Infrastructure and Economic Growth in Egypt

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Motivation

Questions

- How does Egypt compare internationally regarding public infrastructure?

- Is Egypt investing enough in infrastructure?

- What are the economic effects of increasing investment infrastructure in Egypt?
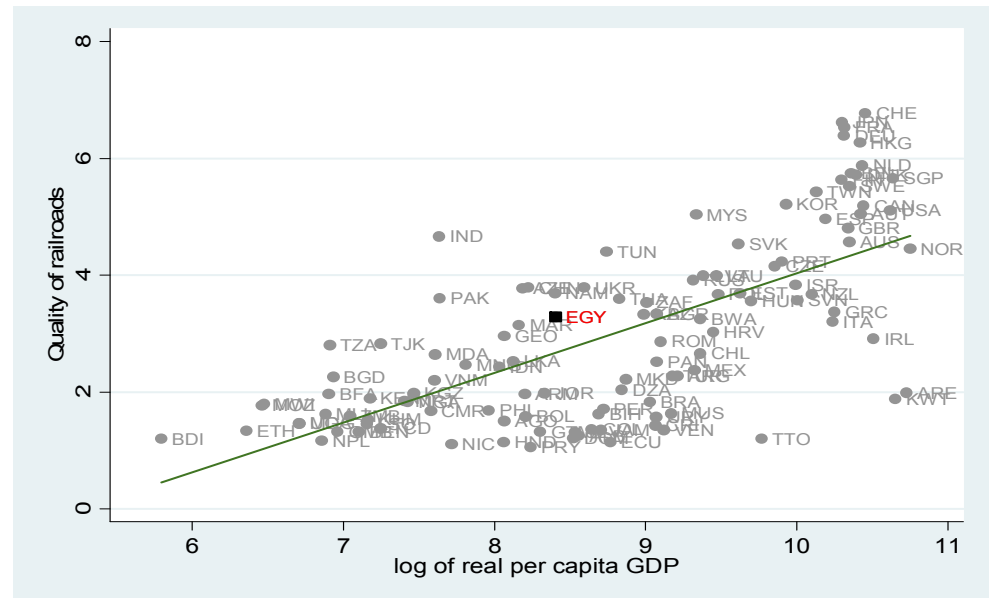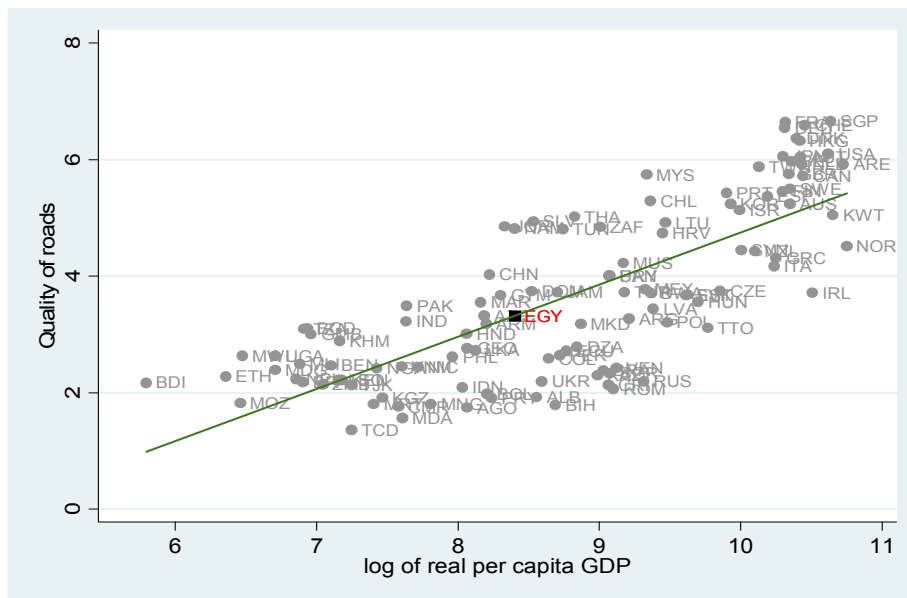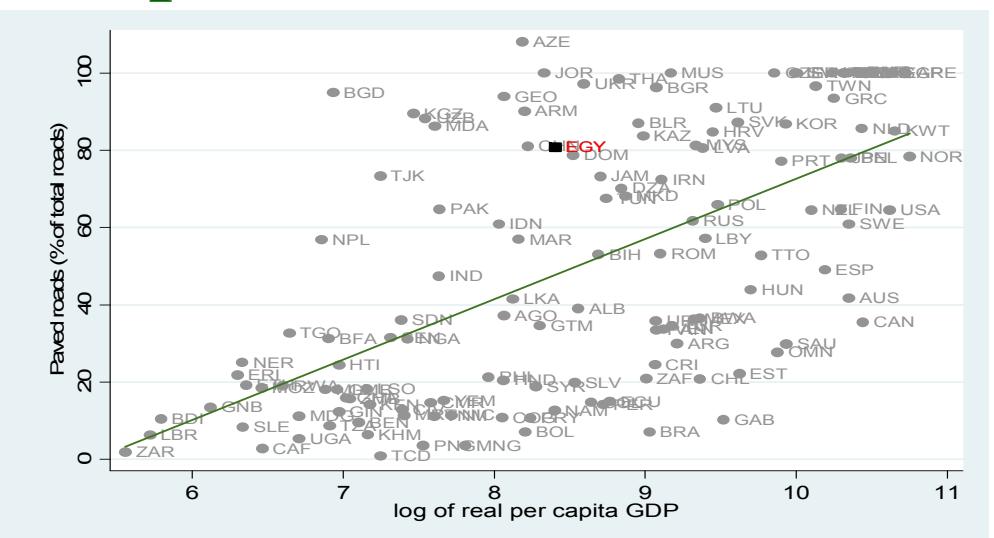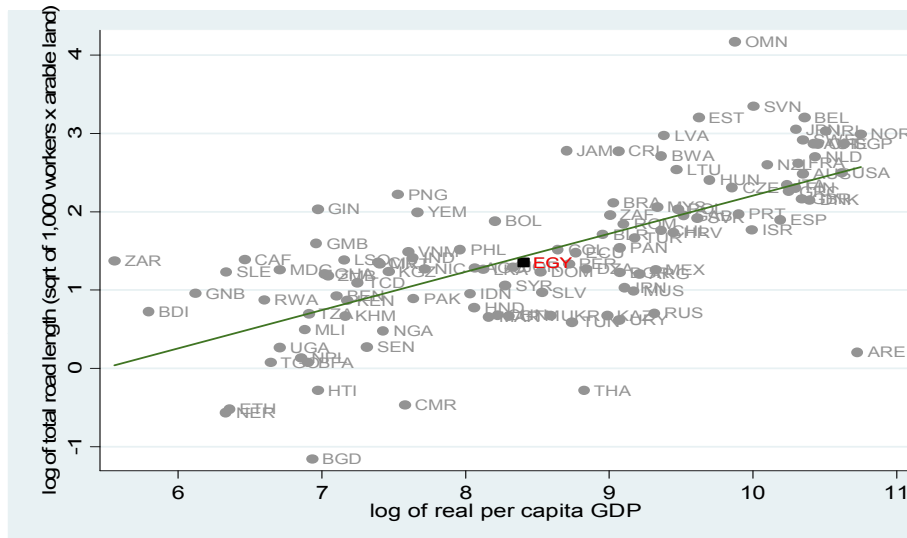 - What can these effects be improved?

