Does Infrastructure Contribute To Economic Growth? Micro-level Evidence From Transportation Projects In China

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Conventional Theory Supports Infrastructure Investment

- Core infrastructure investments are a major determinant of total factor productivity (Aschauer 1989)
- Infrastructure supports increased income and productivity (Fan & Zhang 2004, Donaldson 2010)
- Infrastructure enhances the growth rate of output (Sanchez-Robles1998, Démurger 2001)
- Positive externality and spillover effects (Röller & Waverman 2001, Pereira & Roca-Sagalés 2003)

Conventional Theory: Propositions

Proposition 1

- A larger stock of infrastructure will fuel economic growth by raising private investment.

Proposition 2

- Non-military infrastructure investment acts as a cost-saving mechanism through productivity gains of input factors even in the private sector.

Proposition 3

- Infrastructure causes growth by reducing the cost of production and transportation of goods and services, which increases competitiveness.

Proposition 4

- Investment in infrastructure creates wider economic benefits.

Why Infrastructure Investments Appear So Appealing

1. Creates direct employment
2. Large share of domestic inputs relative to imports
3. Improves productivity by lowering producer costs
4. Benefits consumers through better services
5. Has potential for improving environment

Fine Print: If it is done right!

Case in Point: China

1. In the **five years** 2004-8, China has spent more on infrastructure in real terms than in the whole of the **20th Century**.

2. In the **four years** 2005-8, China has built as many miles of high-speed rail as Europe in **two decades**.

Infrastructure & Growth Paradox

Despite tall claims in the theoretical literature about the macro-level positive effects of large infrastructure investments, the economic, social, and environmental track record at the project-level is strikingly poor. Can the macro versus micro-level evidence be reconciled?

Infrastructure Major Project Performance Map*

	Roads	Links	Energy	Rail	Large Dams	IT	Olympics
Cost overrun	20%	34%	36%	45%	**96%**	107%	219%
Frequency of cost overrun	9 of 10	9 of 10	6 of 10	9 of 10	**7 of 10**	5 of 10	10 of 10
Schedule overrun	38%	23%	38%	45%	**44%**	37%	0%
Benefits shortfall	10%	n/a	n/a	-51%	**-11%**	-29%	n/a
Cost Black Swans	5%	9%	7%	6%	**10%**	18%	6%
Ø duration (years)	5.5	8.0	5.3	7.8	**8.6**	3.3	7.0

*Source: Bent Flyvbjerg, Atif Ansar, Alexander Budzier, Chantal Cantarelli, Allison Stewart and colleagues, University of Oxford.

"Lying with Numbers": Machiavelli's Formula

(underestimate costs)
+ (overestimate revenues)
+ (undervalue environmental impacts)
+ (overvalue development effects)

= **(funding/sale)**

SOURCE: Bent Flyvbjerg (2014)

Inverted Darwinism

Max(B/C) at approval

= Max(benefit shortfall, cost overrun) at implementation

= Max (size and frequency of disasters)

= **Survival of the un-fittest!**

SOURCE: Bent Flyvbjerg (2009)

Planning Fallacy & Over-Optimism

- Human judgement under uncertainty is prone to systematic biases (rather than random errors)
- Experts and laypersons alike are too optimistic about the costs, times to task completion, and the benefits of their decisions

Data & Methods

Methodologically, our approach is motivated by the use of multiple cases grounded in Eisenhardt's (1989, 1991) call that by enabling the identification of "cross-case patterns" (Eisenhardt, 1989: 540), "multiple cases are a powerful means to create theory because they permit replication and extension among individual cases" (Eisenhardt, 1991: 620)

We chose to study **six typical cases** of road transportation investments in China financed by the World Bank (WB) and/or the Asian Development Bank (ADB)

We chose WB/ADB (collectively, International Financial Institutions, IFIs) financed projects for the following reasons:

i) IFI documents are broadly consistent from project to project making it possible to conduct cross-case comparisons across time and geography;
ii) Documents are publicly available, or disclosure can be sought, and open to public challenge with regards to their veracity;
iii) Documents contain valid, reliable, and verifiable *ex ante* and *ex post* data on the physical scope, schedule, cost, and demand of projects—most of the essential data we needed that fit our criteria to evaluate investment outcomes as also described in seminal planning literature (Pickrell, 1989, 1992; Flyvbjerg et al. 2002, 2003).

