ERF Working Papers Series

Is Egypt Ready for the EU Carbon Border Adjustment Mechanism? Evidence from Firm-Level Data

Yasmine Kamal, Mahmoud Mohieldin and Myriam Ramzy

ECONOMIC RESEARCH FORUM
منتدى البحوث الاقتصادية

Working Paper No. 1771
December 2024

IS EGYPT READY FOR THE EU CARBON BORDER ADJUSTMENT MECHANISM? EVIDENCE FROM FIRM-LEVEL DATA

Yasmine Kamal, [1] Mahmoud Mohieldin[2] and Myriam Ramzy[3]

Working Paper No. 1771

December 2024

Send correspondence to:
Yasmine Kamal
Cairo University
Yasmine_k@feps.edu.eg

[1] Assistant Professor of Economics at the Faculty of Economics and Political Science, Cairo University. and Research Associate at the Economic Research Forum.

[2] Professor of Economics at the Faculty of Economics and Political Science, Cairo University.

[3] Assistant Professor of Economics at the Faculty of Economics and Political Science, Cairo University and Research Associate at the Economic Research Forum.

First published in 2024 by
The Economic Research Forum (ERF)
21 Al-Sad Al-Aaly Street
Dokki, Giza
Egypt
www.erf.org.eg

Abstract

Egyptian firms are a vital case for examining the impact of the EU Carbon Border Adjustment Mechanism (CBAM) in its current transitional phase. CO2 emissions tariffs on imports implemented under the CBAM could threaten export competitiveness of developing countries-including Egypt- in the EU market. Thus, this study examines Egyptian firms' performance in greening their production process and the determinants of their environmental measures using data from the World Bank Enterprise Survey. Our findings indicate that green management practices matter for Egyptian firms' probability of adoption of green measures as well as the number of measures they adopt. In contrast, financial constraints negatively impact the probability of undertaking capital-intensive green investments such as machinery and vehicle upgrades. Also, specific targets for carbon emissions and energy consumption exert greater positive effect on the extensive and intensive margins of a firm's environmental performance than any other green management action. Qualitative analysis supports the quantitative findings on the importance of both managerial and financial factors in determining environmental performance. Egyptian firms in steel, fertilizers, and cement sectors that export to the EU have technically complied with CBAM requirements with the help of government bodies and through hiring consultants and training their employees. In interviews, they emphasized their need to establish reliable monitoring, reporting, and verification systems for their carbon emissions and to secure concessional long-term finance to undertake their decarbonization plans. They are also willing to engage in the trading of carbon certificates in the Egyptian exchange on the newly developed voluntary carbon market. Even as they are actively responding to CBAM, firms acknowledged their need to diversify their export destination markets so as not to depend primarily on the EU.

Keywords: CBAM, Firm-level, Financial Constraints, Green Management, Environmental Measures
JEL Classifications: D22, G32, Q50.

ملخص

تعتبر الشركات المصرية حالة حيوية لفحص تأثير آلية الاتحاد الأوروبي لتعديل حدود الكربون في مرحلتها الانتقالية الحالية. يمكن أن تهدد تعريفات انبعاثات ثاني أكسيد الكربون الواردات المنفذة بموجب آلية الاتحاد الأوروبي لتعديل حدود الكربون القدرة التنافسية للصادرات للبلدان النامية - بما في ذلك مصر - في سوق الاتحاد الأوروبي. وبالتالي، تبحث هذه الدراسة أداء الشركات المصرية في تخضير عملية إنتاجها ومحددات مقاييسها البيئية باستخدام بيانات من مسح مشاريع البنك الدولي. تشير النتائج التي توصلنا إليها إلى أن ممارسات الإدارة الخضراء مهمة بالنسبة للشركات المصرية لاعتماد إجراءات خضراء بالإضافة إلى عدد الإجراءات التي تتخذها. وعلى النقيض من ذلك، تؤثر القيود المالية سلبا على احتمال القيام باستثمارات خضراء كثيفة رأس المال مثل تحسين الآلات والمركبات. كما أن الأهداف المحددة لانبعاثات الكربون واستهلاك الطاقة تؤثر تأثيراً إيجابياً أكبر على الهوامش الواسعة والمكثفة للأداء البيئي للشركة من أي إجراء آخر للإدارة الخضراء. ويدعم التحليل النوعي النتائج الكمية بشأن أهمية العوامل الإدارية والمالية في تحديد الأداء البيئي. امتثلت الشركات المصرية في قطاعات الصلب والأسمدة والأسمنت التي تصدر إلى الاتحاد الأوروبي تقنيًا لمتطلبات آلية الاتحاد الأوروبي لتعديل حدود الكربون بمساعدة الهيئات الحكومية ومن خلال تعيين مستشارين وتدريب موظفيها. وفي المقابلات، شددوا على حاجتهم إلى إنشاء نظم موثوقة للرصد والإبلاغ والتحقق فيما يتعلق بانبعاثات الكربون، وإلى تأمين تمويل ميسر طويل الأجل للاضطلاع على خططهم لإزالة الكربون. كما أنهم على استعداد للانخراط في تداول شهادات الكربون في البورصة المصرية في سوق الكربون الطوعي المطور حديثًا. حتى في الوقت الذي تستجيب فيه الشركات بنشاط لآلية الاتحاد الأوروبي لتعديل حدود الكربون ، أقرت الشركات بحاجتها إلى تنويع أسواق وجهات التصدير الخاصة بها حتى لا تعتمد بشكل أساسي على الاتحاد الأوروبي.

1. Introduction

Mitigating climate change requires sharp reduction of the flow of heat-trapping greenhouse gas (GHG) emissions from main sources such as firms, cars, farms, and power plants (European Environment Agency, 2024). Governments must take accelerated actions for decarbonization to limit global warming to 1.5°C, and participants at COP27 should revisit and strengthen their nationally determined contributions to reach the goals of the Paris Agreement (UNFCCC, 2024).

Firms play a role in climate transition by setting targets for their emissions, energy and environmental performance (Center for Climate and Energy Solutions, 2024). The green economy has greatly expanded over the last two decades through their efforts as well as those of governments and individual households. Shifts away from fossil fuels to low-carbon sources of energy such as renewable energy (solar, wind, geothermal power); improving energy efficiency and using less energy overall in industries, in power generation and transmission, in transportation, and in public and private spaces; changing agricultural practices and farming methods that release high amounts of GHG emissions; ensuring a sustainable management and conservation of forests; creating a supportive environment for encouraging green investments to reduce emissions; and putting in place environmental policy instruments that work through market signals such as environmental/carbon taxes, especially for the most polluting sectors have had a cumulative effect (UNDP, 2024). Global investment in clean energy is almost double that of investment in fossil fuels, having grown from 1.125 trillion USD in 2015 to 2.003 trillion USD (International Energy Agency, 2024). Investments in renewable power and energy efficiency and end-use account represent the greatest share (72%; International Energy Agency, 2024).

Firms with better environmental performance tend to have more efficient production processes, and both the adoption of existing green technologies and environmental innovation shape their climate footprints (Capelle et al., 2023). Improvements in energy and operational efficiency, reduction in production costs, and increases in product sales save money (Center for Climate and Energy Solutions, 2024). Nonetheless, green investments, which are defined as "the investments necessary to reduce greenhouse gas and air pollutant emissions without significantly reducing the production and consumption of non-energy goods" require significant capital (Eyraud et al., 2013). While the pace of green capital accumulation has been accelerating since the 2010's (Eyraud et al., 2013), mainly due to technological progress, economies of scale, public policy support, and increasing environmental awareness, firms are very heterogeneous in undertaking decarbonization efforts. Those that are financially constrained (Lanteri and Rampini, 2023), that are not implementing voluntary environmental management systems (Khanna et al., 2009; Mungai et al., 2020), and that do not have high technological capabilities and capital upgrade efforts (Capelle et al., 2023) are lagging.

Governments are recognizing the importance of implementing environmental regulations to support firms' environmental performance by offsetting the problem of market failures associated with green investments persists. Without regulations, firms are unable to under-invest in green technologies since their private rate of returns are too low (Jaffe et al., 2004). Governments in the most advanced economies have focused on implementing more stringent market-based instruments (MBIs) of environmental regulations such as environmental taxes, environmental subsidies, tradable emission permits, and other voluntary schemes (e.g. eco-labeling). These regulations are advantageous since they allow firms to have greater flexibility to develop and adopt green technologies, and they are given more incentives to look for more effective ways of making sustained environmental progress (Stavins, 2001). Moreover, the increasing stringency of environmental regulations pushes firms to adopt green managerial practices and to achieve recognition for these practices through Environmental Management System certification and ISO 14001 certification (Hesse, 2007). The European Union has had a domestic scheme that imposes a price on goods based on emissions released during production; the Carbon Border Adjustment Mechanism (CBAM) extends this to imports. It entered into force in October 2023 in a transitional form and will be gradually ramped up over 12 years, affecting the price of iron and steel, aluminum, fertilizers, hydrogen, electricity, and cement, industries that therefore constitute the CBAM sectors (Jakob, 2024). An analogous measure has been introduced as a legislative proposal in the United States, and the UK has announced that it will implement a CBAM by 2027 (Pomerleau, 2024). Research suggests that these carbon pricing schemes will act as a major determinant of both green investments and the competitiveness of firms in manufacturing industries (Eyraud et al., 2013).

Such impact depends on firms greening their production process. This study explores such impact by studying the performance of Egyptian firms in CBAM sectors and the determinants of their environmental compliance. Given the increasingly negative effects of economic activities on climate change, it is paramount that we understand the main drivers of firm-level green investments (Lanteri and Rampini, 2023). Yet, the literature on the determinant of firms' green strategies is quite limited. In developing countries firms remain climate laggards, i.e., they tend to have higher emission intensities relative to industry-country peers, and thus there is a particular need for research on these contexts (Kalantzis, et al., 2022; Capelle et al., 2023).

