EUROPEAN CENTRAL BANK

EUROSYSTEM

Working Paper Series

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Efficiency, Inefficiency and the MENA Frontier

No 1757 / February 2015

Acknowledgements
We thank one anonymous referee of the ECB working paper series. The views expressed are those of the authors alone.

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ISSN	1725-2806 (online)
ISBN	978-92-899-1497-0
DOI	10.2866/259398
EU catalogue number	QB-AR-14-131-EN-N

Abstract

In a stochastic frontier setting, we examine technical efficiency in the Middle East and North Africa (MENA). Evidence suggests that in addition to economic indicators, political and social ones play a key role in development and frontier technical efficiency profiles. The MENA have been characterized by increasing economic efficiency over time but with marked polarization. The paper analyses and nest many key hypotheses in the literature e.g., the contributions of religion, of natural resources, demographic pressures, human capital etc. The originality of our contribution is the use of a large data set (including principal components), and extensive robustness checks. The paper should set a comprehensive benchmark and cross check for related studies of development technical efficiency.

JEL Classification: C33, C38, C55, D24, E23, O11
Keywords: Frontier Efficiency, MENA, Development, Stochastic Frontier.

Non Technical Summary

We examine the determinants of technical efficiency in the Middle East and North African nations (the MENA) and link it to economic, political and socio-cultural indicators. Our framework mirrors two aspects in the production and growth literature.

First, in exploiting the concept of frontier technology and innovation. Countries might operate near or behind the frontier with corresponding implications for their efficiency. Improvements over time can occur from efficiency improvements within or outward movements of the frontier.

Second, our framework parallels the emphasis in the literature on the quality of institutions and cultural features in supporting sustained growth. Within a Stochastic Frontier panel setting, we use a translog production function where production deviates from its optimum by a random disturbance and a modelled "inefficiency term". A country is technically efficient if it produces the maximum feasible output from a given combination of inputs and technology; inefficiency is measured as the distance of each individual observation from the frontier.

We find that the MENA have been characterized by increasing economic efficiency over time but with marked polarization.

1 Introduction

In the last thirty years, many economies – e.g., in Asia, Eastern Europe, Latin American – experienced dramatic transformations. Their share of world output and trade increased markedly. They witnessed seismic social and political changes.

By contrast, the economies of the Middle East and North Africa (MENA)[1] have, by most assessments, stagnated. Why, in comparison to other (initially not dissimilar) economies, did they fall behind? The "Arab Spring" protests from late 2010 onwards pointed to the answers: poor economic prospects, social and political exclusion etc (e.g., Yousef (2004)).

How the MENA emerge after the Spring will matter for the world economy. But, more generally, it will also provide insights as to how economies, far from the technical frontier, tackle their problems. What stopped the MENA reaching their potential? Was it related to factor accumulation; to the quality of institutional factors; to cultural factors; or all combined? Understanding such issues is the purpose of this paper.

Such themes are familiar in the growth literature. Our contribution, though, is different. We examine the *precursor* for sustained growth, namely efficiency within – and expansion of – the technical frontier among the MENA. As far as we aware, we are the first to address this.[2] Indeed, analytical studies on the Arab developmental model have been surprisingly few (compare the treatment of China and India).[3] Yet the MENA region amounts to almost 420 million in (2012) population, and is of strategic geo-political importance; in short, the region is too big to ignore.

Second, the MENA represent very distinct political economies. "Private" markets are often beholden to the state for contracts and credit provision, and staffed by political insiders etc, World Bank (2009). Moreover, with resource abundance parts of the Arab world have arguably tended towards becoming "rentier" and "extractive" states.[4] Hydrocarbon revenues also partly obviated the need for taxation, weakening citizens' stake in governance, see Nabli (2007). Accordingly, the process of development leading to democracy, and democracy leading to open and contestable markets – as per Modernization theory (Lipset (1959)) – was continuously setback. These aspects necessitate a serious treatment of political, institutional and cultural factors, as well as economic ones, in the measurement of technical frontier characteristics.[5]

The framework used here mirrors two aspects in the production and growth

[1]This block, as defined by the IMF, comprises Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates, Yemen.

[2]Although see Herrala and Turk Ariss (2013) who use stochastic frontier analysis to examine the importance of financing constraints in Arab development.

[3]See for example Stracca (2013) and the references therein.

[4]See Schwarz (2013) for a discussion of the characteristics of "rentier" states and Acemoglu and Robinson (2012) for a historical perspective on extractive states. See also the interesting work of Michalopoulos (2012) for a historical perspective on the influence of geographic, inequality and trade on the spread of Islam.

[5]See Klump (2006) for different approaches to integrating cultural metrics into economic studies.

literature. First, in exploiting the concept of frontier technology and innovation, (Acemoglu et al. (2006)). Countries might operate near or behind the frontier with corresponding implications for their efficiency. Improvements over time can occur from efficiency improvements within the frontier or outward movements of the frontier (through technical progress). Second, our framework parallels the emphasis in the literature on the quality of institutions and cultural features in supporting sustained development.

The paper is organized as follows. The following section provides background on the Arab developmental model. This shows the early growth and developmental gains made by the Arab region following colonial independence. But it also shows that the growth was not sustained, being followed by a deep downturn from the late 1970s to early 1990s.

Section 3 then discusses the model of technical efficiency used. Within a Stochastic Frontier setting, we use a translog production function where production deviates from its optimum by a random disturbance and a modelled "inefficiency term". A country is technically efficient if it produces the maximum feasible output from a given combination of inputs and technology; inefficiency is measured as the distance of each individual observation from the frontier. Inefficiency is modelled using a variety of economic, political and socio-cultural indicators.

Section 4 describes the data, taken from several different sources, and encompassing continuous and categorical series. For example, we use standard indicators like human capital, openness, financial depth in modelling inefficiency, but also less standard one such as political durability, judicial independence, workers' rights, religious fractionalization and so on.

Sections 5 and 6 are the empirical sections. Our intention is to provide a rich characterization of technical efficiency among the MENA. We have tried to take a very broad perspective on the region, given the interconnectedness between many different factors affecting efficiency, and to reduce biases from omitted variables and channels. We also pursue robustness in several directions: in terms of functional forms, and in terms of indicator selection. We define those indicators and their interaction which enhance of impair efficiency. In a further step, we then define the qualitative sign of indicators as reflecting strong or weak robustness depending on their regularity. We further decompose technical progress and technical efficiency into their distributional and country-specific dimensions. Moreover, we make block decompositions (at aggregate and country level) of inefficiency into those factors associated to standard economic constraints, as well as those relating to political and socio-cultural factors. Finally, we conclude.

Our main findings are as follows:

- In addition to purely economic indicators (e.g., factor accumulation, openness etc.), political and social ones play a key role in MENA efficiency profiles. Reforms should therefore attempt to improve all three determinants of the technical frontier.

- Although TFP growth has been positive, but its growth has been more from gains in efficiency rather than from technical progress.

- In terms of technical progress, TP, MENA countries are *not* characterized by well-separated clusters of technologically backward and advanced countries; the TP distribution is uni-model and essentially Normally distributed.

- Performance on technical efficiency tells a different story: there has been a limited number of countries that failed to improve or consolidated their performance through time and share a common low steady state and the rest that significantly improved. Thus whilst the MENA have been characterized by *increasing* economic efficiency, albeit with marked polarization, the efficiency gains witness in the MENA may have saturated.

- Human capital (education) has enhanced efficiency in a strong and pervasive manner.

- Our results confirm the resource-curse interpretation of (some) MENA developments. Resource rents appear to have loosened efficiency incentives. Moreover, exchange rate volatility (typical of "petrocurrencies") has retarded manufacturing growth.

- Financial depth seems not to have enhanced efficiency; this may be consistent with a rent-seeking interpretation and/or that credit has sustained favored "zombie" firms at the expense of smaller ones constrained by retained earnings.

- Religious fractionalization and the catch-all "military" government categorization are clear factors which weaken efficiency and retard attaining the technical frontier.

2 The MENA: Some Simple Background

Figure 1a shows shares of world output (PPP-adjusted) for the major trading blocks. "Developing Asia" and the "Emerging Markets" increased their share of world output since 1980 from around 25%-to-50% and around 8%-to-30%, respectively.[6] The former comparison is striking because Developing Asia's initial share roughly matched that of the MENA block and because they shared similarly weak democratic origins. However, the MENA have however, stayed at around a 5% share.

These developments, moreover, cover a period of great expansion of world trade, growth and technological diffusion – developments which remarkably seem to have by-passed the Arab world. This is puzzling because the MENA enjoy many advantages: proximity to Europe; educated, young labor force; cultural and linguistic similarities; abundant natural resources etc.

Indeed, several decades before the Arab-Spring turbulence, matters looked quite different. Following colonial independence, many Arab states, buoyed by energy

[6] Note, the IMF's definition of Emerging and Developing Markets overlaps some countries in the defined MENA region. Accordingly, in calculating shares we stripped the MENA region out of their definition, and recalculated accordingly.

windfalls, engaged in large-scale state planning, nationalization, import substitution and welfare outreach. This arrangement initially appeared successful. Over the 1960s and 1970s the MENA (alongside the East Asian "tigers") were among the fastest growing in the world, see Amin et al. (2012), World Bank (2004).

Likewise, there was substantial (if uneven) progress on human development[7] – though below that expected given the region's natural wealth and human resources, Boutayeb and Serghini (2006). This was the essence of the Arab "Social Contract": the toleration of autocracy in return for welfare and growth, World Bank (2004).

But the maxim that growth is easier to start than sustain (Rodrik (2005)) matched the MENA experience well, World Bank (2004). Unsurprisingly so given the obstacles: restrictive trade regimes; corruption; under diversified economy; fragmented capital markets; limited firm turnover; chronic slack; large low-skill informal market; sporadic regional conflict etc. (see World Bank (2009), Gourdon (2010), Amin et al. (2012), Malik and Awadallah (2013), Herrala and Turk Ariss (2013)).

Indeed, the commodity-price falls from the mid-1980s onwards – by exposing the region's over-reliance on hydrocarbons – contributed to reversing the earlier growth gains, cut demand and the (shock-absorbing) flow of remittances.[8] It also strained fiscal balances. This was crucial since all social structures and expectations were predicated on the state providing jobs and security. Pro-education and family-friendly welfare policies also helped promote a "youth bulge" which, given the weakened economy, swelled unemployment.[9]

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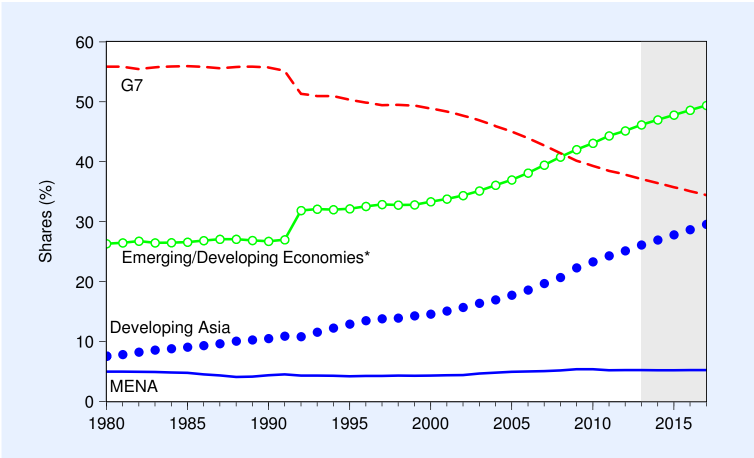
[7]For example on education, mortality and poverty, see the United Nations Development Program data, http://hdr.undp.org/en/statistics.

[8]Some of the countries in the sample are oil exporters, some not. We control for this, other than through fixed effects to account for unobserved heterogeneity, also through the addition of the size of resource rents as an explanatory variable. In addition, though some of the MENA are oil exporters and some not, through the prevalence of job flows, remittances, and cross-border loans and grants, the energy sector has a large effect on the entire region.

[9]Around 60-70% of the region's population is under 30. Such a youth bulge has often been associated with social unrest, e.g. Heinsohn (2006). The idea being that youngest sons, if excluded from economic and social life, compete for social capital through (potentially extreme) religion and political ideology.

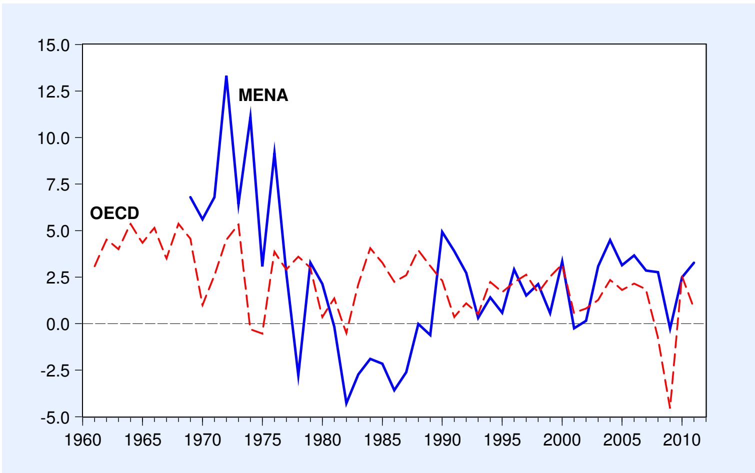
Figure 1: International Output Shares and Comparative Growth

(a) World PPP GDP Shares (%)



Notes: Shaded Area denotes forecast period. *The IMF's definition of Emerging and Developing Markets has some overlaps with countries in the defined MENA region. Accordingly, in calculating trade shares we stripped the MENA region out of their definition, and recalculated accordingly.
Source: Derived from IMF WEO Oct 2013.

(b) Real Per Capita GDP Growth Rates: MENA and OECD



Source: IMF, OECD, World Bank. Growth Rates are:

	1969-2010		1969-1980		1980-2010	
	MENA	OECD	MENA	OECD	MENA	OECD
Mean	2.31	1.92	5.63	2.57	1.05	1.62
Std. Dev.	3.70	1.76	4.35	1.99	2.44	1.61

In response to the downturn, many Arab governments engaged in pro-market policies typically then advocated by the World Bank and IMF (fiscal consolidation, privatization, trade and financial liberalization etc.). Even controlling for the scale of the downturn, the success rate appeared low. This was arguably for two main reasons. First, that the "private sector" was ill-equipped to raise supply consistent with the reforms. And second, that these reforms mostly neglected governance issues[10]; vested interests and political structures remained. The evolution of GDP per capita growth MENA (compared to the OECD) since the 1960s is shown in **Figure 1b**, showing this early boom then protracted and volatile bust.

The region's unusually painful and protracted readjustment points to chronic inefficiencies and persistent barriers to growth. Our purpose is to provide a rich characterisation of these. In the following sections, we outline the methodology and data involved in this assessment.

