When good managers face bad incentives: Management quality and energy intensity in the presence of price distortions*

Helena Schweiger†

Alexander Stepanov‡

September 2019

Abstract

We use unique firm-level data on management practices and energy expenditures in about 2,000 manufacturing firms in central and eastern Europe, Central Asia and Middle East and North Africa to examine how the quality of management practices relates to the energy intensity of firms in the presence of fossil fuel subsidies. We find that better managed firms respond to the incentives and increase their energy intensity if the difference between the supply cost and the consumer price of energy is relatively large. This is particularly relevant for firms in high energy-intensive sectors. However, in the presence of environmental costs in the form of global warming and local pollution all types of firms tend to reduce their energy intensity. Findings suggest that the combined effect of these two forces is not statistically distinguishable from zero for the manufacturing sector overall. In high energy-intensive sectors, the polluting effect of fossil fuel subsidies prevails.

Keywords: Energy intensity, management practices, fossil fuel subsidies, firm behaviour.

JEL: L2, M2, Q48, Q56, Q58, O13, O14.

---

*We would like to thank Ralph de Haas, Sergei Guriev, Valerie Karplus, Alexander Plekhanov, Vessel Vermeulen, Ulrich Wagner and Andreas Wörgötter for helpful comments and discussions, as well as the participants at the EEA 34th Annual Congress, 16th IAEE European Conference, EAERE 24th Annual Conference, 4th CESEEnet research workshop, ISEFI 2018, 2017 Harvard-MIT-Stanford-World Bank Empirical Management Conference and seminars at the EBRD and University of Reading, Henley Business School for their comments and suggestions. The views expressed in this paper are our own and do not necessarily represent those of the EBRD.

†European Bank for Reconstruction and Development (EBRD). E-mail: schweigh@ebrd.com.

‡European Bank for Reconstruction and Development (EBRD). E-mail: stepanoa@ebrd.com.

1 Introduction

The reduction of greenhouse gas (GHG) emissions is an increasingly important policy objective for many governments, both in developed and developing economies. This is reflected, among other things, in the number of new climate change-relevant laws passed, which reached a peak of more than 100 per year in 2009-13 (Nachmany et al., 2017), as well as the emergence of energy efficiency as a high-priority topic on the policy agenda. The International Energy Agency (2017) report even names improved energy intensity as the biggest factor behind the recent flattening of global GHG emissions.

In manufacturing – one of the key sectors from the point of view of GHG emissions[1] and energy intensity – improvements in energy efficiency can come about from upgrading or closing existing plants or adding new production capacity that uses more modern technology. Moreover, recent research has found that management practices (either generic or climate-friendly ones) also play a significant role in reducing the energy intensity of firms (see Bloom et al., 2010; Martin et al., 2012), though they are more likely to do so in energy intensive industries (Boyd and Curtis, 2014).

As pointed out by Bloom et al. (2010) and others, it is not possible to determine the sign of the relationship between management practices and energy intensity a priori. On the one hand, better managed firms typically use more efficient production techniques and should thus be able to reduce their energy usage. On the other hand, better managed firms might achieve higher productivity through more intensive capital utilisation which might in turn lead to higher energy usage.

In this paper, we expand the existing research by looking at the relationship between the quality of management practices and energy intensity of firms in the context of not only differences in energy intensity across industries (as in Boyd and Curtis, 2014), but also the availability of fossil fuel subsidies. We are interested in knowing whether the latter affects the relationship between the quality of management practices and energy intensity. Besides the impact on energy intensity and GHG emissions, energy subsidies may also constrain competition by limiting the entry of new firms and job creation as they disincentivise more labour-intensive activities, resulting in misallocation of capital and consequently, lower aggregate productivity growth.

Our contribution to the literature is three-fold. First, we expand the analysis for the

[1] Together with primary industry, the manufacturing sector accounts for almost 40 per cent of GHG emissions worldwide (Martin et al., 2014).

United Kingdom (Bloom et al., 2010; Martin et al., 2012), United States (Boyd and Curtis, 2014) and a province in China (Karplus and Zhang, 2017) to 38 countries in central and eastern Europe, Central Asia and Middle East and North Africa, using firm-level data on management practices and energy costs from the fifth round of the European Bank for Reconstruction and Development (EBRD) and the World Bank Group (WBG) Business Environment and Enterprise Performance Survey (BEEPS V) and EBRD-European Investment Bank (EIB)-WBG Middle East and North Africa Enterprise Survey (MENA ES). Most of the countries in central and eastern Europe and Central Asia started the transition from central planning to market economies with an economic structure focused on energy-intensive production. At the beginning of the transition, in 1992, their greenhouse gas intensity of GDP (greenhouse gas emissions per international $ of 2011 GDP) was about twice that in comparable countries elsewhere (EBRD, 2017). It has fallen substantially since then as a result of a shift to less GHG-intensive energy sources, deep energy efficiency improvements within sectors and a shift from energy-intensive activities such as heavy industry to less energy-intensive activities such as services (EBRD, 2011), but is still, with some notable exceptions, above the level in comparable countries. The legacy of energy-intensive production makes these countries particularly interesting and relevant for our analysis.

Second, our analysis goes beyond the relationship between management quality and energy intensity, as we also consider comparative levels of energy prices. Energy-intensive production is only possible when cheap energy resources are available locally or in a neighbouring country under certain conditions. A number of countries in our sample are characterised by the abundance of fossil fuels. Enhanced by the presence of infrastructure, which was predominantly constructed under non-market conditions before the transition period started, this allows for the production of energy at prices well below international prices. If these countries charge less than the international prices for energy in domestic markets, the domestic fossil fuel subsidies are implicit, but have no direct implications for government budgets as long as the price covers the cost of production since no government spending is required to reduce energy prices. For net importers, fossil fuel subsidies may be explicit, representing budget expenditures arising from the domestic sale of imported energy at subsidised prices. The variation in the availability of fossil fuel subsidies makes it possible to compare the impact of the quality of firms' management practices on energy intensity under different regimes of fossil fuel prices. Moreover, recent research indicates that firms in countries with fossil fuel subsidies tend to be more capital-intensive (EBRD et al., 2016), strengthening the importance of our research focus. Furthermore, we can explicitly take into account the cost of global warming and local pollution.

Third, we propose an alternative way of identifying firms that benefit from fossil fuel subsidies. To the best of our knowledge, cross-country estimates of fossil fuel subsidies are available at the country level only, which would imply that all firms benefit from them. However, that is typically not the case as energy tariffs for large users (such as those in the smelting industry) often differ from those for regular users. Furthermore, even in case of *de facto* equal energy prices, in sectors where production methodology relies heavily on energy input, firms are likely to be more sensitive to energy prices in general and availability of fossil fuel subsidies in particular. To address this issue, we account for differences in energy intensity across sectors by allowing the coefficients to vary for high versus moderate & low energy-intensive sectors (in the spirit of Boyd and Curtis, 2014), and, alternatively, by constructing a novel fossil fuel subsidy estimate, which measures how much fuel subsidy per unit of output a sector receives. This subsidy measure allows accounting for the variation at the country and sector level.

However, recent evidence (see Lyubich et al., 2018) shows that there is enormous heterogeneity in output per dollar of energy input even across firms within narrowly defined industries. BEEPS V and MENA ES do not collect data on the energy tariffs the firms are on, but they ask whether or not firms have electricity generators and what percentage of their electricity came from them. In the absence of more detailed data, we utilise this information as a proxy for the access to energy subsidies. Firms typically have electricity generators to be able to continue production or provide services when provision of electricity is unreliable. Nonetheless, having an electricity generator is costly and electricity generated by it is more expensive than electricity from the grid, especially if the price of electricity from the grid is subsidised.[2] Firms that use self-generated electricity are thus less likely to be sensitive to energy prices and availability of fossil fuel subsidies.

We focus on fuel intensity due to fossil fuel subsidies data availability and find that fossil fuel subsidies, whether measured at the country- or country-sector level, affect its relationship with management practices quality with the results robust to a large number of additional controls, such as industry, size, ownership, and other firm char-

[2] Electricity generators are often powered by diesel. Sakr et al. (2017) note that in Egypt, many off-grid users obtain diesel fuel for electricity generators at above market prices.

acteristics. In the best case scenario, availability of fossil fuel subsidies reduces the fuel intensity reduction that would otherwise be associated with an improvement in management practices. In the worst case scenario, it increases fuel intensity. Its magnitude is substantial: in countries where fossil fuel subsidies are absent or near-absent, improving management practices from the 25^{th} to the 75^{th} percentile is associated with a 21-22 per cent decrease in fuel intensity. In countries with high fossil fuel subsidies, the same improvement is associated with a much lower reduction in fuel intensity (1-3 per cent). In high energy-intensive sectors, magnitude is even larger: the same improvement in management practices quality is associated with more than a 54 per cent reduction in fuel intensity in countries with no fossil fuel subsidies, but a 35.5 per cent *increase* in countries with high fossil fuel subsidies. In other words, better managed firms' fuel intensity responds more strongly to the availability of fossil fuel subsidies.

The results suggest that these findings are driven by certain types of management practices with the most important ones related to incentives for managers and employees. Firms where individual performance is the basis for managers' bonuses and non-managers' promotion are more likely to respond to incentives provided by fuel prices. If fuel prices are lower thanks to subsidies, those firms tend to be more fuel intensive. We find that distortions in fuel prices have an impact on the relationship between management practices and fuel intensity, and thus environmental outcomes. While our findings indicate that better managed firms do take into account indirect effect of local pollution in particular, the effects of fossil fuel subsidies and environmental costs are similar in magnitude and opposite in direction, so their overall effect on the relationship between fuel intensity and management practices quality is negligible. Under conditions of below-market energy pricing, policies aimed at improving management practices might lead to more, rather than fewer, GHG emissions in the absence of incentives to economise on energy use.

The remainder of the paper is organised as follows. Section 2 describes the data sources used. Section 3 discusses the empirical approach used in the paper, while section 4 provides the results. Section 5 discusses sample selection and robustness and section 6 presents concluding remarks and policy implications.

2 Main data sources

2.1 BEEPS V and MENA ES

The main source of firm-level data are two enterprise surveys conducted in 2011-15: BEEPS V and MENA ES. BEEPS V was conducted by the EBRD and WBG in 2011-14 and 2016 (Cyprus and Greece). It covered 16,310 enterprises in 32 countries of central and eastern Europe and Central Asia. MENA ES was implemented by the EBRD, the European Investment Bank (EIB) and WBG in 2013-14 in Djibouti, Egypt, Israel, Jordan, Lebanon, Morocco, Tunisia, West Bank and Gaza, and Yemen. In these nine countries, 6,511 firms were surveyed.[3]

Both surveys are based on face-to-face interviews with managers of registered firms with at least five employees and follow the World Bank Enterprise Surveys methodology. Stratified random sampling is used to select eligible firms to participate in the survey. Strata are defined by sector (typically manufacturing, retail and other services), size (5-19, 20-99 and 100+ employees) and regions within a country. The main purpose is to examine the quality of the business environment; topics covered are infrastructure, competition, sales and supplies, labour, innovation, land and permits, crime, finance, employment and business-government relations. The surveys also include a section on management practices and basic information on firm performance, such as sales, costs (including fuel and electricity costs) and fixed assets (capital).

2.2 IMF Energy Subsidies Template

Our measures of country- and country-sector fossil fuel subsidies are based on the data from the Energy Subsidies Template database provided by the International Monetary Fund (IMF) (as described in Coady et al., 2017).[4] The IMF Energy Subsidies Template provides annual data for gasoline, diesel, kerosene, coal, natural gas and electricity prices in 188 countries.[5] For each type of fuel, the IMF Energy Subsidies Template includes

[3] BEEPS V and MENA ES data are available at `http://www.ebrd-beeps.com`.

[4] Available at: `http://www.imf.org/external/np/fad/subsidies/index.htm`. Other attempts to measure energy subsidies worldwide are also available (see a database by the International Energy Agency, Clements et al., 2013; OECD, 2013). We use Coady et al. (2017) because it has the best coverage for the countries in our sample.

[5] As discussed in Coady et al. (2017), data constraints prevent the inclusion of some broader oil products, such as jet fuels and home heating oil; as such, energy subsidies in the database are understated.

data on the *real* price (that is, price paid by consumers) in each country,[6] supply cost and the cost of environmental externalities from fuel combustion (global warming and local pollution[7]). For net importers of a fuel, the supply costs are calculated as the international price at the nearest hub, adjusted for quality differences, plus transportation and distribution costs. For net exporters of a fuel, the supply costs are the international price, adjusted for quality differences, minus transportation costs plus distribution costs. Supply costs alone are considered as the benchmark price. Together, the benchmark price and the costs of the externalities represent the total efficient price of a fuel. To ensure comparability across different types of fuels, we express all the prices and costs as per 1 gigajoule (GJ).

