Economic Impact of Water Infrastructure: Proposal of Evaluation

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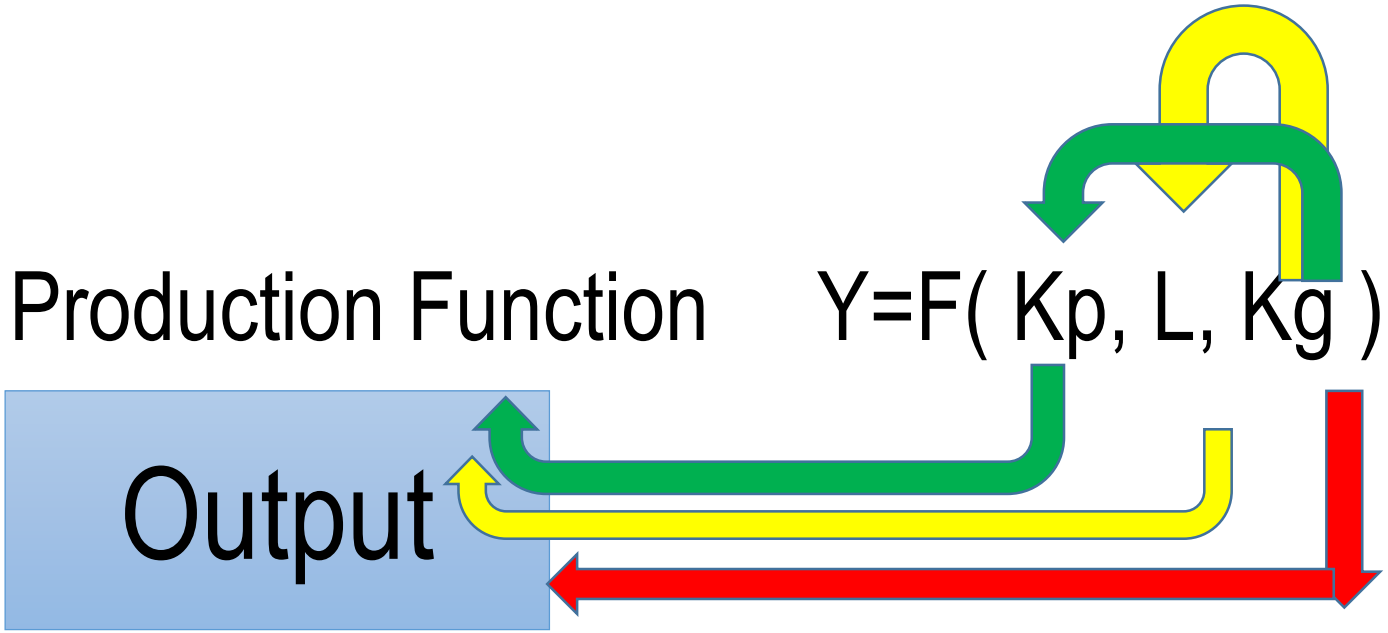
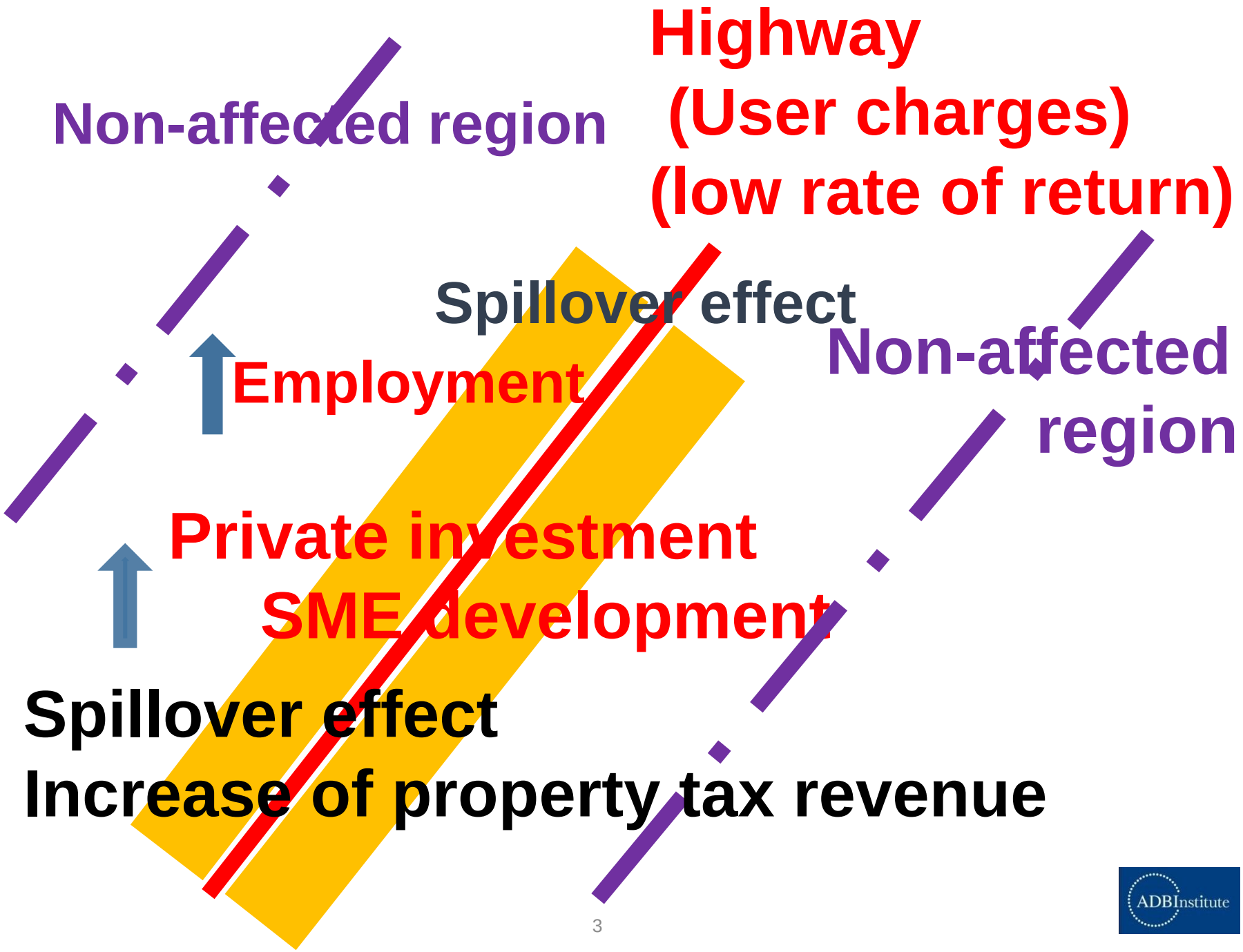
Direct Effect and Spill-over Effects



