



# **METHODOLOGY**

## **EX ANTE AND EX POST ANALYSIS OF INFRASTRUCTURE PROJECTS**

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# Basic principles

- Separating effects
- Taking into account the perspective changes
- Macroindicators

# Criteria for the effectiveness

- Study and comparison of the impact of this project on the improvement and development of related industries
- Comparative analysis
- Net present value (NPV):

$$NPV = \sum_{t=0}^T \frac{FCF_t}{(1+R)^t}$$

$FCF_t$ -free cash flow,  $R$ -discount rate.

# Alternative measures

- Economic net present value (ENPV):

$$ENPV = \sum_{t=1}^n \frac{(B_t - C_t)}{(1 + r)^t}$$

$B_t$ -gross economic benefit,  $C_t$ -sum of economic costs,  $r$ -required discount rate

- Economic internal rate of return (EIRR):

$$\sum_{t=1}^n \frac{B_t}{(1 + r)^t} - \sum_{t=1}^n \frac{C_t}{(1 + r)^t} = 0$$

$r$ - EIRR.

- Benefit-cost ratio (BCR):

$$BCR = \sum_{t=1}^n \frac{B_t}{(1 + r)^t} \div \sum_{t=1}^n \frac{C_t}{(1 + r)^t}$$

# Sectoral examples: Water supply

Year	Capital expenditures	Additional operating and maintenance costs	Resource costs saved	Additional water consumption	Benefit for health	Net benefit
2020	4,634					-4,634
2021	11,122					-11,122
2022	22,245					-22,245
2023	23,171					-23,171
2024	21,318					-21,318
2025	10,195					-10,195
2026		899	5,840	4,275	7,061	16,277
2027		899	5,811	4,670	7,471	17,053
2028		899	5,800	5,068	7,902	17,870
2029		899	5,787	5,469	8,354	18,711
2030		899	5,751	5,874	8,829	19,555
2031		899	5,713	5,912	9,330	20,056
2032		899	5,695	5,950	9,858	20,604
2033		899	5,677	5,988	10,416	21,182
2034		899	5,636	6,026	11,005	21,768
2035		899	5,616	6,063	11,626	22,406
2036		899	5,596	6,100	12,281	23,078
2037		899	5,596	6,137	12,971	23,804
2038		899	5,574	6,173	13,700	24,547
2039		899	5,594	6,209	14,472	25,376
2040		899	5,572	6,247	15,281	26,200
2041		899	5,570	6,282	16,127	27,079
2042		899	5,544	6,314	16,992	27,951
2043		899	5,534	6,336	17,904	28,875
2044		899	5,524	6,358	18,864	29,847
2045		899	5,492	6,380	19,877	30,849
					EIRR =	14.84%
					9% NPV =	48,124

# Sectoral examples: Education

Year	Capital and operating costs	Cash and opportunity costs	Total	Benefits from increasing the number of graduates	Benefits from wages	Total	Net additional benefits	PV
2021	16.3		16.3				(16.3)	(14.9)
2022	23.9		23.9				(23.9)	(20.1)
2023	33.4	5.6	39.0	6.4	1.7	8.1	(30.9)	(23.8)
2024	40.6	6.1	46.7	6.4	5.7	12.1	(34.6)	(24.5)
2025	20.0	7.2	27.2	6.9	9.6	16.5	(10.7)	(6.9)
2026	16.1	7.2	23.3	6.9	14.4	21.3	(2.0)	(1.2)
2027	8.9	7.2	16.1	6.9	19.2	26.1	10.0	5.5
2028	18.4	7.2	25.6	6.9	23.9	30.8	5.2	2.6
2029	11.9	7.2	19.1	6.9	28.7	35.6	16.5	7.6
2030	11.9	7.2	19.1	6.9	33.5	40.4	21.3	9.0
2031-	143.2	71.9	215.1	69.3	619.3	688.6	473.5	116.9
2040								
							NPV	50.0
							EIRR	13.2%

# Risk analysis

- Sensitivity analysis
- Checking NPV for the probable scenarios with changed parameters

# Post-investment appraisal: comparison of initial and final parameters

- Talimarjan transmission project in Uzbekistan:

No	Project indicators	Unit of measurements	Before project implementation	Initial target values (from approval documents)	Actual target values following implementation
1	Reducing the number / duration of power outages in the project area	Hours per year	92	92	24
2	Increasing the supply of electricity to consumers in the southwestern part of Uzbekistan	GWh per year	16,333	22,200	17,460
3	Reducing the voltage range	%	10	5	4.3
4	Average interruption frequency per year in the project area	--	80.00	40.00	37.60



# Post-investment appraisal: comparison of initial and final parameters

- Support to the Land Administration and Geospatial System Modernization Project in Uzbekistan