Coady et al. (2017) estimated that fossil fuel subsidies together with environmental costs amounted to US$ 4.9 trillion worldwide in 2013, equivalent to 6.5 per cent of global GDP. Figure 1 shows the breakdown into fossil fuel subsidies, cost of global warming and local externalities as a share of GDP for the countries in our sample. Several countries do not have fossil fuel subsidies. However, in virtually all of them, the price paid by consumers does not take into account the total cost of environmental externalities from fuel combustion. The leader among countries with fossil fuel subsidies is Uzbekistan, where they were equivalent to more than 20 per cent of GDP in 2013. Ukraine, on the other hand, is the leader once environmental costs are accounted for, with fossil fuel subsidies and environmental costs equivalent to almost 50 per cent of GDP in 2013.

3 Methodology

In this section, we first explain how we measure management practices and fossil fuel subsidies, and then specify estimation models.

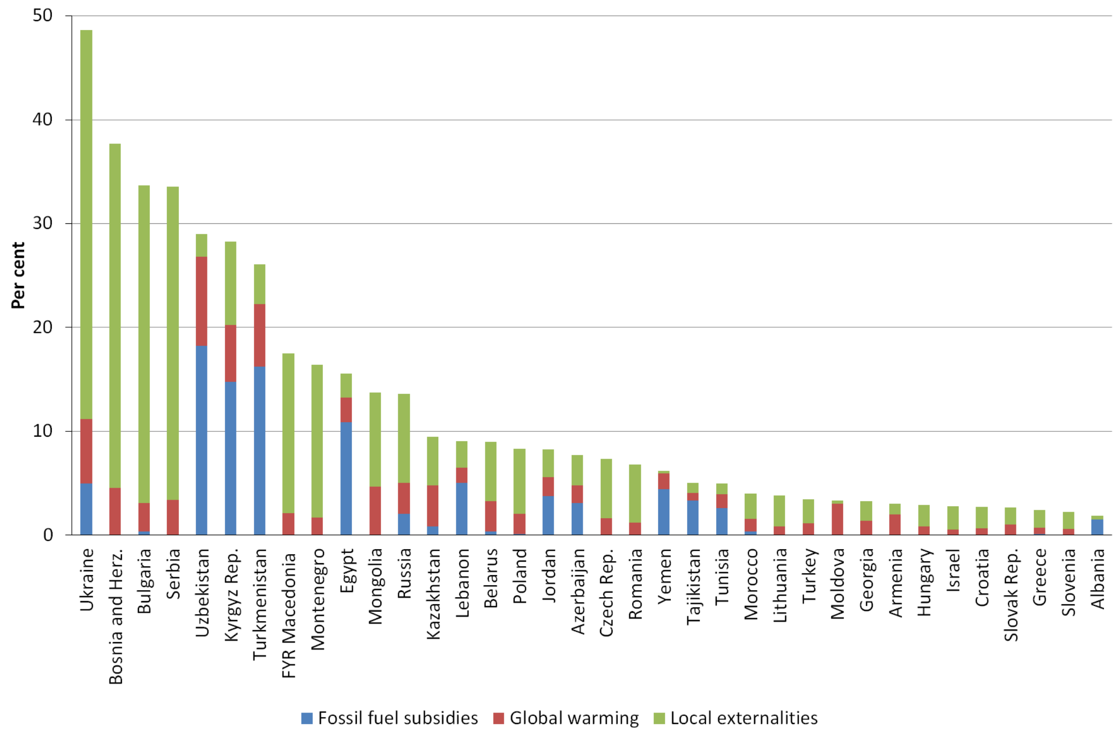
3.1 Measuring management practices

BEEPS V and MENA ES include a selection of questions from the US Census Bureau's Management and Organisational Practices Survey (MOPS) (Bloom et al., 2013). The

[6]Consumer prices are compiled from several sources: IEA, IMF, US Energy Information Administration (EIA) and the World Bank. In some cases, they are assumed equal to supply costs. See Coady et al. (2017, p.15) for more details.

[7]Local pollution includes local air pollution – damages relating to SO_2, NO_x, fine particulate matter ($PM_{2.5}$) and volatile organic compounds (VOCs).

Figure 1: Economic value of fossil fuel subsidies in 2013



Source: IMF Energy Subsidies Template.
Note: In countries where the benchmark price of fossil fuels is lower than the real price, the value of fossil fuel subsidies is set to zero.

questions concerned four aspects of management – operations, monitoring, targets and incentives – and requested unordered categorical responses. The operations question focused on how the firm handled a process-related problem, such as machinery breaking down. The monitoring question covered the collection of information on production indicators. The questions on targets focused on the timescale for production targets, as well as how difficult it was to achieve them and who was aware of them. Lastly, the incentives questions covered criteria governing promotion, practices for addressing poor performance by employees and the basis on which the achievement of production targets was rewarded. These questions were directed to all manufacturing firms with at least 20 employees (50 in the case of Russia).[8]

On the basis of firms' answers, the quality of their management practices can be as-

[8]Russia was the first country in which BEEPS V was implemented. The number of firms with at least 50 employees was not as high as expected, so the threshold was lowered to 20 employees in subsequent countries.

sessed and assigned a rating. As the scaling varies across management practices, we first standardise the scores of each management practice (that is, each question) to having a mean of zero and a standard deviation of one (as in Bloom et al., 2012).[9] We then use the z-scores to calculate unweighted averages making use of the z-scores for each individual section of the respective management practice, in order to prevent accentuating the target or incentives sections, which include multiple questions. Lastly, we compute an unweighted average across the scores for the four management areas, and standardise once more this unweighted average.[10]

This means that the average management score across all firms (for which the underlying variables are available) in all countries in the sample is equal to zero. Management practices of individual firms deviate either left or right from zero, with the former denoting bad (below average) practices and the latter indicating good practices, with the higher z-score reflecting a higher quality of management practices.

3.2 Measuring fossil fuel subsidies

We use two alternative measures of fossil fuel subsidies. The first measure is a gap between the benchmark fuel price and the real fuel price (paid by consumers); it is calculated at the country level. The second measure consists of fossil fuel subsidies received by a sector, normalised by sector output, and is calculated at the country-sector level. In our baseline scenario, the benchmark price is equivalent to the supply cost. We augment our analysis with a scenario that takes into account environmental externalities from fuel combustion.

3.2.1 Country-level price gap

Country-level price gap calculations are based on the data from the IMF Energy Subsidies Template. The price gap for a fuel is defined as the difference between the benchmark price and the average consumer price for a given fuel within a country. Overall, the fossil fuel price gap in a country is calculated as the average of the price gaps of

[9]The questions on management practices came at the end of a long face-to-face interview. This resulted in an unusually large number of people responding “don’t know” or refusing to answer. Observations with a response rate excluding don’t know or refusal below 62.5 per cent prior to recoding described in Appendix C were excluded.

[10]The correlations between the four components are statistically significant at 1 per cent, apart from the correlation between operations and incentives management practices (0.01). With exception of the correlation between the monitoring and targets scores which is 0.33, they are all below 0.20.

three major petroleum products (gasoline, kerosine and diesel), coal[11] and natural gas weighted by the shares of the corresponding fuel in the industry energy consumption mix. In other words,

$$g_c = \frac{\sum_f e_{fc} \times \left(b_{fc} - r_{fc}\right)}{t_c}, \tag{1}$$

where g_c is the fossil fuel price gap in country c, b_{fc} and r_{fc} are the benchmark and the real price of fuel f in country c respectively, e_{fc} and t_c are the amount of fuel f and total amount of energy consumed in country c.[12]

Equation (1) calculates the fossil fuel price gap for a country in a given year, which the energy prices and consumption data refer to. However, due to large unexplained variation in the fuel consumption data, we calculate the average price gap over the years 2010-14, which were the reference years for BEEPS V and MENA ES. To ensure comparability across different years, fuel prices are converted to constant 2010 USD. We match fuel price gaps to the firm-level data based on the country.

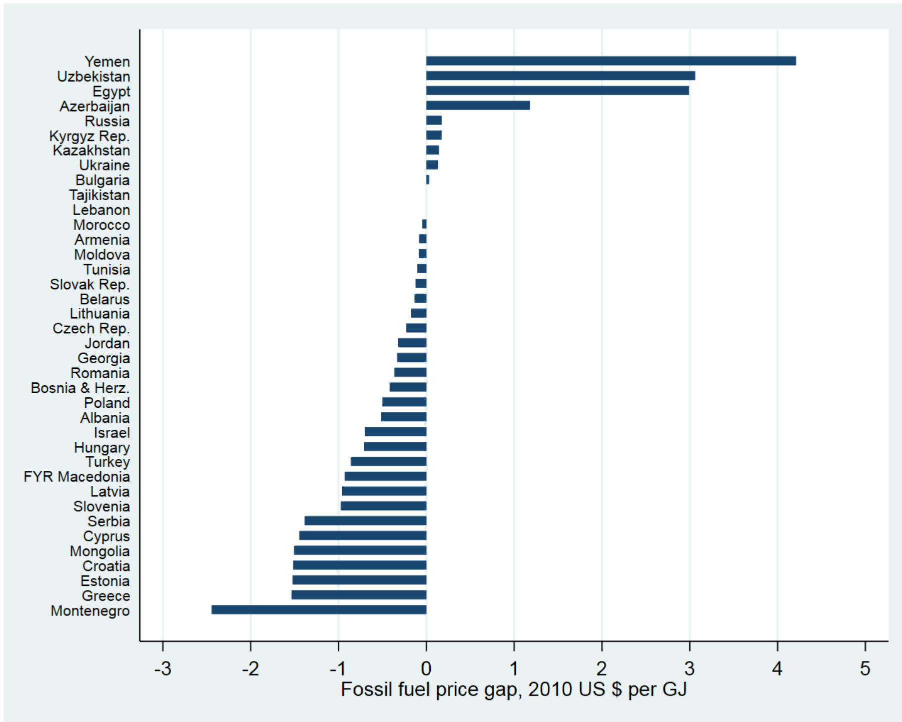
Figure 2 shows fossil fuel price gaps for the countries in our sample in 2010 USD per gigajoule (GJ). In the observed period from 2010 to 2014, the fossil fuel price gap was positive (with the real price below the supply costs) in 9 countries, with the energy subsidy reaching \$4.2 per GJ in Yemen, followed by Uzbekistan (\$3.1 per GJ) and Egypt (\$3.0 per GJ). In the remaining 29 countries, there were no fossil fuel subsidies, but the difference between the real price and the supply cost varied between \$0 per GJ in Lebanon and Tajikistan and \$2.4 per GJ in Montenegro.[13] We expect this *negative* subsidy to have a symmetric, but opposite, effect on outcomes as the *positive* subsidy. In other words, the higher the consumer price is above the supply costs (negative subsidy), the less energy intensive we expect the firm to be. The lower the consumer price below the supply cost (positive subsidy), the more energy intensive the firm.

[11] For two countries in our sample - Jordan and Yemen - the statistics show significant consumption of coal, but its price gap is not available. As other countries in the region are reported to have zero price gap for coal, we assume the same for Jordan and Yemen.

[12] Country- and country-sector level figures on fuel and energy consumption come from the IEA World Energy Balances and World Energy Statistics databases.

[13] Note that Coady et al. (2017) assume that there are no fossil fuel subsidies if the consumer prices are above the supply cost. That is an appropriate approach for their purpose, which is to estimate the aggregate amount of fossil fuel subsidies. For our purpose, however, the difference between the real price and supply cost matters as firms respond to prices they pay.

Figure 2: Average fossil fuel price gaps in 2010-14, 2010 USD per GJ



Source: IMF Energy Subsidies Template, IEA World Energy Balances and World Energy Statistics and authors' calculations.
Note: The fossil fuel price gap is calculated using equation (1).

3.2.2 Country-sector level subsidy per unit of output

Using the price-gap approach for the estimation of fossil fuel subsidies has an important drawback. It does not account for the differences in energy intensity across sectors and countries. In order to overcome this obstacle, we develop an alternative measure of fossil fuel subsidies. To achieve this, the price gap in equation (1) needs to be calculated at the sector level for each country separately:

$$g_{sc} = \frac{\sum_f e_{fsc} \times (b_{fc} - r_{fc})}{t_{sc}}, \tag{2}$$

where g_{sc} is the energy price gap faced by a 2-digit sector s in country c, b_{fc} and r_{fc} are the benchmark and the real price of fuel f in country c respectively, e_{fsc} and t_{sc} are the amount of fuel f and total amount of energy consumed by sector s in country c.

