frac{Y}{K_G} + \eta_L \frac{\eta_{K_G} \eta_L - \beta_{KG}}{\eta_L (1 - \eta_L) + \beta_{KL}} \frac{Y}{K_G} \tag{4}$$

where η_{K_P} , η_L , η_{K_G} represent the output elasticity of private capital, labor and public capital respectively. Based on equation (2), the output elasticity of labor is the same as equation (3) and the output elasticity of private capital and public capital is expressed as follows:

$$\eta_{K_P} = a_K + \beta_{KL} [(\ln L - \ln \bar{L}) - (\ln K_P - \ln \bar{K}_P)] + \beta_{KG} (\ln K_G - \ln \bar{K}_G) \tag{5}$$

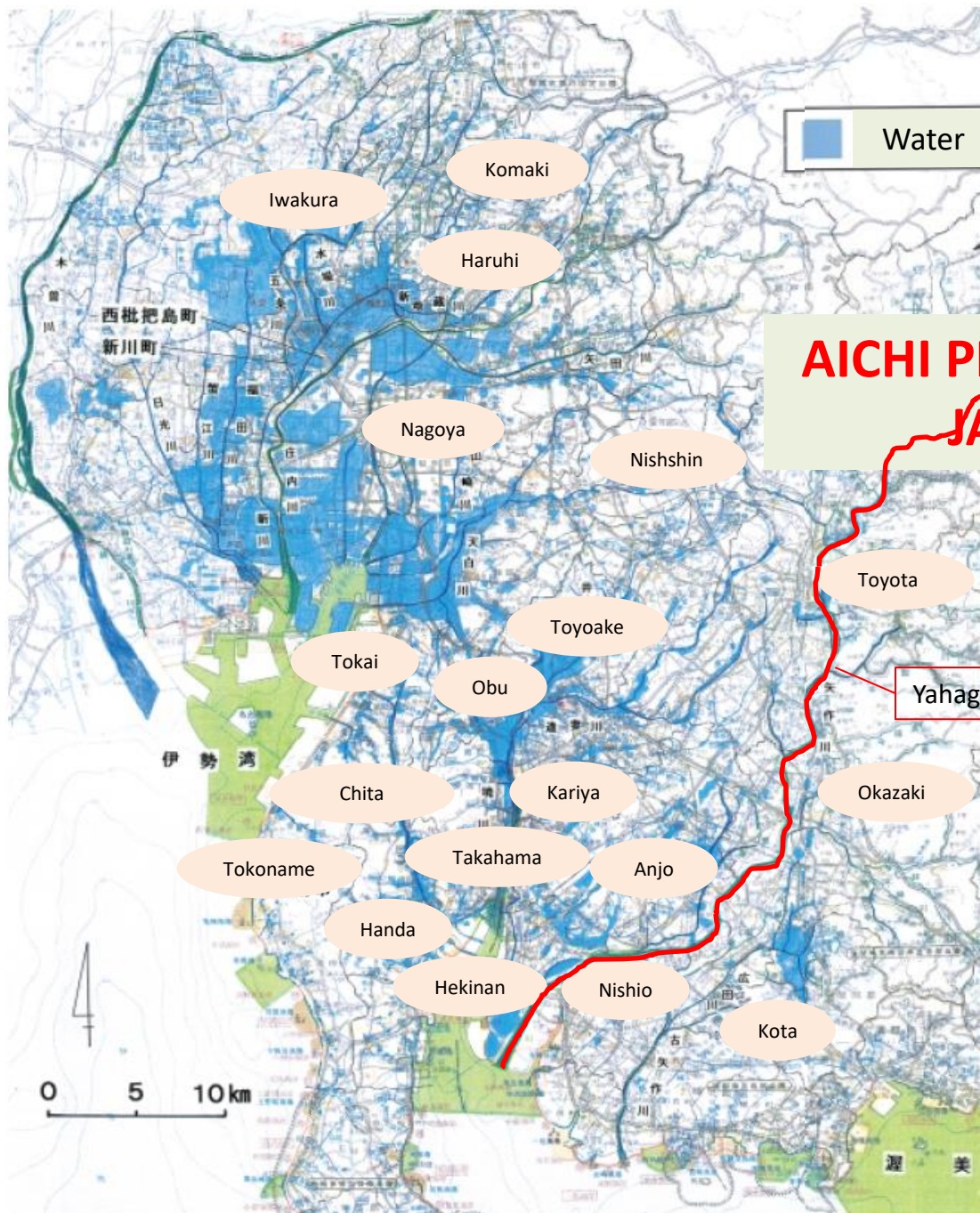
$$\eta_{K_G} = a_G + \beta_{KG} [(\ln K_P - \ln \bar{K}_P) - (\ln L - \ln \bar{L})] + \beta_{GG} (\ln K_G - \ln \bar{K}_G) \tag{6}$$

Macro Estimation of Japan: $Y=F(Kp,L,Kg)$

[illegible]