No	Indicator name	Unit of measurements	Baseline	Actual achieved at completion
1	ICT Competence Center is established and trained in relevant international and industrial standards	Yes/No	N	Y
2	Staff trained in the digitization/data conversion and quality control that are implementing the new digitization methodology and quality control and acceptance activities	Number	0	450
3	Policy, standards and procedures for access and use of geospatial information and data prepared	Yes/No	N	Y
4	Business process review manual prepared	Yes/No	N	Y

# Post-investment appraisal: comparison of initial and final parameters

## ■ Pap-Angren Railway

No	Indicator name	Unit of measurements	Baseline	Actual achieved at completion
1	Transportation cost for public transport users per passenger	Amount(USD)	15.00	10.00
2	Freight cost for oil and oil products per tank	Amount(USD)	1,944.00	1,057.00
3	Pairs of passenger trains per day	Number	0.00	2.70
4	Construction of Power Distribution Line	Text	The power distribution line is not commissioned	The system is commissioned and operational.

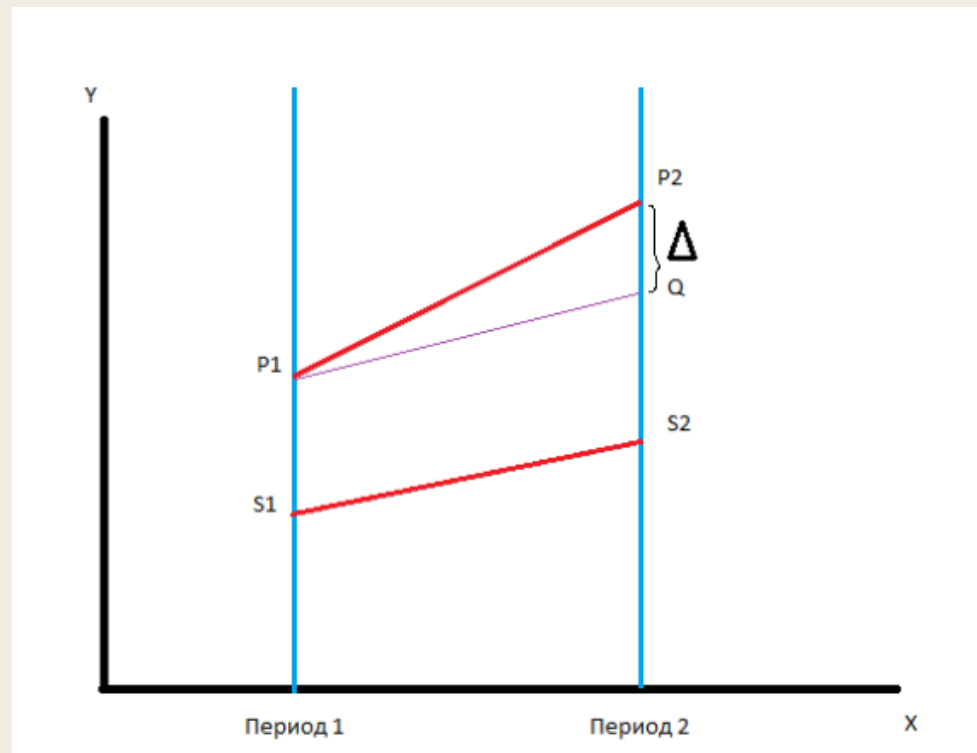
# Post-investment appraisal: comparison of initial and final parameters

- Syrdarya Water Supply Project

No	Indicator name	Unit of measurements	Baseline	Actual achieved at completion
1	People provided with access to improved water sources	Number	0	210000
2	Percentage of regulatory water samples meeting	Percentage	0	80
3	Increased water consumption of the served population (urban)	Liter	15	80
4	Increased water consumption of the served population (rural)	Liter	15	60