Outline

- **Status of Infrastructure**

- **Infrastructure and economic growth**

- **Investment expenditures and infrastructure**

- **Projections:**
  Expenditures → Infrastructure → Growth

Status of Infrastructure in Egypt in International Context

Infrastructure Indicators vs. per capita GDP
Transport

Infrastructure Indicators vs. per capita GDP
Transport (continued)
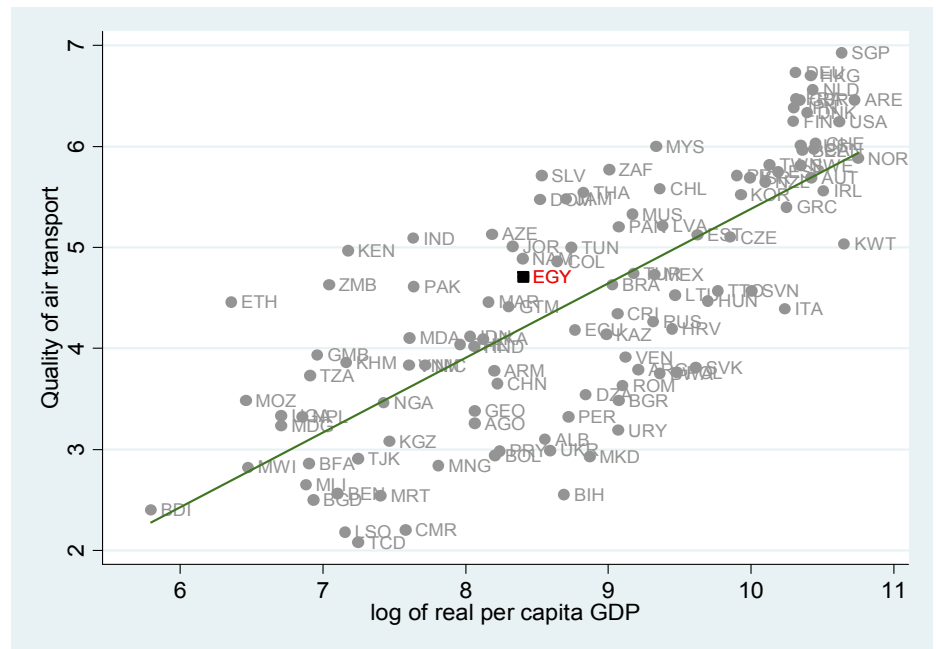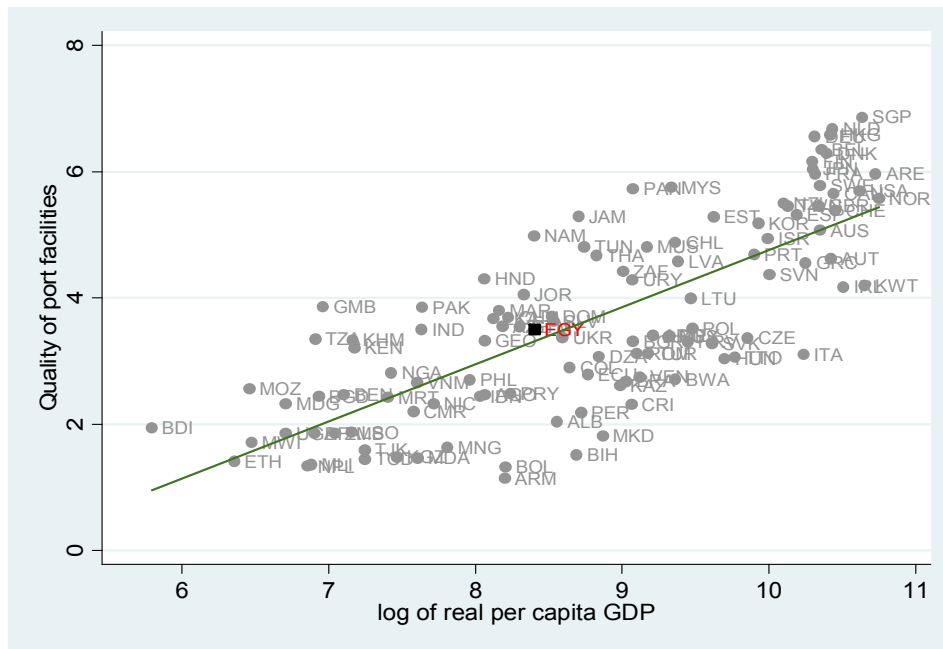
Infrastructure Indicators vs. per capita GDP
Telecommunications

Infrastructure Indicators vs. per capita GDP
Electricity
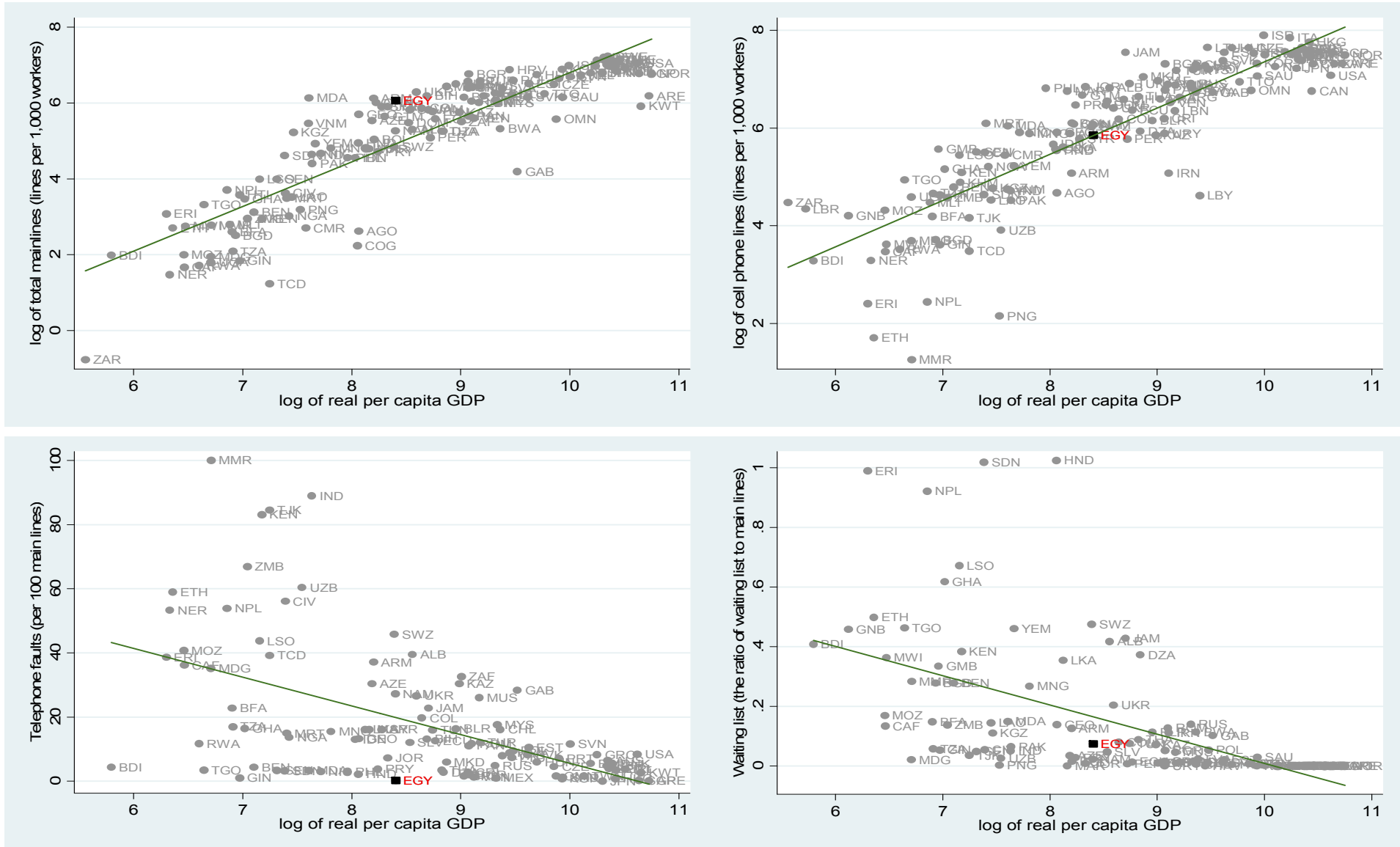
Infrastructure Indicators vs. per capita GDP
Water & Sanitation
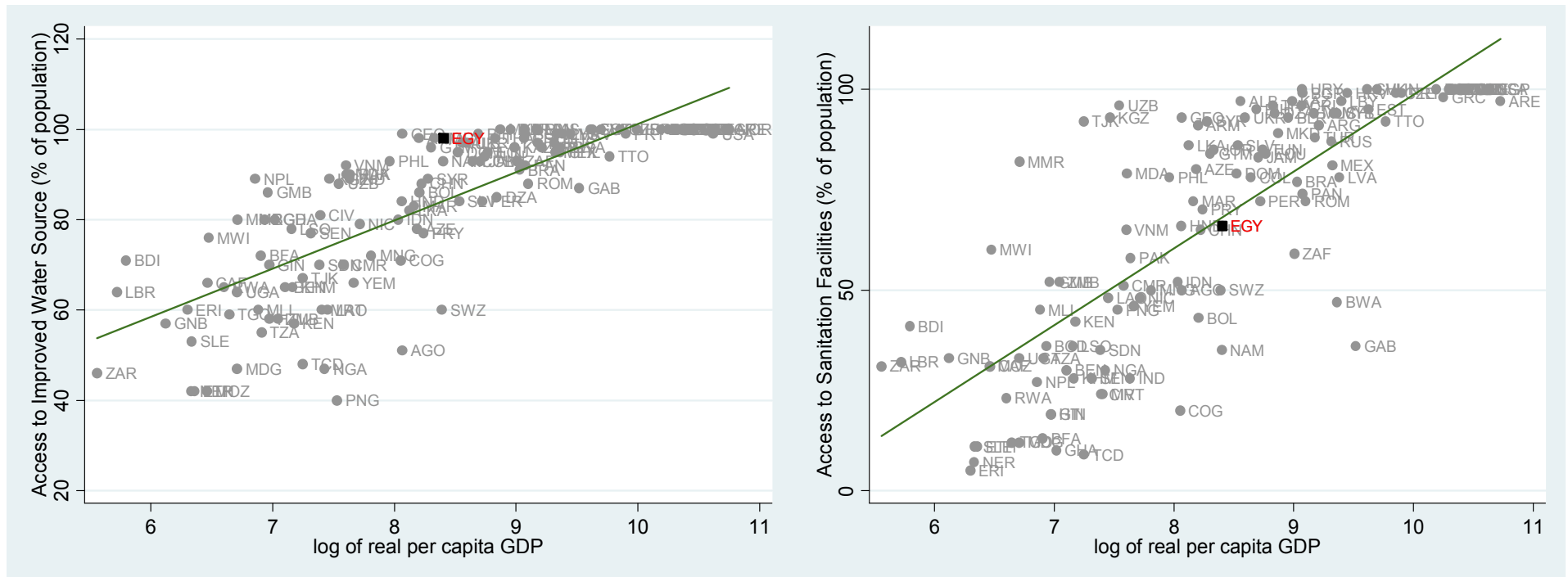
Figure 2. Infrastructure indicators over time -- Transport