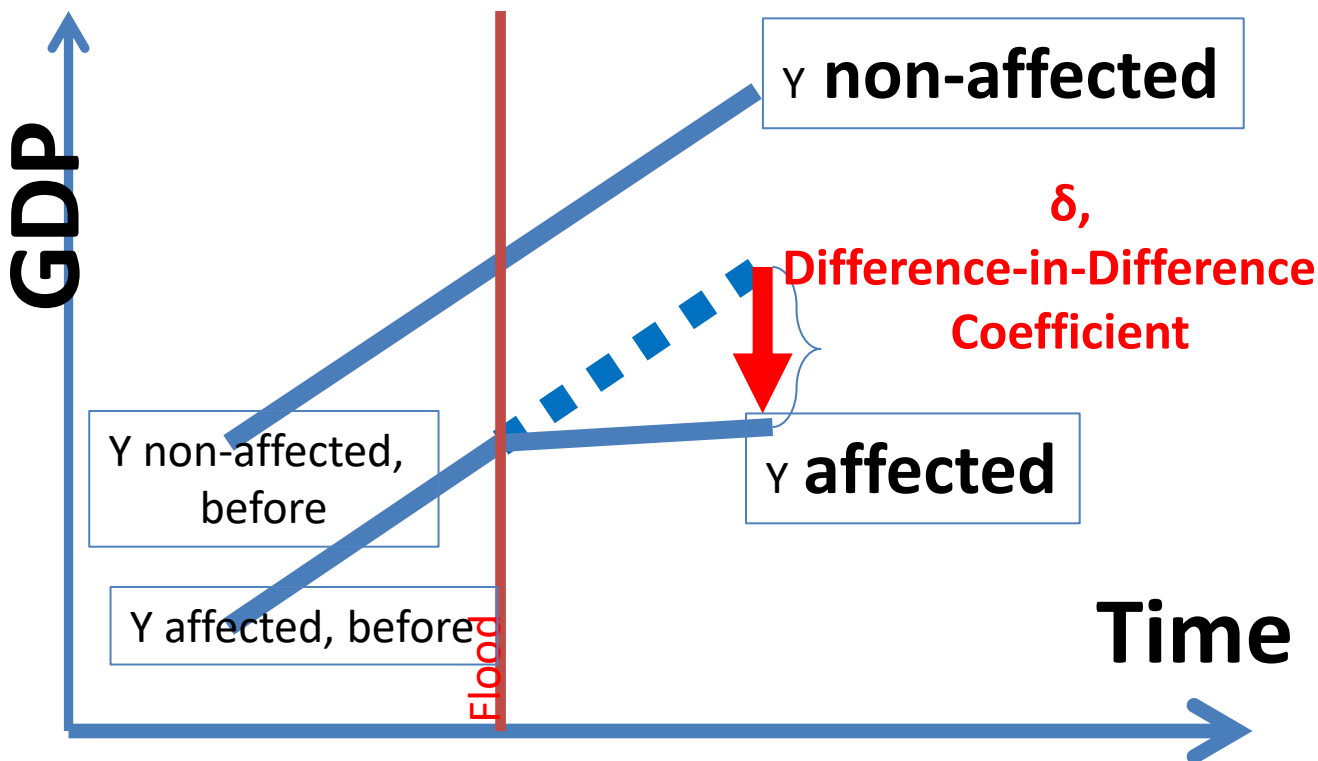
Flood: September 2000

Analysis of 19 cities



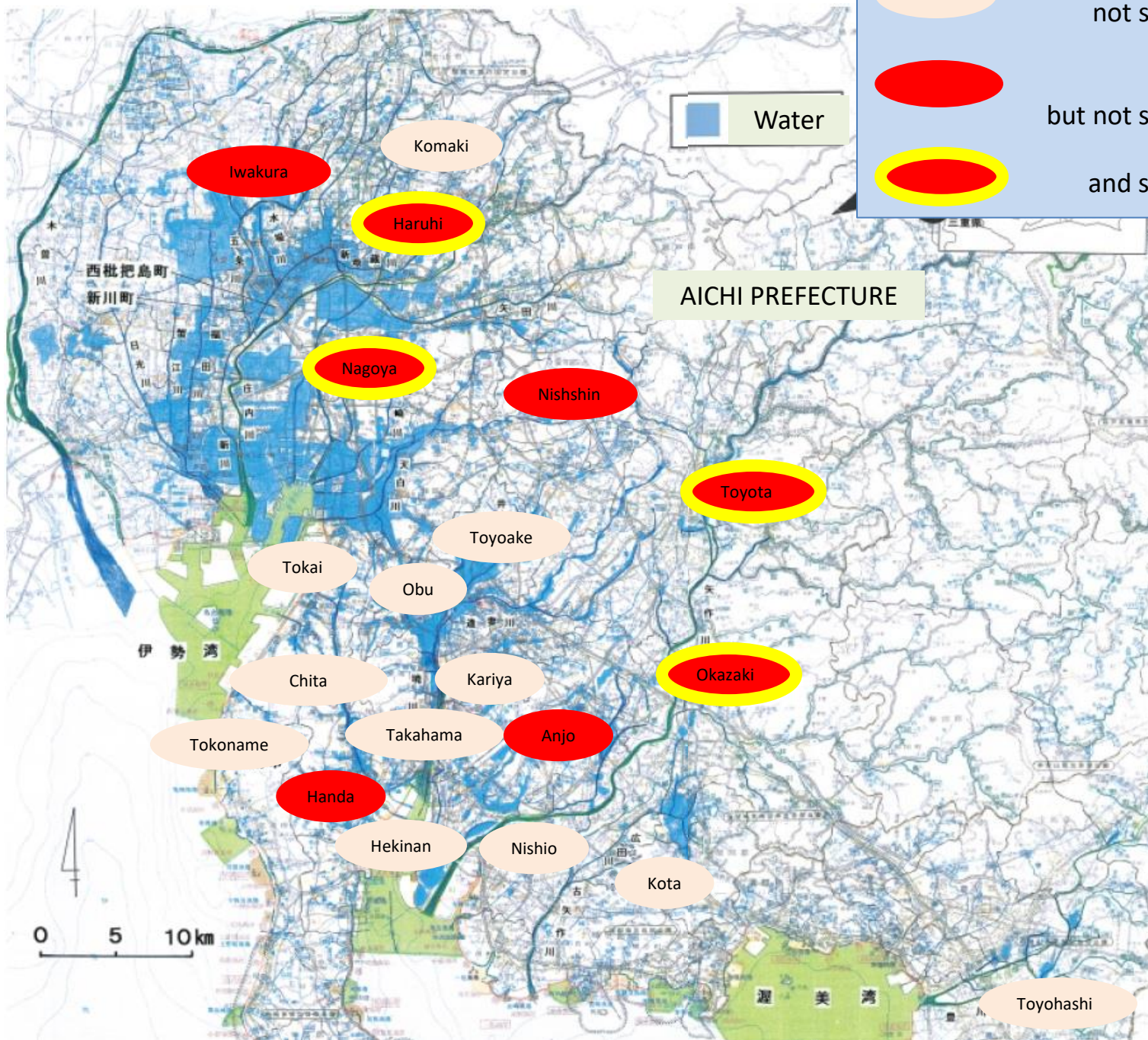
- 1 Anjo
- 2 Chita
- 3 Handa
- 4 Haruhi
- 5 Iwakura
- 6 Kariya
- 7 Komaki
- 8 Kota
- 9 Nagoya
- 10 Nishio
- 11 Nishshin
- 12 Obu
- 13 Okazaki
- 14 Takahama
- 15 Tokai
- 16 Tokoname
- 17 Toyoake
- 18 Toyohashi
- 19 Toyota

Graphical explanation of the model



$$\Delta Y_{it} = \alpha_i + \varphi_t + \delta(D_{flood} \times D_{after})_{it} + \epsilon_{it}$$

ΔY_{it} - GDP growth rate; α_i - sum of autonomous and region specific rate of growth; φ_t - year specific growth effect; $(D_{flood} \times D_{after})_{it}$ - dummy variable indicating that observation belong to affected group after flood period; δ - difference in difference coefficient; ϵ_{it} - error term.



