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EFFICIENCY, INEFFICIENCY, AND THE MENA FRONTIER

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We examine technical efficiency in the Middle East and North Africa (MENA). In addition to economic indicators, political and social ones play a role in development and efficiency profiles. The MENA have been characterized by increasing economic efficiency over time but with marked polarization. We analyze and nest many key hypotheses, 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. It should set a comprehensive benchmark and cross-check for related studies of development and technical efficiency.

Keywords: Frontier Efficiency, MENA

1. INTRODUCTION

This paper examines economic efficiency in the MENA region.[1] Analytical studies on the Arab developmental model have, moreover, been surprisingly few (compare the treatment of China and India). Yet the region amounts to over 400 million in population, and is of clear strategic geopolitical importance.

A key problem, though, is that the MENA region represents quite 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 toward "rentier" and "extractive" states [Acemoglu and Robinson (2012), Schwarz (2013)]. 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,

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institutional, and cultural factors, as well as economic ones, to capture technical frontier characteristics.

The contributions of our paper are fivefold. First, we bring together a large database; this combines and merges data from a number of sources suited to our purpose. Second, and related to the first, this greatly widens the set of admissible indicators used to explain inefficiency. Specifically, we use standard indicators (like human capital, openness, financial depth) in modeling inefficiency, but also less standard ones (e.g., political durability, judicial independence, workers' rights, religious fractionalization, etc.). This is noteworthy because it mixes continuous and categorical data types. Efficiency analysis rarely strays beyond the former.[2] But for the MENA, to do so would miss a wealth of key information.

Third, rather than simply report mean technical efficiency and TFP, we exploit their distributional characteristics—to assess the extent to which there has been convergence, divergence, or polarization between countries. Fourth, we extend our analysis by using principal components with the components representing political, economic, and sociocultural indicators and their interactions. From this, we can unravel the individual efficiency contributions. Finally, we also pursue a very degree high of robustness in our results: in terms of alternate functional forms and indicator selection. We can then define the qualitative sign of indicators as reflecting "strong" or "weak" robustness depending on their regularity.

The paper should set a comprehensive benchmark and cross-check for related studies of development and technical efficiency. It is organized as follows. First, we provide background on the Arab developmental model. This shows the early growth and developmental gains made 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 modeling strategy. Within a stochastic-frontier setting, we use a translog production function where production deviates from its optimum by a random disturbance and a modeled "inefficiency term." A country is technically efficient if it produces the maximum feasible output from a given combination of inputs and technology. Inefficiency, as said, is modeled using a variety of economic, political, and sociocultural indicators. We estimated jointly the production function and the inefficiency equation following the maximum likelihood approach suggested by Battese and Coelli (1995).

Section 4 describes the data. Sections 5 and 6 are the empirical sections. Our main findings are as follows:

- In addition to familiar economic indicators, 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, its growth has reflected more gains in efficiency than technical progress.
- Regarding technical progress (TP), MENA countries are *not* characterized by well-separated clusters of technologically backward and advanced countries; the TP distribution is unimodel and essentially Normally distributed.

- Performance on technical efficiency, however, 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, while 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.
- We 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 weaken efficiency and retard attaining the technical frontier.

2. THE MENA: SOME BACKGROUND

Consider the 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 to 2015 from around 25%–50% and around 8%–30%, respectively.[3] The former comparison is striking: Developing Asia's initial share roughly matched that of the MENA block, plus they shared similarly weak democratic origins. However, the MENA have stayed at around a 5% share.

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

Indeed, several decades before the Arab-Spring turbulence, matters looked quite different. Following independence, many Arab states, buoyed by energy 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 [Amin et al. (2012)].

Likewise, there was substantial (if uneven) progress on human development[4]—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 [World Bank (2004)].

But the maxim that growth is easier to start than sustain [Rodrik (2005)] matched the MENA experience well. Unsurprisingly so, given the obstacles: restrictive

TABLE 1. Growth rates: MENA and OECD averages

	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
Median	2.68	2.22	6.02	2.95	1.46	1.98
Standard deviation	3.70	1.76	4.35	1.99	2.44	1.61

Sources: IMF, OECD, and World Bank.

trade regimes, corruption, underdiversified economy, fragmented capital markets, limited firm turnover, chronic slack, large low-skill informal market, sporadic regional conflict, etc. [World Bank (2009), Gourdon (2010), Malik and Awadallah (2013), Faria and McAdam (2015)].

Indeed, the commodity-price falls from the mid-1980s onward—by exposing the region's overreliance on hydrocarbons—contributed to reversing the earlier growth gains, cut demand and the (shock-absorbing) flow of remittances,[5] and 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.

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/financial liberalization, etc.). Even controlling for the scale of the downturn, success appeared limited. This was arguably because (i) the "private sector" was ill-equipped to raise supply consistent with the reforms, and (ii) these reforms mostly neglected governance issues[6]; vested interests and political structures remained. The relative growth rates are shown in Table 1.

3. EMPIRICAL MODELING STRATEGY

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.

The economics literature has used three different approaches to empirically estimate (in)efficiency. The first is based on a deterministic approach such as the Data Envelopment Analysis (DEA), the second is a parametric stochastic approach, whereas the third is a Bayesian approach (also assigned to the class of nonparametric models).

The DEA approach, suggested by Farrell (1957) and Charnes et al. (1978), employs linear programming techniques, assuming no random errors, used to measure technical efficiency, e.g., Growiec (2012). These models are the less restrictive method in the sense that they avoid the adoption of a specific functional form to describe the production process.

In the class of parametric models, an error is introduced in the empirical model reflecting the stochastic structure of the frontier (Stochastic Frontier Model, SFM). See the seminal papers of Aigner et al. (1977) and Meeusen and van den Broeck (1977). The inclusion of the stochastic error (which may allow for measurement errors, omitted variables, and functional form errors) is the main difference between the parametric and deterministic models.

In addition the stochastic frontier model unlike the DEA approach allows one to model, in an easy and consistent way, heterogeneity variables in a single stage [see Wang (2002)]. However, most economic data contain "noise," and thus, including an error term is advisable. In this regard, the DEA approach is sensitive to sample outliers since it ignores measurement errors.

Finally, van den Broeck et al. (1994) studied the SFM from a Bayesian point of view constituting a third approach. The main advantage of this approach relative to the SFM is that is permits the formal specification of parameter uncertainty. Although Kim and Schmidt (2000) find that both approaches (Bayesian and Classical) give results that are similar in terms of efficiency measurement; recently, Ortega and Gavilan (2014) using Monte Carlo techniques conclude in favor of the Bayesian estimator in terms of finite sample performance. However, in the case of nonlinear frontier models (this approach calls for the application of numerical integration methods) complicated posterior simulations are required. In this paper, we adopt a stochastic frontier model to estimate potential output and efficiency characteristics.

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.

