

Infrastructure and Economic Growth in Egypt

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The Context

- Remarkable progress in Egypt's infrastructure in last 50 years
- This has supported a strong economic growth performance and contributed to social welfare
- Such progress is the result of decades of purposeful and substantial investment

Motivation

- In last 15 years, a decline in infrastructure investment has been observed
- Is this a worrisome trend?
 - The rate of progress has declined
 - There is still much room for progress

Objective

- This study analyzes the situation, trends, and effects of infrastructure in Egypt
 - From an international perspective
 - Emphasis on the long run
 - Focusing on major sectors: electricity generation, transportation, telecommunication, and water and sanitation

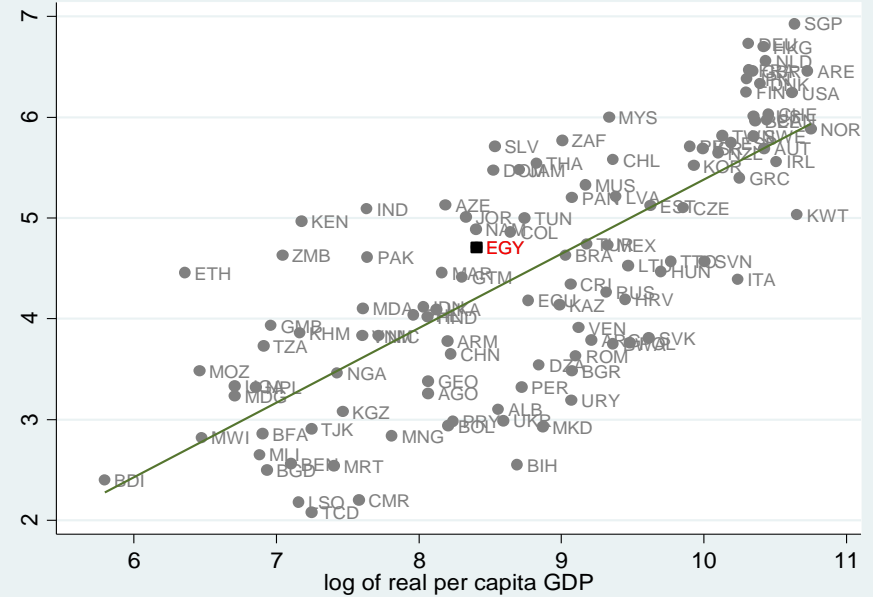
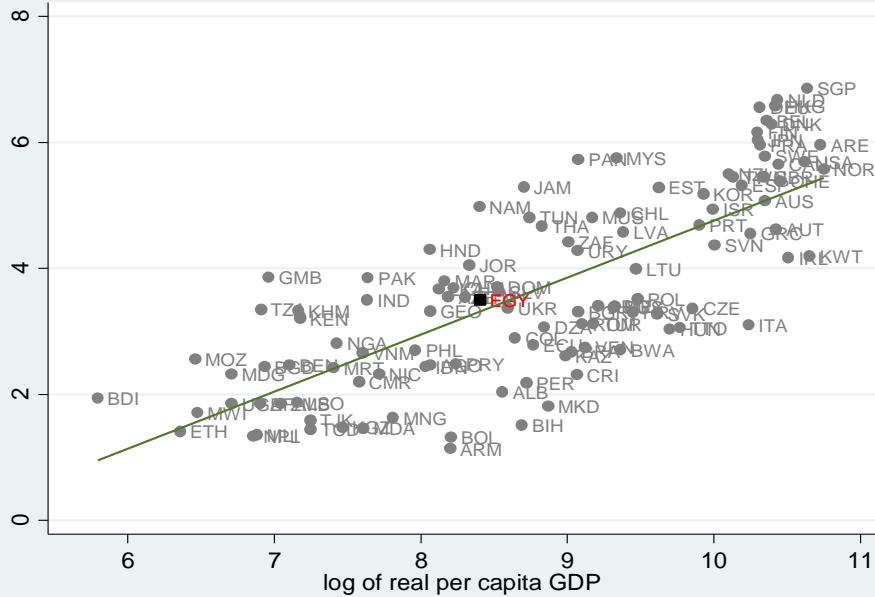
Outline

- **Status of Infrastructure** in Egypt in international context
- **Infrastructure and economic growth**
- **Infrastructure expenditures:** trends in Egypt and other developing countries
- **Expenditures-Infrastructure-Growth: Projections**

Status of Infrastructure in Egypt in International Context

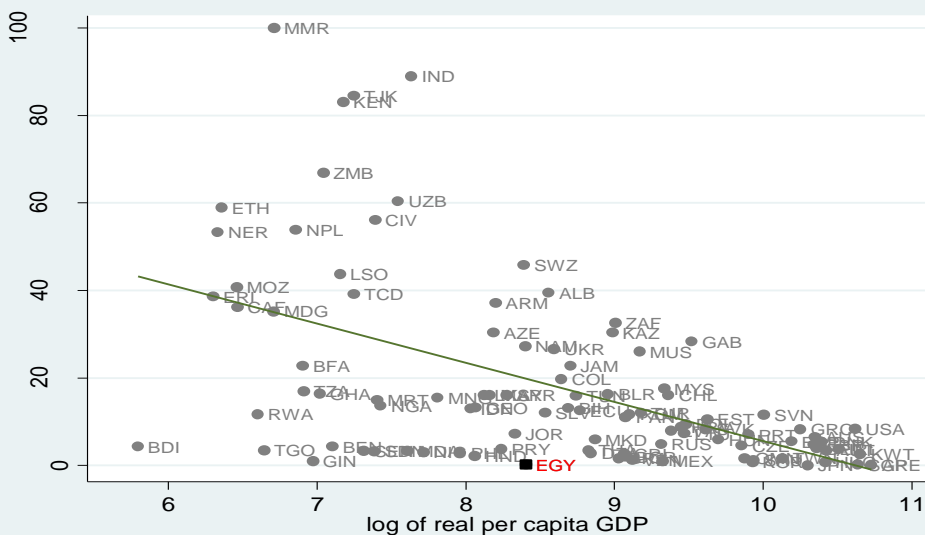
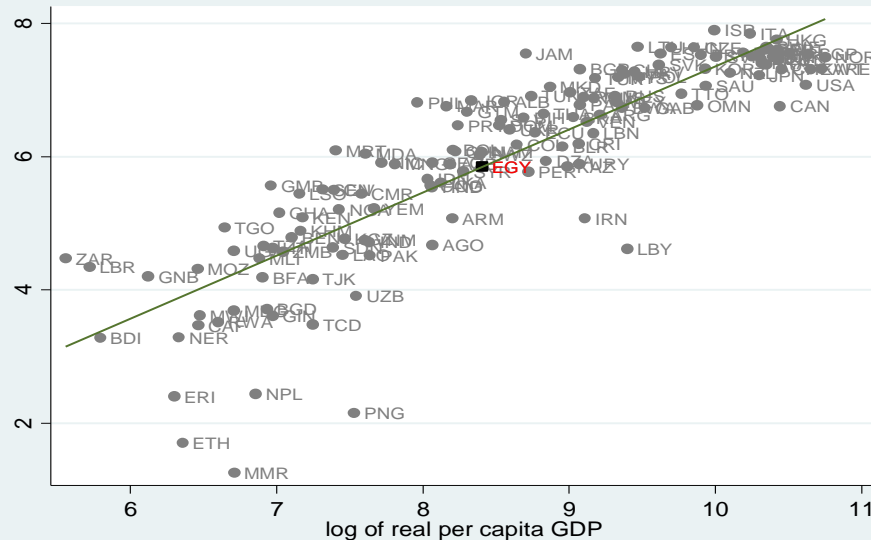
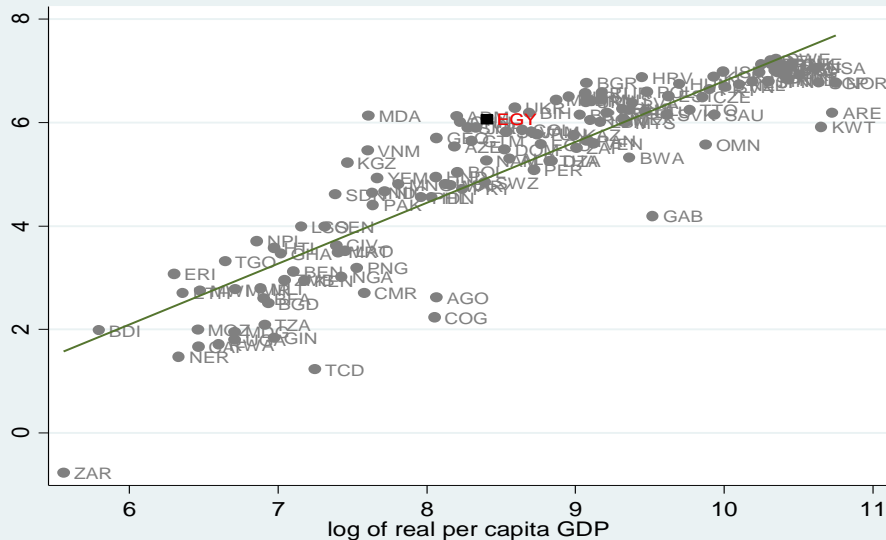
Infrastructure Indicators vs. per capita GDP