Not “U” type dynamics,
not statistically significant

“U” type dynamics,
but not statistically significant

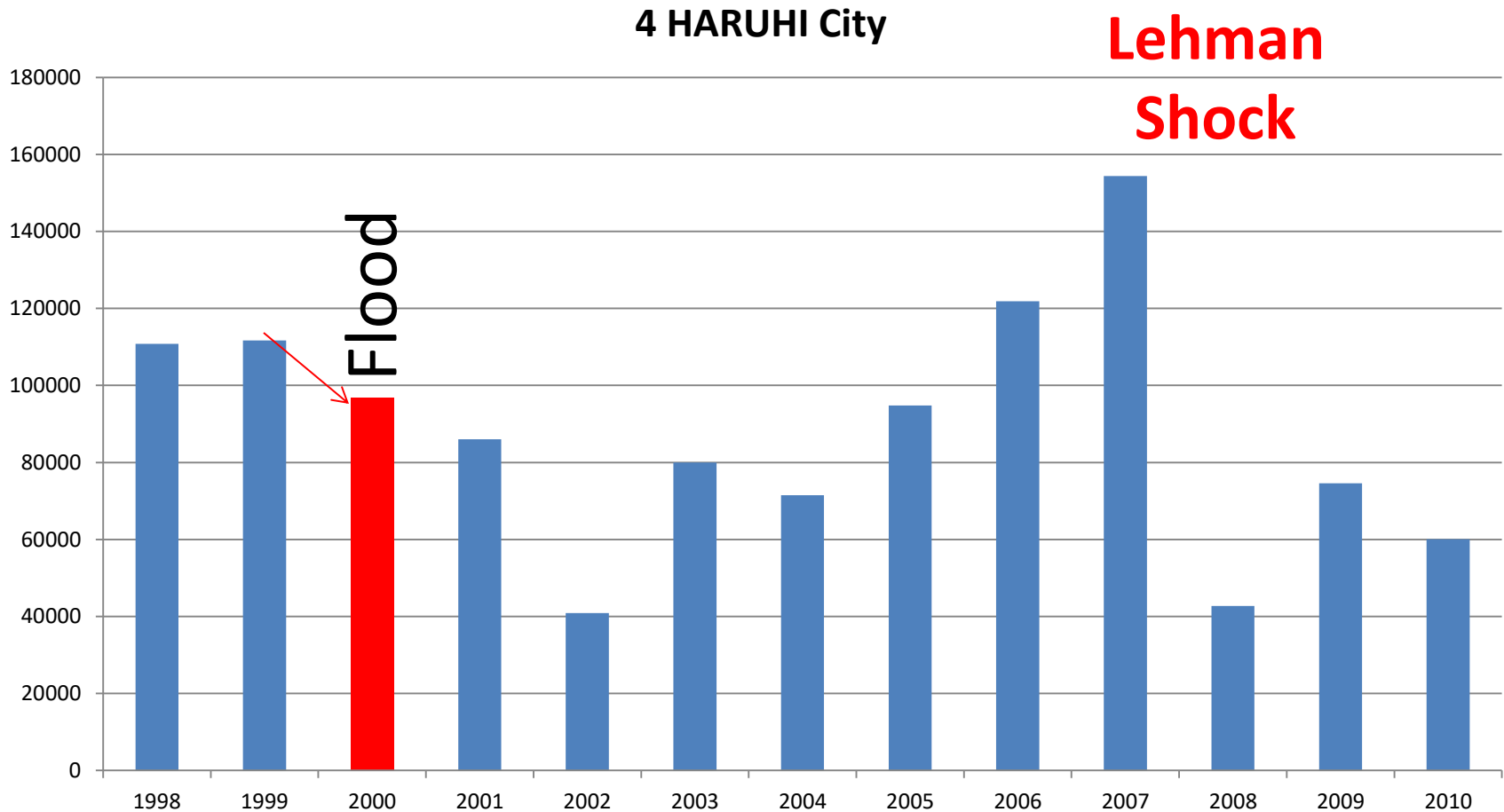
“U” type dynamics
and statistically significant

- 1 Anjo**
- 2 Chita**
- 3 Handa**
- 4 Haruhi**
- 5 Iwakura**
- 6 Kariya**
- 7 Komaki**
- 8 Kota**
- 9 Nagoya**
- 10 Nishio**
- 11 Nishshin**
- 12 Obu**
- 13 Okazaki**
- 14 Takahama**
- 15 Tokai**
- 16 Tokoname**
- 17 Toyoake**
- 18 Toyohashi**
- 19 Toyota**

Difference in difference estimation coefficients, (million Japanese Yen)

	1 Anjo	2 Chita	3 Handa	4 Haruhi	5 Iwakura
Variable					
DiD_1998*City	20434.352	20217.742	36654.248	97035.893**	-3931.4871
DiD_1999*City	47734.918	23325.139	28372.087	98166.949**	-792.32798
DiD_2000*City	40106.972	36643.733	6895.1827	83852.516**	-7569.5478
DiD_2001*City	43708.874	44822.471	32234.741	72895.231*	-2768.5402
DiD_2002*City	73114.89*	-11249.093	28564.366	27927.281	-15292.491
DiD_2003*City	75675.62*	4468.9847	5722.5355	67093.444*	-12701.166
DiD_2004*City	106219.4***	2017.696	-1721.6099	57473.857	-8806.4561
DiD_2005*City	150032.87***	-22016.285	41655.427	79766.134**	-10108.217
DiD_2006*City	239151.15***	-4258.4268	80697.768**	105511.8***	-9904.793
DiD_2007*City	256661.56***	9124.8808	95121.835**	136508.27***	-12325.069
DiD_2008*City	103791.02***	-49773.431	21068.957	30365.093	-13145.828
DiD_2009*City	54733.342	114540.81***	49424.582	63805.519	-11944.99
DiD_2010*City	86913.752**	100956.34**	45915.636	49744.488	-10132.977
DiD_2011*City	132401.57***	103937.16***	14062.713	83423.113**	-5254.5601
DiD_2012*City	301452.53***	69329.751*	85118.236**	107993.56***	-9036.835
DiD_2013*City	273028.54***	-17445.791	92004.894**	117224.73***	-10703.308
DiD_2014*City	189025.32***	7653.2476	65471.362*	78609.523*	-15470.573
GDP_Prefecture	.00112838***	.00108419***	.00111904***	.00116891***	.00108831***
_cons	203963.91***	193436.09***	195889.8***	205375.1***	186576.36***
N	875	875	875	875	875
r2	0.169564	0.034211	0.027171	0.048512	0.000306
F	9.885042	1.71488	1.352153	2.468289	0.014811