3 Empirical Modeling Strategy

A country is technically efficient if it produces the maximum feasible output from a given combination of inputs and technology, regardless of market demand and prices. While if a country produces less than is technically feasible given both technology and inputs, it is inefficient.

Inefficiency is measured as the distance of each individual observation from the frontier. Aigner et al. (1977) and Meeusen and van den Broeck (1977) pioneered a stochastic version of this model, the stochastic frontier analysis (SFA) method to estimate potential output and efficiency characteristics. This was extended by Schmidt and Sickles (1984) in the panel context. Greene (2008a,b) provides excellent discussions of the development of the field, and McQuinn (2013) provides a good recent illustration on international technology spillovers.[11]

Consider the production function,

$$Y_{it} = f\left(K_{it}, L_{it}, H_{it}\right) e^{v_{it}} e^{-u_{it}} \tag{1}$$

where Y denotes output, K, L, H represent physical capital, labor, human capital respectively, and subscripts $i = 1, 2, ...N$ and $t = 1, 2, ...T$ respectively index country and time. $u_{it} \in (0, \infty)$ denotes technical efficiency and v_{it} captures stochastic movements in the frontier.

Given the empirical weakness of Cobb Douglas (e.g., Chirinko (2008), Klump et al. (2007)) we consider $f(\cdot)$ to be instead described by a translog production function:

$$y_{it} = \alpha_{0i} + \sum_j \alpha_j x_{jit} + \frac{1}{2}\sum_j\sum_m \alpha_{jm} x_{jit} x_{mit} + \sum_j \alpha_{jt} x_{jit} t + \alpha_t t + \frac{1}{2}\alpha_{tt} t^2 + v_{it} - u_{it} \tag{2}$$

[10] For example, see Walton (2013) on Egypt's privatization program in the 1990s.

[11] A related but methodologically distinct method of estimating production frontiers is Data Envelopment Analysis analysis. A good recent example in the context of the world technology frontier is by Growiec (2012). Relative to that method, SFA has the advantage of allowing for statistical inference on the efficiency term and on estimated production parameters.

where $y = Log(Y)$, and $\{j \neq m\} \in [k, l, h]$ such that for $j = k$, $x_{jit} = Log(K_{it}) = k_{it}$ etc. Variable t is a time trend that proxies disembodied technical progress.[12] Parameters α_{0i} are country-specific fixed effects specified in order to distinguish unobserved heterogeneity from the inefficiency component. Many studies, including Greene (2005), use dummy variables as environmental variables in stochastic frontier analysis.

The translog is a highly flexible functional form: it nests Cobb Douglas; it does not restrict the elasticity of factor substitution to be constant; nor does it restrict technical change to be neutral (since "technical progress" pre-multiplies all three factors). In **Appendix D**, though, we consider robustness exercises where we use alternative production forms: namely, the *modified translog* and the *fourier* forms.

The error terms have the usual interpretation: v_{it} is a symmetrically distributed as $v_{it} \sim \mathcal{N}(0, \sigma_v^2)$, and u_{it} is a one-sided error truncated at zero $u_{it} \sim \mathcal{N}^+(\mu_{it}, \sigma_u^2)$ where μ_{it}, the mean level of efficiency, is given by,

$$\mu_{it} = \mathbf{z}'_{it}\beta \tag{3}$$

where $\mathbf{z}_{it}$ is a vector of indicators explaining inefficiency.

Let us assume that the indicators, **z**, can be further categorized as economic indicators (**E**), indicators relating to the characteristics of Political Institutions (**P**), and others reflecting Socio-cultural (**S**) type variables (to be defined below):

$$u_{it} = \beta_0 + \beta_{\mathbf{E}}\mathbf{E} + \beta_{\mathbf{P}}\mathbf{P} + \beta_{\mathbf{S}}\mathbf{S} + \beta_{\mathcal{I}}\mathcal{I} + \beta_t t + w_{it} \tag{3'}$$

where w_{it} is an unobservable random variable independently distributed as $\mathcal{N}^+(0, \sigma_w^2)$ such that $u_{it} \geq 0$. Equation (3') also nests the restricted form: $\beta_{\mathbf{P}} = \beta_{\mathbf{S}} = 0$, i.e., where political and socio-cultural indicators play no role in explaining inefficiency. Finally, the rate of change of technical efficiency is given by β_t.

Note we shall include human capital in the inefficiency equation since it is likely that the adoption of best-practice technologies requires skills, see Griffith et al. (2004). Thus, changes in human capital not only shift the frontier (given its inclusion in production function, equation (2)), but also shift economic inefficiency (given its inclusion in inefficiency equation (3')). Moreover, we also find slope (or interactions) effects (contained, amongst other *interactions*, in block $\mathcal{I}$).

The emphasis on human capital is natural. It is central to modern growth theories, as well as to MENA development. Member countries greatly expanded education services (from a low base in the 1960s). They did so both to modernize their economy and, it is often argued, effectively compensate citizens for political exclusion.

[12]For a discussion of the various forms of technical progress and their implications see León-Ledesma et al. (2010). See also Chirinko et al. (2011) and de La Grandville (2009) for a more general discussion of the factor substitution elasticity.

4 Data

4.1 General Description

We use data from a variety of sources: Center for Systemic Peace, CIRI Human Rights Data Project,[13] Database of Political Institutions,[14] Penn World Tables,[15] Polity IV database,[16] as well as the United Nations, the World Bank, the CIA (World Factbook) and the IMF. Some of these data are continuous numerical series (e.g., GDP, employee number, FDI), some are categorical (e.g., polity type, strength of workers' or women's rights) etc.

In collecting the series, we searched for the furthest backdated and most country-wide complete data set for the indicators of interest. The tables in **Appendix A** show the full series, their definitions and sources. The data is annual, covers 14 MENA countries: Bahrain [1980-2008], Egypt [1980-2008], Jordan [1980-2008], Kuwait [1986-2008], Libya [1986-2008], Mauritania [1980-2008], Morocco [1980-2008], Qatar [1986-2008], Saudi Arabia [1980-2008], Sudan [1980-2008], Syria[1980-2008], Tunisia [1980-2008], United Arab Emirates [1986-2008], and Yemen [1989-2008]. Our strategy for dealing with such a relatively large database is twofold.

First, we sought out different data sources and types to provide a rich analysis of production and inefficiency trends in the MENA. That is to say, indicators which covered not only economic features but also those relating to Political and Socio-cultural characteristics. In our first SFA analysis (columns 1: and 2: in Table 1 below), for instance, we use economic indicators alone to model inefficiency. This provides a benchmark since it is most closely aligned with usual practise. After that, we augment the variable set with indicators from the **P** and **S** blocks. This allows us to judge whether the benchmark parameters are qualitatively robust, and then assess the statistical impact of the additional indicators.

Examples of standard *economic* indicators in the inefficiency equation, are education, the degree of openness, sectoral and natural-resource features etc. These capture endowments in the economy and how activity and resources are efficiently allocated across it. *Political and institutional* factors include the type of the Government (military/non-military), the size of the public sector, freedom of movement and assembly, judicial independence, regime durability etc. Note, there is no presumption that political and institutional indicators unanimously hurt efficiency. Public expenditure may contribute positively (e.g., through education, infrastructure, nutrition programs), as may even extended regime duration (through enhanced political stability and order). Moreover, many political indicators such as women's rights have in themselves improved over time. Finally, *socio-cultural* indicators include fractionalization in religious grouping, as well as age distribution, and demographic pressures etc. Again, these may impact efficiency positively or negatively.

[13] Cingranelli and Richards (2010).
[14] Keefer (2010).
[15] Heston et al. (2012).
[16] Marshall et al. (2010).

Naturally, these categorizations are not water-tight. But they constitute an intuitive starting point and a useful narrative. Widening the set of admissible indicators (i.e., to Political and Cultural indicators) in this way is also noteworthy because it mixes continuous and categorical data. SFA analysis rarely strays beyond the former data type. But in the MENA case, to do so would miss a wealth of information.

The second aspect of our data strategy is the following. In our initial stochastic frontier regressions we sample from that large pool of candidate series to uncover a congruent representation of the production-efficiency nexus. To include all series of interest raises multi-collinearity issues. Accordingly, after the "core" SFA exercises, we report results where we extract *principal components* of the $\mathbf{E}, \mathbf{P}$, and $\mathbf{S}$ blocks. This relaxes the dimensionality constraint, whilst still preserving our narrative framework. Within the principal components, we can also retrieve the underlying efficiency coefficients associated to each indicators, further enhancing our understanding. Finally, when principal components is applied to categorical variables, it is important to use, as we do, the polychoric and polyserial (rather than merely Pearson) correlation matrix.

4.2 A First Look at the Data

Figure 2 shows histograms of representative data: human capital, share of manufacturing, openness and trade, government expenditure, regime durability, Chief Executive as Military Officer, the extent of workers' rights, mobile phone ownership, resource rents, financial depth (as measured by credit flows)[17], FDI, religious fractionalizations, and median age. In addition to describing the data, we also discuss their potential impacts on economic efficiency. We group the data discussion into production data (section 4.2.1); Economic indicators (4.2.2), Political and Social indicators (respectively, 4.2.3, and 4.2.4)

4.2.1 Production Data

Regarding the production data, variable Y in equation (2) is defined as GDP in constant 2005$s (chain series). By way of background, though, we note that MENA output characteristics vary considerably.

In terms of living standards, using GDP per capita (PPP), we have (where [.] denotes ranking relative to the World) at the top end Qatar [1], UAE [15], Kuwait [27], Saudi Arabia [46] all the way down to Sudan [182] and Yemen [188]. In terms of the scale of these economies, Egypt has the largest population (roughly 85 million), followed by those in the 30–40 million bracket (Algeria, Sudan, Morocco, Saudi Arabia), then (in the 1-5 million bracket) by the smaller Gulf states (Kuwait, Qatar, UAE and Bahrain) and Mauritania. For scale in terms of GDP level, Saudi Arabia, UAE, and Egypt tend to rank the top, Qatar and Kuwait and Morocco are near the middle, and Yemen, Jordan, Bahrain and Mauritania are the smallest.[18]

[17] The efficiency of the Arab banking sector is examined in Herrala and Turk Ariss (2013).

[18] All figures in this paragraph relate taken from sample year averages from the CIA world Factbook.

Regarding factors of production, the capital stock series was constructed using the perpetual inventory method from the Penn Investment series. Initial capital stocks were constructed for the year 1960: we used the investment share of Real GDP per capita and population data available in the Penn tables and we assumed a depreciation rate of 0.095. Labor is the number of employees. The stock of human capital is from Barro and Lee (2013) and represents the educational attainment of individuals 25 years or older measured as average years of schooling.[19]

4.2.2 Efficiency Indicators: Economic

For *human capital*, the average years of schooling was just over 5 years. By contrast, in 2010 the average years of schooling for the UK, Germany and the US was 9, 12, and 13 years respectively.

Links between human capital and efficiency are intuitive: a high skilled economy allows the workforce to implement and absorb new technologies (e.g., Cohen and Levinthal (1989), Griffith et al. (2004)) and catch up with the technological frontier. The extent to which human capital does so depends on:

(a) its quality and appropriateness, and;

(b) any externalities and complementarities induced by skills.

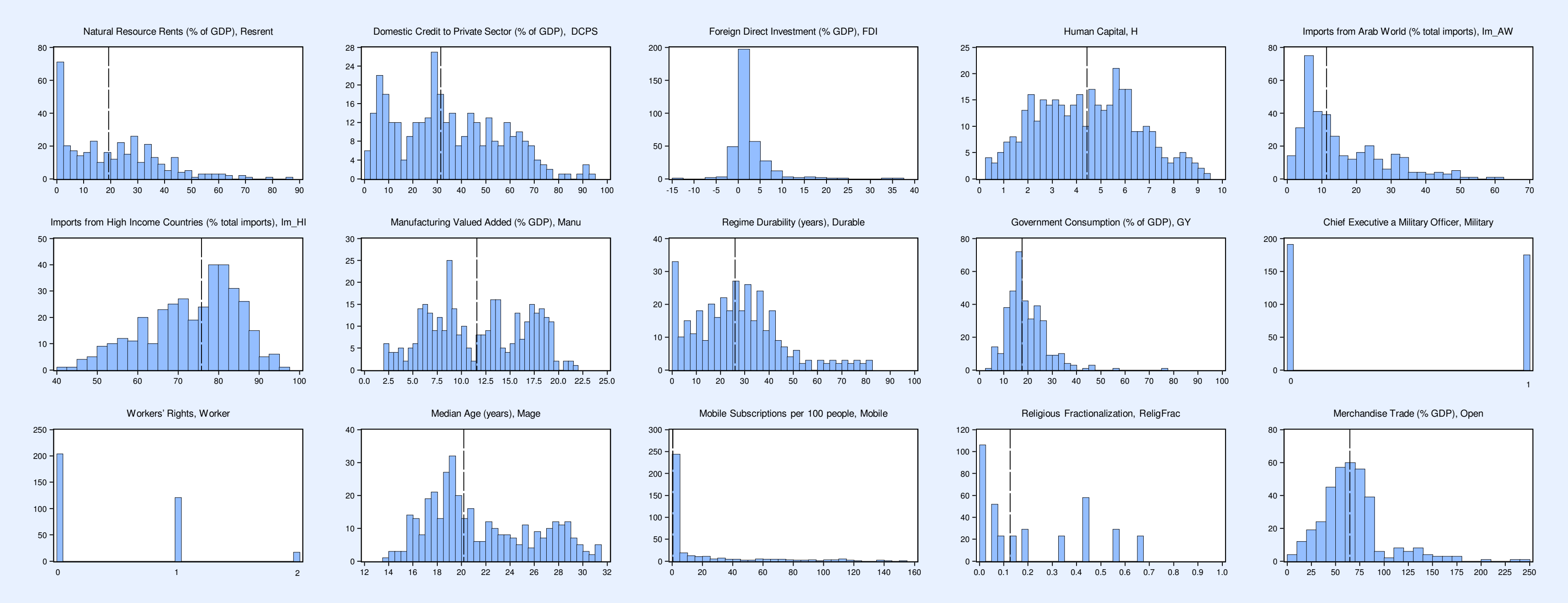
Regarding point (a), despite its expansion in recent decades, the academic *quality* of MENA education relative to the rest of the world is an issue (even controlling for the level of income and development), see Heyneman (1993). Moreover, there is often effectively a two-tier system: returns to basic education are very low, (Pritchett (1999), Makdisi et al. (2006)), but higher following a university education (Salehi-Isfahani et al. (2009)).

But education is also often thought to play a signalling role: strictly interpreted that implies that it has no direct effect on improving skills, but helps identifying the most "suitable" candidates. Accordingly, the tailoring of advanced education towards rote learning and passing entrance exams for tenured state positions (rather than on market-relevant skills) downplays the expected efficiency returns of education, Amin et al. (2012). On the other hand, since these economies lag the world technology frontier, developed-world education may be unsuited to production conditions, Acemoglu et al. (2006).

