An Empirical Analysis of Disasters on Regional Economy

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

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Y=F(Kp, L, Kg, D)

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Attract Private Financing to Infrastructure Investment by Injecting Spillover Tax Revenues

Need for Infrastructure Investment

In Southeast Asia, USD 8 billion in infrastructure investments are implemented every year. However, it is expected that USD 210 billion infrastructure investment is needed every year. Public money is insufficient to satisfy Asia's infrastructure needs. In many developing countries in Asia, we observe heavy traffic congestion in cities; highways, trains and various modes of public transport are lacking. Public-Private Partnerships (PPPs) have been promoted for infrastructure development in India, Thailand and other places in Asia. However, most PPP projects were disappointing since the rate of return on infrastructure depends mainly on user charges, such as train fares and highway tolls. When the region was hit by economic crisis after the Lehman shock, the private sector withdrew from infrastructure investment. Risks associated with infrastructure were so large that private investors were hesitant to put their money in infrastructure.

It is well known that good infrastructure creates huge spillover effects in the

Economic Effects of disaster

(1) Effects on Supply Side (Production)

L= Labor

Kp = Private Capital

Kg = Infrastructure

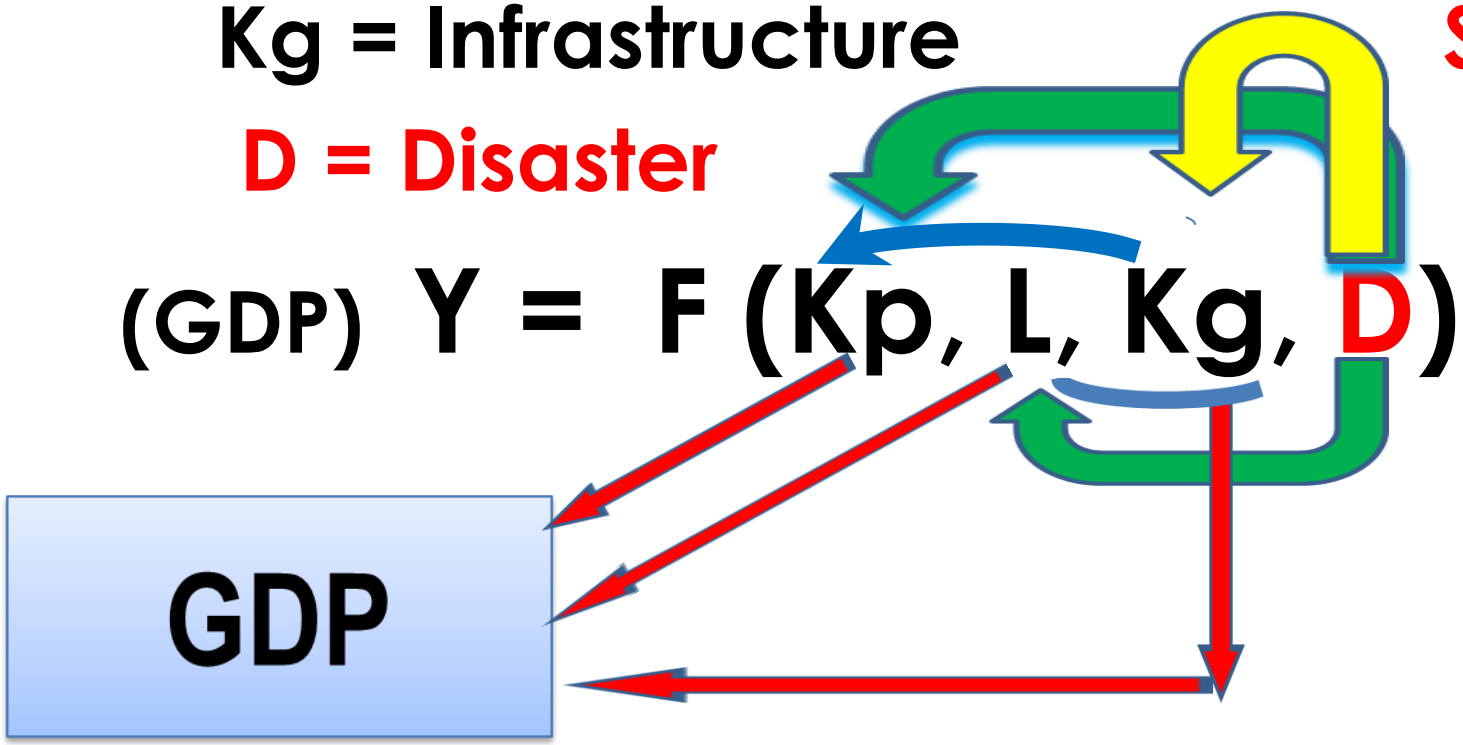
D = Disaster

Agriculture

Manufacture

Service

(GDP) $Y = F(Kp, L, Kg, D)$



(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

$$
\begin{aligned}
&(\ln Y_t - \ln \bar{Y}) - (\ln L_t - \ln \bar{L}) \\
&\quad = \alpha_K \left[(\ln K_{P,t} - \ln \bar{K_P}) - (\ln L_t - \ln \bar{L}) \right] \\
&\quad + \alpha_G (\ln K_{G,t} - \ln \bar{K_G}) + \beta_{KL} \left[(\ln K_{P,t} - \ln \bar{K_P})(\ln L_t - \ln \bar{L}) \right. \\
&\quad \left. - \frac{1}{2} (\ln K_{P,t} - \ln \bar{K_P})^2 - \frac{1}{2} (\ln L_t - \ln \bar{L})^2 \right] \\
&\quad + \beta_{KG} (\ln K_{G,t} - \ln \bar{K_G}) \left[(\ln K_{P,t} - \ln \bar{K_P}) - (\ln L_t - \ln \bar{L}) \right] \\
&\quad + \frac{1}{2} \beta_{GG} (\ln K_{G,t} - \ln \bar{K_G})^2 + \varepsilon_{P,t}
\end{aligned} \tag{2}
$$

$$
S_{L,t} = 1 - \alpha_K + \beta_{KL} \left[(\ln K_{P,t} - \ln \bar{K_P}) - (\ln L_t - \ln \bar{L}) \right] + \beta_{KG} (\ln K_{G,t} - \ln \bar{K_G}) + \varepsilon_{S,t} \tag{3}
$$