# Post-investment appraisal: econometric estimation

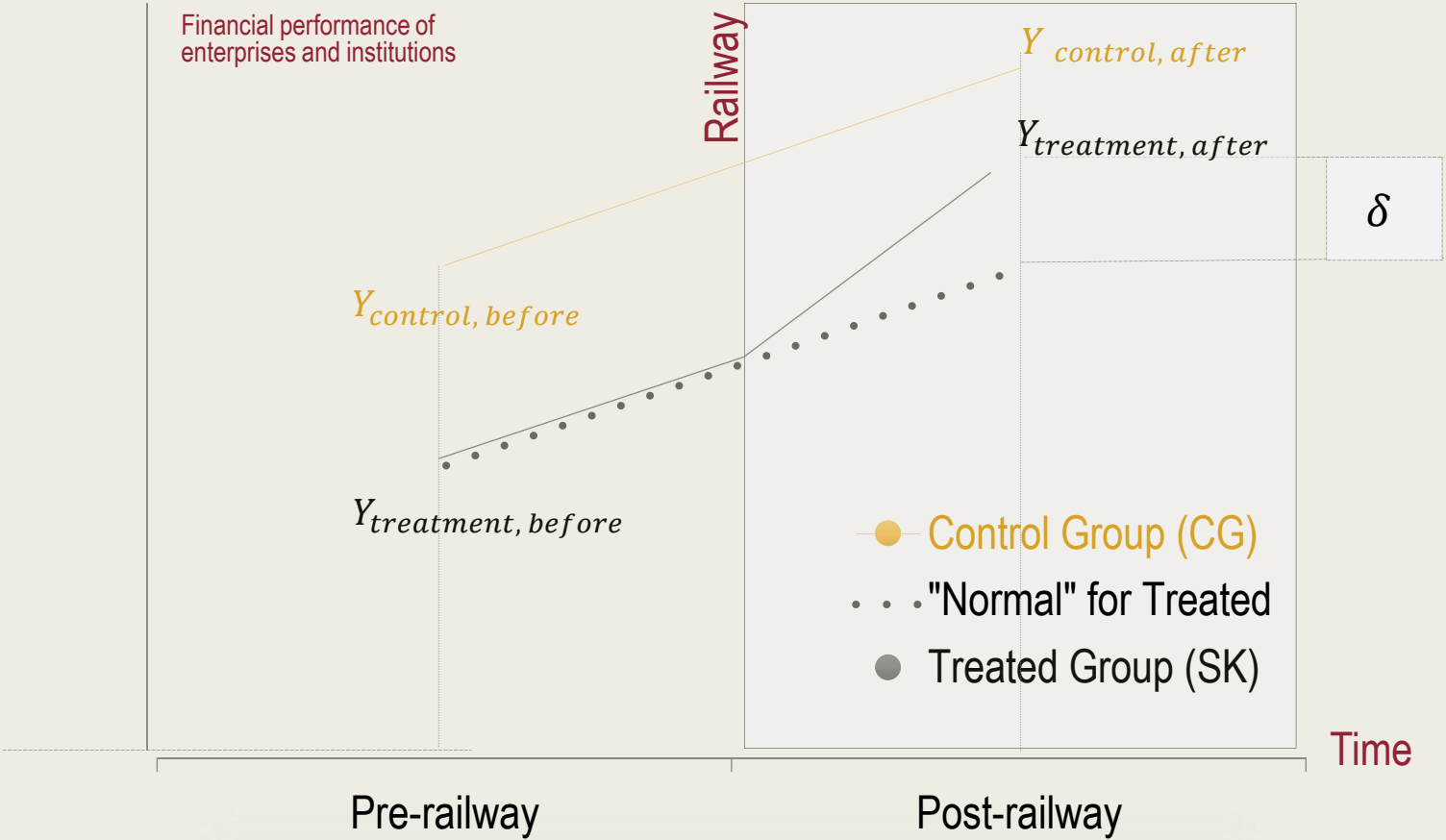
- After the implementation of the project and the passage of 3 years from the start of its operation
- Quantitative methods, including the econometric approach DID (difference in difference).



# Post-investment appraisal: an example

- Study by the Center for Economic Research and Reforms on the evaluation of investment infrastructure projects in Uzbekistan.
- The project for the construction of the Tashguzar-Boysun-Kumkurgan railway line, implemented in 2003-2007, was assessed.
- Variations over time and geographical location

# Methodology: difference-in-difference



Measure "outcomes" for both groups before and after introduction of railway

# Determinants of financial performance of enterprises and institutions

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- Financial performance is determined by:
  - *time-invariant region specific effects* ( $\gamma_i$ ) :
    - idiosyncratic features of a region proceeding from historical, cultural and social development
  - *year specific effects* ( $\varphi_t$ )
    - changes in legislation, overall business climate
  - *time varying covariates* ( $X_{it}$ )
    - External trade, labor force etc.

# Difference-in-difference: regression

- incorporating time varying covariates

$$\text{Control group } E[F_{0it}|i, t, X_{it}] = \alpha + \gamma_i + \varphi_t + X'_{it}\beta$$

$$\text{Treated group } E[F_{1it}|i, t, X_{it}] = E[Y_{0it}|i, t, X_{it}] + \delta$$

- $F_{it} = \alpha_i + \varphi_t + X'_{it}\beta + \delta(D_{rail} \times D_{post})_{it} + \epsilon_{it}$

$F_{it}$  - Financial performance of institutions and enterprises

$\alpha_i$  - sum of autonomous ( $\alpha$ ) and region specific ( $\gamma_i$ ) rate of growth

$\varphi_t$  - year specific growth effect

$X_{it}$  - time varying covariates

$(D_{rail} \times D_{post})_{it}$  - dummy variable indicating that observation belong