Transport (continued)



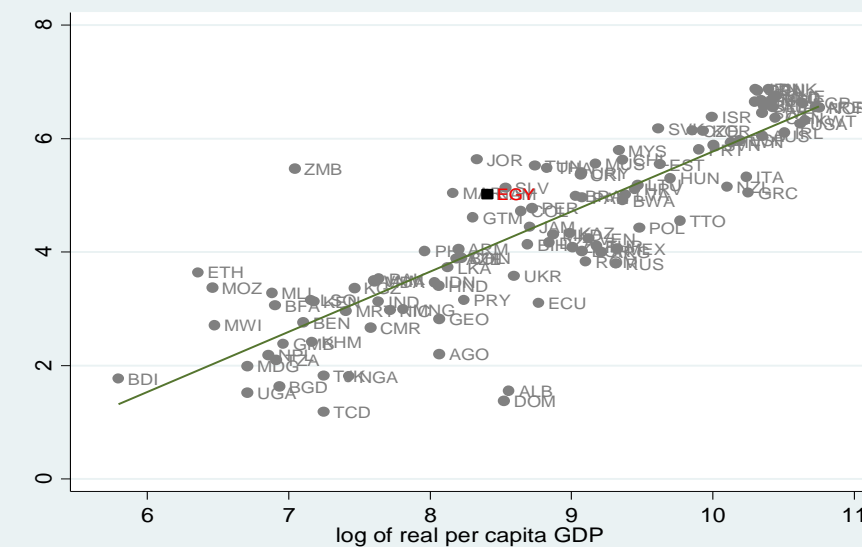
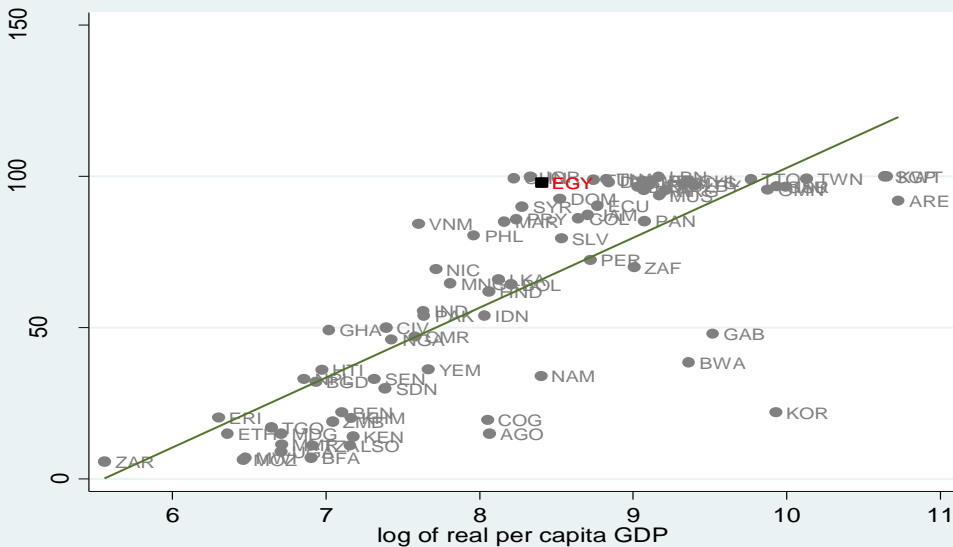
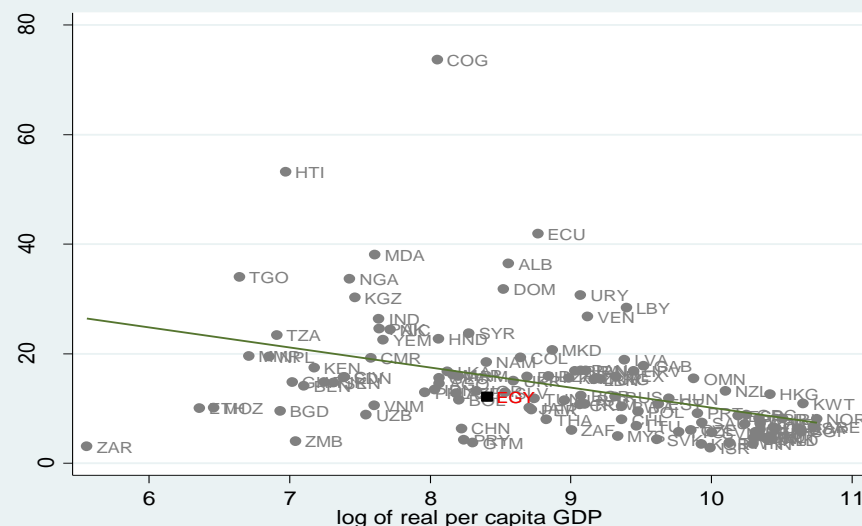
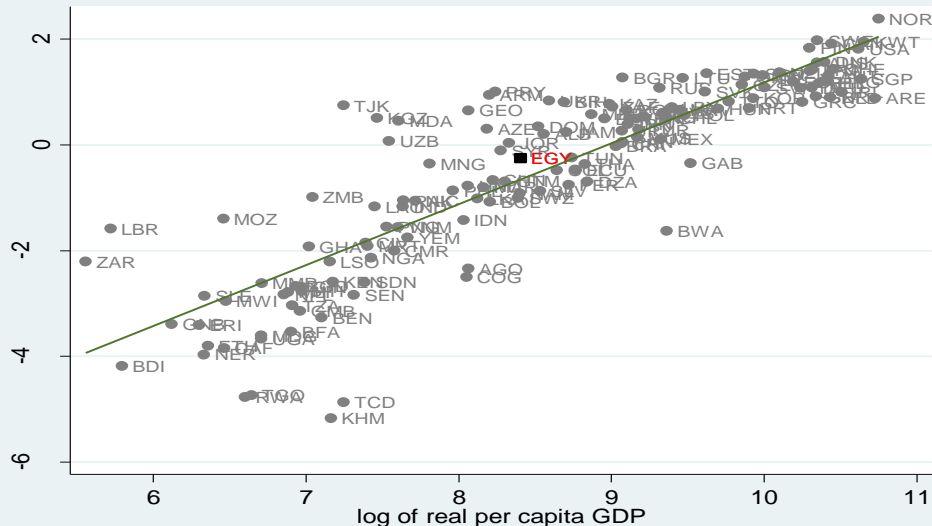
Infrastructure Indicators vs. per capita GDP

Telecommunications



Infrastructure Indicators vs. per capita GDP

Electricity



Pair-wise Correlation

1. Infrastructure Components by Sector

(a) Transport

	roads (in logs)	paved roads	q_roads	q_railroads	q_ports	q_air
roads (in logs)	1					
paved roads	0.2701**	1				
q_roads	0.5106**	0.5382**	1			
q_railroads	0.5787**	0.5787**	0.7769**	1		
q_ports	0.5487**	0.4610**	0.8900**	0.7579**	1	
q_air	0.5506**	0.4737**	0.8565**	0.6957**	0.8690**	1

(b) Telecommunications

	ml (in logs)	cell (in logs)	telf	wl
ml (in logs)	1			
cell (in logs)	0.8223**	1		
telf	-0.4902**	-0.5916**	1	
wl	-0.3950**	-0.4665**	0.1866*	1

(c) Electricity

	egc (in logs)	pl	q_elec	elec_access
egc (in logs)	1			
pl	-0.4232**	1		
q_elec	0.7331**	-0.639**	1	
elec_access	0.8295**	-0.1997*	0.6069**	1

(d) Water & Sanitation

	water	sanitation
water	1	
sanitation	0.8112**	1

Notes:

** denotes the significance level at 5 percent, and * at 10 percent.

Pair-wise Correlation (continued)

2. The Representative Component from Each Sector

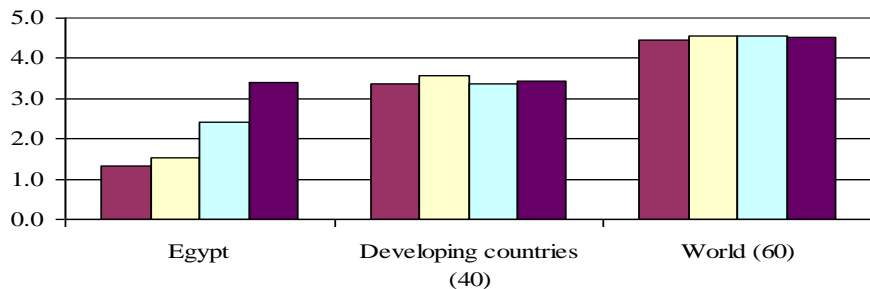
	roads (in logs)	ml (in logs)	egc (in logs)	water
roads (in logs)	1			
ml (in logs)	0.5727**	1		
egc (in logs)	0.6374**	0.8727**	1	
water	0.4902**	0.8644**	0.7785**	1

Notes:

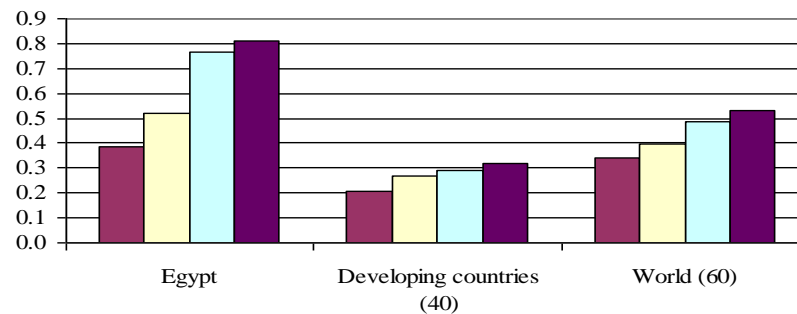
** denotes the significance level at 5 percent, and * at 10 percent.

