



# “Do voluntary environmental practices improve firm productivity? Evidence from Moroccan firms”

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# DO VOLUNTARY ENVIRONMENTAL PRACTICES IMPROVE FIRM PRODUCTIVITY? EVIDENCE FROM MOROCCAN FIRMS

## Abstract

The environmental and economic benefits of voluntary firm-level practices are often assumed but rarely tested, particularly with respect to firm-level heterogeneity in developing economies. This study aims to estimate the effect of two voluntary environmental practices (energy management and CO<sub>2</sub> emissions monitoring) on firm productivity in Morocco, and to test whether these effects vary across the productivity distribution. Using firm-level microdata from the 2023 World Bank Enterprise Survey on 598 Moroccan manufacturing and service firms, conditional quantile regressions and quantile treatment effects with propensity score matching are employed to address heterogeneity and potential endogeneity. The results show that energy management practices increase productivity by 33% and CO<sub>2</sub> monitoring by 57% on average. However, these average effects mask substantial heterogeneity. At the 10th percentile, energy management yields a 9.6% gain while CO<sub>2</sub> monitoring has no significant effect. At the 50th percentile, energy management yields a 46.4% increase, while CO<sub>2</sub> monitoring yields a 61.2% increase. At the 90th percentile, energy management yields 28.4% and CO<sub>2</sub> monitoring 61.7%. Quantile treatment effects confirm this heterogeneity but reveal that energy management benefits mid-to-upper performers (30th–70th percentiles), whereas CO<sub>2</sub> monitoring benefits primarily low-performing firms (10th–20th percentiles). These findings indicate that the impact of voluntary environmental practices is context- and firm-specific. Policy implications suggest that differentiated support strategies are required to enhance both environmental and economic performance in developing economies.

**Keywords** productivity, environment, firms, Morocco, regulation

**JEL Classification** Q52, D24, L25, C21

## INTRODUCTION

The relationship between environmental policy and firm productivity has been widely examined in developed economies, yet firm-level evidence from developing countries remains scarce (Dechezleprêtre & Kruse, 2018; Dechezleprêtre et al., 2019; Khan et al., 2022). These contexts are characterized by limited investment capacity, institutional constraints, and complex industrial transitions, which may alter the effectiveness of environmental policies. In such settings, voluntary environmental practices could constitute an important complement to formal policy. This raises a critical question: Can the Porter hypothesis, which posits that well-designed environmental policies can enhance both innovation and competitiveness (Porter, 1991; Porter & Van der Linde, 1995), be extended to voluntary environmental actions in developing economies?

Morocco provides a relevant case for examining this issue, combining ambitious environmental commitments with limited empirical evidence on firm-level impacts. The country hosted COP22 in 2016 and has pledged to generate 52% of its electricity from renewable sources by 2030, positioning itself as a leader in clean energy within the MENA

region and Africa (Benbba et al., 2024; Michailidis et al., 2025). Over the past two decades, Morocco has adopted several major initiatives, including the National Strategy for Sustainable Development (Stratégie Nationale du Développement Durable, SNDD), the Green Plan, and the Low-Carbon Strategy for 2050. Within this policy framework, firms are encouraged to adopt voluntary environmental practices, often in response to international standards, regulatory expectations, or opportunities for green innovation. As in many developing countries, command-and-control instruments may be less effective in such contexts (Blackman et al., 2010). This explains the growing reliance on voluntary and incentive-based mechanisms. Despite these developments, little is known about how such practices affect Moroccan firms.

Against this background, this study addresses the following question: To what extent do voluntary environmental practices affect firm productivity in developing countries, and are these effects homogeneous across firms with different levels of productivity?

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## 1. LITERATURE REVIEW AND HYPOTHESES

Research on the relationship between environmental action and firm productivity has evolved significantly over the past decades. Early studies, largely focused on pollution-intensive industries in advanced economies, viewed environmental regulation primarily as a cost burden that diverts resources from production, often leading to productivity losses (Gollop & Roberts, 1983; Barbera & McConnell, 1986, 1990; Gray, 1987). These negative effects were found to be particularly pronounced in older, high-cost plants and following the introduction of stricter environmental policies (Gray & Shadbegian, 2003; Greenstone et al., 2012; Hancevic, 2016).