Y= Output, Kp= private capital, L = labor

Kg = public capital (infrastructure)


Highway
(User charges)
(low rate of return)
Non-affected region
Spillover effect
Employment
Non-affected region
Private investment
SME development
Spillover effect
Increase of property tax revenue

Return the spillover effects to Investors

The production technology of the private sector is represented by the following production function.

$$Y = f(K_p, L, K_G) \tag{1}$$

where Y denotes output (in value added) in the private sector. The output is produced by combining private capital stock, Kp, labor input, L, and infrastructure stock, K_G.

In this paper, we assume the translog production function.

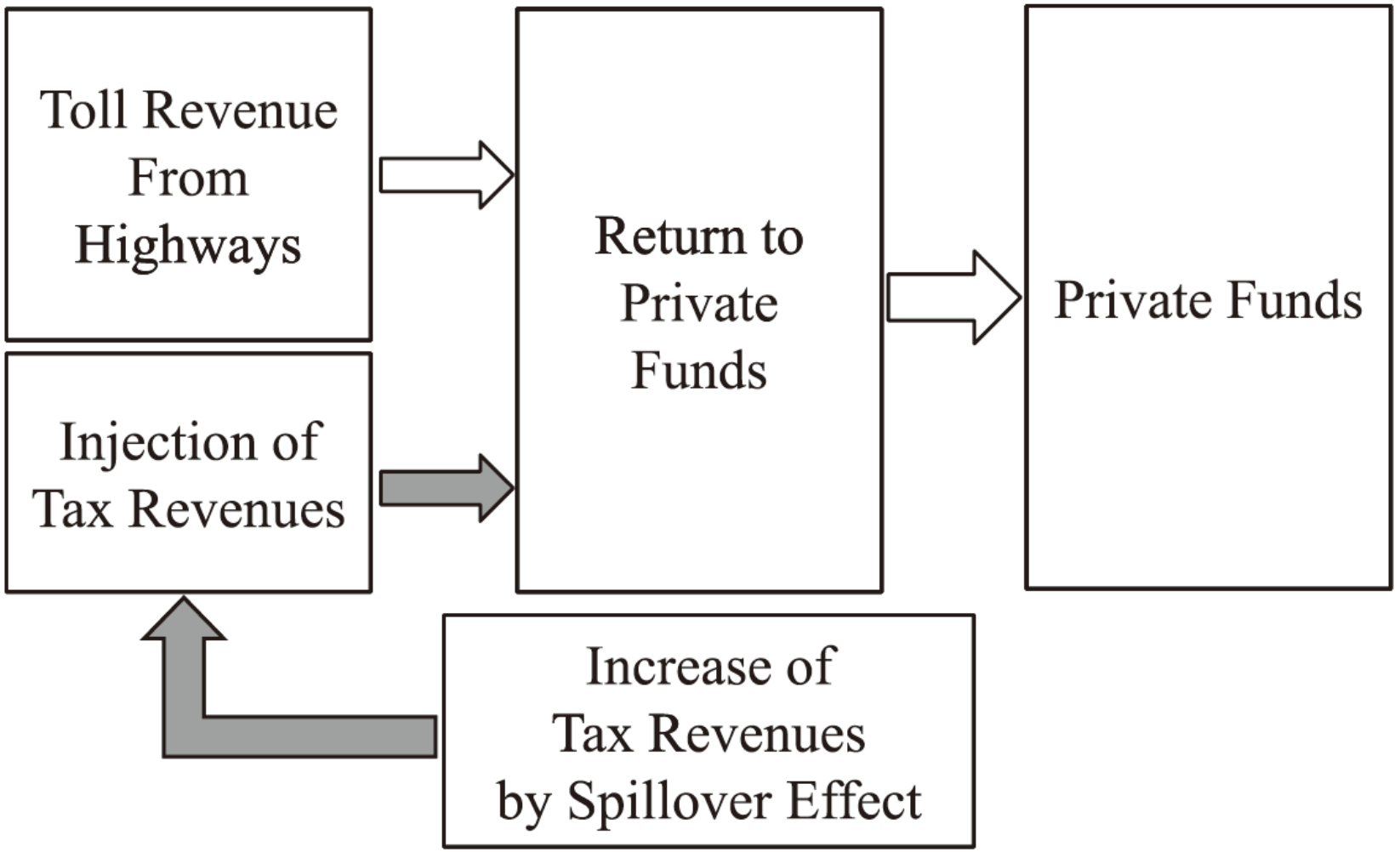
$$\begin{aligned} \ln Y = {} & \alpha_0 + \alpha_K \ln K_p + \alpha_L \ln L + \alpha_G \ln K_G \\ & + \beta_{KK}(1/2)(\ln K_P)^2 + \beta_{KL} \ln K_P \ln L + \beta_{KG} \ln K_P \ln K_G \\ & + \beta_{LL}(1/2)(\ln L)^2 + \beta_{LG} \ln L \ln K_G + \beta_{GG}(1/2)(\ln K_G)^2 \end{aligned} \tag{2}$$

Assuming the production function represented by equation (1), and that factor prices and infrastructure are given for producers in the private sector, the effect of infrastructure on productivity is expressed as:

$$\frac{dY}{dK_G} = \frac{\partial Y}{\partial K_G} + \frac{\partial Y}{\partial K_P}\frac{\partial K_P}{\partial K_G} + \frac{\partial Y}{\partial L}\frac{\partial L}{\partial K_G} \tag{9}$$

Here, the effect of infrastructure is divided into three parts; the first term on the right hand side of equation (9) represents *direct effect;* the second term is the *indirect effect* on output with respect to the resulting change in the input of private capital and the third term is the *indirect effect* on output with respect to the resulting effect on labor input.