Progress in Main Infrastructure Indicators

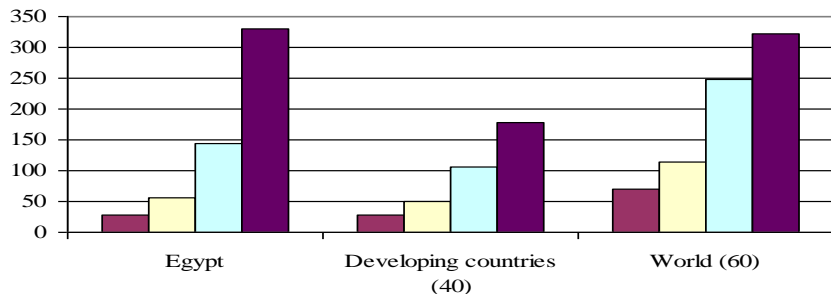
a.) Total road length
(sqrt of 1,000 workers x mean arable land)



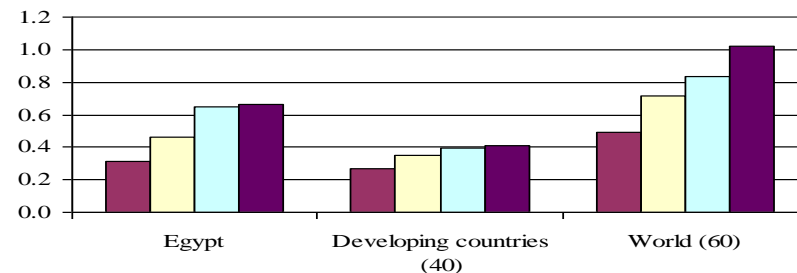
b.) Paved roads (the share to total roads)



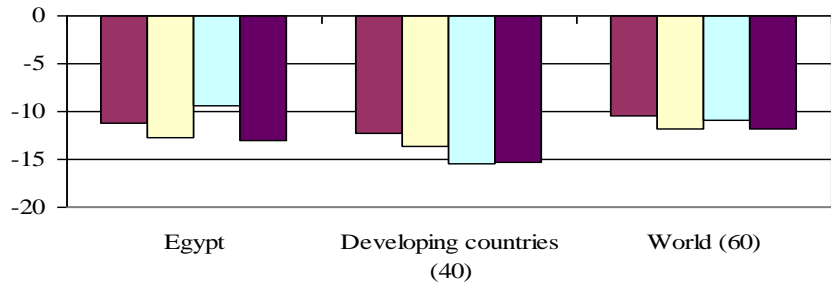
c.) Main lines per 1,000 workers



d.) EGC per 1,000 workers
(megawatts)



e.) Power loss (percentage of total output)



■ 1971-80 ■ 1981-90 ■ 1991-2000 ■ 2001-05

Note: The balanced data are used.

Infrastructure Status -Summary

- Egypt has achieved an infrastructure status that closely corresponds to what could be expected given its income level
- This is the case for all areas of infrastructure.
- Therefore, not only the level but also the internal balance of infrastructure appear to be appropriate

Infrastructure and Economic Growth

Empirical Approach (I)

- *An empirical medium-term growth model:*

$$y_{i,t} - y_{i,t-1} = \beta_0 y_{i,t-1} + \vec{\beta}_1' CV_{i,t} + \beta_2 PI_{i,t} + \mu_t + \eta_i + \varepsilon_{i,t}$$

- *Sample:* 78 countries, 9 non-overlapping five-year obs. per country, 1961-2005
- *Methodology:* Generalized Method of Moments (GMM) for models using panel data

Empirical Approach (II)

- ***Dependent variables:*** GDP Per capita growth rate
- ***Public infrastructure Measures:*** Indices of
 - Electricity, Transportation, Telecommunications
- ***Control Variables:*** Regular growth determinants:
 - Initial Output/Value added, Educational Investment, Financial Depth, Fiscal burden, Macro Volatility, Inflation, Trade Openness, TOT shocks, Period shifts

Economic Growth and Infrastructure

Sample: 78 countries, 1961-2005 (5-year period observations)

Estimation Method: System GMM

	Dependent Variable: GDP per capita Growth			
	[1]	[2]	[3]	[4]
<u>Infrastructure Variables:</u>				
Electricity Index ¹	1.539 *** [6.436]			
Transportation Index ²		2.45 *** [5.631]		
Telecommunication Index ³			1.476 *** [6.687]	
Transportation & Telecommunication Index ⁴				2.81 *** [7.171]
<u>Control Variables:</u>				
Initial GDP per capita	-1.592 *** [-5.175]	-2.072 *** [-5.900]	-1.512 *** [-7.133]	-2.688 *** [-7.576]
in logs				
Education	0.949 ** [2.424]	1.008 *** [2.973]	0.239 [0.813]	0.367 [1.186]
secondary school enrollment rate, in logs				
Financial Depth	0.403 ** [2.114]	0.719 *** [4.226]	1.206 *** [7.165]	1.075 *** [5.925]
private credit/GDP, in logs				
Crisis Volatility	-1.876 *** [-15.070]	-1.734 *** [-15.400]	-1.937 *** [-20.300]	-1.761 *** [-16.120]
std dev of GDP per capita growth ⁵				
Government Burden	-0.919 * [-1.957]	-0.224 [-0.429]	-0.274 [-0.611]	0.102 [0.213]
government expenditure/GDP, in logs				
Inflation	-0.227 [-0.362]	-2.033 *** [-3.189]	-3.036 *** [-5.071]	-2.841 *** [-4.561]
1+Growth rate of CPI, in logs				
Trade Openness	4.221 *** [9.487]	2.062 *** [4.358]	1.287 ** [2.432]	1.586 *** [3.504]
(exports+imports)/GDP, in logs				
Growth rate of Terms of Trade	0.038 *** [3.294]	0.035 *** [2.942]	0.046 *** [4.167]	0.045 *** [4.019]
log differences of terms of trade index				
Constant	0.733 [0.208]	16.826 *** [3.624]	21.379 *** [5.036]	26.997 *** [5.750]
Observations	522	522	522	522
Number of Countries	78	78	78	78
Number of Instruments	58	58	58	58
Arellano-Bond test for AR(1) in first differences	0.000	0.000	0.000	0.000
Arellano-Bond test for AR(2) in first differences	0.064	0.0517	0.134	0.072
Hansen test of overidentifying restrictions	0.182	0.357	0.471	0.435

Numbers in brackets are the corresponding *t*-statistics.

* significant at 10%; ** significant at 5%; *** significant at 1%

Period fixed effects were included (coefficients not reported).

Economic Growth and Infrastructure

Individual Effects

Sample: 78 countries, 1961-2005 (5-year period observations)

Estimation Method: System GMM

	Dependent Variable: GDP per capita Growth			
	[1]	[2]	[3]	[4]
<i>Infrastructure Variables:</i>				
Electricity Index ¹	1.539 *** [6.436]			
Transportation Index ²		2.45 *** [5.631]		
Telecommunication Index ³			1.476 *** [6.687]	
Transportation & Telecommunication Index ⁴				2.81 *** [7.171]
Observations	522	522	522	522
Number of Countries	78	78	78	78
Number of Instruments	58	58	58	58
Arellano-Bond test for AR(1) in first differences	0.000	0.000	0.000	0.000
Arellano-Bond test for AR(2) in first differences	0.064	0.0517	0.134	0.072
Hansen test of overidentifying restrictions	0.182	0.357	0.471	0.435

Economic Growth and Infrastructure

Joint Effects

Sample: 78 countries, 1961-2005 (5-year period observations)

Estimation Method: System GMM

	Dependent Variable:	
	[1]	[2]
<hr/>		
<i><u>Infrastructure Variables:</u></i>		
Electricity Index ¹	0.749 *** [5.353]	0.975 *** [5.292]
Transportation Index ²	1.093 *** [3.102]	
Telecommunication Index ³	1.097 *** [4.754]	
Transportation & Telecommunication Index ⁴		2.135 *** [5.637]
<hr/>		
Observations	522	522
Number of Countries	78	78
Number of Instruments	70	64
Arellano-Bond test for AR(1) in first differences	0.000	0.000
Arellano-Bond test for AR(2) in first differences	0.170	0.107
Hansen test of overidentifying restrictions	0.164	0.340