We contribute to literature in four ways. *First*, we shed light on the link between firms' financial and green management practices and the decisions to undertake green investments. Financial practices of firms are mainly related to whether they report access to finance as a major obstacle or very severe obstacle, while their green management practices are mainly related to whether firms have strategic environmental objectives and managers who are responsible for reporting environment and climate change issues to CEO, Board or Owners of the firms, whether they monitor their energy consumption, and whether they have specific targets for energy consumption and CO_2 emissions. The model is extended by integration of an environmental regulation variable

(energy tax) to see how the tax, along with other explanatory variables, affects the adoption of green practices. *Second*, we restrict the analysis to identifying the determinants of green investments in 455 Egyptian firms. To our knowledge, no previous study has analyzed the determinants of green investments in CBAM sectors in Egypt. Most of the literature focuses either on identifying the determinants of green investments at the macroeconomic level for emerging and advanced economics (see for example Eyraud et al., 2013) or on a cross-section of firms from a single country (e.g., Kenya, Mungai et al., 2020; Ireland, Siedschlag & Yan, 2021; China, An & Madni, 2023) or particular regions (e.g., Europe and Central Asia and the Middle East and North Africa, Kalantzis et al., 2022; the EU, Capozza et al., 2021). A study by Abdou et al. (2020) investigated the main drivers of the adoption of green practices in the hospitality industry in Egypt, which is not subject to any regulations analogous to CBAM. *Third,* unlike the large portion of the literature that examines either the determinants of environmental innovations (Veugelers, 2012; Woerter et al., 2017; Rozendaal & Vollebergh, 2021; Garcia-Quevedo et al., 2022; Tchorzewska et al., 2022; Deng et al., 2023; Cao et al., 2024) or energy-efficient innovations (Costa- Campi et al., 2015; Capozza et al., 2021; Šūmakaris et al., 2021; Clementi & Garofalo, 2023), we focus on a wider range of green investment. Following Kalantzis and Revoltella (2019) and Kalantzis et al. (2022), we focus on 10 ten types: heating and cooling improvements, type of on-site energy generation, machinery and equipment upgrades, energy management, waste management, water management, air pollution control measures, upgrades of vehicles, other pollution control measures, and improvements to lighting systems. *Fourth,* in contrast to scholars who focus on the manufacturing sector as a whole (Martin et al., 2011; Kalantzis et al., 2022), we restrict the analysis to sectors concerned with CBAM regulation, namely chemicals, non-metals, and basic metals. *Fifth* and finally, to give a more nuanced picture on readiness for CBAM, we complement our quantitative findings with qualitative data gathered in focus group discussions about response actions to CBAM and challenges in de-carbonization plans from managers of firms operating in three CBAM sectors.

The paper proceeds as follows. Section two reviews the literature on the determinants of firms' green investments with a focus on managerial and financial factors. Section three describes the data for 455 Egyptian firms operating in CBAM sectors and presents the methodology. Section four examines the impact of managerial and financial factors on Egyptian firms. Section five complements the analysis with qualitative data from focus group discussions. Section six summarizes the findings and provides policy implications at the firm and country levels.

2. Literature review

Considering the pressing challenges imposed by climate change and pollution issues, it is paramount that firms undertake green investments, that is, that they use green technologies and more efficient production techniques to reduce, prevent, and compensate for environmental damage. The key components of these investments are the adoption of energy-saving measures, the deployment of renewable energy or clean energy sources (biofuel or nuclear power), and the

development of new low-carbon technologies that are good for the environment (An and Madni, 2023). The literature divides green measures undertaken by firms to reduce their carbon footprint into two categories. The first are support processes defined by measures that are directly linked to the production line and that are capital-intensive, namely climate friendly energy generation, machinery and equipment, and vehicle upgrades. In general, firms that pursue such measures have energy-intensive production processes. The second are easier to implement and are less disruptive to a firms' operation. They involve changes that are indirectly linked to the production line and are less capital-intensive, namely energy management systems, improvement to lighting, and air control measures. These require neither radical changes in machinery or equipment nor certificates for quality control procedures (Kalantzis and Revoltella, 2019; Kalantzis et al., 2022).

Theoretically speaking, profit maximizing firms that emit large amounts of pollutants and that are not subjected to any kind of regulations or penalties may undertake voluntary actions to reduce the intensity of their emissions. Internal factors and external factors that affect their ability to identify profitable investment opportunities and the learning costs of adoption can drive their motivations. Internal factors are related to their green management practices, the level of their technological capabilities (research and development spending), financial resources, and human resources such as their green employees, whereas external factors are related to their interaction with external stakeholders such as regulators, consumers, and environmental interest groups (Khanna et al., 2009; Eyraud et al., 2013; Capozza et al., 2021).

While the empirical evidence on the main determinants of firm-level green investments is scant (Kalantzis, et al., 2022), the existing literature focuses on a wide range of external and internal factors, which include finance and green management. Regarding the internal factors, the literature focuses on firms' characteristics. It finds that large firms are more likely to increase their environmental expenditures and to engage in green projects (Barbanov et al., 2021). Also, local (non-foreign) and privately owned firms, importers, and energy-intensive firms are more likely than their counterparts to be engaged in green investments (Siedschlag and Yan, 2021). Some studies show that financial performance affects green investments, but the picture is complex. On one hand, some studies report that firms that are more profitable and have high Tobin's Q are less likely to use green investments to enhance their image, and therefore that they invest less in green measures (Barbanov et al., 2021). On the other hand, they find that the rate of return on green investment and efficiency gains matters for firms' engagement in green measures. Therefore, managers focusing on short-term returns acquired by shareholders are less likely to engage in profitable investment for pollution reduction (Ambec and Lanoie, 2007). Furthermore, most findings confirm that firms with high research and development and technological capabilities may be more inclined to invest in innovative green technologies and solutions (An and Madni, 2023). Also, more innovative large firms tend to invest more in energy efficiency measures because they aim for higher productivity rates, investing more in new technologies, using more sources of information, and obtaining greater cost savings (Kalantzis and Revoltella, 2019). Some authors

also investigate the impact of the type of economic activity and show that firms that operate in manufacturing and service sectors are more likely to invest in energy efficiency measures due to the high share of energy cost in firms' turnover (Kalantzis and Revoltella, 2019).

Regarding the external factors, most studies tackle the role of environmental regulations, but their results were mainly inconclusive. While some studies show that regulatory pressures from existing and anticipated regulations stringency (e.g. higher carbon prices in the future) have increased the likelihood of being engaged in green investments (Khanna et al., 2009; Martin et al., 2011), others show that environmental taxes are ineffective at stimulating investment in greener technologies, meaning that environmental taxes are not incentivizing firms to invest in equipment for pollution control or in equipment linked to cleaner technologies (Siedschlag and Yan, 2021; Garcia-Quevedo et al., 2022). In addition, these studies suggest that public policy intervention via tax credits or investment subsidies facilitate access to capital and reduce risk of green investment, thereby enhancing the effect of environmental regulations on green investments (Eyraud et al., 2013; Chitimiea et al., 2021; Garcia-Quevedo et al., 2022). Some scholars also argue that high competition intensity and the pro-innovation effects of competition are more likely to encourage firms in increasing their green investments (Siedschlag and Yan, 2021). Relatedly, when the firm faces intense competition, it is more encouraged to undertake green investment to improve its image among customers and competitors, to reduce its operational costs as well as increase its market share (Abdou et al., 2020). Moreover, firms maximizing earnings always aim to adapt to continuous changes happening in their target market that reacts favorably to green investment. Hence, they become more inclined to invest in green measures (Chitimiea et al., 2021). Studies also show that positive spillover from firms with green investment in the same industry/region would help other firms to learn from their peers and would increase the environmental awareness of their managers, which increase their propensity to invest in clean technologies (Siedschlag and Yan, 2021). Furthermore, empirical evidence shows that firms' engagement in external efforts for climate mitigation/adaption is a strong factor for encouraging green investments (An and Madni, 2023). Yet, some studies acknowledge consumers' awareness of the environmental footprint of the products they buy as well as the pressure exerted by different stakeholders on firms to undertake green projects (Chitimiea et al., 2021). More specifically, university graduate consumers have strong positive commitment toward green consumption, and they tend to encourage firms to produce green products (Aliedan et al., 2023).

When it comes to green management as a determinant for firm-level green investment, empirical studies show that changes in firms' management system in the form of total quality environmental management motivate the adoption of more pollution prevention technologies (Khanna et al., 2009; Martin et al., 2011). These studies also confirmed that introducing environmental management systems increases cleaner production investment oriented to reduce energy consumption (Garcia-Quevedo et al., 2022), and that high commitment to green technology and encouragement of eco-labelling of goods and services are effective (An and Madni, 2023). In

addition, they stress the important role of a firm's culture towards environmental sustainability and the environmental awareness of its employees, managers, and customers (and customers' resulting reaction to firms' environmental practices) as main drivers of firms' adoption of environmentally friendly practices (Abdou et al., 2020). Moreover, some studies highlight the importance of green management practices in overcoming problems of asymmetric information, which would enhance the firm's awareness and willingness to implement climate-related green measures. Such studies indicate energy audit is a useful tool in overcoming information barriers related to mitigation measures and facilitates investments in energy-efficiency measures especially for small firms and for non-capital-intensive support processes. This is mainly explained by the potential higher rate of returns associated with non-capital-intensive support processes, lower capital spending, and ease of implementation (Kalantzis and Revoltella, 2019; Kalantzis et al., 2020).

Regarding the financial determinants of green investments, empirical findings show that finance constraints are a major driver for a firm's decision to invest in green measures. In general, investing in new and cleaner production technologies requires large down payments. Thereby, most empirical findings show that finance constraints could undermine firms' green investments related to energy efficiency measures even if they are deemed to be profitable. This is mainly explained by the fact that the green measures entail high investment costs and the lack of capital flows may slow down the adoption of such measures (Fleitera et al., 2012). Some authors also argue that firms that are exposed to a maturity extension program and rely more on long-term debt can focus on the environment by reducing toxic emissions and improve their use of input resources (Götz, 2018). Also, most studies report negative effects of finance constraints show that the effect is more pronounced for micro-, small-, and medium-sized firms that are associated with low energy-efficiency standards, whereas larger and more innovative firms are found to be operating with higher energy efficiency using new and cleaner technologies (Lanteri and Rampini, 2023). Some empirical findings show that the beneficial impact of green practices can cease to exist when firms, especially small firms, are financially constrained (Kalantzis and Revoltella, 2019). Furthermore, finance constraints exert negative effects on different types of green investments and support or production processes (Kalantzis et al., 2020).