Therefore, the price gap calculated in equation (2) is the amount of subsidy received per unit of energy consumed by a sector. To make this measure comparable across sectors, it needs to be weighted by the energy intensity of the sector:

$$w_{sc} = \left[\frac{\sum_f e_{fsc} \times \left(b_{fc} - r_{fc}\right)}{t_{sc}} \right] \times \frac{t_{sc}}{y_{sc}}, \tag{3}$$

where w_{sc} is the weighted fossil fuel subsidy received by a 2-digit sector s in country c and y_{sc} is sector output.[14] Equation (3) could be presented in a simplified way:

$$w_{sc} = \frac{\sum_f e_{fsc} \times \left(b_{fc} - r_{fc}\right)}{y_{sc}}. \tag{4}$$

This is our preferred formula, when data on fossil fuel consumption and output are available at the 2-digit sector level.[15] However, many countries lack detailed data. In this case, equation (3) could be re-written to accommodate information from a broader sector and other countries:

$$w_{sc} = \left[\frac{\sum_f e_{fmc} \times \left(b_{fc} - r_{fc}\right)}{t_{mc}} \right] \times \frac{1}{K} \sum_{k \neq c}^{K} \frac{t_{sk}}{y_{sk}}. \tag{5}$$

Equation (5) calculates the weighted fossil fuel subsidy received by a 2-digit sector s from country c based on the total amount of energy consumed by the entire manufacturing (or industry) sector of that country, which is denoted as t_{mc}. Rough breakdown of energy consumed by manufacturing, transport, households, and so on is available for almost all countries in our list. However, the energy intensity of the manufacturing sector is not suitable for the second multiplier in equation (3). Instead, equation (5) uses average energy intensity of sector s, calculated across K countries $k \neq c$ where detailed sector data are available.

As the price-gap estimates discussed above, subsidy estimates calculated using equations (4) or (5) are averaged over the years 2010-14 in order to address large unexplained

[14] Sector-level output data are obtained from the United Nations Industrial Development Organisation's (UNIDO) 2016 edition of Industrial Statistics (INDSTAT) database.

[15] Note that the calculation of subsidies excludes sectors with ISIC Rev. 3.1 codes 25 "Rubber and plastic products", 36 "Furniture and other manufacturing n.e.c." and 37 "Recycling". These sectors are aggregated under the "Non-specified" category in the IEA energy consumption data, which can also include other energy consumption that cannot be attributed to any particular industrial sector. Consequently, the "Non-specified" category cannot be used as a proxy for aggregated sectors 25, 36 and 37 because it is likely to overestimate their energy consumption.

variation in the fuel consumption data.

Figure 3 shows a heatmap of the resulting fossil fuel subsidies per unit of output by country and sector. A couple of things stand out. First, if the country has subsidies, they are usually present in all manufacturing sectors. This implies that using country-level fossil fuel price gap in the analysis makes sense. However, in most countries subsidies normalized by output are relatively low. Second, sectors 24 (chemical products), 26 (non-metallic mineral products) and 27 (basic metals) demonstrate the highest subsidies per output. This is not surprising as these sectors are among high-energy intensive ones according to Upadhyaya (2010). Hence, they benefit most from fossil fuel subsidies, but would be expected to suffer the most should subsidies be removed.

3.2.3 Environmental externalities of fossil fuel combustion

Coady et al. (2017) argue that the supply cost alone does not correspond to the efficient price of a fossil fuel. Indeed, as the consumption of fossil fuels is typically associated with environmental costs to be borne by the society, a Pigouvian tax equal to the amount of these costs needs to be introduced in order to resolve the commons dilemma. In the case of fuel combustion during manufacturing process, such a tax should compensate for the costs of global warming, which is caused by greenhouse gas emissions, and local air pollution.

To incorporate the cost of environmental externalities in our analysis, we devise an approach to calculate them in a way comparable with the two measures of fossil fuel subsidies discussed in the previous sections. Therefore, the country-level estimates of environmental costs are based on equation (1) for country-level fuel subsidies and are computed as:

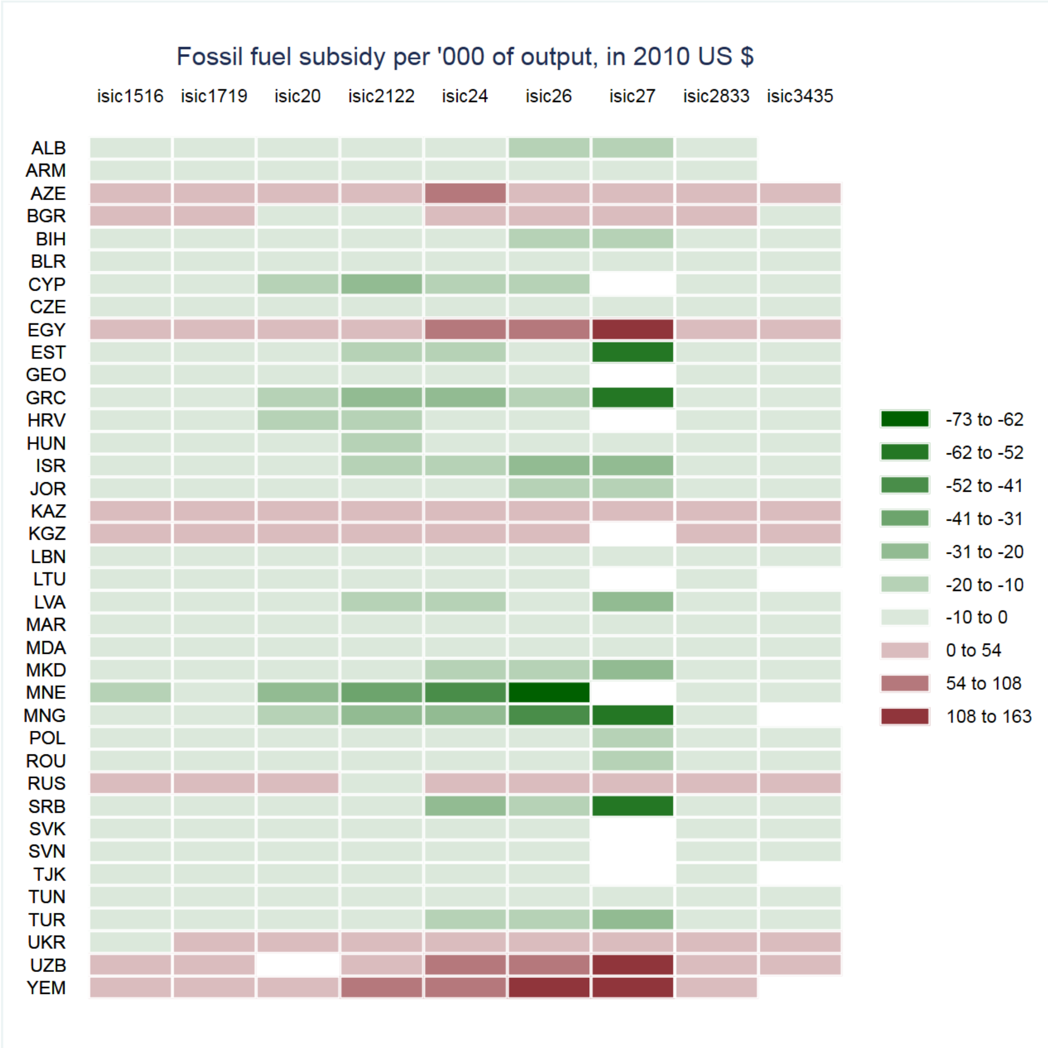
$$Ew_c = \frac{\sum_f e_{fc} \times w_f}{t_c}, \tag{6}$$

and

$$Ep_c = \frac{\sum_f e_{fc} \times p_{fc}}{t_c}, \tag{7}$$

where w_f and p_{fc} are the cost of global warming and local pollution externalities, respectively, associated with the combustion of fuel f required to generate 1 GJ of energy, and e_{fc} and t_c are the amount of fuel f and the total amount of energy consumed in country c. Ew_c is thus the global warming cost and Ep_c the local pollution cost of fossil fuel combustion per GJ weighted by the share of the corresponding fuel in the industry

Figure 3: Fossil fuel subsidies heatmap, 2010 USD per '000 of output



Source: IMF Energy Subsidies Template, IEA World Energy Balances and World Energy Statistics, UNIDO INDSTAT and authors' calculations.
Note: These estimates are averages over 2010-14. Blank (white) cells mean our data contain no firms in these country-sector pairs. Sector names include ISIC Rev 3.1 divisions. For example, "isic1516" is a combination of divisions 15 and 16. For the description of divisions, refer to Table A.1.

energy consumption mix. Note that the cost of local pollution p_{fc} is country-specific while the cost of global warming w_f is constant across countries.

In a similar vein, the country-sector level estimates of environmental costs follow equations (4) and (5). When data on fossil fuel consumption and output are available at the 2-digit level, country-sector level environmental costs are calculated as:

$$Ew_{sc} = \frac{\sum_f e_{fsc} \times w_f}{y_{sc}}, \tag{8}$$

and

$$Ep_{sc} = \frac{\sum_f e_{fsc} \times p_{fc}}{y_{sc}}, \tag{9}$$

where w_f and p_{fc} are the cost of global warming and local pollution externalities as defined above, e_{fsc} is the amount of fuel f consumed by, and y_{sc} is the total output of sector s in country c. Therefore, Ew_{sc} is the global warming cost and Ep_{sc} the local pollution cost of fossil fuel combustion per unit of sector output.

When detailed data on energy use and/or output are not available, Ew_{sc} and Ep_{sc} are calculated as:

$$Ew_{sc} = \left[\frac{\sum_f e_{fmc} \times w_f}{t_{mc}}\right] \times \frac{1}{K}\sum_{k\neq c}^{K} \frac{t_{sk}}{y_{sk}}, \tag{10}$$

and

$$Ep_{sc} = \left[\frac{\sum_f e_{fmc} \times p_{fc}}{t_{mc}}\right] \times \frac{1}{K}\sum_{k\neq c}^{K} \frac{t_{sk}}{y_{sk}}, \tag{11}$$

where e_{fmc} and t_{mc} are the amount of fuel f and the total amount of energy consumed by the entire manufacturing (or industry) sector in country c, while t_{sk} and y_{sk} denote energy use and output in sector s in K countries where detailed sector data are available.

As above for fossil fuel subsidies, the environmental costs calculated using equations (6)-(11) are averaged over the years 2010-2014.

3.3 Empirical specifications

Papers such as Bloom et al. (2012) and Bloom et al. (2010) confirm that firm-level management is significantly correlated to firm-level productivity.[16] The main question of this paper goes further: it asks whether the relationship between the quality of management practices and energy intensity depends on the availability of fossil fuel subsidies. Our methodology is based on Bloom et al. (2010) and the basic specification is as follows:

$$(FE/Y)_{isc} \times 100 = \beta_0 + \beta_1 M_{isc} + \gamma' \mathbf{Z_{isc}} + \nu' \mathbf{W_{ic}} + \sum_{sc=1}^{SC} \delta_{sc} D_{sc} + \epsilon_{isc} \tag{12}$$

[16] See Appendix D for a similar demonstration using the data analysed in this paper.

where FE denotes fuel expenditure, Y denotes total sales, and M is management practices z-score in firm i in sector s and country c. The dependent variable is fuel intensity (fuel costs as a percentage of total sales), winsorised at 5 per cent to minimise the impact of outliers.[17] The reference year was the survey reference year, which ranged from 2010 in Russia to 2014 in Cyprus and Greece.

Matrix **Z** comprises firm characteristics: total sales, capital (cost of machinery and equipment), labour (number of permanent, full-time employees), latitude and longitude of the firm's location, firm age, ownership structure, exporter status, indicator for credit constrained firms, percentage of employees with a university degree, listed status, indicator if electricity is an obstacle for firm's operations and percentage of self-generated electricity.

Matrix **W** includes the average January and July temperatures in the 25 km radius around the firm over 1970-2000,[18] and average intensity of night lights in years 2010-12[19] with a 10 km radius around the firm. We include these variables to control for the general climate and economic conditions around the firm, which could have an impact on its fuel intensity. The temperature averages are calculated over larger area due to a lower data resolution. D_{sc} denotes country*industry fixed effects.