b.) Paved roads (the share to total roads)
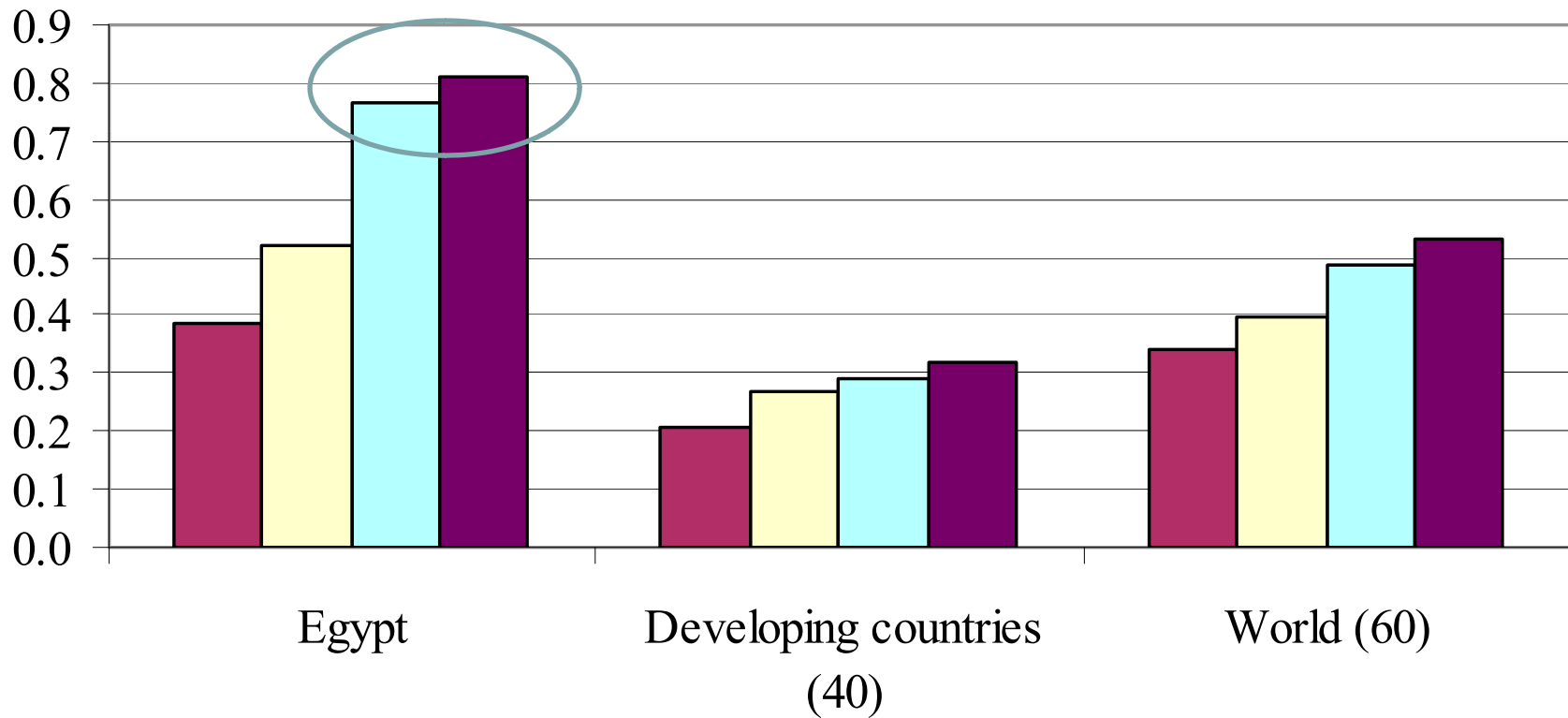
Figure 2. Infrastructure indicators over time -- Telecommunication

c.) Main lines per 1,000 workers
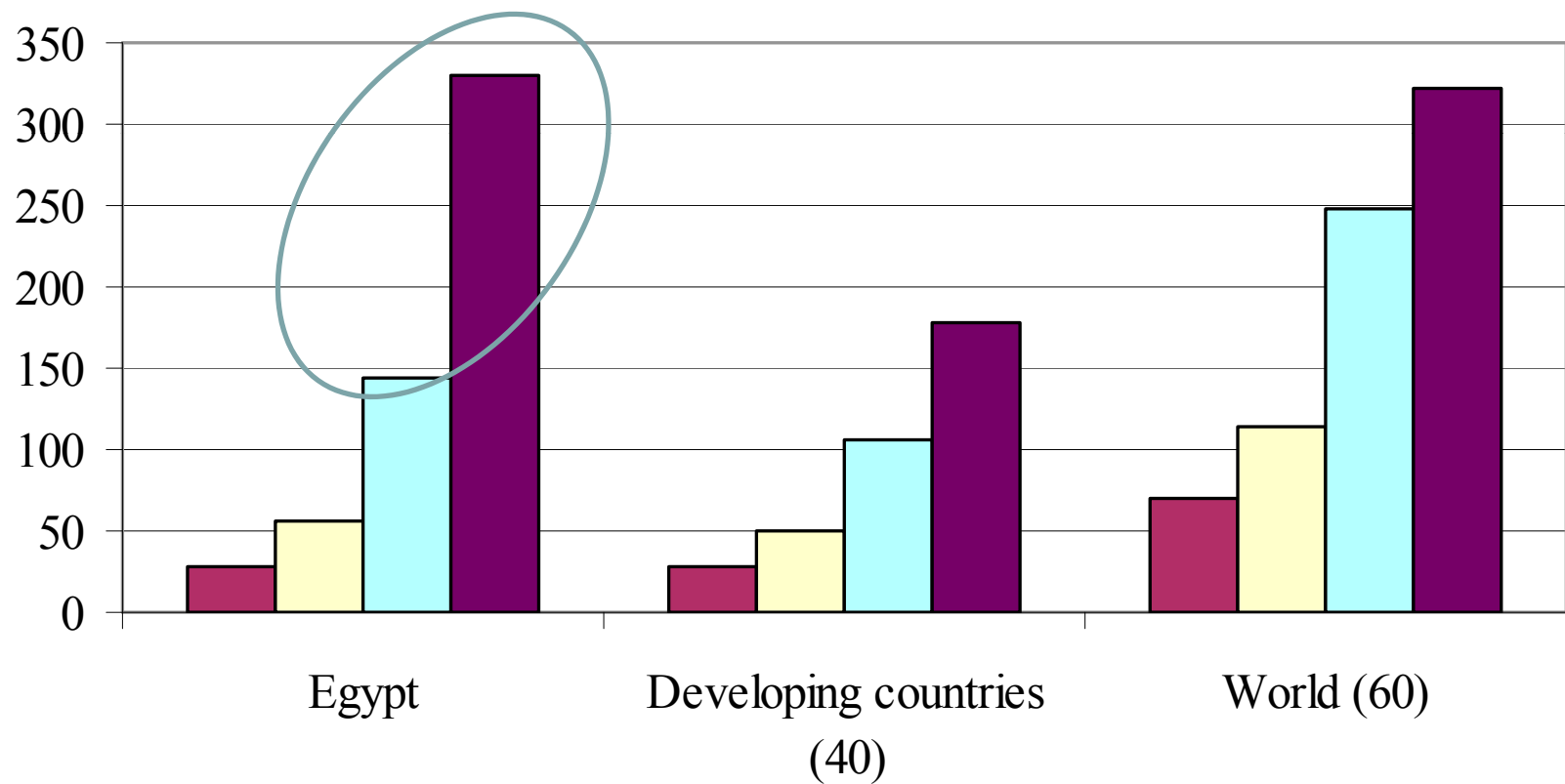
Figure 2. Infrastructure indicators over time -- Electricity