Finally, some studies have considered both green management and finance constraints determinants for green investment. They point out that green quality management matters more than finance constraints for firms' decisions to undertake green investments. Thereby, they highlight the importance of raising environmental awareness among firms and to conduct programs that spread information about climate change problems and the possible climate mitigation measures to be undertaken (Kalantzis and Revoltella, 2019; Kalantzis et al., 2020). In addition, firms need to overcome their finance constraints and seek investment subsidies and soft loans to support their green investment (Fleitera et al., 2012). In general, most empirical studies confirm that it really pays off to invest in green projects, to implement quality green management, and to seek soft financial loans to finance such projects. The temporal aspect of such investments

should be taken into consideration because long-term scenarios should be implemented as the payback of such investments is longer (Ambec and Lanoie, 2007; Chitimiea et al., 2021).

3. Data, descriptive statistics, and methodology

3.1. Data

This study uses firm-level data from the latest World Bank Enterprise Survey of Egypt in 2020. The survey is composed of a representative sample of firms in the non-agricultural formal private sector of a country, where it captures all geographic regions and covers small, medium, and large firms. We focus on 455 firms that operate in CBAM broad sectors (Rev 3.1, ISIC 24, 26 and 27) which are deemed the most energy- and carbon-intensive among manufacturing sectors. This makes the study of their environmental performance's determinants particularly interesting.

A firm's green practices—as reported in the survey's Green Economy Module—reflect its adoption of any of these 10 measures: improving heating and cooling system, climate-friendly energy generation on site, waste management and recycling, energy management, water management, pollution control measures, machinery and equipment upgrades, vehicle upgrades, lighting systems improvements, and measures controlling other pollution. Among these, machinery and equipment upgrades, vehicle upgrades, climate-friendly energy generation, and waste management can be considered relatively capital-intensive and involve greater investments (Kalantzis et al., 2022).

For our explanatory variables of interest, a firm is defined as being financially constrained if it reports that access to finance is a major or very severe obstacle. We also construct an average score of a firm's green management practices that considers the following dimensions: if the firm mentions in its strategic objectives environmental or climate change issues, has a manager responsible for environmental or climate issues, monitors its energy consumption, and has specific environmental targets on energy consumption and CO_2 emissions.

3.2. Descriptive Statistics

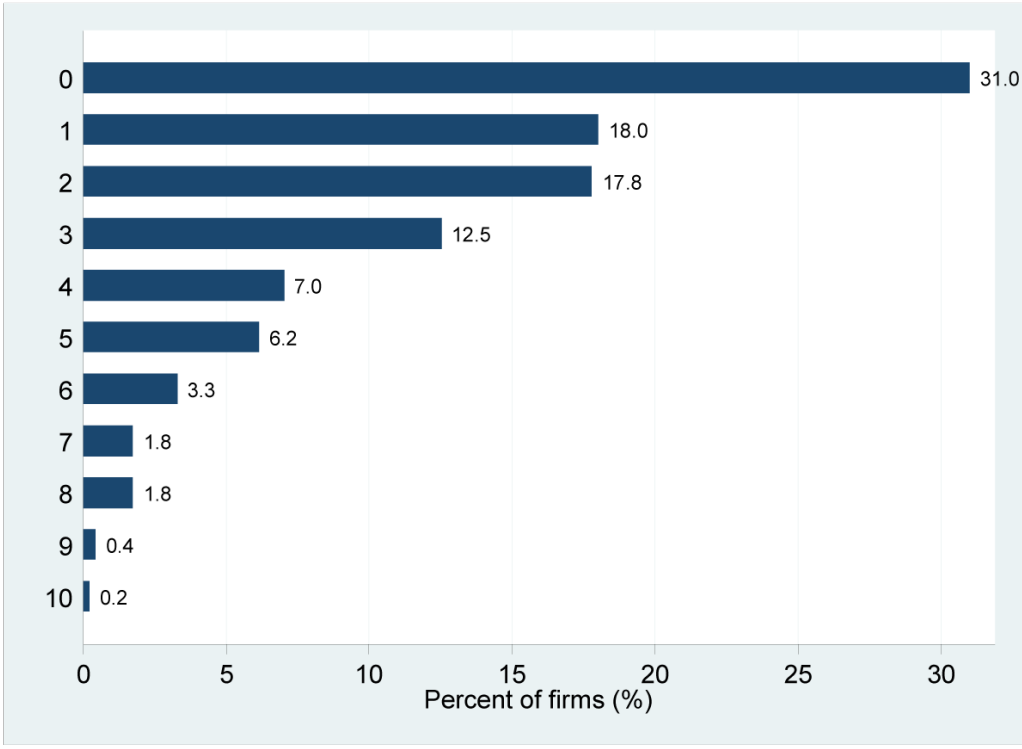
Table 1 shows the summary statistics of variables included in the empirical analysis. We find that an average of 17% of Egyptian firms in CBAM sectors are financially constrained. Additionally, most firms have poor green management practices, in that the average score is low (about 0.15). This can be attributed to the low proportion of firms with strategic objectives related to the environment and climate change (11%) or with a manager responsible for environmental issues (10%). Higher shares of firms have explicit environmental targets (17%), mostly for energy consumption, and engage in monitoring their energy consumption (about 29%).

Table 1. Summary statistics for Egyptian firms in CBAM sectors

Variable	Obs	Mean	Std. Dev.	Min	Max
Financially constrained	452	0.166	0.372	0	1
Strategic environmental objectives	455	0.114	0.319	0	1
Environmental manager	455	0.101	0.302	0	1
Monitoring energy consumption	455	0.286	0.452	0	1
Energy/carbon targets	455	0.174	0.379	0	1
Green management score	455	0.145	0.254	0	1
Energy levy	452	0.272	0.446	0	1
Exporter	455	0.174	0.379	0	1
Ln firm size	455	3.714	1.592	0.693	8.294
Ln firm age	455	3.100	0.776	0.693	7.615
Green investment	455	0.690	0.463	0	1
Green capital investment	455	0.626	0.484	0	1
Machinery upgrades	455	0.525	0.500	0	1
Vehicle upgrades	455	0.332	0.471	0	1
Waste management	455	0.292	0.455	0	1
Number of green investments	455	2.024	2.085	0	10

As Figure 1 shows, the most common response was that the firm had adopted one or two green measures, representing 36% of the sample. Only 14% had a superior green performance through adopting five or more measures, and 31% had not undertaken any green measure over the last three years.

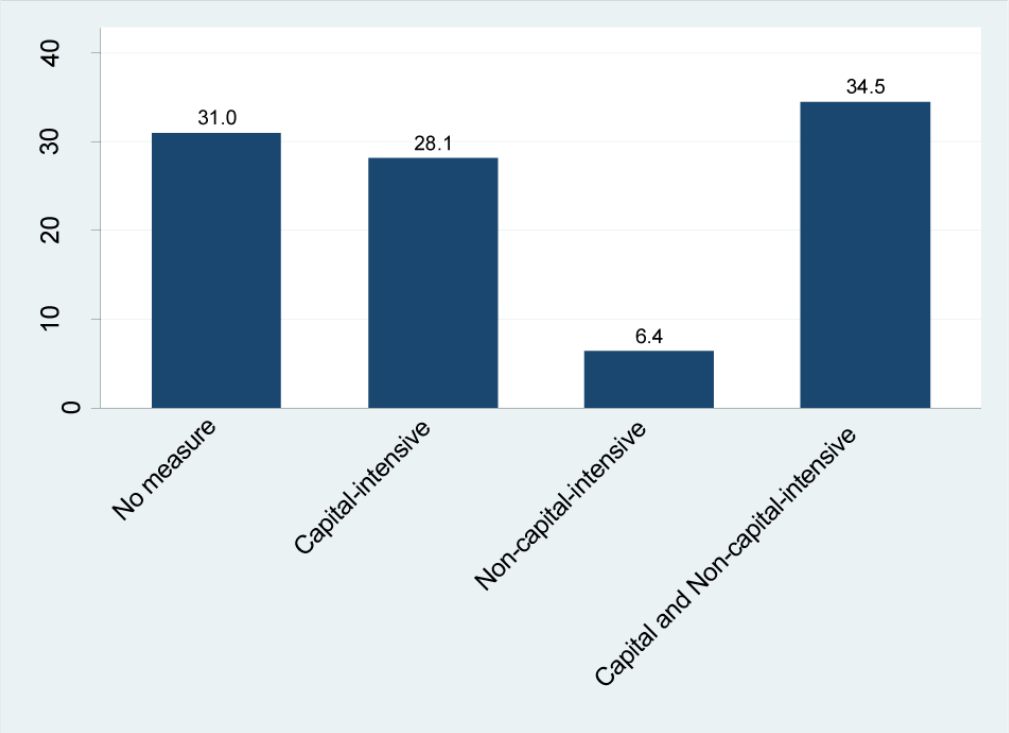
Figure 1. Number of green measures of Egyptian firms in CBAM sectors



Source: Own depiction based on the World Bank Enterprise Survey for Egypt 2020

Differentiating between types of green measures, Figure 2 indicates that most firms (35%) made joint capital and non-capital-intensive green investments, while the share of firms adopting only non-capital-intensive measures is the lowest (6%).