Because the fossil fuel subsidy has a direct economic effect on firms' business, while environmental repercussions of fossil fuel combustion affect firms only indirectly and with a time lag, we first focus on fossil fuel subsidies and adjust equation (12) to produce the following specification:

$$\begin{aligned}(FE/S)_{isc} \times 100 = {} & \beta_0 + \beta_1 M_{isc} * P + \beta_2 M_{isc} \\ & + \gamma^{'}\mathbf{Z_{isc}} + \nu^{'}\mathbf{W_{ic}} + \sum_{sc=1}^{SC} \delta_{sc} D_{sc} + \epsilon_{isc},\end{aligned} \tag{13}$$

where P is a measure of fossil fuel subsidies at the country level (P_c) and at the country-sector (P_{sc}) level. The level of P is absorbed in the country*sector fixed effects.

To formally test whether the firms' energy intensity responds to the difference between the real price and supply costs of fuels as well as to the cost of externalities associ-

[17] Details are provided in Appendix B.

[18] These data come from the WorldClim version 1 database, developed by Hijmans et al. (2005) and available at `http://www.worldclim.org/version1`.

[19] Sourced from Version 4 DMSP-OLS Nighttime Lights Time Series, National Oceanic and Atmospheric Administration (NOAA) and available at `http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html`.

ated with these fuels, we augment specification in equation (13) by adding the environmental costs interacted with the quality of management practices, as follows:

$$
\begin{aligned}
(FE/S)_{isc}\times 100 = \beta_0 + \beta_1 M_{isc} * P + \beta_2 M_{isc} + \beta_3 M_{isc} * Ew + + \beta_4 M_{isc} * Ep \\
+ \gamma^{'}\mathbf{Z_{isc}} + \nu^{'}\mathbf{W_{ic}} + \sum_{sc=1}^{SC} \delta_{sc} D_{sc} + \epsilon_{isc},
\end{aligned}
\tag{14}
$$

where Ew is the global warming cost of fuel combustion and Ep is the local pollution cost of fuel combustion, with both measured either at the country or country-sector level. The levels of P, Ew and Ep are absorbed in country*sector fixed effects and not explicitly included in equation (14). If firms do not consider environmental externalities when deciding on energy intensity of their production, we would expect β_3 and β_4 not to be statistically significantly different from 0.

Models (12), (13) and (14) are estimated by OLS, using the *svy* command in Stata, using Taylor-linearised standard errors that account for survey stratification. To ensure that each economy is given equal consideration in averages, sampling weights within each economy are re-scaled to sum to one. To account for the possibility that management practices may matter more for energy intensity in sectors where energy is a higher portion of their costs, we split the sectors into high energy-intensive and moderate & low energy-intensive sectors according to energy input ratio following Upadhyaya (2010)[20] and allow the coefficients in the models with country-level measures of fossil fuel subsidies to vary by sector energy intensity. This is in the spirit of Boyd and Curtis (2014), who find that the relationship between management and energy intensity is the strongest for firms in energy-intensive sectors.

An alternative way of taking into account differences across sectors is to measure fossil fuel subsidies at the country-sector level. However, Lyubich et al. (2018) show that there is enormous heterogeneity in output per dollar of energy input even across firms within narrowly defined industries. To further account for these differences even when using fossil fuel subsidies measured at the country-sector level, we allow the coefficients to vary by whether or not the firms use self-generated electricity. Firms typically have electricity generators to be able to continue production or provide services when the

[20]For example, manufacture of chemical products, coke and refined petroleum products, paper and paper products are among high energy-intensive sectors, while food products, wood and wood products, machinery and equipment and recycling are among moderate and low energy-intensive sectors. Table A.1 in Appendix A provides more detailed information.

electricity supply is unreliable. However, having an electricity generator is costly and electricity generated by it is more expensive than electricity from the grid, especially if the price of electricity from the grid is subsidised. Firms that use self-generated electricity are thus likely to be less sensitive to energy prices and availability of fossil fuel subsidies.

3.4 Sample size and descriptive statistics

We focus on manufacturing firms with at least 20 employees (50 in Russia), for which measures of management practices are available. Table B.1 in Appendix B provides a breakdown of our sample by country. The number of observations ranges from 15 in Montenegro to 439 in Russia, 656 in Turkey, and 1,132 in Egypt.

Once the sample is restricted to firms with available data for variables used in the analysis (see section 3.3), the total number of observations drops from 4,973 to 2,246. Most of this drop is due to the availability of data for capital, fuel expenditures and sales – only 2,445 firms have non-missing data on all.[21] Out of these, 2,269 firms have non-missing data on management practices and percentage of employees with a university degree. The sample is further reduced to 2,246 due to missing data for age, exporter status, ownership and severity of electricity as an obstacle. We discuss possible sample selection issues in section 5.[22]

Table 1 presents descriptive statistics for all firm-level variables used in the analysis (with the exception of GPS coordinates). Energy expenditure constitutes 7.4 per cent of total sales, with electricity costs amounting to 3.9 per cent and fuel costs to almost 3.3 per cent of total costs, with all of them winsorised at 5 per cent.[23] Firms in the sample were on average better managed than all firms for which we have data on management practices. They had on average 106 permanent, full-time employees, generated just under US$ 22.8 million in sales during the last complete fiscal year, and have been operating for around 19.3 years. Of these firms, 16.2 per cent had at least 25 per cent foreign ownership, 43.1 per cent of them were exporters and 18 per cent of them were credit-constrained.

[21] Data are classified as missing if the response is don't know or refusal.

[22] BEEPS V and MENA ES also cover Djibouti, Kosovo and West Bank and Gaza. They are excluded from the analysis because all eligible observations in Djibouti have missing data on capital and the IMF Energy Subsidies Template does not have data on energy subsidies for Kosovo and West Bank and Gaza.

[23] See Appendix B for details on additional data cleaning.

Table 1: Firm-level descriptive statistics, sample

	Obs.	Mean	Std. Error
Energy costs, % total sales	2,205	7.356	0.380
Fuel costs, % total sales	2,246	3.271	0.224
Electricity costs, % total sales	2,205	3.868	0.224
Management (z-score)	2,246	0.029	0.047
Total sales, '000 USD	2,246	22,807.693	15,242.706
Number of PFT employees	2,246	105.715	6.383
Net book value of equipment, '000 USD	2,246	8,601.413	3,549.658
Credit-constrained firm, dummy	2,246	0.180	0.016
Exporting firm, dummy	2,246	0.431	0.021
Firm age	2,246	19.342	0.554
25+% foreign ownership, dummy	2,246	0.162	0.015
25+% state ownership, dummy	2,246	0.017	0.005
Percentage of employees with a university degree	2,246	17.430	0.691
Listed firm, dummy	2,246	0.043	0.008
% self-generated electricity	2,246	4.433	0.555
Electricity is major or severe obstacle	2,246	0.240	0.019

Source: BEEPS V, MENA ES and authors' calculations.
Note: Means and standard errors are calculated using survey-weighted observations (using Stata's svy prefix). Standard errors are Taylor-linearised standard errors. Energy, fuel and electricity costs as a % of total sales are winsorised at 5 per cent. PFT - permanent, full-time.

Self-generated electricity on average accounted for about 4.4 per cent of total electricity usage.[24] However, there were also firms that relied exclusively on self-generated electricity for their production needs. Overall, 24 per cent of firms stated that electricity was a very severe or major obstacle to their current operations.

4 Results

In this section we discuss the results obtained by estimating equations (12), (13) and (14). We also look into which component(s) of management practices are driving the results and check whether the findings still hold if we use total energy intensity rather than fuel intensity.

[24] In our data, no firms in Azerbaijan, Armenia, Czech Republic, Estonia, Latvia and Slovak Republic use self-generated electricity. Moreover, none of the firms in Azerbaijan and Slovak Republic owns or shares an electricity generator. Likelihood of using it varies across countries and industries.

4.1 Baseline specification

The baseline specification in equation (12) looks at the relationship between the quality of management practices and fuel intensity, not taking into account possible fossil fuel subsidies. We find a negative relationship between the quality of management practices and fuel intensity, statistically significant at the 10 per cent level (see Table 2, column 1). When we allow the coefficients to vary by the sector's energy intensity (column 2), using the classification from Upadhyaya (2010), it becomes clear that the correlation between the quality of management practices and fuel intensity is negative and statistically significant at the 5 per cent level for firms in moderate & low energy-intensive sectors, but close to zero (0.013) and insignificant for firms in high energy-intensive sectors. The lack of more statistically significant results for the latter in particular could be attributed to a number of different factors. As discussed earlier, better managed firms may either decrease their fuel intensity while using more efficient production techniques or increase it because of higher capital utilisation. It may also be that the relationship in high energy-intensive sectors in particular depends on the availability of fossil fuel subsidies, which is what we explore in the next section.

Models whose estimates are shown in Table 2 include a number of unreported firm characteristics that are statistically significantly associated with fuel intensity. The correlation between the volume of total sales and fuel intensity, on the one hand, is negative and significant. This suggests that larger firms need less fuel to produce a unit of output, which is consistent with economies of scale.[25] Labour and capital, on the other hand, are strongly and positively associated with fuel intensity, though this is driven by firms in the moderate & low energy intensity sectors. Intuitively, a higher amount of capital deployed in production should lead to higher fuel expenditures, *ceteris paribus*. A higher number of employees may require more equipment, leading to higher fuel expenditures, *ceteris paribus*. Among the firms in high energy-intensive sectors, the correlation between fuel intensity and share of employees with a completed university degree is negative and statistically significant at the 5 per cent level, suggesting that a more educated workforce could be more aware of or open to ways of reducing fuel intensity.

[25] To some extent, this is an artefact of the specification, because total sales are in the denominator of the dependent variable. Using log sales three fiscal years ago instead of log sales last complete fiscal year, the coefficient estimate on log sales three fiscal years ago is positive, but not significant. Results are available on request.

Table 2: Management practices and fuel intensity

Dep. var.: Fuel intensity	(1)	(2)
Management (z-score)	-0.302*	-0.426**
	(0.162)	(0.174)
Management (z-score) *		0.440
High energy intensity sectors		(0.378)
High energy intensity sectors		0.945
		(25.305)
Sales, log	-0.849***	-0.906***
	(0.179)	(0.216)
Sales, log *		0.204
High energy intensity sectors		(0.361)
Labour, log	0.889***	0.954***
	(0.246)	(0.282)
Labour, log *		-0.367
High energy intensity sectors		(0.528)
Capital, log	0.361***	0.430***
	(0.100)	(0.119)
Capital, log *		-0.246
High energy intensity sectors		(0.184)
Estimate for high energy intensity sectors		
Management (z-score)		0.013
		(0.335)
R^2	0.669	0.679
Observations	2,246	2,246

Source: BEEPS V, MENA ES and authors' calculations.
Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales and winsorised at 5 per cent. Sectors are split into high vs. moderate & low energy-intensive sectors according to Upadhyaya (2010). All regressions include country*sector fixed effects and control for other firm characteristics (log of firm age, percentage of employees with a college degree, percentage of self-generated electricity, longitude and latitude of the firm's location, January and July mean temperatures and nightlights around the firm, as well as indicators for listed firms, credit constrainedness, 25 per cent foreign and state ownership, exporter status and electricity as a major or very severe obstacle).

4.2 Country-level subsidies

To estimate the effect of relative price of fossil fuels on a firm's fuel intensity, we estimate the model in specification (13) for the full sample, as well as allow the coefficients to vary by sector energy intensity, to check whether fossil fuel subsidies on their own and interacted with management practices matter more for sectors where energy is a higher proportion of the firms' costs. The results are reported in Table 3.

Table 3: Management practices and fuel intensity: fossil fuel price gap

Dep. var.: Fuel intensity	(1)	(2)
Management (z-score)	-0.319**	-0.433**
	(0.162)	(0.173)
Management (z-score) * High energy intensity sectors		-0.014
		(0.423)
Management (z-score) * Fuel price gap	0.166	-0.114
	(0.109)	(0.110)
Management (z-score) * Fuel price gap * High energy intensity sectors		0.741***
		(0.232)
High energy intensity sectors		2.099
		(24.540)
Sales, log	-0.856***	-0.900***
	(0.180)	(0.216)
Sales, log * High energy intensity sectors		0.178
		(0.368)
Labour, log	0.886***	0.953***
	(0.246)	(0.281)
Labour, log * High energy intensity sectors		-0.279
		(0.517)
Capital, log	0.365***	0.428***
	(0.099)	(0.119)
Capital, log * High energy intensity sectors		-0.215
		(0.180)
Estimates for high energy intensity sectors		
Management (z-score)		-0.447
		(0.386)
Management (z-score) * Fuel price gap		0.626***
		(0.204)
R^2	0.670	0.683
Observations	2,246	2,246

Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales and winsorised at 5 per cent. Sectors are split into high vs. moderate & low energy-intensive sectors according to Upadhyaya (2010). Other control variables are the same as those listed under Table 2.