d.) EGC per 1,000 workers (megawatts)
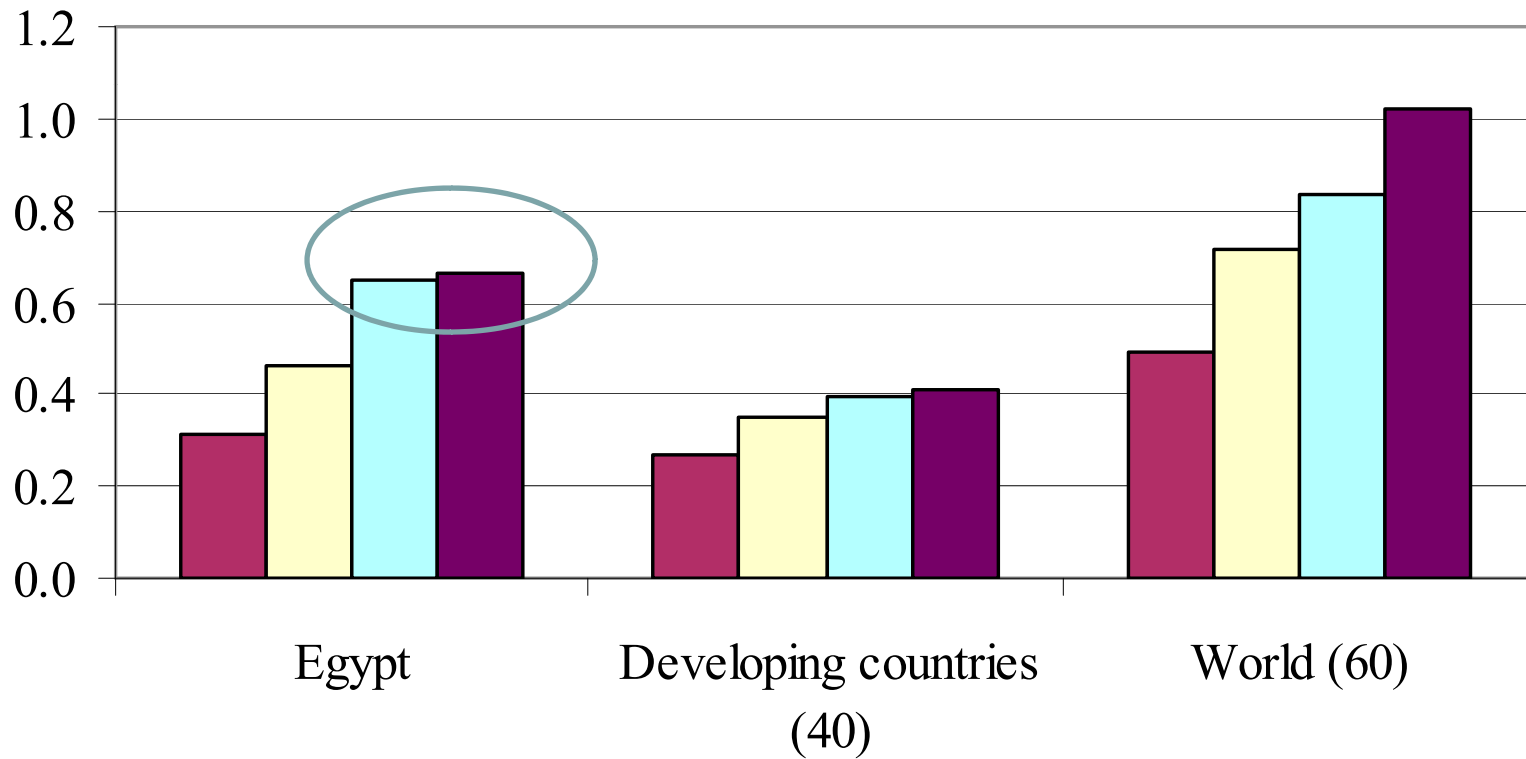
Status of infrastructure in Egypt

- Egypt has a level of public infrastructure consistent with its income level

    - The result of decades of purposeful investment

- Notwithstanding this progress,

    - Slowdown in electricity generation and transportation in last decade

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

- ***Variables of interest:***
  – Indices of Electricity, Transportation & Telecomm.
  – Government expenditures (burden of taxation)
  – Initial GDP per capita (convergence)

- ***Control Variables:*** Regular growth determinants:
  – Initial Output/Value added, Educational Investment, Financial Depth, Fiscal burden, Macro Volatility, Inflation, Trade Openness, TOT shocks, Period shifts

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

Table 4. Economic Growth and Public 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]
Infrastructure Variables:				
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]
Control Variables:				
Initial GDP per capita	-1.592 ***	-2.072 ***	-1.512 ***	-2.688 ***
in logs	[-5.175]	[-5.900]	[-7.133]	[-7.576]
Education	0.949 **	1.008 ***	0.239	0.367
secondary school enrollment rate, in logs	[2.424]	[2.973]	[0.813]	[1.186]
Financial Depth	0.403 **	0.719 ***	1.206 ***	1.075 ***
private credit/GDP, in logs	[2.114]	[4.226]	[7.165]	[5.925]
Crisis Volatility	-1.876 ***	-1.734 ***	-1.937 ***	-1.761 ***
std dev of GDP per capita growth[5]	[-15.070]	[-15.400]	[-20.300]	[-16.120]
Government Burden	-0.919 *	-0.224	-0.274	0.102
government expenditure/GDP, in logs	[-1.957]	[-0.429]	[-0.611]	[0.213]
Inflation	-0.227	-2.033 ***	-3.036 ***	-2.841 ***
1+Growth rate of CPI, in logs	[-0.362]	[-3.189]	[-5.071]	[-4.561]
Trade Openness	4.221 ***	2.062 ***	1.287 **	1.586 ***
(exports+imports)/GDP, in logs	[9.487]	[4.358]	[2.432]	[3.504]
Growth rate of Terms of Trade	0.038 ***	0.035 ***	0.046 ***	0.045 ***
log differences of terms of trade index	[3.294]	[2.942]	[4.167]	[4.019]
Constant	0.733	16.826 ***	21.379 ***	26.997 ***
	[0.208]	[3.624]	[5.036]	[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).

Table 4. Economic Growth and Public Infrastructure – Individual Effects

Sample: 78 countries, 1961-2005 (5-year period observations)
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	[1]	[2]	[3]	[4]
Infrastructure Variables:				
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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

Table 5. Economic Growth and Public Infrastructure –Joint Effects

Sample: 78 countries, 1961-2005 (5-year period observations)
Estimation Method: System GMM

	Dependent Variable: GDP per capita Growth	
	[1]	[2]
Infrastructure Variables:		
Electricity Index[1]	0.749 ***	0.975 ***
	[5.353]	[5.292]
Transportation Index[2]	1.093 ***	
	[3.102]	
Telecommunication Index[3]	1.097 ***	
	[4.754]	
Transportation & Telecommunication Index[4]		2.135 ***
		[5.637]
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

Growth Effects

1. Improvement by 1 std. dev.

    - electricity: 0.89 pp (EGY to ESP)

    - transportation: 1.24 pp (EGY to NOR)
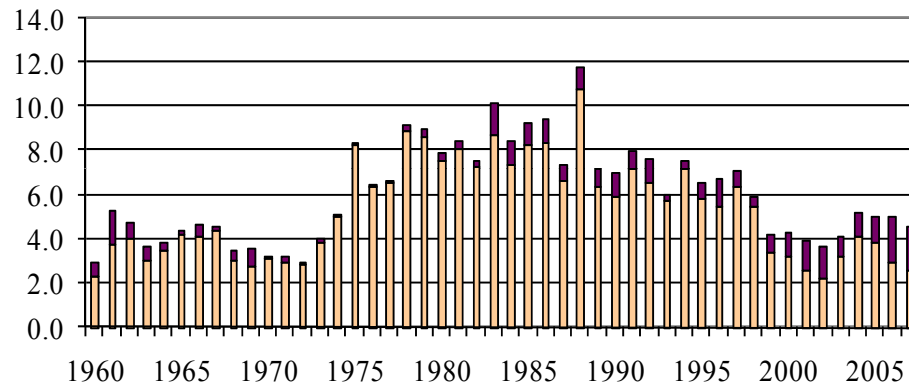
    - telecommunications: 1.26 pp (EGY to DEU)

2. Improvement from 25th to 75th percentile

    - electricity: 1.23 pp (PHL to ITA)

    - transportation: 2.05 pp (NGA to NZL)
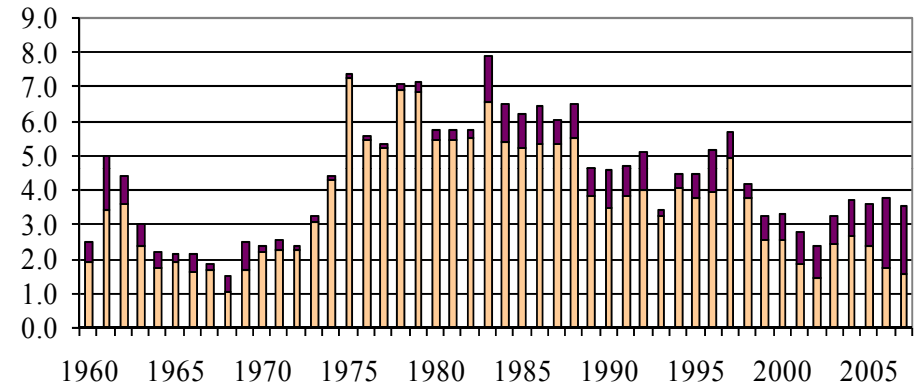
    - telecommunication: 2.08 pp (IND to PRT)