The debate was reshaped by the Porter hypothesis, which posits that well-designed environmental policies can stimulate innovation and improve resource efficiency, potentially offsetting compliance costs (Porter & Van der Linde, 1995). This hypothesis is commonly distinguished into three versions: the weak form (regulation stimulates innovation), the strong form (innovation offsets compliance costs, improving competitiveness), and the narrow form (flexible, well-designed regulation outperforms command-and-control) (Jaffe & Palmer, 1997). Empirical evidence on the “strong” version remains mixed (Cohen & Tubb, 2018; Kozluk & Zipperer, 2015; Ambec et al., 2013; Mansouri & Tounsi, 2026a). While some studies document productivity gains in specific contexts, such as in the U.S. paper industry, Los Angeles refineries, and Quebec manufacturing (Boyd & McClelland, 1999; Berman & Bui, 2001; Lanoie et al., 2008), others find neutral or negative ef-

fects (Albrizio et al., 2014; Gray & Shadbegian, 2003). One explanation is that regulation can force modernization, replacing old capital with newer, more productive technology (Xepapadeas & de Zeeuw, 1999). As a result, the literature has moved away from a binary view toward a conditional perspective emphasizing that the impact of environmental policies depends on firm characteristics, policy design, and institutional context (Ambec et al., 2013; Dechezleprêtre & Sato, 2017).

A central insight is the importance of firm heterogeneity. Stricter environmental policies tend to enhance productivity primarily among frontier firms (those already more productive and innovative) while imposing net costs on less efficient firms (Albrizio et al., 2014, 2017; Rubashkina et al., 2015). This leads to non-linear and distributional effects. In China, for example, evidence shows everything from no impact to an inverted U-shaped relationship where productivity gains appear only after a regulatory threshold is crossed (Wang & Shen, 2016; Wang et al., 2018; Yang et al., 2021). Similar dynamics are seen in Mexico (Alpay et al., 2002). At the aggregate level, productivity gains may still emerge through resource reallocation, even when firm-level effects are heterogeneous (Cohen & Tubb, 2018).

Recent evidence reinforces this conditional view. A 2024 meta-analysis of 58 studies found support for the overall Porter hypothesis in relation to green innovation and, more specifically, for its “narrow” version, showing that flexible regulatory approaches can stimulate innovation more effectively than rigid instruments (Zhang et al., 2024). Using World Bank Enterprise Survey data from 68 developing econo-

mies, Bambe et al. (2026) find that stricter environmental policies can raise firm efficiency, but mainly once regulation reaches a moderate threshold; the gains are stronger for medium-sized and pollution-intensive firms and where institutional quality is higher. Evidence from Europe suggests that tighter environmental regulation may reduce productivity growth in the short term, particularly for pollution-intensive firms and under more rigid policy instruments. However, these negative effects tend to be mitigated for larger and more innovative firms (Albrizio et al., 2017; Dechezleprêtre & Sato, 2017; Aghion et al., 2016). By contrast, Dechezleprêtre et al. (2023) find that the EU Emissions Trading System reduced carbon emissions by about 10% without significantly harming profits or employment, while increasing revenues and fixed assets among regulated firms.

A related but distinct strand of literature focuses on voluntary environmental practices (VEPs), which differ fundamentally from regulation as they reflect internal strategic choices rather than external constraints (Lyon & Maxwell, 2008). Firms adopt such practices, such as energy management or emissions monitoring, for cost reduction, reputational concerns, and anticipation of future regulation (Delmas & Toffel, 2008; Darnall et al., 2010; Arimura et al., 2011). Using firm-level data from 41 countries, Wu (2023) finds that environmental management and environmental innovation both improve productivity, although their gains are partly substitutable rather than cumulative. In a focused synthesis, Zubeltzu-Jaka et al. (2024) report a positive association between voluntary environmental certification and corporate financial performance, while also showing that better-performing firms are more likely to adopt certification in the first place (the “selection effect”).