Consider the production function

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

where Y denotes output, K, L, and$H$ represent physical capital, labor, and human capital, respectively, and $i = 1, 2, \ldots N$ and $t = 1, 2, \ldots T$, 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 [Klump et al. (2007)], we consider $f(\cdot)$ to be described by the more general Translog:

$$y_{it} = \alpha_{0i} + \sum_{j=1}^{J} \alpha_j x_{jit} + \frac{1}{2} \sum_{j=1}^{J} \sum_{m=1}^{J} \alpha_{jm} x_{jit} x_{mit} + \sum_{j=1}^{J} \alpha_{jt} x_{jit} t + \alpha_t t + \frac{1}{2} \alpha_{tt} t^2 + (v_{it} - u_{it}), \tag{2}$$

where $y = \mathrm{Log}(Y)$, $x = \mathrm{Log}(X)$, $X \in [K, L, H]$, $J = 3$ (reflecting the three production factors). Variable t is a time trend that proxies disembodied technical progress [León-Ledesma et al. (2010)]. Parameters α_{0i} are country-specific fixed effects specified in order to distinguish unobserved heterogeneity from the inefficiency component. The presence of fixed effects provides us with a mechanism able to separate individual time invariant unobserved heterogeneity from inefficiency. According to Greene (2005), ignoring the presence of country-specific heterogeneity terms would lead to misguided conclusions about the measurement of Technical Efficiency index as any unobservable would end up in the inefficiency measure [see also Chen et al. (2014)].

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" premultiplies all factors). In Appendices D and E, though, we consider alternative production forms: *modified Translog* and the *Fourier* forms.[7]

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 associated with technical inefficiency truncated at zero $u_{it} \sim \mathcal{N}^+(\mu_{it}, \sigma_u^2)$, where μ_{it}, the mean level of inefficiency, is given by

$$\mu_{it} = \mathbf{z}'_{it}\beta, \qquad \mathbf{(3)}$$

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

The Translog production function (2) and inefficiency equation (3) were jointly estimated by maximum likelihood assuming the parameters are nonrandom constants, following Battese and Coelli (1995).[8] We employ an unbalanced sample, with the maximum dimensions being 1980–2008 (see Table 2).

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 Sociocultural (**S**) type variables (to be defined below). This results in the following inefficiency equation:

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

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 sociocultural indicators play no role in explaining inefficiency. Finally, the rate of change of technical efficiency is given by β_t.

We include human capital in the inefficiency equation since it is likely that the adoption of best-practice technologies requires skills [see Christopoulos and León-Ledesma (2014)]. From an econometric point of view, Huang and Liu (1994) and Battese and Coelli (1995) claim that the explanatory variables in the inefficiency equation may include all or some of the input variables in the production frontier, provided that the inefficiency effects are stochastic. This is feasible as their approach consists of making only the mean of the pretruncated distribution of the inefficiency term depend on a set of exogenous variables (z). Battese and Coelli (1995) extended also this approach to a panel data setting.

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, among other *interactions*, in block $\mathcal{I}$).

The emphasis on human capital is natural.[9] 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, arguably, compensate citizens for political exclusion.

4. DATA

4.1. General Description

We use data from a variety of sources: Center for Systemic Peace, CIRI Human Rights Data Project, Database of Political Institutions, Penn World Tables, Polity IV database as well as the United Nations, the World Bank, the CIA (World Factbook), and the IMF. Some are continuous numerical series [e.g., GDP, employee number, foreign direct investment (FDI)], some are categorical (e.g., polity type, workers' strength, or women's rights), etc.[10]

We searched for the furthest backdated and most country-wide complete data for the indicators of interest. The tables in Appendix A show the full series, their definitions, and sources.[11] The data are annual and cover 14 MENA countries: Bahrain, Egypt, Jordan, Mauritania, Morocco, Saudi Arabia, Sudan, Syria, Tunisia (all 1980–2008); Kuwait, Libya, Qatar, United Arab Emirates (UAE) (all 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 2), for instance, we use economic indicators alone to model inefficiency. This provides a benchmark since it is most closely aligned with usual practice. 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/nonmilitary), 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

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hurt efficiency. Public expenditure may contribute positively (e.g., through education, infrastructure, nutritional 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, *sociocultural* indicators include fractionalization in religious grouping, as well as age distribution, and demographic pressures, etc. Again, these may impact efficiency positively or negatively.

Naturally, these categorizations are not water-tight. But they constitute an intuitive starting point and 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 multicollinearity issues. Accordingly, after the "core" SFA exercises, we report results where we extract *principal components* of the **E**, **P**, and **S** blocks. This relaxes the dimensionality constraint, while still preserving our narrative framework. Within the principal components, we can also retrieve the underlying efficiency coefficients associated to each indicator, 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 1 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), 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 below into production data, Economic indicators, Political indicators, and Social indicators.

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

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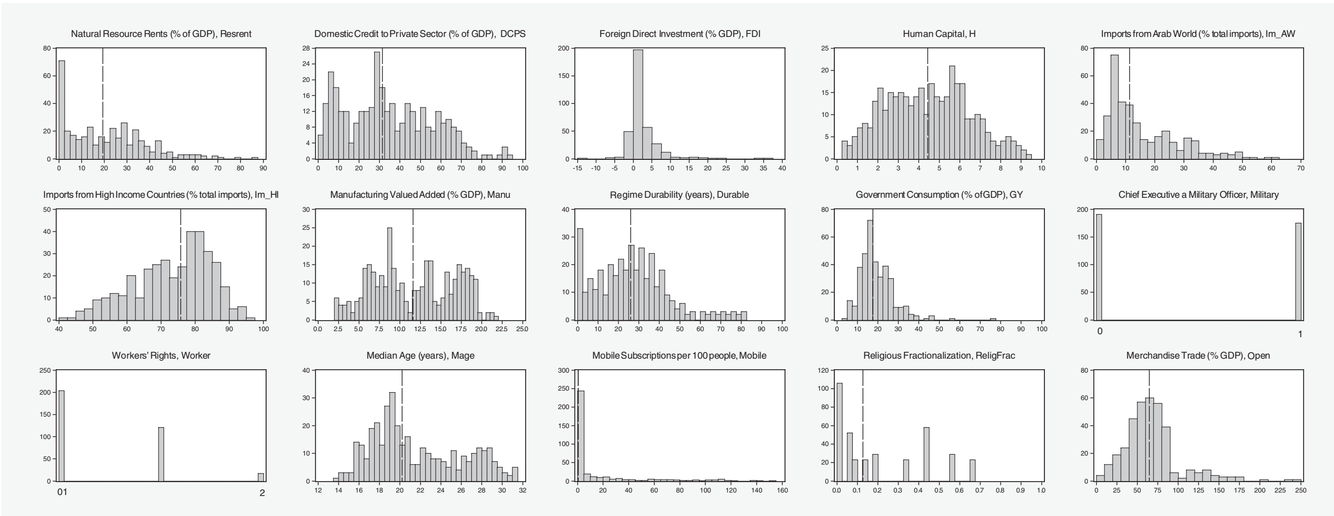

FIGURE 1. Histogram of selected indicators. Dashed vertical lines indicate medians (for the continuous variables). These histograms pool all countries and all years.