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:

$$
\eta_{K_P} = \alpha_K + \beta_{KL} \left[(\ln L - \ln \bar{L}) - (\ln K_P - \ln \bar{K_P}) \right] + \beta_{KG} (\ln K_G - \ln \bar{K_G}) \tag{5}
$$

$$
\eta_{K_G} = \alpha_G + \beta_{KG} \left[(\ln K_P - \ln \bar{K_P}) - (\ln L - \ln \bar{L}) \right] + \beta_{GG} (\ln K_G - \ln \bar{K_G}) \tag{6}
$$

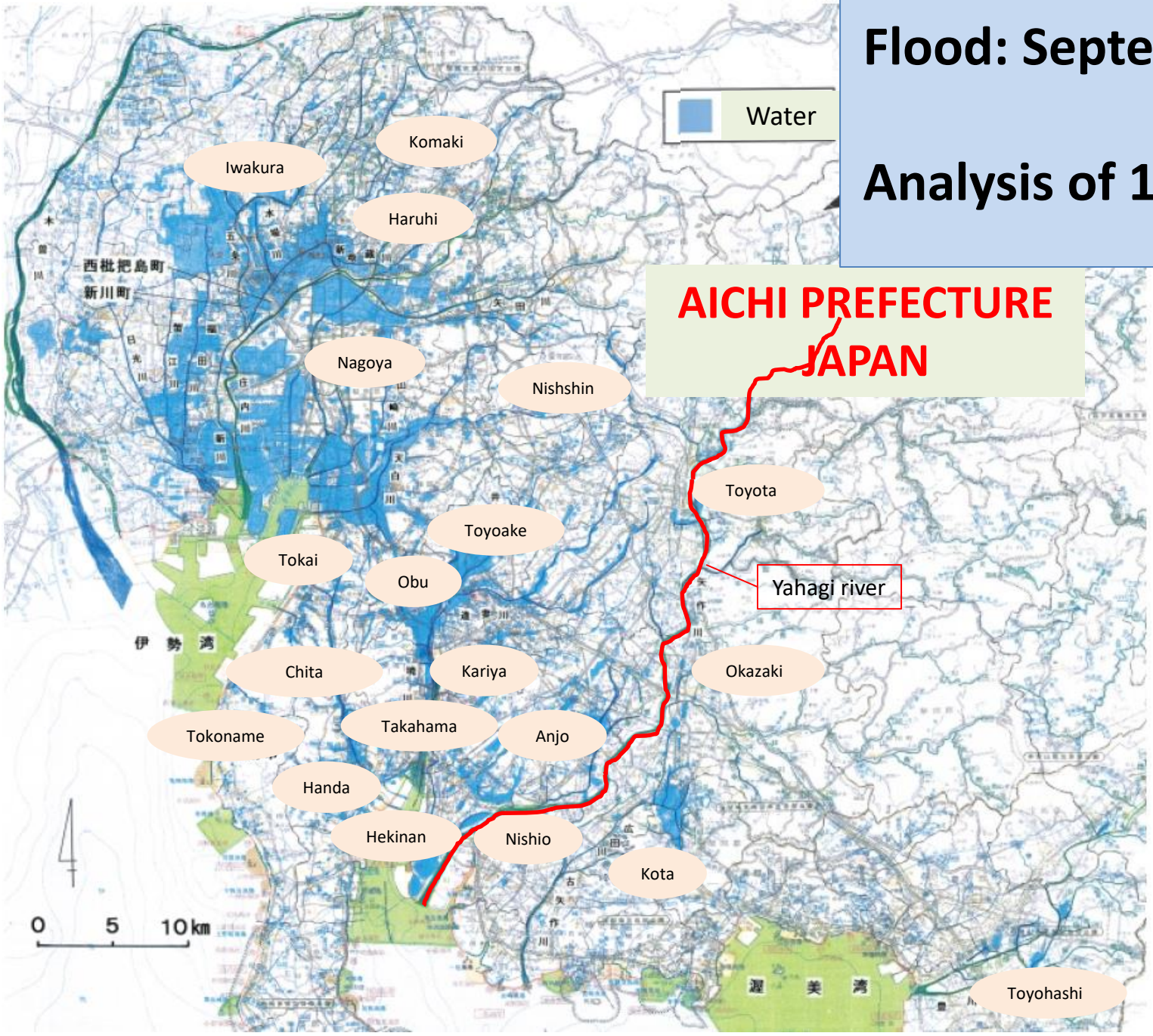
Macro Estimation of Japan: Y=F(Kp,L,Kg)

	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85
Direct Effect (Kg)	0.696	0.737	0.638	0.508	0.359	0.275
Indirect Effect (Kp)	0.453	0.553	0.488	0.418	0.304	0.226
Indirect Effect (L)	1.071	0.907	0.740	0.580	0.407	0.317

	1986-90	1991-95	1996-00	2001-05	2006-10
Direct Effect (Kg)	0.215	0.181	0.135	0.114	0.108
Indirect Effect (Kp)	0.195	0.162	0.122	0.091	0.085
Indirect Effect (L)	0.193	0.155	0.105	0.132	0.125
				2002 Flood	