Recent country-level studies confirm that voluntary environmental actions can enhance firm performance, particularly when embedded in structured management systems. Song et al. (2026) find that ISO 14001 certification improves technical efficiency among high-polluting manufacturing firms in South Korea, increasing output by an average of 2.7%. In South Africa, Lawton et al. (2025) show that ISO 14001 adoption is associated with improved environmental awareness, better data management, lower operating and production costs, and new income streams linked to reuse and recycling. Other work on China’s green factory accreditation reports

gains in green technological innovation, environmental investment, and investment efficiency (Wang et al., 2025). The common thread is that voluntary environmental action seems most valuable when embedded in managerial systems that improve information, discipline resource use, and create learning effects inside the firm (Christmann, 2000).

This internal managerial dimension is further emphasized in the literature on environmental management accounting (EMA). Studies argue that environmental performance rarely improves through technical choices alone; it also depends on whether firms can measure environmental costs, integrate them into decision-making, and connect them to innovation (Burritt et al., 2002). Evidence from Pakistan shows that EMA has a direct positive effect on firm performance, with part of this effect operating through environmental innovation (Gerged et al., 2024). A recent meta-analysis by Barani et al. (2025) reaches a similar conclusion, finding that EMA is positively associated with organizational performance overall, with stronger effects in contexts where national EMA systems are more mature and in larger firms. This matters for the present study because practices such as energy management and emissions monitoring are unlikely to affect productivity unless firms have the routines and capabilities needed to translate information into operational change.

What remains missing is robust evidence from North Africa, and Morocco in particular. Compared with the dense evidence now available for OECD countries, China, and multi-country developing-economy panels, recent Moroccan research still concentrates more on ESG disclosure and the broader sustainability agenda than on firm-level productivity effects (El Baz & Laguir, 2017). That gap is worth addressing because Morocco is not a peripheral case. It has adopted ambitious green transition goals, including a target of 52% renewable installed electricity capacity by 2030 (El Hafdaoui et al., 2025). Moreover, the 2023 World Bank Enterprise Survey interviewed 598 firms, providing rare and timely microdata on how environmental practices are diffusing across businesses (World Bank, n.d.). Morocco has also committed to CO<sub>2</sub> emission reductions under its Nationally Determined Contribution (NDC), its industrial sector is energy-intensive, and firm-level adoption of energy management practices varies widely – yet no study has systematically examined

their productivity effects. In a setting marked by heterogeneous firm capabilities, financing constraints, and uneven sectoral structures, there is good reason to expect that the benefits of voluntary environmental practices will differ substantially across firms rather than appear as a single average effect.

Taken together, the literature now points to a more nuanced conclusion than the early Porter debate allowed. Environmental action can improve firm outcomes, but the effect is usually conditional, not automatic. It depends on the kind of environmental measure adopted, the firm's absorptive capacity, and the institutional environment. What remains insufficiently understood is whether relatively simple voluntary practices, such as energy management and CO<sub>2</sub> emissions monitoring, translate into higher productivity in a developing-country context, and whether such gains are concentrated among already strong firms (frontier firms) or can also help weaker firms catch up.

Accordingly, the purpose of this study is to examine the effect of voluntary environmental practices, namely energy management and CO<sub>2</sub> emissions monitoring, on firm productivity in Morocco, and to assess whether these effects vary across the productivity distribution. The following hypotheses were formulated:

- H1: Voluntary energy management practices have a positive effect on firm productivity in Morocco.*
- H2: Voluntary CO<sub>2</sub> emissions monitoring has a positive effect on firm productivity in Morocco.*
- H3: The productivity effects of voluntary environmental practices vary across the firm productivity distribution. Specifically, drawing on the frontier-firm literature, positive effects are expected to be concentrated among higher-productivity firms, with weaker or null effects for lower-productivity firms.*

## 2. METHODS

This study uses firm-level data from the 2023 World Bank Enterprise Surveys (WBES) for Morocco. The data include 598 establishments op-

erating in manufacturing and service sectors and are nationally representative. The WBES data are publicly available upon request from the World Bank Enterprise Surveys database and have been widely used in previous empirical studies on firm performance and environmental practices.