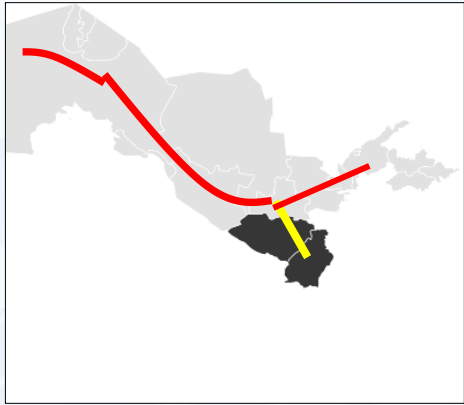
to treated group after treatment period

$\delta$  - difference in difference coefficient

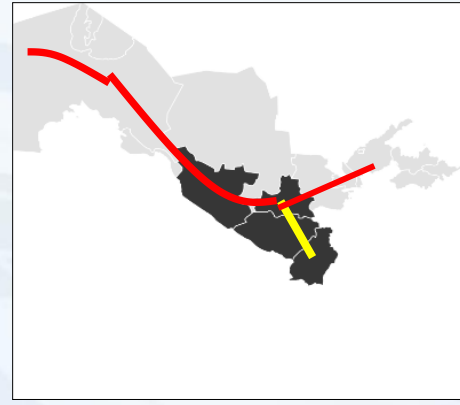
$\epsilon_{it}$  - error term



# Assumption about geographical focus



Regional effect (by region of infrastructure)



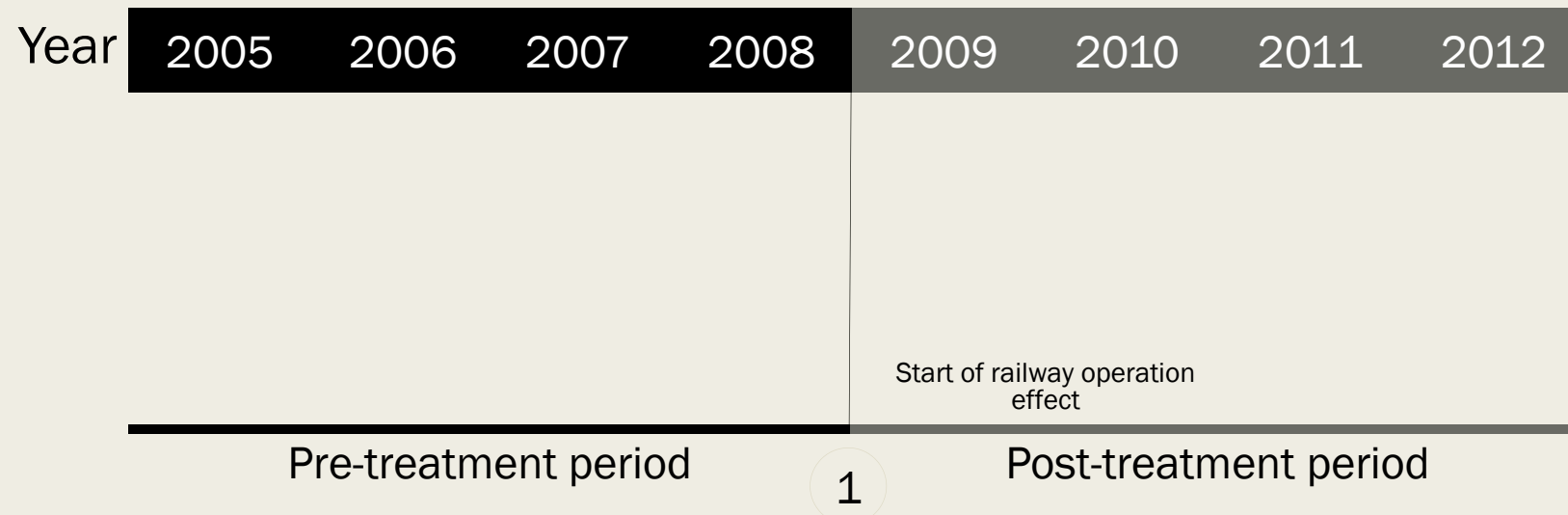
Spillover effect (by neighboring regions)