The second way human capital may affect efficiency comes from demonstration effects, complementarities and diffusion processes induced by skills. Such effects can take place through openness and FDI (Foreign Direct Investment), both of which affect (and are affected by) human capital. Openness and FDI can transfer technology and more efficient production techniques between countries, helping to diversify exports, raising productivity and wages, and reinforcing incentives for acquiring skills (e.g., Benhabib and Spiegel (2005), Grossman and Helpman (1993)).

[19] Since this data set is available for 5-year periods, we followed common practice and used linear interpolation to generate complete data records for all years.

Figure 2: Histogram of Selected Indicators



Notes: Dashed vertical Lines indicates median histogram values (for the continuous variables). Note, these histograms pool all countries and all years.

Alternatively, trade and investment openness may increase economic volatility, e.g., through international shocks, displacing home industries and skill structures. They may also lead to *lower* levels of skill accumulation if countries import skill-intensive goods rather than producing them domestically. Efficiency gains from such sources may therefore be contingent on the pre-existence of skilled labor, see Wijeweera et al. (2010).

Moreover, around two-thirds of MENA FDI goes to resource-rich, labor-scarce countries (e.g., Saudi Arabia and Qatar attracted respectively around over 45% and 10%, in 2010). Most of this is horizontal FDI and associated to the energy sector. The rest is largely found in non-tradeables (telecommunications, tourism, construction).[20] FDI in Manufacturing, in particular, tends to be low (at best around 10% of all FDI)[21] and FDI in high-tech services in the MENA region is essentially zero (see World Bank (2009) and Gourdon (2010)).

On merchandize trade, judged on tariff and non-tariff barriers (as well as infrastructure bottlenecks), MENA trade regimes are among the most globally protected and fragmented, Bhattacharya and Wolde (2010), Kee et al. (2009). There is thus relatively limited regional trade (intra-MENA trade has for the last three decades typically been below 10% of total exports). What intra-MENA trade there is appears to be highly regionally clustered. Exports, moreover, are dominated by fuels and minerals. Weak trade links have been compounded by chronic over-valuation and volatility of real exchange rates, Nabli (2007), the similarity of inter-MENA factor and resource endowments, the dominance of fuels themselves (which have inhibited diversification), as well as political and rent-seeking factors (see Malik and Awadallah (2013)).

Another important aspect for efficiency among Economic factors is the *sectoral composition* of the economy. The median value added of Manufacturing is around 12% (and bi-modal in distribution). Otherwise, natural resource rents amount to around 20% of GDP, with positive skew (indicating members with substantial resource rents as a proportion of output).

Natural resources are thus a key component in the MENA (directly or indirectly through remittances). However, countries with a high ratio of natural resources exports to GDP tend to growth slowly in the medium run compared to their resource-scarce counterparts, see Gylfason (2001).[22] Resource rich economies may lose sight of the need for efficient use of resources, may under accumulate human capital and delay reductions in fertility, Gylfason (2001), Galor and Mountford (2008). These disadvantages are in addition to the usual concern that resource wealth encourages rent seeking. Finally, and somewhat in contrast to the MENA situation, Imbs and Wacziarg (2003) shows that advanced and technically efficient economies are more

[20]Source: UNCTAD (2011).

[21]The comparative advantage of MENA manufacturing tends to be in unskilled labor (e.g, clothing). Moreover, the significant wage premia in the public sector works against the development of labor-intensive manufacturing (in labor-abundant MENA countries).

[22]Although in the MENA region, high resource rents helped fund the expansion in education, health and welfare which is deemed to have positively affected efficiency. This had spillovers to non oil-producing countries via remittances, job flows and cross-border loans and grants.

likely to be characterized by *less* economic specialization as they become richer (see also World Bank (2009)).

In contrast to resource rents case, we might expect large efficiency gains from Manufacturing. This reflects its tradeable nature, its capital and skill intensity, its ease of technology transfer. Moreover Rodrik (2013) identifies industrialization and manufactured exports as the most reliable drivers for rapid and sustained growth (embodying, quite uniquely, unconditional convergence). One factor potentially retarding the development of manufacturing is (1) its generally very small size in the MENA, and (2) exchange rate volatility typical of petro-currencies (perhaps itself also linked to policy preferences for cheap, imported staples). Services and Agriculture, by contrast, are often characterized by low productivity, low skill intensity, sheltered competition and are constrained by home markets.[23]

4.2.3 Efficiency Indicators: Political

Whether the *chief executive* officer is a current military officer (=1 if a military rank applies, 0 otherwise) is a catch all for the influence of the military in government. Judging by the histogram, outcome are equally split in the MENA region. The effect on efficiency though may be ambiguous.

Military-dominated governments may divert scarce resources away from productive civilian use. Sporadic regional conflict in the MENA region undermines macroeconomic stability. Alternatively, in so far as Military-led government emphasise internal stability and containing ethnic rivalries etc., they may promote a more stable business climate than would otherwise prevail.

Workers' Rights indicates the extent to which workers enjoy internationally recognized rights, including a prohibition on forced labor; a minimum age for child labor; and acceptable conditions of work with respect to minimum wages, hours of work, and occupational safety and health. A score of 0 [1] and {2} indicates that workers' rights were severely restricted [somewhat restricted] and {fully protected} during the year in question. The first two cases categories dominate the distribution.

Again, the effect of workers' rights on efficiency is unclear. Negative consequences might be that they entrench insider power and slow reallocation within the economy. Positive effects might arise if employment stability promotes worker loyalty and productivity and, more generally, improved nutrition and health (relative to, say, the informal sector).

Finally, regime durability (*Durable*) refers to the number of years since the most recent regime change (defined by a three-point change in the "POLITY"[24] score over a period of three years or less) or the end of transition period defined by the lack of stable political institutions. Like the military indicator, its efficiency effect is not clear cut.

[23] Although given the scarcity of water resources in the MENA region, agriculture is not a dominant economic activity in most countries.

[24] This variable is described in Appendix A.

4.2.4 Efficiency Indicators: Socio-Cultural

A defining characteristic of the MENA is their low *median age*. Median age can matter for economic efficiency; east Asia's economic performance is often associated with its "demographic dividend". But this seems not to have carried over to the MENA (e.g., Amin et al. (2012), Chap. 3). Job creation, although high by international standards in recent decades, was surpassed by labor force growth.[25] High levels of youth unemployment mean faster depreciation of skills, weakened incentives to acquire skills, and many first jobs starting in the informal economy.

Information plays an important role for efficiency. In this framework information and communication technologies such as the cultural adoption of *Mobile* technologies (phones, internet access, text messaging, pagers) etc. are expected to improve countries' efficiency performance and promote growth, e.g., Jensen (2007).

Finally, consider *Religious fractionalization*. This is computed as $Frac_j = 1 - \sum_{i=1}^{N} s_{ij}^2$ where s_{ij} is the share of group i in country j; the higher the index the greater the fractionalization. Religious fractionalization may create efficiency bottlenecks in the form of biases in credit allocation and financial depth, home bias, limits on market size, low social trust (although it may enhance intra-group cohesion) etc. Any such negative effects are likely, though, to be contingent on the state of economic development, the quality of institutions, the level of religious tolerance, Alesina et al. (2003).[26]

Moreover, most MENA members have a dominant religious group, usually Sunni Islam. The remaining religions include Shia and other Islamic sects, Christian and Coptic (in Egypt), some Jewish and migrants' religions (e.g., Hindu) etc.[27] The distribution of religious fractionalization appears bi-model with a median around 0.13 which suggests relatively small religious fractionalization against some countries which have somewhat larger fractionalization.

5 Estimation Results

In our exercises, Equations (2) and (3) can be estimated in one single step by a maximum likelihood estimator, following Battese and Coelli (1995). We employ an unbalanced sample, with the maximum dimensions of the sample being 1980 to

[25]Although overall fertility rates have declined since 1980 to around 2.8 children/woman. Note, the MENA tend to have a low labor participation rate (just over 50%), driven mainly by low female participation.

[26]We restrict our analysis to the Religion variable only since for two countries (i.e., UAE and Yemen) the Ethnic and Language diversification variables (often also used in this context) are missing for the years 2007- 2008 and 1991-2006 respectively.

[27]Note some interesting cases: in Syria although Sunnis dominate the population, the minority Alawite Shia (just over 10%) dominate government and military. Also in Bahrain, 60-70% are Shia Islam whilst King Hamad bin Isa bin Salman Al Khalifa is a Sunni.

2008, see **Table 1**.[28]

In keeping with our motivation, we first estimate a (B)aseline model of production and inefficiency equations which emphasises economic indicators, with and without interactions: respectively, models $\mathbb{M}^B$ and $\mathbb{M}^B_{\mathcal{I}}$. We then (A)ugment that baseline model with the addition of political and socio-cultural indicators, again with and without interactions: $\mathbb{M}^A$ and $\mathbb{M}^A_{\mathcal{I}}$.

Most of the translog production parameters have no direct interpretation. Accordingly, we derive the following more informative statistics (see **Appendix B**):[29]:

1. Input elasticities, $E_{y,j} = \frac{\partial Y}{\partial J} \cdot \frac{J}{Y}$;
2. Technical Progress, $TP = \partial y / \partial t$;
3. Total Factor Productivity growth, $TFP = TP + (-\partial \mu / \partial t)$.

Due to the use of a translog, metrics [1.] to [3.] are time and country specific (we evaluate them at the mean and median).[30] The second section of table 1 shows the inefficiency parameter estimates, followed by the Technical Efficiency Index.

Table 2 examines various production restrictions and diagnostics:

1. Production is separable in its inputs;
2. Technical Progress is neutral;
3. Validity of country fixed effects;[31]
4. Incremental significance of the **E**, **P**, **S** and $\mathcal{I}$ blocks;
5. The significance of the parameter, $\gamma = \sigma_u^2 / \sigma^2$ which indicates the extent to which deviations from the frontier are due to noise, $\gamma \to 0$, or technical inefficiency, $\gamma \to 1$;
6. As well as the Silverman bootstrapped p-value for the null of Uni-modality in the TE and TP series (see Tables 1, 2 and Table 5) and;[32]
7. The Bayesian Information Criteria (BIC) and the observation number.[33]

[28]For Egypt, Mauritania, Morocco, Saudi Arabia, Sudan, Syria, Tunisia, Jordan and Bahrain we have 1980-2008. For Kuwait, Libya, Qatar, and the UAE we have 1986-2008. And 1989-2008 for Yemen.

[29]The full set of parameter results are available in Appendix E

[30]We report both, reflecting the possibility of skewness and/or multi-modality.

[31]Note, for brevity the fixed are not reported in the tables but are available on request.

[32]**Appendix C** defines the test and the particular bootstrap method we used.

[33]The lower the BIC the better the fitting is the model; this result is valid under the assumption that the models under comparison have the same number of observations.

Table 1: Technology Frontiers: Estimates

	$\mathbb{M}^B$	$\mathbb{M}^B_{\mathcal{I}}$	$\mathbb{M}^A$	$\mathbb{M}^A_{\mathcal{I}}$
Production Equation				
$E_{y,k}$	0.180***	0.196***	0.081	0.022
$E_{y,l}$	0.489***	0.569***	0.568***	0.468***
$E_{y,h}$	0.509***	0.222***	0.164***	0.216***
TP	−0.024***	−0.008***	−0.008***	−0.016***
TP median	−0.023***	−0.012***	−0.020***	−0.013***
TFP	0.026***	0.036***	0.020***	0.018***
TFP median	0.028***	0.032***	0.008***	0.012***
Inefficiency Equation				
β_0	2.369***	3.004***	0.329	3.842***
h	0.230***	−0.542***	−0.187***	−1.146***
$resrent$	0.069***	0.171***	0.026***	0.143***
GY	0.001	0.038	0.145***	0.148***
$Open$	−0.128***	−0.387***	−0.089***	−0.292***
FDI	0.091***	0.012***	0.004***	0.011***
$ManuY$	−0.113***	−0.109***	−0.119***	−0.079***
M^{AW}	−0.028***	−0.033***	−0.047***	−0.046***
M^{HI}	−0.334***	−0.322***	−0.076	−0.024
X^{HI}	0.046	0.055*	0.012	0.006
$dcps$	0.065***	0.075***	0.596***	0.288***
β_t	−0.050***	−0.044***	−0.028***	−0.034***
$Assn$			−0.009	−0.013
$MedAge$			0.139	−0.725***
$Worker$			−0.007	−0.554***
$ReligFrac$			0.637***	0.165***
$Durable$			−0.003***	−0.003***
$Military$			0.056**	0.172***
$Mobile$			0.001	0.005
$Resrent \times h$		−0.075***		−0.091***
$Open \times h$		0.228***		0.165***
$FDI \times h$		−0.005**		−0.006***
$ManuY \times \Delta e$		0.0001		0.0001***
$MedAge \times h$				0.003***
$Worker \times MedAge$				0.183**
TE	0.787	0.789	0.723	0.748
TE median	0.821	0.823	0.748	0.859

Notes: *Baseline*: $\mathbb{M}^B$; *Baseline with interactions*: $\mathbb{M}^B_{\mathcal{I}}$; *Augmented*: $\mathbb{M}_A$; *Augmented with Interactions*: $\mathbb{M}^A_{\mathcal{I}}$. ***, ** and * respectively indicate the 1%, 5%, and 10% level of significance. Numbers in squared brackets denote probability values. $E_{y,j}$ is the elasticity of output with respect to factor inputs. TP is the technical progress growth rate. TFP is the total factor productivity growth rate. TE is technical efficiency. See **Appendix B** for derivations. Values are means unless otherwise stated. Fixed effect estimates, α_{0i} are suppressed for reasons of space but are available on request.

There are many complementarities between the various model results, indicative of the underlying robustness. Almost all parameters are significant, qualitatively robust[34] and, in the inefficiency equation, appear to have plausibly-signed coefficients.

Although all models are nested, we cannot discriminate between them since the first two and last two have different sample sizes. But, within those two groups and using the BIC statistic, model $\mathbb{M}^B_{\mathcal{I}}$ outperforms $\mathbb{M}^B$, and $\mathbb{M}^A_{\mathcal{I}}$ outperforms $\mathbb{M}^A$. Thus, the addition of the interaction variables is supported by the data. The final model $\mathbb{M}^B_{\mathcal{I}}$ is attractive from our standpoint since it is both congruent with the data (all blocks are significant) and the most general. It is our preferred case.[35] In the following sections, we shall discuss the production and inefficiency estimation results in a sequential manner (respectively, in sections 5.1 and then in 5.2).