The dependent variable is firm productivity, measured by the logarithm of total annual sales. This is a standard approach in the literature when physical output data are unavailable (Huang & Liu, 1994).

For the explanatory variables, voluntary environmental practices are captured using two binary indicators (Mansouri & Tounsi, 2026b). The first measures whether the establishment adopted tools to monitor CO<sub>2</sub> emissions over the past three years, reflecting environmental awareness and responsiveness. The second captures the implementation of energy management measures to reduce emissions over the same period.

To account for observable firm heterogeneity, a set of control variables is included. Innovation activity is measured by a binary indicator of R&D investment (Bu et al., 2020). Firm size is proxied by the logarithm of total labor costs to capture scale and resource effects (Yang et al., 2012). Managerial human capital is measured by the number of years of experience the CEO has in the firm's industry (Bloom & Van Reenen, 2007). A binary indicator captures whether the firm holds a quality certification or label (Benner & Tushman, 2002). Exporter status is measured by a dichotomous indicator (Bernard & Jensen, 1999). Finally, a categorical variable controls for sectoral affiliation and industry-specific effects (Lanoie et al., 2011).

The empirical analysis proceeds in three steps.

First, the average effect of voluntary environmental practices on firm productivity is estimated using the following baseline specification:

$$Y_i = \alpha + \beta_Z Z_i + \beta_X X_i + \varepsilon_i \quad (1)$$

where  $Y_i$  denotes firm productivity,  $Z_i$  represents environmental practices, and  $X_i$  is the vector of

control variables. Equation (1) is estimated using an ordinary least squares (OLS) regression to obtain average effects.

Second, to explore heterogeneity along the conditional distribution of production, conditional quantile regressions are also estimated (Koenker & Bassett, 1978). This approach extends beyond traditional mean regression by enabling the estimation of multiple points along the conditional distribution of the dependent variable. This method estimates parameters for a given quantile  $\tau$  by minimizing a weighted sum of absolute residuals. The specification for quantile  $\tau$  is:

$$Q(Y_i | Z_i, X_i) = \alpha + \beta_Z \cdot Z_i + \beta_X \cdot X_i. \quad (2)$$

This approach allows the estimation of effects at different points of the conditional distribution of firm performance.

Third, potential endogeneity is a major concern in our analysis, particularly due to possible reverse causality between firm productivity and voluntary adoption of environmental measures. To address this issue, propensity score matching (PSM) is employed to estimate treatment effects (Dehejia & Wahba, 2002). A logit model estimates the propensity score for adopting environmental measures based on observable firm characteristics (e.g., size, sector, quality certification, managerial experience). Treated firms are then matched with similar control firms using nearest neighbor matching with replacement. On the matched sample, both the average treatment effect (ATE) and quantile treatment effects (QTE) (Firpo, 2007) are estimated to capture average and heterogeneous productivity differences across the distribution. While PSM mitigates selection on observables, unobserved factors may still bias the estimates; therefore, results should be interpreted as suggestive rather than fully causal.

### 3. RESULTS

Table 1 presents the ordinary least squares (OLS) estimation results regarding the effects of voluntary environmental measures on firms' production levels. Models (1) and (2) consider energy management practices and CO<sub>2</sub> monitoring tools,

respectively. Both environmental measures are positively and significantly associated with production levels (0.329,  $p < 0.01$ ; and 0.576,  $p < 0.001$ , respectively), providing support for *H1* and *H2*. Regarding the control variables, labor costs are consistently positive and highly significant across specifications, while most sectoral and firm characteristics show no statistically significant effects.

