Policy Research Working Paper 5105

Infrastructure and Economic Growth in the Middle East and North Africa

Paul Noumba Um
Stéphane Straub
Charles Vellutini

The World Bank
Middle East and North Africa Region
Sustainable Development Department
October 2009

Policy Research Working Paper 5105

Abstract

This paper analyzes the impact of infrastructure on growth of total factor productivity and per capita income, using both growth accounting techniques and cross-country growth regressions. The two econometric techniques yield some consistent and some different results. Regressions based in the growth accounting framework suggest that electricity production helps explain cross-country differences in total factor productivity growth in the Middle East and North Africa region. Growth regressions support that conclusion, while also stressing an effect of telecommunications infrastructure. Finally, growth regressions also indicate quite consistently that the returns to infrastructure have been lower in the Middle East and North Africa region than in developing countries as a whole.

This paper—a product of the Economics Support Unit, the Sustainable Development Department, Middle East and North Africa Region—is part of a larger effort in the department to promote knowledge sharing and empirical research assessing the impact of infrastructure investment on growth and the importance of institutional reforms. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at pnoumbaum@worldbank.org.

Infrastructure and Economic Growth in the Middle East and North Africa[‡]

Paul Noumba Um[§], Stéphane Straub[†] and Charles Vellutini[‡]

[‡] This paper has benefited from discussions comments and suggestions from Laslo Lovei, Jonathan D. Walters, Antonio Estache, Farid Gasmi, and Auguste Kouame. It represents the views of its authors, and does not reflect the views of the institutions they are affiliated with. Any mistake is therefore the responsibility of the authors. We are also grateful to the valuable support provided by Loic Whitmore in the preparation of the infrastructure data set.
[§] Lead economist, Sustainable Development Department, MENA Region, World Bank. Email: pnoumbaum@worldbank.org
[†] Toulouse School of Economics (ARQADE and IDEI). Email: stephane.Straub@univ-tlse1.fr
[‡] Toulouse School of Economics and ECOPA. Email: charles.vellutini@univ-tlse1.fr

1. Introduction

Policy-makers around the world see infrastructure investment as an essential determinant of growth.[1] However, as Table 1 shows, different regions display different behavior in terms of infrastructure investment and economic performance. For example, Straub et al. (2008) show that between 1975 and 1995 East Asia's economic growth outpaced the growth of other world regions and also displayed larger rates of infrastructure stocks increase, while the Middle East and North Africa group of countries' GDP grew only by a factor of 1.8, despite having one of the highest growth rate in terms of both electricity generating capacity and telephone coverage.

Table 1: Growth of GDP and Infrastructure Stocks

1995 levels as multiples of 1975 levels

	GDP	Electricity	Roads	Telecoms
East Asia	4.8	5.9	2.9	15.5
South Asia	2.6	4.4	2.5	8.2
Middle East & North Africa	1.8	6.1	2.1	7.2
Latin America & Caribbean	1.8	3.0	1.9	5.1
OECD	1.8	1.6	1.4	2.2
Pacific	1.7	2.0		4.3
Sub-Saharan Africa	1.4	2.6	1.7	3.9
Eastern Europe	1.0	1.6	1.2	6.9

GDP – PPP constant 2000 international $; Electricity - MW of generating capacity; Roads – km of paved road; Telecoms – number of main lines. See Straub et al. (2008) for construction. Sources: World Development Indicators and Canning (1998).

One possibility is that the growth impact of infrastructure policies might depend on the correct placement of specific investment projects, the composition of infrastructure investments and on their efficiency in relieving infrastructure constraints of the economy as they emerge. As a matter of fact, Table 2 shows that Middle Eastern and North African countries fare badly in terms of a number of infrastructure constraints such as connection delays or electricity outages. It is likely that, in contrast to other regional blocks, the Middle East and North Africa region does not face an infrastructure access gap, but faces an infrastructure quality gap. Indeed, with the exception of Yemen and Djibouti or Iraq, MENA countries have attained universal access in most basic

[1] See for example JBIC et al. (2005)

infrastructure (water, sanitation, telecommunications, electricity, transport) as depicted in Table A1 in the Appendix, whereas the infrastructure quality gap has been widening across countries due to delays in structural and institutional reforms. In spite of significant public investment in infrastructure, most countries in the region have been unable to cope with pressing needs stemming from population growth, rapid urbanization and economic growth. A good illustration of the inability of governments in MENA to cope with growing demand for infrastructure services is given by the electricity sector whereby installed generation capacity is estimated to be 20 percent below the aggregate demand for electricity.