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.[12]

Regarding factors of production, the capital stock series was constructed using the perpetual inventory method from the investment series. Initial capital stocks were constructed for 1960: We used the investment share of real per-capita GDP and population data available in the Penn tables and assumed a 0.095 depreciation rate. Labor is the number of employees. The stock of human capital represents the educational attainment of individuals 25 years or older measured as average years of schooling.

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 United Kingdom, Germany, and the United States 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 and catch up with the technological frontier. The extent to which human capital does so depends on the following:

(a) its quality and appropriateness;
(b) any externalities and complementarities induced by skills.

Regarding (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. (2003)] but higher following a university education [Salehi-Isfahani et al. (2009)].

But education is also often thought to play a signaling 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 toward 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, 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 [Benhabib and Spiegel (2005)].

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 preexistence of skilled labor [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 nontradeables (telecommunications, tourism, construction).[13] FDI in Manufacturing, in particular, tends to be low (at best around 10% of all FDI)[14] and FDI in high-tech services in the MENA region is essentially zero [World Bank (2009), Gourdon (2010)].

On merchandize trade, judged on tariff and nontariff barriers (as well as infrastructure bottlenecks), MENA trade regimes are among the most globally protected and fragmented [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 overvaluation 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 [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 bimodal 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 [Gylfason (2001)].[15] Resource-rich economies may lose sight of the need for efficient use of resources, may underaccumulate 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) show that advanced and technically efficient economies are more 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). Two factors potentially retarding the development of manufacturing are (1) its generally very small size in the MENA, and (2) exchange rate volatility typical of petrocurrencies (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.[16]

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 governments emphasize internal stability and the containing of ethnic rivalries, etc., they may promote a more stable business climate than would otherwise prevail.

Workers' Rights indicate 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 0/1/2 indicates that workers' rights were severely restricted/somewhat restricted/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"[17] 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.

Efficiency indicators: Sociocultural. 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 [Amin et al. (2012, Chap. 3)]. Job creation, although high by international standards in recent decades, was surpassed by labor force growth.[18] 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 $\text{Frac}_j = 1 - \sum_{i=1}^{N} s_{ij}^2$, 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 intragroup 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.[19]

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.[20] The distribution of religious fractionalization appears bimodel with a median around 0.13 which suggests relatively small religious fractionalization against some countries which have somewhat larger fractionalization.

5. ESTIMATION RESULTS

Consistent with our motivation, we first estimate a (Base)line model of production and inefficiency equations which emphasizes economic indicators, without and with interactions, respectively, models $\mathbf{M}^{\text{Base}}$ and $\text{M}_{\mathcal{I}}^{\text{Base}}$. Moreover, although we found the correlations between regressors and the residual typically small (maximum ≈0.33 in absolute value), we nonetheless reran the latter case using lagged values as instruments ($\mathbf{M}_{\mathcal{I}}^{\text{Base.Inst}}$); as can be seen, the results are qualitatively very similar. Thereafter, we (Aug)ment that baseline model with the addition of political and sociocultural indicators, again without and with interactions: $\mathbf{M}^{\text{Aug}}$ and $\mathbf{M}_{\mathcal{I}}^{\text{Aug}}$.

Most of the Translog parameters have no direct interpretation. Accordingly, we derive the following more informative statistics (see Appendix B)[21]:

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)–(3) are time and country specific (we evaluate them at the mean and median).[22] The second section of Table 2 shows the inefficiency parameter estimates, followed by the Technical Efficiency Index.

TABLE 2. Technology frontiers: Estimates

	$\mathbf{M}^{\text{Base}}$	$\mathbf{M}_{\mathcal{I}}^{\text{Base}}$	$\mathbf{M}_{\mathcal{I}}^{\text{Base.Inst}}$	$\mathbf{M}^{\text{Aug}}$	$\mathbf{M}_{\mathcal{I}}^{\text{Aug}}$
Production equation					
$E_{y,k}$	0.180***	0.196***	0.213**	0.081	0.022
$E_{y,l}$	0.489***	0.569***	0.381**	0.568***	0.468***
$E_{y,h}$	0.509***	0.222***	0.375**	0.164***	0.216***
TP	−0.024***	−0.008***	−0.010**	−0.008***	−0.016***
TP median	−0.023***	−0.012***	−0.011**	−0.020***	−0.013***
TFP	0.026***	0.036***	0.026**	0.020***	0.018***
TFP median	0.028***	0.032***	0.025**	0.008***	0.012***
Inefficiency equation					
β_0	2.369***	3.004***	1.013***	0.329	3.842***
h	0.230***	−0.542***	−0.015***	−0.187***	−1.146***
Resrent	0.069***	0.171***	0.158***	0.026***	0.143***
GY	0.001	0.038	0.135***	0.145***	0.148***
Open	−0.128***	−0.387***	−0.319***	−0.089***	−0.292***
FDI	0.091***	0.012***	0.004*	0.004***	0.011***
ManuY	−0.113***	−0.109***	−0.068***	−0.119***	−0.079***
M^{AW}	−0.028***	−0.033***	−0.019**	−0.047***	−0.046***
M^{HI}	−0.334***	−0.322***	−0.062*	−0.076	−0.024
X^{HI}	0.046	0.055*	0.016	0.012	0.006
dcps	0.065***	0.075***	0.266***	0.596***	0.288***
β_t	−0.050***	−0.044***	−0.037***	−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 ×*h*		−0.075***	−0.081***		−0.091***
Open ×*h*		0.228***	0.164***		0.165***
FDI ×*h*		−0.005**	−0.002		−0.006***
ManuY ×Δ*e*		0.0001	0.001		0.0001***
MedAge ×*h*				0.003***	
Worker ×*MedAge*				0.183**	
TE	0.787	0.789	0.735	0.723	0.748
TE median	0.821	0.823	0.744	0.748	0.859

Notes: Baseline: $\mathbf{M}^{\text{B}}$; Baseline with interactions: $\mathbf{M}_{\mathcal{I}}^{\text{Base}}$; Baseline with interactions and lagged values as instruments: $\mathbf{M}_{\mathcal{I}}^{\text{Base.Inst}}$; Augmented: $\mathbf{M}^{\text{Aug}}$; Augmented with interactions: $\mathbf{M}_{\mathcal{I}}^{\text{Aug}}$. ***, **, and *, respectively, indicate the 1%, 5%, and 10% levels of significance. Numbers in squared brackets denote probability values. $E_{y,j}$ is the elasticity of output with respect to factor input j. *TP* is the technical progress growth rate. *TFP* is the total factor productivity growth rate. *TE* is technical efficiency. Values are means unless otherwise stated. Fixed effect estimates, α_{0i} are suppressed for brevity.