**Table 1.** Effects of environmental measures on production (linear regression)

Dependent variable	(1)	(2)
	Production	Production
Energy	0.329** (2.76)	
CO <sub>2</sub>		0.576*** (3.83)
Labor costs	0.777*** (26.69)	0.767*** (26.02)
Manager	0.000120 (0.03)	-0.000942 (-0.22)
Exports	-0.191 (-1.67)	-0.209 (-1.83)
Certification	-0.197 (-1.65)	-0.175 (-1.49)
Garments	-0.226 (-1.66)	-0.200 (-1.51)
Other manufacturing.	-0.0564 (-0.40)	-0.0656 (-0.47)
Retail	-0.216 (-1.55)	-0.243 (-1.75)
Other services	-0.270 (-1.86)	-0.297* (-2.08)
R&D	0.0521 (0.39)	0.122 (0.93)
Constant	4.897*** (9.48)	5.024*** (9.75)
Observations	510	510

Note: For the Industry variable, the "Food" category is used as a reference. \*\*\*, \*\*, and \* denote significance at the 0.1%, 1%, and 5% levels, respectively. t statistics in parentheses.

To explore whether these average effects mask heterogeneity across the production distribution (*H3*), conditional quantile regressions are estimated at the 10th, 50th, and 90th percentiles (Table 2). The effect of energy management is positive and significant across all quantiles, but varies in magnitude: it is strongest at the median (0.464,  $p < 0.001$ ), weaker at the top (0.284,  $p < 0.01$ ), and smallest at the bottom (0.096,  $p < 0.001$ ). In contrast, CO<sub>2</sub> monitoring has no significant effect at the 10th percentile, but becomes positive and highly significant from the median onward (0.612 and 0.617,

**Table 2.** Effects of environmental measures (energy and CO<sub>2</sub>) on production quantiles

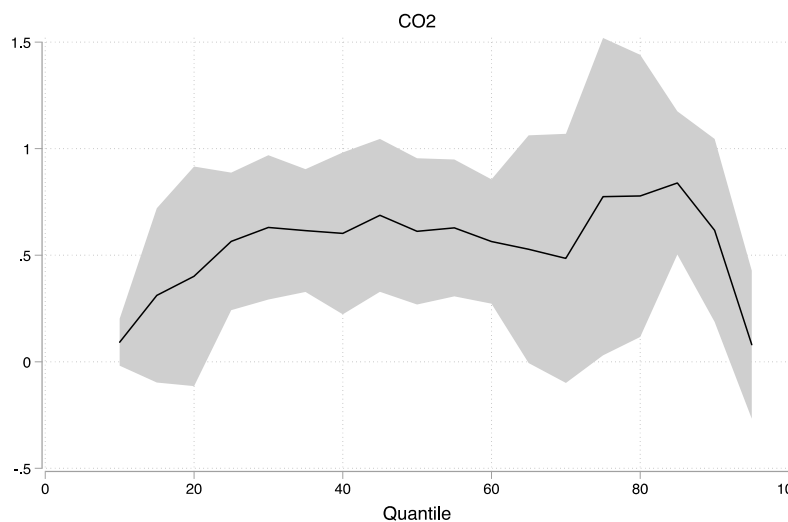
Production	10 <sup>th</sup> percentile		50 <sup>th</sup> percentile		90 <sup>th</sup> percentile	
	(1)	(2)	(3)	(4)	(5)	(6)
Energy	0.0956*** (5.66)		0.464*** (4.33)		0.284** (2.35)	
CO <sub>2</sub>		0.0918 (1.64)		0.612*** (3.50)		0.617** (2.82)
Labor costs	0.870*** (70.56)	0.885*** (83.53)	0.820*** (26.97)	0.820*** (21.44)	0.734*** (15.49)	0.676*** (11.68)
Manager	0.000757 (0.71)	0.00189 (1.52)	-0.00345 (-0.94)	-0.00413 (-0.91)	0.00191 (0.31)	0.0100 (1.20)
Exports	0.00540 (0.13)	-0.0323 (-0.99)	-0.251* (-2.34)	-0.208 (-1.51)	-0.188 (-1.19)	-0.407* (-2.36)
Certification	-0.0390 (-0.89)	-0.0284 (-0.60)	0.00572 (0.05)	-0.0561 (-0.33)	-0.214 (-1.45)	-0.325 (-1.56)
Garments	-0.0261 (-0.88)	-0.0411 (-1.18)	-0.0884 (-0.49)	-0.245 (-1.37)	-0.732** (-2.73)	-0.534 (-1.83)
Other manufacturing	-0.00626 (-0.11)	-0.0517 (-1.29)	-0.00210 (-0.01)	-0.224 (-1.07)	0.0895 (0.23)	0.268 (0.99)
Retail	-0.0996 (-1.31)	-0.111 (-1.66)	-0.112 (-0.54)	-0.311 (-1.54)	-0.387 (-1.32)	-0.225 (-0.72)
Other services	-0.171*** (-3.96)	-0.187*** (-4.51)	-0.248 (-1.18)	-0.497* (-2.54)	-0.436 (-1.36)	-0.224 (-0.89)
R&D	0.0925*** (3.43)	0.0905*** (6.15)	0.128 (1.22)	0.237 (1.96)	-0.0182 (-0.10)	0.0954 (0.38)
Constant	2.230*** (9.40)	2.016*** (10.20)	3.645*** (7.01)	3.941*** (5.99)	6.840*** (8.80)	7.668*** (8.55)
Observations	510	510	510	510	510	510