We chose road transportation projects as our empirical setting because:

i) On the demand-side, road transportation is considered to be one of the most basic and homogenous social goods with inelastic demand. Reducing transport costs is seen as the essential feature of infrastructure investments. Consequently, literature suggests that demand for roads is easily predictable. If the conventional theory could be shown to be weak in its application even to roads, its overall validity can be brought under serious doubt.
ii) On the supply-side, the design of conventional road assets and networks are seen as a widely studied engineering problem, or what conventional theory might consider "a standardized production technology" (Sidak and Spulber, 1997). The cost of supplying roads should contain few surprises, the convention theory predicts.

We chose China because:

i) The country has experienced high economic growth routinely associated with its high infrastructure spending
ii) China is perceived to be competitive advantage in delivering infrastructure due to low input costs, an autocratic political system and perceived high demand due to a large population.

Measures

- Standard Methods for Measuring Cost Overrun

1. $O = C_a/C_e$ (ratio)
2. $O = (C_a/C_e-1)x100$ (percentage)

Where

O = Overrun in ratio or percent

C_a = Actual costs

C_e = Estimated costs **at date of decision to build**

All costs measured in **constant (real) prices**

- Similar methods are applied to calculate schedule under/overrun and benefit shortfall or excess

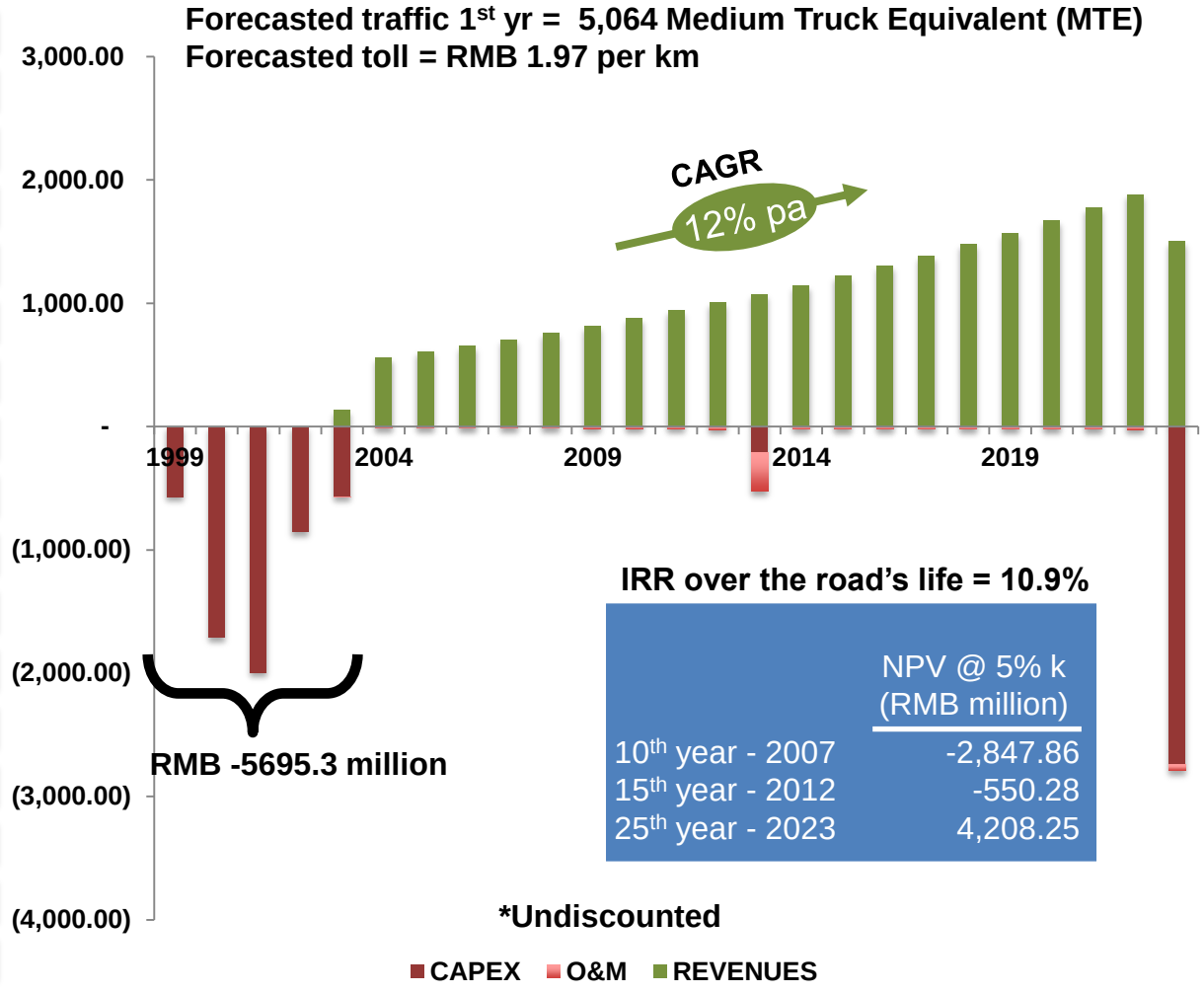
Evidence from China

World Bank or Asian Development Bank ID	Project Name	Type	Physical Features, at opening	Date of Decision (DoD) to Build (yr:mo)	Estimated Schedule (Years)	Actual Schedule (Years)	Schedule Overrun Ratio	Cost Overrun Ratio (RMB constant prices)	Benefit Shortfall Ratio
1387-PRC	Baodi-Shanhaiguan (section of Beijing-Qinhuangdao (Jing-Qin)) Expressway, 1995-1999	Road - Expressway	199 km toll expressway, 2X2 lns, 3.75 m width for each driving lane.	1995:5	5.1	3.7	0.73	**1.15**	0.59
1325-PRC	Chuxiong-Dali Expressway, 1994-1998	Road - Expressway	179 km toll expressway, 2X2 lns	1994:4	4.1	4.3	1.05	**1.31**	0.47