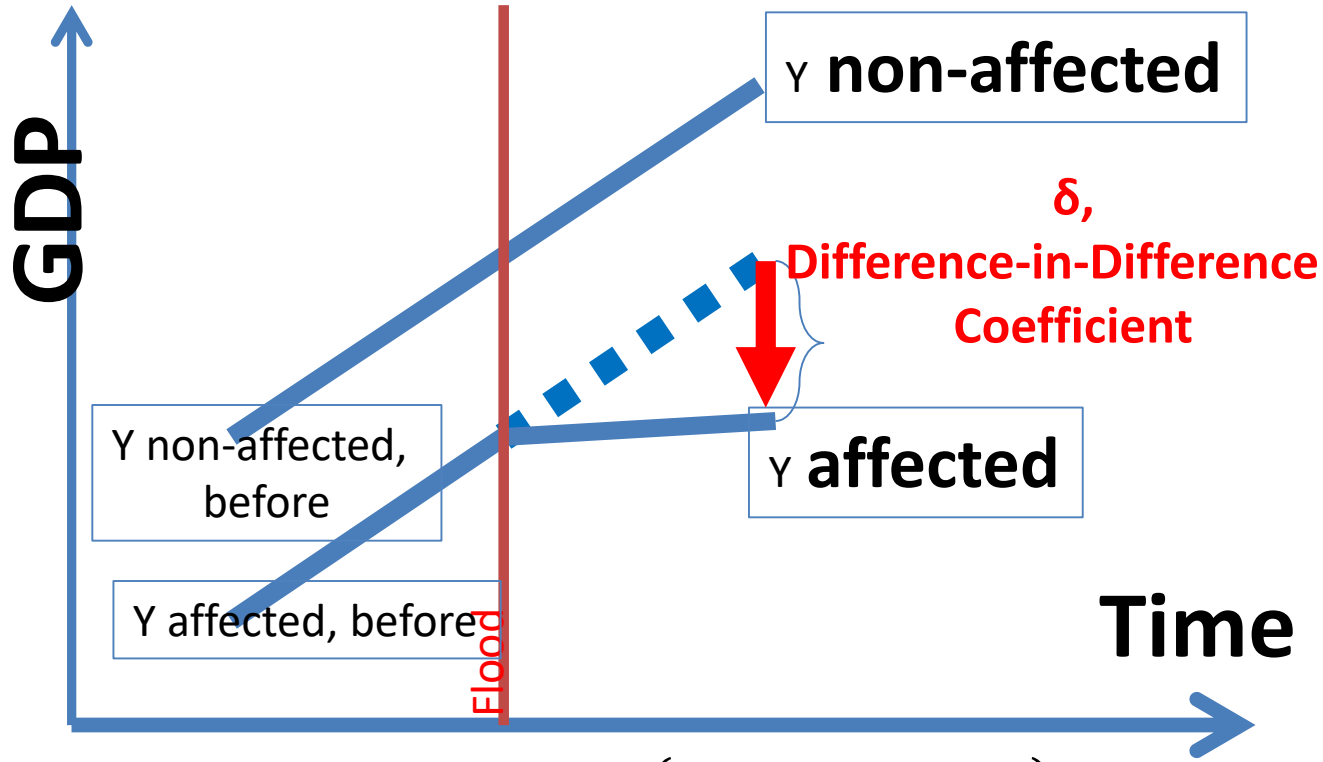
Flood: September 2000

Analysis of 19 cities



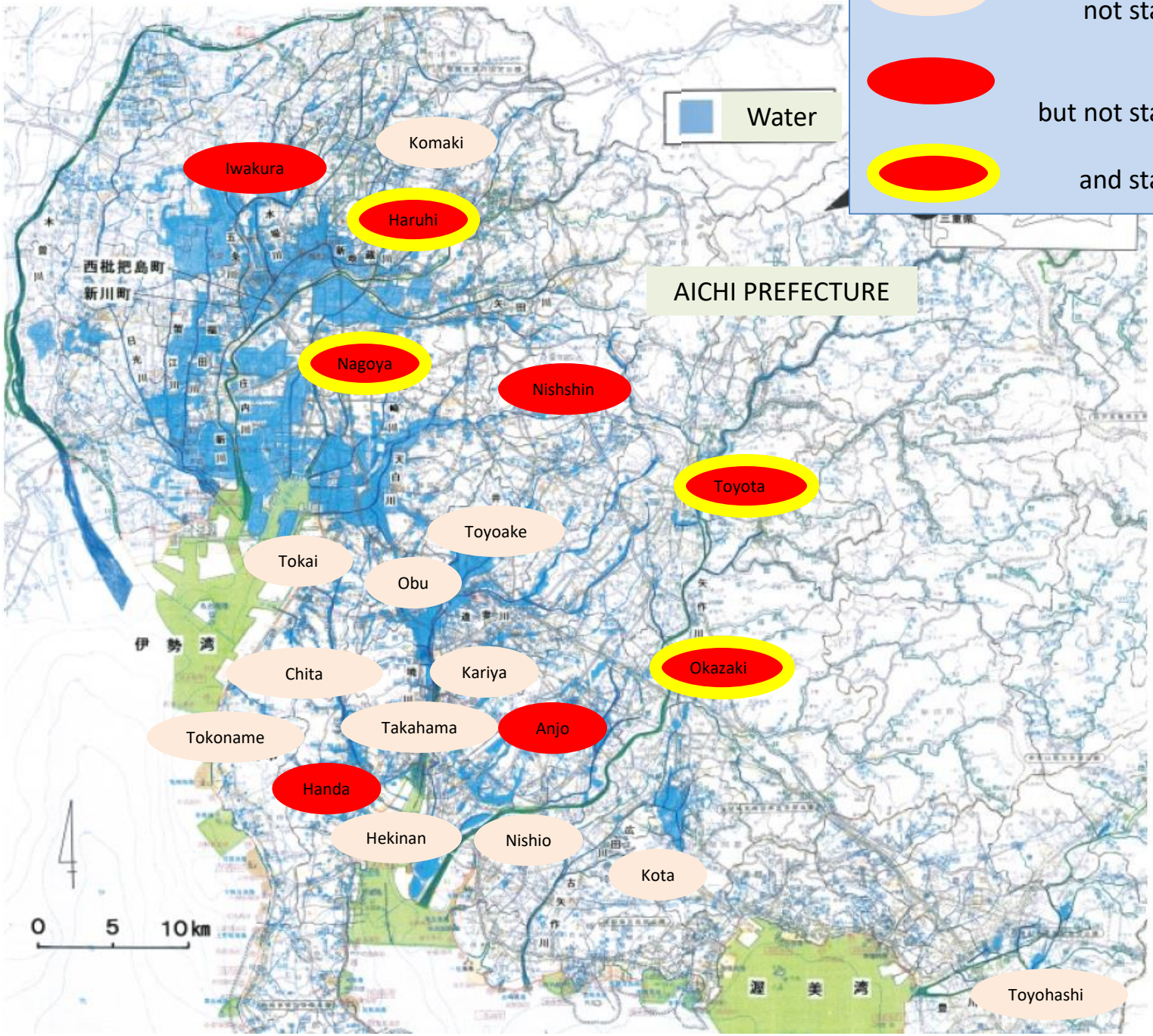
1 Anjo
2 Chita
3 Handa
4 Haruhi
5 Iwakura
6 Kariya
7 Komaki
8 Kota
9 Nagoya
10 Nishio
11 Nishshin
12 Obu
13 Okazaki
14 Takahama
15 Tokai
16 Tokoname
17 Toyoake
18 Toyohashi
19 Toyota