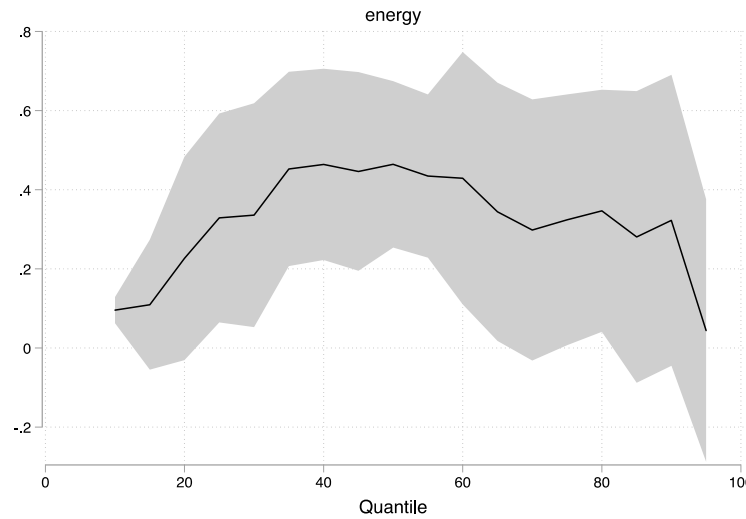
Note: For the Industry variable, the "Food" category is used as a reference. \*\*\*, \*\*, and \* denote significance at the 0.1%, 1%, and 5% levels, respectively. t statistics in parentheses.

$p < 0.001$  and  $p < 0.01$ , respectively). These results indicate heterogeneous effects across the distribution, consistent with  $H3$ .

These patterns are illustrated in Figures 1 and 2, which plot the conditional effects across the full

production distribution, from the 10th to the 95th percentiles. The shaded area indicates the 95% confidence interval. The effect of CO<sub>2</sub> monitoring remains positive throughout, peaking around the 85th percentile before declining (Figure 1). Energy management exhibits an inverted U-shaped pat-

**Figure 1.** Effect of CO<sub>2</sub> monitoring on the distribution of firm production



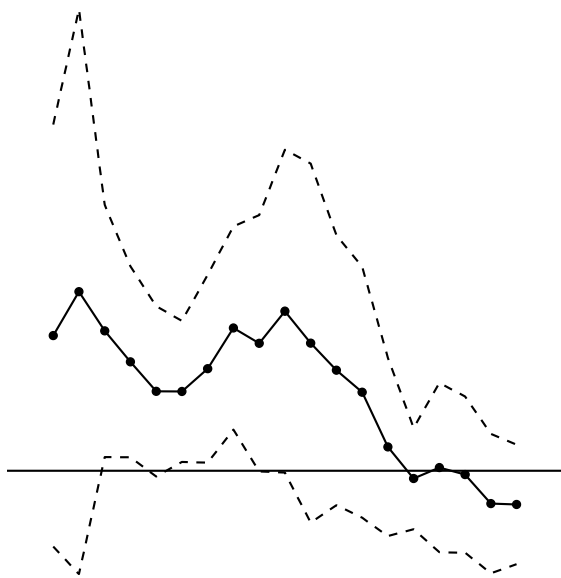
**Figure 2.** Effect of energy management on the distribution of firm production

tern, with the strongest effects concentrated around the median (Figure 2).