TABLE 3. Tests and diagnostics

	$\mathbf{M}^{\text{Base}}$	$\mathbf{M}_{\mathcal{I}}^{\text{Base}}$	$\mathbf{M}_{\mathcal{I}}^{\text{Base.Inst}}$	$\mathbf{M}^{\text{Aug}}$	$\mathbf{M}_{\mathcal{I}}^{\text{Aug}}$
Production					
Cobb–Douglas	(0.003)	(0.001)	(0.001)	(0.015)	(0.001)
Neutral technical change	(0.007)	(0.002)	(0.002)	(0.001)	(0.001)
$\alpha_{0i} = 0\ \forall i$	(0.010)	(0.008)	(0.005)	(0.003)	(0.007)
TP unimodal	(0.574)	(0.614)	(0.524)	(0.997)	(0.860)
Inefficiency					
γ	0.989***	0.990***	0.998***	0.741***	0.929***
σ^2	0.011***	0.008***	0.004***	0.005***	0.006***
$\beta_{\mathbf{E}} = 0$	(0.003)	(0.001)	(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)	(0.200)	(0.222)	(0.005)
BIC	−318.657	−321.277	−254.990	−280.266	−300.831
Obs.	316	316	308	302	302

Table 3 examines various production restrictions and diagnostics:

1. production being separable in its inputs;
2. technical progress being neutral;
3. validity of country fixed effects;
4. incremental significance of the **E**, **P**, **S**, and $\mathcal{I}$ blocks;
5. significance of 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. the Silverman bootstrapped p-value for the null of unimodality in the TE and TP series (see Tables 2, 3, and 7)[23];
7. Bayesian Information Criteria (BIC) and observation number.

There are many complementarities between the various model results, indicative of the underlying robustness. Almost all parameters are significant, qualitatively robust,[24] 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, pairwise within those two groups and using the BIC statistic, model $\mathbf{M}_{\mathcal{I}}^{\text{Base}}$ outperforms $\mathbf{M}^{\text{Base}}$, and $\mathbf{M}_{\mathcal{I}}^{\text{Aug}}$ outperforms $\mathbf{M}^{\text{Aug}}$. Thus, the addition of the interaction variables is supported by the data. $\mathbf{M}_{\mathcal{I}}^{\text{Aug}}$ is attractive from our standpoint since it is both congruent with the data (all blocks are significant) and is the most general. Accordingly, it is our preferred case.[25] 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).

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5.1. Production

The labor elasticity is estimated at around 0.47–0.57. The (physical) capital elasticity is estimated rather less precisely: 0.02–0.20. These factor elasticity figures, though, are close to Saliola and Seker (2011) who report labor and capital elasticities for 51 counties (including six MENA members) of 0.4 and 0.1, respectively; for some countries such as Egypt they report capital elasticities of an even lower value.[26] The capital elasticities by country are shown in Table E.10. 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 diagnostics (Table 3), 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) report similar values using country-level data sets. Moreover, block exclusion of the E, P, S, and Interaction indicators is statistically inadmissible, thus justifying their inclusion.[27]

Total factor productivity (TFP) and technical progress (TP). The MENA average annual TFP growth is around 2%–3%. However, there is an interesting compositional story behind the TFP growth numbers. Technical progress TP has diminished TFP growth (by -1% to -2%) while the rate of efficiency change $-\beta_t$ is positive, significant, and greater in absolute size than the TP value.

Table 4, which shows the results by country, give a more nuanced picture. Some countries, for instance, obtain positive TP rates: Libya, Jordan, Qatar, UAE, Kuwait.

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 (a theme we will take up in Section 5.5).

The negative values for the TP are not necessarily a surprising finding. For example, Kumbhakar and Wang (2005) employing SFA with three factors and a much larger sample of countries ($N = 82$) over 1960–1987, found that technical progress take values between -0.03 and -0.04, whereas the TFP growth rate takes values between -0.014 and -0.016 respectively. Moreover, Pires and Garcia (2012) estimated a world stochastic frontier model using a sample of 75 countries over the period 1950–2000 and employing two factor inputs found that some MENA countries showed negative values for the TP namely Syria -0.030, Egypt -0.036, Morocco -0.030, and Jordan -0.043, respectively. These figures turn out to be very close to our estimates.[28]

However, one issue still pertains to the negative TP values. In particular, is the estimated production function well specified including all the relevant factors of production? Since MENA's revenues coming from natural resources such as

TABLE 4. Technical efficiency and technical progress, by country

Country	TE	TP
Bahrain	0.928	−0.010
Libya	0.922	0.010
Saudi Arabia	0.918	−0.020
Morocco	0.906	−0.030
Jordan	0.860	0.030
Yemen	0.828	−0.110
Tunisia	0.823	−0.010
Syria	0.806	−0.050
Egypt	0.803	−0.050
Qatar	0.802	0.040
Mauritania	0.744	−0.030
Sudan	0.716	−0.060
UAE	0.678	0.040
Kuwait	0.448	0.020
Average	0.789	−0.017

oil enter the GDP, one could naturally wonder that the production function is misspecified. To eliminate this problem, we estimate our benchmarking model excluding resource revenues from GDP.[29] The new estimates remain negative. The TP is equal to −0.003 higher than the previous one (−0.017), whereas the TFP growth rate is positive and equals 0.030. Results are available upon request.

Technical progress over time. Figure 2 draws an estimated Epanechnikov kernel density for TP in five-year windows (based on our preferred model preferred model $\mathbf{M}_{\mathcal{I}}^{\text{Aug}}$). Also shown (in Table 5) are the higher moments of the TP distribution, and the probability-values from the Jarque-Bera (JB) Normality test (results are robust to different Normality tests). We also, to repeat, employ the Silverman test to test the null of unimodality in the distribution of TP. The test results are depicted as bootstrapped probability values. The null hypothesis of unimodality cannot be rejected by the bootstrapped Silverman test. This indicates that the TP distribution has not transformed over time from a single-peaked to a twin-peaked distribution in Arab countries.[30]

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.