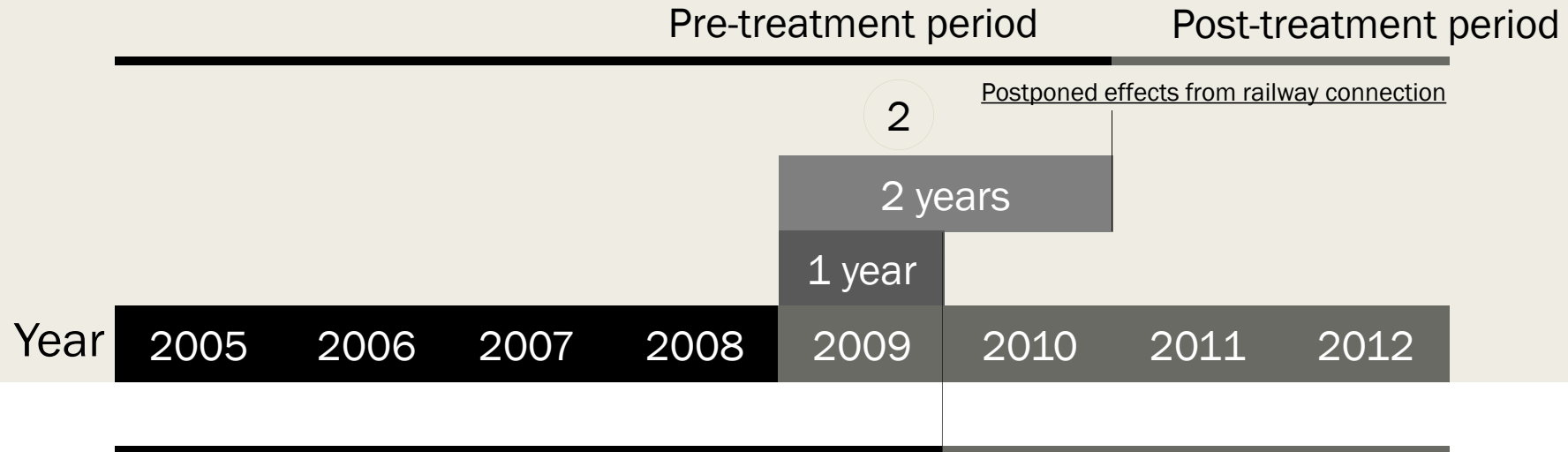
Connectivity effect (by terminal regions of the rail system)

# Launching effects

$$\frac{Y_{it} - Y_{it-1}}{Y_{it-1}} * 100 = \alpha_i + \varphi_t + X'_{it}\beta + (D_i \times D_{t>2008}) + \epsilon_{it}$$