P040513	Luoyang-Sanmenxia Highway, 1996-2001	Road - Expressway	136 km toll expressway, 2X2 lns, including supply and installation of electrical, electronic and mechanical equipment for toll collection, telecommunication and lighting facilities, as well as construction of service areas and management and maintenance buildings	1996:5	5.1	5.6	1.1	**1.24**	0.55
P003530	Sanyuan-Tongchuan Highway, 1987-1993	Road - Class 1 Highway	51.3 km toll Class 1 Highway, 2X2 lns, (includes an additional 15.1 km two-lane class II highway)	1987:6	3.6	6	1.67	**1.44**	0.51
P041268	Tucheng-Changsha Expressway, 1999-2002	Road - Expressway	183 km toll expressway, 2X2 lns, (an additional 30km of 2 lane interconnecting approaches). Includes 11 interchanges, service areas, facilities for expressway administration and maintenance and electrical and mechanical (E&M) installations for toll collection, traffic monitoring, telecommunications and lighting.	1999:6	3.2	3.4	1.06	**1.26**	0.76
1691-PRC	Yuanjiang-Mohei Expressway, 1999-2003	Road - Expressway	147 km toll expressway, 2X2 lns, including nine interchanges as planned at appraisal, large and medium bridges totaling about 31,409 linear meters, and tunnels totaling about 12,764 linear meters. 3 service areas.	1999:01	4.8	5	1.04	**1.24**	0.51

Case Study:
Yuanjiang-Mohei Expressway, 1999-2003.
Yunnan Province, China

ADB's Estimates of Financial Return at Appraisal[1]

	CAPEX*	O&M*	REVENUES*
1999	-569.50	-	-
2000	-1,708.60	-	-
2001	-1,993.40	-	-
2002	-854.30	-	-
2003	-569.50	-3.50	128.30
2004	-	-14.40	553.30
2005	-	-14.70	607.90
2006	-	-15.10	654.10
2007	-	-15.50	703.10
2008	-	-15.90	754.90
2009	-	-16.40	809.80
2010	-	-16.80	877.20
2011	-	-17.30	938.00
2012	-	-24.90	1,002.50
2013	-214.10	-309.80	1,071.00
2014	-	-21.00	1,142.60
2015	-	-21.40	1,218.40
2016	-	-21.70	1,298.50
2017	-	-22.10	1,383.20
2018	-	-22.50	1,472.80
2019	-	-22.90	1,567.60
2020	-	-23.40	1,668.00
2021	-	-23.80	1,771.30
2022	-	-24.30	1,880.60
2023	-2,740.60	-47.10	1,497.20



[1]SOURCE: Asian Development Bank 1999 (p. 82). China Southern Yunnan Road Development Project. Report and Recommendation of the President, Report No: 30081, 1 May 1999, Manila: Asian Development Bank. [ADB ID: 1691-PRC]. Document can be accessed at: http://www.adb.org/projects/documents/southern-yunnan-road-development-project