Difference in difference estimation coefficients, mln. JPY



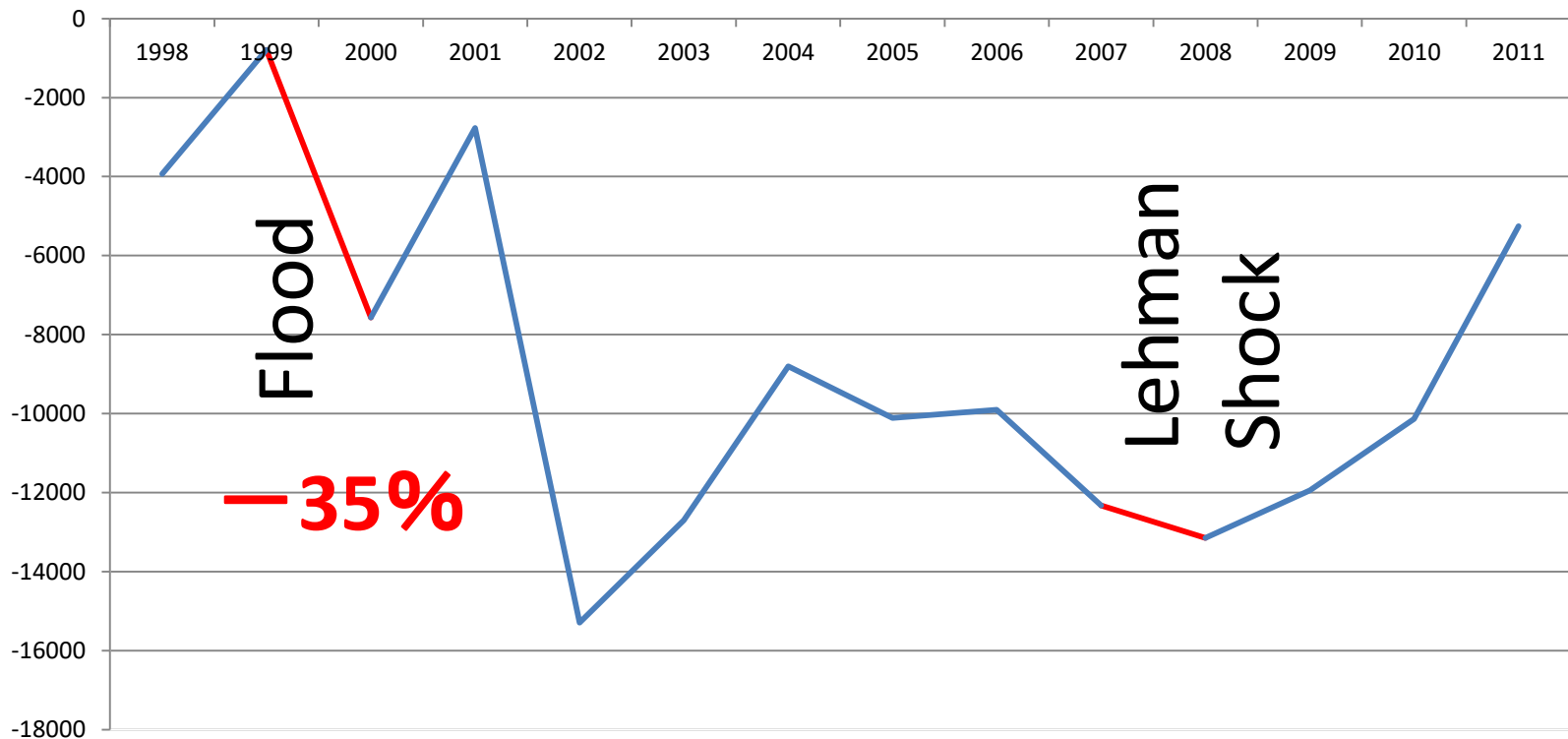
Haruhi City (Only 2 years impact)

GDP	%	Year
• 96738		2000
• 85988	-11.1%	2001
• 40846	-52.4%	2002
• 79942	+95.7%	2003

Difference in difference estimation coefficients, million. JPY

Agricultural Region: Big Drop
It took 3 years for the recovery

Iwakura



Agriculture

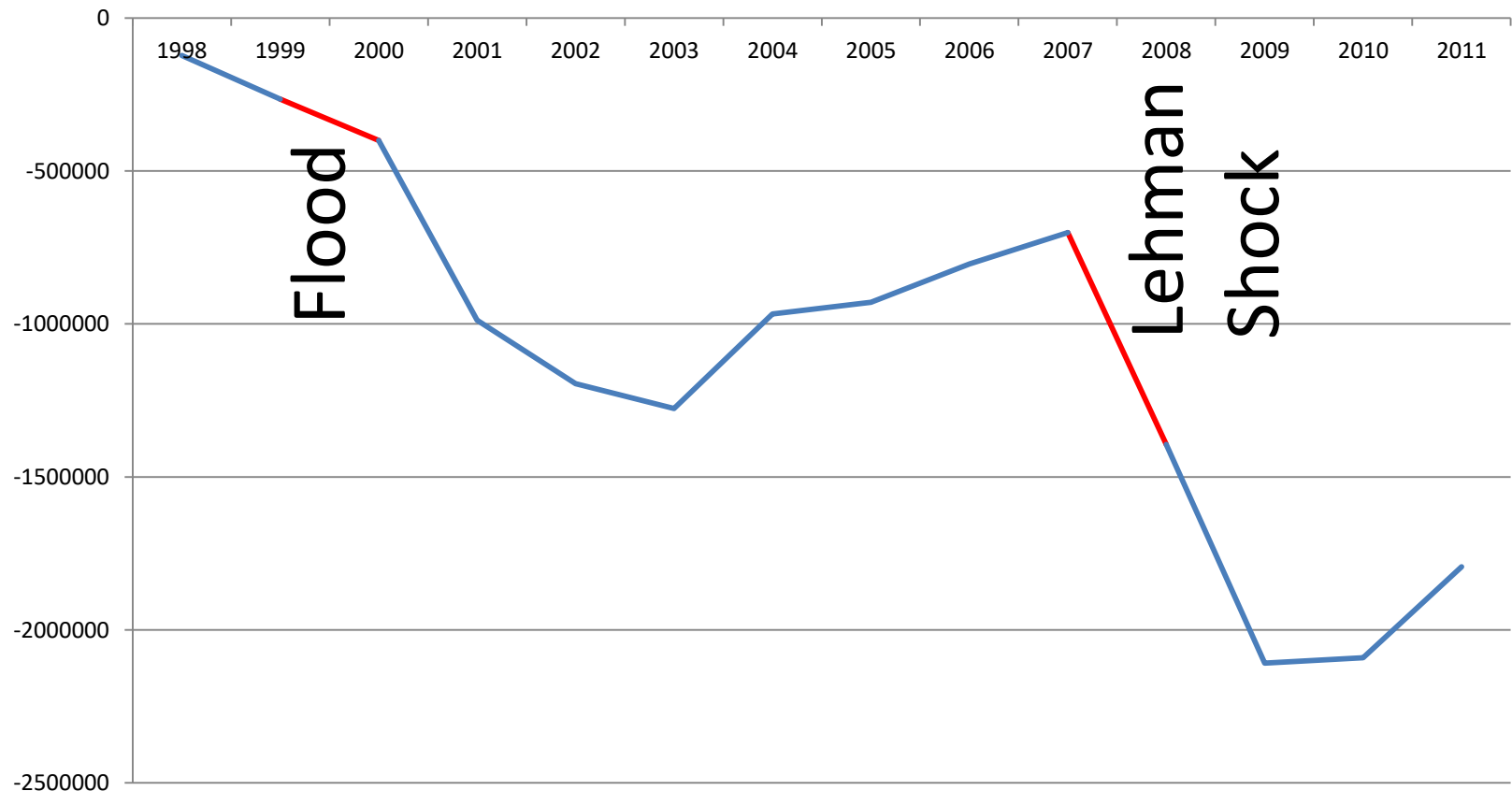
Difference in difference estimation coefficients, (million JPYen)