In column 1, the estimated coefficient on management practices quality is negative and statistically significant at the 5 per cent level, while its interaction with the fossil fuel price gap is positive, but not statistically significant. Allowing the coefficients to vary by sector energy intensity reveals that while the estimated coefficient on management practices quality is statistically significant for firms in moderate & low energy-intensive sectors, it is not statistically significant for firms in high energy-intensive sectors. The latter are much more responsive to fossil fuel price gap, with the coefficient on its interaction with management practices quality statistically significant at the 1 per cent level.

To understand the magnitude of the total impact of management practices on fuel intensity, we look at what happens when the quality of a firm's management practices improves from the 25^{th} to the 75^{th} percentile of the management practices quality distribution.[26] In a country where the fuel price gap is in the bottom quartile of the fuel price distribution, such improvement is associated with a 22.1 per cent *decrease* in their fuel intensity (statistically significant at the 5 per cent level). Conversely, in a country where the fuel price gap is in the top quartile, the same improvement is associated with a 0.9 per cent decrease in fuel intensity (not statistically significant). Estimates in column 2 indicate that firms in high energy-intensive sectors are more sensitive to fossil fuel prices and subsidies. For this subset of firms, such improvement is associated with a 54.1 per cent *decrease* in their fuel intensity (statistically significant at the 5 per cent level) in a country where the fuel price gap is in the bottom quartile of the fuel price distribution. In the top quartile, the same improvement is associated with an 35.5 per cent *increase* in fuel intensity (statistically significant at the 5 per cent level).

The implications of these results are that firms respond to incentives provided by fossil fuel subsidies: higher fossil fuel subsidies are associated with higher fuel intensity in high energy-intensive sectors.

4.3 Sector-level subsidies

The benefits of fossil fuel subsidies are not equally distributed among all firms within a country. Firms in high energy-intensive sectors are more likely to benefit from them than firms in sectors with moderate & low energy intensity, and their management is

[26]The magnitude of these effects is calculated by estimating the average marginal effects of management practices by quartiles of pre-tax fuel price (using the margins command in Stata), multiplying them by the interquartile range of the distribution of management practices quality and normalising the amount by the average fuel intensity in the estimation sample.

more likely to respond to the incentives provided by fossil fuel subsidies. But sectors use a different mix of fossil fuels in each country, and energy intensity differs even within high energy-intensive sectors. The results in Table 4 use a country-sector-level measure of fossil fuel subsidies, which accounts for these differences. Because we expect firms that use self-generated electricity to be less sensitive to fossil fuel prices, we allow the coefficients to vary by whether or not the firms use self-generated electricity in column 2.[27]

In column 1, the estimated coefficient on management practices quality is negative and the estimated coefficient on its interaction with fuel subsidy per output positive, with both estimates statistically significant at the 5 per cent level. In column 2, where the coefficients are allowed to vary by whether or not a firm uses self-generated electricity, none of the estimated coefficients is statistically significant. The subset of firms that use self-generated electricity and are thus less sensitive to energy prices is relatively small (361 out of 2,038), so the lack of significance is not surprising. However, the combined coefficient on management practices quality for firms that use self-generated electricity is positive, statistically significant at the 5 per cent level and more than 3.7-times larger in magnitude than the same coefficient for firms that do not use self-generated electricity (which is not statistically significant). Taken together, these results suggest that better managed firms that use self-generated electricity are less fuel intensive - which makes sense, since self-generated electricity using fossil fuels tends to be more expensive than electricity from the grid. In contrast, firms that do not use self-generated electricity and rely on the electricity from the grid, appear to be slightly more responsive to availability of fossil fuel subsidies, though the estimated coefficient is not statistically significant.

To understand the magnitude of the total impact of management practices on fuel intensity, we again look at what happens when a firm's management practices quality improves from the 25th to the 75th percentile of the management practices quality distribution, using estimates from column 1.[28] In country-sector pairs where the fuel subsidy per output is in the bottom quartile of the fuel price distribution, such improvement is

[27] The number of observations in Table 4 is lower than in Table 3, because IEA energy consumption data are not available for sectors with ISIC Rev. 3.1 codes 25 "Rubber and plastic products", 36 "Furniture and other manufacturing n.e.c." and 37 "Recycling". This makes it impossible to calculate country-sector-level subsidies and leads to the exclusion of these sectors for this part of the analysis.

[28] As in section 4.2, the magnitude of these effects is calculated by estimating the average marginal effects of management practices by quartiles of pre-tax fossil fuel subsidy per output (using the margins command in Stata), multiplying them by the interquartile range of the distribution of management practices quality and normalising the amount by the average fuel intensity in the estimation sample.

Table 4: Management practices and fuel intensity: fossil fuel subsidy per output

Dep. var.: Fuel intensity	(1)	(2)
Management (z-score)	-0.364**	-0.264
	(0.170)	(0.191)
Management (z-score) * Use self-generated electricity		-0.725
		(0.477)
Management (z-score) * Fuel subsidy/output	0.014**	0.014
	(0.007)	(0.009)
Management (z-score) * Fuel subsidy/ output * Use self-generated electricity		-0.001
		(0.014)
Use self-generated electricity		4.753
		(13.032)
Sales, log	-0.858***	-0.854***
	(0.192)	(0.203)
Sales, log * Use self-generated electricity		-0.050
		(0.456)
Labour, log	0.849***	0.700**
	(0.259)	(0.283)
Labour, log * Use self-generated electricity		0.610
		(0.584)
Capital, log	0.386***	0.385***
	(0.105)	(0.111)
Capital, log * Use self-generated electricity		0.084
		(0.244)
Estimates for firms that use self-generated electricity		
Management (z-score)		-0.989**
		(0.428)
Management (z-score) * Fuel subsidy/output		0.012
		(0.011)
R^2	0.659	0.666
Observations	2,038	2,038

Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales and winsorised at 5 per cent. Other control variables are the same as those listed under Table 2.

associated with a 20.7 per cent decrease in fuel intensity of firms (statistically significant at the 1 per cent level). Conversely, in country-sector pairs where the fuel subsidy per output is in the top quartile (that is, fossil fuel subsidies per output are high), the same improvement is associated with a 3.3 per cent decrease in fuel intensity (though not statistically significantly different from zero) – about a sixth of the impact associated with fossil fuel subsidy per output in the bottom quartile.

Comparing estimates in Table 4 with estimates in Table 3, it is clear that the change in the way we measure fossil fuel subsidies does not substantially affect the relationship between fossil fuel subsidies, on the one hand, and fuel intensity on the other hand. While the relevant coefficient estimates differ, the magnitude of the estimated total impact of management practices on fuel intensity is quite similar in the full sample regardless of the fossil fuel subsidy measure used. An improvement of management practices quality from the 25th to the 75th percentile of the management practices quality distribution is associated with about 21-22 per cent fuel intensity reduction when fossil fuel subsidies are low (negative) and with about a 1-3 per cent fuel intensity reduction when fossil fuel subsidies are high.

4.4 Management practices components

So far, we used an overall index of the quality of management practices, obtained by averaging the scores across the underlying management practices, grouped into four management areas. In Table 5, we look at whether certain management practices are more strongly correlated with fuel savings than others. The coefficients come from separate regressions of fuel intensity on the various management scores, fossil fuel subsidy measures and their interactions. Models in columns 1 and 2 correspond to the specifications tested in Table 3, columns 1 and 2 respectively. Model in column 3 correspond to the specification tested in Table 4, column 1. Therefore, fuel subsidy is measured at the country level (price gap) in columns 1-2 and at the country-sector level (subsidy per unit of output) in column 3.

Out of eight management practices, seven are negatively and one positively correlated with fuel intensity, though only the correlations of fuel intensity with the management practices on time frame of production targets and awareness of production targets are statistically significant in column 1. Some of the interactions of management practices with fuel price gap are positive and statistically significant, though. In particular, the time frame of production targets, the basis for managers' performance bonuses and primary way of promoting non-managers.

Allowing the coefficients to vary by sector energy intensity (column 2) reveals that six out of eight management practices are negatively correlated with fuel intensity for the subset of firms in moderate & low energy-intensive sectors, with the management practices on dealing with problems in the production process and time frame of production targets statistically significant at the 5 per cent level. Production targets could improve forecasts of input requirements, reducing waste and improving (fuel) efficiency. The coefficients on the interactions of fuel price gap with the number of production performance indicators, achievement of production targets, basis for managers' performance bonuses and primary way of promoting non-managers are all positive and statistically significant at the 5 per cent level for the subset of firms in high energy intensive sectors. This indicates that firms in high energy-intensive sectors respond to incentives more than those in moderate & low energy-intensive sectors.

Estimates in column 3, which use fuel subsidy per output rather than fuel price gap as a measure of fuel subsidies, are similar. All the estimated coefficients on management practices quality are negative, though only the awareness of production targets one is statistically significant (at the 1 per cent level). As before, the coefficients on the interactions of fuel subsidy per output with time frame of production targets, basis for managers' performance bonuses and primary way of promoting non-managers are positive and statistically significant at at least the 10 per cent level of significance (with the latter two statistically significant at the 5 per cent level).

Overall, it appears that practices related to people management are more strongly linked with fuel intensity once fossil fuel subsidies are taken into account than practices related to operations, monitoring or targets. This is similar in spirit to the findings of Bloom et al. (2010), though rather than indicating that the "use and analysis of performance indicators accompanied by some form of consequence management leads firms" to be less fuel intensive, it indicates that firms where individual performance is the basis for managers' bonuses and non-managers' promotion are more likely to respond to incentives provided by fuel prices. If fuel prices are lower thanks to fossil fuel subsidies, those firms tend to be more fuel intensive.

Table 5: Management practices components and fuel intensity (separate regressions for each component)

	Fuel subsidy measure		
	Price gap		Subsidy/output
Dep. Var.: Fuel intensity	(1)	(2)	(3)
Dealing with problems in the production process	-0.248	-0.381**	-0.272
Dealing with problems in the production process * High energy intensity sectors		0.231	
Dealing with problems in the production process * Fuel subsidy	-0.106	-0.197*	-0.011
Dealing with problems in the production process * Fuel subsidy * High energy intensity sectors		0.185	
Number of production performance indicators	-0.094	-0.190	-0.109
Number of production performance indicators * High energy intensity sectors		0.400	
Number of production performance indicators * Fuel subsidy	0.100	-0.036	0.007
Number of production performance indicators * Fuel subsidy * High energy intensity sectors		0.498**	
Time frame of production targets	-0.382**	-0.482**	-0.303
Time frame of production targets * High energy intensity sectors		0.182	
Time frame of production targets * Fuel subsidy	0.303***	0.298***	0.015*
Time frame of production targets * Fuel subsidy * High energy intensity sectors		0.048	
Achievement of production targets	0.035	0.066	-0.004
Achievement of production targets * High energy intensity sectors		-0.404	
Achievement of production targets * Fuel subsidy	-0.084	-0.221***	0.002
Achievement of production targets * Fuel subsidy * High energy intensity sectors		0.643**	
Awareness of production targets	-0.471***	-0.281	-0.511***
Awareness of production targets * High energy intensity sectors		-1.120**	
Awareness of production targets * Fuel subsidy	0.193	0.152	0.009
Awareness of production targets * Fuel subsidy * High energy intensity sectors		0.395	
Basis for managers' performance bonuses	-0.083	0.028	-0.050
Basis for managers' performance bonuses * High energy intensity sectors		-0.319	
Basis for managers' performance bonuses * Fuel subsidy	0.220**	0.044	0.018**
Basis for managers' performance bonuses * Fuel subsidy * High energy intensity sectors		0.428**	
Primary way of promoting non-managers	-0.017	-0.109	-0.013
Primary way of promoting non-managers * High energy intensity sectors		0.019	
Primary way of promoting non-managers * Fuel subsidy	0.277***	0.089	0.022**
Primary way of promoting non-managers * Fuel subsidy * High energy intensity sectors		0.489**	
Dismissal of under-performing non-manager	-0.062	-0.094	-0.047
Dismissal of under-performing non-manager * High energy intensity sectors		0.037	
Dismissal of under-performing non-manager * Fuel subsidy	-0.138	-0.020	-0.007
Dismissal of under-performing non-manager * Fuel subsidy * High energy intensity sectors		-0.323	

Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Every section represents a separate regression of fuel intensity on a different management practices z-score. Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively, using Taylor-linearised standard errors that account for survey stratification (not reported). The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales and winsorised at 5 per cent. Other control variables are the same as those reported in Table 2.