ADB's Estimates of Financial Return at Completion

Table A14.3: Financial Internal Rate of Return[1]
(CNY million)

Year	Capital Investment	Operation and Maintenance Costs	Project Revenues	Business Tax	Corporate Income Tax	Net Cash Flow After Income Tax
2000	668.7	0.0	0	0.0	0	(668.7)
2001	1,546.4	0.0	0	0.0	0	(1,546.4)
2002	1,780.1	0.0	0	0.0	0	(1,780.1)
2003	1,432.0	0.0	0	0.0	0	(1,432.0)
2004	1,641.5	4.7	108	6.1	0	(1,554.0)
2005	0.0	0.5	170	9.5	0	139.7
2006	0.0	1.6	193	10.8	0	160.4
2007	0.0	2.9	219	12.3	0	183.8
2008	0.0	4.2	[illegible]	14.7	0	223.2
2009	0.0	5.6	[illegible]	16.7	0	255.6
2010	0.0	7.0	[illegible]	19.0	0	292.8
2011	0.0	8.8	[illegible]	21.0	0	325.1
2012	0.0	0.7	415	23.2	0	360.9
2013	0.0	2.7	456	25.5	0	398.0
2014	0.0	4.8	502	28.1	0	439.0
2015	260.6	37.0	552	30.9	0	223.5
2016	0.0	9.4	607	34.0	49	484.8
2017	0.0	1.9	667	37.3	62	525.4
2018	0.0	4.7	733	41.0	74	572.5
2019	0.0	7.6	805	45.1	88	624.5
2020	0.0	0.6	885	49.5	93	691.3
2021	0.0	3.3	959	53.7	106	746.7
2022	0.0	6.2	1,040	58.3	120	806.3
2023	0.0	9.2	1,128	63.2	134	872.1
2024	0.0	2.4	1,224	68.5	149	943.7
2025	(3,420.0)	5.7	1,326	74.3	164	4,441.9
FIRR before corporate tax = 4.5%				FIRR after corporate tax = 4.1%		

FIRR = financial internal rate of return.

RMB -7068.7 million

CAGR 13% pa

O&M costs and periodic upgrade costs miraculously reduced nearly 80%!

RMB -309.8 million to only RMB -37.0 million without explanation

NPV @ 5% k < 0 for all time horizons

[1]SOURCE: Asian Development Bank 2006 (p. 54). China Southern Yunnan Road Development Project. Project Completion Report, Report No: 30081, 1 February 2006, Manila: Asian Development Bank. [ADB ID: 1691-PRC]. Document can be accessed at: http://www.adb.org/projects/documents/southern-yunnan-road-development-project

2Contant (1999) Yuan.

Traffic Forecasts: Before vs. After

ORIGINAL FORECAST AT APPRAISAL

Table A12.1 Traffic Forecast at Appraisal for the Yunnan YuanMo Expressway, Selected Years

Year	Average Annual Daily Traffic			
	Passenger (in vehicles)	Freight (in vehicles)	Total (in vehicles)	Total (in MTEs)
2003	2,127	3,836	5,963	5,064
2005	2,529	3,899	6,428	5,451
2010	3,683	6,486	10,169	8,565
2015	5,088	8,931	14,019	11,806
2020	6,930	12,120	19,050	16,040
2023	8,335	14,493	22,828	19,204

MTE = medium-truck equivalent.

REVISED FORECAST AT COMPLETION

Table A12.2 Traffic Forecast by the PCR Mission for the Yunnan YuanMo Expressway, Selected Years
(average annual daily traffic)

Year	Passenger (in vehicles)	Freight (in vehicles)	Total (in vehicles)	Total (in MTEs)
2005	2,633	2,391	5,025	3,895
2010	4,012	3,536	7,547	5,896
2015	6,583	5,653	12,237	9,560
2020	10,559	8,813	19,372	15,247
2023	13,272	10,344	13,616	18,893

MTE = medium truck equivalent, PCR = project completion review.

Note: 1 passenger car or minibus=0.5 MTE, 1 large bus or medium truck=1 MTE, one large truck and trailer=1.5 MTEs.

SOURCE: Asian Development Bank 2006 (p. 46). China Southern Yunnan Road Development Project. Project Completion Report, Report No: 30081, 1 February 2006, Manila: Asian Development Bank.