Table 2: Impact of Infrastructure Shortages on Firms

Region	Electricity connection delay (days)	Value lost to power outages (% of sales)	Water connection delay (days)	Mainline telephone connection delay (days)
East Asia & Pacific	21	2.6	18	16
Europe & Central Asia	15	3.0	9	16
Latin America & Caribbean	34	4.1	35	36
Middle East & North Africa	62	4.3	44	49
South Asia	49	7.4	29	50
Sub-Saharan Africa	38	5.9	42	54
OECD	10	2.3	—	9

Source: The data are derived from World Bank Investment Climate Assessments, and reported at www.enterprisesurveys.org

In addition, political and institutional factors (i.e. inefficiencies in government decisions and actions) also affect the level of infrastructure stock and quality in a given country. This is particularly acute in MENA countries which have yet to implement structural institutional reforms, including the implementation of market liberalization policies, effective regulation of service providers, and roll back subsidies distorting end users' tariffs. In addition, lack of institutional reform and inefficient public investment policies contain the impact of infrastructure investment on growth. Mustapha Kamel Nabli & Marie-Ange Véganzonès-Varoudakis (2007) investigate the linkage between economic reforms, human capital, infrastructure and economic growth in MENA. Employing growth regressions that include composite indicators of infrastructure on panel data, they find that the contribution of infrastructure on growth in MENA has been substantial but has declined from 1.4 during between 1980 and 1989 to 1.0 between 1990 and 1999. In the same vein, Agenor et al. (2005) investigate the impact of public infrastructure on private investment in three MENA countries (Egypt, Jordan and Tunisia) and conclude that reducing unproductive public infrastructure expenditure and improving quality must be accompanied by institutional reform to limit the eviction effects of public investment on private sector investment. Institutional reforms aiming to establish enabling environments for private sector development are therefore crucial to maximize infrastructure impact on growth.

This paper examines whether infrastructure investment has contributed to Middle East and North Africa's economic growth using both a growth accounting framework and cross-country regressions, as in Straub et al. (2008). Specifically, Middle East and North Africa is understood to include:

* Algeria
* Bahrain
* Djibouti
* Egypt
* Iran
* Iraq
* Israel
* Jordan
* Kuwait
* Lebanon
* Libya
* Morocco
* Oman
* Qatar
* Saudi Arabia
* Syria
* Tunisia
* United Arab Emirates
* West Bank and Gaza
* Yemen

Together, these countries represent about 6% of the total world population, almost equivalent to the population of the European Union, and one and a quarter times larger than that of the United States. The region is also characterized by the presence of vast reserves of petroleum and natural gas, estimated to represent 70% of the world's oil reserves and 46% of the world's natural gas reserves, and comprises 8 of the 12 OPEC nations.

The structure of the paper is as follows. Section 2 presents the growth accounting exercise. Section 3 turns to cross-country growth regressions. Finally, Section 4 discusses the results, compares them to other related studies and concludes.

2. Growth accounting

2.1. Methodology

Standard growth accounting

The methodology closely follows Straub et al. (2008). The formal framework of growth accounting is the production function

(1) $$Y = A.F(K, L),$$

where *Y* is aggregate GDP, *A* is the time-varying total factor productivity (TFP) and *K* and *L* are respectively (total) capital and labor. This leads to the canonical growth accounting equation

(2) $$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - S^L \frac{\dot{L}}{L} - S^K \frac{\dot{K}}{K}$$

where S^L and S^K are the respective observed shares of income. (3) is typically not implemented through econometric estimation but rather through direct calculation: all the variables on the right-hand side are observed.

Growth accounting with infrastructure

As in Hulten et al. (2006), we assume that infrastructure (*X* in the following equations) influences output through two channels. First, it impacts TFP through

(3) $$A = A(X) = \tilde{A}.X^{\eta}$$

where $\tilde{A}$ is the « true » TFP and η is the elasticity of *A* with respect to *X*. Here, infrastructure raises output without any payments by firms for infrastructure services. This channel captures the externality aspect of infrastructure; this is clearly the value we are interested in estimating.

Second, infrastructure can enter the production function as an additional production factor:

$$(4) \qquad Y = \tilde{A}.X^{\eta}.F(\tilde{K}, L, X)\,.$$

where $\tilde{K}$ is the stock of non-infrastructure capital. The specification of infrastructure as one more factor reflects its market-mediated impact, whereby firms pay for infrastructure services.

Note that η, the elasticity of TFP with respect to infrastructure, is not observable as it captures the externality dimension of infrastructure: no income and price data can be used. Also, in practice neither data on infrastructure prices nor on different types of capital are available in a consistent way (we only have data on *K*, not $\tilde{K}$).

As a result, we need to rewrite to model so as to fit the available data, as:

$$(5) \qquad Y = \tilde{A}.X^{\eta}.F(K, L)$$

which leads to (appending an error term):

$$(6) \qquad \frac{\dot{Y}}{Y} = \frac{\dot{\tilde{A}}}{\tilde{A}} + \eta\frac{\dot{X}}{X} + S^{L}\frac{\dot{L}}{L} + S^{K}\frac{\dot{K}}{K} + \varepsilon\,.$$

Finally, we substitute (2) into (6), so that:

$$(7) \qquad \frac{\dot{A}}{A} = \frac{\dot{\tilde{A}}}{\tilde{A}} + \eta\frac{\dot{X}}{X} + \varepsilon\,.$$

The left-hand side of (7) is TFP growth as computed (not estimated) in the standard growth accounting approach. An alternative route to a full estimation of (6) is thus to estimate the reduced form (7) using the (year by year) available results from (2) in terms of TFP growth rates ($\frac{\dot{A}}{A}$). This is convenient as these are indeed readily available from standard growth accounting exercises for a number of countries, including MENA countries (see below).

We will therefore use (7) below to estimate η, the pure externality effect of infrastructure.

2.2. Data and estimation

There are two main options for estimating (7). One is based on regional panel data, while the other one is a country-per-country approach based on time series data.