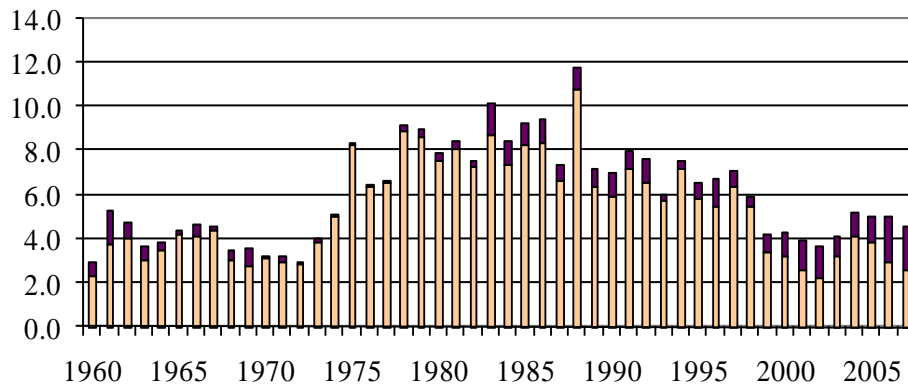
Infrastructure and Growth – Illustration of Effects

1. Improvement by 1 std. dev.
 - electricity: 0.89 pp (EGY to ESP)
 - transportation: 1.24 pp (EGY to NOR)
 - telecommunications: 1.26 pp (EGY to DEU)
2. Improvement from 25th to 75th percentile
 - electricity: 1.23 pp (PHL to ITA)
 - transportation: 2.05 pp (NGA to NZL)
 - telecommunication: 2.08 pp (IND to PRT)