Variable	6 Kariya	7 Komaki	8 Kota	9 Nagoya	10 Nishio
DiD_1998*City	-26571.579	49656.273	5269.5621	-122128.83***	-31538.9
DiD_1999*City	-14574.012	32466.25	28427.946	-265427.14***	-14310
DiD_2000*City	36527.193	49028.611	56954.118	-399787.84***	4956.45
DiD_2001*City	51485.729	76405.078*	86930.991**	-988127.34***	35448.89
DiD_2002*City	35221.495	36063.62	98255.833**	-1195450.9***	37632.1
DiD_2003*City	6101.3027	28416.159	151568.88***	-1276363.4***	59205.29
DiD_2004*City	36045.384	58588.036	167459.89***	-967076.44***	62725.93
DiD_2005*City	40443.531	129821.43***	193726.09***	-928771.82***	93576.882**
DiD_2006*City	28839.231	89806.145**	210114.55***	-804326.47***	98064.717**
DiD_2007*City	212318.64***	107818.87***	226885.95***	-701078.62***	123405.81***
DiD_2008*City	83448.972**	-7815.8008	169392.34***	-1393814.8***	-48507.2
DiD_2009*City	54104.093	-35692.81	175429.55***	-2108818.1***	-44306.7
DiD_2010*City	34998.01	-55207.546	133756.89***	-2091046***	-62398.5
DiD_2011*City	62653.738	-1169.5441	160363.5***	-1794032.4***	-73411.055*
DiD_2012*City	123823.82***	8526.7281	146453.17***	-1875063.4***	-8697.46
DiD_2013*City	250070.48***	16620.008	225863.13***	-1642416.9***	89253.766**
DiD_2014*City	143511.85***	53812.022	207863.98***	-1500546.4***	48435.43
GDP_Prefecture	.00107969***	.00112519***	.00110035***	.00109117***	.00110279***
_cons	202905.8***	206185.82***	188520.27***	487551.19***	203122.93***
N	875	875	875	869	875
r2	0.096445	0.04301	0.148796	0.877915	0.055887
F	5.167467	2.175786	8.462678	345.5905	2.865771