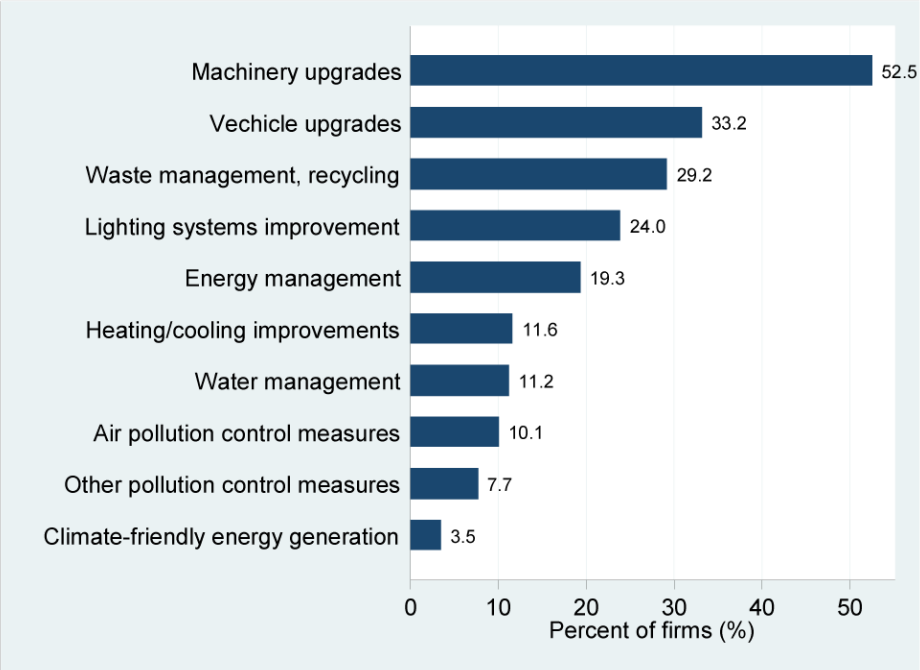
Figure 2. Type of green measures of Egyptian firms in CBAM sectors



Source: Own depiction based on the World Bank Enterprise Survey for Egypt 2020

Looking at the prevalence of each measure, Figure 3 shows that the top implemented green investments are machinery and equipment upgrades, followed by vehicle upgrades, and waste management and recycling. This indicates that green-oriented firms in CBAM sectors are likely to undertake relatively capital-intensive measures which concern their production process. The most frequent non-capital-intensive measures are lighting systems improvement and energy management. On site green energy generation is the least prevalent measure, with only 3.5% of firms adopting it.

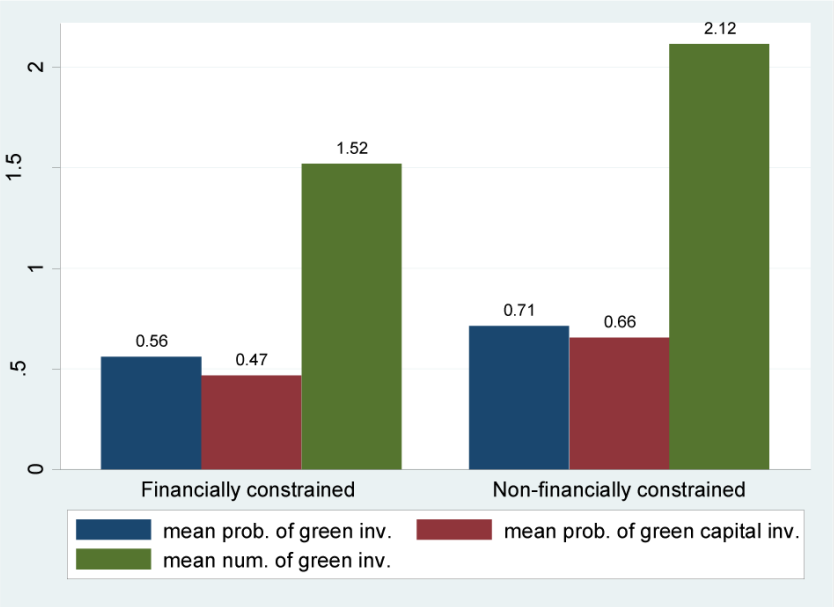
Figure 3. Prevalence of green measures of Egyptian firms in CBAM sectors



Source: Own depiction based on the World Bank Enterprise Survey for Egypt 2020

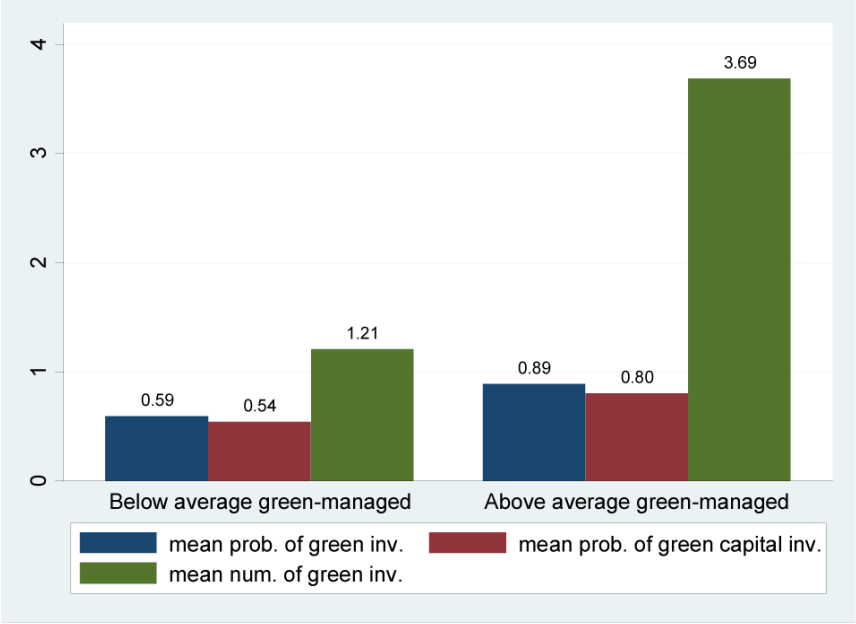
Next, the following figures give a preliminary idea of the correlation between firms' green measures and their financial and managerial characteristics. Figure 4 shows that financially constrained firms are less likely to adopt any green measure, especially a capital-intensive one; and that they tend to have a lower average number of measures compared to non-constrained firms. Similarly, badly green-managed firms (i.e., those with lower than the sample average green management score) exhibit worse green performance indicators, especially in the number of measures, compared to firms with better green management practices.

Figure 4. Financial constraints and green measures of Egyptian firms in CBAM sectors



Source: Own depiction based on the World Bank Enterprise Survey for Egypt 2020

Figure 5. Green management and green measures of Egyptian firms in CBAM sectors



Source: Own depiction based on the World Bank Enterprise Survey for Egypt 2020

3.3. Methodology

Ordinary least squares (OLS) regressions are used to estimate the effect of financial and managerial factors on firms' environmental performance. Equation 1 estimates the probability of adopting any of the 10 green measures reported in the survey, i.e. the extensive margin of green performance (EM) as follows:

$$ProbGreenMeaure_i = \alpha + \beta\ FinObstacle_i + \gamma\ GreenMgmt_i + \delta\ X_i + I + \epsilon_i \quad (1)$$

Where i denotes a firm operating in one of the CBAM sectors (ISIC 24, 26 and 27).

The dependent variable in (1) is the probability that the firm undertakes any green measure. Our main explanatory variables are whether the firm faces constraints in its access to finance and the average score of its green management practices. X_i is a set of control variables that include a firm's size and age (in logs), its exporter status (measured as a dummy variable that equals 1 if it directly exports at least 10% of its sales) and a dummy variable of its exposure to an energy tax/levy. I controls for two sets of fixed effects; the sub-regional and sector effects to capture unobserved heterogeneity across firms. A probit model is also used to estimate Equation 1 for robustness.

On the other hand, Equation 2 estimates the intensive margin of a firm's green performance (IM) as follows:

$$NumGreenMeaures_i = \alpha + \beta\ FinObstacle_i + \gamma\ GreenMgmt_i + \delta\ X_i + I + \epsilon_i \quad (2)$$

The dependent variable in (2) is the number of adopted green measures (from 0 to 10). An ordered probit model is also used to estimate Equation 2 for robustness, where the number of green measures is grouped into four categories: zero green measures, 1 measure, 2-4 measures, and 5 or more measures.

Additionally, Equation 3 estimates the probability of undertaking a green "capital-intensive" investment given its requirement of relatively larger financial resources as follows:

$$ProbGreenCapitalMeaure_i = \alpha + \beta\ FinObstacle_i + \gamma\ GreenMgmt_i + \delta\ X_i + I + \epsilon_i \quad (3)$$

The dependent variable in (3) is the probability that the firm undertakes a green capital-intensive measure. We also examine the determinants for the most prevalent types of capital measures, namely machinery upgrades, vehicle upgrades, and waste management. A probit model is also used to estimate Equation 3 for robustness.

Moreover, we examine the relative importance of the different green management components (strategic objectives, dedicated manager, monitoring, and targeting) on the firm's green performance.

4. Empirical results

Table 2 shows the results for Egyptian CBAM firms' extensive and intensive green performance. We find that financial constraints do not have a significant effect on either margin, whereas green management practices exert a significantly positive effect on both margins. Specifically, a one standard deviation increase in a firm's green management score is associated with a 13% higher probability of adopting a green measure and increases the number of its adopted measures by 1.2. Concerning our control variables, larger-sized firms fare better on both margins. Also, younger firms and those subject to an energy tax/levy are more likely to implement a green measure. On the other hand, being an exporter is non-significant. These results are robust to the use of Probit/Ordered Probit estimation methods (Appendix Table A.1).