The panel estimation technique rests on the assumption that a common production function exists for the countries under analysis, with individual country effects to be controlled for. While this approach has been extensively used with state / provincial panel data for India (Hulten et al. 2006), Italy (La Ferrara & Marcellino, 2000) and the US (Holtz-Eakin, 1994), it remains to be seen whether it can work when applied to a set of countries, albeit in the same region[2]. We report below panel estimations suggesting that indeed this modeling of growth accounting could be fruitful in the specific case of MENA countries.

We then perform individual country estimations, which more realistically do not assume that there is a common underlying technology for all countries. This has been the approach used by most non-infrastructure growth accounting studies. [3]

[2] In a similar exercise for East Asian countries, Straub et al. (2008) found that panel models could not cope with cross-country heterogeneity.
[3] See for example Barro & Sala-i-Martin (2003).

Concerning any possible simultaneity in the estimation of (7) we cannot rule out a priori an influence of TFP growth on investment in infrastructure, $\frac{\dot{X}}{X}$. Possible causes of simultaneity include endogenous responses of infrastructure policies to TFP growth, making it necessary to test the presence of reverse causation in the data. This will need to be tested.

Country-specific estimations, as opposed to panel estimations, call for longer time series in order to produce efficient estimators. Two sets of long time series can be considered. First, physical indicators of infrastructure stocks have been used in the literature. Canning (1999) uses indicators of telephones lines availability, electricity generating power and length of paved roads and railways to estimate an aggregate production function. This dataset and the one available from the World Bank Indicators (WDI) database include time series of usable length for key infrastructures (excluding water) for all countries included in our exercise. Second, it is in theory possible to build time series of infrastructure stocks based on investment data together with the perpetual inventory method – just as time series of *K* are normally constructed. Unfortunately, in practice financial data on infrastructure (in monetary terms or as percentage of GDP) are scarce for the sample countries. Also, some authors (see Pritchett, 1996) have warned against the poor quality of financial indicators of public investment. For these reasons, we concentrate on physical indicators of infrastructure.

With respect to explanatory variables, we use data from WDI, covering a time period up to 2005:

- Number of mobile and fixed-lines telephone subscribers [WDI variable name: **it_tel_totl**];
- Electricity:
  - Electricity generation in kwh [WDI variable name: **eg_elc_prod_kh**];
  - Electricity power transmission and distribution losses [WDI variable name: **eg_elc_loss_zs];**
  - These two variables were combined to calculate the Electricity generation in kwh, net of transmission and distribution losses. In most of the estimations below, this quality-adjusted time series was used.
- Railway lines, total route in kms [WDI variable name: **is_rrs_totl_km**].

- Roads data [WDI variable name: **is_rrs_totl_km**] and water data [WDI variable name: **sh_h2o_safe_zs**] could not be used as the corresponding time series are too short for almost all of MENA countries.

The TFP growth rates provided by UNIDO's World Productivity Database (WPD)[4], which contains information on levels and growth of aggregate total factor productivity (TFP) for as many as 112 countries between 1960 and 2000, are used as the dependent variable, as in (7) (see Isaksson, 2008). UNIDO calculated (not estimated) TFP growth rates following the standard methodology that is, following equation (3)[5] and, in addition, taking into account changes in labor quality. In addition UNIDO provides a series of *estimations* of TFP growth using (3) as a regression, with S^L and S^K parameters to be estimated, not observed. They provide results from a variety of techniques, including a non-parametric one using Data Envelopment Analysis with Long Memory.[6] These econometric estimates of TFP have been used in addition to the standard calculated hicks-neutral TFP growth as a test of robustness of the results we get with the latter.

Only 8 countries (see below) in the MENA sample have sufficient data (particularly TFP growth rates) for us to carry out the estimations. This is an area where future research could be developed. In particular, future work could focus on the specific case of Gulf countries (GCC) where the bulk of infrastructure investment in the region has materialized.

2.3. Results

Table 3 reports results from panel regressions with random individual effects. First, we note that telephone and rail variables are not significant in explaining TFP growth, while gross electricity production is (columns 1 and 2). This is robust in the versions of the regression where two different kinds of TFP growth is used (standard Hick-neutral calculated TFP growth and a non-parametric econometric estimate of the same) and where gross electricity production is the sole regressor (columns 5 and 6). While this finding is counter-intuitive regarding

[4] www.unido.org/data1/wpd
[5] This is referred to in Isaksson (2008) as Hicks-neutral TFP change.
[6] See Isaksson (2008). Essentially the LM DEA method relies on linear programming estimators.

telecommunications, it is less surprising regarding railways. Few countries in MENA have efficiently run railways, and when they do exist, they are not interconnected across countries because of political problems (Algeria/Morocco) or incompatible standards.

Using the quality-adjusted electricity production variable (net of transmission and distribution losses), however, the result holds only when that variable is used alone (columns 7 and 8), and not jointly with other infrastructure variables (columns 3 and 4).

Second, in one specification (column 1), railways significantly influence TFP growth, estimated through non-parametric methods. However, the result is not robust to changes in the choice of the electricity variable (gross or net of losses) and the specification of the TFP growth.

Thirdly, the rho coefficient in all the panel regressions in Table 3 is very close to zero, which means that most of the result comes from 'between' (that is, cross-country) variation. Also, note that overall R^2 (measuring goodness of fit for both between and within variations) remains modest in all regressions.

