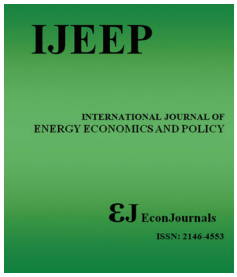

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Voluntary Environmental Regulation, Innovation and Access to Finance in Moroccan Firms: Revisiting Porter's Hypothesis

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ABSTRACT

This paper investigates the effects of voluntary environmental regulation on innovation in Morocco, a country engaged in an ambitious environmental transition. Using data from the 2023 World Bank Enterprise Survey, we analyze the impact of two types of environmental practices—energy management and CO_2 emissions monitoring—on firms' decisions to invest in Research & Development (R&D). To assess the role of financial constraints, we estimate our model separately for sub-samples of firms with and without access to external financing. The results indicate that energy management is positively associated with a higher probability of investing in R&D, while CO_2 emissions monitoring has no significant effect. Furthermore, access to finance does not enhance the effect of environmental practices on innovation. These findings provide new empirical evidence on Porter's hypothesis in a developing economy, highlighting that the driver of innovation is the adoption of specific, efficiency-oriented practices, and that this mechanism operates independently of firms' access to external capital.

Keywords: Porter Hypothesis, Voluntary Environmental Regulation, Innovation, Access to Finance, Morocco
JEL Classifications: L51, D24, O32, O55

1. INTRODUCTION

While the synergistic dynamics between environmental regulation, innovation, and financial access are well-documented in advanced economies, a significant knowledge gap persists regarding their interplay in developing nations. This gap is particularly pronounced at the micro-level, where firms operate under constraints of institutional fragility and limited capital (Shi et al., 2017; Charafeddine and Azzouz, 2024). In such contexts, the central tenet of the Porter Hypothesis is that well-designed environmental policies can stimulate innovation and enhance competitiveness (Porter, 1991; Porter and Van der Linde, 1995).

Morocco exemplifies this developing economy paradox. Despite its ambitious national strategies, such as the National Sustainable Development Strategy and its pledge to achieve 52% renewable energy by 2030, the empirical evidence on how these top-down commitments translate into firm-level action and innovation remains scarce (Hahn and Auktor, 2018). The Moroccan policy landscape has increasingly emphasized voluntary and incentive-based mechanisms, moving beyond traditional command-and-control approaches, which often prove less effective (Blackman et al., 2010). Consequently, firms are navigating this transition through voluntary environmental practices, driven by international standards, market incentives, and regulatory expectations.

This paper narrows its focus to investigate one critical aspect of this complex landscape: the role of voluntary environmental practices in firm innovation, and how this relationship is affected by access to finance. Using original firm-level data from the 2023 World Bank Enterprise Survey (WBES) for Morocco and employing Probit models, this study pursues two primary objectives: (1) to empirically test a version of the Porter Hypothesis by evaluating the impact of voluntary energy management and CO_2 monitoring

on innovation, and (2) to analyze whether a firm's access to finance strengthens or weakens this relationship—a question of paramount importance in credit-constrained environments (Falavigna and Ippoliti, 2022).

Our research makes several distinct contributions. It is, to our knowledge, the first micro-econometric study to examine voluntary environmental practices in Morocco. It extends the Porter Hypothesis literature, predominantly concerned with mandatory regulation (Zhuge et al., 2020; Zhang et al., 2024), into the realm of voluntary action. Furthermore, it provides novel insights into the critical conditioning role of finance, thereby bridging literature on environmental economics with that on innovation determinants (Chen, 2008; Fan et al., 2022) in a developing economy setting.

The findings reveal a nuanced reality: while energy management is positively associated with a higher probability of investing in R&D, CO_2 emissions monitoring has no significant effect. Furthermore, access to finance does not enhance the effect of environmental practices on innovation, suggesting other factors may be at play.

The remainder of this paper is structured as follows: Section 2 reviews the pertinent literature, Section 3 describes the data and methodology, Section 4 presents and discusses the empirical results, and Section 5 concludes with policy implications and avenues for future research.

2. LITERATURE REVIEW

2.1. Environmental Regulations and Innovation

A large part of the recent literature has focused on China, where environmental regulation has generated varied outcomes. Several studies highlight that the effects are not uniform across regions: in the eastern provinces, with stronger institutions and more advanced industrial structures, regulation has been shown to stimulate innovation more effectively (Wang et al., 2022; Nie et al., 2022). Yet the evidence is not unanimous. Feng et al. (2018), for example, report that regulatory pressure can in some contexts reduce firms' innovative capacity. Beyond mandatory rules, voluntary standards have also been studied. Bu et al. (2020) show that ISO 14000 certification significantly promotes R&D spending and patenting activity, suggesting that voluntary initiatives can complement regulation by encouraging firms to adopt greener technologies.