Figure 4
Injection of a fraction of tax revenues gained from spillover effect



Spillover effects → Return to investors

	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
20% Returned	0.3048	0.292	0.2456	0.1996	0.1422	0.1086
%Increment	43.8	39.6	38.5	39.3	39.6	39.5

1986-90	1991-95	1996-00	2001-05	2006-10
0.215	0.181	0.135	0.114	0.108
0.195	0.162	0.122	0.1	0.1
0.193	0.155	0.105	0.09	0.085
0.0776	0.0634	0.0454	0.038	0.037
36.1	35.0	33.6	33.3	34.3

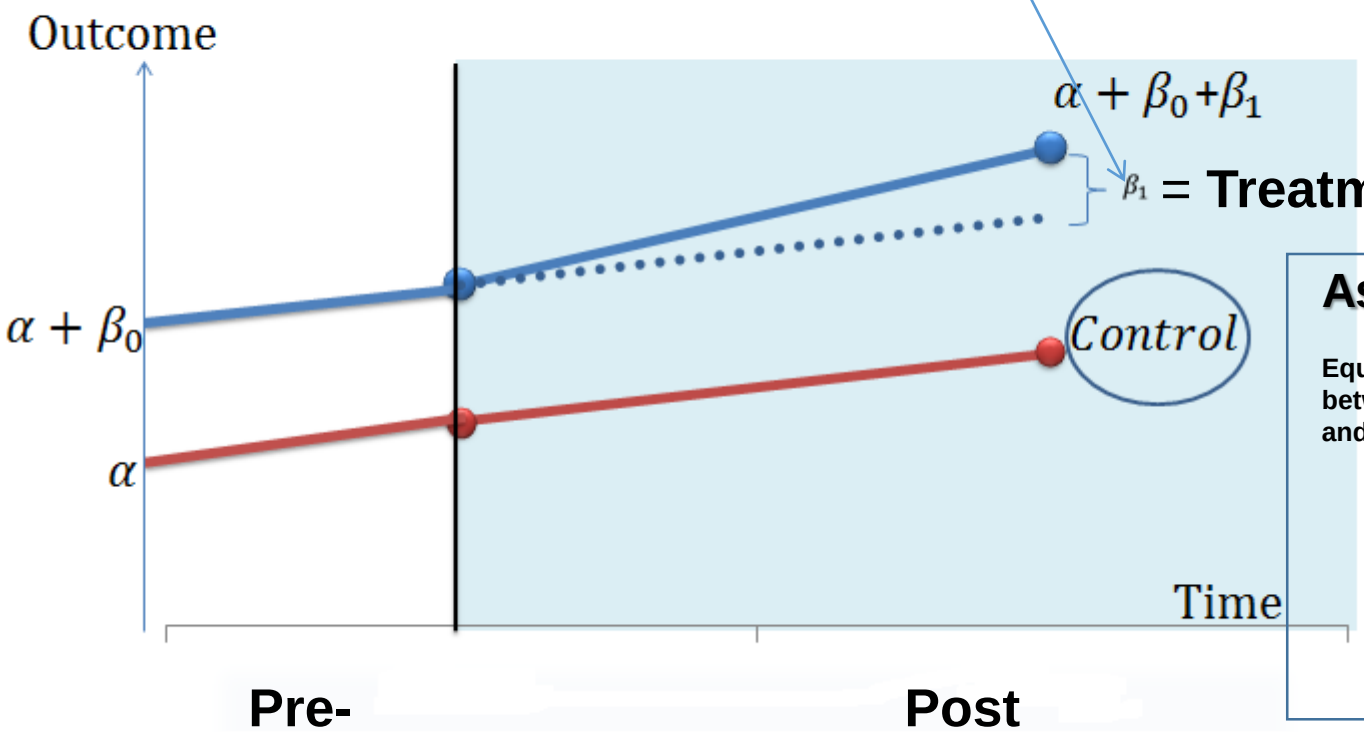
Case Study: Southern Tagalog Arterial Road (STAR) , Philippines (Micro-data Analysis)

- The Southern Tagalog Arterial Road (STAR) project in Batangas province, Philippines (south of Metro Manila) is a modified Built-Operate-Transfer (BOT) project.
- The 41.9 km STAR tollway was built to improve road linkage between Metro Manila and Batangas City, provide easy access to the Batangas International Port, and thereby accelerate industrial development in Batangas and nearby provinces.

Difference-in-Difference (DiD) Analysis

$$\text{Outcome} = \alpha + \beta_0 D + \sum_{t+2}^{t-4} \beta_1 D \times T + \varepsilon$$

where: D = 1 (Treatment group) T = Treatment period
D = 0 (Control group)



Assumption:

Equal trends between Treatment and Control groups

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

Tax Revenues in three cities

Yoshino and Pontines (2015) ADBI Discussion paper 549

表 8　フィリピンの STAR 高速道路の影響のない地域と比較した事業税の増加額

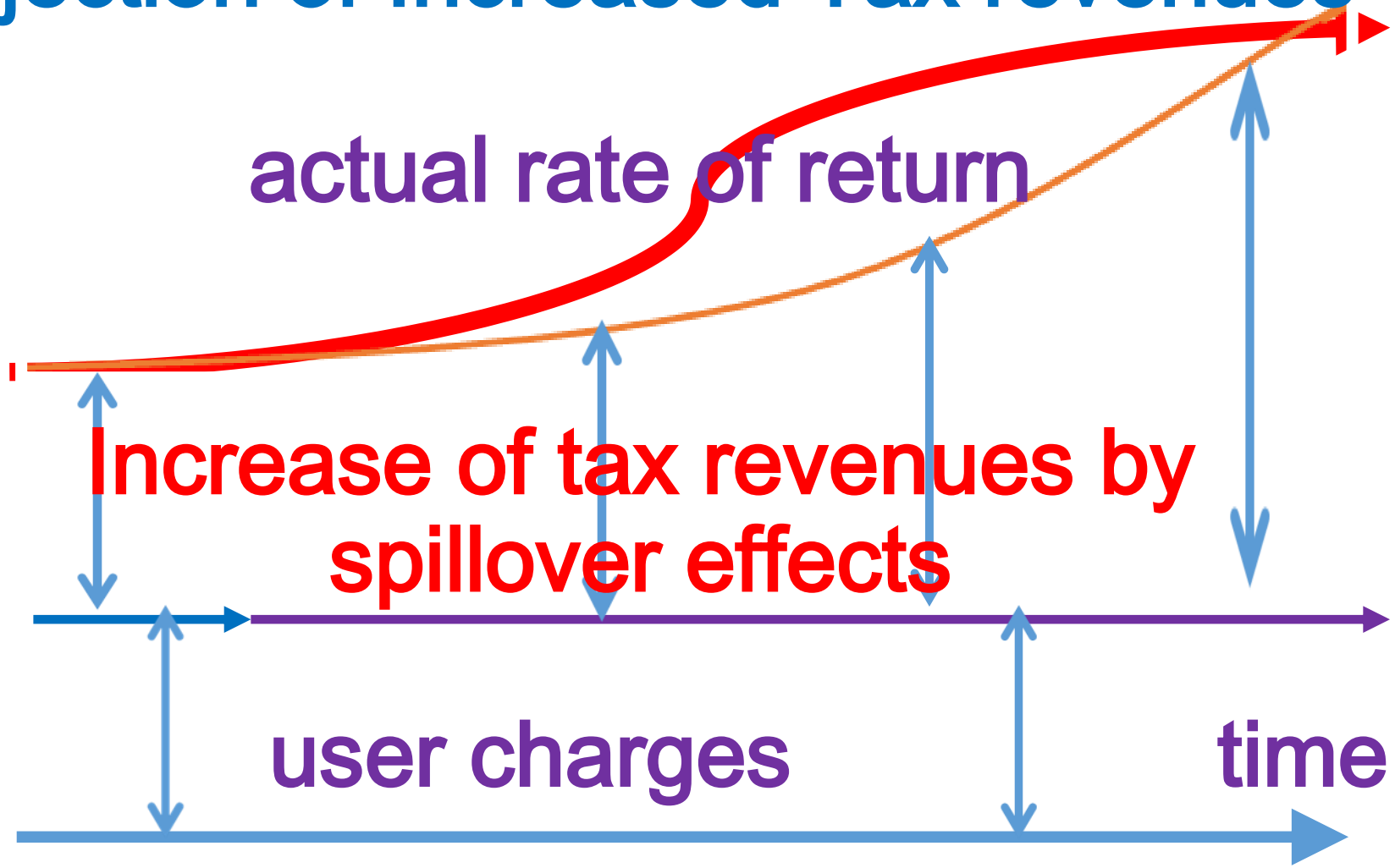
（単位：100 万ペソ）

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

（出所）Yoshino and Pontines (2015)より筆者作成

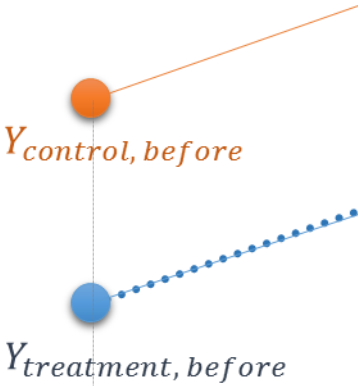
Completion

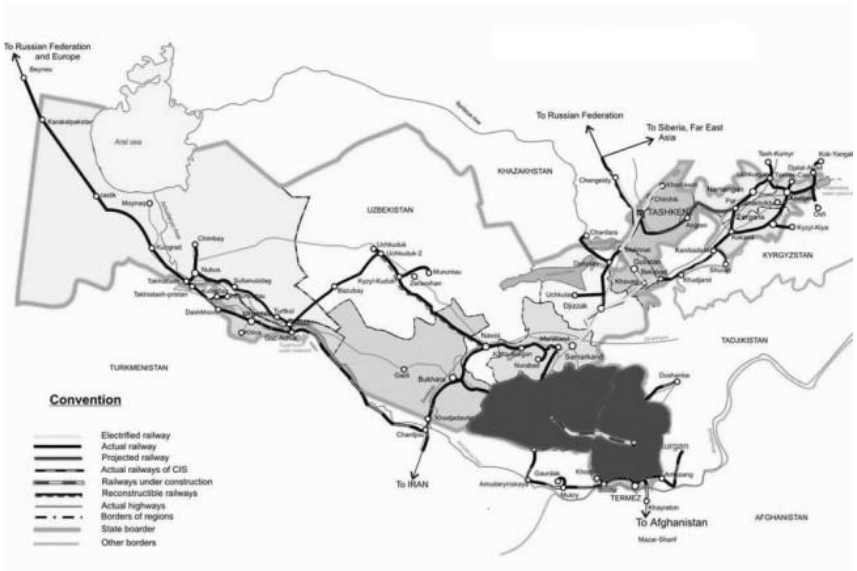
Injection of Increased Tax revenues



Uzbekistan Railway: Connectivity is important

GDP growth rate





Time

Divide regions affected and not affected by railway connection to “Treated group” and “Control group”

GDP

	GDP	Term	Connectivity spillover effect	Regional spillover effect	Neighboring spillover effect
	Launching Effects	Short	2.83***[4.48]	0.70[0.45]	1.33[1.14]
		Mid	2.5***[6.88]	0.36[0.29]	1.27[1.46]
		Long	2.06***[3.04]	-0.42[-0.29]	2.29**[2.94]
1 year	Anticipated	Short	0.19[0.33]	0.85[1.75]	-0.18[-0.20]
		Mid	0.31[0.51]	0.64[1.30]	-0.02[-0.03]
		Long	0.07[0.13]	-0.006[-0.01]	0.50[0.67]
	Postponed Effects		1.76*[1.95]	-1.49[-0.72]	2.58*[2.03]
2 years	Anticipated	Short	-1.54[-1.66]	1.42[0.78]	-1.32[-0.92]
		Mid	0.32[0.44]	0.84[1.42]	0.13[0.13]
		Long	0.11[0.15]	0.10[0.16]	0.87[1.19]
	Postponed Effects		-0.14[-0.20]	-1.71[-1.35]	1.05[1.44]

Note: t-values are in parenthesis. t-value measures how many standard errors the coefficient is away from zero.

legend: * p<.1; ** p<.05; *** p<.01

Additional tax revenue, Regional GDP growth and Railway Company Net Income, LCU (bln.)