# Postponed effects

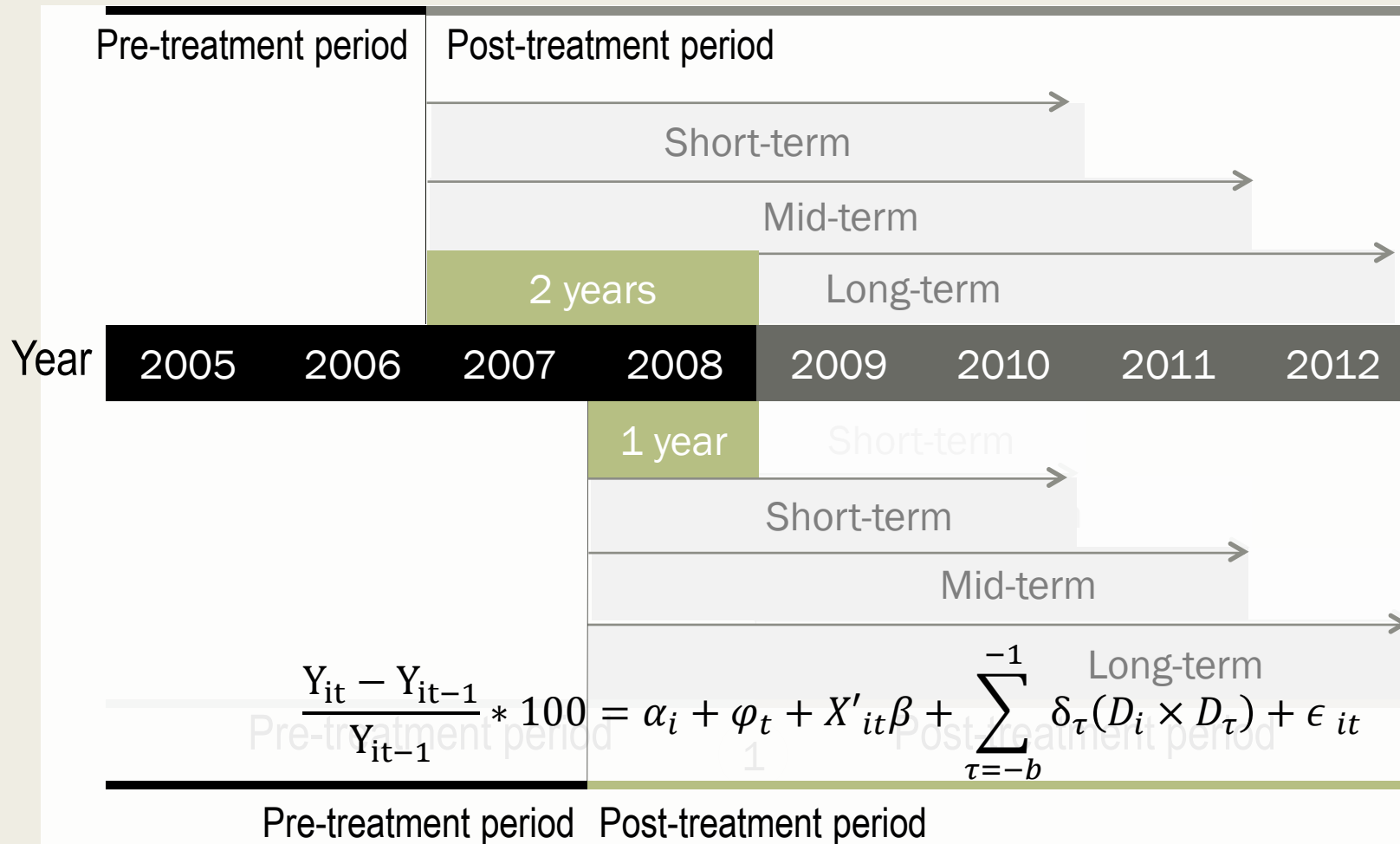


Pre-treatment period Post-treatment period

$$\frac{Y_{it} - Y_{it-1}}{Y_{it-1}} * 100 = \alpha_i + \varphi_t + X'_{it}\beta + (D_i \times D_{2012 > t > 2010}) + \epsilon_{it}$$

$$\frac{Y_{it} - Y_{it-1}}{Y_{it-1}} * 100 = \alpha_i + \varphi_t + X'_{it}\beta + (D_i \times D_{2012 > t > 2009}) + \epsilon_{it}$$

# Anticipation effects

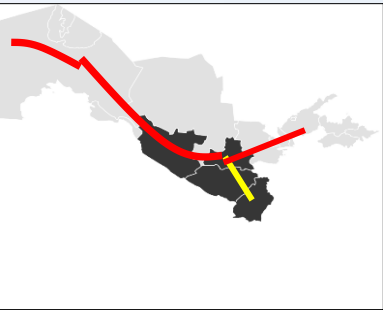
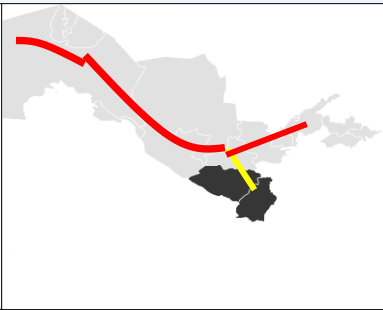
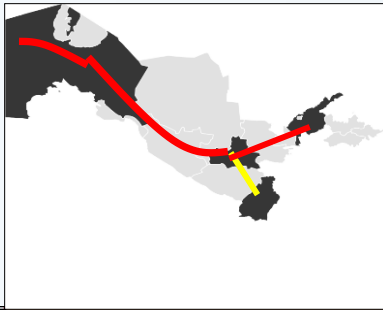


3 Anticipation effects of railway connection

# Post-investment appraisal: an example

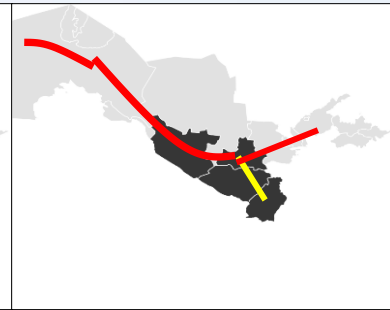
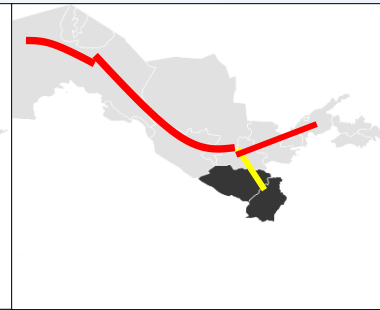
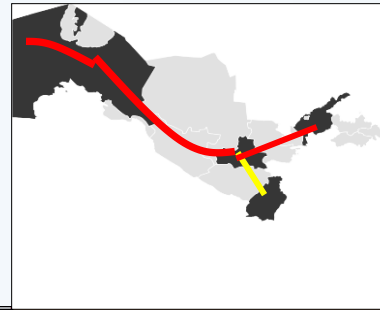
			Regional effects	Spillover effects	Connectivity effects
		$D_i$ $D_t$	$D_g = \text{regional}$	$D_g = \text{spillover}$	$D_g = \text{connectivity}$
Launch effects					
	Short term	$D_{t=(2010:2009)}$	22.886 (0.29)	-101.619 (1.60)	-33.880 (0.56)
	Medium term	$D_{t=(2011:2009)}$	245.747 (2.64)**	31.597 (0.40)	-29.421 (0.40)
	Long term	$D_{t=(2012:2009)}$	318.811 (3.53)**	81.156 (1.03)	-11.967 (0.16)
Anticipation effects					
1 year	Short term	$D_{t=(2010:2008)}$	-29.616 (0.40)	-82.686 (1.42)	-3.214 (0.06)
	Medium term	$D_{t=(2011:2008)}$	137.818 (1.44)	-11.762 (0.15)	-6.277 (0.08)
	Long term	$D_{t=(2012:2008)}$	206.355 (2.14)*	19.849 (0.25)	2.723 (0.04)
Postponed effects		$D_{t=(2012:2010)}$	491.275 (5.68)***	156.736 (2.02)*	5.601 (0.07)
Anticipation effects					
2 years	Short term	$D_{t=(2010:2007)}$	-33.313 (0.42)	-65.749 (1.08)	-33.678 (0.56)
	Medium term	$D_{t=(2011:2007)}$	95.749 (0.91)	-21.316 (0.25)	-35.996 (0.44)
	Long term	$D_{t=(2012:2007)}$	155.936 (1.43)	-0.905 (0.01)	-29.011 (0.34)
Postponed effects		$D_{t=(2012:2011)}$	559.690 (5.86)***	197.991 (2.32)*	12.941 (0.15)