Outside China, the evidence remains relatively scarce but insightful. Jiménez (2005), using data from Chile, compares voluntary agreements with command-and-control regulation and finds that firms engaged in voluntary programs were more likely to adopt environmental management systems and incremental innovations. This points to the potential of voluntary approaches in contexts where regulatory enforcement is weaker.

In developed economies, the evidence is generally more consistent with the weak form of the Porter Hypothesis: environmental regulation tends to encourage innovation. Jaffe and Palmer (1997), for instance, find that higher abatement costs are associated with greater R&D spending, although not necessarily with more patents. Subsequent work has reinforced this conclusion, showing that stricter regulation pushes firms toward cleaner technologies and higher investment in environmental R&D (Brunnermeier and Cohen, 2003; Lanoie et al., 2011). Studies in OECD countries also confirm that well-designed policies, such as feed-in tariffs can promote patents in renewable technologies (Johnstone et al., 2010). More recently, Weiss et al. (2019) document how environmental regulation in Sweden improved firms' innovative capacities while creating innovation offsets that compensated for compliance costs.

2.2. The Role of Financing in the Relationship between Environmental Regulation and Innovation

While regulation can stimulate innovation, financial constraints may limit firms' ability to respond. Better access to credit has been shown to raise the likelihood of eco-innovation (Ghisetti et al., 2017), whereas liquidity constraints hinder adoption of environmental practices (Allet, 2017). Internal funds support green investment, but high leverage constrains it (Bouchmel et al., 2024). At a systemic level, green finance, subsidies, and digital inclusion can amplify innovation responses (Chen et al., 2025; Bakry et al., 2024). However, SMEs in developing countries still face structural barriers in accessing sustainable financing, limiting their potential (OECD, 2024). Overall, finance not only alleviates constraints but also reinforces complementarities between regulation and innovation (Del Río et al., 2015).

3. DATA AND EMPIRICAL STRATEGY

3.1. Data Source and Sample

This study employs firm-level data from the 2023 World Bank Enterprise Surveys (WBES) for Morocco. The WBES is a nationally representative survey that collects detailed information from senior managers and business owners on a comprehensive range of topics, including the business environment, firm performance, innovation, and environmental practices. The sample for our analysis consists of 598 firms across various industry sectors, all surveyed in 2023.

3.1.1. Variable construction

- Dependent variable. Our dependent variable is Innovation. In line with Bu et al. (2020), we measure innovation using a binary indicator that equals one if the firm invested in research and development (R&D) activities, and zero otherwise.
- Sub-sample analysis. To examine the role of financial access, we split the sample into two groups depending on whether the firm has an active line of credit or a loan from a financial institution. This allows us to compare the impact of environmental practices across financially constrained and unconstrained firms.
- Key independent variables. Our variables of interest pertain to firms' environmental practices. We utilize two primary measures:
    1. CO_2 monitoring: A binary variable indicating whether the firm adopted tools to monitor its carbon emissions over the previous three years. This metric captures proactive environmental management.
    2. Energy management: A binary variable indicating whether the firm implemented specific energy management

measures aimed at reducing its emissions during the same period.

- Control variables. We include a standard set of firm-level controls, guided by established literature:
  1. Firm size: Proxied by the logarithm of total annual labor costs, to account for organizational resources and scale (Yang et al., 2012).
  2. CEO industry experience: Measured as the number of years the top manager has worked in the sector, to control for leadership and industry-specific human capital (Bloom and Van Reenen, 2007).
  3. Quality certification: A binary variable indicating if the firm holds an internationally recognized quality certificate (e.g., ISO), which signals adherence to formal processes and innovation capabilities (Benner and Tushman, 2002).
  4. Export status: A dichotomous variable identifying exporting firms, which are typically more productive and exposed to competitive innovation pressures (Bernard and Jensen, 1999).
  5. Industry fixed effects: A categorical variable based on the firm's main sector of activity, to control for unobserved time-invariant heterogeneity across industries (Lanoie et al., 2011).

3.1.2. Descriptive statistics

Descriptive statistics for all variables are presented in Table 1. The data indicate that innovation, measured by R&D investment, is undertaken by 11.7% of firms in the sample. Access to finance remains limited, with only 24% of firms reporting a line of credit or loan. Regarding environmental engagement, 16.4% of firms have implemented energy management measures, while a smaller proportion (8.2%) monitor their CO_2 emissions directly. The profile of the average firm's management shows a CEO with substantial industry experience (mean = 19.64 years), though with significant variation (range: 1-67 years). Firm size, measured by the log of labor costs, also exhibits considerable dispersion (mean = 13.76; min = 9.39; max = 18.31), reflecting the heterogeneity of the sample.