Graphical explanation of the model



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

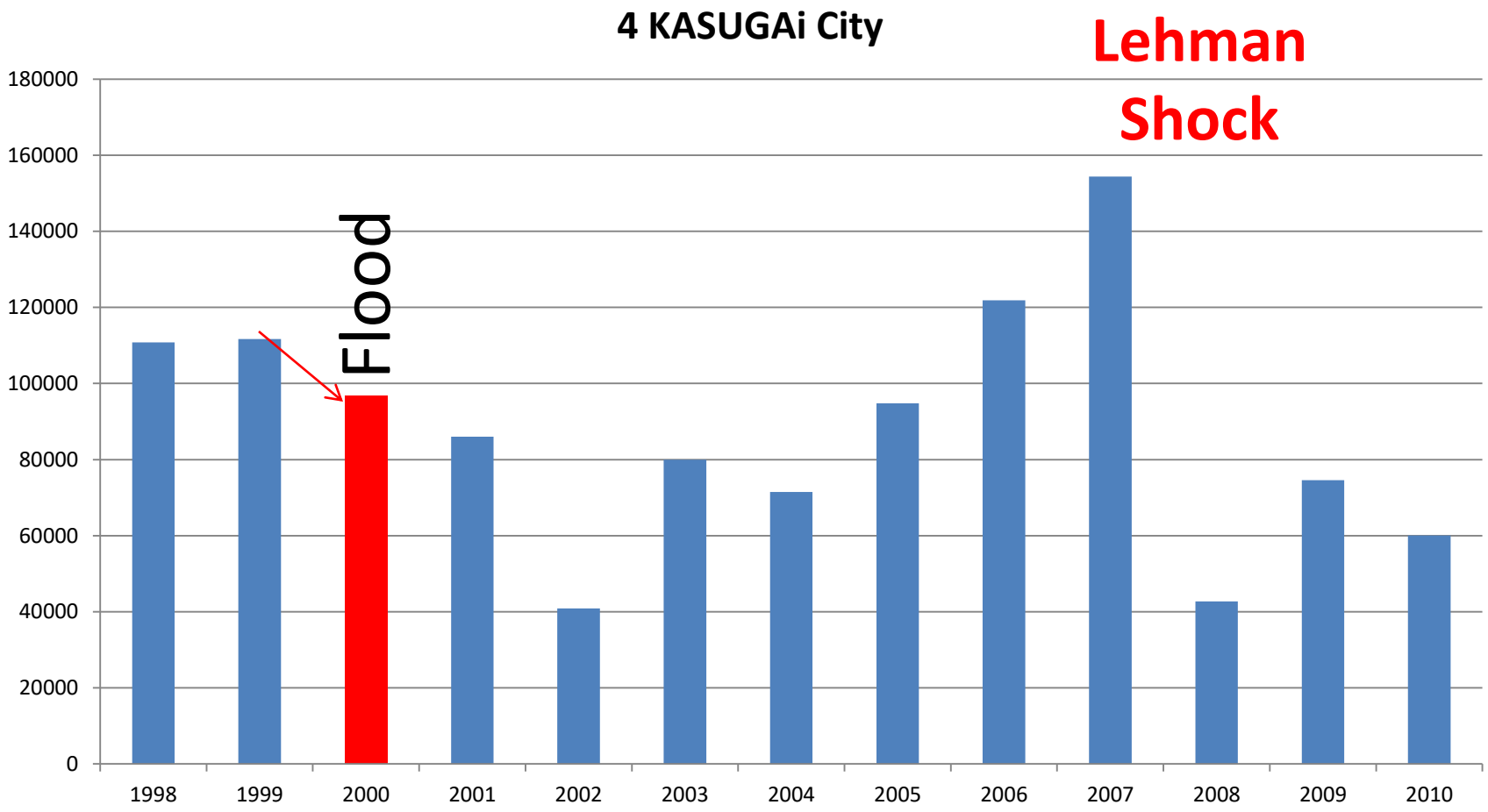
ΔY_{it} - GDP growth rate; α_i - sum of autonomous and region specific rate of growth; φ_t- year specific growth effect; $\left(D_{flood} \times D_{after}\right)_{it}$- dummy variable indicating that observation belong to affected group after flood period; δ- difference in difference coefficient; ϵ_{it}-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


Water
Not "U" type dynamics, not statistically significant
U" type dynamics, but not statistically significant
"U" type dynamics and statistically significant
AICHI PREFECTURE
Komaki
Iwakura
Haruhi
Nagoya
Nishshin
Toyota
Toyoake
Tokai
Obu
Chita
Kariya
Okazaki
Takahama
Anjo
Tokoname
Handa
Hekinan
Nishio
Kota
Toyohashi
0 5 10 km
伊勢湾
渥美湾
西枇杷島町
新川町
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)

Variable	1 Anjo	2 Chita	3 Handa	4 Haruhi	5 Iwakura
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