All in all, these regressions suggest that the growth rate of electricity production is moderately successful in explaining TFP growth and that most of the explained variation is cross-country.

Finally, two specification tests are carried out:

- A Hausman test shows that the model with random effects is preferable to fixed effects; this is consistent with the fact the 8 countries under analysis are drawn from a larger population of countries.
- An endogeneity test for the electricity variable using its own lag as an instrumental variable rejects reverse causation from the explained variable.

Table 3: Panel regressions

VARIABLES	(1) TFP growth Long Memory DEA	(2) TFP growth hicks neutral	(3) TFP growth Long Memory DEA	(4) TFP growth hicks neutral	(5) TFP growth Long Memory DEA	(6) TFP growth hicks neutral	(7) TFP growth Long Memory DEA	(8) TFP growth hicks neutral
WDI: Growth rate of Mobile and fixed-line tel. subscr.	0.00115	0.899	-0.00158	0.590				
	(0.0292)	(3.046)	(0.0324)	(3.427)				
WDI: Growth rate of electricity prod	0.171**	18.67**			0.262***	30.75***		
	(0.0848)	(8.168)			(0.0713)	(7.108)		
WDI: Growth rate of kms rail	-0.0999*	-9.278	-0.0860	-7.787				
	(0.0546)	(5.856)	(0.0555)	(6.007)				
WDI: Growth rate of electricity prod, net of losses			0.0743	8.727			0.243***	28.15***
			(0.0663)	(6.455)			(0.0693)	(7.125)
Constant	0.993***	-1.059	1.001***	-0.229	0.983***	-2.074***	0.985***	-1.776**
	(0.00862)	(0.857)	(0.00798)	(0.801)	(0.00673)	(0.677)	(0.00686)	(0.704)
Observations	137	137	137	137	232	232	232	232
Number of id_country[7]	8	8	8	8	8	8	8	8
r2_o	0.0496	0.0580	0.0200	0.0225	0.0677	0.0929	0.0658	0.0874
Rho	0	0	0	0	0	0	0	0

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Next, we turn to the results from cross-country regressions. Not surprisingly given the above results, only on country (Tunisia) has its TFP growth explained by the electricity variable – as we now lost the cross-country dimension of the panel estimations. Being a small oil producing countries, Tunisia has successfully implemented measures to roll back subsidies on electricity consumption by households and industries. The implementation of cost reflective electricity, combined with policies promoting the adoption of energy efficient technology by industries and large electricity consumers can therefore explain this finding.

[7] Algeria, Egypt, Iran, Israel, Jordan, Morocco, Syria, Tunisia.

In Iran and Morocco, the railways variable also influences TFP growth, which is consistent with the result of the panel regression in column 1, Table 3 above. This finding can be explained by the fact that railways in Morocco and Iran are relatively much developed as opposed to other countries part of this sample.

Only in Morocco does the telephone variable influence TFP growth significantly.

In Algeria, Israel, any Jordan we do not find any influence over time of infrastructure variables on TPF growth. However, again, the panel regressions above do suggest that the electricity variable has influenced differences in TFP growth levels between countries.

Table 4: Individual country regressions

Endogenous variable: TFP growth Hicks neutral

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Algeria	Egypt	Iran	Israel	Jordan	Morocco	Syria	Tunisia
WDI: Growth rate of Mobile and fixed-line tel. subscr.	-8.028	0.0679	32.39	-1.858	7.295	-6.285*	6.313	19.22
	(23.82)	(2.203)	(29.42)	(4.388)	(7.625)	(3.179)	(12.09)	(12.74)
WDI: Growth rate of electricity prod, net of losses	10.61	0.707	82.30	-12.14	7.785	7.158	21.89	39.62*
	(13.81)	(4.324)	(47.16)	(6.567)	(13.38)	(16.92)	(14.40)	(20.18)
WDI: Growth rate of kms rail	-16.41	-2.616	80.66**	37.03	-29.23	-129.0**	-19.88*	-6.800
	(15.70)	(1.796)	(37.07)	(16.17)	(23.95)	(48.73)	(10.89)	(8.040)
Constant	-0.581	1.727**	-11.07*	2.245	-3.632	1.649	-1.399	-3.852
	(2.163)	(0.672)	(5.972)	(1.081)	(2.856)	(1.491)	(2.520)	(2.758)
Observations	20	15	20	5	20	20	20	17
R-squared	0.118	0.077	0.223	0.824	0.047	0.145	0.189	0.279

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The next section revisits these results, using standard growth regression techniques.

3. Growth regression

3.1 Framework

Cross-country specifications explain real per capita GDP growth using as explanatory variables the initial level of real per capita GDP and other additional factors such as physical investment, human capital, etc.[8]

Infrastructure capital can be included in the specification, which then takes the following form:

(8) $$g_i = \alpha y_{i0} + \beta K_i^I + Z_i \gamma + \nu_i$$

where g_i is the growth rate of real per capita GDP for country i, y_{i0} is initial income (possibly in log form), K^I_i is a measure of infrastructure capital, and Z_i is a vector of covariates as mentioned above.[9]

3.2. Data

As in Straub, Vellutini and Warlters (2008), we use physical infrastructure indicators. As detailed there, this choice is motivated by the weakness and lack of availability of public investment data, as well as by the fact that we want to use similar data to allow direct comparisons with the results from the growth accounting exercise.