Period	Coefficients	T(20)*ΔY (Tax revenue)	ΔY Affected (Direct + Spillover effects)	Company net income (Revenue - Costs)
Short term (2009-2010)	2.83*** [4.48]	**16.0**	**79.9**	**315.5**
Mid-term (2009-2011)	2.48*** [6.88]	**16.3**	**81.5**	**411.7**
Long-term (2009-2012)	2.06*** [3.04]	**14.7**	**73.5**	**509.0**

Source: Authors' calculations

Japanese Bullet Train

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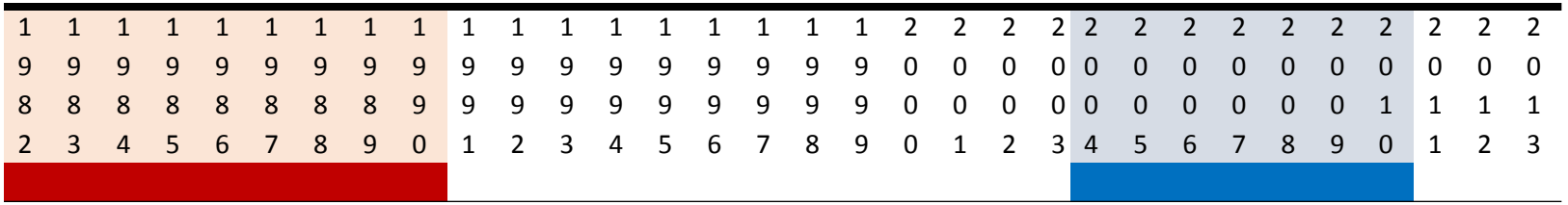
Impact of Kyushu Shinkansen Rail on CORPORATE TAX revenue during 1st PHASE OF OPERATION period

{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

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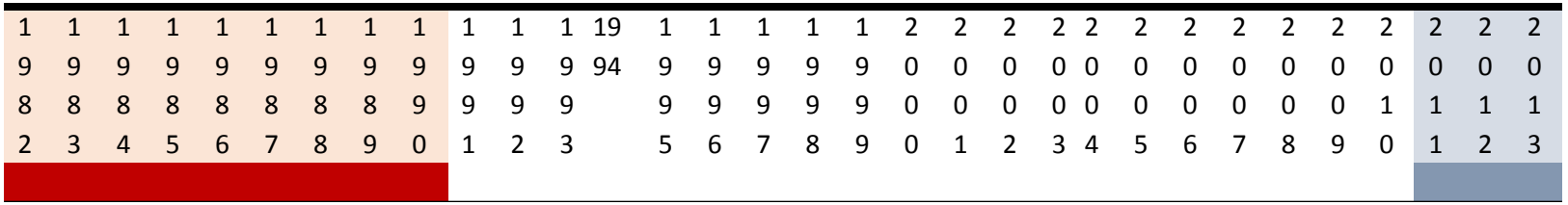
Impact of Kyushu Shinkansen Rail on CORPORATE TAX revenue during 2nd PHASE OF OPERATION period