3.2. Empirical Model

The main objective of the study is to assess whether the voluntary environmental measures undertaken by Moroccan firms have an impact on innovation. The estimated equation is specified as follows:

$$Innovation = \alpha_2 + \gamma_z Z + \delta_x X$$

The dependent variable (Innovation) is a binary variable indicating whether the firm invests in R&D. Furthermore, (Z) is a matrix representing the two selected environmental variables, and (X) groups the various control variables presented earlier.

First, we estimate the overall effect of these measures on the dependent variable using a Probit model. We then examine whether the effect of environmental measures on the innovation decision varies with firms' access to financing, using a Probit model. To do so, we estimate the equation separately for firms with and without access to external financing.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
R&D	598	0.117	0.322	0	1
Energy	598	0.164	0.37	0	1
CO_2	598	0.077	0.267	0	1
Finance	598	0.246	0.431	0	1
Labor costs	598	13.764	1.714	9.393	18.315
Manager	561	19.636	10.772	1	67
Exports	598	0.176	0.381	0	1
Certification	538	0.183	0.385	0	1
Industry	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Food	598	0.206	0.405	0	1
Garments	598	0.179	0.384	0	1
Other manufacturing	598	0.186	0.389	0	1
Retail	598	0.211	0.408	0	1
Other services	598	0.219	0.414	0	1

4. ESTIMATION RESULTS

4.1. Average effects: Innovation

Table 2 presents the estimation results regarding the effects of voluntary environmental measures on firms' decisions to invest in R&D (Models 1 and 2). Models (1) considers energy management practices implemented by firms over the past three years as the environmental measure, while Models (2) focuses on the use of CO_2 monitoring tools during the same period. The energy management measure shows a positive and significant impact on the dependent variable, while CO_2 emission monitoring tools do not significantly affect innovation. On the one hand, energy management is associated with a 14% higher likelihood of

Table 2: Effects of environmental measures on R&D investment (Probit)

Variables	(1)	(2)
	Innovation	Innovation
Energy	0.141***	
	(4.87)	
CO_2		0.00848
		(0.17)
Labor costs	0.0181*	0.0218*
	(2.04)	(2.12)
Manager	0.00142	0.00197
	(1.35)	(1.60)
Exports	−0.0658	−0.0873*
	(−1.77)	(−2.15)
Certification	−0.00141	−0.0510
	(−0.38)	(−1.35)
Garments	0.0544	0.105*
	(1.32)	(2.18)
Other manufacturing.	0.0372	0.0512
	(0.99)	(1.25)
Retail	0.00734	−0.00984
	(0.20)	(−0.26)
Other services	0.0487	0.0564
	(1.26)	(1.31)
Constant		
Observations	598	510

The coefficients of probit estimates (1) and (2) represent marginal effects. For the Industry variable, the "Food" category is used as a reference. t statistics in parentheses. *P<0.05, **P<0.01, ***P<0.001

investing in R&D. On the other hand, the lack of a significant effect of the second indicator (CO_2) on innovation suggests that not all dimensions of innovation respond equally to such environmental practices.

Regarding the control variables, the coefficient for labor input (Labor Cost) is positive and significant in both models, while the firm's export status (Export) is significant only in Model (2). By contrast, managerial experience (Manager) and quality certification (Certification) do not yield statistically significant effects.

The first set of results might imply that voluntary environmental measures, particularly energy consumption management, are associated with a significant increase in R&D investment. These empirical findings partially support the weak versions of Porter's hypothesis and align with other empirical studies which have confirmed this relationship for Northern countries (Lanoie et al., 2011; Ambec et al., 2013). The positive relationship between energy performance and innovation is consistent with the findings of Horbach et al. (2012), who show that environmental innovations are often driven by incentives to reduce energy costs. In the Moroccan context, this relationship is particularly linked to firm performance. Indeed, as noted in recent surveys by the HCP (2020) and CGEM (2024), energy costs are among the main barriers to competitiveness for manufacturing industries, particularly in energy-intensive sectors such as agri-food and textiles. For the second variable, CO_2 emissions monitoring, the results indicate a non-significant effect on R&D investment. This finding is consistent with the results of Frondel et al. (2008), who argue that, in many cases, the benefits of environmental regulation result from rationalization effects rather than from innovation in the strict sense. In Morocco, a possible explanation could be that a number of industrial firms have implemented internal emissions control systems, often in connection with international partnerships or external audits.