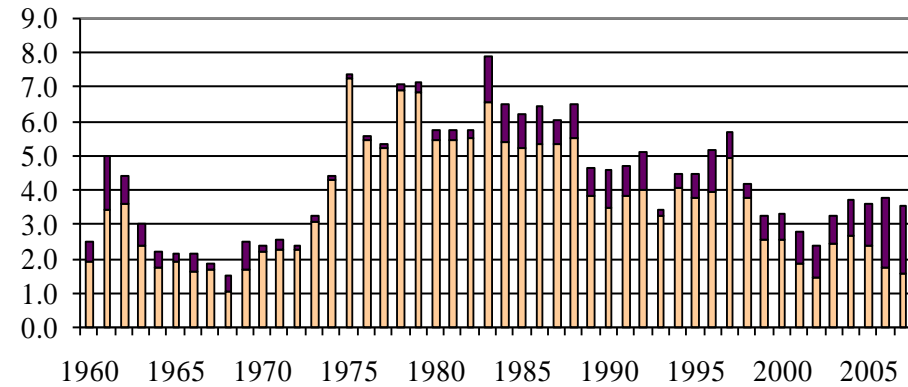
Infrastructure Expenditures

Infrastructure Expenditure in Egypt 1960-2007, % of GDP

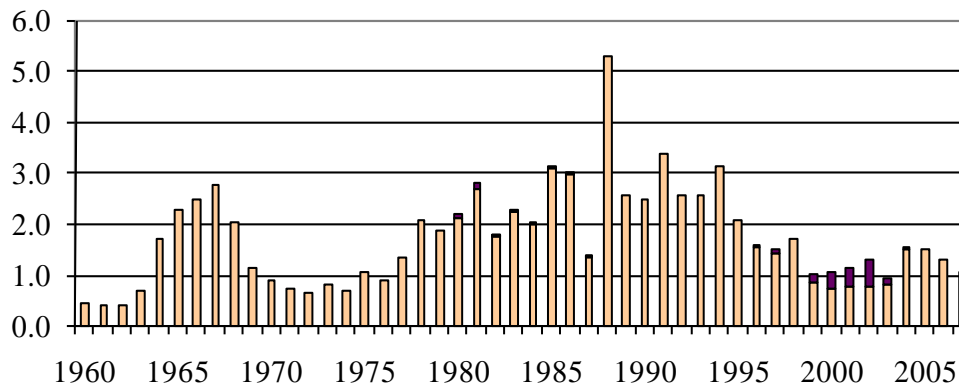
(a) Total Investment



(b) Transportation (incl. SC) & Communications



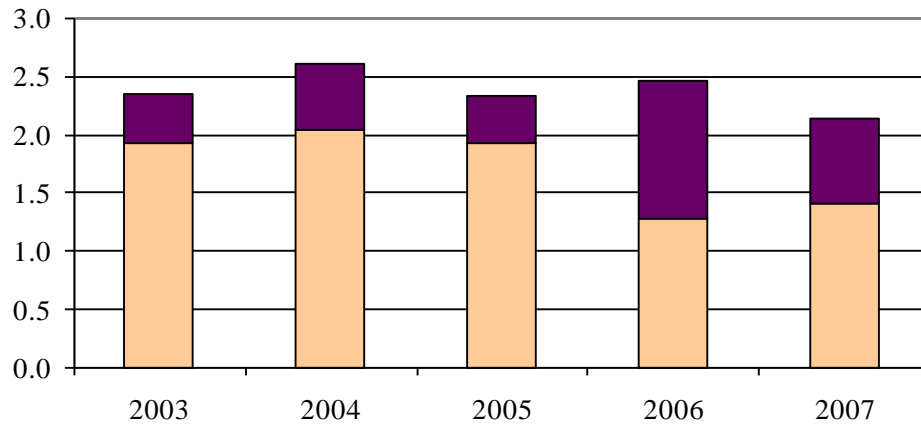
(c) Electricity



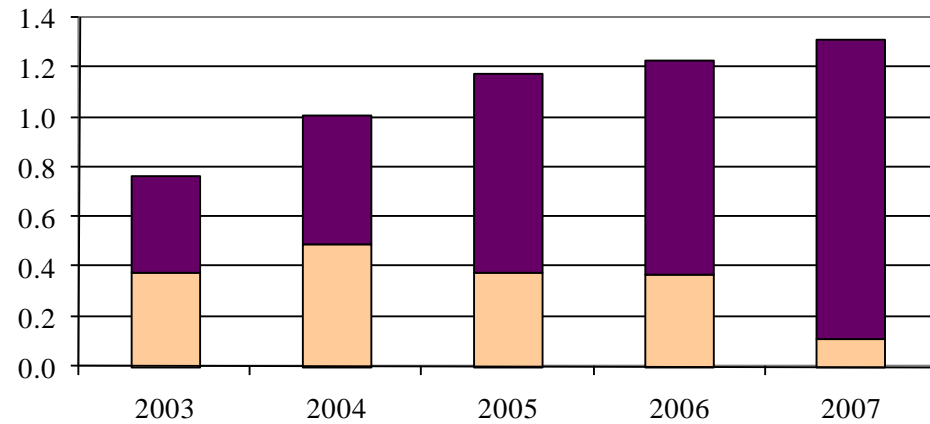
Public Private

Infrastructure Expenditure in Egypt 2003-2007, % of GDP

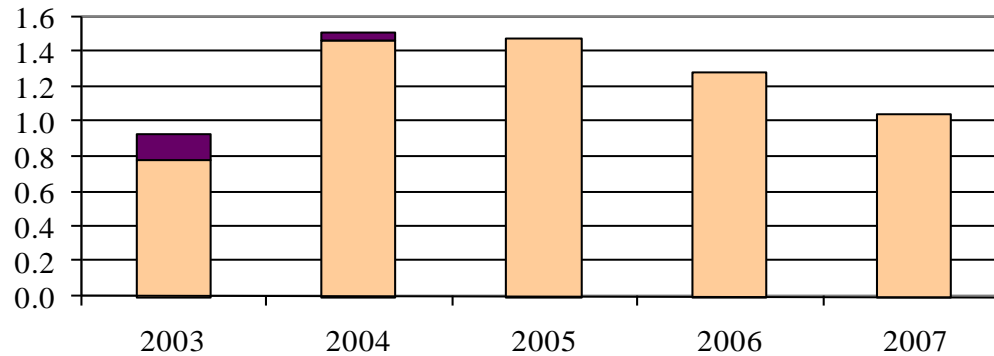
(a) Transportation



(b) Communications



(c) Electricity

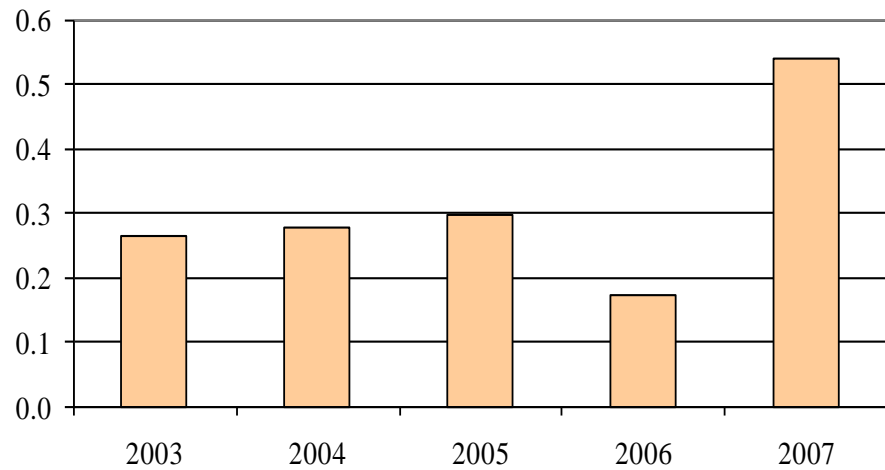


Public Private

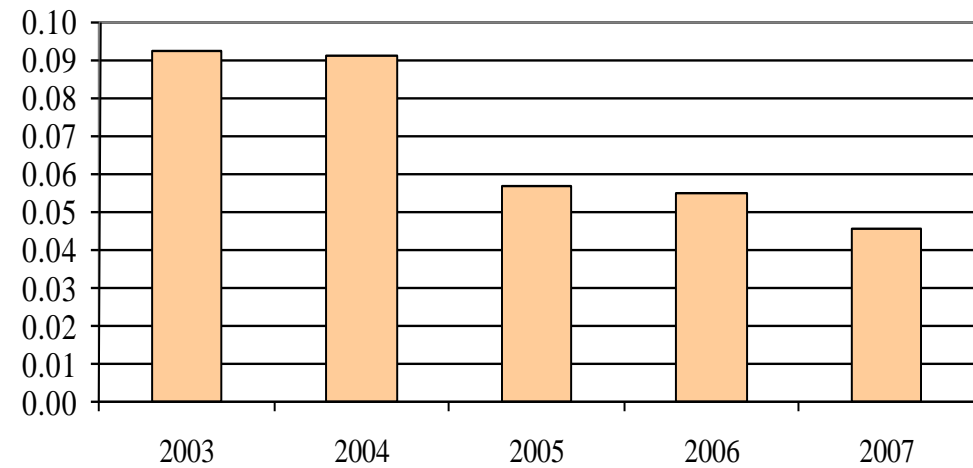
Infrastructure Expenditure in Egypt (cont.)

2003-2007, % of GDP

(d) Water



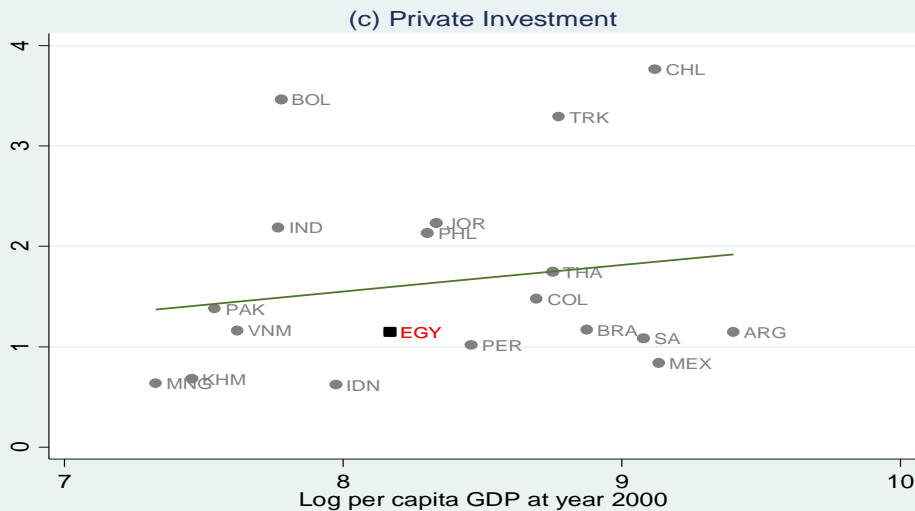
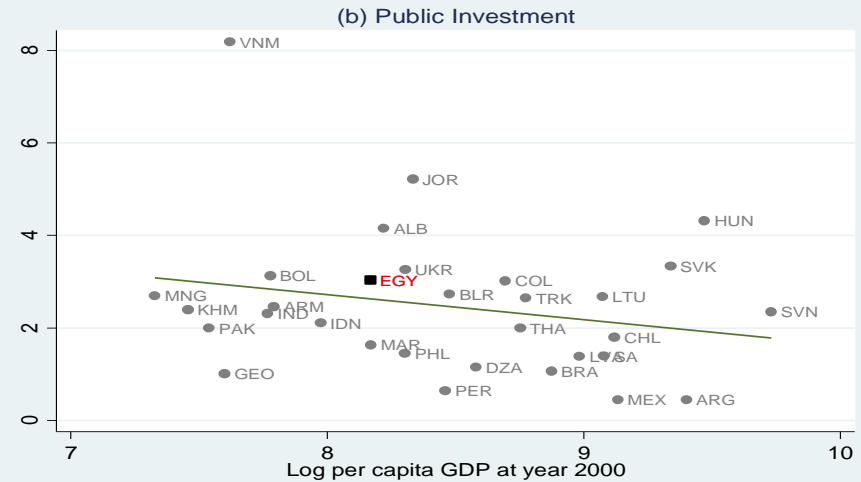
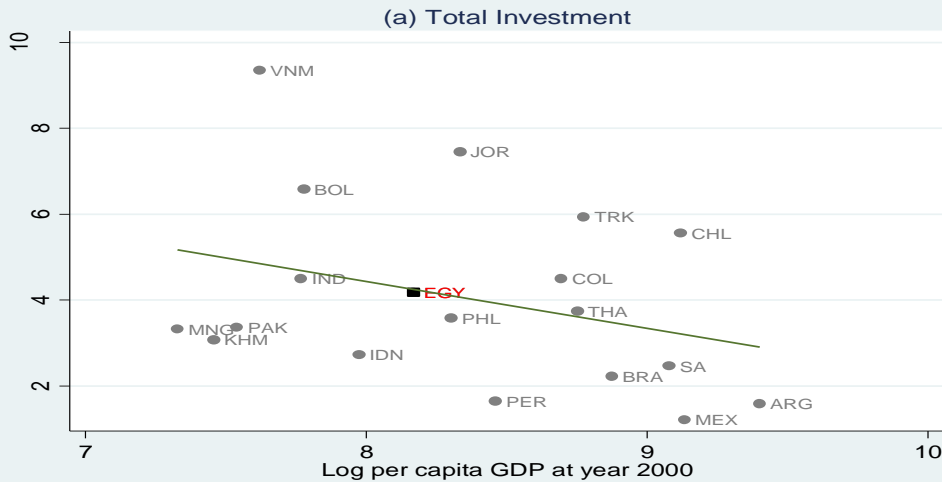
(e) Suez Canal



Public Private

Infrastructure Expenditure and per Capita GDP

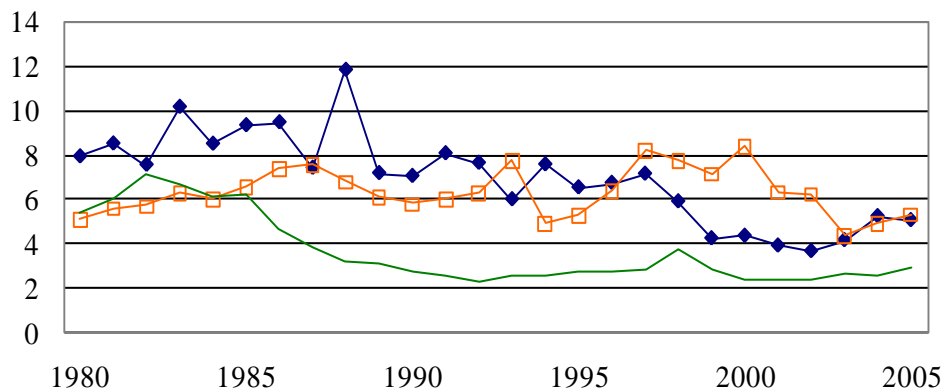
(average of 2000-05, % of GDP)



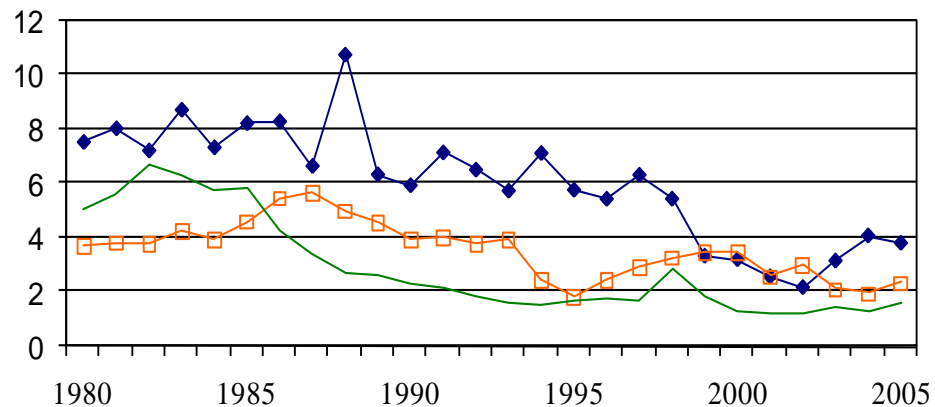
Infrastructure Expenditure

Egypt and Selected Countries (% of GDP)