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



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

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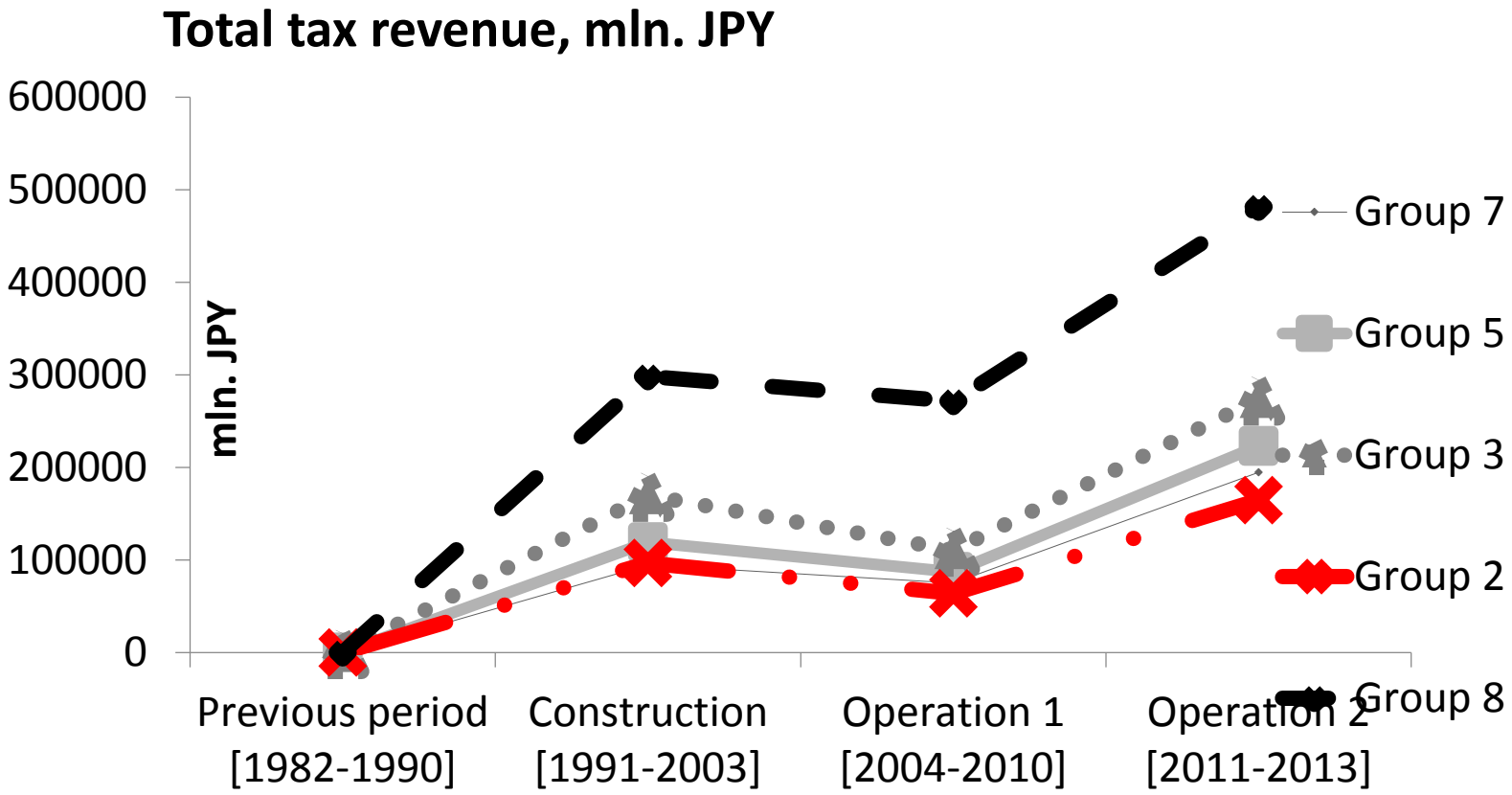
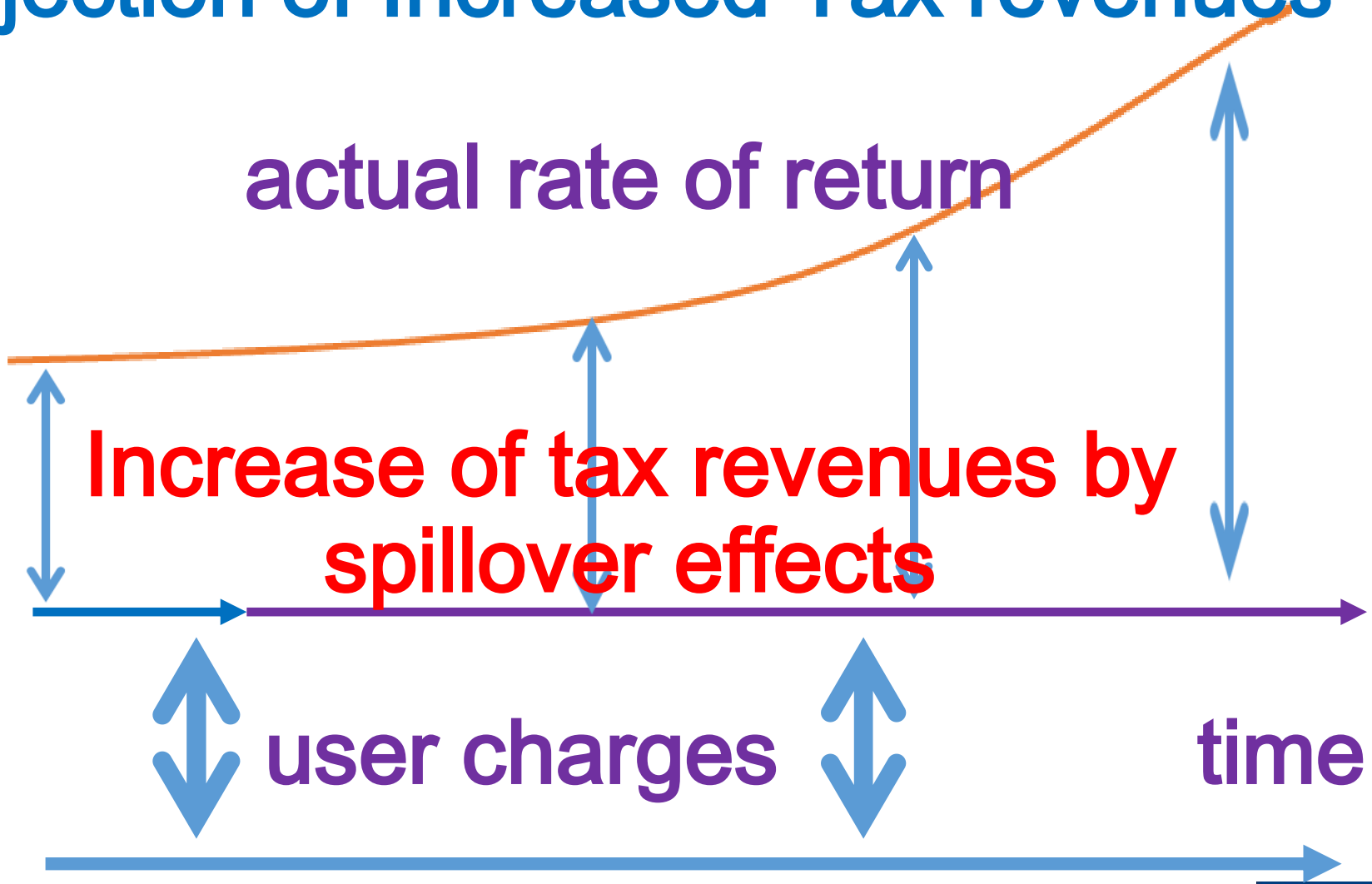

Total tax revenue, mln. JPY
600000
500000
400000
300000
200000
100000
0
mln. JPY
Group 7
Group 5
Group 3
Group 2
Group 8
Previous period [1982-1990]
Construction [1991-2003]
Operation 1 [2004-2010]
Operation 2 [2011-2013]

Injection of Increased Tax revenues



Estimation of water related Risk

1. Negative Effects of Flood, Typhoon etc.

How to measure negative impacts?