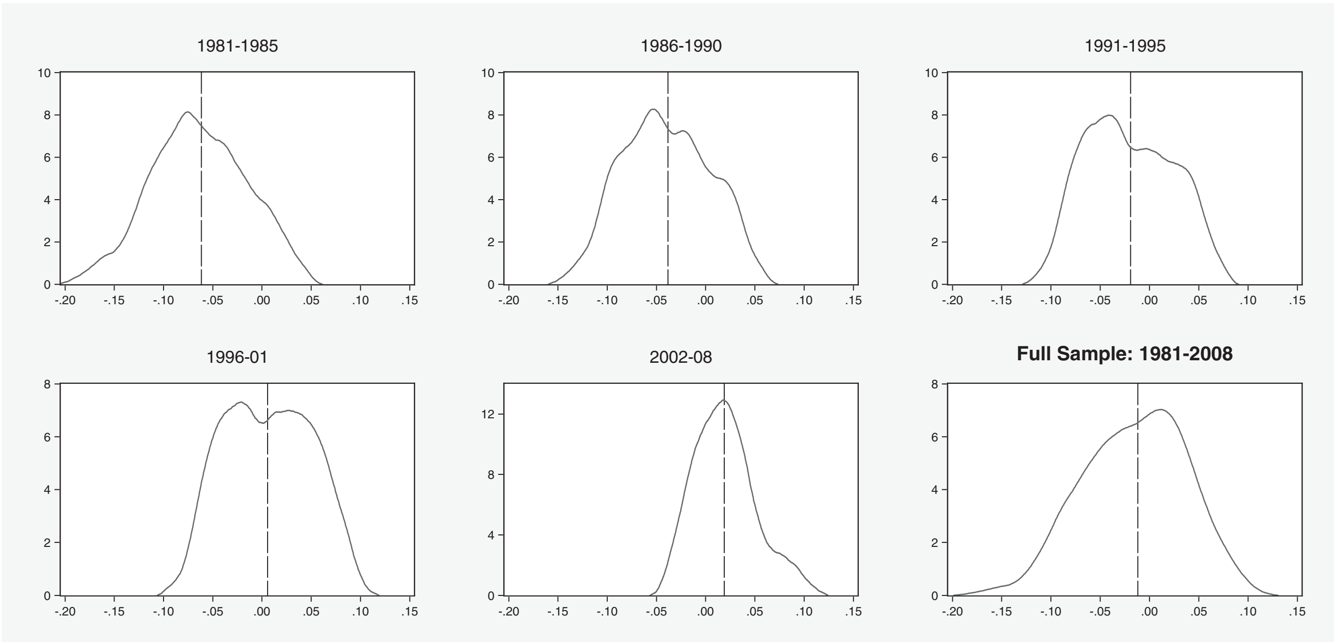

FIGURE 2. Technical progress distributions. Dashed vertical lines indicate medians.

Table 5. 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
Standard deviation	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 unimodality	(0.257)	(0.287)	(0.228)	(0.299)	(0.562)	(0.860)

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 toward 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

From Table 2, indicators which worsen inefficiency are (excluding interactions) as follows:

- resource dependency;
- government expenditure;
- FDI;
- financial depth;
- religious fractionalization;
- military governments.

We already discussed the possible pro and con efficiency effects of resource dependency, FDI,[31] 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.[32] 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 regional resources [Malik and Awadallah (2013)].[33] 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, e.g., only 10% of MENA firms using bank finance (World Bank Business Environment

Survey). Bank lending tends to have been skewed to large, well-connected enterprises in low-turnover markets [World Bank (2009), Herrala and Turk Ariss (2013)]. 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, skewed allocation).

5.4. Indicators which Enhance Efficiency

These include the following:

- human capital;
- median age;
- openness[34];
- manufacturing share;
- workers' rights[35];
- regime duration.

We already discussed human capital, manufacturing share, and openness. The 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.[36] Stable autocratic governments therefore seem to represent a double-edged sword. Their military characteristic may, e.g., 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.[37]

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:

$$\begin{aligned}\mu = \ldots\ & \underset{+}{\beta_R} Resrent + \underset{-}{\beta_{R,h}} (Resrent \times h) \\ & \times \underset{-}{\beta_O} Open + \underset{+}{\beta_{O,h}} (Open \times h) \\ & \times \underset{+}{\beta_F} FDI + \underset{-}{\beta_{F,h}} (FDI \times h) \\ & \times \underset{-}{\beta_M} MedAge + \underset{+}{\beta_{M,h}} (MedAge \times h)\end{aligned}$$

TABLE 6. 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***

$$\times \underset{-}{\beta_W} Worker + \underset{+}{\beta_{W,M}} (Worker \times MedAge)$$
$$\times \underset{-}{\beta_{MY}} ManuY + \underset{+}{\beta_{MY,\Delta e}} (ManuY \times \Delta e) + \ \ldots \qquad \textbf{(4)}$$

From this, we see the key role played by human capital; while $resrent$ 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 6).

Likewise, for median-age interactions that $\beta_{W,M}, \beta_{M,h} > 0$ is striking since both of their individual (noninteracted) 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 [World Bank (2004)] and are associated to social unrest. This deprives the economy of high-potential employees and strengthens insiders' power. Likewise, while workers' rights positively impact efficiency,[38] as applied to high-skill outsiders it could be used as a barrier to entry (to new labor cohorts).

Finally, Table 6 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).

Technical efficiency. Technical Inefficiency compares the inefficiency under firms' control 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 $\mathbf{E}\{u_{it} \mid \varepsilon_{it}\}$.

Recalling Table 2, 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.[39] As with technical progress, moreover, we can decompose Technical Efficiency into a time and country-specific dimension, with the same supporting metrics.

TABLE 7. Technical efficiency: Distributional characteristics

	1981–1985	1986–1990	1991–1995	1996–2001	2002–2008	1981–2008
Standard deviation	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 unimodality	(0.113)	(0.060)	(0.010)	(0.001)	(0.146)	(0.005)

Technical efficiency over time. Figure 3 and Table 7 reveal the general rejection of unimodality 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 bimodal 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.

Technical efficiency by country. Over the full sample, the TE distribution thus appears bimodal and negatively skewed (a fat tail to the left). And so, unlike the unimodal 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 4 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 ($TE < 0.6$).

To benchmark and cross-check our efficiency estimates, we compared them with other relevant studies in the field. For example, Kumar and Russell (2002) using a sample for 57 countries over the period 1965–1990 and employing two factors of production report a value for the technical efficiency (TE) index for Morocco for the 1990 equal to 0.86 (our TE index for Morocco is 0.90). Christopoulos (2007) using a sample of 83 countries (1960–1989) and utilizing a nonparametric method to estimate a world frontier find a TE for Jordan equal to around one (our TE index for Jordan is 0.86). Henry et al. (2009) using a sample of 57 countries and employing three inputs (i.e., including human capital) over 1970–1998 report a score index for TE of 0.95 for Egypt, 0.94 for Tunisia, 0.92 for Jordan. Christopoulos and León-Ledesma (2014) estimated a world frontier consisting of 70 countries over 1960–2000. They report a TE index for Syria equal to 0.82. Henderson and Russell (2005) report a similar value for Syria in 1990 (TE = 0.80) using a sample of 52 countries for the period 1965–1990. Our TE index for Syria is 0.806.