"At appraisal, average annual daily traffic along the proposed Yunnan YuanMo expressway in 2003, the first year it would be in use, was estimated at 5,064 MTEs, and was projected to grow to 8,565 MTEs by 2010 and 19,204 MTE by 2023.

Actual traffic was 2,597 MTEs in 2004, about 49% lower than that forecast at appraisal"

"At appraisal, the ratio of passenger to freight vehicles per day on the project expressway was expected to be 36:64, whereas the actual ratio was 52:48." (World Bank, 2006: 43).

Actual first full year of operation = 2,597 MTE
Estimated first full year of operation = 5,064 MTE
Traffic demand shortfall = 2,597/5,064 = 0.51
Or a -49% shortfall.

As of **5 May 2011** the traffic count (total vehicles and not Medium-Truck Equivalent) was still **only 5,400** vehicles **over 35%** lower than even the revised forecast*.

*SOURCE:
http://yn.people.com.cn/GB/212782/14569266.html

Traffic Forecasts: Before vs. After

ORIGINAL FORECAST AT APPRAISAL

Table 4: Proposed Toll Rates for the Project Expressway
(Yuan per vehicle-km – 1999 prices)

Vehicle Type	Proposed Toll
Small Passenger Car	0.35
Large Passenger Car	0.75
Small Truck	1.20
Medium Truck	2.30
Large Truck	3.10
Truck with Trailer	3.60

SOURCE: ADB (1999: 31)

Actual Weighted Avg. Toll Rate = RMB 0.92
Estimated Weighted Avg. Toll Rate Toll = RMB 1.97

Toll price shortfall = 0.92/1.97 = 0.47

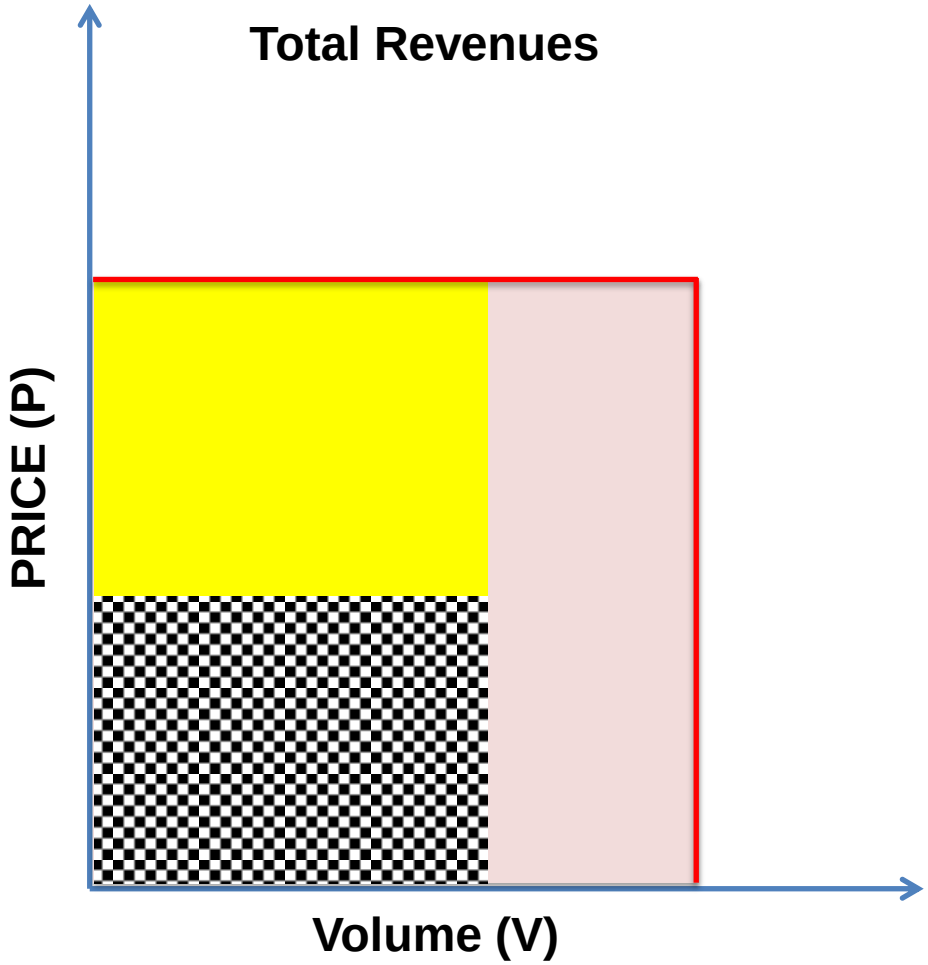
Or a -53% shortfall.