(1) <Direct effects>

Changes in Production of Agricultural products

Changes in Income tax revenues

Changes in Corporate tax revenues

Changes in Sales → Consumption tax

(2)<Spillover effects>

Decline in supply of food and other goods

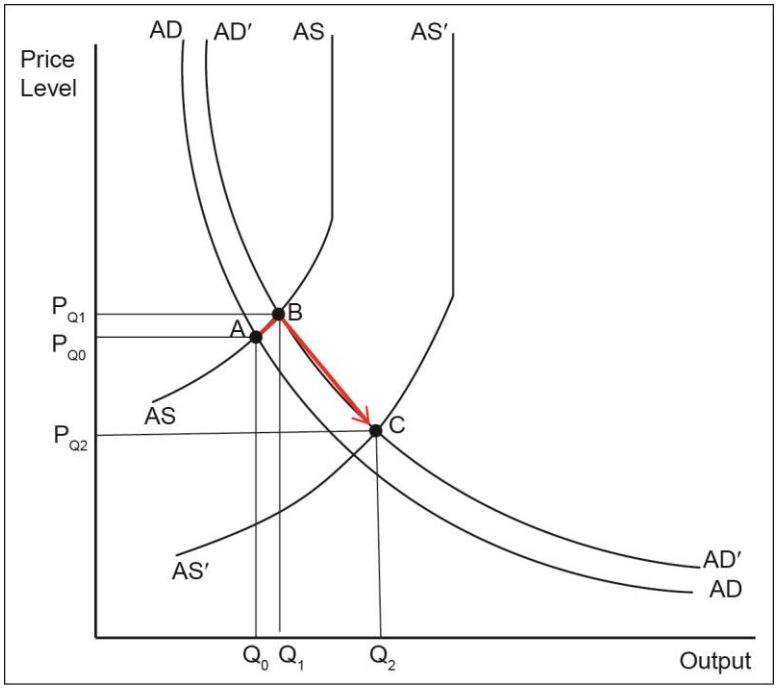
→ Increase in prices of goods and services

Estimation of Indirect Effects of Disaster to Macro economy

(3) Impact of rising price of commodities

→ Households' consumption declines

→ Increase of general price level



Economic Effects of Dam Construction

1, Stable supply of clean water

2, Increase of property value (Ex. Manila water)

changes in property prices

3, Industries come to the region

corporate tax revenues, increase in Sales

4, Clean water improves health condition

number of patients

5, Increase in Tax revenues will tell the impact

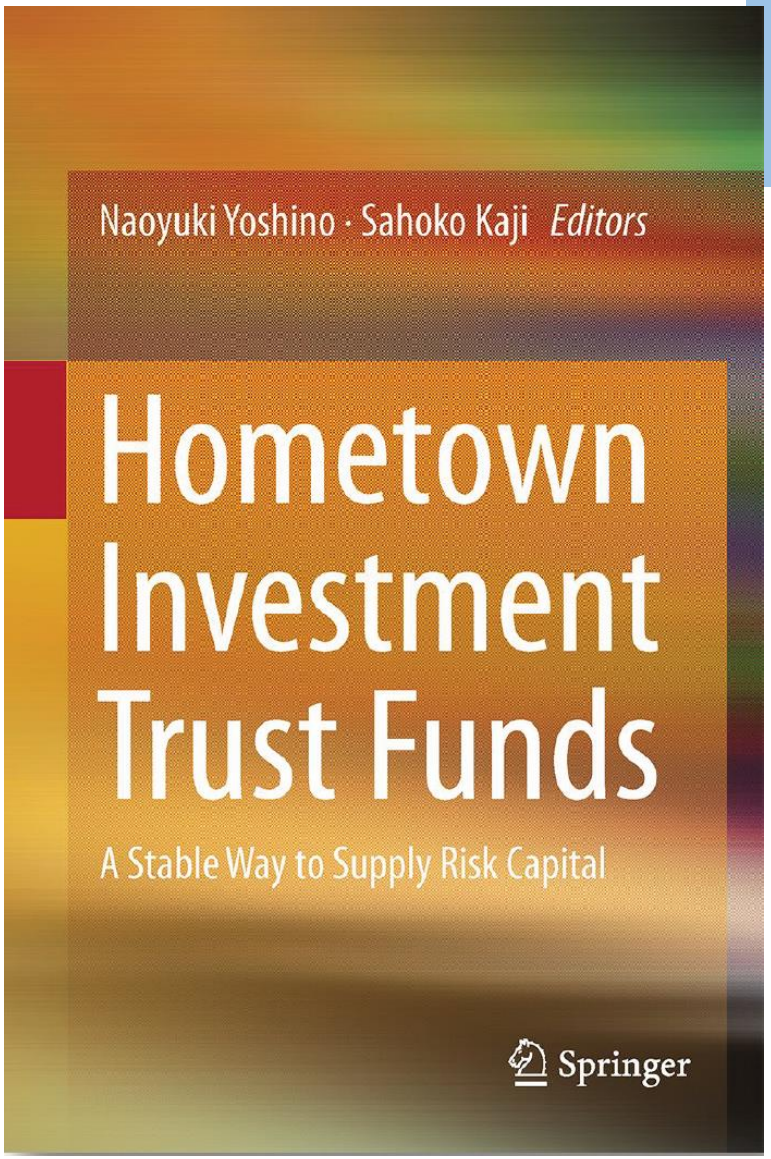
Income tax revenues

Case Study of Natural Disaster

1, Japanese Dam construction
2, Thailand flood case
3, Philippines typhoon case
4, Difference in difference method and Macro economic data
5, Estimation of the negative impact
6, Compare with construction costs

Springer

Possible Solutions
by use of community funds



Hometown Investment

A Stable Way to Supply Risk Capital

Yoshino, Naoyuki; Kaji Sahoko (Eds.), 2013,

Revitalization of Tsukubane Hydro Power (Nara state)

250 investors, total 525 thousand US dollars, Japan

Original Dam was constructed more than 100 years ago

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Private Financial Scheme of Wind Power Collected by Individuals (started in 2001-9)

Investors
2000 people

Each person
1000 US$

Hokkaido Green Fund

Construction Costs =
2million US $

Sell to Power Company

Final User

PE
1+0.05
5%
surcharge

Scheme of Financing Power Panels

Local Government
Subsidies (2/3)

377
Solar power
plants

Power
Company

Private Individuals

Hometown Trust Funds

1000 US$ -– 5000 US $

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References

Yoshino N. Kaji, S. (2013) *Hometown Investment Trust Funds*, Springer, March 2013

Yoshino, N., Taghizadeh Hesary, F. (2014), 'Analytical Framework on Credit Risks for Financing SMEs in Asia'. Asia-Pacific Development Journal. United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP)

Yoshino, N. and Pontines, Victor (2015) "The Highway-Effect on Public Finance: Case of the STAR Highway in the Phillippines", GIE | AAA Special Kick-off Edition, GIE Network publishing.