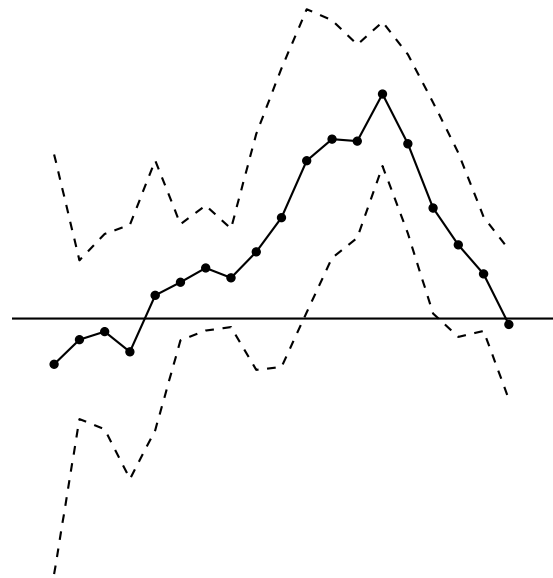
To account for potential selection bias, quantile treatment effects (QTE) are estimated using propensity score matching (Figures 3 and 4). The results provide a different picture. For CO<sub>2</sub> monitoring (Figure 3), the strongest positive effects are found in the lower deciles (10<sup>th</sup>–20<sup>th</sup>), suggesting a catch-up dynamic among low-performing firms, while effects become insignifi-

cant in the upper tail. For energy management (Figure 4), the treatment effect is near zero or negative at the lowest quantiles, becomes positive from the 30th percentile onward, and peaks around the 70th percentile, before declining sharply at the top.

These findings reinforce the presence of heterogeneous effects and confirm that the impact of voluntary environmental practices varies across the productivity distribution, in line with *H3*.



**Figure 3.** Effect of CO<sub>2</sub> monitoring on the distribution of firm production (QTE)



**Figure 4.** Effect of energy management on the distribution of firm production (QTE)

## 4. DISCUSSION

The results offer partial support for the Porter hypothesis (*H1* and *H2*), while revealing important contingencies related to firm productivity and identification strategy (*H3*).

Ordinary least squares (OLS) estimates indicate positive and statistically significant effects of both voluntary environmental practices on firm production (Table 1). Firms that manage energy exhibit, on average, approximately 33% higher production levels than non-adopters, *ceteris paribus*; those monitoring CO<sub>2</sub> emissions show a 57% increase. These findings align with the strong version of the Porter hypothesis (Porter & van der Linde, 1995) and with prior evidence documenting productivity gains from environmental practices (Berman & Bui, 2001; Lanoie et al., 2008). However, these estimates do not account for selection into treatment and should not be interpreted causally.

Conditional quantile regressions (Table 2) reveal substantial heterogeneity. The effect of energy management is positive across all quantiles, increasing from 0.09 at the 10th percentile to 0.46 at the median, then declining to 0.28 at the 90th percentile – consistent with non-linear effects of environmental regulation (Albrizio et al., 2017). In contrast, CO<sub>2</sub> monitoring has no significant effect among low-production firms, becoming positive and significant from the median onward (approximately 61–62% increase). This suggests that more productive firms may derive greater benefits from certain environmental measures, consistent with the literature on firm capabilities and resource access (Dechezleprêtre & Sato, 2017; Johnstone et al., 2017). Figures 1 and 2 illustrate these patterns.

The quantile treatment effects (QTE) analysis, which accounts for selection bias, challenges several conditional quantile findings. For CO<sub>2</sub> monitoring (Figure 3), the strongest positive effects appear in the lower deciles (10<sup>th</sup>–20<sup>th</sup>), pointing to catch-up dynamics – a pattern absent from the conditional results. The effect remains significant at the median but declines from the 70th percentile onward, becoming insignificant in the upper tail. For energy manage-

ment (Figure 4), the treatment effect is negligible or negative (though insignificant) at the lowest quantiles, becomes positive from the 30th percentile, and peaks at the 70th quantile (1.24 log-points, approximately a 245% increase in output – a magnitude that warrants caution and may reflect sample-specific conditions). The effect then approaches zero at the top of the distribution.