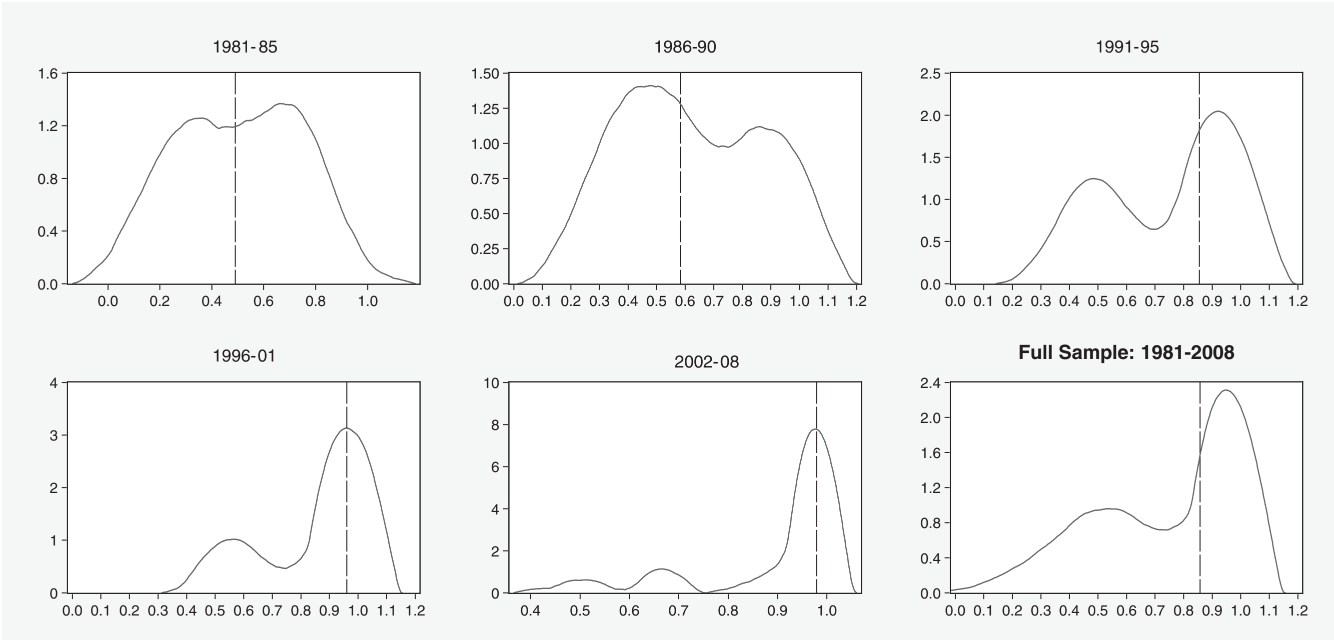

FIGURE 3. Technical efficiency distributions. Dashed vertical lines indicate median histogram values. Smoothness and bandwidth consideration imply Kernel densities are not necessarily truncated at unity.

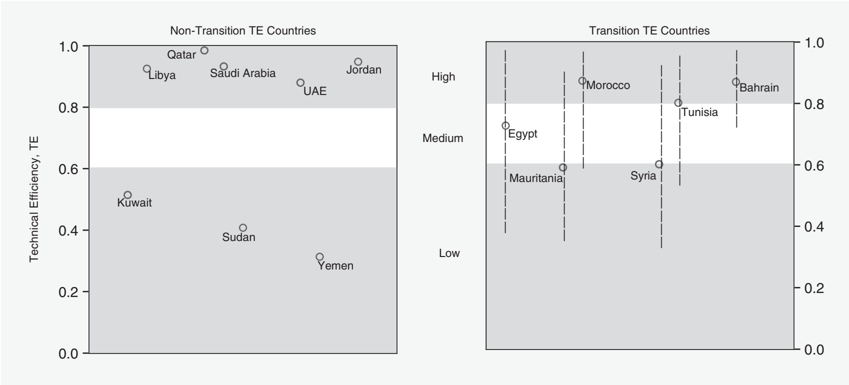

FIGURE 4. Polarization and shifts in technical efficiency. Dashed vertical lines in the rhs panel indicate max–min ranges for countries which have moved between categories. Note the horizontal axes have no interpretation; they merely admit sufficient space to separate out the country names.

It is clear from the above analysis that our estimates for TE index are very close to these reported in the literature derived from munch larger data sets. Our efficiency results therefore benchmark well with those found in the literature, although we have the benefit and value added of using covariates and distribution analysis to better understand the determinants and patters of technical efficiency.

We also further categorize into countries which have exhibited interband transition (shown in the right panel in dashed vertical lines).[40]

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. 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.

- 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 unimodel 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

We performed robustness with respect to functional form consistent with the final column of Table 2. We chose Fourier and Modified Translog as alternative (and more general) specifications (see Appendices D and E).

However, we also check robustness with respect to additional variables. To include all the series of interest 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 analysis (PCA), we are able to transform the original variables $\mathbf{z} = [z_1, z_2, \ldots, z_k]'$ into a new set $\underline{\mathbf{z}} = \left[\underline{\mathbf{z}}_1, \underline{\mathbf{z}}_2, \ldots, \underline{\mathbf{z}}_k\right]'$ which are linear combinations of the original **z**'s and are mutually orthogonal [Jolliffe (2004)]. 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

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

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 [Kolenikov and Angeles (2009)]. 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 practices 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 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 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 8 shows the values of β_{pc}, and Table E.7 shows the full SFA estimates. Our aims in running PCA are threefold:

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TABLE 8. Retrieved PCA coefficients

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	$Resrent \times h$	−0.0290**
$Urban$	−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***		

(1) To assess whether the Table 2 parameters 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 Sociocultural Indicators to technical efficiency, by country.

Points (1) and (3) are, respectively, covered in Sections 6.2 and Appendix F.

On point (2) we see, for example, that an increase in *urbanization* (commonly regarded as promoting scale economies and demonstration effects) is efficiency enhancing.[41] By contrast, the two *age dependency terms* (old and young) worsen inefficiency.[42]

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.

An additional exercise, which separates out country components, is found in Appendix F.

6.2. Robustness Comparisons

Now we pool results: those of Table 2, two variants of model $\mathbf{M}_{\mathcal{I}}^{\mathrm{Aug}}$ under different production specifications (Fourier and Modified Translog), see Table E.9, plus the PCA (Table 8). This variety allows us to assess model robustness with respect to coefficients signs across methods.[43]

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TABLE 9. Sign robustness

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

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.[44] Otherwise, there is no robustness. According to this classification, we derive Table 9 (derived from Table E.9):

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, as proxied by domestic credit, has also not enhanced technical efficiency.

7. CONCLUSIONS

We estimated the MENA technical frontier and established its determinants. We divided efficiency-related variables into economic, political, and sociocultural 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 in many cases, with the MENA consigned to a low average technological base. The corollary of this is that the MENA may have exhausted efficiency gains.

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 nonresource economy. Moreover, exchange rate volatility and likely overvaluation (characteristic of petrocurrencies) has retarded manufacturing growth. Other related features may also hinder efficiency: heightened rent seeking; underdiversified 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 contribute more generally to discussions of how regional efficiency and development may progress.

NOTES

1. Following the IMF's definition, this comprises: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates (UAE), Yemen.
2. See Dal Bo and Rossi (2007) and Henry et al. (2009).
3. The IMF's definition of Emerging and Developing Markets overlaps some countries in the defined MENA region. Accordingly, in calculating these shares, we stripped the MENA region out of their definition, and recalculated accordingly.
4. On education, mortality, and poverty, see the United Nations Development Program data: http://hdr.undp.org/en/statistics.
5. Some of the sampled countries 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 pervasive effect on the entire region.
6. See Walton (2013) on Egypt's 1990s privatization program.
7. An interesting extension would be estimating a world frontier including MENA and other commonly modeled countries, modeling (in)efficiency with a rich set of covariates. We leave this as an exercise for future research.