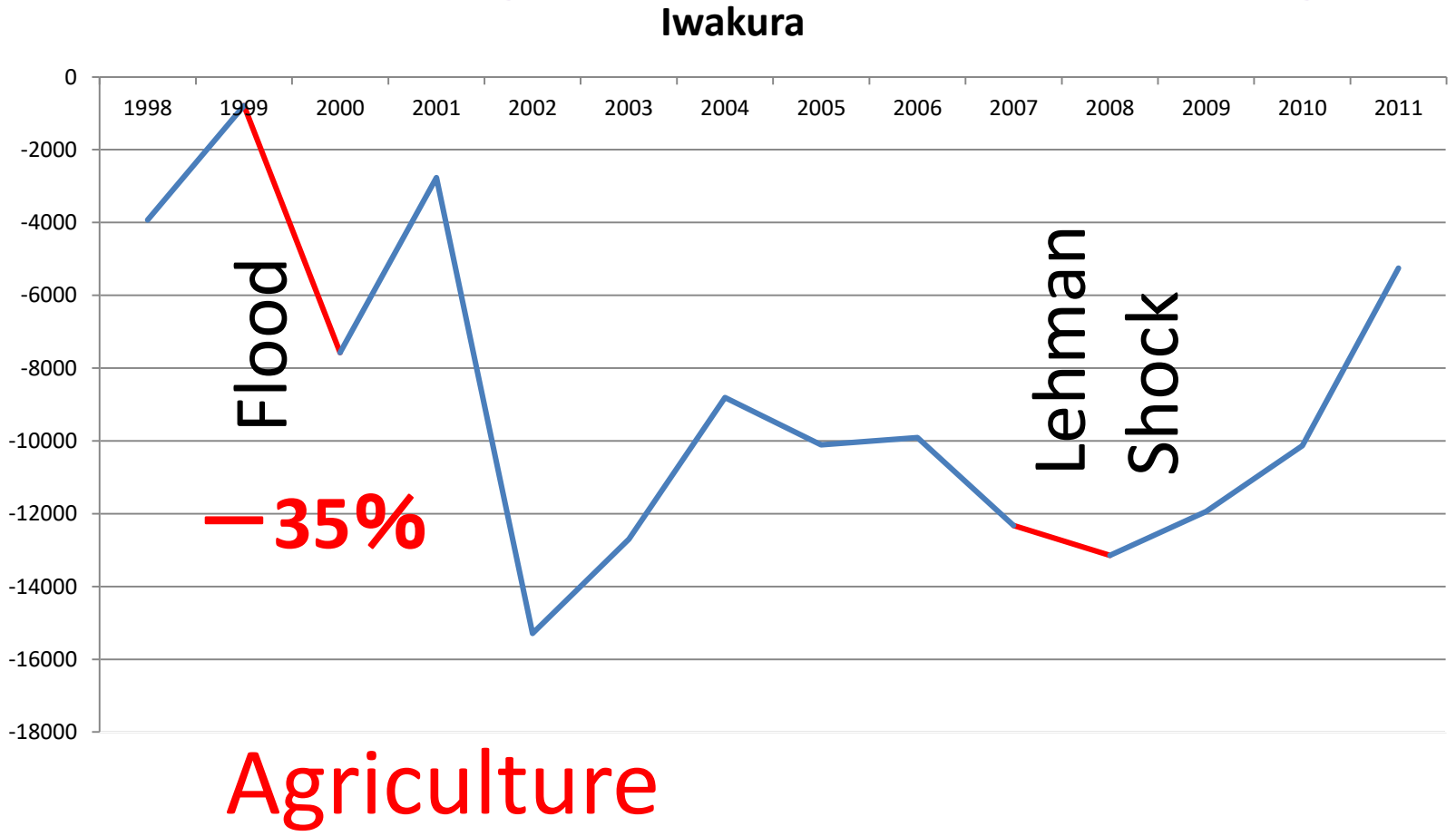
Kasugai City (Only 2 years impact)