Infrastructure Expenditures

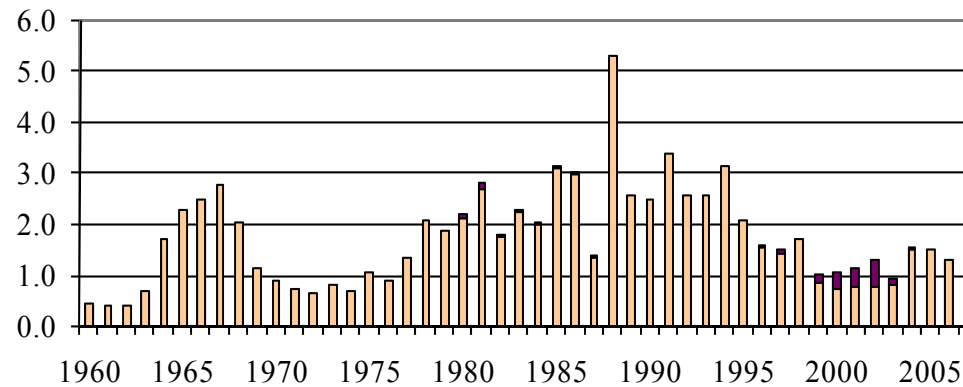# Figure 4. Infrastructure Investment in Egypt: 1960-2007
(% of GDP)

(a) Total Investment

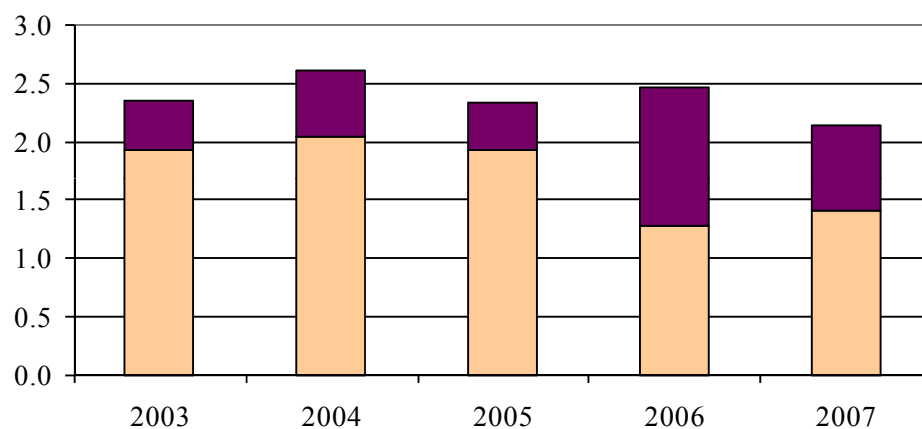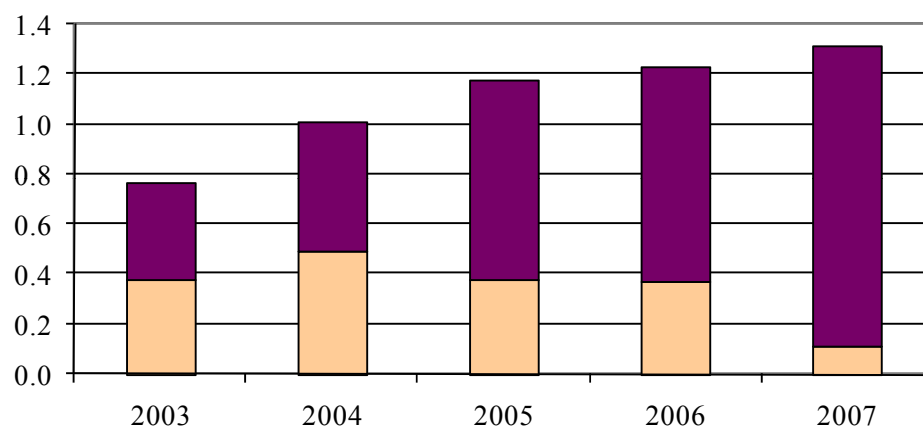**(b) Transportation (incl. SC) & Communications**

(c) Electricity

□ Public ■ Private

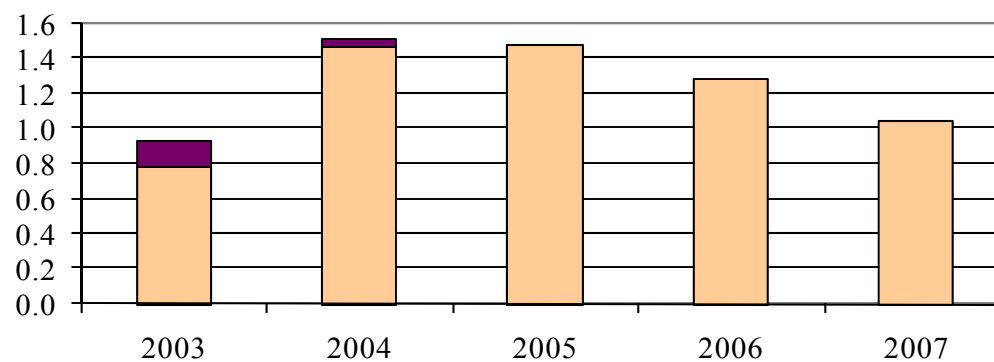# Figure 5. Infrastructure Investment in Egypt: 2003-2007
(% of GDP)
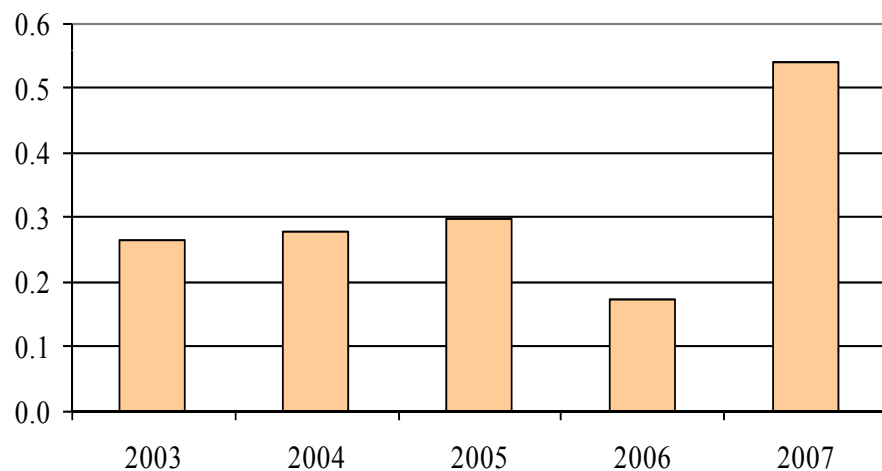
(a)Transportation
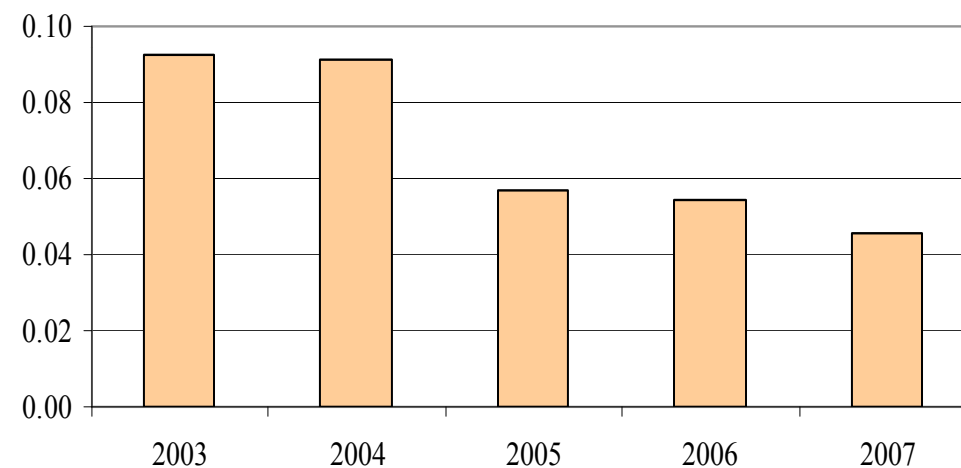