Table 2. Financial constraints, green management, and green measures

	(1) Prob. Green Measure (EM)	(2) Num. Green Measures (IM)
Financially constrained	-0.0893	0.0125
	(0.0644)	(0.238)
Green management score	**0.513*** **	**4.765*** **
	(0.0799)	(0.375)
Ln size	0.0696***	0.379***
	(0.0141)	(0.0555)
Ln age	-0.0613**	-0.0103
	(0.0275)	(0.0897)
Exporter	0.0125	-0.0341
	(0.0545)	(0.239)
Energy levy	0.111**	0.173
	(0.0465)	(0.171)
Observations	449	449
R-squared	0.209	0.514
Subregional fixed effects	Yes	Yes
Sector fixed effects	Yes	Yes
Estimation method	OLS	OLS

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

Moving to green capital-intensive measures, Table 3 shows that being financially constrained reduces a firm's probability of making any green capital investments by about 11% at a significance level of 0.1. This is driven by its negative effect on the likelihood of implementing upgrades in machinery and equipment and in vehicles (columns 2 and 3). This indicates that access to finance plays an important role in helping firms undertake green investments that are particularly capital intensive in nature. This result aligns with De Haas et al. (2024), who found that credit constraints are holding back firm investments in more energy-efficient machinery and cleaner vehicles in 22 emerging countries. We also find that good green management practices strongly encourage such capital investments, apart from having a non-significant effect on vehicle upgrades. A one standard deviation improvement in a firm's green management score increases

the probability of machinery upgrades and waste management and recycling by 10% and 20%, respectively. As in our results for financial constraints and green management, a larger firm size has a significantly positive effect on adopting green capital-intensive measures. A firm's exporter status and age do not have significant effects, while its exposure to an energy levy increases the likelihood of machinery and vehicle upgrades. These results are robust to the use of a Probit estimation method (Appendix Table A.2).

Table 3. Financial constraints, green management and green capital-intensive measures

	(1) Prob. Green Capital Investment	(2) Prob. Machinery Upgrades	(3) Prob. Vehicle Upgrades	(4) Prob. Waste Management
Financially constrained	**-0.108***	**-0.131***	**-0.105***	-0.0233
	(0.0652)	(0.0667)	(0.0558)	(0.0513)
Green management score	**0.476*****	**0.405*****	-0.0635	**0.798*****
	(0.0828)	(0.0927)	(0.103)	(0.0860)
Ln size	0.0874***	0.0948***	0.108***	0.0459***
	(0.0145)	(0.0152)	(0.0162)	(0.0133)
Ln age	-0.0403	-0.0354	-0.0206	0.0150
	(0.0292)	(0.0283)	(0.0245)	(0.0246)
Exporter	-0.0679	-0.101	-0.000285	-0.0625
	(0.0643)	(0.0692)	(0.0721)	(0.0595)
Energy levy	0.142***	0.120**	0.200***	-0.0816*
	(0.0479)	(0.0502)	(0.0537)	(0.0417)
Observations	449	449	449	449
R-squared	0.208	0.197	0.204	0.350
Subregional fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Estimation method	OLS	OLS	OLS	OLS

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

Next, we investigate the individual effect of each component of green management practices on the extensive and intensive margins of adopting green measures and the probability of making green capital investments. Table 4 shows that including environmental issues in a firm's strategic objectives increases the probability of implementing green measures by about 15% (column 1). Higher probabilities are associated with having a manager responsible for environmental issues and monitoring energy consumption, 23% and 24% respectively (columns 2 and 3). Moreover, a firm that has specific targets for its energy consumption or CO_2 emissions is the most likely to adopt green measures, with a probability of 33% (column 4). Similarly, as Table 5 indicates, setting clear energy/carbon targets has the largest effect on a firm's number of adopted green measures, increasing it by about three measures. Having an environmental manager has the second largest effect. Also, Table 6 shows that the probability of implementing green capital-intensive measures increases the most (by 36%) when a firm has explicit environmental targets.

Table 4. Green management components and extensive margin of green measures

	(1)	(2)	(3)	(4)
	Prob. Green Measure (EM)			
Financially constrained	**-0.134****	**-0.121***	**-0.108***	-0.0918
	(0.0637)	(0.0630)	(0.0634)	(0.0656)
Strategic environmental objectives	**0.147****			
	(0.0642)			
Environmental manager		**0.232*****		
		(0.0477)		
Monitoring energy consumption			**0.242*****	
			(0.0477)	
Energy/carbon targets				**0.332*****
				(0.0543)
Ln size	0.0874***	0.0839***	0.0776***	0.0718***
	(0.0139)	(0.0137)	(0.0138)	(0.0137)
Ln age	-0.0574**	-0.0585**	-0.0546**	-0.0609**
	(0.0289)	(0.0283)	(0.0277)	(0.0277)
Exporter	0.0359	0.0392	0.0388	0.0204
	(0.0555)	(0.0549)	(0.0536)	(0.0540)
Energy levy	0.0845*	0.0785*	0.107**	0.122***
	(0.0457)	(0.0452)	(0.0481)	(0.0465)
Observations	449	449	449	449
R-squared	0.167	0.178	0.199	0.209
Subregional fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Estimation method	OLS	OLS	OLS	OLS

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

Table 5. Green management components and intensive margin of green measures

	(1)	(2)	(3)	(4)
	Num. Green Measures (IM)			
Financially constrained	-0.376	-0.259	-0.212	-0.0537
	(0.262)	(0.246)	(0.241)	(0.268)
Strategic environmental objectives	**1.876*****			
	(0.361)			
Environmental manager		**2.389*****		
		(0.364)		
Monitoring energy consumption			**1.911*****	
			(0.225)	
Energy/carbon targets				**2.804*****
				(0.291)
Ln size	0.524***	0.502***	0.476***	0.418***
	(0.0614)	(0.0624)	(0.0576)	(0.0613)
Ln age	0.0122	0.00978	0.0528	-0.000940
	(0.107)	(0.102)	(0.0969)	(0.0938)
Exporter	0.128	0.201	0.228	0.0663
	(0.256)	(0.263)	(0.253)	(0.243)
Energy levy	-0.0491	-0.130	0.0923	0.238
	(0.192)	(0.188)	(0.202)	(0.183)
Observations	449	449	449	449
R-squared	0.361	0.397	0.424	0.476
Subregional fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Estimation method	OLS	OLS	OLS	OLS

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

Table 6. Green management components and green capital-intensive measures

	(1)	(2)	(3)	(4)
	Prob. Green Capital Investment			
Financially constrained	**-0.148****	**-0.140****	**-0.131****	-0.107
	(0.0646)	(0.0643)	(0.0647)	(0.0665)
Strategic environmental objectives	**0.169****			
	(0.0669)			
Environmental manager		**0.187*****		
		(0.0607)		
Monitoring energy consumption			**0.190*****	
			(0.0529)	
Energy/carbon targets				**0.335*****
				(0.0586)
Ln size	0.103***	0.102***	0.0971***	0.0876***
	(0.0142)	(0.0141)	(0.0144)	(0.0142)
Ln age	-0.0376	-0.0372	-0.0340	-0.0406
	(0.0301)	(0.0298)	(0.0293)	(0.0291)
Exporter	-0.0498	-0.0416	-0.0417	-0.0631
	(0.0645)	(0.0646)	(0.0642)	(0.0627)
Energy levy	0.119**	0.112**	0.134***	0.156***
	(0.0475)	(0.0474)	(0.0495)	(0.0478)
Observations	449	449	449	449
R-squared	0.177	0.179	0.191	0.215
Subregional fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Estimation method	OLS	OLS	OLS	OLS

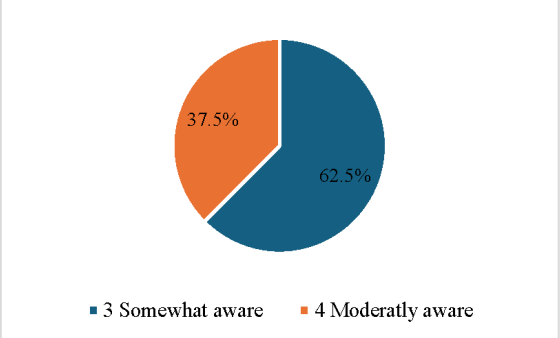
*Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1*

5. Qualitative analysis of Egyptian firms' preparedness for EU CBAM

5.1. Survey results

To get a closer picture of Egyptian firms' preparedness for the EU CBAM regulation, we conducted focus group discussions with a sample of 25 firms in three meetings held at the Federation of Egyptian Industries (FEI). We also surveyed eight of them, four in iron and steel, three in fertilizers, and one in cement, about their awareness about the regulation, response actions, and suggestions to ease compliance. The following figures depict their responses to the main survey questions.

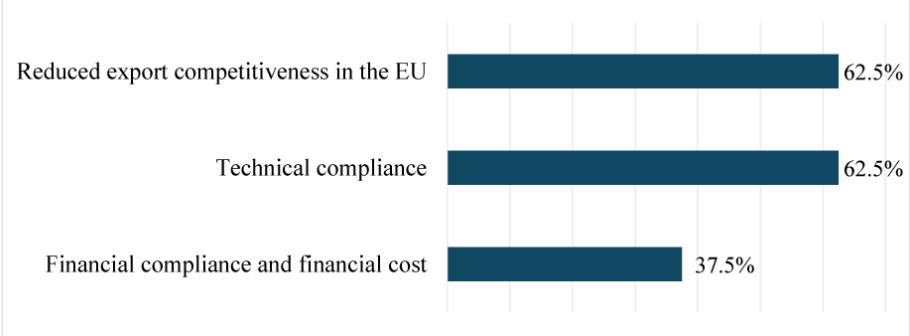
Figure 6. On a scale from 1-5, how do you rate your knowledge about CBAM?



Source: Own depiction based on a survey of Egyptian firms in CBAM sectors

As shown, all surveyed firms are aware of the CBAM regulation, though moderately at best.

Figure 7. What are your top concerns regarding CBAM?