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



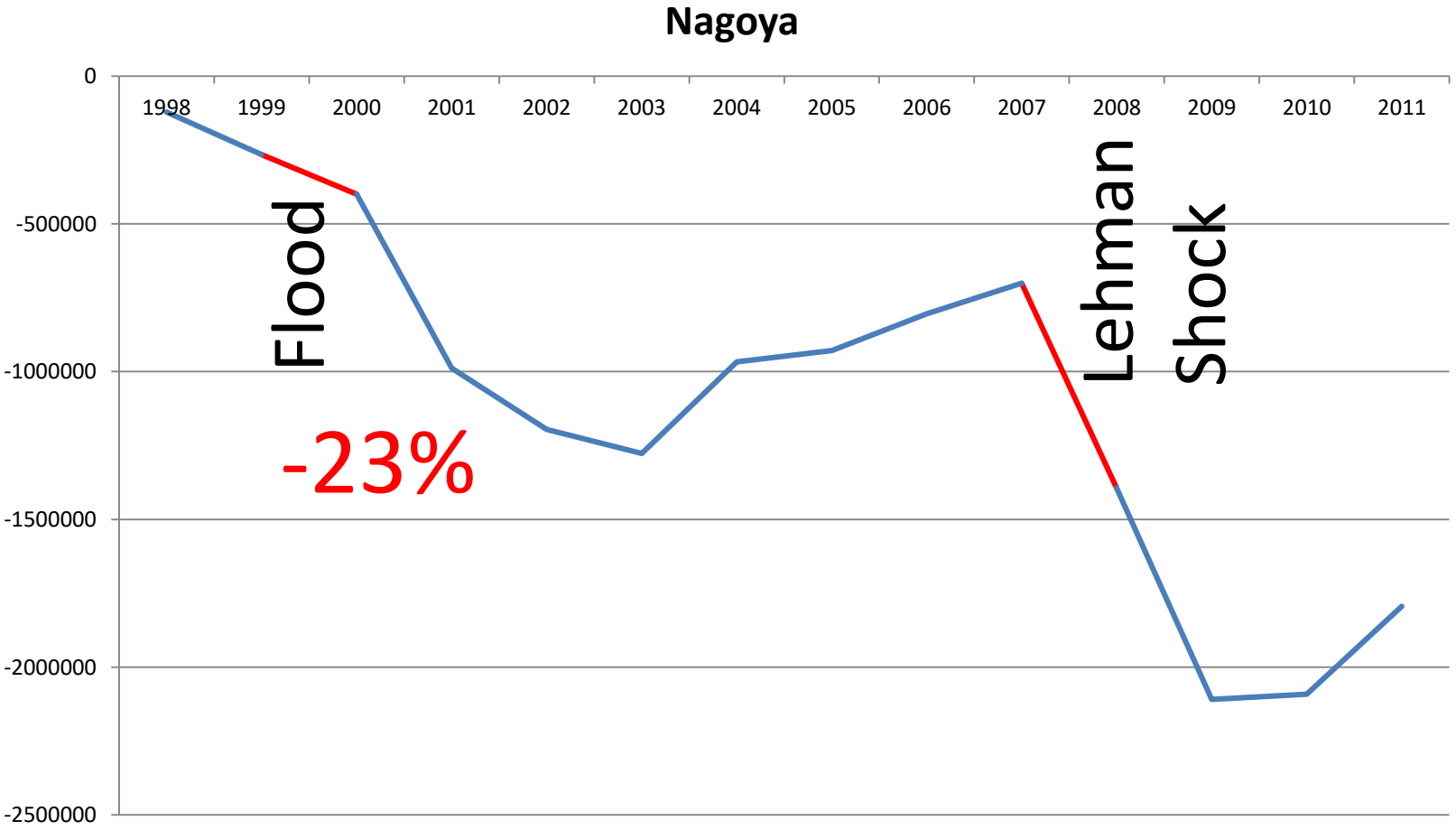
Agriculture

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

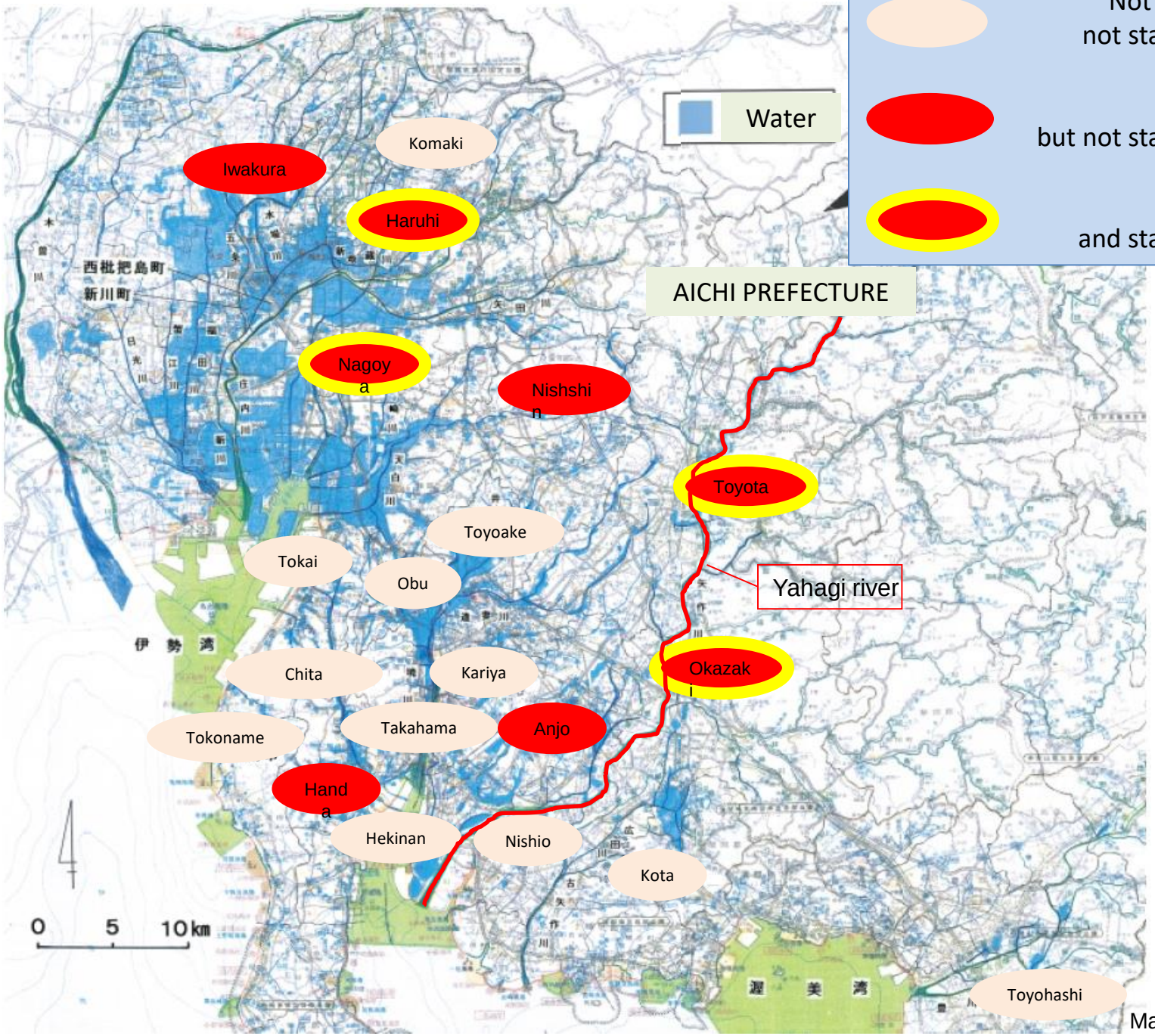
Difference in difference estimation coefficients, million. JPY