If we include all management practices components and their interactions with fossil fuel subsidies in the same regression, the estimated coefficients generally keep their sign and magnitude, but not necessarily significance. When using fossil fuel subsidy per output instead of fuel price gap, the coefficient on the interactions of fossil fuel subsidy with the basis for managers' performance bonuses remain positive and statistically significant at the 5 per cent level, but the coefficient on the interaction of fossil fuel subsidy with awareness of production targets and primary way of promoting non-managers lose their significance.

4.5 Environmental externalities

We have shown that the firm's fuel intensity responds differently to fuel price distortions depending on the quality of management practices adopted by the firm. We proceed with testing whether firms take into account environmental externalities of fuel combustion (global warming and local pollution) in their decision-making process by estimating equation (14). The models in columns 1 and 2 of Table 6 use the country level measures of fuel subsidies (i.e. price gap) and environmental costs, while model in column 3 utilises the country-sector level measures (subsidy and environmental costs per output).[29]

The results in Table 6 mostly reaffirm our previous findings: the estimated coefficients on management practices quality interacted with fossil fuel subsidy are similar to their counterparts in Tables 3 and 4. As before, better managed firms in high energy-intensive sectors are more likely to take advantage of fossil fuel subsidies by increasing their fuel intensity (column 2).

The interaction of management practices quality with the local pollution cost provides further insight into firms' behaviour. The estimated coefficients in all columns are negative and statistically significant at at least the 10 per cent level of significance. This indicates that good managers, regardless of their sector's energy intensity, are aware of the costs of local pollution paid by the society and take them into account at least to some degree when deciding on the level of their firms' fuel intensity. However, they do not take into account the cost of global warming, which may be less tangible - the estimated coefficients on the interaction of management practices quality with the cost of global warming are not statistically significantly different from zero.

[29] For Yemen, the breakdown of environmental costs into global warming and local pollution is not available, so it is excluded from the analysis.

Table 6: Management practices and fuel intensity: fossil fuel subsidies and environmental externalities

	Fuel subsidy measure		
	Price gap		Subsidy/output
Dep. Var.: Fuel intensity	(1)	(2)	(3)
Management (z-score)	0.073	0.078	-0.232
	(0.525)	(0.564)	(0.188)
Management (z-score) *		-0.954	
High energy intensity sectors		(1.220)	
Management (z-score) * Fuel subsidy	0.088	-0.187	0.003
	(0.121)	(0.119)	(0.009)
Management (z-score) * Fuel subsidy *		0.634***	
High energy intensity sectors		(0.236)	
Management (z-score) * Global warming costs	-0.013	-0.130	0.035
	(0.523)	(0.556)	(0.023)
Management (z-score) * Global warming costs *		1.131	
High energy intensity sectors		(1.228)	
Management (z-score) * Local pollution costs	-0.147**	-0.139*	-0.028**
	(0.068)	(0.076)	(0.012)
Management (z-score) * Local pollution costs *		-0.271	
High energy intensity sectors		(0.211)	
Estimates for high energy intensity sectors			
Management (z-score)		-0.876	
		(1.081)	
Management (z-score) * Fuel subsidy		0.447**	
		(0.203)	
Management (z-score) * Global warming costs		1.001	
		(1.094)	
Management (z-score) * Local pollution costs		-0.409**	
		(0.197)	
R-squared	0.675	0.693	0.667
Observations	2,225	2,225	2,018

Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales and winsorised at 5 per cent. Other control variables are the same as those listed under Table 2. The sample excludes Yemen as the data on the costs of local pollution are not available for this country.

Nevertheless, they cannot ignore the availability of fossil fuel subsidies, which tend to work in the opposite direction. The combined effect of fossil fuel subsidy and environmental costs interacted with management practices quality is negative in column 1 and positive in column 3, but neither estimate is statistically significant. However, the results in column 2 demonstrate that the average energy intensity of the sector matters. In sectors with moderate & low energy intensity, better quality of management practices is associated with lower fuel intensity. In contrast, in high energy-intensive sectors the effect of management practices quality interacted with fossil fuel subsidies prevails - with better quality of management practices associated with higher fuel intensity. This overall effect, however, is also not statistically significant.

4.6 Energy intensity

Several papers find that electricity and at least some of the fossil fuels are, to a certain degree, substitutes (see, for example, Serletis et al., 2010, 2011, for 15 countries, including Hungary, Poland and Turkey). Ideally, we would calculate total fossil fuel subsidies, including subsidies for electricity generated using fossil fuels, and estimate their impact on energy intensity (fuel and electricity intensity). However, it is very difficult to obtain the cost of electricity generation. Electricity price gap measure is only available for 14 countries in our sample, which further reduces the sample available for estimation. To provide at least an indication of how fossil fuel subsidies affect energy intensity, we estimate models (12) and (13) using energy intensity as the dependent variable.

As before, the correlation between management practices quality and energy intensity is negative overall and for the subset of firms in moderate & low-energy intensive sectors, but positive for the subset of firms in high energy-intensive sectors. However, it is never statistically significant.[30] Once we control for fossil fuel subsidies (see Table 7), the coefficient on management practices quality remains negative and insignificant, regardless of the specification. However, the coefficient on the interaction between management practices quality and fossil fuel subsidy is positive and statistically significant at at least the 10 per cent level of significance for both types of fossil fuel subsidy measures (columns 1 and 3).

Allowing the coefficients to vary by sector energy intensity (column 2) reveals that this is driven by high energy-intensive sectors. Improving a firm's management practices quality from the 25th to the 75th percentile of the management practices quality distribution in a country where the fuel price gap is in the top quartile of the fuel price

[30] Results available on request.

Table 7: Management practices and energy intensity: fossil fuel subsidy

	Fuel subsidy measure		
Dep. var.: Energy intensity	(1)	(2)	(3)
Fuel subsidy measure	Price gap		Subsidy/output
Management (z-score)	-0.201	-0.399	-0.181
	(0.268)	(0.284)	(0.279)
Management (z-score) * Fuel subsidy	0.340*	-0.068	0.026**
	(0.181)	(0.177)	(0.012)
Management (z-score) * High energy intensity sectors		-0.048	
		(0.687)	
Management (z-score) * Fuel subsidy * High energy intensity sectors		1.098***	
		(0.388)	
High energy intensity sectors		13.057	
		(43.761)	
Sales, log	-2.078***	-2.099***	-2.057***
	(0.293)	(0.352)	(0.313)
Sales, log * High energy intensity sectors		0.073	
		(0.590)	
Labour, log	1.986***	1.789***	1.933***
	(0.407)	(0.439)	(0.428)
Labour, log * High energy intensity sectors		0.536	
		(0.912)	
Capital, log	0.547***	0.744***	0.582***
	(0.165)	(0.189)	(0.173)
Capital, log * High energy intensity sectors		-0.552*	
		(0.299)	
Estimates for high energy intensity sectors			
Management (z-score)		-0.447	
		(0.625)	
Management (z-score) * Fuel price gap		1.030***	
		(0.345)	
R^2	0.686	0.700	0.670
Observations	2,205	2,205	2,002

Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. The dependent variable, energy intensity, is calculated as fuel and electricity expenditures over total sales and winsorised at 5 per cent. Fossil fuel subsidy is measured at the country level (price gap) in columns 1 and 2 and at the country-sector level (subsidy/output) in column 3. Sectors are split into high vs. moderate & low energy-intensive sectors according to Upadhyaya (2010). Other control variables are the same as those listed under Table 2.

gap distribution is associated with a 7.7 per cent *increase* in energy intensity (not statistically significant). Conversely, in a country where the fuel price gap is in the bottom quartile, the same improvement in the quality of management practices is associated with a 12.0 per cent *decrease* in energy intensity (statistically significant at the 10 per cent level). In high energy-intensive sectors, the increase is 32.2 per cent (statistically significant at the 5 per cent level) and decrease 34.4 per cent (statistically significant at the 10 per cent level).

5 Sensitivity analysis

In the empirical analysis, we control for country*industry fixed effects, as well as for firm characteristics. We winsorise the outcome variables at 5 per cent, to exclude outliers and we use survey weights that sum up to 1 within each country, so that each country has the same weight in the regressions, regardless of the number of observations.

However, given that the availability of variables included in the regressions varies by country and by firms within countries, we run the risk that the results are driven by a specific country. Moreover, as shown in section 2.1, we lose observations due to missing values for both dependent and independent variables and the results are potentially affected by the selection bias. We address these two concerns below.

5.1 Changes in the sample

To test for the robustness of our results to changes in the sample, we re-estimate specifications in Tables 3 (column 1 and estimates for high energy-intensive sectors in column 2) and 4 (column 1), removing one country and one sector at a time from the sample.

Figure 4 illustrates the stability of the estimated coefficient on the quality of management practices interacted with fuel subsidy using price gap and subsidy per output measures, excluding one country at a time on the left (4a) and one sector at a time on the right (4b). Although the coefficients on the left are broadly robust, Egypt – which has the largest number of firms in our sample – has important influence on the overall coefficient. Excluding it from the sample results in a coefficient estimate that is larger in magnitude and statistically significant at higher level of significance in panels B and C than at the levels in the corresponding tables and columns for the full sample. This could be because the quality of management practices in Egyptian firms is on average lower than in firms in most of the other countries, and they do not adapt their energy intensity behaviour to the fossil fuel subsidy availability to the same extent as better managed firms would under the same circumstances.

Figure 4 also confirms that the stability of the estimated coefficient for the quality of management interacted with fuel subsidy using price gap and subsidy per output measures generally holds if we exclude one sector at a time (4b). The estimates in panels A and B are somewhat sensitive to the exclusion of sector 17 (textiles), and estimates in all panels are sensitive to the exclusion of sector 26 (non-metallic mineral products). In panel B, the estimates remain statistically significant at the 10 per cent level, but they lose their significance in panel C. Sectors 17 and 26 are both high energy-intensive, and fuel subsidies per output are highest on average in the latter (as indicated in Figure 3), so this is not surprising.

5.2 Selection bias

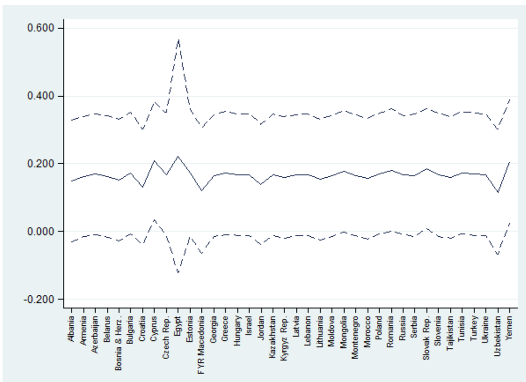
How do the firms in the final sample differ from the full sample? Table 8 shows the differences in the average fuel intensity by the availability of right-hand-side variables which cause the number of observations to drop. The results indicate that firms with missing: (i) exporter status; (ii) assessment of electricity as an obstacle; and (iii) data on the percentage of employees with a completed university degree are statistically significantly less fuel intensive than firms that provide this information. However, the difference in the average fuel intensity of firms with non-missing data for all independent variables and firms for which at least one of the control variables has missing values is not statistically significant ($p = 0.797$).

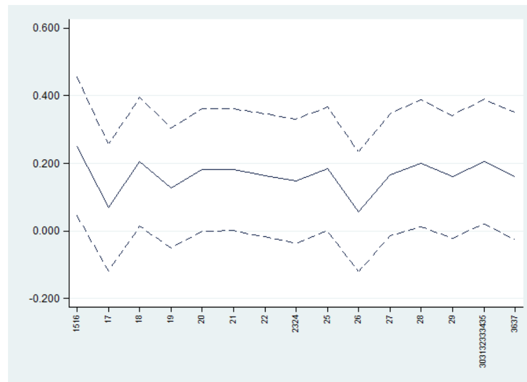
The number of observations also drops because of missing values for the dependent variable, fuel intensity. Table B.2 in Appendix B looks at whether any of the independent variables is statistically significantly associated with the likelihood that data on fuel intensity are missing; the dependent variable is an indicator equal to 1 if data are missing and 0 otherwise. Column 1 uses the sample with all control variables; it indicates that credit-constrained firms are less likely to have missing data on fuel intensity.

