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**CAN NATIONAL INNOVATION SUBSTITUTE THE ROLE OF
ENVIRONMENTAL REGULATION TO IMPROVE CORPORATE
ENVIRONMENTAL PERFORMANCE?**

**Natalia Ortiz-de-Mandojana, Javier Aguilera-Caracuel, José Manuel
de la Torre-Ruiz, Vera Ferrón-Vílchez**

Universidad de Granada

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***CAN NATIONAL INNOVATION SUBSTITUTE THE ROLE OF
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Abstract

Environmental regulatory uncertainty has attracted extraordinary attention among scholars, managers, policy-makers and other members of society. Despite this increasing attention, the impact of environmental regulatory uncertainty on the environmental approaches of firms is difficult to estimate in the business context. Considering that environmental regulations are not the only mechanism enabling firms to develop proactive environmental management practices, we show that the national institutional profile delineates a firm's environmental progress. Specifically, we argue that the national level of innovation is an essential institutional condition that can encourage firms to develop advanced environmental approaches and even overcoming the effect of environmental regulatory uncertainty on corporate environmental performance. Using a sample of 1,912 firms from 19 countries, we developed different scenarios that combine the effects of environmental regulatory uncertainty and the national level of innovation. Knowledge of these different situations illustrates how managers cope with environmental regulatory uncertainty.

Keywords: Environmental Regulatory Uncertainty; National Level of Innovation; Corporate Environmental Performance.

Environmental problems such as oil spills, nuclear accidents, and climate change have increased public concern about the negative environmental impact of business activities¹. In this context, the role of national and international environmental regulations has become increasingly important in limiting and controlling the environmental management practices of firms worldwide.²

Regulations have traditionally been understood to influence the strategic decision making of firms by structuring competition within industries³ or by favoring and providing incentives for entrepreneurs.⁴ Regulatory pressures have been identified as a main determinant of the environmental conduct of firms in many countries.⁵ As a result, the environmental management literature has paid special attention to explaining their environmental management through the analysis of environmental regulations.⁶

Environmental regulations present challenges, however, because they may be inefficient and difficult to implement, lead to managerial uncertainty⁷ and have a different level of stringency in each country. Similarly, assessing the environmental impact of business activity draws on long term considerations and depends on the ongoing adjustment of environmental regulations based on new scientific findings. Consequently, this instability caused by environmental regulations makes it difficult for managers and policy makers to predict the future state of the regulatory environment.⁸

Therefore, it is unclear how firms react to this unpredictable situation. Some firms have adopted a reactive and defensive environmental strategy, but others have supported a more proactive one.⁹ These contradictory approaches to environmental regulatory uncertainty question the logic of using this uncertainty as a predictor of a firm's environmental strategy.

In this respect, the economic arena has debated whether a more stringent environmental regulations would be suitable over a more lax interventionist position

that promotes innovation and flexibility within the business context. Some scholars have argued that a highly regulated environmental context enables firms to develop advanced environmental management practices,¹⁰ whereas others have argued that less stringent environmental regulations lead firms toward innovation and continual improvements in their products and processes.¹¹ Defenders of the latter position have argued that environmental regulation alone insufficiently promotes an advanced environmental behavior within the firm due to the difficulty of transforming the strengths of regulation into opportunities. In fact, effective implementation of environmental regulation requires an innovative context that encourages firms to improve their environmental progress. Determining the extent to which environmental regulatory uncertainty may be complemented and even overcoming by a highly innovative context remains relevant to describing advanced environmental approaches used by firms.

As a result, we propose that the national level of innovation (i.e. the overall sources of innovation at the country level)¹² can play a key role in the way firms cope with environmental regulatory uncertainty. Using a sample of 1,912 firms from 19 countries, we analyzed whether the national level of innovation may complement and replace the environmental regulations to the extent that firms can develop advanced environmental approaches independently of the level of environmental regulatory uncertainty. This work assesses the moderating role of the national level of innovation on the relationship between environmental regulatory uncertainty and the advanced environmental approaches of firms.

This analysis is essential for managers and policy makers for several reasons. First, because firms must allocate resources to continuously prepare for and adapt to future regulations, managers must understand how to face this uncertainty. In response, this

paper describes how the national level of innovation influences the effect that environmental regulatory uncertainty has on a firm's environmental decision-making. Second, managers may regard environmental issues as business opportunities through innovation gains, eliminating the hesitation to act related to environmental regulatory uncertainty. From a governmental point of view, regulators and policy makers should be able to promote initiatives (i.e., subsidies and tax benefits) to improve the national level of innovation.