Services sector : 4 years decline



Nagoya 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



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

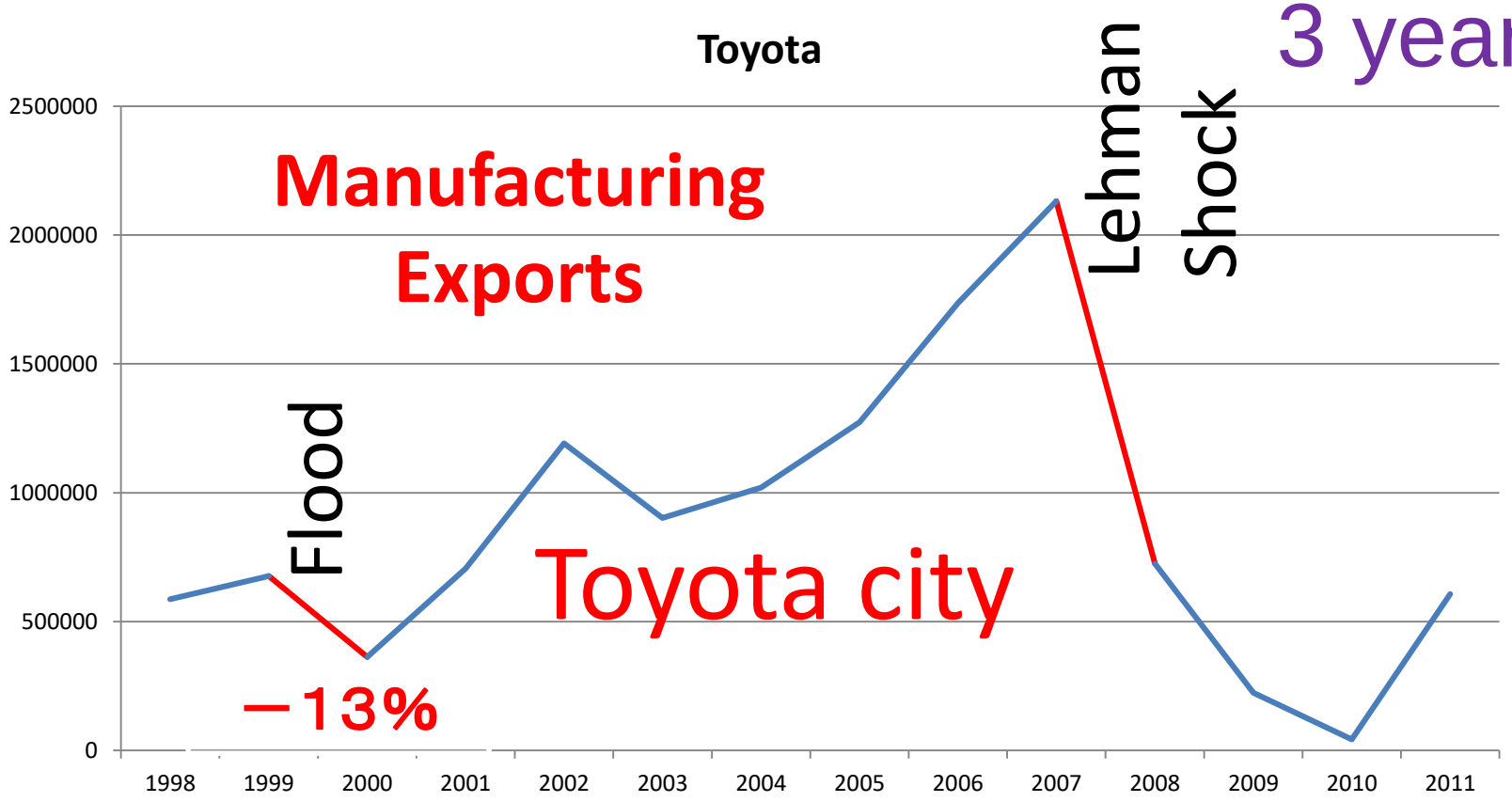
Map source: SATO Teruko (20

Difference in difference estimation coefficients, mln. JPY

	16 Tokoname	17 Toyoake	18 Toyohashi	19 Toyota
Variable				
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 Recovery	Agrculture	Services Sector	Stable Industry	Exports
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

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

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

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

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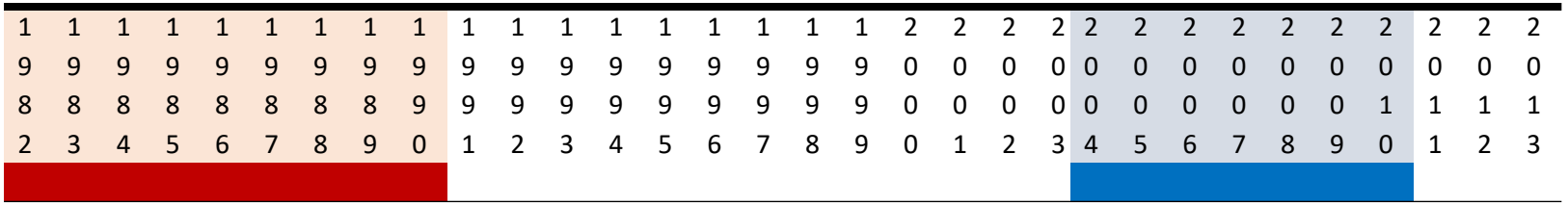
Japanese Bullet Train

Impact of Kyushu Shinkansen Rail on CORPORATE TAX revenue during 1st PHASE OF OPERATION period

{2004-2010} , mln. JPY (adjusted for CPI, base 1982)



Variable	Regression 1	Regression 2	Regression 3	Regression 4	Regression 5
Treatment2	-4772.54				
	[-0.2]				
Number of tax payers	5.8952514*	5.8957045*	5.896112*	5.8953585*	5.8629645*
	[1.95]	[1.95]	[1.95]	[1.95]	[1.91]
Treatment3		-15947.8			
		[-0.87]			
Treatment5			-13250.4		
			[-1.06]		
Treatment7				-6883.09	
				[-0.7]	
TreatmentCon					-28030.8
					[-0.65]
Constant	-665679	-665418	-665323	-665358	-658553
	[-1.35]	[-1.35]	[-1.35]	[-1.35]	[-1.32]
N	799	799	799	799	799
R2	0.269215	0.269281	0.269291	0.269241	0.269779
F	1.934589	2.106448	2.074548	2.100607	8.497174

COMPOSITION OF GROUPS

Group2	**Group5**
Kagoshima	Kagoshima
Kumamoto	Kumamoto
	Fukuoka
Group3	Oita
Kagoshima	Miyazaki
Kumamoto	
Fukuoka	
	GroupCon
Group7	Kagoshima
Kagoshima	Kumamoto
Kumamoto	Fukuoka
Fukuoka	Osaka
Oita	Hyogo
Miyazaki	Okayama
Saga	Hiroshima
Nagasaki	Yamaguchi