# GDP



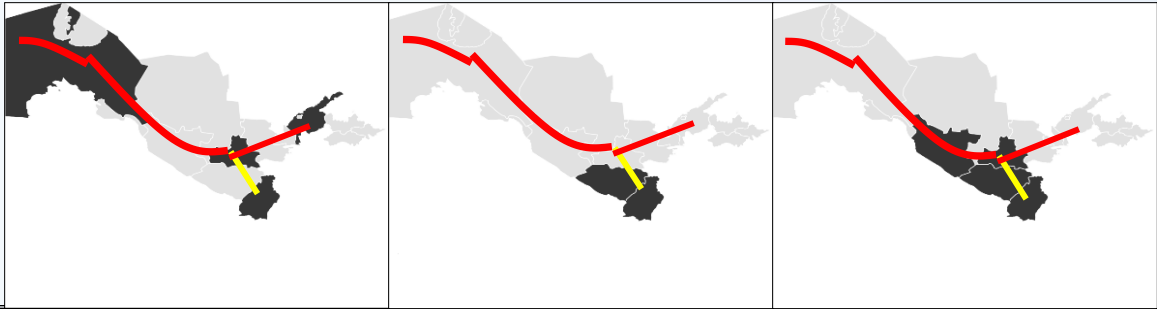
		$D_i$	$D_{g = \text{connectivity}}$	$D_{g = \text{regional}}$	$D_{g = \text{spillover}}$
<b>Launch effects</b>					
	Short-term	$D_{t=2010:2009}$	<b>2.83***[4.48]</b>	0.70[0.45]	1.33[1.14]
	Mid-term	$D_{t=2011:2009}$	<b>2.5***[6.88]</b>	0.36[0.29]	1.27[1.46]
	Long-term	$D_{t=2012:2009}$	<b>2.06***[3.04]</b>	-0.42[-0.29]	2.29**[2.94]
<b>Anticipation effects</b>					
1 year	Short-term	$D_{t=2010:2008}$	0.19[0.33]	0.85[1.75]	-0.18[-0.20]
	Mid-term	$D_{t=2011:2008}$	0.31[0.51]	0.64[1.30]	-0.02[-0.03]
	Long-term	$D_{t=2012:2008}$	0.07[0.13]	-0.006[-0.01]	0.50[0.67]
	<b>Postponed effects</b>	$D_{t=2012:2010}$	1.76*[1.95]	-1.49[-0.72]	2.58*[2.03]
<b>Anticipation effects</b>					
2 years	Short-term	$D_{t=2010:2007}$	-1.54[-1.66]	1.42[0.78]	-1.32[-0.92]
	Mid-term	$D_{t=2011:2007}$	0.32[0.44]	0.84[1.42]	0.13[0.13]
	Long-term	$D_{t=2012:2007}$	0.11[0.15]	0.10[0.16]	0.87[1.19]
	<b>Postponed effects</b>	$D_{t=2012:2011}$	-0.14[-0.20]	-1.71[-1.35]	1.05[1.44]

# Agriculture



		$D_i$	$D_{g = \text{connectivity}}$	$D_{g = \text{regional}}$	$D_{g = \text{spillover}}$
<b>Launch effects</b>					
	Short-term	$D_{t=2010:2009}$	<b>2.95*[1.91]</b>	1.35[0.70]	0.69[0.53]
	Mid-term	$D_{t=2011:2009}$	<b>2.06*[2.09]</b>	0.14[0.07]	0.43[0.33]
	Long-term	$D_{t=2012:2009}$	<b>0.98[1.48]</b>	-0.68[-0.65]	-0.11[-0.11]
<b>Anticipation effects</b>					
1 year	Short-term	$D_{t=2010:2008}$	0.66[0.60]	0.35[0.49]	-1.05[-1.29]
	Mid-term	$D_{t=2011:2008}$	0.32[0.35]	-0.39[-0.56]	-1.05[-1.32]
	Long-term	$D_{t=2012:2008}$	-0.56[-0.81]	<b>-1.25*[-1.82]</b>	<b>-1.98**[-2.79]</b>
	<b>Postponed effects</b>	$D_{t=2012:2010}$	-1.11[-0.99]	-0.98[-1.30]	0.28[0.29]
<b>Anticipation effects</b>					
2 years	Short-term	$D_{t=2010:2007}$	-1.03[-0.85]	-0.26[-0.14]	-1.95[-1.40]
	Mid-term	$D_{t=2011:2007}$	-1.18[-1.41]	-0.20[-0.27]	-0.87[-1.11]
	Long-term	$D_{t=2012:2007}$	<b>-2.48***[-3.79]</b>	-1.16[-0.60]	-1.97[-1.66]
	<b>Postponed effects</b>	$D_{t=2012:2011}$	-1.71[-1.25]	<b>-3.19**[-2.23]</b>	-1.14[-1.07]