Nakahigashi, M and Yoshino, N. (2016) “Changes in Economic Effect of Infrastructure and Financing Method”, Public Policy Review, Vol.12, No.1.

Yoshino, Naoyuki（2010）“Financing Transport Infrastructure Investment”, OECD（ed.）, Southeast Asian Economic Outlook 2010, OECD Publishing.

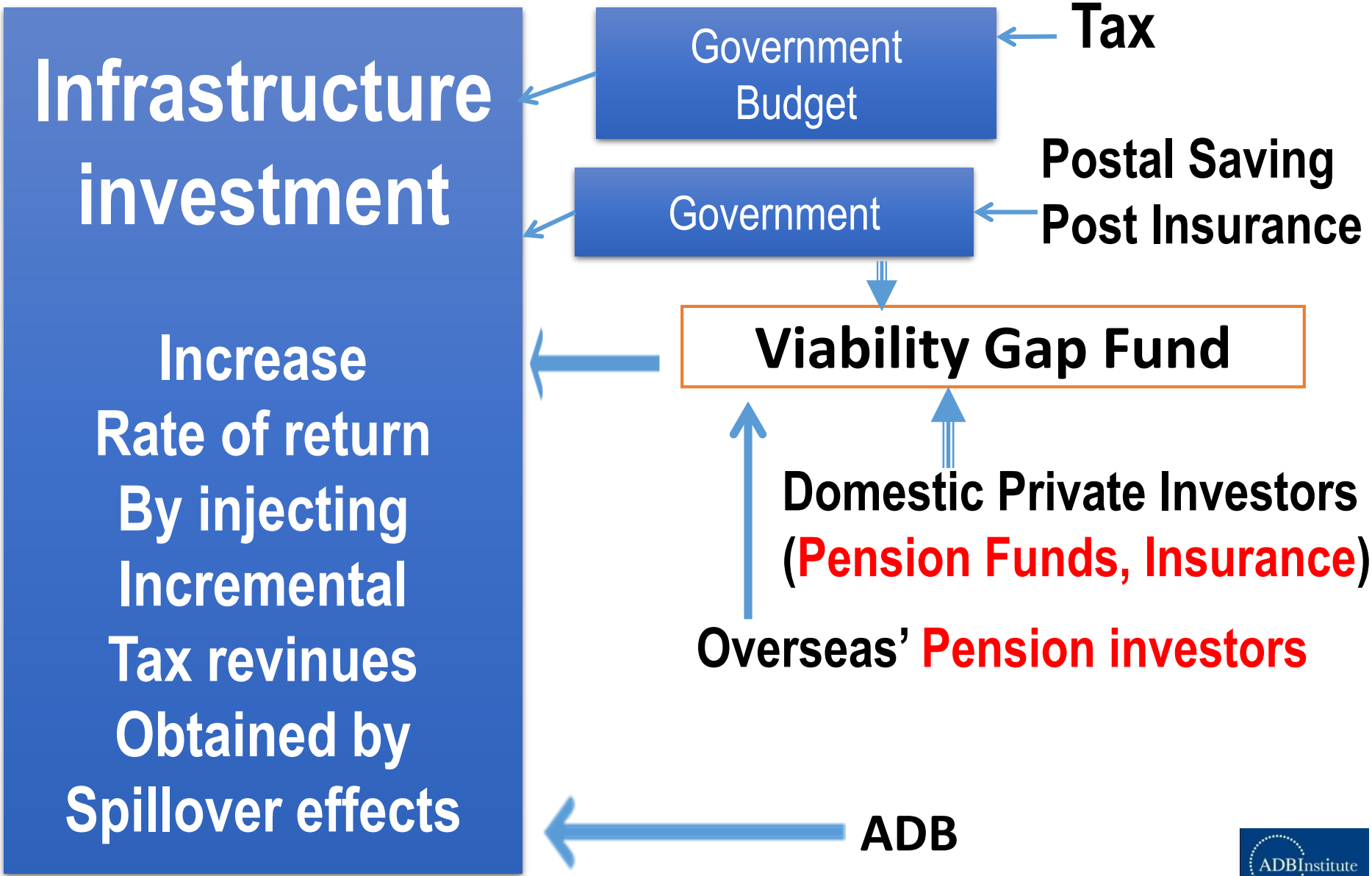
Yoshino, Naoyuki（2012）“Global Imbalances and the Development of Capital Flows among Asian Countries”, OECD Journal: Financial Market Trends, Vol. 2012/1

Yoshino, Naoyuki and Masaki Nakahigashi（2004）“The Role of Infrastructure in Economic Development”, ICFAI Journal of Managerial Economics, 2, pp. 7-24

Yoshino, Naoyuki and Victor Pontines（2015）“The Highway Effect on Public Finance: Case of the STAR Highway in the Philippines”, Asian Development Bank Institute（ADBI）Working Paper No.549.

Yoshino, Naoyuki, Victor Pontines and Umid Abidhadjaev（2015）“Impact Evaluation of Infrastructure Provision on Public Finance and Economic Performance: Empirical Evidence from Philippines and Uzbekistan”, Asian Development Bank Institute（ADBI）, Working Paper, No.548.

Infrastructure Finance



Viability Gap Fund and Government Burden

Investors only benefit