Difference in difference estimation coefficients, million. JPY

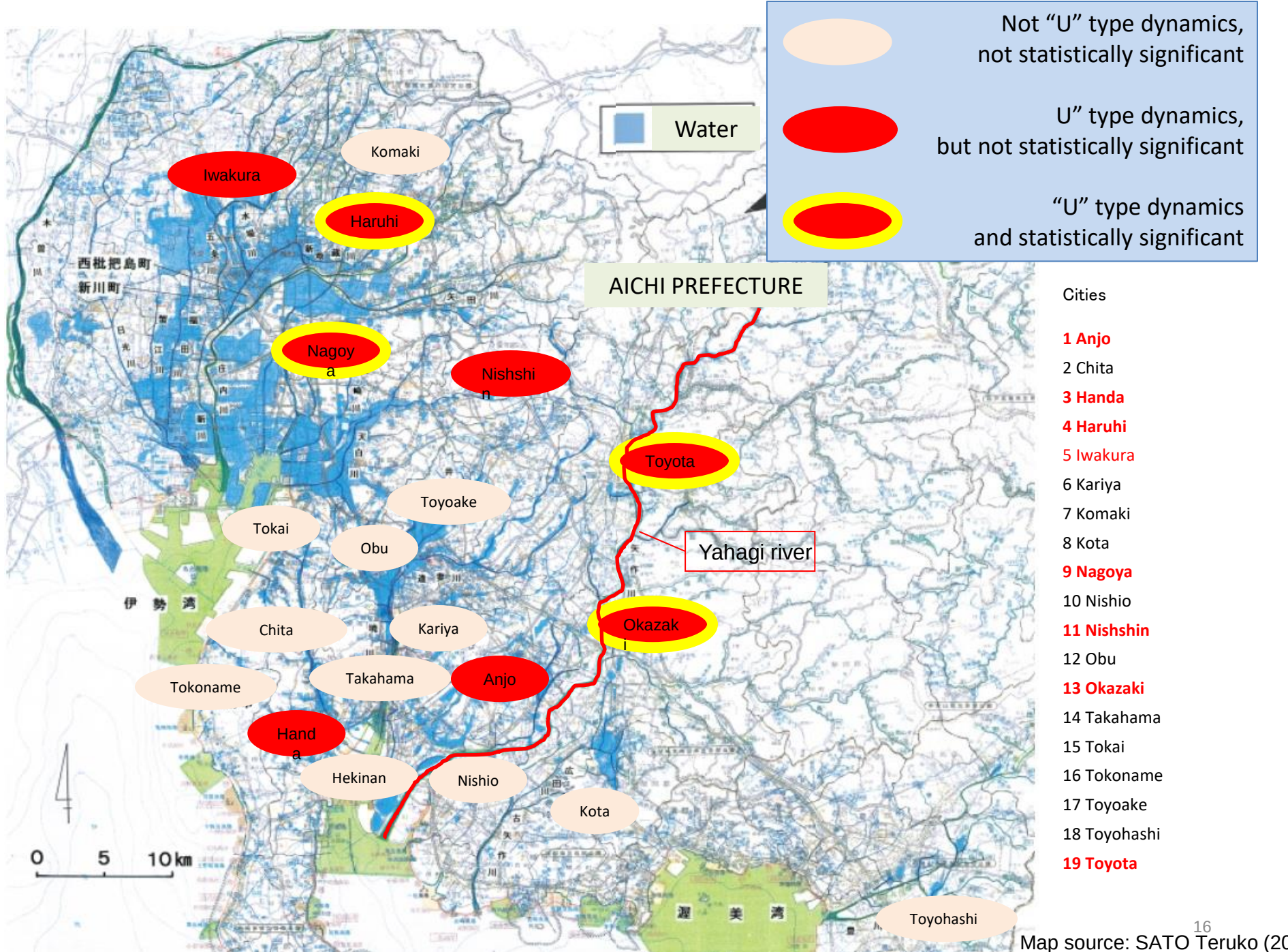
Services sector : 4 years decline

Nagoya



Nagoya City (continuous decline)

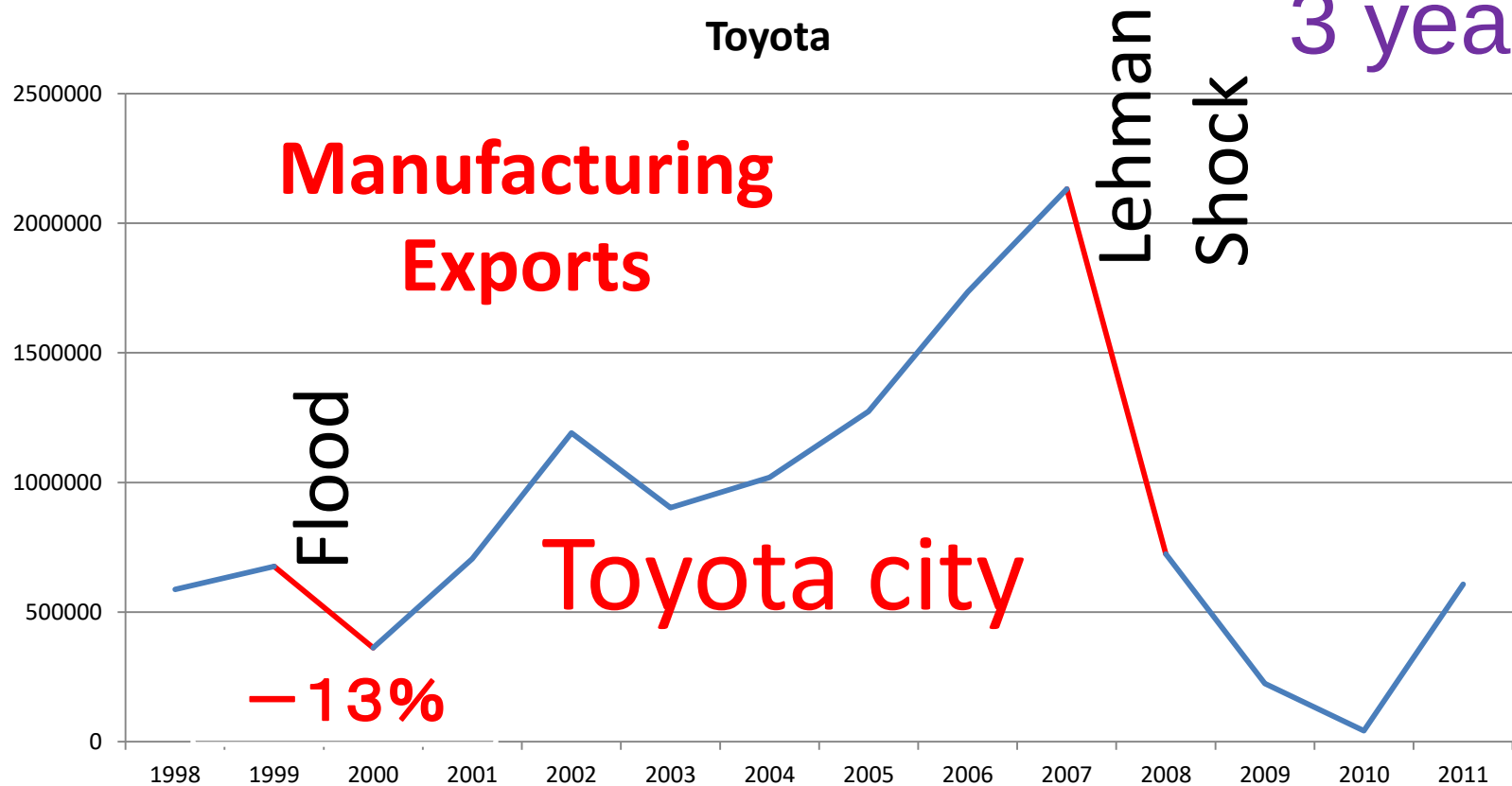
ΔGDP	%	Year
-400810		2000
-988956	-146.7 %	2001
-1196442	-20.9 %	2002
-1277420	-6.7	2003
-967073	-24.2	2004
-927767	-4.0	2005
-802147	-13.5	2006
-697420	-13.0 %	2007



Difference in difference estimation coefficients, mln. JPY

Variable	16 Tokoname	17 Toyoake	18 Toyohashi	19 Toyota
DiD_1998*City	-8562.73	6226.992	88268.296**	587035.52***
DiD_1999*City	-18242.6	6968.685	92331.453**	676380.53***
DiD_2000*City	-19822.1	8887.869	95117.057**	362390.57***
DiD_2001*City	2732.018	9695.406	75976.756*	705729.36***
DiD_2002*City	3760.841	1935.691	42784.5	1191326.6***
DiD_2003*City	11312.48	3705.513	53334.34	902530.03***
DiD_2004*City	29788.14	7771.163	97731.712**	1019870.9***
DiD_2005*City	48059.61	14405.79	94531.555**	1273758.2***
DiD_2006*City	48248.44	28231.28	109501.98***	1735146.9***
DiD_2007*City	23603.12	30785.76	143163.04***	2131338.1***
DiD_2008*City	12321.03	23778.38	1342.834	724527.74***
DiD_2009*City	7616.929	25467.5	-32717.3	223900.63***
DiD_2010*City	-1421.19	27850.5	-29897.2	42400.69
DiD_2011*City	6972.406	32151.02	3184.474	606963.58***
DiD_2012*City	16225.48	22025.93	-20106	1372324.8***
DiD_2013*City	19343.31	20326.55	38040.06	1406327.6***
DiD_2014*City	25750.66	31818.67	49406.01	1662908.5***
GDP_Prefecture	.00109351***	.00109661***	.00118027***	.00143915***
_cons	188680.04***	187790.34***	218905.54***	245345.62***
N	875	875	875	875
r2	0.008451	0.005903	0.053797	0.830496
F	0.412617	0.287489	2.752503	237.1963