Figure 4: Estimated coefficient on the quality of management interacted with fossil fuel price gap and 90 per cent confidence intervals, excluding one country or one sector at a time

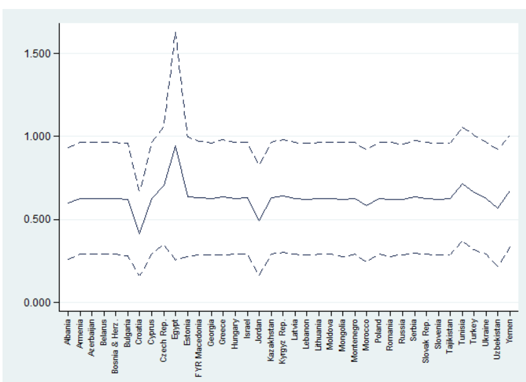
(a) Excluding one country at a time **(b)** Excluding one sector at a time

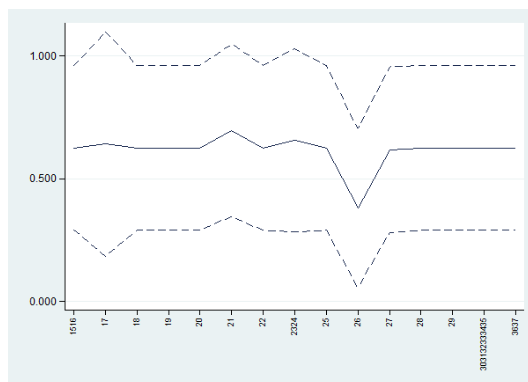
Panel A: Table 3, column 1



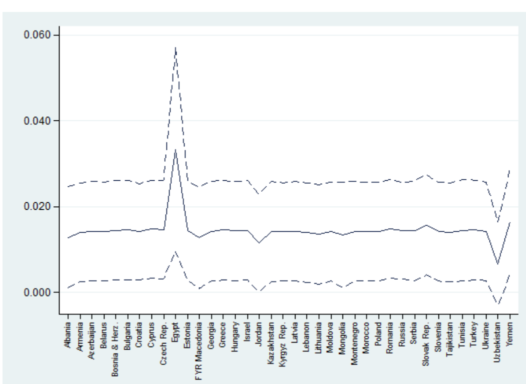


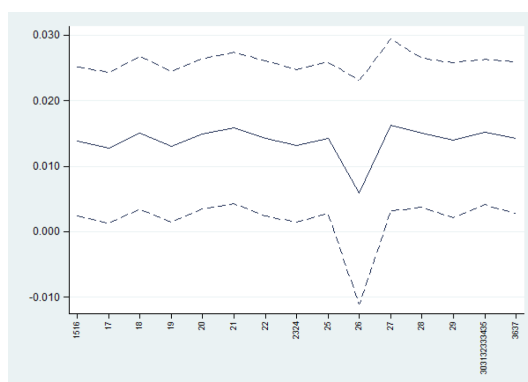
Panel B: Table 3, column 2, high energy-intensity sectors





Panel C: Table 4, column 1





Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Dashed lines represent the 90 per cent confidence interval. Refer to Table A.1 for the names of sectors.

Table 8: Differences in fuel intensity by data availability

Has data on	No Mean	Std. error	Yes Mean	Std. error	p-value
Management (z-score)	2.736	0.542	3.338	0.219	0.303
Capital, log	3.634	0.533	3.193	0.211	0.442
% with a completed university degree	2.333	0.340	3.356	0.220	0.012
Age	4.114	0.796	3.312	0.212	0.330
25+% foreign ownership	5.803	2.788	3.308	0.212	0.372
25+% state ownership	6.519	3.013	3.307	0.212	0.288
Exporter status	1.254	0.313	3.324	0.213	0.000
Electricity as an obstacle	1.288	0.553	3.319	0.212	0.001
All control variables	3.399	0.445	3.271	0.227	0.797

Source: BEEPS V, MENA ES and authors' calculations.
Note: Means using survey-weighted observations (using Stata's svy prefix). Fuel intensity is winsorised at 5 per cent. Taylor-linearised standard errors account for survey stratification.

Because availability of some of the control variables is limited, the specification does not include a measure of capital in columns 2-5. In columns 4 and 5, management practices quality is no longer included as a control variable, in addition to capital. Samples in columns 3 and 5 use the same sample as specification in column 1. While some estimates are statistically significant in some of the columns, none is statistically significant in all of them.

Taken together, Tables 8 and B.2 suggest that selection bias due to missing values for outcome and control variables is unlikely to significantly bias our findings.

6 Conclusion

In this paper, we combine information on firm-level quality of management practices and firm-level fuel and energy intensity with the information on fossil fuel subsidies, measured at the country and country-sector level. We focus on fuel intensity and find that fossil fuel subsidies, whether measured at the country level or country-sector level, have an impact on the relationship between fuel intensity and management practices quality with the results robust to a large number of additional controls, such as industry, size, ownership and other firm characteristics.

An improvement of management practices quality from the 25^{th} to the 75^{th} percentile of the management practices quality distribution is associated with a 21-22 per cent fuel intensity reduction when fossil fuel subsidies are low (or negative) and with a

1-3 per cent fuel intensity reduction when fossil fuel subsidies are high. The relationship is stronger in high energy-intensive sectors and its magnitude is substantial: the same improvement in management practices quality is associated with a 35.5 per cent *increase* in fuel intensity in a country where the fuel price gap is in the top quartile, and a 54.1 per cent *decrease* in fuel intensity in a country where the fossil fuel price gap is in the bottom quartile. In other words, better managed firms are less fuel intensive when fossil fuel prices are not distorted by fossil fuel subsidies, and more fuel intensive when fossil fuel prices are distorted by fossil fuel subsidies.

The results suggest that these findings are driven by certain types of management practices with the most important one being incentives to employees. Firms where individual performance is the basis for managers' bonuses and non-managers' promotion are more likely to respond to incentives provided by fuel prices. If fuel prices are lower thanks to fossil fuel subsidies, those firms tend to be more fuel intensive.

We find that the relationship between fuel intensity and management practices quality does not change once we control for environmental externalities of fossil fuel combustion. However, higher local pollution costs are associated with lower fuel intensity, indicating that better managed firms do take into account indirect effect of at least one type of environmental externalities. On average, the effects of fossil fuel subsidies and environmental costs are similar in magnitude and opposite in direction, so their overall effect on the relationship between fuel intensity and management practices quality is negligible. However, in high energy-intensive sectors the "cleansing" effect of environmental costs does not completely compensate for the advantage associated with the gap between the real price and the supply costs of fossil fuels.

These results suggest that management practices that are associated with improved productivity (see Bloom et al., 2012, for a similar group of countries) may be linked to worse environmental performance in the absence of incentives to economise on energy use. Well-run firms use energy inputs more efficiently and thereby increase their productivity while at the same time reducing GHG emissions only when fuel prices are not distorted by subsidies. In a similar vein, improving the quality of their management practices could help firms reduce their energy intensity further when they face fuel taxes, including carbon taxes. Governments wishing to reduce GHG emissions should carefully consider the impact fuel prices have on firm behaviour.

References

Bloom, Nicholas, Christos Genakos, Ralf Martin, and Raffaella Sadun (2010) "Modern management: Good for the environment or just hot air?" *The Economic Journal*, Vol. 120, No. 544, pp. 551–572.

Bloom, Nicholas, Helena Schweiger, and John Van Reenen (2012) "The land that lean manufacturing forgot? Management practices in transition countries," *Economics of Transition*, Vol. 20, No. 4, pp. 593–635.

Bloom, Nicholas, Erik Brynjolfsson, Lucia Foster, Ron Jarmin, Itay Saporta-Eksten, and John Van Reenen (2013) "Management in America," CES Working Paper CES-WP-13-01, US Census Bureau Center for Economic Studies.

Boyd, Gale A. and E. Mark Curtis (2014) "Evidence of an "Energy-Management Gap" in U.S. manufacturing: Spillovers from firm management practices to energy efficiency," *Journal of Environmental Economics and Management*, Vol. 68, No. 3, pp. 463–479.

Clements, Benedict, David Coady, Stefania Fabrizio, Sanjeev Gupta, Trevor Alleyne, and Carlo Sdralevich (2013) *Energy subsidy reform: Lessons and implications*: Washington, D.C.: International Monetary Fund.

Coady, David, Ian Parry, Louis Sears, and Baoping Shang (2017) "How large are global fossil fuel subsidies?" *World Development*, Vol. 91, pp. 11–27.

EBRD (2011) *The Low Carbon Transition. Special Report on Climate Change*, London: EBRD.

——— (2017) *EBRD Transition Report 2017-18: Sustaining Growth*: EBRD.

EBRD, EIB, and WB (2016) *What's Holding Back the Private Sector in MENA? Lessons from the Enterprise Survey*, Washington, DC: The World Bank. License: Creative Commons Attribution CC BY 3.0 IGO.

Hijmans, Robert J., Susan E. Cameron, Juan L. Parra, Peter G. Jones, and Andy Jarvis (2005) "Very high resolution interpolated climate surfaces for global land areas," *International Journal of Climatology*, Vol. 25, No. 15, pp. 1965–1978.

International Energy Agency (2017) *Energy Efficiency 2017*, Paris: IEA.

Karplus, Valerie J. and Da Zhang (2017) "Management and energy efficiency in a Chinese manufacturing cluster," draft. Submission to the 9th Annual ARCS Research Conference.

Lyubich, Eva, Joseph S. Shapiro, and Reed Walker (2018) "Regulating mismeasured pollution: Implications of firm heterogeneity for environmental policy," NBER Working Paper 24228, National Bureau of Economic Research.

Martin, Ralf, Mirabelle Muûls, Laure de Preux, and Ulrich J. Wagner (2012) "Anatomy of a paradox: Management practices, organizational structure and energy efficiency," *Journal of Environmental Economics and Management*, Vol. 63, pp. 208–223.

Martin, Ralf, Laure de Preux, and Ulrich J. Wagner (2014) "The impact of a carbon tax on manufacturing: Evidence from microdata," *Journal of Public Economics*, Vol. 117, pp. 1–14.

Nachmany, Michal, Sam Fankhauser, Joana Setzer, and Alina Averchenkova (2017) *Global Trends in Climate Change Legislation and Litigation: 2017 Update*: Grantham Research Institute on Climate Change and the Environment.

OECD (2013) *Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels*, Paris: OECD.

Sakr, Dalia, Joern Huenteler, Tyeler Matsuo, and Ashish Khanna (2017) "Scaling up distributed solar in emerging markets: The case of the Arab Republic of Egypt," The World Bank Policy Research Working Paper 8103.

Serletis, Apostolos, Govinda R. Timilsina, and Olexandr Vasetsky (2010) "International evidence on sectoral interfuel substitution," *The Energy Journal*, Vol. 31, No. 4, pp. 1–29.

——— (2011) "International evidence on aggregate short-run and long-run interfuel substitution," *Energy Economics*, Vol. 33, No. 2, pp. 209–216, March.

Upadhyaya, Shyam (2010) "Compilation of energy statistics for economic analysis," Working Paper 01/2010, UNIDO, Vienna.

Appendices

A Classification of manufacturing sectors by energy input ratio

Table A.1: Classification of manufacturing sectors by energy input ratio

Intensity of energy consumption	ISIC	Description of activities
High energy-intensive	17	Textiles
	21	Paper and paper products
	23	Coke and refined petroleum products
	24	Chemical products
	26	Non-metallic mineral products
	27	Basic metals
Moderate energy-intensive	15	Food products and beverages
	18	Wearing apparel; dressing and dyeing
	19	Leather products
	20	Wood and wood products
	22	Printing and publishing
	25	Rubber and plastic products
	28	Fabricated metal products
Low energy-intensive	16	Tobacco products
	29	Machinery and equipment n.e.c.
	30	Office, accounting and computing machinery
	31	Electrical machinery and apparatus n.e.c.
	32	Radio, TV and communication equipment
	33	Medical, precision and optical instruments
	34	Motor vehicles, trailers and semi-trailers
	35	Other transport equipment
	36	Furniture and other manufacturing n.e.c.
	37	Recycling

Source: Upadhyaya (2010).

B Data cleaning and sample selection characteristics

Table B.1 shows the sample breakdown according to the availability of the outcome variable of interest and right-hand-side variables. In the raw data, there were 434 observations with fuel, electricity and energy costs below 0.01 per cent of sales or these costs exceeding 100 per cent of sales in the full sample. To check whether some of these were due to data entry errors (too few or too many zeroes for sales), we searched for these firms in Bureau van Dijk's Orbis and compared the magnitude of sales of these firms in BEEPS data with the magnitude of operating revenues there, where available. We were able to find 268 of these firms in Bureau van Dijk's Orbis database, with 169 of them having information on operating revenues in the fiscal year to which the BEEPS data refer.

We compared the magnitude of sales of these firms in BEEPS data with the magnitude of operating revenues in Orbis, and made corrections in 44 cases. Before winsorising the values at 5 per cent, we dropped 44 observations with fuel, electricity or energy costs equal to 100 or more percent of sales.