REALITY AT COMPLETION

"Giving due consideration to affordability by road users and other social and economic impacts, the existing weighted, average toll rates are lower than those proposed at appraisal: CNY0.92 per km–MTE compared with CNY1.97 per km–MTE."

SOURCE: ADB (2006: 11).

The Incredibly Shrinking Revenues

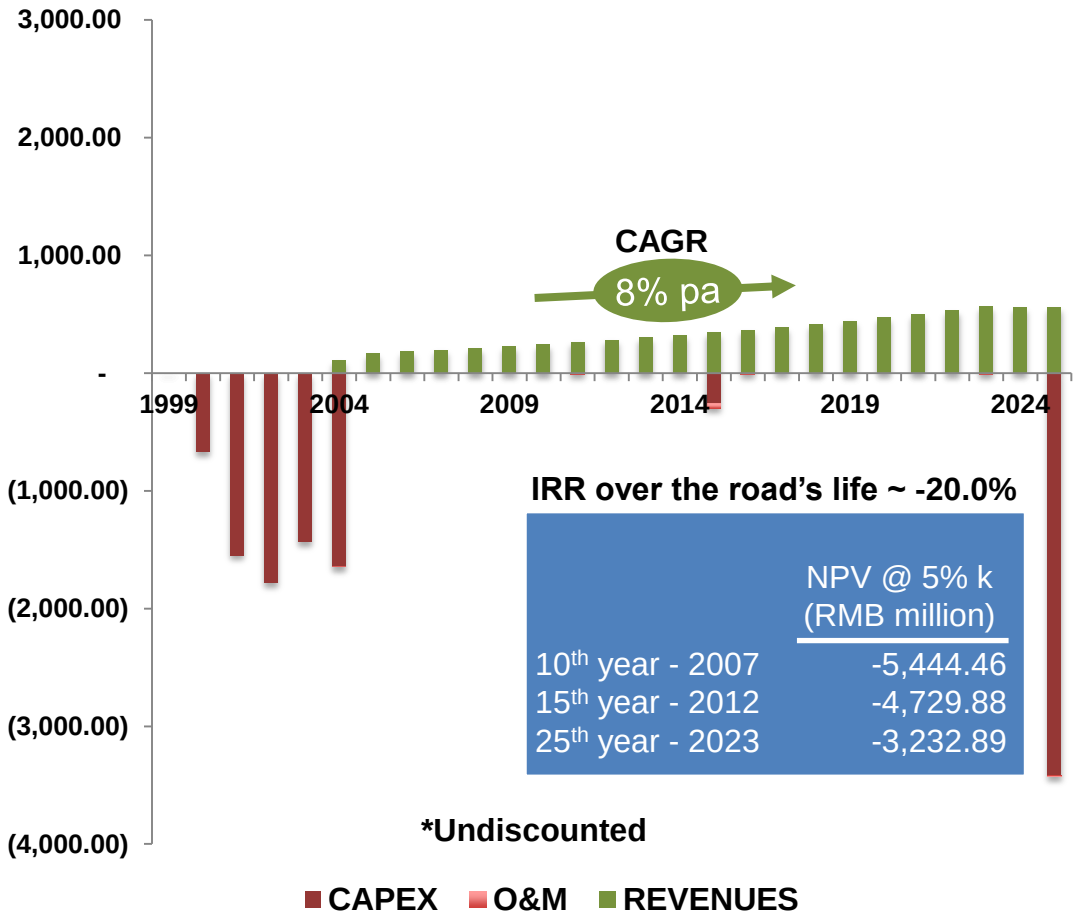


- What effect do traffic counts 35-49% lower than estimated and toll prices 53% lower than estimated have on cash flows?
- V * P = R
- 0.65V * 0.47P = 0.31R