(b) Communications

(c) Electricity

☐ Public ■ Private

Figure 5 (continued). Infrastructure Investment in Egypt: 2003-2007
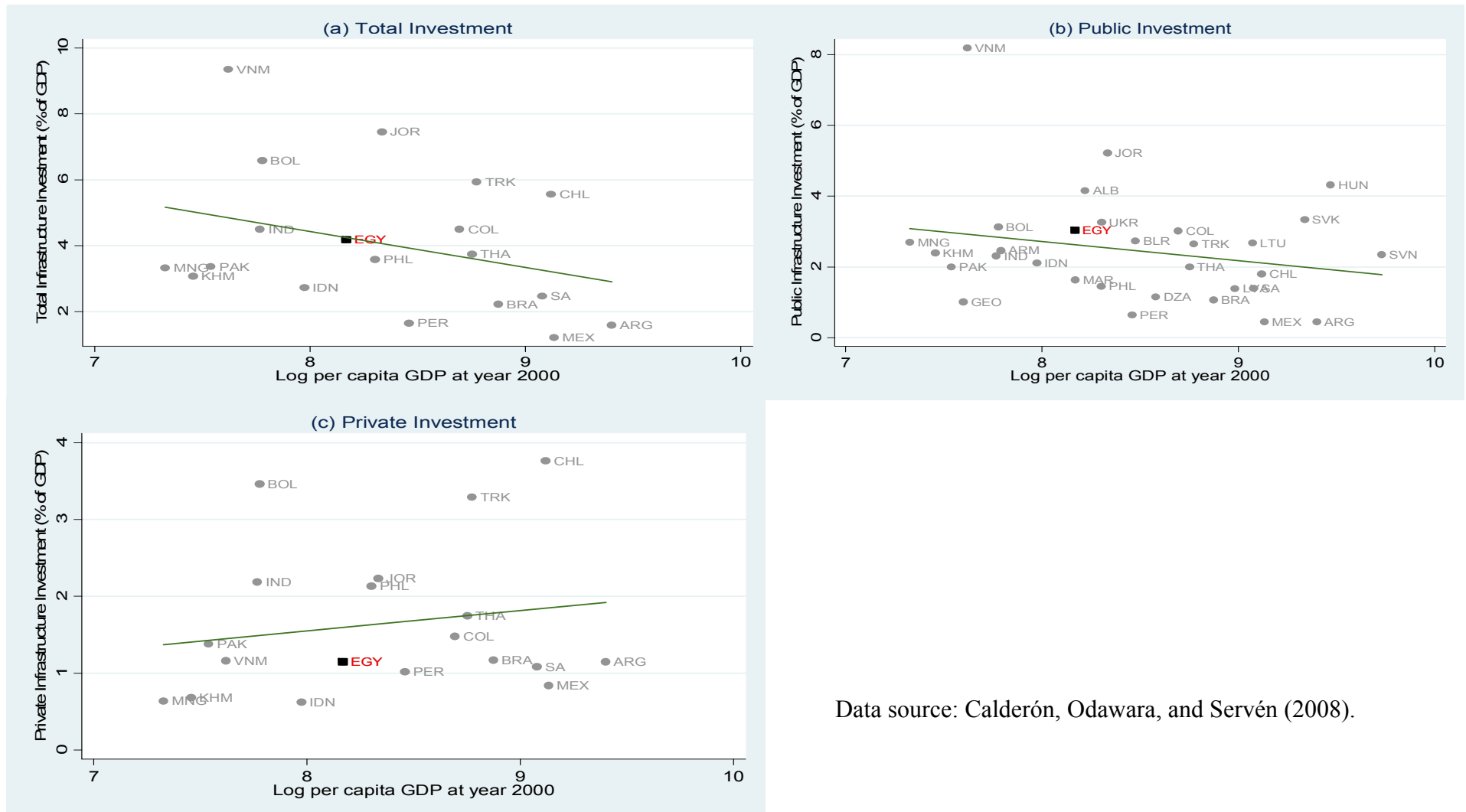## (% of GDP)

(d) Water

(e) Suez Canal

☐ **Public** ■ **Private**

Figure 6. Infrastructure Investment relative to log per capita GDP
(average of 2000-05, % of GDP)

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

Infrastructure Expenditures and Progress in Infrastructure

Table 6. Electricity Exp. 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 *** [5.00]			
Ratio of expenditure to labor force (expenditure on electricity per 100,000 workers, in logs)		0.051 *** [5.04]		
Ratio of expenditure to GDP (expenditure on electricity / 1,000 GDP)			0.005 *** [6.84]	
Ratio of expenditure to GDP (expenditure on electricity / 1,000 GDP, in logs)				0.079 *** [8.02]
Constant	-0.056 *** [3.57]	-0.094 *** [3.89]	-0.084 *** [5.32]	-0.206 *** [7.39]
Observations	34	34	34	34
R-squared	0.37	0.32	0.41	0.37

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%

Table 7. 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%

Projections

Project effect of…

- Increasing infrastructure expenditures
  - from 5 % of GDP
  - to 6% of GDP or 8% of GDP
- Assuming high and low government burden

Figure 8: Projected Growth Improvement from Higher Infrastructure Investment
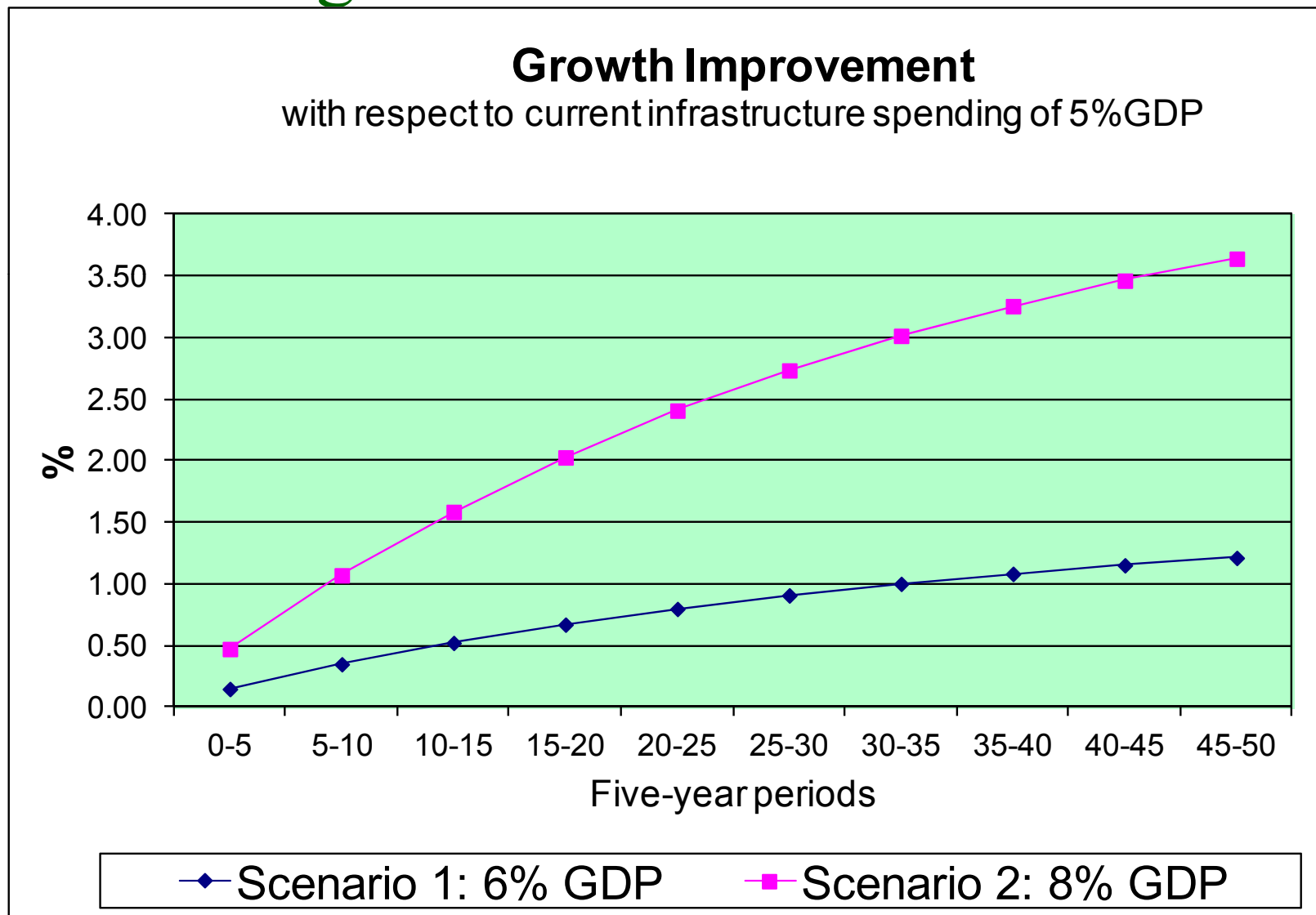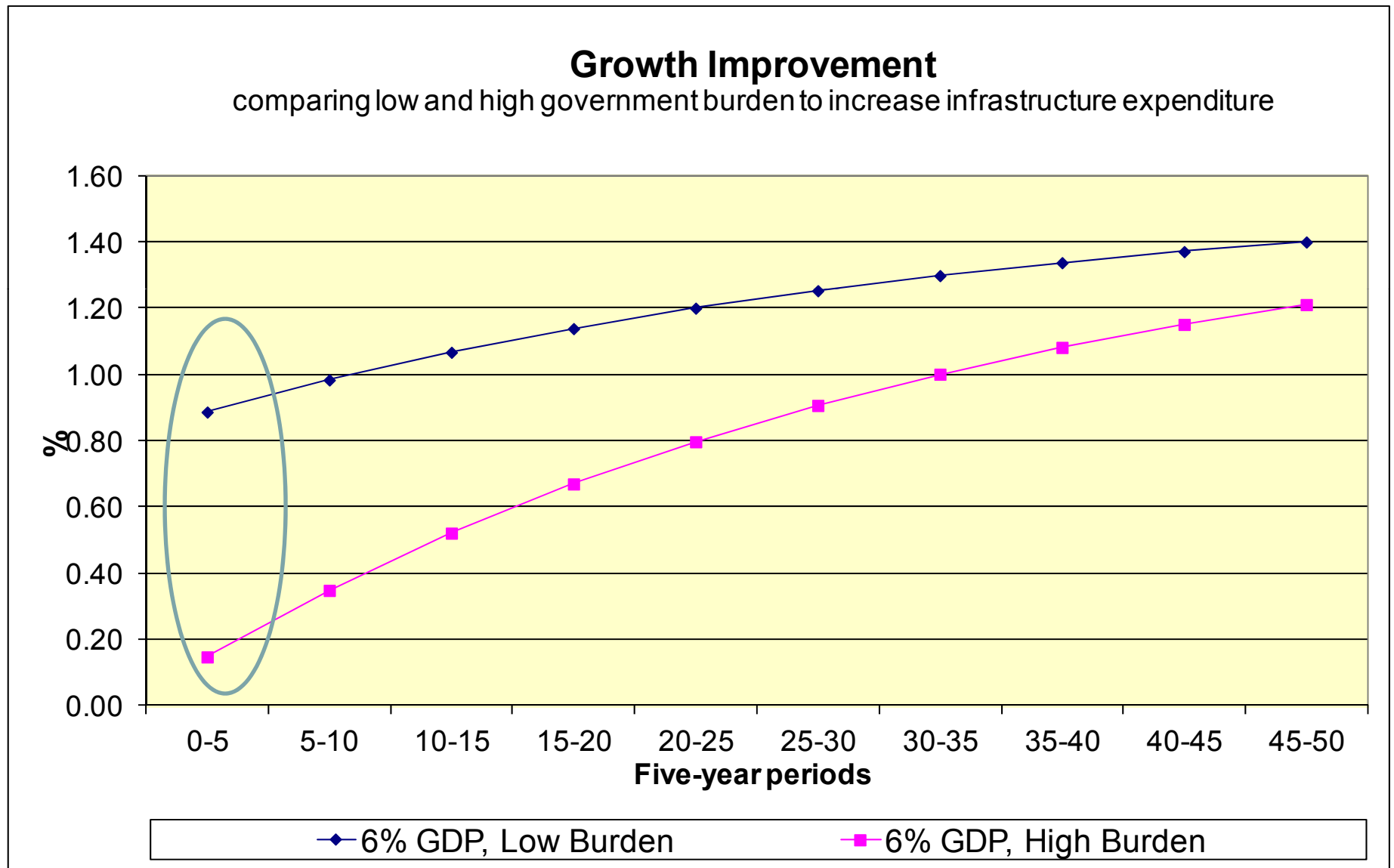