Physical indicators for four different sectors (telecom, energy, transport and water) are taken from the World Development Indicators database, covering the 1971-2006 period. Specifically, we use the following series:

---

[8] See for example Levine & Renelt (1992) and Sala-i-Martin (1997) and (Romp & Haan 2007) for a discussion.
[9] See Straub (2007) for a discussion of the limitations of such estimations.

- Telecommunications:
    - Main telephone lines.
    - Number of mobile phones.
- Energy:
    - Electricity generating capacity (in million kilowatt).
    - Electric power transmission and distribution losses (in % of output)
- Transport:
    - Road total network (in km).
    - Paved roads (in % of total network).
    - Rail route length (in km).
- Water:
    - improved water source (% of population with access)

Notice that when available, we use "quality proxies": electric power transmission and distribution losses as a % of output for the quality of electric services, and paved roads as a % of total network for roads. Additional variables used include GDP per capita, gross fixed capital formation, primary and secondary school enrolment, life expectancy, and inflation (all from WDI).

3.3. Sample

We rely on a sample of 102 developing or emerging countries, of which 20 (Algeria, Bahrain, Djibouti, Egypt, Arab Republic, Iran Islamic Republic, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates, Yemen Republic, West Bank and Gaza) belong to the MENA geographical area.

3.4. Techniques

In what follows we present two types of estimations. First, we perform simple cross country estimations based on the collapsed dataset[10] for 1971-2006 in the case of electricity (due to the coverage of series, the period is reduced to 1975-2006 for fixed plus mobile telephony, 1980-2006 for mobile telephony, 1980-2006 for rail, 1990-2006 for roads and 1990-2006 for water), using the rate of growth of GDP per capita as dependent variable and standard controls (initial level of GDP, investment, proxies for human capital). Note that we introduce infrastructure proxies in two ways: first we use the mean level over the relevant period, and second we use the growth rate of this variable over the same period.

In each case, after testing simple OLS specifications we instrument potentially endogenous infrastructure indicators and perform related tests. In all cases, the instruments are beginning of the period indicators for the relevant infrastructure variable, the share of agriculture over GDP, population density, and total population. We also test specifications with interactions between a specific Middle East and North Africa dummy and the alternative infrastructure indicators mentioned above. Results for each infrastructure dimension are included in a separate table: Table 5 for electricity, Table 6 for telecommunications (both fixed + mobile phone lines and mobile phones alone), Table 7 for railroads, Table 8 for roads, and Table 9 for water.

Then, we present panel regressions on 5-year sub period averages with the same dependent variable. This frequency should result in enough variations in infrastructure indicators to allow the use of fixed effects. Finally, we also perform instrumental estimations.

[10] Using means over the period.

3.5. Results

Table 5 presents the regression using the per capita electricity generating capacity. First, we see that the standard results of growth regressions are present: initial per capita GDP are strongly significant, with the right, negative sign indicating convergence conditional on the other variables. Similarly, education and investment variables are significant with the right, positive sign expect for primary enrolment. These results are robust across Tables 5 to 9.

Table 5 : Electricity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	OLS	OLS	OLS	OLS	2SLS	2SLS
	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth
Constant	-0.015	-0.013	-0.248	-0.014	-0.285	-0.012	-0.377
	(0.016)	(0.017)	(0.071)***	(0.017)	(0.077)***	(0.024)	(0.150)**
pcgdp71	-0.000	-0.000	-0.000	-0.000	-0.000	0.000	-0.000
	(0.000)***	(0.000)**	(0.000)***	(0.000)*	(0.000)***	(0.000)	(0.000)***
school_enrol_secondary	0.001	0.001	0.000	0.001	0.001	0.001	0.000
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)**	(0.000)
school_enrol_primary	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)*	(0.000)	(0.000)
inv_gdp	0.149	0.154	0.110	0.151	0.141	0.128	0.094
	(0.052)***	(0.054)***	(0.048)**	(0.052)***	(0.040)***	(0.065)*	(0.043)**
Pcegc	0.001	0.001		0.001		-0.019	
	(0.002)	(0.002)		(0.002)		(0.013)	
electric_power_transloss		-0.000					
		(0.001)					
pcegc_gr			0.222		0.263		0.343
			(0.065)***		(0.070)***		(0.143)**
pcegc_mena				-0.001			
				(0.002)			
pcegc_grmena					-0.013		
					(0.006)**		
Observations	48	47	46	48	46	38	37
R-squared	0.51	0.52	0.63	0.51	0.69		
Wu-Hausman F test, p-value						0.01	0.35

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%
Instruments are beginning of the period indicators for: infrastructure, agri/gdp, population density, population.
Variables are in per capita terms except where variable name does not begin with ‘pc’

Table 5 shows that when introduced in level, the per capita electricity generating capacity appears to have no effect on growth, either in the overall sample or when interacted with a MENA dummy, in columns 1, 2, 4 and 6. On the other hand, the growth rate of this variable appears to have a positive and significant effect on growth in columns 3, 5 and 7. The direct effect is that an additional point in the average growth rate of electricity generating capacity results in 0.22 additional average per capita growth over the period. Note also that our quality proxy in column 2 is not significant.