8. We estimate jointly equations (2) and (3) instead of using a two-step approach, where the obtained efficiency measures in the first stage are regressed in the second stage over a set of covariates. The two-step approach contrary to the one-step approach we adopt here leads to inconsistent estimators [see Wang (2002), Simar and Wilson (2007)].

9. Following the Penn tables, our measure of human capital is years of schooling. This is admittedly crude at first sight; often schooling is converted to measures of human capital using Mincerain returns to education. There are, though, highly unusual wage skill patterns in the region, sometimes rather thin functioning private markets, considerable informal activity and so on. We preferred a more indirect approach. For instance, some of these effects might be implicitly absorbed by the quadratic trend, which we allow for in the production function and the rich set of human–capital interactions which are admitted into the efficiency formulation.

10. All data and transformations as well as the replication code is available from the authors on request.

11. Note, for compactness, we have not included the appendices in this paper. Instead these may be downloaded from our working paper version at http://www.surrey.ac.uk/sites/default/files/DP04-15.pdf.

12. All figures in this paragraph are taken from sample-year averages from the CIA world Factbook.

13. Source: UNCTAD (2011).

14. 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).

15. 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.

16. Although given the scarcity of water resources in the MENA region, agriculture is not a dominant regional activity.

17. This variable is described in Appendix A.

18. Although, overall fertility rates have declined since 1980 to around 2.8 children/woman. The MENA tend to have a low labor participation rate (just over 50%), reflecting low female participation.

19. 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 2007–2008 and 1991–2006, respectively.

20. 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 while King Hamad bin Isa bin Salman Al Khalifa is a Sunni.

21. Full results in Appendix E.

22. We report both, reflecting the possibility of skewness and/or multimodality.

23. Appendix C defines the test and the particular bootstrap method used.

24. All overlapping parameters are qualitatively the same (except β_h in $\mathbf{M}^{\text{Base}}$ which is positive and significant).

25. 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 four and six degrees of freedom are 7.78 and 12.59, respectively. Accordingly, we select model M_I^B over M^B and M_I^A over M^A.

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

27. We made several specification searches: For several inefficiency indicators, we included quadratic and higher powers to examine nonlinearity and threshold effects, plus a wider variety of interactions. However, these were rarely statistically significant and did not improve fit.

28. We should point out that Kumbhakar and Wang (2005) and Pires and Garcia (2012) model inefficiency in terms of generic distributional assumption rather than through a set of explicit covariates as we do here.

29. This issue was brought to our attention by an anonymous referee.

30. Henderson et al. (2008) followed a similar approach to test the existence of polarization using a sample of 118 countries from the Penn world data.

31. Gente et al. (2015) develop a framework for analyzing conditions under which FDI may or may not be growth enhancing.

32. The effect is positive in all cases in Table 2 but only significant in the final two columns.

33. 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).

34. Exports to high-income countries are either insignificant (the full case) or only significant at 10%. In both cases, the effect is to deepen inefficiency.

35. The rights to freedom of assembly and association (Assn) imparts a positive effect but only significant at 12%.

36. Muammar al-Gaddafi ruled Libya over 1969–2011, Ali Abdullah Saleh was President of North then unified Yemen over 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.

37. Such an interpretation is consistent with Olson (2000) on autocrats distinguishing "roving" and "stationary" bandits.

38. The exact channels are unclear but could, e.g., be related to strengthening trust and promoting long-term planning, generating incentives for skills, promoting nutrition, etc.

39. Henry et al. (2009) report an average efficiency index of 0.73 for a sample of 57 developing countries over 1970–1998.

40. 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.

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

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

43. We do not try to assign model weights. That would not be straightforward since they have different sample sizes and thus noncomparable likelihoods. Although, we did earlier note an ordering of the B and A models in favor of interactions.

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

REFERENCES

Acemoglu, D., P. Aghion and F. Zilibotti (2006) Distance to frontier, selection, and economic growth. *Journal of the European Economic Association* 4(1), 37–74.

Acemoglu, D. and J. Robinson (2012) *Why Nations Fail*. New York: Crown Business.

Aigner, D., C. Knox Lovell and P. Schmidt (1977) Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6(1), 21–37.

Amin, M., R. Assaad, N. al-Baharna, K. Dervis, R. M. Desai, N. S. Dhillon, A. Galal, H. Ghanem, C. Graham and D. Kaufmann (2012) *After the Spring*. New York: Oxford University Press.

Battese, G. and T. Coelli (1995) A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* 20(2), 325–332.

Benhabib, J. and M. Spiegel (2005) Human capital and technology diffusion. In P. Aghion and S. Durlauf (eds.), *Handbook of Economic Growth*, vol. 1, chap. 13, pp. 935–966. North Holland: Elsevier.

Boutayeb, A. and M. Serghini (2006) Health indicators and human development in the Arab region. *International Journal of Health Geographics* 61(5), 1–13.

Charnes, A., W. W. Cooper and E. L. Rhodes (1978) Measuring the efficiency of decision making units. *European Journal of Operational Research* 2, 429–444.

Chen, Y.-Y., P. Schmidt and H. -J. Wang (2014) Consistent estimation of the fixed effects stochastic frontier model. *Journal of Econometrics* 181(2), 65–76.

Christopoulos, D. K. (2007) Explaining country's efficiency performance. *Economic Modelling* 24(2), 224–235.

Christopoulos, D. K. and M. A. León-Ledesma (2014) Efficiency and production Frontiers in the aftermath of recessions: International evidence. *Macroeconomic Dynamics* 18(6), 1326–1350.

Dal Bo, E. and M. A. Rossi (2007) Corruption and inefficiency: Theory and evidence from electric utilities. *Journal of Public Economics* 91(5–6), 939–962.

Draper, N. and H. Smith (1981) *Applied Regression Analysis*. New York: John Wiley and Sons.

Faria, J. R. and P. McAdam (2015) Macroeconomic adjustment under regime change: From social contract to Arab Spring. *Journal of International Money and Finance* 56, 1–22.

Farrell, M. J. (1957) The measurement of productive efficiency. *Journal of the Royal Statistical Society* 120(3), 253–290.

Galor, O. and A. Mountford (2008) Trading population for productivity. *Review of Economic Studies* 75(4), 1143–1179.

Gente, K., M. León-Ledesma and C. Nourry (2015) External constraints and endogenous growth: Why didn't some countries benefit from capital flows? *Journal of International Money and Finance* 56, 223–249.

Gourdon, J. (2010) FDI flows and export diversification. In J. R. López-Cálix, P. Walkenhorst and N. Diop (eds.), *Trade Competitiveness of the Middle East and North Africa*, vol. 1, pp. 13–44. Washington, DC: World Bank Publications.