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 CORPORATE TAX revenue during 2nd PHASE OF OPERATION period

{2011-2013} , mln. JPY (adjusted for CPI, base 1982)

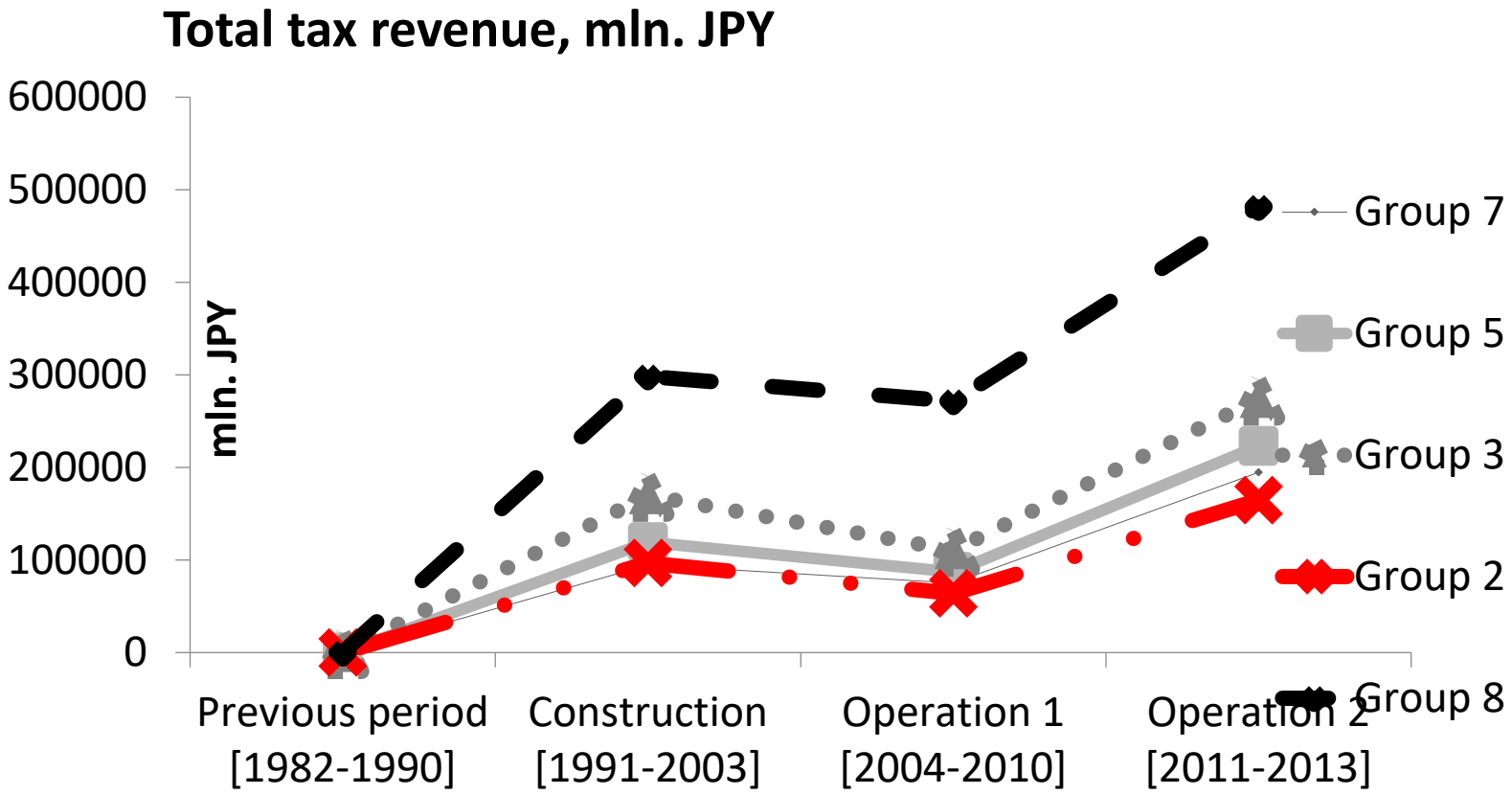
1	1	1	1	1	1	1	1	1	1	1	1	19	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
9	9	9	9	9	9	9	9	9	9	9	9	94	9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0
8	8	8	8	8	8	8	8	9	9	9	9		9	9	9	9	9	0	0	0	0	0	0	0	0	0	0	1	1	1
2	3	4	5	6	7	8	9	0	1	2	3		5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3

Variable	Regression 1	Regression 2	Regression 3	Regression 4	Regression 5
Treatment2	72330.012**				
	[2.2]				
Number of tax payers	5.5277056***	5.5585431***	5.558603***	5.5706545***	5.9640287***
	[3.13]	[3.14]	[3.14]	[3.14]	[3.07]
Treatment3		104664.34*			
		[2]			
Treatment5			82729.673**		
			[2.1]		
Treatment7				80998.365**	
				[2.34]	
TreatmentCon					179632
					[1.58]
Constant	-568133.98**	-573747.28**	-574245.87**	-576867.56**	-642138.87**
	[-2.07]	[-2.08]	[-2.08]	[-2.09]	[-2.1]
N	611	611	611	611	611
R2	0.350653	0.352058	0.352144	0.352874	0.364088
F	5.062509	5.486197	5.351791	5.431088	16.55518

COMPOSITION OF GROUPS

Group2	Group5
Kagoshima	Kagoshima
Kumamoto	Kumamoto
	Fukuoka
Group3	Oita
Kagoshima	Miyazaki
Kumamoto	
Fukuoka	
	GroupCon
Group7	Kagoshima
Kagoshima	Kumamoto
Kumamoto	Fukuoka
Fukuoka	Osaka
Oita	Hyogo
Miyazaki	Okayama
Saga	Hiroshima
Nagasaki	Yamaguchi

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
600000
500000
400000
300000
200000
100000
0
mln. JPY
Previous period [1982-1990]
Construction [1991-2003]
Operation 1 [2004-2010]
Operation 2 [2011-2013]
Group 7
Group 5
Group 3
Group 2
Group 8

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