When the interaction with the MENA dummy is introduced, we see that the effect is actually lower for this subgroup of countries: in column 5, the overall effect is 0.26, but only 0.25 for MENA countries (marginal effect = 0.263 – 0.013*MENA). While a full interpretation of this result can only be tentative at this stage, a possible explanation could be that MENA countries have invested significantly larger amount in energy infrastructure than most developing countries, possibly as a result of abundant oil resources in key countries or as result of below cost tariffs of electricity which have inducted wasteful use and therefore more investment, so that decreasing returns to investments have implied lower overall returns. Finally, when instrumented the estimates rises to 0.34 in column 7. Note that exogeneity is rejected by the Wu-Hausman test for the variable in level but not for the growth rate.

In Table 6, we present results for the telecommunications variables. Columns 1 through 6 use the sum of fixed and mobile phone lines. This variable is positive and significant both when introduced in level (columns 1 and 3) and in growth rate (columns 2 and 4). As for the growth rate effect, an additional point in the average growth rate of the number of per capita phone lines results in 0.23 additional average per capita growth over the period. Again, when interactions with the MENA dummy are introduced, we see that the effect is actually lower for this subgroup of countries. For example in column 3, the overall effect is 0.048, but only 0.022 for MENA countries (marginal effect = 0.048 – 0.026*MENA). Finally, when instrumented the growth rate estimate rises to 0.36 in column 7. Again, exogeneity is rejected by the Wu-Hausman test for the variable in level but not for the growth rate. As for electricity, while MENA countries have made progress in reforming their telecommunications sector, this process has not been deep enough to induce more efficient and productive use of ICT technology in the economy. In MENA, Internet penetration remains relatively low, and e-services remain overall under-developed.

In columns 7 to 9, we consider mobile phones only.[11] The positive and significant effect on growth remains, and again is lower in the MENA subsample (0.054 versus 0.117 in the overall sample). However, when instrumented, mobile phones are no longer significant, but exogeneity is not rejected by the Wu-Hausman test for this variable.

Table 6: Telecommunications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	OLS	OLS	2SLS	2SLS	OLS	OLS	2SLS
	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	Pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth
Constant	-0.009	-0.276	-0.009	-0.291	-0.005	-0.428	-0.014	-0.013	-0.011
	(0.011)	(0.095)***	(0.012)	(0.096)***	(0.014)	(0.137)***	(0.012)	(0.012)	(0.011)
pcgdp75	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000			
	(0.000)***	(0.000)***	(0.000)***	(0.000)*	(0.000)	(0.000)			
pcgdp80							-0.000	-0.000	-0.000
							(0.000)***	(0.000)***	(0.000)**
school_enrol_sec	0.000	0.001	0.000	0.001	0.001	0.001	0.000	0.000	0.000
	(0.000)**	(0.000)***	(0.000)**	(0.000)***	(0.000)*	(0.000)***	(0.000)*	(0.000)	(0.000)
school_enrol_pri	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)*	(0.000)	(0.000)**	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
inv_gdp	0.110	0.109	0.112	0.118	0.109	0.090	0.135	0.136	0.132
	(0.029)***	(0.031)***	(0.029)***	(0.029)***	(0.036)***	(0.030)***	(0.023)***	(0.023)***	(0.025)***
pctel	0.037		0.048		-0.052				
	(0.017)**		(0.014)***		(0.094)				
pctel_gr		0.231		0.244		0.362			

[11] We do not consider growth rates for mobiles phones, as all the series start from *0* and therefore are characterized by very high rates in the first years. However, the variable considering jointly fixed and mobile phones should capture the growth effect in the number of lines linked to the introduction of mobile phones.

		(0.078)***		(0.079)***		(0.117)***			
pctel_mena			-0.026						
			(0.013)**						
pctel_grmena				-0.008					
				(0.006)					
pcmob							0.082	0.117	0.132
							(0.031)**	(0.026)***	(0.082)
pcmob_mena								-0.063	
								(0.024)**	
Observations	66	57	66	57	48	46	72	72	60
R-squared	0.47	0.54	0.48	0.56	0.30	0.59	0.50	0.52	0.53
Wu-Hausman F test, p-value					0.09	0.28			0.64

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments are beginning of the period indicators for: infrastructure, agri/gdp, population density, population. Variables are in per capita terms except where variable name does not begin with 'pc'

Table 7 reports the regressions relative to railroads. Overall, no results are significant, except the effect of the growth rate on the MENA subgroup of countries, indicating a lower overall effect for that group (although the overall effect is not significant).

Table 7: Railroads

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	2SLS	2SLS
	Pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth
Constant	-0.026	-0.407	-0.029	-0.361	-0.025	-0.527
	(0.022)	(0.268)	(0.022)	(0.223)	(0.019)	(0.659)
pcgdp80	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)**	(0.000)***	(0.000)	(0.000)*	(0.000)	(0.000)
school_enrol_secondary	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)*	(0.000)	(0.000)*	(0.000)	(0.000)*	(0.000)
school_enrollment_primary	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
inv_gdp	0.155	0.161	0.182	0.245	0.138	0.169
	(0.061)**	(0.074)**	(0.060)***	(0.059)***	(0.054)**	(0.059)**
pcrail	3.968		3.131		-2.587	
	(7.129)		(7.762)		(18.910)	
pcrail_gr		0.413		0.365		0.541
		(0.283)		(0.235)		(0.716)
pcrail_mena			-92.189			
			(58.814)			
pcrail_grmena				-0.027		
				(0.008)***		
Observations	39	26	39	26	32	24
R-squared	0.46	0.51	0.51	0.70	0.46	0.51
Wu-Hausman F test, p-value					0.46	0.83

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments are beginning of the period indicators for: infrastructure, agri/gdp, population density, population. Variables are in per capita terms except where variable name does not begin with 'pc'.