5.1 Production

Regarding factor elasticities, the labor elasticity is estimated at around $0.47 - 0.57$, whilst the (physical) capital elasticity is estimated less precisely: $0.02 - 0.20$. These figures though are close to Saliola and Seker (2011) who report labor and capital elasticities for 51 counties (including 6 MENA members) of 0.4 and 0.1, respectively; for some countries such as Egypt they report capital elasticities of an even lower value.[36] The low and sometimes insignificant capital elasticity may reflect low capital intensity in production or that the capital stock is essentially unproductive.[37] The human-capital elasticity tends to be estimated at around 0.2. Our results thus support Henry et al. (2009) and other studies who find significant human capital elasticities (albeit in a different sample context).

Regarding the diagnostic tests (**Table 2**), the restrictions of a unitary substitution elasticity, of neutral technology, and of no underlying country heterogeneity are all strongly rejected. The production function chosen therefore seems an adequate representation of the data. Parameter γ tends to be estimated above 0.9 suggesting that large parts of the total variation in output from the frontier is attributable to technical efficiency. Kneller and Stevens (2003) reports similar values of the γ coefficient using country-level data sets. Moreover, block exclusion of the E, P, S and Interaction indicators is statistically inadmissible, justifying their inclusion.[38]

[34] All overlapping parameters are qualitatively the same (except β_h in $\mathbb{M}^B$ which is positive and significant).

[35] A Likelihood ratio (LR) test, equal to twice the log of the ratio of the likelihoods and distributed as $\chi^2(m_b - m_b^*)$ (where m_b^*, m_b denote the number of parameters in model M_I^B and M^B, respectively) further confirmed this. For models M_I^B vs. M^B and M_I^A vs. M^A the LR test equals 28.26 and 75.4 respectively while the 5% critical values for 4 and 6 degrees of freedom are $7.78, 12.59$ respectively. Accordingly we select model M_I^B over M^B and M_I^A overM^A.

[36] See also Bond (2002).

[37] For a similar conclusion on some African states, see Devarajan et al. (2001)

[38] Note, we made several specification searches: for several inefficiency indicators we included quadratic and higher powers to examine non linearity and threshold effects, plus a wider variety of interactions. However, these were rarely statistically significant and did not produce a better fit.

Table 2: Technology Frontiers: Tests and Diagnostics

	$\mathbb{M}^B$	$\mathbb{M}^B_{\mathcal{I}}$	$\mathbb{M}^A$	$\mathbb{M}^A_{\mathcal{I}}$
Production Equation				
Cobb Douglas	[0.003]	[0.001]	[0.015]	[0.001]
Neutral Technical Change	[0.007]	[0.002]	[0.001]	[0.001]
$\alpha_{0i} = 0 \; \forall i$	[0.010]	[0.008]	[0.003]	[0.007]
TP Unimodal	[0.574]	[0.614]	[0.997]	[0.860]
Inefficiency Equation				
γ	0.989***	0.990***	0.741***	0.929***
σ^2	0.011***	0.008***	0.004***	0.006***
$\beta_{\mathbf{E}} = 0$	[0.003]	[0.001]	[0.020]	[0.002]
$\beta_{\mathbf{P}} = 0$			[0.002]	[0.002]
$\beta_{\mathbf{S}} = 0$			[0.010]	[0.001]
$\beta_{\mathcal{I}} = 0$		[0.021]	[0.014]	[0.001]
TE Unimodal	[0.435]	[0.212]	[0.222]	[0.005]
BIC	−318.657	−321.277	−280.266	−300.831
Obs.	316	316	302	302

Notes: See notes to Table 1.

5.1.1 Total Factor Productivity (TFP) and Technical Progress (TP)

TFP growth indicates the extent to which the frontier grows over time (keeping inefficiency constant). The MENA average annual TFP growth is around 2% to 3%. However, there is an interesting compositional story behind the TFP growth numbers. Technical progress TP has diminished TFP growth (−1% to −2%) while the rate of efficiency change $-\beta_t$ is positive, significant and greater in absolute size than the TP value. This suggests that it is *developments in efficiency* that has been the most important factor in the improvement in the TFP growth in Arab world (this is a theme we will take up in section 5.5.1).

The use of average full-sample numbers such as these, however, masks two key aspects:

(1) How technical progress rates have evolved *over time*.
(2) How technical progress rates rank *by country*.

We discuss these below, focusing mostly on preferred model $\mathbb{M}^A_{\mathcal{I}}$.

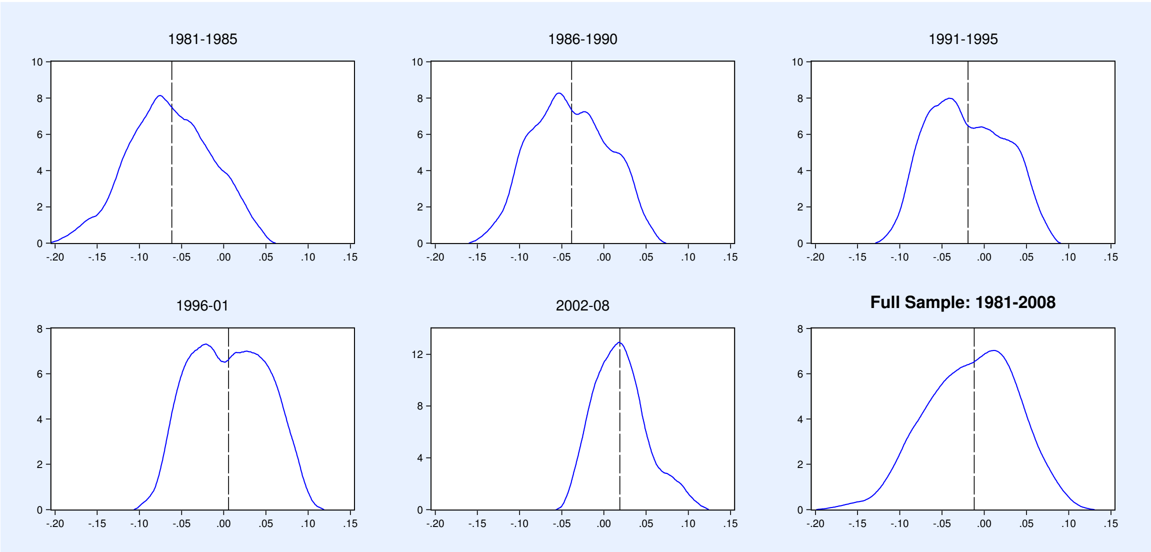
Technical Progress Over Time. **Figure 3** draws an estimated Epanechnikov kernel density for TP in five-year windows.[39] Also shown (in **Table 3**) are the higher moments of the TP distribution, and the probability-values from the Jarque-Bera (JB) Normality test. We also, to repeat, employ the Silverman (1981) test to test

[39] The histograms have been suppressed for brevity but are available on request.

the null of uni-modality in the distribution of TP. The test results are depicted as bootstrapped probability values. In effect, this modality test allows us to examine convergence or divergence in technology characteristics among the MENA.[40]

The TP distribution appears Normally distributed and uni-modal. In intuitive terms, this indicates that Arab countries share a *common technology* which remains effectively unchanged over time. This is interesting since it suggests that there is no (statistically significant) technological leaders among the MENA. There may be differences between countries in terms of TFP growth but it is not related to technical progress. Instead, as hinted above, it must be related to differing degrees of technical efficiency. Some countries are clearly hampered in reaching their most efficient production by the factors we identified, relating to institutional and cultural factors as well as economic ones.

Figure 3: Technical Progress Distributions



Note: Dashed vertical Lines indicates median histogram values.

Table 3: Technical Progress: Distributional Characteristics

	1981-1985	1986-1990	1991-1995	1996-2001	2002-2008	**1981-2008**
Median	−0.061	−0.038	−0.019	0.006	0.019	−0.012
Std. Dev	0.046	0.042	0.042	0.042	0.030	0.051
Skewness	−0.033	0.070	0.173	0.047	0.598	−0.240
Kurtosis	2.411	2.035	1.802	1.792	2.968	2.560
Normality	[0.669]	[0.337]	[0.168]	[0.186]	[0.194]	[0.110]
TP Uni-modality	[0.257]	[0.287]	[0.228]	[0.299]	[0.562]	[0.860]

[40]The final, full sample, bootstrap Silverman p-value in Table 3 corresponding to that reported in Table 2. Henderson et al. (2008) followed a similar approach to test the existence of a common steady state using a sample of 118 countries from the the Penn world data.

5.2 Inefficiency Equation

The inefficiency equation represented by (3) is in terms of distance to the technical frontier. Thus a negative coefficient indicates a variable that contributes towards a catching up of that frontier (i.e., implies a decrease in inefficiency).

In the following sections, we review variables which, respectively, worsen and enhance efficiency. Thereafter we analyze the interaction effects. Finally, we examine the behavior of the series of Technical Inefficiency itself.

5.3 Indicators which worsen Efficiency

Looking across Table 1, indicators which worsen inefficiency are (excluding interactions),

- Resource-dependency;
- Government expenditure;
- FDI;
- Financial Depth;
- Religious Fractionalization, and;
- Military governments.

We already discussed the possible pro and con efficiency effects of resource dependency, FDI[41], religious fractionalization and military governments. We therefore need not repeat them, except to confirm that they worsen efficiency. Consider the two remaining terms.

Government expenditures comprise purchases of goods and services, subsidies, employees' compensation, and most expenditures on defense and security. Such expenditures have not enhanced efficiency.[42] In the case of subsidies, their intention is clearly social cohesion (essential in the Arab world). Regarding defense expenditures, these have tended to involved arguably wasteful duplication of resources across the region, Malik and Awadallah (2013).[43] Plus given that much of the military hardware is imported, technology spillovers to other sectors appear to have been limited.

Severe *financial* frictions are known to characterize the MENA region with, for example, only 10% of MENA firms using bank finance (World Bank Business Environment Survey)[44]. Bank lending tends to have been skewed to large, well-connected enterprises in low turnover markets (see Herrala and Turk Ariss (2013),

[41] Gente et al. (2014) develop a framework for analyzing conditions under which FDI may or may not be growth enhancing. See also de La Grandville (2012).

[42] The effect is positive in all cases in Table 1 but only significant in the final two columns.

[43] By way of illustration, the average (over 1998-2012) of military expenditures as a fraction of output were OECD (2.5%) as against 6.6% in the Arab region (Source: SIPRI Database).

[44] This is based on 1999-2000 survey data, see http://go.worldbank.org/RV060VBJU0

Rocha et al. (2011), World Bank (2009)). Otherwise, firms are mostly small family businesses with limited access to external finance; and domestic equity and debt markets are underdeveloped. Financial infrastructures in general are weak with high agency and monitoring costs, weak judicial systems etc. Unsurprisingly therefore financial depth has not enhanced efficiency (given its inefficient and skewed allocation).

5.4 Indicators which enhance Efficiency

Factors *enhancing* efficiency include,

- human capital;
- median age;
- openness;[45]
- manufacturing share;
- workers' rights and;[46]
- regime duration;

We have already discussed human capital, manufacturing share, and openness. The previous arguments as to their efficiency effects need not therefore be repeated. The other variables which enhance efficiency are median age, workers' rights and regime duration. The first two will be discussed in the next section.

The Military indicator, recall, worsened efficiency. But, perhaps surprisingly, regime durability improves it. Certainly, a key feature of the Arab world is/was the remarkable longevity of its leaders.[47] Stable autocratic governments therefore seem to represent a double-edged sword. Their military characteristic may, for example, by crowding out civilian activities worsen efficiency but their durability might, by putting emphasis on internal stability and the containing of ethnic rivalries stabilize the business climate. Moreover, durability may positively enhance policy makers' time preferences and their commitment to large investment projects.[48]

[45]Exports to High Income countries are either insignificant (the full case) or only significant at 10%. And in both cases, the effect is to deepen inefficiency.

[46]The rights to freedom of assembly and association (*Assn*) imparts a positive effect but is only significant at the 12% level.

[47]Muammar al-Gaddafi ruled Libya for over 40 years (1969-2011), Ali Abdullah Saleh was President of North then unified Yemen for over 30 years (1978-2012), Hosni Mubarak served a similar term as Egyptian President (1981-2011) – and before him, Nasser (18 years) and Sadat (11 years) – the al-Assad family have ruled Syria since 1971, and the House of Saud, the Al Thani family (Qatar) and al-Khalifa (Bahrain) represent long-standing ruling dynasties.

[48]Such an interpretation is consistent with the seminal work of Olson (2000) on autocrats distinguishing "roving" and "stationary" bandits.

5.5 Interaction Terms

The interacted variables in the inefficiency equation (from the final column) are human capital, median age and the growth of the effective exchange rate:

$$\begin{aligned} \mu = \quad \ldots \ & \underset{+}{\beta_R} Resrent &+& \quad \underset{-}{\beta_{R,h}} \left(Resrent \times h \right) \\ & \underset{-}{\beta_O} Open &+& \quad \underset{+}{\beta_{O,h}} \left(Open \times h \right) \\ & \underset{+}{\beta_F} FDI &+& \quad \underset{-}{\beta_{F,h}} \left(FDI \times h \right) \\ & \underset{-}{\beta_M} MedAge &+& \quad \underset{+}{\beta_{M,h}} \left(MedAge \times h \right) \\ & \underset{-}{\beta_W} Worker &+& \quad \underset{+}{\beta_{W,M}} \left(Worker \times MedAge \right) \\ & \underset{-}{\beta_{MY}} ManuY &+& \quad \underset{+}{\beta_{MY,\Delta e}} \left(ManuY \times \Delta e \right) + \ \ldots \end{aligned} \tag{4}$$

From this, we see the key role played by human capital; whilst *resrent* and FDI worsen inefficiency in isolation, when interacted with h they improve efficiency (i.e., $\beta_{R,h}, \beta_{F,h} < 0$). In other words, that part of resource rent and FDI activity that is skill intensive boosts efficiency. By contrast, the previous benevolent effects of openness on efficiency reverses when interacted with h (although the net effect is good for efficiency, see later table 4).

Likewise, for median-age interactions that $\beta_{W,M}, \beta_{M,h} > 0$ is striking since both of their individual (non-interacted) effects improves efficiency. The positive product can perhaps best be interpreted as the "youth bulge" phenomenon: in the Arab World well educated youth often experience high entry barriers into formal employment (see World Bank (2004)) and are associated to social unrest. This deprives the economy of high-potential employees and strengthens insiders' power. Likewise, whilst workers' rights positively impact efficiency,[49] as applied to high-skill outsiders it could be used as a barrier to entry (to new labor cohorts).

Finally, **Table 4** shows the total effect in terms of elasticities. The elasticity of inefficiency with respect to human capital is negative, as is median age, the share of manufacturing, as well as in fact openness. However the net effect of resource rents and FDI remain significantly positive (i.e., such as to worsen inefficiency).