Table B.1: Sample breakdown

	No. of obs.				No. of obs.		
Country	All	With fuel exp. and sales	With fuel exp., sales, and all control variables	Country	All	With fuel exp. and sales	With fuel exp., sales, and all control variables
Albania	42	23	12	Latvia	50	14	9
Armenia	61	33	19	Lebanon	116	97	57
Azerbaijan	68	35	2	Lithuania	52	30	20
Belarus	74	47	33	Moldova	52	33	16
Bosnia and Herz.	59	42	33	Mongolia	58	42	25
Bulgaria	51	41	34	Montenegro	15	5	4
Croatia	52	45	38	Morocco	116	84	27
Cyprus	24	9	5	Poland	98	19	13
Czech Rep.	51	30	25	Romania	101	81	70
Egypt	1,132	921	790	Russia	439	221	134
Estonia	39	29	19	Serbia	43	34	28
FYR Macedonia	50	47	42	Slovak Rep.	51	22	16
Georgia	45	32	21	Slovenia	35	28	21
Greece	42	32	18	Tajikistan	50	27	17
Hungary	43	14	12	Tunisia	230	213	195
Israel	113	88	54	Turkey	656	172	128
Jordan	199	167	107	Ukraine	363	166	73
Kazakhstan	120	49	24	Uzbekistan	88	75	65
Kyrgyz Rep.	63	30	19	Yemen	32	25	21
Total					**4,973**	**3,102**	**2,246**

Source: BEEPS V and MENA ES.

Note: Control variables used are management practices, number of permanent, full-time employees, net book value of equipment, firm age, % of employees with a university degree, % of self-generated electricity, exporter status, indicators for listed firms and firms where electricity is major or severe obstacle. Exp. - expenditures.

Table B.2: Sample selection characteristics

	(1)	(2)	(3)	(4)	(5)
Dep. var.: Has data on fuel intensity	Restricted	No K	No K, restricted	No K or M	No K or M, restricted
Management (z-score)	0.125	0.139***	0.118		
	(0.091)	(0.049)	(0.090)		
Labour, log	-0.134	-0.066	-0.157*	-0.040	-0.133
	(0.095)	(0.052)	(0.085)	(0.049)	(0.088)
Capital, log	-0.024				
	(0.037)				
Firm age	0.093	0.077	0.091	0.080	0.087
	(0.145)	(0.079)	(0.144)	(0.076)	(0.145)
25+% foreign ownership, dummy	0.253	-0.140	0.235	-0.105	0.240
	(0.259)	(0.144)	(0.257)	(0.139)	(0.261)
25+% state ownership, dummy	0.048	0.235	0.055	0.239	-0.122
	(0.672)	(0.307)	(0.659)	(0.310)	(0.649)
Exporting firm, dummy	0.100	0.310***	0.089	0.318***	0.109
	(0.212)	(0.114)	(0.209)	(0.109)	(0.209)
% employees with a university	-0.006	-0.010***	-0.006	-0.008***	-0.006
degree	(0.005)	(0.002)	(0.005)	(0.002)	(0.005)
Credit-constrained firm, dummy	-0.429**	-0.115	-0.425**	-0.117	-0.414**
	(0.199)	(0.118)	(0.198)	(0.114)	(0.196)
Listed firm, dummy	0.539	-0.006	0.571	-0.093	0.517
	(0.465)	(0.236)	(0.460)	(0.219)	(0.454)
% self-generated electricity	-0.005	-0.006**	-0.005	-0.006**	-0.006
	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
Electricity is a major or	0.004	-0.109	0.011	-0.076	0.011
severe obstacle	(0.185)	(0.112)	(0.186)	(0.108)	(0.185)
Latitude	0.008	0.002	-0.001	0.008	0.005
	(0.079)	(0.039)	(0.076)	(0.037)	(0.077)
Longitude	-0.020	-0.006	-0.021	-0.006	-0.022
	(0.015)	(0.009)	(0.014)	(0.009)	(0.015)
Average January temperatures	0.002	0.015	-0.004	0.007	-0.015
in the firm's vicinity	(0.065)	(0.035)	(0.064)	(0.034)	(0.064)
Average July temperatures	-0.100	-0.034	-0.099	-0.026	-0.096
in the firm's vicinity	(0.074)	(0.034)	(0.073)	(0.033)	(0.074)
Average intensity of nighttime	0.006	-0.002	0.005	-0.003	0.005
lights in the firm's vicinity	(0.006)	(0.003)	(0.006)	(0.003)	(0.006)
F-test	4.00	4.47	4.12	4.32	4.20

Table B.2 – continued from previous page					
	(1)	(2)	(3)	(4)	(5)
Dep. var.: Has data on fuel intensity	Restricted	No K	No K, restricted	No K or M	No K or M, restricted
Observations	1,890	3,807	1,890	4,041	1,890

Source: BEEPS V, MENA ES and authors' calculations.

Note: *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. Average marginal effects based on probit using survey-weighted observations (using Stata's svy prefix). K - capital, E - electricity intensity, M - management (z-score).

C Construction of the management practice variable

We distinguish four management areas:

1. Operations

   Practice 1 (question R.1): Over the last complete fiscal year, what best describes what happened at this establishment when a problem in the production process arose?
   Answers (score in parentheses): "No action was taken" or "Don't know' (1), "We fixed it but did not take further action" (2), "We fixed it and took action to make sure it did not happen again" (3), "We fixed it and took action to make sure that it did not happen again, and had a continuous improvement process to anticipate problems like these in advance" or "Does not apply" (4).

2. Monitoring

   Practice 2 (question R.2): Over the last complete fiscal year, how many production performance indicators were monitored at this establishment?
   Answers (score in parentheses): "No production performance indicators" or "Don't know" (1), "1-2 production performance indicators" (2), "3-9 production performance indicators" (3), "10 or more production performance indicators" (4).

3. Targets

   Practice 3 (question R.6): Over the last complete fiscal year, what best describes the time frame of production targets at this establishment? Examples of production targets are: production, quality, efficiency, waste, on-time delivery.
   Answers (score in parentheses): "No production targets" or "Don't know" (1), "Main

focus was on short-term (less than one year) production targets" (2), "Combination of short-term and long-term production targets" (3), and "Main focus was on long-term (more than one year) production targets" (4).

Practice 4 (question R.7): Over the last complete fiscal year, how easy or difficult was it for this establishment to achieve its production targets?

Answers (score in parentheses): "Possible to achieve without much effort" or "Only possible to achieve with extraordinary effort" or "Don't know" or "Does not apply" (1), "Possible to achieve with some effort" (2), "Possible to achieve with normal amount of effort" (3), "Possible to achieve with more than normal effort" (4).

Practice 5 (question R.8): Over the last complete fiscal year, who was aware of the production targets at this establishment?

Answers (score in parentheses): "Only senior managers" or "Don't know" or "Does not apply" (1), "Most managers and some production workers" (2), "Most managers and most production workers" (3), "All managers and most production workers" (4).

4. Incentives

   Practice 6 (question R.11): Over the last complete fiscal year, what were managers' performance bonuses usually based on?

   Answers (score in parentheses): "No performance bonuses" or "Don't know" (1), "Their company's performance as measured by production targets" (2), "Their establishment's performance as measured by production targets" (3), "Their team or shift performance as measured by production targets" (4), "Their own performance as measured by production targets" (5).

   Practice 7 (question R.13): Over the last complete fiscal year, what was the primary way non-managers were promoted at this establishment?

   Answers (score in parentheses): "Non-managers are normally not promoted" or "Don't know" or "Does not apply" (1), "Promotions were based mainly on factors other than performance and ability (for example, tenure or family connections)" (2), "Promotions were based partly on performance and ability, and partly on other factors (for example, tenure or family connections)" (3), "Promotions were based solely on performance and ability" (4).

   Practice 8 (question R.15): Over the last complete fiscal year, when was an under-performing non-manager reassigned or dismissed?

Answers (score in parentheses): "Rarely or never" or "Don't know" or "Does not apply" (1), "After 6 months of identifying non-manager under-performance" (2), "Within 6 months of identifying non-manager under-performance" (3).

D Management practices and productivity

In this appendix we do a basic check on the data to confirm that our firm-level measure of the quality of management practices is correlated with the firm-level productivity, mirroring the results of Bloom et al. (2012).

We use the following firm-level production function:

$$y_{isc} = \alpha_0 + \alpha_l l_{isc} + \alpha_k k_{isc} + \alpha_n n_{isc} + \alpha_f f_{isc} + \beta M_{isc} + \nu' \mathbf{G_{isc}} + \sum_{s=1}^{S} \delta_s D_s + \sum_{c=1}^{C} \delta_c D_c + u_{isc} \tag{D.1}$$

where Y denotes total sales, L labour, K capital, N expenditure on materials (non-energy intermediate inputs), F fuel expenditure and M is management practices z-score of firm i in sector s and country c. Lower case letters denote natural logarithms, that is, $l = ln(L)$. The matrix **G** includes other controls that will affect productivity, such as workforce characteristics (employees with a completed university degree) and firm characteristics (firm age, indicators for at least 25 per cent foreign ownership, exporter and whether the firm is listed on the stock market). D_s and D_c denote industry and country fixed effects, respectively.[31]

We estimate equation D.1 by running OLS using the *svy* command in Stata, using Taylor-linearised standard errors that account for survey stratification. The results reveal nothing about causality, we look purely at the association between the quality of management practices and productivity.

Table D.1 investigates the association between firm performance and the quality of management practices. Column 1 reports an OLS regression of total sales controlling for worker and firm characteristics, country and sector fixed effects. The management practices score is positively and significantly correlated with higher sales. In column 2, we add log (employment) as additional control variable. As more productive firms tend to be larger, this reduces the management coefficient by more than a half, but it remains strongly significant at 5 per cent. In columns 3 and 5, we examine the association be-

[31] We group together ISIC Rev 3.1 sectors 15-16, 18-19, 21-22, 23-24, 26-27, 30-35 and 36-37.

tween management practices and total factor productivity by including further production factors: materials, fuel and capital. The point estimate on management practices falls substantially and the coefficient loses significance. However, the sample size drops substantially, too - by more than 1,000 observations. If we do not control for additional production factors on the same sample, the association between management practices and sales remains positive and statistically significant at the 10 per cent level (see column 4).

Table D.1: Management practices and productivity

Dep. var.: Sales, log	(1)	(2)	(3)	(4)	(5)	(6)
Management (z-score)	0.237***	0.104**	0.041	0.081*	0.020	0.057
	(0.046)	(0.043)	(0.037)	(0.042)	(0.043)	(0.049)
Labour, log		0.948***	0.777***	0.994***	0.741***	0.997***
		(0.047)	(0.050)	(0.043)	(0.059)	(0.048)
Materials, log			0.142***		0.150***	
			(0.026)		(0.021)	
Fuel, log			0.060***		0.054***	
			(0.013)		(0.014)	
Capital, log					0.039	
					(0.028)	
R^2	0.540	0.540	0.698	0.627	0.725	0.643
Observations	3,685	3,685	2,658	2,658	2,197	2,197

Source: BEEPS V, MENA ES and authors' calculations.
Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1 per cent level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. All regressions include country and sector fixed effects and control for other firm characteristics (log of firm age, percentage of employees with a college degree, indicators for listed firms, 25 per cent foreign ownership, and exporter status).

Since the results suggest that there could be differences between firms with data on additional variables and those without, we check the differences in management practices quality by data availability in Table D.2. It confirms that firms that provide information on their capital, fuel and energy expenditures are on average better managed than firms that do not provide this information, with the differences significant at 5 per cent level for capital and 10 per cent level for fuel and energy expenditures. This in effect reduces the variation in management practices quality in the sample used for estimation, and may result in the coefficient on management practices losing its significance

Table D.2: Differences in management (z-score) by data availability

Has data on	No Mean	Std. error	Yes Mean	Std. error	p-value
Capital, log	-0.124	0.044	0.019	0.044	0.021
Fuel expenditures, log	-0.134	0.054	-0.006	0.038	0.052
Energy expenditures, log	-0.123	0.051	-0.008	0.039	0.074
% with a completed university degree	0.008	0.125	-0.054	0.032	0.631
Age	-0.287	0.214	-0.048	0.031	0.269
25+% foreign ownership	-0.152	0.241	-0.049	0.031	0.674
Exporter status	-0.140	0.429	-0.049	0.031	0.831
All controls	-0.100	0.041	0.015	0.049	0.069

Source: BEEPS V, MENA ES and authors' calculations.
Note: Means using survey-weighted observations (using Stata's svy prefix). Taylor-linearised standard errors account for survey stratification.

in columns 3, 5 and 6.