Table 8 reports regressions for roads. Again, most of the results fail to be significant. However, in column 4, the interaction with the MENA dummy indicates that the length of the road network has a positive effect on the MENA region (effect of 0.568 = -0.930 + 1.498*MENA). On the other hand, the quality dummy is negative and significant, indicating that the low proportion of paved roads has been a drag on growth.

Table 8: Roads

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	OLS	OLS	OLS	OLS	2SLS	2SLS
	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth
Constant	-0.023	-0.024	-0.122	-0.025	-0.118	-0.012	-0.457
	(0.012)**	(0.012)**	(0.085)	(0.012)**	(0.086)	(0.011)	(0.314)
pcgdp90	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)*	(0.000)*	(0.000)	(0.000)*	(0.000)	(0.000)	(0.000)
school_enrol_secondary	0.000	0.000	0.000	0.000	0.000	0.000	-0.000
	(0.000)*	(0.000)*	(0.000)	(0.000)*	(0.000)	(0.000)**	(0.000)
school_enrol_primary	0.000	0.000	-0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
inv_gdp	0.144	0.140	0.154	0.135	0.132	0.141	0.135
	(0.026)***	(0.027)***	(0.037)***	(0.028)***	(0.038)***	(0.030)***	(0.043)***
Pcroad	-0.570	-0.518		-0.930		-1.547	
	(0.568)	(0.561)		(0.659)		(0.936)	
Roadqual		0.000		0.000	0.000	-0.000	0.000
		(0.000)		(0.000)	(0.000)	(0.000)	(0.000)
pcroad_mena				1.498			
				(0.830)*			
roadqual_mena				-0.000			
				(0.000)**			
pcroad_gr			0.104		0.103		0.446
			(0.085)		(0.086)		(0.320)
pcroad_grmena					-0.007		
					(0.007)		
Observations	79	79	59	79	59	58	51
R-squared	0.47	0.47	0.45	0.49	0.48	0.47	0.24
Wu-Hausman F test, p-value						0.27	0.36

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments are beginning of the period indicators for: infrastructure, agri/gdp, population density, population. Variables are in per capita terms except where variable name does not begin with ‘pc’.

Table 9 reports regressions for water, showing no significant link between the number of connections and growth. Although some studies (WHO, 2006) have found that countries with a well functioning water sector also experiment strong growth, the findings of this study are not conclusive in this area. Investment in water may have indirect impact to growth through external effects such better health and better productivity of workers (Galiani et al, 2005).

Table 9: Water

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	2SLS	2SLS
	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth	pcgdpgrowth
Constant	-0.023	-0.153	-0.022	-0.105	-0.028	-0.178
	(0.013)*	(0.159)	(0.013)*	(0.154)	(0.013)**	(0.216)
pcgdp90	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)*	(0.000)*	(0.000)	(0.000)	(0.000)	(0.000)
school_enrol_secondary	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.000)	(0.000)*
school_enrol_primary	0.000	-0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
inv_gdp	0.149	0.213	0.149	0.223	0.210	0.217
	(0.028)***	(0.036)***	(0.028)***	(0.036)***	(0.032)***	(0.033)***
pcwater	-0.000		-0.000		-0.000	
	(0.000)		(0.000)		(0.000)	
pcwater_gr		0.118		0.072		0.140
		(0.150)		(0.145)		(0.212)
pcwater_mena			-0.000			
			(0.000)			
pcwater_grmena				-0.010		
				(0.006)		
Observations	77	60	77	60	61	57
R-squared	0.46	0.55	0.46	0.57	0.54	0.57
Wu-Hausman F test, p-value					0.27	0.89

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Instruments are beginning of the period indicators for: infrastructure, agri/gdp, population density, population. Variables are in per capita terms except where variable name does not begin with ‘pc’.

Finally, we performed panel regressions using 5-year averages.[12] The results are disappointing: all infrastructure variables negative and not significant most of the time, with the exception of electricity generating capacity and the interaction of roads with the MENA dummy. When performing panel regressions with fixed effects and instruments, results are very similar with no influence of infrastructure variables on growth, the only exception being the MENA interactions term in regression of the electricity variables – but even in that case the coefficient, albeit significant, is negative again suggesting a lower effect than in the whole sample. As for panel regressions with instruments and random effects, again results are disappointing as none of the infrastructure variables or their MENA interactions is significant, except for the mobile phone one and the rail interaction which has a strongly negative coefficient.

[12] The Tables with the results, omitted to save space, are available from the authors.

Overall, the growth regressions support mostly an effect of electricity generating capacity and telecommunication development on the average per capita growth rate of the last decades. In these two cases, it is noteworthy that the subgroup of MENA countries presents lower returns than developing countries as a whole, probably as a result of higher levels of investment and the subsequent diminishing returns effect, or because of lack of institutional and pro-market reforms in most MENA countries. To a lesser extent, there seems to be also a positive effect of roads on growth in the MENA region, although quality appears to limit that effect.