[49] The exact channels are unclear but could, for example be related to strengthening trust and promoting longer-term planning, generating incentives for skills, promoting nutrition etc.

Table 4: Key Elasticities

	Elasticities
$E_{\mu,FDI}$	0.002^{***}
$E_{\mu,H}$	-0.695^{***}
$E_{\mu,MedAge}$	-0.322^{***}
$E_{\mu,ManuY}$	-0.078^{***}
$E_{\mu,Open}$	-0.069^{***}
$E_{\mu,Resrent}$	0.021^{***}

5.5.1 Technical Efficiency

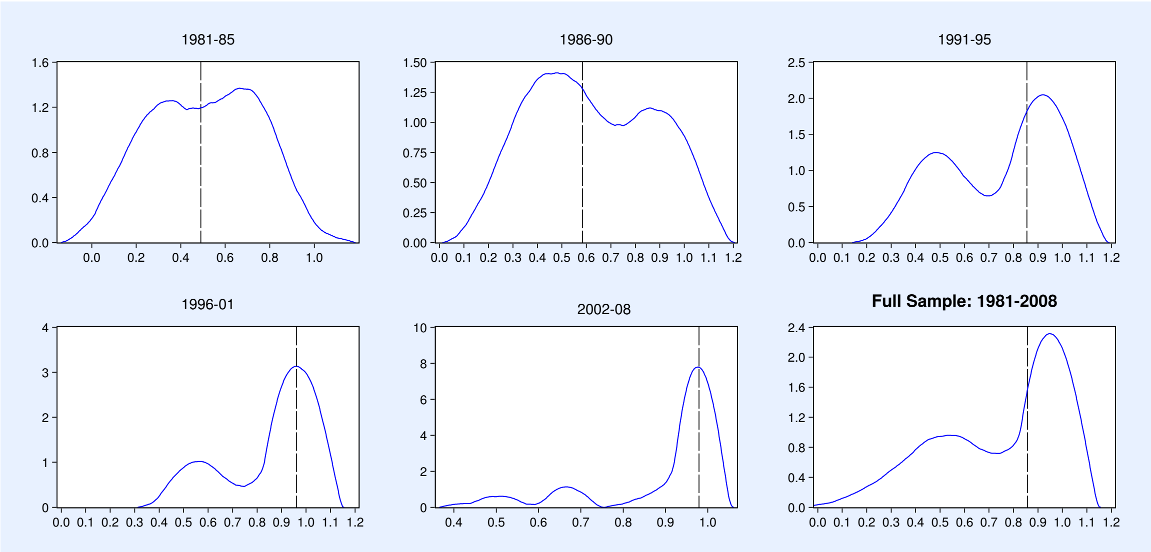
Technical Inefficiency compares the inefficiency under the control of firms inside the economy to purely stochastic factors. Given the estimated equations, we calculate the composite error $\varepsilon_{it} = v_{it} - u_{it}$. Technical inefficiency is then computed using the conditional expectation $\mathbb{E}\left\{u_{it} \mid \varepsilon_{it}\right\}$, see Jondrow et al. (1982) ((B.1)) .

Looking back at Table 1 we see that average technical efficiency is around 0.75. This implies that the average MENA TE could be increased by 25% if inputs were used at their most efficient point. Such a level of technical efficiency is comparable to other country-group studies.[50] As with Technical Progress, moreover, we can decompose Technical Efficiency into a time and country-specific dimension, with the same supporting metrics.

Technical Efficiency over Time. **Figure 4** and **Table 5** reveal the general rejection of uni-modality in the distribution of technical efficiency. Over the full sample, this is strongly rejected and only marginally accepted (i.e., barely above 10%) in the early 1980s and at the end of the sample. The distribution is therefore not only generally bi-modal but is also characterized by visually well-separated peaks. There has also been, as we demonstrate below, much country flux in efficiency rankings. Finally, the figure also reveals the remarkable transformation that has taken place over time in median technical efficiency: rising from around 0.5 to almost unity.

[50] Henry et al. (2009) report an average efficiency index of 0.73 for a sample of 57 developing countries over 1970-1998.

Figure 4: Technical Efficiency Distributions



Note: Dashed vertical Lines indicates median histogram values. Smoothness and bandwidth consideration imply Kernel densities do not necessarily truncated at unity.

Table 5: Technical Efficiency: Distributional Characteristics

	1981-1985	1986-1990	1991-1995	1996-2001	2002-2008	**1981-2008**
Std. Dev	0.235	0.240	0.224	0.180	0.153	0.252
Skewness	−0.061	0.123	−0.439	−1.030	−1.743	−0.702
Kurtosis	1.919	1.695	1.535	2.352	4.682	2.210
Normality	[0.258]	[0.132]	[0.035]	[0.005]	[0.000]	[0.000]
TE Uni-modality	[0.113]	[0.060]	[0.010]	[0.001]	[0.146]	[0.005]

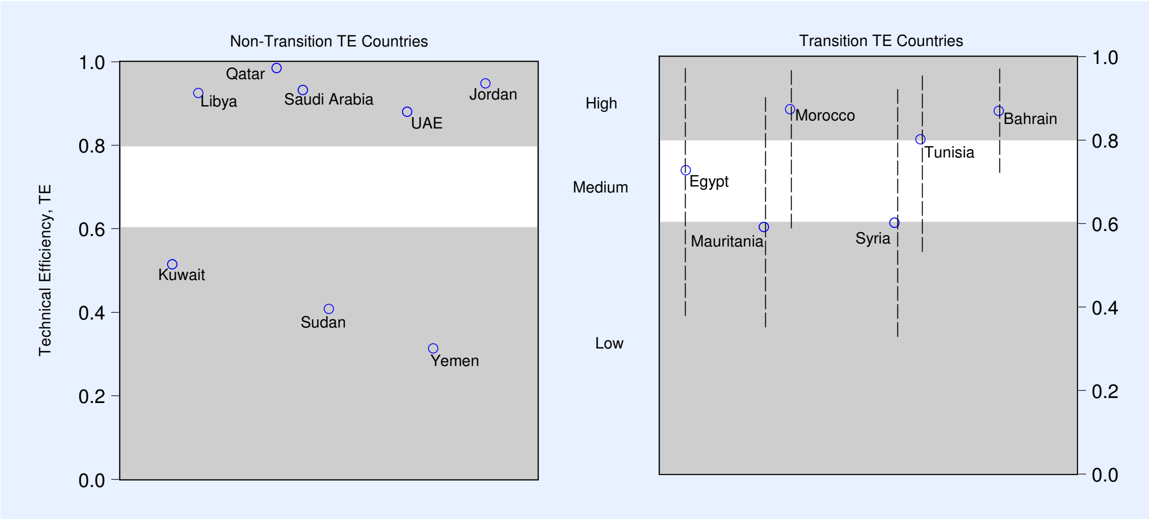
Technical Efficiency by Country. Over the full sample, the TE distribution thus appears bi-modal and negatively skewed (a fat tail to the left). And so, unlike the uni-modal Normally distributed TP series, these features suggest that there has been polarization across countries in terms of technical efficiency with respect to the frontier.

Accordingly, the panels in **Figure 5** further categorize countries into those with *High* ($0.8 \leq TE \leq 1$), *Medium* ($0.6 \leq TE < 0.8$) and *Low* average technical efficiency ($TE < 0.6$). We also further categorize into countries which have exhibited inter-band transition (shown in the right panel in dashed vertical lines).[51]

To illustrate: Qatar, Libya, Saudi Arabia, UAE and Jordan show zero transition from the High region; Kuwait, Sudan, and Yemen are clustered at the other extreme.

[51]Note, this country ranking appears relatively robust. Table E.8 calculates the Spearman rank correlation coefficient of the country set across several methods and finds the correlation in the range of around 0.7-1.0.

Figure 5: Polarization and Shifts in Technical Efficiency



Notes: Dashed vertical lines in the rhs panel indicate max-min ranges for countries which have moved between categories. Note the horizontal axes have no interpretation; they merely admit sufficient space to separate out the country names.

However six states (Egypt, Mauritania, Morocco, Syria, Tunisia, Bahrain) have risen over time, often from initially very low efficiency levels.

Summary and Comparison of TP and TE So far we have looked at the distributional characteristics of both TE and TP over the full sample and over sub samples. We conclude:

- In terms of technical progress, MENA countries are *not* characterized by well-separated clusters of technologically backward and advanced countries. This is because the TP distribution is uni-model and essentially Normal.
- Performance on technical efficiency tells a different story: there has been a limited number of countries that failed to improve or consolidated their performance through time and share a common low steady state and the rest that significantly improved their performance.

6 Robustness

In addition to these results, we performed robustness with respect to functional form assuming the same indicators as in the final column of Table 1. We chose Fourier and Modified translog as alternative (and more general) specifications. Full results are in **Appendix D**.

However, we also check robustness with respect to additional variables. To include all the series of interest that are listed in Appendix A raises issues of dimensionality and collinearity. Accordingly, as discussed below, we estimate stochastic frontier systems where we extract *principal components* from the **E**, **P**, and **S** blocks.

6.1 Principal Components Analysis

With principal component (PC) analysis we are able to transform the original variables $\mathbf{z} = [z_1, z_2, ..., z_k]'$ into a new set $\underline{\mathbf{z}} = [\underline{\mathbf{z}}_1, \underline{\mathbf{z}}_2, ..., \underline{\mathbf{z}}_k]'$ which are linear combinations of the original **z**'s and are mutually orthogonal (see Jolliffe (2004) for a thorough treatment). They are constructed by calculating the eigenvectors of the correlation matrix of the original variables. By ranking the new orthogonal variables by importance, we can summarize the data with fewer components, say $k - m$.

The inefficiency equation corresponding to (3) is then,

$$\mu_{it} = \underline{\mathbf{z}}'_{it(k-m)}\beta^*_{k-m} + \omega^*_{it} \tag{5}$$

where $\beta^*_{k-m} = \left[\beta^*_1, \beta^*_2, \cdots \beta^*_{k-m}\right]$ is the reduced vector coefficient and ω^*_{it} is a disturbance vector.

When PCA is applied to *categorical* variables, note, it assigns larger weights to the most skewed variables, creating a biased correlation matrix, see Kolenikov and Angeles (2009), Holgado-Tello et al. (2010). In such cases, it makes more sense to use *polychoric* or *polyserial* correlations. We use the following rule. If a series contains more than 10 categories it is considered to be continuous. And any correlation between continuous variables is calculated using the standard Pearson correlation coefficient (e.g., as in the GY-FDI bivariate correlation). If there are fewer than 10 categories, we implement a polychoric correlation (e.g., as in the Military-Injud correlation). If there is a mix of data types, we chose polyserial/biserial correlation (e.g., as in the Military-Durable correlation).

There are several practises for reducing the number of principal components from k to $k - m$. We retained those principal components with eigenvalues at or above unity, Draper and Smith (1981). We then paired down the number of PCs in the estimation system by using the BIC; if the exclusion of one additional PC did not increase the BIC statistic, the procedure is terminated and the model with the lowest BIC is retained as the best-fitting model.

Once the final model is obtained in terms of the selected $\underline{\mathbf{z}}_{it}$, we retrieve the coefficients of each group-variable according to (see Myers (1986)):

$$\beta_{pc} = \Lambda'_{k-m}\widetilde{\beta}^*_{k-m} \tag{6}$$

where Λ'_{k-m} is a $k \times (k-m)$ matrix of eigenvectors and $\widetilde{\beta}^*_{k-m}$ is the vector of estimated coefficients. **Table 6** shows the β_{pc}'s, and **Table E.7** shows the full SFA estimates. Our aims in running PCA are three fold:

(1) To assess whether the parameters in Table 1 are robust to the inclusion of additional indicators.

(2) To assess the significance and sign of the additional indicators contained in the PCs.

(3) To assess the overall *contribution* of the Economic, Political and Socio-Cultural Indicators to technical efficiency, by country.

Points (1) and (3) will be respectively covered in sections 6.2 and 6.1.1.

Table 6: Retrieved Coefficient Values: principal components

S		**P**		**E**		$\mathcal{I}$	
$Agde_O$	0.068***	$Assn$	0.034***	H	−0.025***	$FDI \times H$	−0.0027*
$Agde_Y$	0.088***	$Disap$	−0.012	$Dcbs$	−0.026	$Open \times H$	−0.0115**
$MedAge$	−0.026	$Domov$	0.003	$Dcps$	−0.034***	$ManuY \times \Delta e$	0.0016***
$Mobile$	−0.122***	$Durable$	−0.004***	Δe	0.018***	$Worker \times MedAge$	0.0017
$ReligFrac$	0.057***	$Formov$	−0.011*	FDI	−0.011	$Resrent \times h$	−0.029**
$Urban$	−0.089***	$Injud$	−0.012**	GY	−0.047		
$Worker$	−0.089***	$Military$	0.015***	M^{AW}	0.057***		
		$Tort$	−0.019	M^{HI}	−0.017		
		$Wopol$	0.022	$ManuY$	−0.011*		
				$Open$	0.088		
				$Resrent$	−0.013		
				β_t	−0.030***		
				X^{HI}	−0.054***		

On point (2) we see, for example that an increase in *urbanization* (commonly regarded as promoting scale economies and demonstration effects) is efficiency enhancing.[52] By contrast, the two *age dependency terms* (old and young) worsen inefficiency.[53]

Variables associated with the protection of basic rights – *Women's Rights*, *Torture* and *Disappearances* – are intuitively signed (i.e., improvements on these indices promotes efficiency). But they are not significant. The efficiency-enhancing effects of improvements in external freedom of movement and in judicial independence, though, are significant.

6.1.1 Principal Component Contributions

Now we come to Point (3) above: overall contributions. In tables 1 and 6, we can see the individual impacts on (in)efficiency: e.g., human capital (an **E** variable) reduces economic inefficiency, Religious fractionalization (a **S** variable) raises it. In the principal components context, however, we can also examine the marginal contribution to efficiency of the entire block variables in themselves.

To calculate the contribution of Political, Social and Economic blocks to technical efficiency we modify the method of Coelli et al. (1999) to the principal components

[52] We also tried estimating with population density as a substitute for urbanization and found similar results.