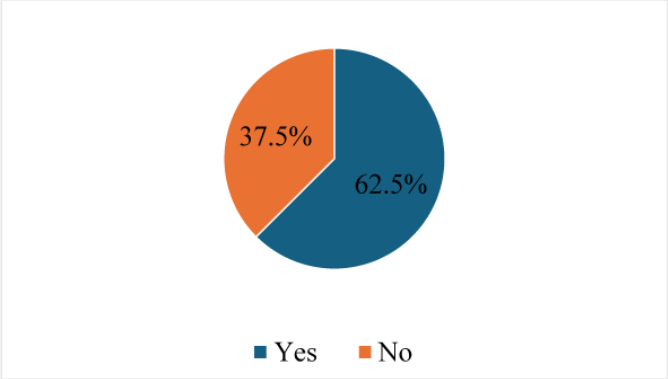


Source: Own depiction based on a survey of Egyptian firms in CBAM sectors

Firms' greatest concerns about CBAM relate to losing their export competitiveness in the EU market and difficulties complying with emissions reporting requirements. They also expressed concerns about financial costs, especially when CBAM's definitive regime of carbon pricing starts in 2026.

As the following figure indicates. most participating firms have difficulty measuring their carbon emissions, be they direct (related to the production process) or indirect emissions (related to the use of electricity).

Figure 8. Do you have difficulty in providing information about your direct and indirect CO_2 emissions?

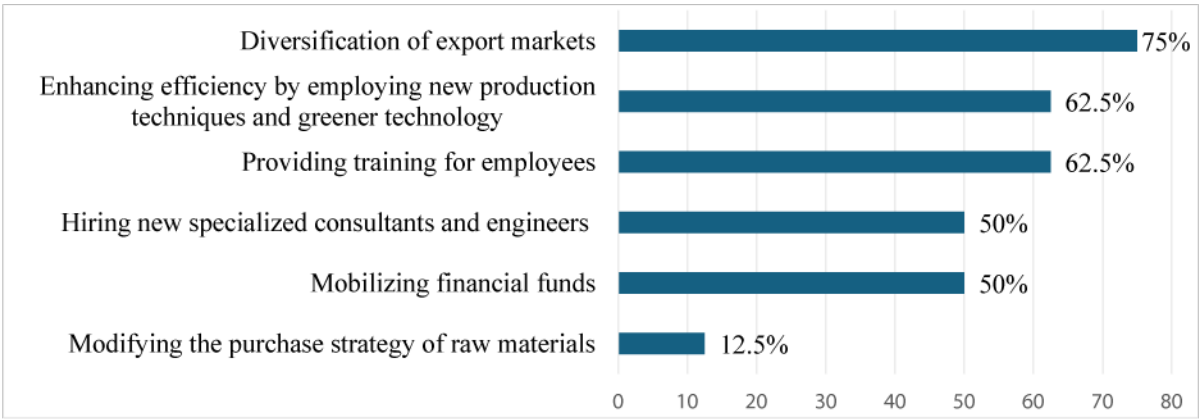


Source: Own depiction based on a survey of Egyptian firms in CBAM sectors

For actions that firms see they should undertake in response to CBAM, most mentioned the need to diversify their export destination markets so as not to depend solely or primarily on the EU. They also said they would need to adopt more efficient and green production methods and

technologies and train their employees to use them accordingly. Half said they would need to hire consultants and engineers in the areas of environment and sustainability and mobilize financial funds for that purpose to manage CBAM technical and financial compliance. A firm also mentioned that it needs to change its raw materials to reduce emissions.[4]

Figure 9. What are the main kinds of action that your firm should make in retaken to CBAM?

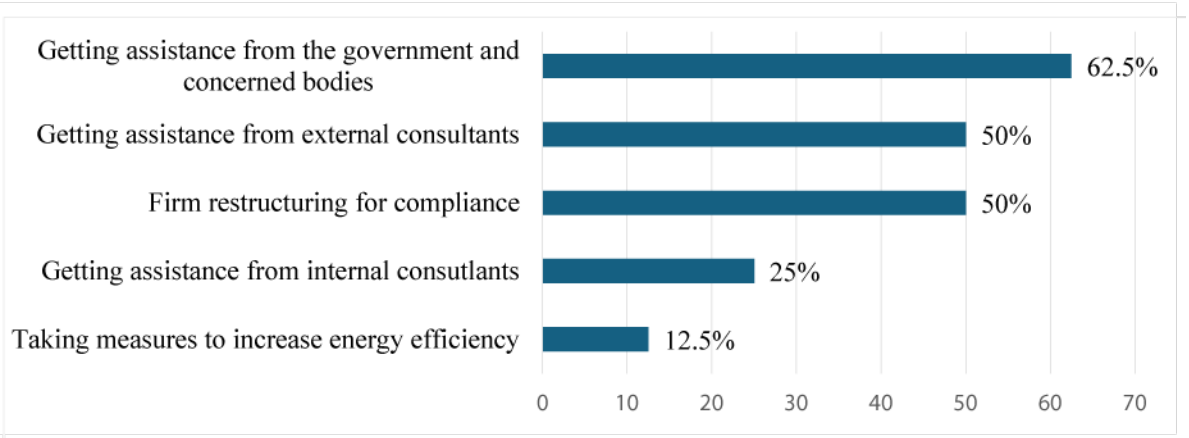


Source: Own depiction based on a survey of Egyptian firms in CBAM sectors

Firms have already taken some actions to prepare for CBAM. Most sought assistance from the government of Egypt (GoE) and concerned bodies and attended technical workshops, including those organized by the Federation of Egyptian industries and the European Commission, about fulfilling requirements by EU importers for reporting product emissions. Half got the advice of specialized consultants from outside their firms and did some necessary restructuring to ease compliance, while a quarter received assistance from their internal consultants. One firm indicated that it started to work on reducing its energy consumption through an enhanced handling of scrap inputs and is also considering the establishment of a solar power station to lower its carbon emissions.

[4] Relatedly, several cement firms in focus group meetings said refuse-derived fuel should be made available to make them competitive when exporting to countries applying CBAM.

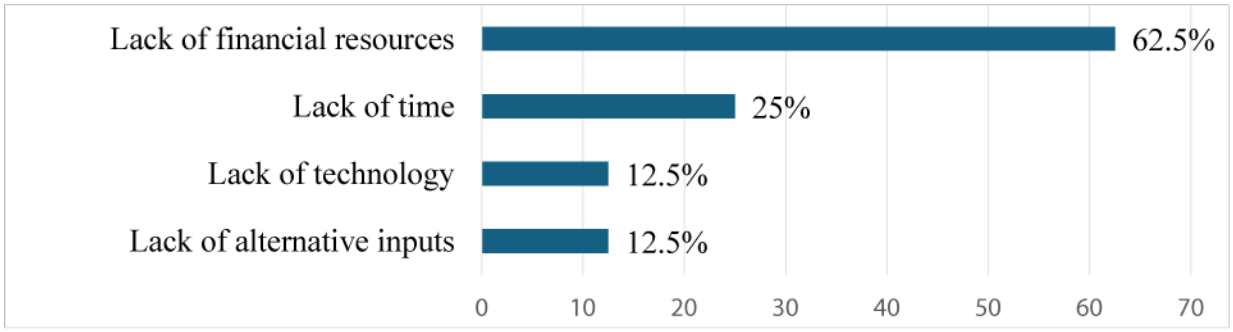
Figure 10. What are the main kinds of action that your firm has already taken in reaction to CBAM?



Source: Own depiction based on a survey of Egyptian firms in CBAM sectors

All firms but one mentioned that CBAM will affect their plans for CO_2 emissions. However, in accordance with our previous empirical findings, most regard the lack of financial resources as their main challenge for decarbonization. Other cited challenges include time constraints and the non-availability of technology and alternative greener inputs. It is interesting that none of them regard low carbon transition to be of low priority or non-profitable.

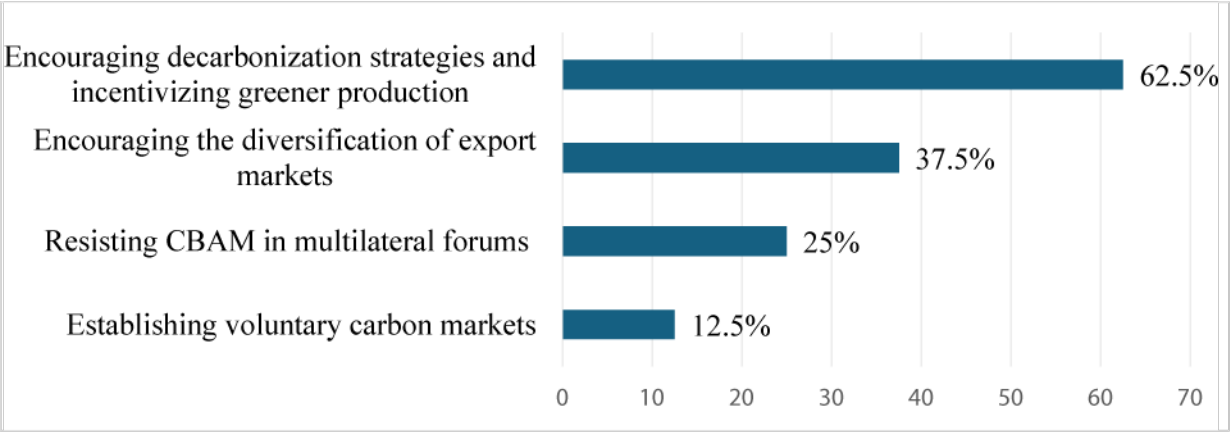
Figure 11. What do you think is the most important challenge for decarbonizing your firm?



Source: Own depiction based on a survey of Egyptian firms in CBAM sectors

Regarding perceptions of the GoE's role in reacting to CBAM, most firms mentioned that it should provide incentives to encourage decarbonization and the adoption of greener production methods, including facilitated access to concessional green finance. Some also said that the GoE should encourage firms to diversify their export markets. A few indicated that the government has room to resist CBAM in multilateral forums such as the World Trade Organization and within the framework of Egypt- EU Association Agreement. A firm indicated that a voluntary carbon market with tradable carbon credits needs to be developed in Egypt as a tool to mobilize financial funds for decarbonization. Importantly, no firm has called for introducing a domestic tax on carbon emissions due to its large perceived financial burden.

Figure 12. How do you think Egypt should react to EU CBAM?