Difference in difference estimation
coefficients, million JPYen (Exports)
Only 1 year damage: Lehman was bigger
3 years



Characteristics of Each City are different

Agriculture, Services, Export Manufacturing

GDP damages and GDP recoveries

GDP	Quick	Agriculture	Services	Stable	Exports
	Recovery		Sector	Industry	
Year	Anjo City	Iwakura	Nagoya	Nisshin	Toyota
DiD_1998	33680.875	8844.625	-122370	36225.625	603930.25
DiD_1999	60772.875	11782.625	-265870	44103.625	693009.25
DiD_2000	52545.875	4427.625	-400810	35857.625	378255.25
DiD_2001	56347.875	9421.625	-988956	39017.625	721849.25
DiD_2002	85585.875	-3264.375	-1196442	46314.625	1207232.2
DiD_2003	88078.875	-738.375	-1277420	37609.625	918349.25
DiD_2004	119718.87	4213.625	-967073	43177.625	1037088.2
DiD_2005	164567.87	3910.625	-927767	56074.625	1292296.2
DiD_2006	254900.87	5285.625	-802147	63834.625	1755234.2
DiD_2007	273940.87	4340.625	-697420	71076.625	2153376.2
DiD_2008	115713.87	-1646.375	-1395336	57111.625	739734.25
DiD_2009	65121.875	-1925.375	-2111823	58109.625	237150.25

Flood Prevention: Impact on GDP

- 1, Agricultural Sector --- GDP decline (-35%)
- 2, Services Sector --- GDP decline (-23%)
- 3, Domestic Manufacturing – Small decline in GDP
- 4, Export Oriented Manufacturing -- Small decline

**Flood Effects ← 15-20% decline in
GDP in the region**

Flood Impacts for about 3 years

Same Methods can be applied to various disasters

→ Need for Disaster Prevention

→ Ex Post Policy: such policies as Low interest government loans, emergency loans

Fiscal Disaster Prevention based on Expected Damages

1, Forward Looking Finance

$$\left[\frac{\tau_A D_0^A}{(1+r_0)^0} + \frac{\tau_A D_1^A}{(1+r_1)^1} + \frac{\tau_A D_2^A}{(1+r_2)^2} + \dots + \frac{\tau_A D_n^A}{(1+r_n)^n} = \alpha \left[\frac{E_0}{(1+r_0)^0} + \frac{E_1}{(1+r_1)^1} + \frac{E_2}{(1+r_2)^2} + \dots + \frac{E_n}{(1+r_n)^n} \right] + \right. \\ \left. \frac{F_0^A}{(1+r_0)^0} + \frac{F_1^A}{(1+r_1)^1} + \frac{F_2^A}{(1+r_2)^2} + \dots + \frac{F_n^A}{(1+r_n)^n} + \beta \left[\frac{RES_n}{(1+r_n)^n} \right] \right]$$

1-1, Reserves should be set up

1-2, Expected Damage → Compute present value

1-3, Fiscal support to prevent possible damages

2, Ex Post Finance

2-1, Issue of Disaster bond (**UN-Disaster bond**)

2-2, Domestic Purchase of Disaster bond

2-3, Gradual return from future tax revenues

Fair Premium rate of the Deposit Insurance system based on banks creditworthiness

Naoyuki Yoshino, Ph.D.

Dean, Asian Development Bank Institute (ADBI)
Professor Emeritus, Keio University, Tokyo, Japan
nyoshino@adbi.org

Farhad Taghizadeh-Hesary, Ph.D.^{*}

Assistant Professor of Economics, Keio University, Tokyo, Japan
Visiting Professor, Graduate school of Economics, The University of Tokyo
farhadth@gmail.com, farhadth@keio.jp

Farhad Nili, Ph.D.

Senior Advisor to the Executive Director, World Bank, Washington D.C.
fnili@worldbank.org

Japanese Bullet Train



**Impact of Kyushu Shinkansen Rail on
E TAX revenue during 1st PHASE OF OPERATION period
{2004-2010} , mln. JPY (adjusted for CPI, base 1982)**

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3		

						COMPOSITION OF GROUPS	
Variable	Regression 1	Regression 2	Regression 3	Regression 4	Regression 5	Group2	Group5
Treatment2	-4772.54 [-0.2]					Kagoshima Kumamoto	Kagoshima Kumamoto
Number of tax payers	5.8952514* [1.95]	5.8957045* [1.95]	5.896112* [1.95]	5.8953585* [1.95]	5.8629645* [1.91]	Group3 Kagoshima Kumamoto Fukuoka	Fukuoka Oita Miyazaki
Treatment3		-15947.8 [-0.87]					
Treatment5			-13250.4 [-1.06]				
Treatment7				-6883.09 [-0.7]			GroupCon Kagoshima
TreatmentCon					-28030.8 [-0.65]	Group7 Kagoshima Kumamoto Fukuoka Oita	Kumamoto Fukuoka Osaka Hyogo
Constant	-665679 [-1.35]	-665418 [-1.35]	-665323 [-1.35]	-665358 [-1.35]	-658553 [-1.32]	Miyazaki	Okayama
N	799	799	799	799	799	Saga	Hiroshima
R2	0.269215	0.269281	0.269291	0.269241	0.269779	Nagasaki	Yamaguchi
F	1.934589	2.106448	2.074548	2.100607	8.497174		

Note: Treatment2 = Time Dummy {1991-2003} x Group2. etc. t-values are in parenthesis. Legend: * p<.1; ** p<.05; *** p<.01. Clustering standard errors are used, allowing for heteroscedasticity and arbitrary autocorrelation within a prefecture, but treating the errors as uncorrelated across prefectures