[53] This is plausible: a population skewed towards retirees faces shortfalls in their labor force and may bias public funds towards pension/health expenditures (potentially at the cost of productive investment). Likewise, one skewed towards the very young, downward biases efficiency for the reasons already discussed.

case. The contribution of each block on technical efficiency is computed as the difference between gross efficiency (full model, $\mathbb{M}^{A}_{\mathcal{I}}$) and efficiency net of the contribution of the relevant blocks. The latter can be computed – to take the example of Political block – by replacing equation (3) by,

$$\mu^* = z_*^{'} \beta_* \tag{7}$$

where,

$$\mu^* = \min \left[\beta_{0^*} + \beta_{\mathbf{E}^*} \mathbf{E} + \beta_{\mathbf{S}^*} \mathbf{S} + \beta_{\mathcal{I}^*} \mathcal{I} + \beta_{t^*} t - \beta_{\mathbf{P}^*} \mathbf{P} \right] \tag{8}$$

and then recalculating the efficiency predictions. Thus the marginal contribution of the Political block to efficiency relative to the full model is given by,

$$\mathcal{C}^{\mathbf{P}} = 100 \cdot \frac{\mathbb{E}\left\{-u_{it} \mid \varepsilon_{it}\right\} - \mathbb{E}\left\{-u^*_{it} \mid \varepsilon^*_{it}\right\}}{\mathbb{E}\left\{-u_{it} \mid \varepsilon_{it}\right\}} \tag{9}$$

where u^* is the one-sided error and composite error associated with the mean efficiency process, equation (8), and ε^* is the associated composite error. The results are reported in **Table 7**.

To illustrate: (1) the average contribution of Polity block for Bahrain to efficiency is 1.5%. Thus, if that country had a gross efficiency score of 0.90, efficiency would be 0.89 were it not for the effect of polity block; (2) the average contribution of Polity block for Jordan to efficiency is -7.1%. Thus if the country also had a gross efficiency score of 0.90, efficiency would be 0.97 were it not for the effect of polity block has on efficiency levels. Thus a negative multiplier denotes that the block constitutes a constraint in attaining high(er) efficiency.

According to these findings:

(i) For almost all countries the contributions of the Polity block is such as to reduce efficiency.[54] For example, in Mauritania, Qatar, Sudan, and Yemen the effect is of the order of a 10-15% loss in efficiency from the influence of Political factors.

(ii) Outcomes are in absolute terms more dramatic among Social variables (**S**). In Bahrain, Jordan, Kuwait, Sudan and Tunisia they change the efficiency effect by around 20% in absolute value. There is a 50-50 split between positive and negative contributions. Thus, unlike Political factors, social factors (demographics, urbanization, workers' rights) can be both supportive or unsupportive.

(iii) The economic block (**E**) is more mixed between negative and positive marginal contributions. In most countries, taking out the economic variables would make major changes in technical efficiency.

[54]Three countries (Bahrain, Egypt, Saudi Arabia) do register positive contributions but these are very close to zero in value.

The picture across countries is often a rather nuanced one. For *Kuwait*, for example, (S)ocial factors place a big constraint on efficiency (−25.5), driven largely by its high religious fractionalization. However, *Bahrain*, which also has high fractionalization (though below Kuwait's), has a high penetration of mobile technologies and high median age, which implies that social factors play a net enhancing role in efficiency (+19.1). On (P)olitical factors, *Yemen*, for example, suffers from low durable regimes, and high restrictions on external and domestic freedom of movement. On Economic factors, *Qatar*, even though it defines the technical frontier for the MENA, still has many constraining economic factors (when viewed through the lens of the PCs): principally its high resource rents. If it had fewer such rents and a higher manufacturing sector, for example, it would (all else constant) enjoy higher overall technical efficiency from its E(conomic) inputs.

Note, some variables in Table 6 are insignificant, and *Assn* has a counter-intuitive sign. So there are some noise factors, and caution should be exercised in too literal an interpretation. However, Table 7 does confirm that Political, and Social factors alongside Economic ones do matter for the attainment of efficiency and frontier performance. And that they can differ considerably across countries, being either supportive or un-supportive. Moreover, in using the PC retrieved coefficients and the original indicators, one can trace out the determinants of country-specific block constraints for the attainment of technical efficiency.

Table 7: Contributions of Political and Socio-Cultural Factors In Efficiency

	$\mathcal{C}^{\mathbf{P}}$	$\mathcal{C}^{\mathbf{S}}$	$\mathcal{C}^{\mathbf{E}}$
Bahrain	1.5	19.1	15.5
Egypt	1.0	−0.6	−16.5
Jordan	−7.1	22.5	15.2
Kuwait	−0.6	−25.5	8.9
Libya	−5.3	1.3	4.0
Mauritania	−15.0	−7.4	−19.2
Morocco	−1.2	12.8	12.4
Qatar	−14.4	2.7	−19.7
Saudi Arabia	4.6	1.8	9.3
Sudan	−9.6	−22.4	−13.6
Syria	−1.1	−11.5	−15.0
Tunisia	−0.1	15.5	−7.5
UAE	−2.1	−10.1	8.9
Yemen	−8.3	−4.5	−9.2

Finally, **Table 8** shows the correlations of the first principal component of each of the blocks.[55] All PCs are positively correlated, in the range 0.2-0.6. This confirms that economic and political reform and even social factors are complementary in raising economic efficiency. Put another way, economic reforms (e.g., those enacted

[55]The first principal component has the largest possible variance (that is, accounts for the maximum of the data variability).

in the 1980s) may have limited success unless accompanied by institutional reforms. Interestingly, though, the highest correlation lies with cultural factors (e.g., demographic characteristics, religious fractionalization, urbanization, workplace rights).

Two caveats should be borne in mind. First, as always, correlation does not imply causation. Thus, we do not know whether political factors should be "fixed" prior to, or along side, economic reforms. Second, the splitting of variables into blocks is, to repeat, far from watertight. For example, we considered human capital to be an economic variable, but we could equally rationalize it as a political one – part of the Arab Social Contract that compensated oppressed citizens. The correlations between the principal components reflects those links, without necessarily being informative about causality between them.

Table 8: Correlations of First principal components

	E	**P**	**S**
E	1		
P	0.19	1	
S	0.55	0.35	1

6.2 Robustness Comparisons

Now we can pool our various results: those of Table 1, two variants of model $\mathbb{M}_{\mathcal{I}}^{A}$ under different production specifications (Fourier and Modified Translog), see **Table E.9**, plus the PCA (Table 6). This variety allows us to assess model robustness which we here define as the robustness of coefficients signs across methods.[56]

In that respect, we define variables as "strongly" sign-robust as ones having a common and significant sign across all methods. Variables are "weakly" sign robustness if at least one of the coefficient signs is distinct and/or insignificant.[57] Otherwise, there is no robustness. According to this classification, we derive **Table 9** (derived from **Table E.9**):

[56]Note, we do not try to assign model weights. That would not be straightforward since they have different sample sizes and thus non-comparable likelihoods. Although we did earlier note an ordering of the B and A models in favor of interactions.

[57]Some variables cannot be used to assess robustness since they only appear in one method (e.g., $Injud$)

Table 9: Robustness in Sign

	Strongly Robust	Weakly Robust
Enhance Efficiency	β_t $H \times FDI$ $H \times Resrent$ $ManuY$ $Worker$	$Durable$ H M^{AW} $Open$
Weaken Efficiency	$Military$ $ReligFrac$	$Dcps$ FDI $ManuY \times \Delta e$ $Resrent$ $Worker \times MedAge$

From this we see the efficiency importance of human capital, both in itself but also as an enabling factor in FDI and resource rents, which otherwise retard efficiency. Trade and manufacturing share also robustly enhance efficiency. The protection of workers' rights (perhaps for efficiency wage and nutrition reasons) also enhances efficiency in a strongly robust manner.

The presence of a military-led government and religious fractionalization worsen efficiency in a strongly robust sense. Finally, financial depth (long a specific concern in the Arab world, Herrala and Turk Ariss (2013)), as proxied by domestic credit, has also not enhanced technical efficiency.

7 Conclusions

Why has the Arab world fallen behind? Which factors shaped this outcome? To begin to address those questions, we estimated the MENA technical frontier and established its determinants. We divided efficiency-related variables into economic, political and socio-cultural ones. We estimated the frontier in multiple ways: using different production functions and exploiting a large data set using principal components. Our results paint a remarkably consistent and robust picture. In some dimensions we confirm received wisdom, in others we modify or overturn it.

The MENA have been characterized by *increasing* economic efficiency, albeit with marked polarization: some countries consistently at the top or bottom of efficiency ranges, around half having improved over time. Such increased average efficiency contributed positively to TFP growth. But technical progress – another element in TFP growth – has been regressive, with the MENA consigned to a low average technological base. The flip side of this is that the MENA may have exhausted efficiency gains, and so moving forward there must be significant and improved progress on economic fundamentals.

Human capital has enhanced efficiency; more educated workers are better able to implement advanced technologies. Thus the MENA's pro-education emphasis, although behind Western proficiency levels, has yielded (perhaps unexpectedly) strong and pervasive returns. Indeed, when FDI and merchant trade are skill-intensive, they become efficiency enhancers, otherwise not. Trade, manufacturing share and the protection of workers' rights also are identified as robustly enhancing efficiency.

We confirm the resource-curse interpretation of MENA developments. Resource rents may loosen efficiency incentives. This is intuitive in so far as much of the extraction work may be done by foreign firms with limited spillover of technical expertise to the non-resource economy. Moreover, exchange rate volatility and likely overvaluation (characteristic of petro-currencies) has retarded manufacturing growth. Other related features may also hinder efficiency: heightened rent seeking; under-diversified product range; and governance issues. On the other hand, such revenues helped fund the education expansion that underpinned MENA development.

Financial depth seems not to have enhanced efficiency; this may be consistent with the rent-seeking view and/or that credit has sustained favored "zombie" firms at the expense of smaller ones constrained by retained earnings. Finally, we identified religious fractionalization and the catch-all "military" government categorization as being strongly robust determinants of weakened efficiency.

In providing such a comprehensive characterization of the MENA efficiency profiles, we have attempted to set a benchmark and cross check for related studies in the literature. And to contribute more generally to ongoing discussions of how regional efficiency and development may progress.

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A Data Sources and Definitions

Table A: Data Description (I)

Variables	Full Description
$AGDE_o$	Old Age dependency ratio. The ratio of older dependents, people older than 64 to the working-age population (those aged 15-64). Data are shown as the proportion of dependents per 100 working-age population. **Source:** World Bank. [**S**]
$AGDE_y$	Young Age dependency ratio. The ratio of population younger than 15 years of age to the working-age population (those aged 15-64). Data are shown as the proportion of dependents per 100 working-age population. **Source:** World Bank. [**S**]
ASSN	A score of 0 indicates that citizens' rights to freedom of assembly or association were severely restricted or denied completely to all citizens; 1 indicates that these rights were limited for all citizens or severely restricted or denied for select groups; 2 indicates that these rights were virtually unrestricted and freely enjoyed by practically all citizens in a given year. **Source:** CIRI Human Rights Data Project. [**P**]
DCBS	Domestic credit provided by the banking sector includes all credit to various sectors on a gross basis, with the exception of credit to the central government. The banking sector includes monetary authorities and deposit money banks, and savings and mortgage loan institutions and building and loan associations. **Source:** World Bank.
DCPS	Domestic credit to private sector: financial resources provided to the private sector (e.g., loans, purchases of non-equity securities, trade credits etc) that establish a claim for repayment. For some countries these claims include credit to public enterprises. **Source:** World Bank.
DISAP	Disappearances are cases in which people have disappeared, political motivation appears likely, and the victims have not been found. Knowledge of the whereabouts of the disappeared is, by definition, not public knowledge. However, while there is typically no way of knowing where victims are, it is typically known by whom they were taken and under what circumstances. A score of 0 indicates that disappearances have occurred frequently in a given year; 1 indicates that disappearances occasionally occurred; 2 indicates that disappearances did not occur in a given year. **Source:** CIRI Human Rights Report. [**P**]
DOMMOV	Freedom of Domestic Movement. This variable indicates citizens' freedom to travel within their own country. A score of 0 indicates that this freedom was severely restricted, 1 indicates the freedom was somewhat restricted, and 2 indicates unrestricted freedom of foreign movement. **Source:** CIRI Human Rights Report. [**P**]

Note: Textual descriptions of the variables are generally taken from their description in the original sources, or edited versions of that text. We generally use the variable names consistent with those given in the corresponding data set. [**S**]=Sociocultural, [**P**]=Political indicator. Non labelled indicators are [**E**]conomic ones.

Table A: Data Description (II)

Variables	Full Description
DURABLE	Regime Durability: The number of years since the most recent regime change (defined by a three-point change in the POLITY score over a period of three years or less) or the end of transition period defined by the lack of stable political institutions (denoted by a standardized authority score). In calculating the DURABLE value, the first year during which a new (post-change) Polity is established is coded as the baseline "year zero" (value = 0) and each subsequent year adds one to the value of the DURABLE variable consecutively until a new regime change or transition period occurs. Values are entered for all years beginning with the date of independence if that event occurred after 1800. **Source:** Marshall et al. (2010). [**P**]
E	Trade-Weighted Real Exchange Rate. **Source:** IMF.
FDI	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, and is divided by GDP. **Source:** World Bank.
FORMOV	Indicates citizens' freedom to leave and return to their country. 0= indicates that this freedom was severely restricted, 1=freedom was somewhat restricted, 2= unrestricted freedom of foreign movement **Source:** CIRI Human Rights Report. [**P**]
GY	General government final consumption expenditure (calculated as % of GDP). This includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation. **Source:** World Bank. [**E**]
H	Human Capital (educational attainment of individuals 25 years or older measured as average years of schooling). Because these data are available for 5-year periods, we follow standard practise and linearly interpolated between periods. **Source:** Barro and Lee (2013).
INJUD	Independence of the Judiciary. This variable indicates the extent to which the judiciary is independent of control from other sources, such as another branch of the government or the military. 0="not independent", 1="partially independent", 2= "generally independent". **Source:** CIRI Human Rights Report. [**P**]
K	Physical Capital. Estimates of the physical capital stock are generated using the perpetual inventory method. **Source:** Penn World Tables.
L	Number of Employees. **Source:** Derived from Penn World Tables.