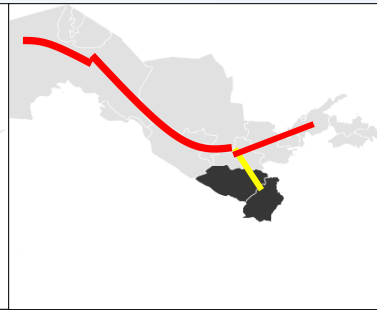
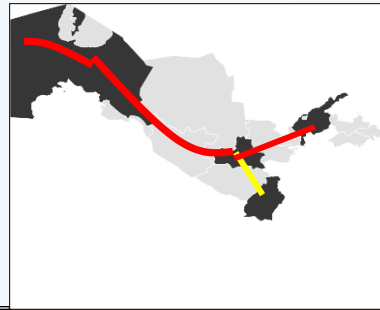
# Industry



		$D_i$	$D_{g = \text{connectivity}}$	<b>Regional effect</b> $D_{g = \text{regional}}$	<b>Spillover effect</b> $D_{g = \text{spillover}}$
<b>Launch effects</b>		$D_t$			
	Short-term	$D_{t=2010:2009}$	5.27*[1.94]	3.14[0.68]	2.82[0.99]
	Mid-term	$D_{t=2011:2009}$	4.5[1.61]	2.56[0.80]	2.13[0.83]
	Long-term	$D_{t=2012:2009}$	5.23[1.51]	3.16[0.67]	3.54[0.92]
1 year	<b>Anticipation effects</b>				
	Short-term	$D_{t=2010:2008}$	2.47[1.74]	<b>3.89**[2.60]</b>	<b>4.03**[2.58]</b>
	Mid-term	$D_{t=2011:2008}$	2.53[1.50]	<b>3.69*[2.02]</b>	<b>3.43*[2.02]</b>
	Long-term	$D_{t=2012:2008}$	3.79[1.68]	<b>4.62[1.51]</b>	<b>5.13*[1.85]</b>
	<b>Postponed effects</b>	$D_{t=2012:2010}$	6.12[1.65]	-0.21[-0.03]	3.92[0.95]
2 years	<b>Anticipation effects</b>				
	Short-term	$D_{t=2010:2007}$	-0.85[-0.25]	4.81[0.71]	4.01[1.07]
	Mid-term	$D_{t=2011:2007}$	3.90*[1.93]	3.68[1.23]	5.21**[2.33]
	Long-term	$D_{t=2012:2007}$	5.83**[2.72]	4.60[1.37]	8.14[2.45]
	<b>Postponed effects</b>	$D_{t=2012:2011}$	1.61[0.46]	1.15[0.27]	0.61[0.19]



# Services



		$D_i$	$D_{g = \text{connectivity}}$	$D_{g = \text{regional}}$	$D_{g = \text{spillover}}$
<b>Launch effects</b>					
	Short-term	$D_{t=2010:2009}$	<b>7.76***[3.07]</b>	-3.90[-0.53]	0.03[0.01]
	Mid-term	$D_{t=2011:2009}$	<b>6.48**[2.41]</b>	-1.83[-0.22]	0.37[0.09]
	Long-term	$D_{t=2012:2009}$	<b>6.92***[2.72]</b>	-1.45[-0.17]	3.08[0.71]
<b>Anticipation effects</b>					
1 year	Short-term	$D_{t=2010:2008}$	4.20[1.67]	-3.58[-0.70]	-2.95[-0.83]
	Mid-term	$D_{t=2011:2008}$	4.07[1.39]	-2.31[-0.35]	-2.34[-0.59]
	Long-term	$D_{t=2012:2008}$	5.41[1.69]	-2.17[-0.31]	-0.85[-0.20]
	<b>Postponed effects</b>	$D_{t=2012:2010}$	0.88[0.29]	-0.02[-0.01]	3.05[0.80]
<b>Anticipation effects</b>					
2 years	Short-term	$D_{t=2010:2007}$	4.70**[2.19]	0.40[0.10]	-3.23[-0.82]
	Mid-term	$D_{t=2011:2007}$	4.62[1.72]	-0.24[-0.05]	-2.63[-0.78]
	Long-term	$D_{t=2012:2007}$	6.61**[2.27]	0.38[0.07]	-0.90[-0.26]
	<b>Postponed effects</b>	$D_{t=2012:2011}$	1.33[0.47]	3.03[0.57]	4.02[1.53]