4. Conclusion

The two econometric techniques used in this report yield some consistent and some different results. Regressions based in the growth accounting framework suggest that electricity production helps explain cross-country differences in TFP growth in the MENA region. On the other hand, growth regressions also support that conclusion, while also stressing an effect of telecommunications infrastructure. Finally, growth regressions also indicate quite consistently that the returns to infrastructure have been lower in the MENA region than in developing countries as a whole.

A possible interpretation of these findings is that delays affecting institutional and pro-market reforms in infrastructure sectors in MENA have limited the impact on growth. Of all the infrastructure sectors, the telecommunications sector is the only one where substantial institutional reforms have been implemented in MENA. While the privatization of incumbent telecommunications operators has made little progress, competition has been introduced in the mobile communication and data segments. Autonomous regulatory entities (13 countries out of 21 have established regulators) have also been established to regulate anti-competitive practices and protect consumers' rights. These developments have therefore led to less distorted prices and improved quality of services.

In contrast to telecommunications, electricity, water and transport have been much affected by structural reforms. While these sectors have also witnessed some development of private sector participation, governments have been reluctant to roll-back the massive energy subsidies which are used to maintain social and political stability. As a consequence, below cost tariffs remain the norm, therefore inducing wasteful use of resources. This paper suggests that despite consistent investment efforts by governments in infrastructure during the past years, the resulting impact on growth has been curtailed or limited because of insufficient commitment to institutional and structural reforms. Moving the infrastructure agenda forward might therefore be more about the quest for greater efficiency.

Table A1 – Infrastructure Access Indicators in MENA countries.

Country	Mobile & Fixed line telephones (per 100 people)	Roads paved (% of total roads)	Improved water source (% population with access)	Improved sanitation facilities (% of population with access)	Electrification rate (% population connected to electricity)
Algeria	90.5		85	94	98.1
Bahrain	211.2	-	-	-	99.0
Djibouti	6.82	-	92	67	
Egypt	65.4	-	98	66	98.0
Iran	94.2	72.8			97.3
Iraq	52.2		77	76	15.0
Israel	162.6	100	100		96.6
Jordan	98.8	100	98	85	99.9
Kuwait	117.7				100.0
Lebanon	47.8		100		99.9
Libya	48.2			97	97.0
Morocco	82.7	61.9	83	72	85.1
Oman	125.4				95.5
Qatar	152		100	100	70.5
Saudi Arabia	163.3	21.5			96.7
Syria	50.4	100	89	92	90.0
Tunisia	95		94	85	98.9
United Arab Emirates	242.3		100	97	91.9
West Bank Gaza	37.1	100	89	80	
Yemen	18.2	8.7	66	46	36.2

Source: WDI, 2005, 2006 and 2007 and OECD/IEA, 2007 for electrification rates.

References

Agenor, P., Nabli, M.K. & Yousef, T., 2005. Public Infrastructure and Private Investment in the Middle East and North Africa. *World Bank Policy research working paper*, 3661.

Barro, R.J. & Sala-i-Martin, X., 2003. *Economic Growth, 2nd Edition*, The MIT Press.

Canning, D., 1999. Infrastructure's contribution to aggregate output. *World Bank Policy Research Paper*, 2246.

Canning,, D., 1998. A Database of World Stocks of Infrastructure, 1950-95. *World Bank Econ Rev*, 12(3), 529-547.

Holtz-Eakin, D., 1994. Public-Sector Capital and the Productivity Puzzle. *Review of Economics & Statistics*, 76, 12-21.

Hulten, C.R., Bennathan, E. & Srinivasan, S., 2006. Infrastructure, Externalities, and Economic Development: A Study of the Indian Manufacturing Industry. *World Bank Economic Revue*, 20(2), 291-308.

Isaksson, A., 2008. *World Productivity Database : a technical description*, Vienna: UNIDO.

JBIC, ADB & WB, 2005. *Connecting Esat Asia. A New Framework for Infrastructure,* The World Bank.

La Ferrara, E. & Marcellino, M., 2000. *TFP, Costs, and Public Infrastructure: An Equivocal Relationship*, mimeo, IGIER (Innocenzo Gasparini Institute for Economic Research), Bocconi University.

LeVine, R. & Renelt, D., 1992. A sensitivity analysis of cross-country growth regressions. *American Economic Review*, 82, 942-963.

Mustapha Kamel Nabli & Marie-Ange Véganzonès-Varoudakis, 2007. Reform complementarities and economic growth in the Middle East and North Africa. *Journal of International Development*, 19(1), 17-54.

Pritchett, L., 1996. Mind your P's and Q's. The cost of Public Investment is Not the Value of Public Capital. *World Bank Policy Research Paper*, 1660.

Romp, W. & Haan, J.D., 2007. Public Capital and Economic Growth: A Critical Survey. *Perspektiven der Wirtschaftspolitik*, 8(S1), 6-52.

Sala-i-Martin, X., 1997. I Just Ran Two Million Regressions. *American Economic Review,* 87(2), 178-83.

Straub, S., Vellutini, C. & Warlters, M., 2008. Infrastructure and Economic Growth in East Asia.

World Bank Policy Research Paper, 4589.