Table A: Data Description (III)

Variables	Full Description
M^{AW}	Merchandize imports from economies in the Arab World are the sum of Merchandize imports by the reporting economy from economies in the Arab World. Data are expressed as a percentage of total Merchandize imports by the economy. Data are computed only if at least half of the economies in the partner country group had non-missing data. **Source:** World Bank.
M^{HI}	Merchandize imports from high-income economies are the sum of Merchandize imports by the reporting economy from high-income economies according to the World Bank classification of economies. Data are expressed as a percentage of total Merchandize imports by the economy. Data are computed only if at least half of the economies in the partner country group had non-missing data. **Source:** World Bank.
MEDAGE	Median Age. The data is every five years and was linearly interpolated. **Source:** CIA World FactBook. [**S**]
MANUY	Manufacturing value added to total value added. Manufacturing refers to industries belonging to ISIC divisions 15-37. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. **Source:** UNData *http://data.un.org/Browse.aspx?d=SNA*.
MILITARY	This indicator = 1 if the source includes a rank in their title, 0 otherwise. If chief executives were described as officers with no indication of formal retirement when they assumed office, they are always listed as officers for the duration of their term. If chief executives were formally retired military officers upon taking office, then this variable scores 0. **Source:** Keefer (2010). [**P**]
MOBILE	Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service using cellular technology, which provide access to the public switched telephone network. Post-paid and pre-paid subscriptions are included. **Source:** World Bank. [**S**]
OPEN	Merchandize trade as a share of GDP is the sum of Merchandize exports and imports divided by the value of GDP, all in current U.S. dollars. **Source:** World Bank.
POLITY	Revised Polity2 Score. Subtracts "AUTOC" from "DEMOC" indices. Ranges from +10 (strongly democratic) to -10 (strongly autocratic). See Polity IV documentation for further details (see www.systemicpeace.org/inscr/p4manualv2010.pdf) **Source:** Marshall et al. (2010). [**P**]

Table A: Data Description (IV)

Variables	Full Description
POPDEN	Population density is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship–except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes. **Source:** World Bank. [**S**]
RELIGFRAC	Following the literature fractionalization is computed as: $Frac_j = 1 - \sum_{i=1}^{N} s_{ij}^2$ where s_{ij} is the share of group i in country j. The higher the index the greater the fractionalization. **Source:** Alesina et al. (2003) and Encyclopedia Britannica Book of the Year 2010. [**S**]
RESRENT	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. **Source:** World Bank.
TORT	Torture refers to the purposeful inflicting of extreme pain, whether mental or physical, by government officials or by private individuals at the instigation of government officials. Torture includes the use of physical and other force by police and prison guards that is cruel, inhuman, or degrading. This also includes deaths in custody due to negligence by government officials. A score of 0 indicates that torture was practiced frequently in a given year; 1 indicates that torture was practiced occasionally; and 2 indicates that torture did not occur in a given year. **Source:** CIRI Human Rights Report. [**P**]
URBAN	Population in the largest city (% of urban population). Population in largest city is the percentage of a country's urban population living in that country's largest metropolitan area. **Source:** World Bank. [**S**]
WOPOL	Women's Political Rights. These include: the right to vote; to run for political office; to hold elected and appointed government positions; to join political parties; to petition government officials. A score of 0 indicates that women's political rights were not guaranteed by law during a given year. A score of 1 indicates that women's political rights were guaranteed in law, but severely prohibited in practice. A score of 2 indicates that women's political rights were guaranteed in law, but were still moderately prohibited in practice. Finally, a score of 3 indicates that women's political rights were guaranteed in both law and practice. **Source:** CIRI Human Rights Data Project. [**P**]

Table A: Data Description (V)

Variables	Full Description
WORKER	Workers' Protection. Indicates the extent to which workers enjoy internationally recognized rights at work, including a prohibition on the use of any form of forced or compulsory labor; a minimum age for the employment of children; and acceptable conditions of work with respect to minimum wages, hours of work, and occupational safety and health. A score of 0 indicates that workers' rights were severely restricted; 1 indicates that workers' rights were somewhat restricted; and 2 indicates that workers' rights were fully protected during the year in question. **Source:** CIRI Human Rights Data Project. [**S**]
X^{HI}	Merchandize exports to high-income economies are the sum of Merchandize exports from the reporting economy to high-income economies according to the World Bank classification of economies. Data are expressed as a percentage of total Merchandize exports by the economy. Data are computed only if at least half of the economies in the partner country group had non-missing data. **Source:** World Bank.
Y	GDP in constant 2005$s (chain series). **Source:** Penn World Tables.

B Production and Technical Metrics

Technical Inefficiency, TE, compares the inefficiency under the control of the economy to stochastic factors beyond its control. Given the estimated production function, we can calculate the residuals $\varepsilon_{it} = v_{it} - u_{it}$ for each observation. Technical inefficiency $e^{u_{it}}$ can then be computed using the standard Bayes conditional probability formula (Jondrow et al. (1982)) as the expected value of u_{it} conditional on ε_{it}:

$$TI_{it} = \mathbb{E}\left\{u_{it} \mid \varepsilon_{it}\right\} = \frac{\sigma\lambda}{1+\lambda^2}\left\{\frac{\phi\left(\widetilde{Z}_{it}\right)}{1-\Phi\left(\widetilde{Z}_{it}\right)} - \widetilde{Z}_{it}\right\} \tag{B.1}$$

where (omitting subscripts for convenience) $\lambda = \frac{\sigma_u}{\sigma_v}, \sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$, $\widetilde{Z} = \frac{\mu}{\lambda\sigma} - \frac{\varepsilon\lambda}{\sigma}$, $\mathbb{E}\left(u\right) = \mu = \mathbf{z}'\beta$ and $\phi\left(\cdot\right)$ and $\Phi\left(\cdot\right)$ are the respective density and cumulative density function of the standard Normal. Technical efficiency is then solved as,

$$TE_{it} = e^{-TI_{it}}$$

We also report parameter,

$$\gamma = \frac{\sigma_u^2}{\sigma^2} \in (0,1) \tag{B.2}$$

This indicates the extent to which deviations from the frontier are due to noise, $\gamma \to 0$, or technical inefficiency, $\gamma \to 1$. Differentiating production function (2) with respect to time keeping inefficiency constant, we obtain the rate of **Technical Progress**:

$$TP_{it} = \frac{\partial y}{\partial t} = \alpha_t + \sum_j \alpha_{jt} x_{jit} + \alpha_{tt} t \tag{B.3}$$

This is time-varying and country-specific. The growth of **Total Factor Productivity** is given by,

$$TFP = TP_{it} - \frac{\partial u_{it}}{\partial t} \tag{B.4}$$

where $|\frac{\partial \mu}{\partial t}|$ is the **rate of change of Technical Efficiency**

Regarding the **production and inefficiency elasticities**, these were derived as usual by the coefficient in the log case, and by differentiate the inefficiency equation with respect to the variables of interest in the non-logged (e.g., level, ratio) case.

Finally, we assess the validity of a number of interesting **production restrictions**. First, that production is separable in its inputs. In terms of (2), this Cobb-Douglas restriction amounts to:

$$\alpha_{jm} = \alpha_{jt} = \alpha_{tt} = 0 \tag{B.5}$$

Second, the test of neutral technical progress amounts to,

$$\sum_j \alpha_{jt} = 0 \tag{B.6}$$

Third, given our classification of data into Economic, Political and Sociocultural indicators (and interactions), we can test their incremental block significance in inefficiency as,

$$\beta_{\mathbf{E}} = 0; \beta_{\mathbf{P}} = 0; \beta_{\mathbf{S}} = 0; \beta_{\mathcal{I}} = 0 \tag{B.7}$$

C The Silverman test and Bootstrap

Let Z_i, $i = 1, 2, ...m$ denote a sample Z of size m from a distribution with unknown density f. A non parametric estimate of this density $\tilde{f}(z)$ is as follows,

$$\tilde{f}(z, \bar{h}) = m^{-1}\bar{h}^{-1} \sum_{i=1}^{m} K\left[(1/\bar{h})(z_i - z)\right] \tag{C.1}$$

where K is a kernel normal function while $\bar{h} > 0$ is the bandwidth. A test statistic (Silverman (1981)) can then be written as,

$$\tilde{h}^q_{crit} = \inf\left\{\bar{h} : \tilde{f}(z, \bar{h}) \text{ has at most } q \text{ modes}\right\} \tag{C.2}$$

which is used to test the null hypothesis that is f has q modes against the alternative of greater than q modes. A bootstrap procedure is employed to compute the $\tilde{h}^q_{crit}$ statistic, given by,

$$y_i = [1 + (\tilde{h}^q_{crit})^2/\sigma^2)^{-0.5}(Z_i + (\tilde{h}^q_{crit})^2 e_i)] \tag{C.3}$$

where Z_i is sampled uniformly, with replacement, from the data $z_1, ...z_m$, σ^2 is the sample variance of the data, and e_i is a normal random variable. In this way y_i is randomly drawn from a smooth conditional distribution. The conditional kernel density for a bootstrap sample $Y = \{y_1, ...y_m\}$ is given by,

$$\tilde{f}_*(z, \bar{h}) = m^{-1}(\tilde{h}^q_{crit})^{-1} \sum_{i=1}^{m} K\left[(1/\tilde{h}^q_{crit})(y_i - z)\right] \tag{C.4}$$

Acceptance or rejection of the null hypothesis can be based on the following expression,

$$\tilde{P} = P[\tilde{h}^{q*}_{crit} \geq \tilde{h}^q_{crit}] \tag{C.5}$$

where $\tilde{h}^{q*}_{crit}$ is associated with the conditional kernel density $\tilde{f}_*(z, \bar{h})$ using the bootstrapped sample $Y = [y_1, ...y_m]$. Finally, the Hall and York (2001) method was applied to Silverman's test to obtain the correct critical values.

D Robustness

To check the robustness of our model to alternative functional forms, we also use the Modified Translog and Fourier production functions.

D.1 Modified Translog

The modified translog production function (MT) suggested by Griliches and Ringstad (1971) is given by:

$$\begin{aligned}(y_{it} - l_{it}) = {} & \alpha_{0i} + \alpha_k(k_{it} - l_{it}) + \alpha_l l_{it} + \alpha_h(h_{it} - l_{it}) \\ & + \alpha_{kl} k_{it} l_{it} + \alpha_{kh} k_{it} h_{it} + \alpha_{lh} l_{it} h_{it} \\ & + \alpha_{kk} k_{it}^2 + \alpha_{ll} l_{it}^2 + \alpha_{hh} h_{it}^2 \\ & + \alpha_{kt} k_{it} t + \alpha_{lt} l_{it} t + \alpha_{ht} h_{it} t + \alpha_t t + \alpha_{tt} t^2 + v_{it} - u_{it}\end{aligned} \tag{D.1}$$

D.2 Fourier Production Function

The Fourier production function (F) is a flexible functional form that combines trigonometric and polynomial terms considered to achieve a close approximation to the true frontier, e.g., Mitchell and Onvural (1996), Berger and Mester (1997). In particular the trigonometric terms are mutually orthogonal in the interval $[0, 2\pi]$ so that each additional term can make the approximating function closer to the true DGP. This form is given by,

$$\begin{aligned} y_{it} = {} & \alpha_{0i} + \sum_j \alpha_j z_{jit} + \frac{1}{2}\sum_j \sum_m \alpha_{jm} z_{jit} z_{mjt} + \sum_j \alpha_{jt} z_{jit} t + \alpha_t t + \frac{1}{2}\alpha_{tt} t^2 \\ & + \rho_t Cos(x_t) + \rho_t^* Sin(x_t) + \sum_{j=1}^{J} \sum_{\kappa > j}^{J} \Big[\rho_{j\kappa} Cos(x_{jit} - x_{i\kappa t}) - \rho_{j\kappa}^* Sin(x_{i\kappa y} - x_{i\kappa t})\Big] \\ & + \sum_{j=1}^{J} \sum_{\kappa > j}^{J} \Big[\psi_{j\kappa} Cos(x_{ijt} - x_{i\kappa t} - x_t) - \psi_{j\kappa}^* Sin(x_{i\kappa y} - x_{i\kappa t} - x_t)\Big] + v_{it} - u_{it} \end{aligned} \tag{D.2}$$

The variables x are re-scaled values of the original variables, such that each re-scaled variable is in the interval $[0, 2\pi]$, and where $J = 3$ reflecting the three factors of production (we follow Gallant (1982) in constructing the re-scaled variables).[58]

[58]Let us set $x_i = \bar{\delta} h_a^{'}(\ln \omega_i + \ln \varsigma_i)$, $i = 1, 2, ...N$ where $\omega_i = -\min[\ln \kappa_i] + 1/10^5$, ς is a vector of inputs and trend while $h_a^{'} = [h_{z1}, h_{z2}, ..., h_{zN}]$ is a vector of multi indices. The common scaling factor $\bar{\delta} = \frac{6}{\max\{d_i\}}$, where $d_i = \ln \omega_i + \ln \varsigma_i$ is chosen to restrict $x \in [0, 2\pi]$ in order to reduce approximation problems near endpoints.

E Additional Tables

Table E.1: Model $\mathbb{M}^B$

Production Function		**Inefficiency Equation**	
k	-2.989^{***}	β_0	2.369^{***}
l	-2.867^{***}	h	0.230^{***}
h	-0.937	$resrent$	0.069^{***}
kk	0.270^{***}	GY	0.001
hh	-0.308	$Open$	-0.128^{***}
ll	0.266^{***}	FDI	0.091^{***}
kl	0.113^{***}	$ManuY$	-0.113^{***}
kh	-0.164^{*}	M^{AW}	-0.028^{***}
lh	0.423^{***}	M^{HI}	-0.334^{***}
kt	0.003	X^{HI}	0.046
lt	-0.022^{***}	$dcps$	0.065^{***}
ht	0.008	β_t	-0.050^{***}
t	0.051		
tt	0.004^{***}		
$E_{y,k}$	0.180^{***}		
$E_{y,l}$	0.489^{***}		
$E_{y,h}$	0.509^{***}		
TP	-0.024^{***}		
TP median	-0.023^{***}		
TFP	0.026^{***}	TE	0.787
TFP median	0.028^{***}	TE median	0.821
Diagnostics and Tests			
Cobb Douglas	[0.003]	γ	[0.989]
Neutral Technical Change	[0.007]	σ^2	[0.011]
$\alpha_{0i} = 0\ \forall i$	[0.010]	$\beta_{\mathbf{E}} = 0$	[0.003]
TP unimodality	[0.574]	TE unimodality	[0.435]

Notes: See notes to Table 1. $BIC = -318.657$, Obs $= 316$.

Table E.2: Model $\mathbb{M}_{\mathcal{I}}^{B}$

Production Function		Inefficiency Equation	
k	-2.802^{***}	β_0	3.004^{***}
l	-2.871^{***}	h	-0.542^{***}
h	-1.481	$resrent$	0.171^{***}
kk	0.253^{***}	$resrent \times h$	-0.075^{***}
hh	-0.252	GY	0.038
ll	0.273^{***}	$Open$	-0.387^{***}
kl	0.105^{***}	$Open \times h$	0.228^{***}
kh	-0.127	FDI	0.012^{***}
lh	0.440^{***}	$FDI \times h$	-0.005^{**}
kt	0.002	$ManuY$	-0.109^{***}
lt	-0.019^{***}	$ManuY \times \Delta e$	0.0001
ht	0.006	M^{AW}	-0.033^{***}
t	0.068	M^{HI}	-0.322^{***}
tt	0.004^{***}	X^{HI}	0.055^{*}
		$dcps$	0.075^{***}
E_{yk}	0.196^{***}	β_t	-0.044^{***}
E_{yl}	0.569^{***}		
E_{yh}	0.222^{***}		
TP	-0.008^{***}		
TP median	-0.012^{***}		
TFP	0.036^{***}	TE	0.789
TFP median	0.032^{***}	TE median	0.823
Diagnostics and Tests			
Cobb Douglas	[0.001]	γ	0.990^{***}
Neutral Technical Change	[0.002]	σ^2	0.008^{***}
$\alpha_{0i} = 0 \; \forall i$	[0.008]	$\beta_{\mathbf{E}} = 0$	[0.001]
TP unimodality	[0.614]	TE unimodality	[0.212]

Notes: See notes to Table 1. $BIC = -321.274$, Obs $= 316$.