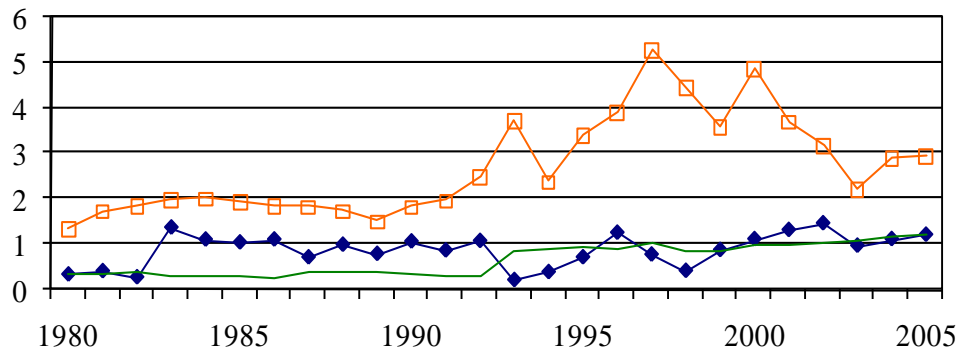
(a) Total Investment



(b) Public Investment



(c) Private Investment

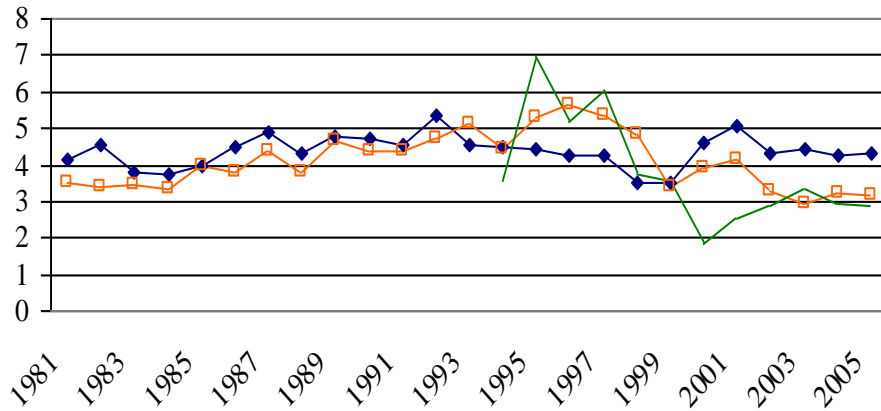


—◆— EGY —□— TRK — SA

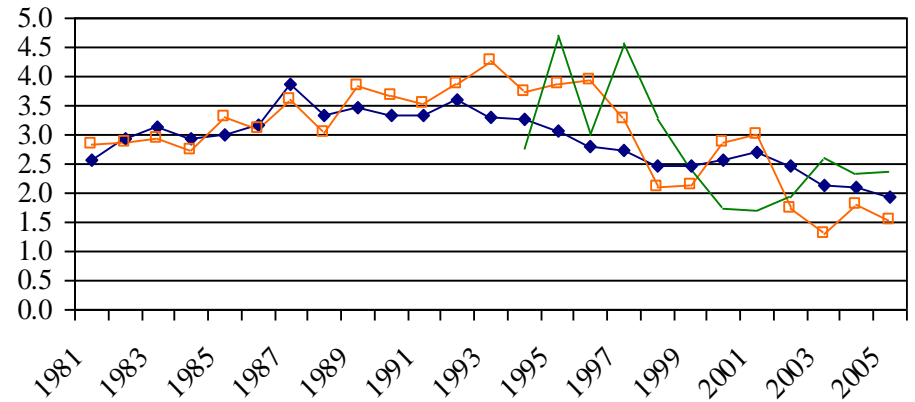
Data source: Calderón, Odawara, and Servén (2008).

Infrastructure Expenditure Selected Countries (% of GDP)

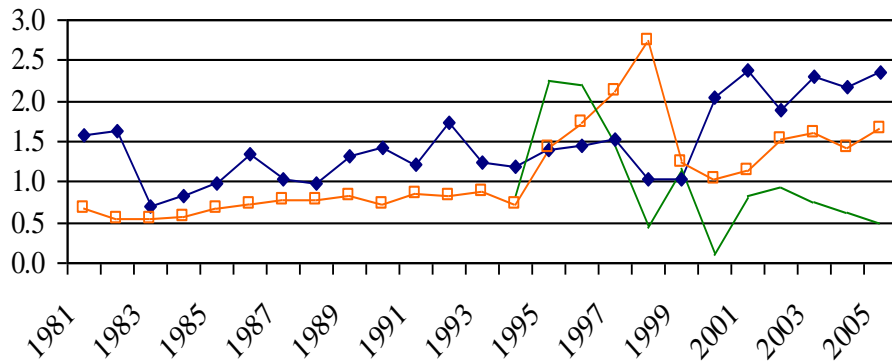
(a) Total Investment



(b) Public Investment



(c) Private Investment



—◆— IND —□— PAK —— IDN

Data source: Calderón, Odawara, and Servén (2008).

Infrastructure Expenditure - Summary

- In the last 15 years, infrastructure investment has experienced a substantial decline
 - In part, this is normal: “product cycle”
 - In part, this may reflect better expenditure quality
 - But, is there room for a moderate increase?
- Possibly yes, but in the context of public-private cooperation
 - Already present but not forcefully in Egypt

Infrastructure Expenditures and Progress in Infrastructure

Electricity Expenditures and Improvement

Estimation Method: Quantile regression

	Dependent variable:			
	Change in Electricity Infrastructure Index			
	[1]	[2]	[3]	[4]
Ratio of expenditure to labor force (expenditure on electricity per 100,000 workers)	0.006 *** [5.40]			
Ratio of expenditure to labor force (expenditure on electricity per 100,000 workers, in logs)		0.051 *** [4.56]		
Ratio of expenditure to GDP (expenditure on electricity / 1,000 GDP)			0.005 *** [4.39]	
Ratio of expenditure to GDP (expenditure on electricity / 1,000 GDP, in logs)				0.078 *** [4.83]
Constant	-0.065 *** [4.14]	-0.096 *** [3.64]	-0.094 *** [3.72]	-0.205 *** [4.45]
Observations	34	34	34	34
R-squared	0.33	0.24	0.41	0.35

Notes:

The dependent variable is smoothed by using the Hodrik Prescott filter.

All the expenditure variables are the moving average of expenditures in the last three years.

Numbers in brackets are the corresponding t-statistics.

** significant at 10%; ** significant at 5%; *** significant at 1%*

Transport and Telecom. Exp. and Improvement

Estimation Method: Quantile regression

	Dependent variable: Change in Transportation & Telecommunication Infrastructure Index			
	[1]	[2]	[3]	[4]
Ratio of expenditure to labor force (expenditure on transportation & telecommunication per 100,000 workers)	0.002 *** [14.22]			
Ratio of expenditure to labor force (expenditure on transportation & telecommunication per 100,000 workers, in logs)		0.038 *** [9.46]		
Ratio of expenditure to GDP (expenditure on transportation & telecommunication / 1,000 GDP)			0.002 *** [5.08]	
Ratio of expenditure to GDP (expenditure on transportation & telecommunication / 1,000 GDP, in logs)				0.061 *** [3.96]
Constant	-0.016 *** [3.84]	-0.076 *** [6.16]	-0.036 ** [2.08]	-0.18 *** [3.16]
Observations	45	45	45	45
R-squared	0.47	0.44	0.19	0.22

Notes:

All the expenditure variables are the moving average of expenditures in the last three years.

Numbers in brackets are the corresponding t-statistics.