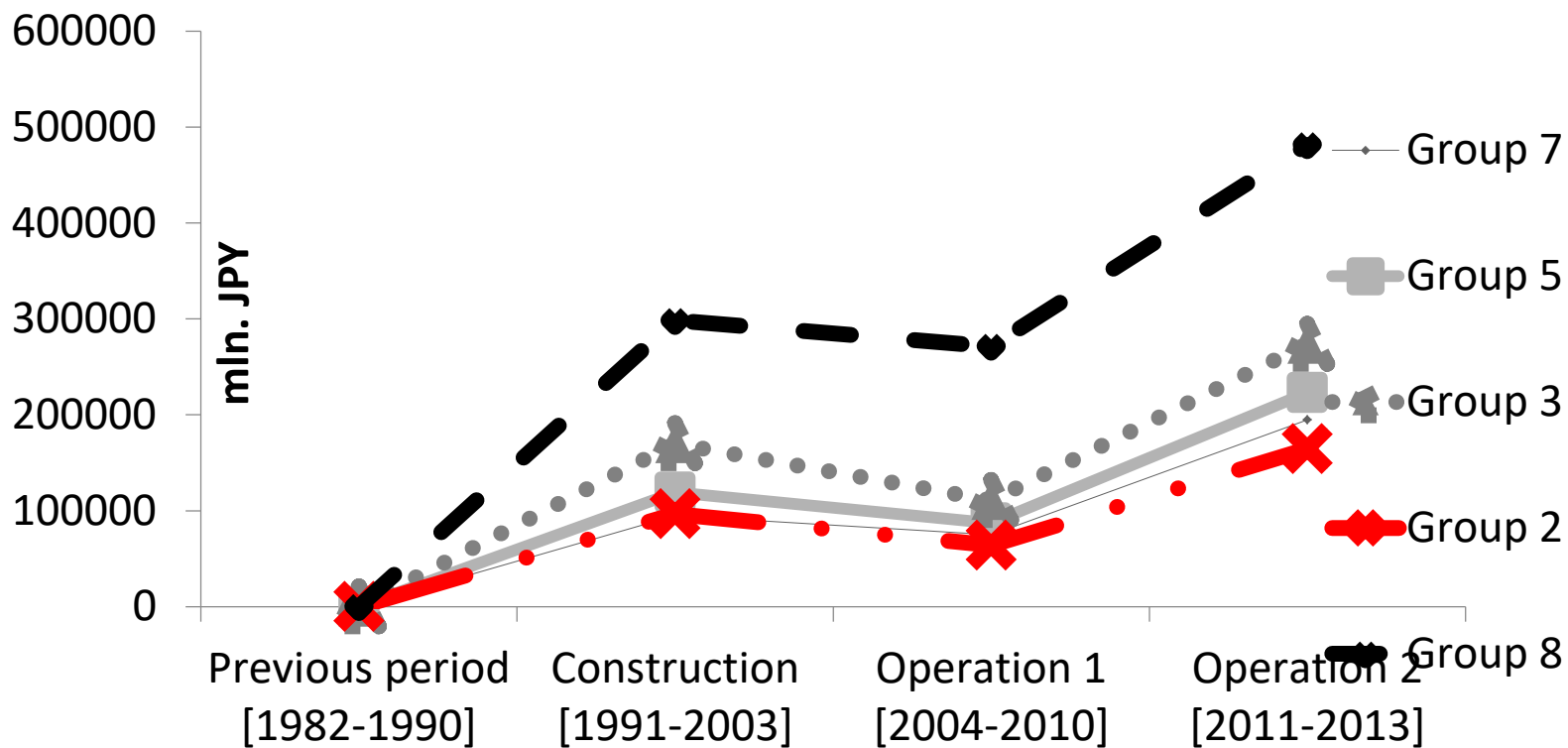
**Impact of Kyushu Shinkansen Rail on
E TAX revenue during 2nd PHASE OF OPERATION period
{2011-2013} , mln. JPY (adjusted for CPI, base 1982)**

1	1	1	1	1	1	1	1	1	1	1	1	1	19	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	9	9	9	9	9	9	9	9	9	9	9	9	94	9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	8	8	8	8	8	8	8	8	9	9	9	9		9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	1	1	1
2	3	4	5	6	7	8	9	0		1	2	3		5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0			

						COMPOSITION OF GROUPS	
Variable	Regression 1	Regression 2	Regression 3	Regression 4	Regression 5	Group2	Group5
Treatment2	72330.012** [2.2]					Kagoshima Kumamoto	Kagoshima Kumamoto
Number of tax payers	5.5277056*** [3.13]	5.5585431*** [3.14]	5.558603*** [3.14]	5.5706545*** [3.14]	5.9640287*** [3.07]	Group3 Kagoshima Kumamoto Fukuoka	Fukuoka Oita Miyazaki
Treatment3		104664.34* [2]					
Treatment5			82729.673** [2.1]				
Treatment7				80998.365** [2.34]			GroupCon Kagoshima
TreatmentCon					179632 [1.58]	Group7 Kagoshima Kumamoto Fukuoka Oita	Kumamoto Fukuoka Osaka Hyogo
Constant	-568133.98** [-2.07]	-573747.28** [-2.08]	-574245.87** [-2.08]	-576867.56** [-2.09]	-642138.87** [-2.1]	Miyazaki	Okayama
N	611	611	611	611	611	Saga	Hiroshima
R2	0.350653	0.352058	0.352144	0.352874	0.364088	Nagasaki	Yamaguchi
F	5.062509	5.486197	5.351791	5.431088	16.55518		

Note: Treatment2 = Time Dummy {1991-2003} x Group2. etc. t-values are in parenthesis. Legend: * p<.1; ** p<.05; *** p<.01. Clustering standard errors are used, allowing for heteroscedasticity and arbitrary autocorrelation within a prefecture, but treating the errors as uncorrelated across prefectures

Total tax revenue, mln. JPY



The Southern Tagalog Arterial Road (STAR Highway), Philippines, Manila

$$T_{it} = c + \alpha D_g + X'_{it}\beta + \sum_t \delta_t D_g + \varepsilon_{it} \quad (10)$$

where c is the constant term, and D_g is the dummy variable that the regions affected by the highway are set as 1 and the other regions are set as 0. If δ_t is significantly positive, the tax revenue of affected areas would increase as compared with that of unaffected areas.

Table 8 shows estimates of the increase in business tax of affected regions as compared to that of unaffected regions before and after the completion of the STAR highway, using results for equation (10). represents the completion year of the STAR highway and its sub-

Table 8

Increase in business tax in affected regions as compared to unaffected regions of Philippine STAR highway

(Unit : Million Pesos)

	t_{-2}	t_{-1}	t_0	t_{+1}	t_{+2}	t_{+3}	After t_{+4}
Lipa city	134.36	173.50	249.70	184.47	191.81	257.35	371.93
Ibaan city	5.84	7.04	7.97	6.80	5.46	10.05	12.94
Batangas city	490.90	622.65	652.83	637.89	599.49	742.28	1208.61