Table E.3: Model $\mathbb{M}^A$

Production Function		Inefficiency Equation	
k	-0.629	β_0	0.329
l	0.588	h	-0.187^{***}
h	0.518	$resrent$	0.026^{***}
kk	0.093^{**}	GY	0.145^{***}
hh	-0.001	$Open$	-0.089^{***}
ll	-0.010	FDI	0.004^{***}
kl	-0.017	$ManuY$	-0.119^{***}
kh	-0.149^{**}	M^{AW}	-0.047^{***}
lh	0.124	M^{HI}	-0.076
kt	0.013^{***}	X^{HI}	0.012
lt	0.003	$dcps$	0.596^{***}
ht	0.004	β_t	-0.028^{***}
t	-0.197^{***}	$Assn$	-0.009
tt	0.003^{***}	$MedAge$	0.139
		$Worker$	-0.007
E_{yk}	0.081	$ReligFrac$	0.637^{***}
E_{yl}	0.569^{***}	$Durable$	-0.003^{***}
E_{yh}	0.163^{***}	$Military$	0.056^{**}
		$Mobile$	0.001
TP	-0.008^{***}		
TP median	-0.020^{***}		
TFP	0.020^{***}	TE	0.723
TFP median	0.008^{***}	TE median	0.748
Diagnostics and Tests			
Cobb Douglas	[0.115]	γ	0.741^{***}
Neutral Technical Change	[0.001]	σ^2	0.004^{***}
$\alpha_{0i} = 0 \; \forall i$	[0.003]	$\beta_{\mathbf{E}} = 0$	[0.020]
		$\beta_{\mathbf{P}} = 0$	[0.002]
		$\beta_{\mathbf{S}} = 0$	[0.010]
TP unimodality	[0.997]	TE unimodality	[0.222]

Notes: See notes to Table 1. $BIC = -280.266$. Obs = 302.

Table E.4: Model $\mathbb{M}^{A}_{\mathcal{I}}$

Production Function		**Inefficiency Equation**	
k	-0.631	β_0	3.842^{***}
l	-0.286	h	-1.146^{***}
h	-0.836^{***}	$resrent$	0.143^{***}
kk	0.135^{***}	$resrent \times h$	-0.091^{***}
hh	0.338	GY	0.148^{***}
ll	0.158^{**}	$Open$	-0.292^{***}
kl	-0.084^{**}	$Open \times h$	0.165^{***}
kh	-0.188^{**}	FDI	0.011^{***}
lh	0.321^{***}	$FDI \times h$	-0.006^{***}
kt	0.023^{***}	$ManuY$	-0.079^{***}
lt	-0.008^{**}	$ManuY \times \Delta e$	0.0001^{***}
ht	-0.007	M^{AW}	-0.046^{***}
t	-0.214^{***}	M^{HI}	-0.024
tt	0.005^{***}	X^{HI}	0.006
		$dcps$	0.288^{***}
E_{yk}	0.022	β_t	-0.034^{***}
E_{yl}	0.468^{***}	$Assn$	-0.013
E_{yh}	0.216^{***}	$MedAge$	-0.725^{***}
		$MedAge \times h$	0.003^{***}
TP	-0.016^{***}	$Worker$	-0.554^{***}
TP median	-0.013^{***}	$Worker \times MedAge$	0.183^{**}
		$ReligFrac$	0.165^{***}
TFP	0.018^{***}	$Durable$	-0.003^{***}
TFP median	0.021^{***}	$Military$	0.172^{***}
		$Mobile$	0.005
		TE	0.748
		TE median	0.859
Diagnostics and Tests			
Cobb Douglas	[0.001]	γ	0.929^{***}
Neutral Technical Change	[0.001]	σ^2	0.006^{***}
$\alpha_{0i} = 0 \; \forall i$	[0.007]	$\beta_{\mathbf{E}} = 0$	[0.002]
		$\beta_{\mathbf{P}} = 0$	[0.002]
		$\beta_{\mathbf{S}} = 0$	[0.001]
TP unimodality	[0.860]	TE unimodality	[0.005]

Notes: See notes to Table 1. $BIC = -300.831$. Obs = 302.

Table E.5: Stochastic Frontier using Modified Translog Production Function

Production Function		**Inefficiency Equation**	
k	-0.631	β_0	3.842^{***}
l	-0.286	h	-1.146^{***}
h	-0.836^{***}	$resrent$	0.143^{***}
kk	0.135^{***}	$resrent \times h$	-0.091^{***}
hh	0.338	GY	0.148^{***}
ll	0.158^{**}	$open$	-0.292^{***}
kl	-0.084^{**}	$open \times h$	0.165^{***}
kh	-0.188^{**}	FDI	0.011^{***}
lh	0.321^{***}	$FDI \times h$	-0.006^{***}
kt	0.023^{***}	$ManuY$	-0.079^{***}
lt	-0.008^{**}	$ManuY \times \Delta e$	0.0001^{***}
ht	-0.007	M^{AW}	-0.046^{***}
t	-0.214^{***}	M^{HI}	-0.024
tt	0.005^{***}	X^{HI}	0.006
		$dcps$	0.288^{***}
$E_{y,k}$	0.022	β_t	-0.034^{***}
$E_{y,l}$	0.468^{***}	$Assn$	-0.013
$E_{y,h}$	0.216^{***}	$MedAge$	-0.725^{***}
		$MedAge \times h$	0.003^{***}
TP	-0.016^{***}	$Worp$	-0.554^{***}
TP median	-0.013^{***}	$Worp \times MedAge$	0.183^{**}
		$ReligFrac$	0.165^{***}
TFP	0.018^{***}	$Durable$	-0.003^{***}
TFP median	0.021^{***}	$Military$	0.172^{***}
		$Mobile$	0.005
		TE	0.748
		TE median	0.859
Diagnostics and Tests			
Cobb Douglas	[0.001]	γ	0.929^{***}
Neutral Technical Change	[0.001]	σ^2	0.006^{***}
$\alpha_{0i} = 0 \; \forall i$	[0.007]	$\beta_{\mathbf{E}} = 0$	[0.002]
		$\beta_{\mathbf{P}} = 0$	[0.002]
		$\beta_{\mathbf{S}} = 0$	[0.001]
TP Uni-modality	[0.069]	TE Uni-modality	[0.005]

Notes: See notes to Table 1. $BIC = -241.202$. Obs = 302.

Table E.6: Stochastic Frontier Analysis using Fourier Production Function

Production Function		**Inefficiency Equation**	
k	-1.067^{***}	β_0	-1.774^{**}
l	-1.712^{***}	h	0.773
h	-0.323	$resrent$	0.020
kk	0.159^{***}	$resrent \times h$	-0.022
ll	0.285^{***}	GY	0.229^{***}
hh	0.281	$open$	-0.050^{***}
kl	-0.028	$open \times h$	-0.002
kh	-0.027^{***}	FDI	0.012^{***}
lh	0.402^{***}	$FDI \times h$	-0.003
kt	0.018^{***}	$ManuY$	-0.153^{**}
lt	-0.017^{***}	$ManuY \times \Delta e$	0.0001^{*}
ht	-0.003	M^{AW}	-0.042^{***}
t	-0.121^{***}	M^{HI}	-0.063
tt	0.004^{***}	X^{HI}	0.017
		$dcps$	0.448^{***}
ρ_T	0.013	β_t	-0.043^{***}
ρ_T^*	-0.061^{***}	$Assn$	0.034
ρ_{kl}	-0.030	$MedAge$	0.771^{***}
ρ_{kh}	-0.042	$MedAge \times h$	-0.007^{***}
ρ_{lh}	-0.075^{***}	$Worker$	-0.446^{***}
ρ_{kl}^*	-0.093^{***}	$Worker \times MedAge$	0.143^{*}
ρ_{kh}^*	0.037	$ReligFrac$	1.803^{***}
ρ_{lh}^*	-0.100^{**}	$Durable$	-0.0004
		$Military$	0.079^{***}
$E_{y,k}$	0.052^{***}	$Mobile$	0.0003
$E_{y,l}$	0.524^{***}		
$E_{y,h}$	0.608^{***}		
TP	-0.030^{***}		
TP median	-0.028^{***}		
TFP	0.014^{***}	TE	0.777
TFP median	0.016^{***}	TE median	0.938
Diagnostics and Tests			
Cobb Douglas	[0.001]	γ	0.885^{***}
Neutral Technical Change	[0.023]	σ^2	0.006^{***}
$\alpha_{0i} = 0 \;\forall i$	[0.001]	$\beta_{\mathbf{E}} = 0$	[0.001]
		$\beta_{\mathbf{P}} = 0$	[0.012]
		$\beta_{\mathbf{S}} = 0$	[0.001]
TP unimodality	[0.354]	TE unimodality	[0.152]

Notes: See notes to Table 1. $BIC = -294.124$. Obs = 302.

Table E.7: Stochastic Frontier Analysis using principal components

Production Function		Inefficiency Equation	
k	0.191	β_0	0.765***
l	0.766*	$\mathbf{P}_1$	−0.029**
h	0.087	$\mathbf{P}_2$	0.041***
kk	0.034*	$\mathbf{P}_3$	0.034**
hh	−0.285	$\mathbf{P}_4$	0.006
ll	0.005	$\mathbf{S}_1$	0.161***
kl	−0.060*	$\mathbf{S}_2$	0.105***
kh	−0.061	$\mathbf{S}_3$	0.056
lh	0.09	$\mathbf{S}_4$	0.046
kt	0.007***	$\mathbf{E}_1$	−0.018
lt	0.0008	$\mathbf{E}_2$	0.082***
ht	0.015*	$\mathbf{E}_3$	−0.004
t	−0.131***	$\mathbf{E}_4$	0.052***
tt	0.003***	$\mathbf{E}_5$	0.015***
		β_t	−0.030***
$E_{y,k}$	0.053	$FDI \times h$	−0.003*
$E_{y,l}$	0.412***	$open \times h$	−0.012**
$E_{y,h}$	0.090***	$ManuY \times \Delta e$	0.002***
		$Worker \times MedAge$	0.007
TP	−0.0003***	$resrent \times h$	−0.025**
TP median	0.002***		
TFP	0.030***	TE	0.798
TFP median	−0.039***	TE median	0.848
Diagnostics and Tests			
Cobb Douglas	[0.007]	γ	0.992***
Neutral Technical Change	[0.042]	σ^2	0.007***
$\alpha_{0i} = 0 \; \forall i$	[0.001]		
TP Uni-modality	[0.909]	TE Uni-modality	[0.271]

Notes: See notes to Table 1. $BIC = -330.240$. Obs = 316.

Table E.8: Spearman Rank Correlation Between TE and TP w.r.t $\mathbb{M}_{\mathcal{I}}^{A}$

	TE	TP
$\mathbb{M}_{\mathcal{I}}^{B}$	0.68	0.77
$\mathbb{M}_{\mathcal{I}}^{A}$	1	1
$\mathbb{M}_{\mathcal{I}}^{PC}$	0.79	0.85
$\mathbb{M}_{\mathcal{I}}^{MT}$	0.70	0.78
$\mathbb{M}_{\mathcal{I}}^{F}$	0.88	0.98

Table E.9: Robustness in Sign

	$\mathbb{M}^B$	$\mathbb{M}^B_{\mathcal{I}}$	$\mathbb{M}^A$	$\mathbb{M}^A_{\mathcal{I}}$	$\mathbb{M}^{PC}_{\mathcal{I}}$	$\mathbb{M}^{MT}_{\mathcal{I}}$	$\mathbb{M}^F_{\mathcal{I}}$
E							
$\langle H \rangle$	+	−	−	−	−	−	−
$\langle Resrent \rangle$	+	+	+	+	(−)	+	+
GY	(+)	(+)	+	+	(−)	+	+
$\langle Open \rangle$	−	−	−	−	(+)	−	−
$\langle FDI \rangle$	+	+	+	+	(−)	+	+
$\langle\langle ManuY \rangle\rangle$	−	−	−	−	−	−	−
$\langle M^{AW} \rangle$	−	−	−	−	+	−	−
M^{HI}	−	−	(−)	(−)	(−)	+	−
X^{HI}	(+)	+	(+)	(+)	−	+	+
Δe					+		
$Dcbs$					(−)		
$\langle Dcps \rangle$	+	+	+	+	−	+	+
$\langle\langle \beta_t \rangle\rangle$	−	−	−	−	−	−	−
P							
$Assn$			(−)	(−)	+	−	+
$\langle Durable \rangle$			−	−	−	+	−
$\langle\langle Military \rangle\rangle$			+	+	+	+	+
$Wopol$					(+)		
$Disap$					(−)		
$Tort$					(−)		
$Formov$					−		
$Dommov$					(+)		
$Injud$					−		
S							
$Agde_o$					+		
$Agde_y$					+		
$MedAge$			(−)	−	+	−	+
$Mobile$			(+)	(+)	−	(+)	(+)
$Urban$					−		
$\langle\langle ReligFrac \rangle\rangle$			+	+	+	+	+
$\langle Worker \rangle$			(−)	−	−	−	−
$\mathcal{I}$							
$\langle\langle Resrent \times H \rangle\rangle$		−		−	−	−	−
$Open \times H$		+		+	−	+	−
$\langle\langle FDI \times H \rangle\rangle$		−		−	−	−	−
$\langle Worker \times MedAge \rangle$				+	(+)	+	+
$\langle ManuY \times \Delta e \rangle$		(+)		+	+	+	+
$MedAge \times H$				+		−	−

Notes: *Baseline*: $\mathbb{M}^B$; *Baseline with interactions*: $\mathbb{M}^B_{\mathcal{I}}$; *Augmented*: $\mathbb{M}_A$; *Augmented with Interactions*: $\mathbb{M}^A_{\mathcal{I}}$. All of these results taken from (Table 1). *principal components*: $\mathbb{M}^{PC}_{\mathcal{I}}$ (Tables 6 and E.7); *Modified Translog*: $\mathbb{M}^{MT}_{\mathcal{I}}$ (Table E.5); *Fourier*: $\mathbb{M}^F_{\mathcal{I}}$ (Table D.2). Variables within "$\langle\langle\rangle\rangle$" and "$\langle\rangle$" denotes "strong" and "weak" sign robustness, respectively. A blank entry means not applicable. Variable signs within "()" indicate that the signed coefficient is not significance at 10%.