Growth Improvement
with respect to current infrastructure spending of 5%GDP

X-axis: Five-year periods (0-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50)
Y-axis: % (0.00 to 4.00)

Legend:
- Scenario 1: 6% GDP
- Scenario 2: 8% GDP

Figure 9: Projected Growth Improvement under Different Fiscal Burden

Growth Improvement
comparing low and high government burden to increase infrastructure expenditure

Y-axis: %

X-axis: Five-year periods

Legend: 6% GDP, Low Burden — 6% GDP, High Burden

Conclusions

Some critical values for policy (I)

1. Fiscal multiplier for infrastructure

   1 pp of GDP increase leads to

   - Short run: small effects (time to build)

   - Long run: 1.6 pp of GDP

   - … much larger than multiplier for gvt. consumption

Some critical values for policy (II)

2. Fiscal sustainability of infrastructure expenditures

   Assume tax revenues of 30% of GDP

   - Short run: self financed portion is 35% of expenditure
   - Long run: self financed portion rises to 75%
   - … will not pay for itself from general revenues

Some critical values for policy (III)

3.   Increase in per capita GDP for the economy

   1 pp of GDP increase leads to

   -   Net Present Value of 6 pp of GDP for first 25 yrs
   -   (assuming a discount rate of 5% over growth rate)
   -   … clearly worth it from a social perspective

The mode of funding matters

- Positive effects can increase sharply, especially in the short run, if

    – Infrastructure is built in coordination with the private sector … for funding and efficiency

    – Increase in infrastructure expenditure is accompanied by public expenditure reform (… subsidies)

A caveat on value of economic effects

- Full social welfare evaluation will take into account the direct benefits of infrastructure on the health and comfort of beneficiaries

Thanks

Additional slides

Table 2. 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	-0.4230**	1		
q_elec	0.7331**	-0.6391**	1	
elec_access	0.8295**	-0.2005*	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.

Table 2. 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.
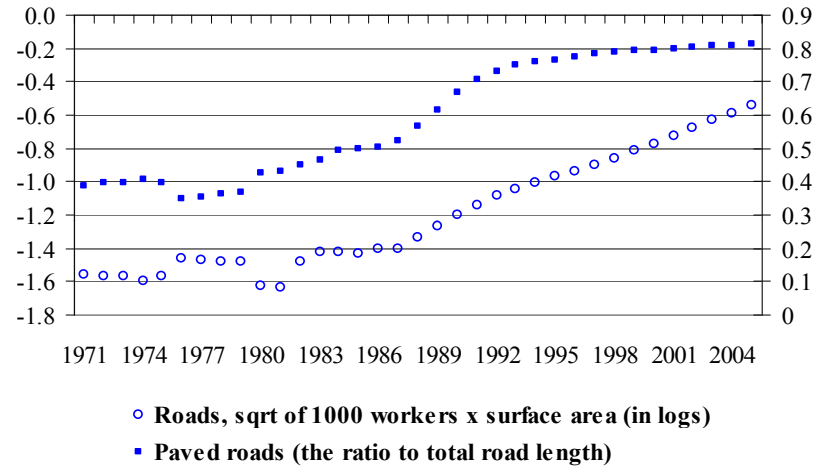
Table 3. Variance by Sector Using Principal Component Analysis

Sector	Variance
Transport	0.7231
Telecommunications	1.000
Electricity	0.7330
Transport & Telecommunications	0.9018

Figure 3. Infrastructure Indices by Sector in Egypt (1971-2005)

Infrastructure Indices by Sector
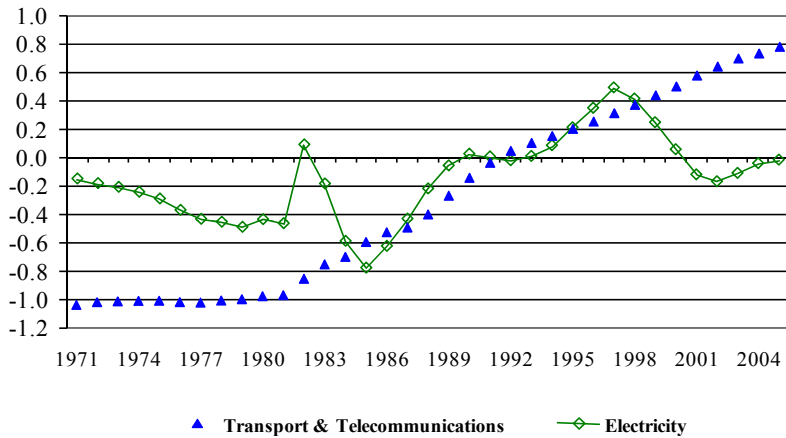
(a) Components of Transport Index