Greene, W. H. (2005) Reconsidering heterogeneity in panel data estimators of the stochastic frontier model. *Journal of Econometrics* 126, 269–303.

Greene, W. H. (2008a) *Econometric Analysis*. Upper Saddle River, NJ: Prentice Hall.

Greene, W. H. (2008b) The econometric approach to efficiency analysis. In H. Fried, C. Knox Lovell and P. Schmidt (eds.), *The Measurement of Productive Efficiency*, pp. 92–250. New York: Oxford University Press.

Growiec, J. (2012) The world technology frontier: What can we learn from the US States? *Oxford Bulletin of Economics and Statistics* 74(6), 777–807.

Gylfason, T. (2001) Natural resources, education, and economic development. *European Economic Review* 45(4–6), 847–859.

Henderson, D. J., C. F. Parmeter and R. R. Russell (2008) Modes, weighted modes, and calibrated modes. *Journal of Applied Econometrics* 23(5), 607–638.

Henderson, D. J. and R. R. Russell (2005) Human capital and convergence: A production-frontier approach. *International Economic Review* 46(4), 1167–1205.

Henry, M., R. Kneller and C. Milner (2009) Trade, technology transfer and national efficiency in developing countries. *European Economic Review* 53(2), 237–254.

Herrala, R. and R. Turk Ariss (2013) Credit Constraints, Political Instability, and Capital Accumulation: Evidence from the MENA Region. Working paper no. 13/246, International Monetary Fund.

Heyneman, S. (1993) Human development in the Middle East and North Africa Region. In S. El-Naggar (ed.), *Economic Development of the Arab Countries*, vol. 1, pp. 204–226. Washington, DC: International Monetary Fund.

Huang, C. J. and J. -T. Liu (1994) Estimation of a non-neutral stochastic frontier production function. *Journal of Productivity Analysis* 5, 171–180.

Imbs, J. and R. Wacziarg (2003) Stages of diversification. *American Economic Review* 93(1), 63–86.

Jensen, R. (2007) The digital provide. *Quarterly Journal of Economics* 122(3), 879–924.

Jolliffe, I. (2004) *Principal Component Analysis*. Amsterdam: Springer.

Kee, H. L., A. Nicita and M. Olarreaga (2009) Estimating trade restrictiveness indices. *Economic Journal* 119(534), 172–199.

Kim, Y. and P. Schmidt (2000) A review and empirical comparison of Bayesian and classical approaches to inference on efficiency levels in stochastic frontier models with panel data. *Journal of Productivity Analysis* 14(2), 91–118.

Klump, R., P. McAdam and A. Willman (2007) Factor substitution and factor augmenting technical progress in the US. *Review of Economics and Statistics* 89, 183–192.

Kneller, R. and P. Stevens (2003) The specification of the aggregate production function in the presence of inefficiency. *Economics Letters* 81(2), 223–226.

Kolenikov, S. and G. Angeles (2009) Socioeconomic status measurement with discrete proxy variables. *Review of Income and Wealth* 55(1), 128–165.

Kumar, S. and R. R. Russell (2002) Technological change, technological catch-up, and capital deepening: Relative contributions to growth and convergence. *American Economic Review* 92(3), 527–548.

Kumbhakar, S. and H. -J. Wang (2005) Estimation of growth convergence using a stochastic production frontier approach. *Economics Letters* 88(3), 300–305.

León-Ledesma, M., P. McAdam and A. Willman (2010) Identifying the elasticity of substitution with biased technical change. *American Economic Review* 100(4), 1330–1357.

Lipset, S. (1959) Some social prerequisites for democracy. *American Political Science Review* 53(1), 69–105.

Makdisi, S., Z. Fattah and I. Liman (2003) Determinants of Growth in the MENA Countries. Arab Planning Institute working paper no. 39.

Malik, A. and B. Awadallah (2013) The economics of the Arab spring. *World Development* 45(1), 296–313.

Meeusen, W. and J. van den Broeck (1977) Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review* 8, 435–444.

Myers, R. (1986) *Classical and Modern Regression with Applications.* Boston: Duxbury Press.

Nabli, M. (2007) Long term economic development challenges and prospects for the Arab countries. In M. Nabli (ed.), *Breaking the Barriers to Higher Economic Growth*, vol. 1, pp. 3–28. Washington, DC: The World Bank.

Olson, M. (2000) *Power and Prosperity*. New York: Basic Books.

Ortega, J. F. and J. M. Gavilan (2014) A comparison between maximum likelihood and Bayesian estimation of stochastic frontier production models. *Communications in Statistics - Simulation and Computation* 14(7), 1714–1725.

Pires, J. O. and F. Garcia (2012) Productivity of nations: A stochastic frontier approach to tfp decomposition. *Economics Research International*, Article ID 584869 (1–19).

Pritchett, L. (1999) Has Education Had a Growth Payoff in the MENA Region? Middle East and North Africa working paper 18, World Bank.

Rodrik, D. (2005) Growth strategies. In P. Aghion and S. Durlauf (eds.), *Handbook of Economic Growth*, vol. 1, pp. 967–1014. North Holland: Elsevier.

Rodrik, D. (2013) Unconditional convergence in manufacturing. *Quarterly Journal of Economics* 128(1), 165–204.

Salehi-Isfahani, D., I. Tulani and R. Assaad (2009) A comparative study of returns to education of urban men in Egypt, Iran and Turkey. *Middle East Development Journal* 1(2), 145–187.

Saliola, F. and M. Seker (2011) Total Factor Productivity Across the Developing World. Enterprise Note 23, World Bank Group.

Schmidt, P. and R. Sickles (1984) Production frontiers and panel data. *Journal of Business and Economic Statistics* 2(4), 367–374.

Schwarz, R. (2013) *War and State Building in the Middle East*. Gainesville, FL: University Press of Florida.

Simar, L. and P. W. Wilson (2007) Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics* 136(1), 31–64.

UNCTAD (2011) UN Conference on Trade and Development Database. www.unctad.org/Templates.

van den Broeck, J., G. Koop, J. Osiewalski and M. Steel (1994) Stochastic frontier models: A Bayesian perspective. *Journal of Econometrics* 61, 273–303.

Walton, C. (2013) Revolution and Redistribution. Reflections on France and Egypt. www.booksandideas.net/IMG/pdf/20130423_revolution_walton.pdf.

Wang, H.-J. (2002) Heteroscedasticity and non-monotonic efficiency effects of a stochastic frontier model. *Journal of Productivity Analysis* 18(3), 241–253.

Wijeweera, A., R. Villano and B. Dollery (2010) Economic growth and FDI inflows: A stochastic frontier analysis. *Journal of Developing Areas* 43(2), 143–158.

World Bank, T. (2004) Unlocking the Employment Potential in the Middle East and North Africa. MENA Development report, World-Bank Publications.

World Bank, T. (2009) *From Privilege to Competition*. Washington, DC: World-Bank Publications.