Source: Own depiction based on a survey of Egyptian firms in CBAM sectors

5.2. Focus group discussions

The CBAM sectoral meetings with representatives from 25 Egyptian firms revealed heterogeneity in firms' preparedness for the EU CBAM. In the steel sector for example, firms that use scrap-based electric arc furnace (EAF) production see CBAM as an opportunity to enhance their competitiveness in the EU market given their low carbon emissions compared to firms using blast furnace–basic oxygen furnace or direct reduced iron-based EAF routes. However, not all firms are equally able to green their production techniques. For example, some firms in the cement sector lamented the insufficiency of refuse-derived fuel to substitute for coal and said the GoE should be facilitating its importation to help them lower their emissions. They also reported a lack of access to traditional energy sources for production, and that the decrease of government subsidies to energy and Egypt's struggle to become self-sufficient in natural gas had worsened the problem (Kamal and Ramzy, 2024).

Regarding green management practices, some firms already have experience with preparing carbon footprint reports which cover their emissions under scopes 1, 2 and 3. These firms will likely face less difficulty reporting actual embedded emissions of their products under CBAM than other firms. The Environmental Compliance and Sustainable Development Office at the FEI,[5] with the cooperation of Chapter Zero Egypt Climate Forum,[6] conducted a CBAM workshop with firms to raise awareness about the CBAM and its implications. The office also provided some training on the use of the European Commission's CBAM communication template, which firms must use

[5] The office was established within the Federation of Egyptian Industries in compliance with presidential decree No. 64 for the year 2001. It provides consultancy services to the industry sector in the field of environmental compatibility, environmental management systems, energy conservation, and renewable energy (http://www.eco-fei.org/).

[6] The forum is the 27th active chapter in the Climate Governance Initiative's global network and the first in the continent of Africa. Its main mission is to make climate change a boardroom priority for Egyptian organizations and to unite efforts between different stakeholders across the public and private sectors to advance the net-zero transition in the country (https://climate-governance.org/chapter-zero-egypt- launches/).

to report emissions. Also, some multinational firms already have a de-carbonization roadmap, and some have worked on energy efficiency programs to decrease their operation costs. However, they cited challenges about the need to establish a reliable system for monitoring, reporting, and verification (MRV) of carbon emissions to ensure data accuracy, especially when the definitive period of CBAM begins and they must report actual emissions instead of default values. Firms are also concerned with the availability of workers with training in data processing and reporting procedures. They also referenced EU Emission Trading System (EU ETS), saying they would need to better gauge their current carbon intensity, set the appropriate carbon targets, and plan the required decarbonization investments in a timely manner to prepare for the yearly benchmark emissions under the EU Emission Trading System EU ETS for concerned products.[7] Moreover, they need to keep close relationships with their suppliers and to trace emissions along their supply chain to provide evidence of whether they are integrated in low-or high-emission supply chains. This requires maximum transparency in disclosing detailed information about the raw materials used in the production of CBAM products, the suppliers of raw materials and the country of origin, and compliance with detailed data provision and carbon accounting through the entire value chain (Kamal and Ramzy, 2024).

With respect to financial factors, most firms agree referenced the same challenges related to financing their de-carbonization projects. They are mainly concerned with the lack of finance to invest in material efficiency and adopt mitigation practices. They hope to be able to take out loans with facilitated terms that enable repayment over a period that exceeds five years. They referenced the large upfront investment costs involved in carbon capture, utilization, and storage because it requires durable industrial plants, high temperature heat, and expensive production processes. For example, a large fertilizer firm will seek a concessional loan as it plans to use the carbon its factory emits to produce other goods (such as soda ash) (International Energy Agency, 2020; Kamal and Ramzy, 2024). Firms call for an increased governmental role in making such loans available by expanding program such as the Egyptian Pollution Abatement Programme. Initiated by the Ministry of Environment with EU support, the program provides a mix of loans and grants to help Egyptian firms improve environmental performance and reduce energy and resource consumption.

6. Conclusion and policy implications

This study examined the effect of green management and financial constraints on Egyptian firms' environmental investments. Using the 2020 World Bank Enterprise Survey, it found that firms operating in CBAM sectors (chemicals, non-metals, basic metals) are more likely to adopt any green measure as their average green management score increases. Also, the number of adopted green measures increases as this score improves. While all green management components are

[7] The EU ETS provides some free allowances to EU firms, which will be gradually cut over time and hence would influence their carbon payments.

significant for both margins of green measures, targeting carbon emissions and energy consumption has the greatest effect. Moreover, being financially constrained negatively impacts a firm's investment in machinery and vehicle upgrades, which are capital intensive.

Focus group discussions and surveys with firms in steel, fertilizers, and cement also emphasized the lack of financial funds as a top challenge towards their decarbonization plans. For firms to remain competitive in the EU market under CBAM, they need to seek concessional finance for their green investments. This includes loans and grants offered by the GoE to the private sector through international partnerships which need to be expanded in both volumes and firm coverage. Additionally, the newly developed voluntary carbon market in Egypt can facilitate the green transition of firms, as issuers of carbon credits resulting from their reduction of emissions can mitigate their decarbonization costs by mobilizing funds, and buyers of these credits can use them to offset their carbon footprints. It remains uncertain, however, whether the CBAM regulation will recognize the use of such credits.

Importantly, as CBAM will enter into full operation in 2026, firms need to prepare by establishing their own carbon accounting system which involves MRV for their emissions, both direct and indirect. Relevant government bodies should provide technical assistance and capacity building to concerned firms, especially in carbon measurement. In addition, the GoE exerts efforts and undertakes important initiatives to enhance its climate actions and to promote de- carbonization. These actions and initiatives would accelerate green transition at the country and firm levels, which would help mitigate some of the challenges imposed by the EU CBAM regulations. Of relevance to prioritization are the Egypt 2030 vision and Egypt's National Climate Change Strategy 2050 (NCCS 2050), which stress the importance of striking a balance between the priorities of economic growth and environmental sustainability. They also aim to achieve sustainable and low-emission economic growth while enhancing the country's resilience and adaptive capacity through effective climate change action and governance, as well as the development of climate financing infrastructure. These priorities should be adequately reflected in countries' Nationally Determined Contributions (NDCs)[8] and their implementation plans with a full partnership between the government and the private sector.

The GoE already undertook concreate measures towards green transition and energy efficiency by promoting the use of clean and renewable energy sources. First, while Egypt ranked 7th in the value of international investment in renewable energy, preceded by Brazil, Vietnam, Chile, India, Kazakhstan, and Taiwan (UNCTAD, 2023), it needs to capitalize on this progress by attracting more investments in renewable energy generation (such as wind, solar, and hydropower generation), clean/low-emission technologies (as nuclear power, hydrogen, and biogases), components of renewables (as solar panels, and wind turbines) and carbon capture and storage.

[8] Updating countries' NDCs is a main priority and deliverable for COP30 to be held in Brazil in 2025.

Moreover, the Integrated Sustainable Energy Strategy 2035 is designed to increase the supply of electricity generated from renewable sources to 42% by 2035 with wind energy accounting for 14%, hydroelectricity making up 2%, and solar energy accounting for 25% of the total electricity generated by renewable energy resources (Egypt Energy, 2022).

Second, conscious of the leading role Egypt can play in achieving the EU's RePowerEU hydrogen import target of 10 million tons by 2030 (Pearce, 2024), the GoE aims to pave a smooth path for new projects in the nascent green hydrogen industry. The GoE developed a national green hydrogen strategy which aims at capturing 5–8% of the global hydrogen market, at achieving energy security by 2040, and at significantly reducing carbon dioxide emissions by 40 million tons annually.[9] In addition, a newly ratified legislation provides several tax and non-tax incentives to encourage Egypt's green hydrogen industry. These include a cash investment incentive equivalent to 33–55% of the tax paid on revenues generated by the project, exemptions from value added tax for equipment and raw materials, and other incentives such as facilitations in licensing and trade. These generous incentives are conditioned on having at least 70% of the investment project or its expansion financed by foreign currency, which opens a large opportunity for foreign investments in Egypt in this promising technology. With more production of green hydrogen, firms operating in carbon-intensive sectors such as steel and fertilizers can increase their reliance on it as a clean alternative fuel.

Finally, the GoE must focus on enhancing the green management and financial determinants as drivers for firms' green transition, especially for those producing and exporting CBAM goods. On one hand, it needs to empower firms' green management by enhancing their MRV systems and by establishing an appropriate infrastructure to enhance national data ecosystem and statistical capacity to improve data processing and reporting. It also needs to establish and identify the national institutions/parties that are specialized and accredited in providing green technical assistance to firms. On the other hand, it needs to assist firms in securing the financing of their green transition, especially for small and medium-sized firms, which are expected to rely heavily on public policy interventions (e.g. tax incentives or investment subsidies) to finance their green investments. Such measures will ensure Egypt is getting better prepared for CBAM and is becoming a part of global climate solutions.