4.2. The Effects of Access to Finance

Table 3 reports the results of a Probit model estimating the effect of environmental measures on firms' innovation, segmented by access to financing. The findings reveal an ambiguous role of credit access in shaping innovation dynamics driven by voluntary environmental measures in the Moroccan context. While the literature finds a positive association (Ayyagari et al., 2011; Dethier et al., 2011), our estimates do not show any significant effect of credit access on the likelihood of investing in R&D. Among firms without credit access, the marginal effect of energy management on the likelihood of innovation is significant and substantial (coefficient of 0.11). By contrast, the effect is more moderate and statistically insignificant among firms with access to credit. Similarly, the marginal effect of CO_2 emissions reduction is statistically insignificant for both firms with and without access to financing. This may be explained, in the Moroccan context, by firms' use of credit primarily for routine operational expenses rather than for longer-term projects such as environmental innovation. In addition, firms with adequate self-financing capacity may view environmental initiatives as secondary priorities. Furthermore, greater reliance on external financing may lead to decision-making biases, especially during periods of uncertainty, affecting how projects are selected and prioritized (Naeem and Li, 2019; He et al., 2024). These findings also point to the need for targeted support mechanisms for green innovation, tailored to the specific constraints faced by Moroccan SMEs, particularly in terms of strategic foresight, market access, and technical support.

Table 3: Effects of environmental measures on R&D based on access to finance (Probit)

Variables	(1)	(2)	(3)	(4)
	Finance	No finance	Finance	No finance
Energy	0.157	0.115***		
	(1.68)	(3.55)		
CO_2			−0.153	0.0450
			(−1.21)	(0.85)
Labor costs	0.0307	0.0139	0.0494	0.0147
	(1.22)	(1.40)	(1.95)	(1.32)
Manager	0.00607*	−0.000332	0.00563	−0.000691
	(1.98)	(−0.27)	(1.81)	(−0.56)
Exports	−0.0899	−0.0567	−0.131	−0.0725
	(−0.92)	(−1.18)	(−1.37)	(−1.57)
Certification	−0.0644	0.000943	−0.0679	−0.0101
	(−0.72)	(0.02)	(−0.77)	(−0.21)
Garments	0.0993	0.0910	0.174	0.111
	(0.97)	(1.79)	(1.84)	(1.90)
Other manufacturing	0.172	0.0271	0.212*	0.0305
	(1.70)	(0.68)	(2.08)	(0.72)
Retail	0.0911	0.000870	0.0874	−0.0109
	(0.79)	(0.02)	(0.90)	(−0.29)
Other services	0.227*	0.0385	0.261*	0.0272
	(2.07)	(0.88)	(2.51)	(0.61)
Observations	115	358	115	358
Pseudo R^2	0.112	0.129	0.098	0.066

The coefficients of probit estimates (1), (2), (3) and (4) represent marginal effects. For the Industry variable, the "Food" category is used as a reference. t statistics in parentheses. *P<0.05, **P<0.01, ***P<0.001

5. CONCLUSION

This study has empirically examined the impact of voluntary environmental practices on innovation among firms in Morocco, offering a nuanced perspective on the Porter Hypothesis in a developing economy. The analysis, based on World Bank Enterprise Survey data and employing probit models, yields a mixed verdict. We find that voluntary commitments to energy management are a significant driver of innovation, measured through R&D investment. In contrast, monitoring of CO_2 emissions demonstrates no statistically significant effect. Furthermore, a key finding is that a firm's access to finance does not appear to reinforce the positive link between environmental practices and innovation.

These findings translate into several actionable policy insights. To foster sustainable innovation, policymakers should prioritize promoting and facilitating voluntary environmental management systems. Rather than relying on direct subsidies, which our results suggest may not be the primary lever, authorities can deploy a suite of indirect incentives. These could include offering preferential treatment in public procurement processes, tax credits for adopting certified environmental practices, or public recognition schemes that enhance corporate reputation. Such measures can make eco-

conscious practices more attractive to firms, thereby achieving environmental and innovation goals simultaneously.

Notwithstanding these contributions, this research is subject to certain limitations that also pave the way for future scholarly inquiry. The cross-sectional nature of the data restricted our ability to robustly address endogeneity or establish causality with greater certainty. The measurement of innovation, while standard, could be refined by distinguishing between general R&D and environmentally-specific technological advances. Moreover, the exclusive focus on voluntary instruments precludes a comparative analysis with the effects of mandatory or market-based regulations.

Addressing these limitations provides a clear agenda for subsequent research. First, the acquisition of panel data would allow for a longitudinal assessment, tracking firm behavior over time to better capture the dynamic effects of environmental practices. Second, a disaggregated sectoral analysis could reveal critical industry-specific heterogeneities that are masked in a broader sample. Finally, extending this analytical framework to compare findings across different countries would help determine the generalizability of these results and the role of national institutional contexts in shaping the regulation-innovation nexus.

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