This divergence between conditional quantile and QTE results suggests that positive associations observed at the distribution tails in the conditional model may reflect correlation rather than causal effects. After accounting for selection, energy management benefits mid-to-upper performers, while CO<sub>2</sub> monitoring primarily benefits lower performers. The conditional quantile results – which showed CO<sub>2</sub> monitoring helping only from the median upward – prove misleading on this point.

What explains these divergent patterns? Energy management practices (e.g., equipment upgrades, process optimization) typically require upfront capital and technical know-how. Low-performing firms may lack the financial slack or managerial bandwidth to adopt them effectively, while frontier firms may have exhausted low-cost energy efficiency gains. Mid-to-upper performers, by contrast, possess sufficient flexibility and resources to innovate without being fully constrained by the productivity frontier (Johnstone et al., 2017). CO<sub>2</sub> monitoring, being primarily an information-gathering practice with low upfront costs, may serve as a low-cost entry point for productivity gains, particularly for lower-performing firms in developing countries. These firms can identify emission hotspots and waste, then implement low-cost operational changes, a catch-up dynamic that QTE captures but conditional quantile regressions miss.

These findings support the contingent nature of the Porter hypothesis (Ambec et al., 2013; Lanoie et al., 2011) and align with evidence of heterogeneous regulatory effects (Dechezleprêtre & Sato, 2017). The result that CO<sub>2</sub> monitoring benefits lower-performing firms is novel and suggests this practice may serve as an accessible pathway for productivity gains in developing economies. Nevertheless, several limitations should be ac-

knowledge. The QTE results are sensitive to the specification of the propensity score model, and unobserved confounders that jointly affect treatment assignment and quantile positions cannot be entirely ruled out. Future research should explore alternative identification strategies, such as instrumental variable quantile regression, to further validate these patterns. Despite these caveats, the clear divergence be-

tween conditional and selection-corrected estimates highlights the importance of the identification strategy and points to the need for differentiated environmental policy instruments (subsidies for energy management among mid-performing firms, and technical assistance for CO<sub>2</sub> monitoring among low-performing firms) that can foster convergence and catch-up dynamics.

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## CONCLUSION

This study examined the effects of voluntary environmental practices on firm productivity in Morocco using conditional quantile regressions and quantile treatment effects with matching. Our findings provide partial support for the Porter hypothesis, but this support is conditional on both firm position in the productivity distribution and the estimation strategy employed. Energy management exhibits positive effects that peak among mid-to-upper performing firms (around the 70th percentile) before declining to near-zero for the highest performers, a saturation effect not detectable in conventional conditional quantile estimates. For CO<sub>2</sub> monitoring, the conditional quantile regressions suggested persistent positive effects across all quantiles, but the QTE estimates reveal a different story: stronger impacts at lower quantiles, with effects diminishing and becoming statistically insignificant toward the upper tail. These contrasting patterns highlight that failing to account for selection bias can produce misleading conclusions about which firms benefit from voluntary environmental practices.

Policy implications include promoting voluntary environmental practices through differentiated and targeted support that reflects firms' heterogeneous responses across the productivity distribution. Energy management subsidies and technical assistance are likely most effective when directed at mid-to-upper performing firms, while low-cost CO<sub>2</sub> monitoring programs can serve as an entry point for productivity catch-up among lower-performing firms. Such an approach can enhance productivity for specific groups of firms while supporting an inclusive and efficient green transition.

Limitations include data constraints, the focus on voluntary regulation, and the inability to fully address endogeneity or track dynamic effects. The QTE results, while an improvement over conditional quantile regressions, remain sensitive to propensity score specification. Future research could explore sector-specific and longitudinal analyses, extend comparisons to other developing and developed countries, and assess whether the catch-up effects observed for CO<sub>2</sub> monitoring persist over time or eventually plateau. Such studies would deepen understanding of how voluntary environmental practices interact with firm characteristics, economic contexts, and dynamic productivity paths.

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