The Real Financial Return At Completion

	CAPEX*	O&M*	REVENUES*
1999	-	-	-
2000	-668.70	-	-
2001	-1,546.40	-	-
2002	-1,780.10	-	-
2003	-1,432.00	-	-
2004	-1,641.50	-4.70	108.00
2005	-	-0.50	165.99
2006	-	-1.60	182.37
2007	-	-2.90	196.23
2008	-	-4.20	210.93
2009	-	-5.60	226.47
2010	-	-7.00	242.94
2011	-	-8.80	263.16
2012	-	-0.70	281.40
2013	-	-2.70	300.75
2014	-	-4.80	321.30
2015	-260.60	-37.00	342.78
2016	-	-9.40	365.52
2017	-	-1.90	389.55
2018	-	-4.70	414.96
2019	-	-7.60	441.84
2020	-	-0.60	470.28
2021	-	-3.30	500.40
2022	-	-6.20	531.39
2023	-	-9.20	564.18
2024	-	-2.40	560.00
2025	-3,420.00	-5.70	560.00

SOURCE: ADB (2006: 54)



Obfuscation Gets Worse with "Wider Economic Benefits"

	Before (RMB million)				AFTER (RMB million)				
	VOC Savings	VOT Savings	VOA Savings	**Total Wider Economic Benefits**	VOC Savings	VOT Savings	VOA Savings	Benefits from additional traffic generated	**Total Wider Economic Benefits**
1999	-	-	-	**-**	-	-	-	-	**-**
2000	-	-	-	**-**	-	-	-	-	**-**
2001	-	-	-	**-**	-	-	-	-	**-**
2002	-	-	-	**-**	-	-	-	-	**-**
2003	310.80	6.80	15.90	**333.50**	-	-	-	-	**-**
2004	1,245.00	28.20	64.80	**1,337.90**	263.13	20.25	33.26	17.30	**333.93**
2005	1,247.70	29.60	66.80	**1,344.00**	394.50	30.35	49.86	25.94	**500.65**
2006	1,245.60	30.70	68.50	**1,344.80**	467.40	38.91	53.72	30.18	**590.22**
2007	1,248.30	31.90	70.60	**1,350.70**	552.79	49.73	57.86	35.13	**695.50**
2008	1,251.10	33.10	72.90	**1,357.10**	652.70	63.37	62.31	40.88	**819.25**
2009	1,254.10	34.50	75.50	**1,364.10**	769.51	80.56	67.08	47.57	**964.72**
2010	1,253.00	36.10	79.10	**1,368.20**	905.97	102.20	72.19	55.35	**1,135.71**
2011	1,258.70	37.60	82.40	**1,378.80**	1,061.71	124.01	79.34	62.26	**1,327.32**
2012	1,262.80	39.20	86.30	**1,388.30**	1,242.19	150.39	87.18	70.02	**1,549.78**
2013	1,260.70	40.80	90.70	**1,392.20**	1,451.18	182.28	95.77	78.76	**1,807.99**
2014	1,265.00	42.50	95.60	**1,403.10**	1,692.98	220.83	105.19	88.58	**2,107.58**
2015	1,269.60	44.40	101.10	**1,415.10**	1,972.56	267.41	115.51	99.63	**2,455.10**
2016	1,276.80	46.30	107.30	**1,430.40**	2,295.59	323.67	126.81	112.05	**2,858.13**
2017	1,283.20	48.30	114.30	**1,445.90**	2,668.59	391.61	139.19	126.03	**3,325.43**
2018	1,281.50	50.50	122.30	**1,454.20**	3,099.03	473.64	152.75	141.75	**3,867.18**
2019	1,288.50	52.80	131.10	**1,472.40**	3,595.49	572.65	167.61	159.43	**4,495.17**
2020	1,308.60	55.20	141.20	**1,504.90**	4,167.76	692.11	183.87	179.31	**5,223.06**
2021	1,318.80	57.80	152.40	**1,528.90**	4,388.21	747.43	197.13	200.06	**5,532.83**
2022	1,297.90	60.50	165.10	**1,523.40**	4,611.63	806.96	211.34	223.22	**5,853.15**
2023	1,012.30	47.50	134.50	**1,194.40**	4,836.38	871.02	226.56	249.05	**6,183.01**
2024	Not included				5,060.41	939.90	242.85	277.87	**6,521.03**
20225					5,281.24	1,013.93	260.30	310.03	**6,865.50**
EIRR	**17.40%**				**16.80%**				

VOA = value of accident, VOC = vehicle operating cost, VOT = value of time.

Keep It Simple Stupid (KISS)

Cash flow is King
(user fees or demonstrable tax revenues)

GDP is a poor measure to link to infrastructure

Less Is More

Improve the efficiency and productivity of assets