** significant at 10%; ** significant at 5%; *** significant at 1%*

Infrastructure and Progress - Summary

- Expenditures in electricity, transportation, and telecommunication have indeed led to improvements in objective indicators
- There is some evidence that the efficiency of expenditures has risen with the infrastructure indicators

Growth Projections

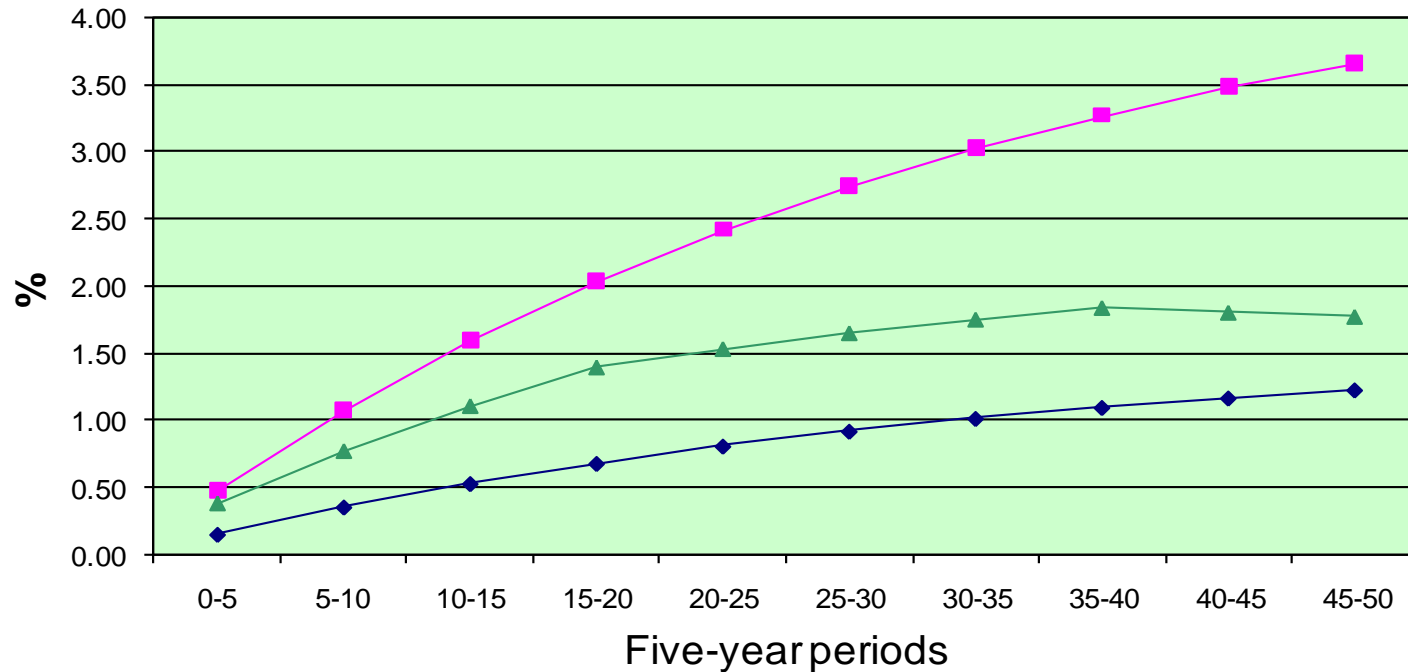
The projection exercise

- Simulate the growth effect of an increase in infrastructure expenditure from 5 to 6% of GDP
 - Proportional:
 - Electricity: 1.3% to 1.56%
 - Transportation and telecommunication: 3.7% to 4.4%
- Take into account:
 - Positive impact of infrastructure improvement
 - Negative “convergence” effect
 - Negative impact of higher fiscal burden

Projected Growth Improvement from Higher Infrastructure Investment

Growth Improvement

with respect to current infrastructure spending of 5%GDP



◆ Scenario 1: 6% GDP

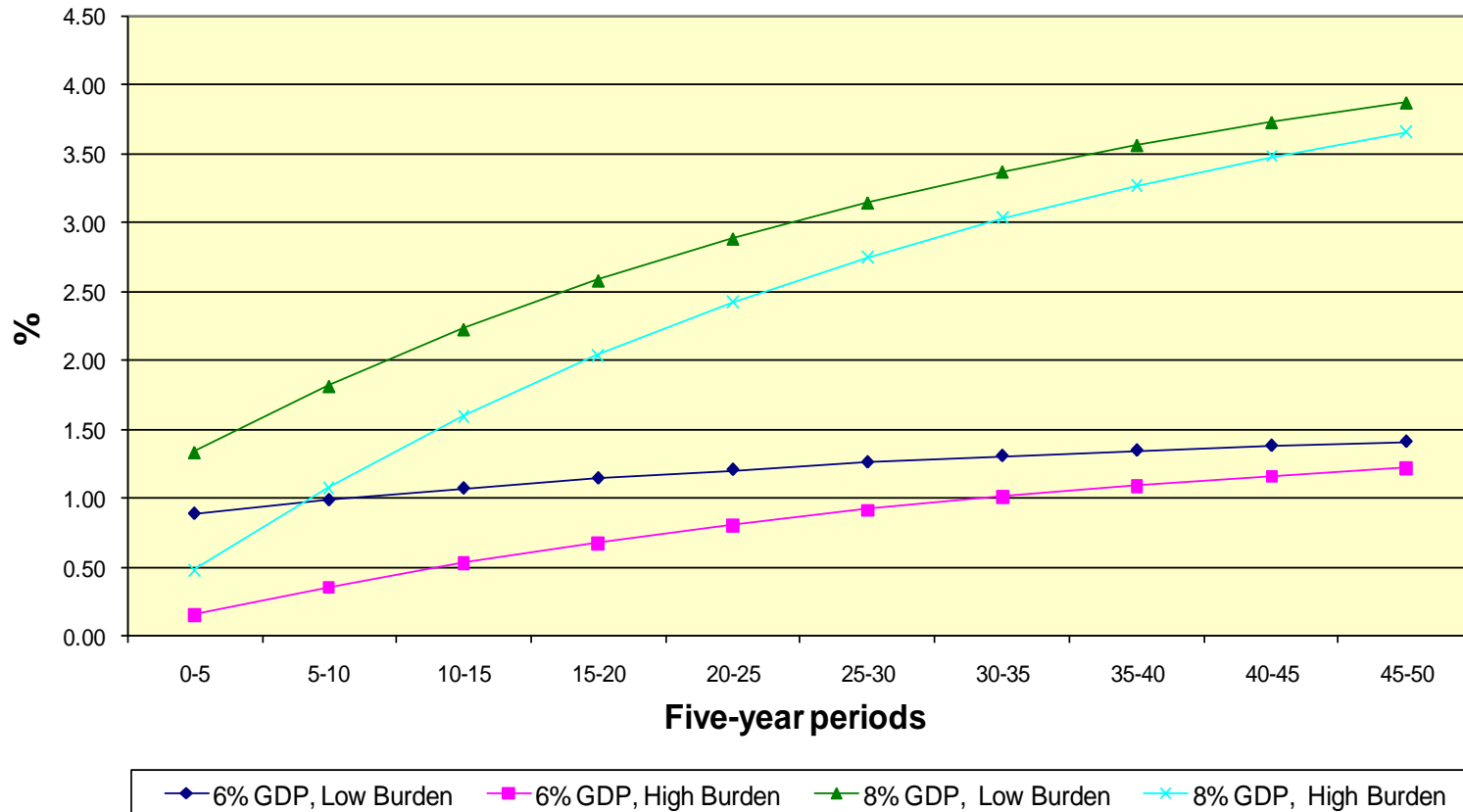
■ Scenario 2: 8% GDP

▲ Scenario 3: 7/6.5/6% GDP

Projected Growth Improvement under Different Fiscal Burden

Growth Improvement

comparing low and high government burden to increase infrastructure expenditure



Implications for public policy analysis

- *Fiscal multiplier:*
 - Increasing over time:
 - **1pp by first decade and 1.6pp in long run**

Implications for public policy analysis

- *Fiscal sustainability:*
 - Public infrastructure won't pay for itself
 - Assuming 30% government revenue rate,
 - Infrastructure growth effect will pay **35% of expenditures in first 5 years**, 50% by end of second decade, and 75% in long run

Implications for public policy analysis

- *Social welfare:*
 - Net social gains
 - Assuming a discount rate of 5% over growth rate
 - Net present value gain of
 - **6% in the first 25 years**
 - **10.5% in 50 years**

Conclusions

- An increase in infrastructure expenditures may have a **positive effect on economic growth**
- The size (and even sign) of the effect depends on,
 - whether infrastructure investment is considered in the larger context of **public sector reform**
 - that is, rationalizing all public expenditures and improving infrastructure expenditure quality
 - possibly encouraging stronger participation of private sector