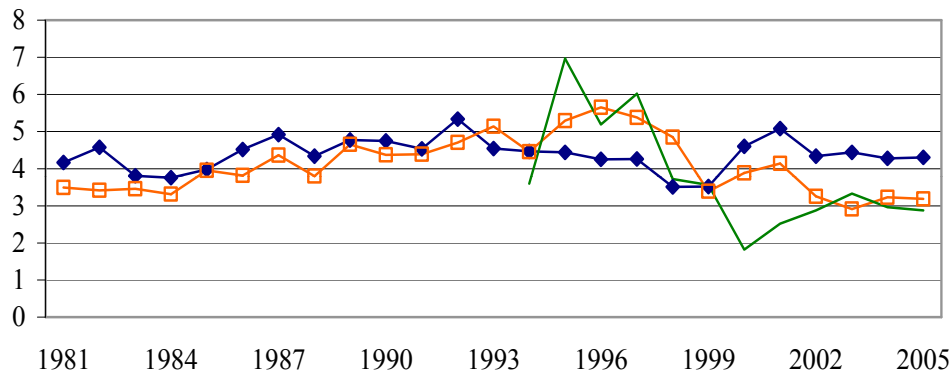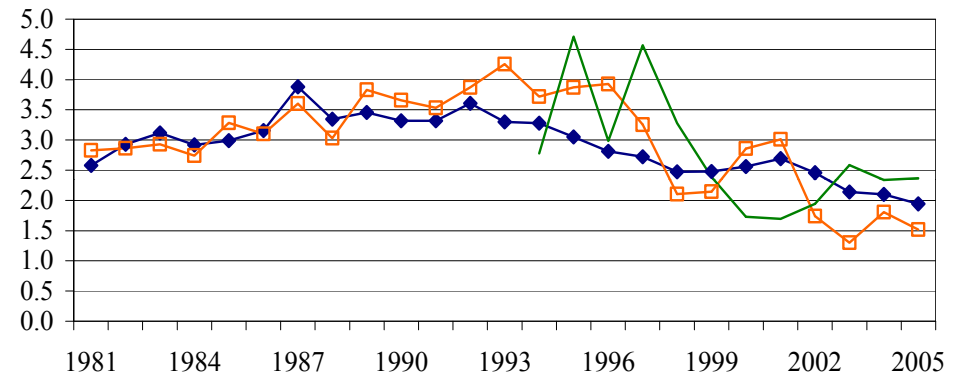*(b) Components of Telecommunications Index*
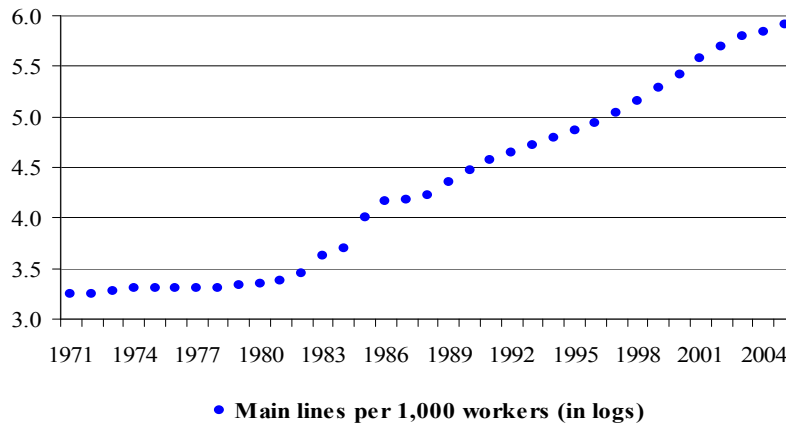
(c) Components of Electricity Index
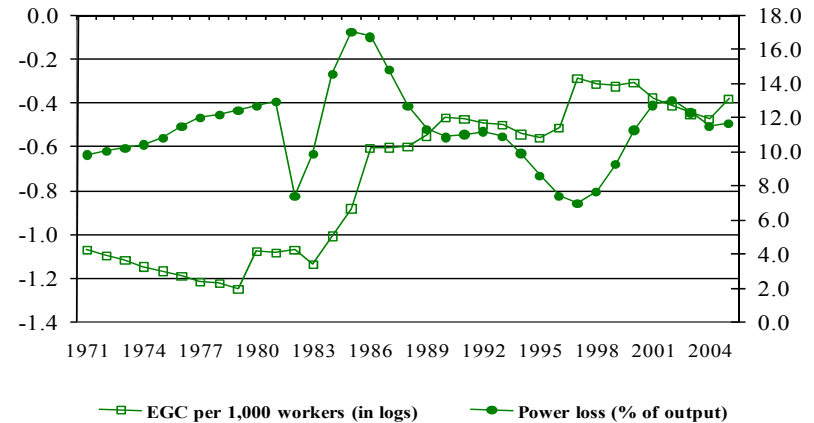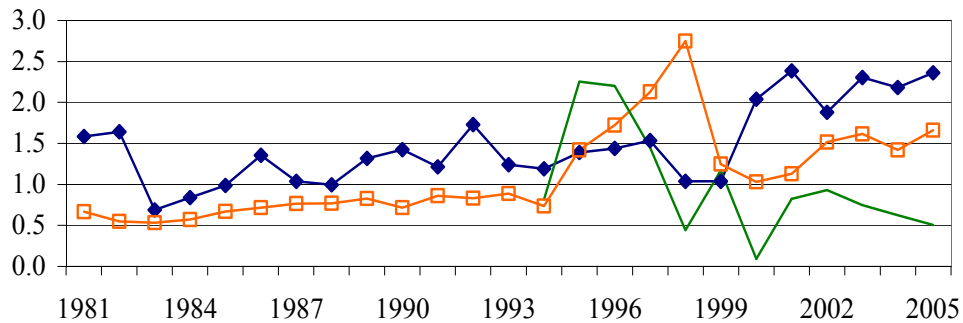
Figure 7-1. Infrastructure Investment across Countries (% of GDP)

(a) Total Investment
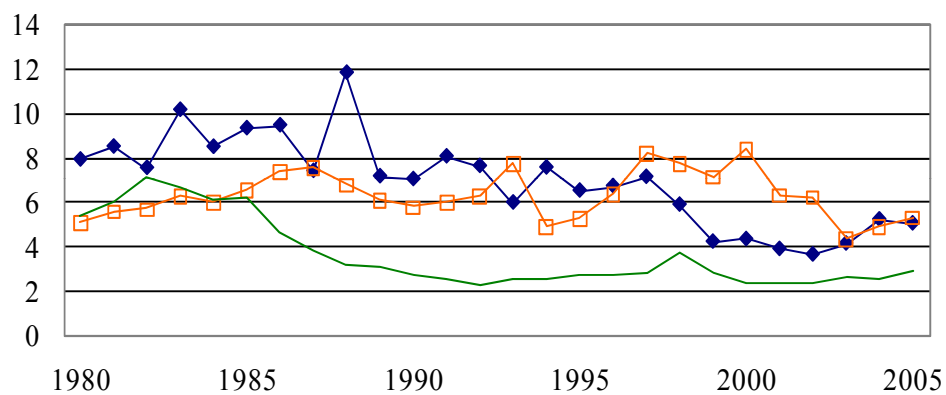

(b) Public Investment

(c) Private Investment
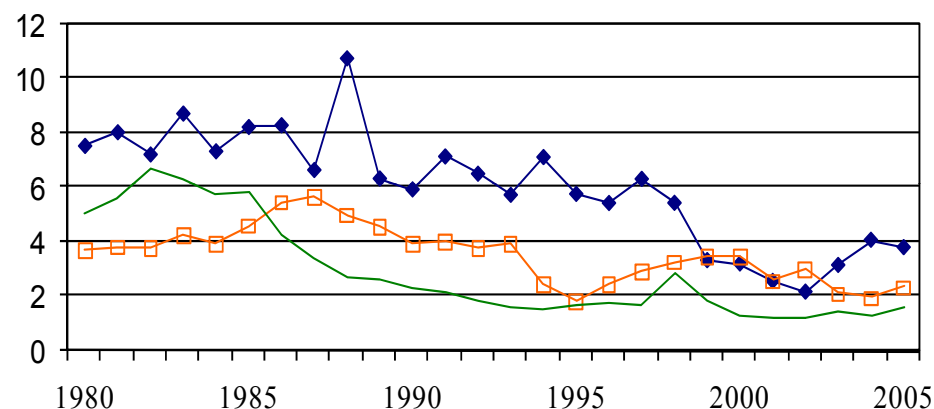

Data source: Calderón, Odawara, and Servén (2008).

Legend: IND   PAK   IDN

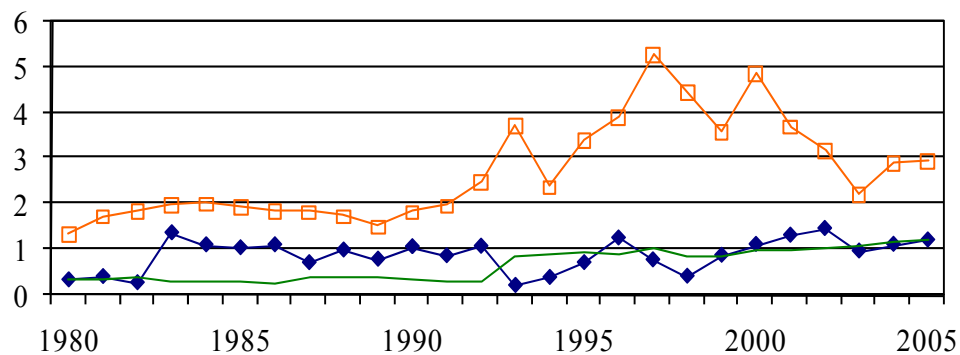# Figure 7-2. Infrastructure Investment across Countries
(% of GDP)

(a) Total Investment

(b) Public Investment

(c) Private Investment

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

EGY   TRK   SA