[9] https://egyptoil-gas.com/features/egypt-blazes-a-trail-in-clean-energy-revolution/

Appendix

Table A.7. Financial constraints, green management and green measures: alternative estimation method

	(1) Prob. Green Measure	(2) Num. Green Measures (categorized)
Financially constrained	-0.306	-0.169
	(0.207)	(0.172)
Green management score	**3.087*****	**3.414*****
	(0.680)	(0.374)
Ln size	0.240***	0.267***
	(0.0549)	(0.0411)
Ln age	-0.187*	-0.0764
	(0.0975)	(0.0771)
Exporter	0.215	-0.0370
	(0.236)	(0.164)
Energy levy	0.435**	0.313**
	(0.172)	(0.132)
Observations	449	449
Subregional fixed effects	Yes	Yes
Sector fixed effects	Yes	Yes
Estimation method	Probit	Ordered Probit

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

Table A.8. Financial constraints, green management and green capital-intensive measures: alternative estimation method

	(1) Prob. Green Capital Investment	(2) Prob. Machinery Upgrades	(3) Prob. Vehicle Upgrades	(4) Prob. Waste Management
Financially constrained	**-0.332***	**-0.356***	**-0.359***	-0.104
	(0.199)	(0.199)	(0.210)	(0.226)
Green management score	**2.111*****	**1.265*****	-0.175	**2.643*****
	(0.470)	(0.346)	(0.308)	(0.380)
Ln size	0.283***	0.276***	0.336***	0.175***
	(0.0526)	(0.0485)	(0.0529)	(0.0503)
Ln age	-0.116	-0.110	-0.0844	0.0664
	(0.0936)	(0.0853)	(0.0842)	(0.0996)
Exporter	-0.176	-0.268	0.0178	-0.168
	(0.217)	(0.201)	(0.206)	(0.235)
Energy levy	0.473***	0.346**	0.584***	-0.292
	(0.162)	(0.150)	(0.155)	(0.186)
Observations	449	449	449	449
Subregional fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Estimation method	Probit	Probit	Probit	Probit

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

References

Abdou, A.H.; Hassan, T.H.; & El Dief, M. M.(2020). A Description of Green Hotel Practices and Their Role in Achieving Sustainable Development, *Sustainability*, 12(22), 9264, 1-20. https://doi.org/10.3390/su12229624

Aliedan, M.M.; Alyahya, M.A.; Elshaer, I.A.; & Sobaih, A.E.E. Who is Going Green? Determinants of Green Investment Intention in the Saudi Food Industry, *Agriculture,* 13(5), 1047, 1-17. https://doi.org/10.3390/agriculture13051047

Ambec, S. & Lanoie, P. (2007). *When and Why does it Pay to be Green?* Working Paper GAEL 2007-05, Laboratoire d'Economie Appliquée de Grenoble, Grenoble, France.

An, M. & Madni, G. R. (2023). Factors Affecting the Green Investment and Assessing Sustainable Performance of Firms in China*, Plos One,* 18(12): e029609, 1-17. https://doi.org/10.1371/journal.pone.029609

Barbanov, S.S.; Basnet, A.; Waker, T. J.; Yuan, W.; & Wendt, S.(2021). Firm- and Country- Level Determinants of Green Investments: An Empirical Analysis, *Managerial Finance*, 47 (11), 1672-1692. https://doi.org/10.1108/MF-06-2020-0311

Capelle, D.; Kirti, D.; Pierri, N.; and Bauer, G. V. (2023). Mitigating Climate Change at the Firm Level*: Mind the Laggards*, IMF Working Paper No.23/242, Research Department and Fiscal Affairs Department International Monetary Fund, Washington D.C, available online https://www.imf.org/en/Publications/WP/Issues/2023/11/22/Mitigating-Climate-Change-at-the-Firm-Level-Mind-the-Laggards-541713

Capozza, C.; Divella, M.; and Rubino, A. (2021), Exploring Energy Transition in European Firms: The Role of Policy Instruments, Demand-pull Factors and Cost-saving Needs in Driving Energy-efficient and Renewable Energy Innovations, *Energy Sources*, *Part B: Economics, Planning, and Policy,* 16(11-12), 1094-1109. https://doi.org/10.1080/15567249.2021.1939462

Center for Climate and Energy Solutions. (2024). *Business Strategies to Adress Climate Change*, available online https://www.c2es.org/content/business-strategies-to-address- climate-change/.

Chițimiea, A.; Minciu, M.; Manta, A.M.; Ciocoiu, C.N.; & Veith, C. 2021. The Drivers of Green Investment: A Bibliometric and Systematic Review, *Sustainability, MDPI*, 13(6), 1- 25, https://doi.org/10.3390/su13063507

Egypt Energy. (2022). *Egypt Energy Sector, Market Report.* https://www.egypt-energy.com/content/dam/Informa/egypt-energy/en/pdf/Egypt%20Energy%20Report-16- 5%20.pdf

Egyptian Environmental Affairs Agency. (2022). *Egypt National Climate Change Strategy (NCCS) 2050.* https://www.eeaa.gov.eg/Uploads/Topics/Files/20221206130720583.pdf

European Environment Agency. (2024a). *Climate change mitigation: reducing emissions*, available online https://www.eea.europa.eu/en/topics/in-depth/climate-change- mitigation-reducing-emissions

Eyraud, L.; Clement, B.; & Wane, A. (2013). Green Investment: Trends and Determinants, *Energy Policy,* Volume 60(C), 852-865. https://doi.org/10.1016/j.enpol.2013.04.039

Fleitera, T.; Schleich, J.; Ravivanpong, P. (2012). Adoption of Energy-Efficiency Measures in SMEs - An Empirical Analysis Based on Energy Audit Data, *Energy Policy*, 2012, 51, pp.863 875, available online https://hal.science/hal-00805748/document

Garcia-Quevedo, J.; Martinez-Ros, E.; & Tchorzewska, E.B. (2022). End-of-pipe and cleaner production technologies. Do policy instruments and organizational capabilities matter? Evidence from Spanish firms, *Journal of Cleaner Production*. 340(1), 1-9. https://doi.org/10.1016/j.enpol.2021.11246

Götz, M. (2018). *Financial constraints and Corporate Environmental Responsibility*, SAFE Working Paper No. 241, Goethe University Frankfurt, SAFE – Sustainable Architecture for Finance in Europe, Frankfurt a. M., https://doi.org/10.2139/ssrn.323034

Hesse, D. (2007). *Environmental Policy and International Competitiveness in a Globalized World: Challenges for Low-Income Countries in the UNECE Region,* Discussion Paper Series No.2007.6, United Nations Economic Commission for Europe, Geneva. Available online https://unece.org/DAM/env/epr/documents/ECE.CEP.146.e.pdf

International Energy Agency. (2020. *World Energy Outlook,* available online https://iea.blob.core.windows.net/assets/a72d8abf-de08-4385-8711-b8a062d6124a/WEO2020.pdf

International Energy Agency. (2024). *World Energy Investment 2024*, available online https://www.iea.org/reports/world-energy-investment-2024/overview-and-key- findings

IRENA. (2018). *Renewable Energy Outlook: Egypt.* International Renewable Energy Agency, available online. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf

Jaffe, A. B.; Newell, R.; and Stavins, R. N. (2004). *The tale of two failures: technology and environmental policy*, RFF Discussion Paper No. 04-38, Resource For the Future, Washington D.C. Available online https://www.rff.org/publications/working- papers/a-tale-of-two-market-failures-technology-and-environmental-policy/

Kalantzis, F. and D. Revoltella (2019). *How energy audits promote SMEs' energy efficiency Investment*, Working Paper No.2019/02, European Investment Bank, available online https://www.eib.org/en/publications/economics-working-paper-2019-02

Kalantzis, F.; Schweiger, H.; & Dominguez, S. (2022). *Green Investment by Firms: Finance or Climate Driven?* World Bank, Washington, DC and EBRD Working Paper No. 268, available online https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099725305102236711/idu02bf347ba086050401008674010ed29aa4f84

Kamal, Y. and Ramzy, M. (2024). *The Carbon Border Adjustment Mechanism and Egyptian Competitiveness: A Trade Facilitator or a Trade Barrier*, Chapter in EuroMeSCo Policy Study No.33 on Implementing the CBAM: How are the EU's Southern Neighbours Preparing and What the EU can do to Help?, European Institute of the Mediterranean, https://www.euromesco.net/publication/implementing-the-cbam-how-are-the-eus-southern-neighbours-preparing-and-what-can-the-eu-do-to-help/

Khanna, M.; Deltas, G.; & Harrington, D. R. (2009). Adoption of Pollution Prevention Techniques: The Role of Management Systems and Regulatory Pressures, Environmental and Resource Economics, Volume 45, 85-106. 10.1007/s10640-009-9263- y

Lanteri, A. & Rampini, A. A. (2023). *Financing the Adoption of Clean Technology,* available online https://people.duke.edu/~rampini/papers/cleantechnology.pdf

Mohieldin, M. (2023). *The Carbon Border Adjustment Mechanism (EU CBAM)*, 10.13140/RG.2.2.32342.42565

Martin, R.; Muûls,M;,& Wagner,U.2011. *Climate Change, Investment and Carbon Markets and Prices—Evidence from Manager Interviews* , Climate Policy Initiative, San Francisco, available online https://climatepolicyinitiative.org/wp-content/uploads/2011/12/Climate-Change-Investment-and-Carbon-Markets-and-Prices.pdf

Mungai, E.M.; Ndiritu, S.W. ; & Rajwani, T. (2020). Do Voluntary Environmental Management systems Improve Environmental Performance? Evidence from Waste Management by Kenyan Firms, *Journal of Cleaner Production*, Volume 265, 1-12. https://doi.org/10.1016/j.jclepro.2020.121636

Pearce, O. (2024). *Egypt launches new hydrogen incentives,* available online https://ammoniaenergy.org/articles/egypt-launches-new-hydrogen-incentives/

Pomerleau, S. (2024). *Carbon border adjustment bills: how do the U.S. proposals compare to the EU one?,* available online https://www.niskanencenter.org/carbon-border- adjustment-bills-how-do-the-u-s-proposals-compare-to-the-eu-one/

Siedschlag, I. & Yan, W. (2021). Firms' Green Investments: What Factors Matter? *Journal of Cleaner Production,* Volume 310*,* 1-15. https://doi.org/10.1016/j.jclepro.2021.127554

Stavins, N. (2001). *Experience with Market-Based Environmental Policy Instruments,* Discussion Paper No.01- 58, Resources for the Future, Washington, D.C. Available online https://media.rff.org/documents/RFF-DP-01-58.pdf

UNCTAD (2023). *World Investment Report Investing in Sustainable Energy For All,* United Nations Conference on Trade and Development, https://unctad.org/system/files/official-document/wir2023_en.pdf.

UNDP. (2024). *What is climate change mitigation and why is it urgent?*, Climate Promise, available online https://climatepromise.undp.org/news-and-stories/what-climate- change-mitigation-and-why-it-urgent

UNFCCC. (2024). *The Paris Agreement*, available online https://unfccc.int/process-and-meetings/the-paris-agreement