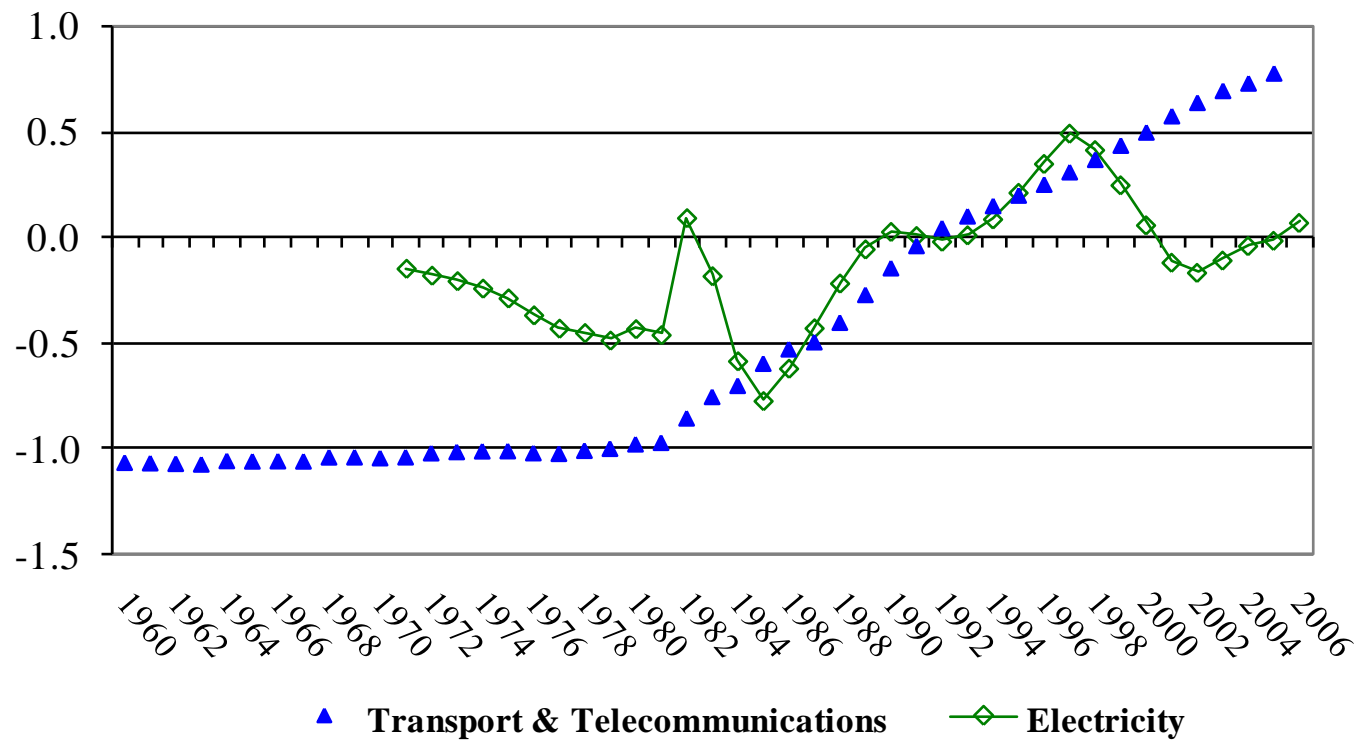
Additional slides

Data sources for infrastructure indicators

Variable	Definition	Year	Source
roads	Length of total roads (km, sqrt of 1,000 workers x mean arable land for 1971-2005)	2004	International Road Federation (IRF)
paved roads	Paved roads (the ratio of paved roads to total road length)	2004	International Road Federation (IRF)
ml	The number of main phone lines (per 1,000 workers)	2004	Int'l Telecommunications Union (ITU)
cell	The number of cell phone lines (per 1,000 workers)	2004	Int'l Telecommunications Union (ITU)
telf	Telephone faults (the number of reported telephone faults for the year per 100 main phone lines)	Avg. of 2001-06	Int'l Telecommunications Union (ITU)
wl	Waiting list for main line installation (the ratio of waiting list to main lines)	Avg. of 2000-04	Int'l Telecommunications Union (ITU)
egc	Energy generating capacity (megawatts, per 1,000 workers)	2004	Statistical Yearbook, United Nations. US- Energy Information Administration
pl	Power loss (% of total output)	2004	WDI, The World Bank.
q_roads	Quality of roads	2006	Global Competitiveness Report
q_railroads	Quality of railroads	2006	Global Competitiveness Report
q_ports	Quality of port facilities and inland waterways	2006	Global Competitiveness Report
q_air	Quality of air transport	2006	Global Competitiveness Report
q_elec	Quality of electricity supply	2006	Global Competitiveness Report
elec_accesss	Access to electricity: Electrification rate (%)	2006	World Energy Outlook
water	Access to water: Improved water sources (% of population with access)	2006	WDI, The World Bank.
sanitation	Access to sanitation: Improved sanitation facilities (% of population with access)	2006	WDI, The World Bank.

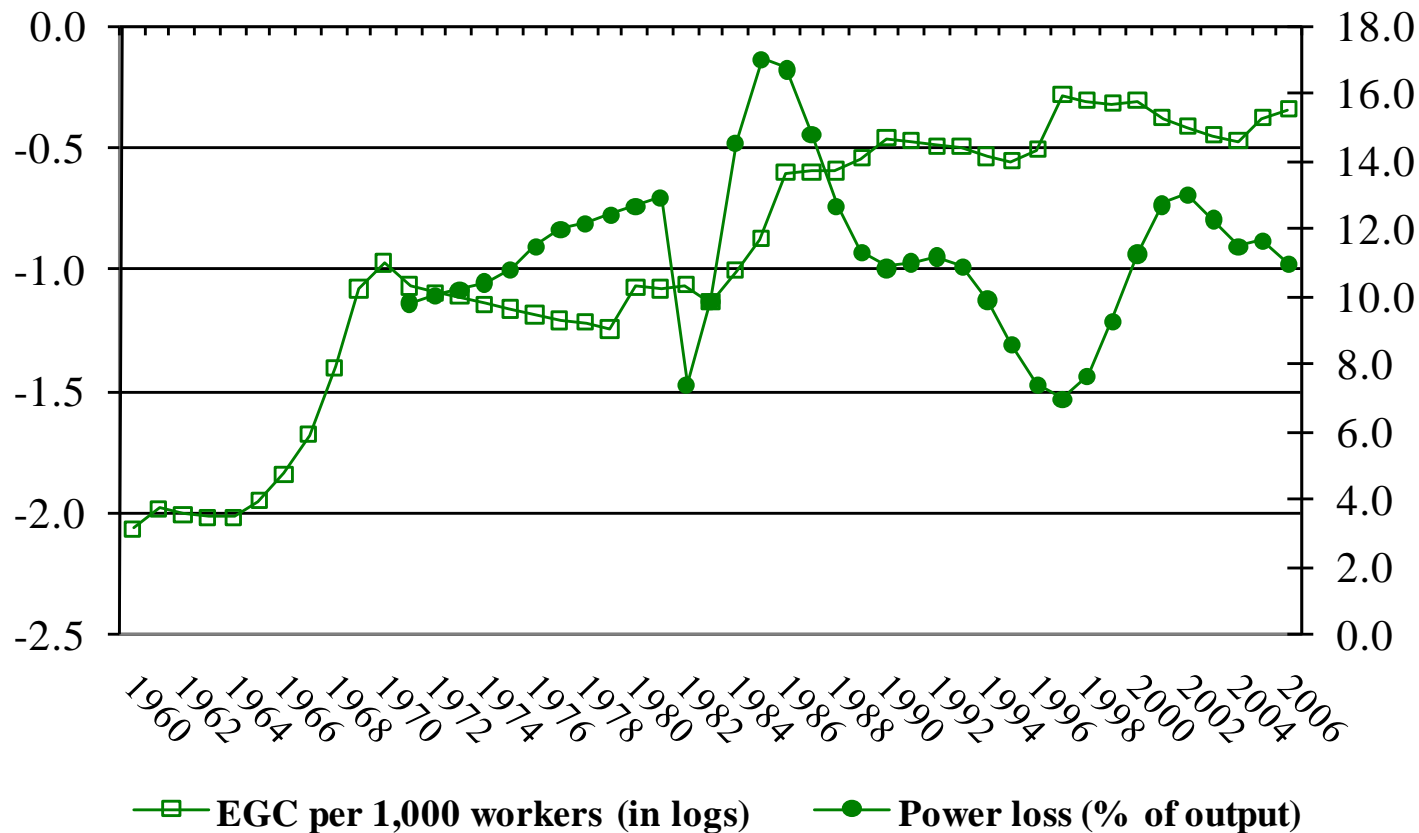
Figure 6. Infrastructure Indices by Sector in Egypt (1971-2006)

Infrastructure Indices by Sector



Infrastructure Indices by Sector in Egypt (1971-2006)

(c) *Components of Electricity Index*



Econometric methodology

- **Estimation challenges:**
 - Joint endogeneity
 - Unobserved country factors
 - Dynamic equation
- **Methodology:** GMM for dynamic models of panel data (Arellano and Bond 1991, Arellano and Bover 1995) – GMM system estimator
 - Joint endogeneity: “Internal instruments” -lagged levels and differences
 - Unobserved country factors: Differencing and stationarity assumptions
 - Specification tests: Sargan and serial correlation tests
- Previous applications:
 - Growth: Levine, Loayza, and Beck (2000)
 - Saving: Loayza, Schmidt-Hebbel, and Serven (2000)
 - Crime: Fajnzylber, Lederman, and Loayza (2002)

GMM for dynamic models of panel data

- GMM system estimator: Combines regression in differences and regression in levels into one system
- Regression in levels:

$$y_{i,t} = \alpha y_{i,t-1} + \vec{\beta}' X_{i,t} + \eta_i + \varepsilon_{i,t}$$

- Instruments: lagged differences of the explanatory and lagged dependent variables

- Regression in Differences:

$$y_{i,t} - y_{i,t-1} = \alpha(y_{i,t-1} - y_{i,t-2}) + \beta'(X_{i,t} - X_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1})$$

- Instruments: previous observations of the explanatory and lagged dependent variables in levels