Environmental regulatory uncertainty and firms' environmental approaches

Uncertainty refers to "the degree to which an organization's environment can be predicted."¹³ Uncertainty implies that a manager perceives a lack of information about the contextual evolution requiring continuous adaptation on the part of the organization.¹⁴ In this paper, we focus on analyzing the uncertainty derived from the regulatory context, defined as "an individual's perceived inability to predict the future state of the regulatory environment."¹⁵

In recent years, efforts to reduce the negative environmental impacts generated by business activity have increased regulatory uncertainty because of the multiple and diverse interests that make it difficult to establish a common international standard for environmental regulation.¹⁶ For instance, the 1997 Kyoto Protocol well illustrates the uncertainty caused by environmental regulations in the last decade. This international treaty, created under the United Nations Framework Convention on Climate Change, attempts to counteract climate change by reducing greenhouse gases by 5.2% below their 1990 levels, on average, through the 2008-2012 commitment period.¹⁷ Because this Protocol expires in 2012, it is unclear how the post-2012 regulations will be structured and how individual countries will adapt their national regulations. Although the 2011 Climate Change Conference in Durban, South Africa, is expected to propose a

revision of the Protocol ensuring no gap between the first and second commitment periods under the treaty, the negotiating positions are far away from one another, and an agreement seems difficult in the short-term. In the preparatory meeting organized in Bangkok, Thailand, in April, 2011, Japan and Russia stated that they will not participate in a second commitment period. The absence of Japan and Russia, along with the United States, China, and India, indicates that the five largest emitters of carbon dioxide from burning fossil fuels will not ratify the treaty. Several resulting questions related to future environmental regulations remain unanswered, such as when global greenhouse output should peak, what long-term global emissions goal will be adopted, and whether the next environmental commitments will be legally binding.

In this study, we analyze the environmental regulatory uncertainty using information obtained through the variable “Environmental Governance” included as a main indicator of the Environmental Sustainability Index (ESI) created by Yale Center for Environmental Law and Policy (Source: World Economic Forum). Specifically, the “Environmental Governance” indicator accounts for the following aspects related to the environmental regulatory uncertainty in a country: *air pollution regulations, chemical waste regulations, clarity and stability of regulations, flexibility of regulations, environmental regulatory innovation, leadership in environmental policy, consistency of regulation enforcement, environmental regulatory stringency, toxic waste disposal regulations, and water pollution regulations.*¹⁸

Although regulatory uncertainty is increasing worldwide, there are significant differences between countries. Column 1 of Table 1 shows the different levels of environmental regulatory uncertainty for each country included in our sample. India, Brazil, and South Africa are the countries with the greatest level of environmental

regulatory uncertainty, and Finland, Germany, and Sweden are the countries with the most certain environmental regulations.

INSERT TABLE 1 about here

Scholars have attempted to understand the various approaches developed by managers to address environmental regulatory uncertainty,¹⁹ resulting in contradictory arguments. On the one hand, several scholars suggest that firms facing environmental regulatory uncertainty are unwilling or hesitant to invest in advanced environmental management approaches.²⁰ Other researchers note that several firms, “stuck in the middle,” have ignored the effect of regulatory uncertainty and continued with their business as usual, including “no-regret moves.”²¹ These firms may also imitate the strategies of their peers or focus their decisions on environmental dimensions with a higher degree of certainty.

On the other hand, other scholars have defended the opposite arguments, suggesting that firms may face environmental uncertainty by adopting environmentally proactive strategies. Several studies have argued that a higher level of environmental uncertainty leads firms to develop innovative strategies. According to these studies, uncertain contexts encourage firms to anticipate events, implement preventive actions,²² and even increase their product variety to reduce the risk of focusing on an inappropriate market.²³ Related to regulatory uncertainty, Rugman and Verbeke²⁴ suggest that firms should focus on reversible investments using flexible resources with a high potential to increase performance. Combining these arguments, the environmental regulatory uncertainty may imply a scenario in which managers should pay more attention to environmental progress.

These different approaches to coping with environmental regulatory uncertainty illustrate the necessity of analyzing whether an additional contextual factor may further explain why managers decide to adopt a more (or less) advanced environmental strategy. Similarity among national environmental regulations does not determine the same degree of environmental development among different countries.²⁵ The effective implementation of environmental regulation requires an innovative context that encourages firms to improve their environmental progress. An innovative context not only moves firms toward a reduction of their negative environmental impacts, but it also complements the effectiveness of environmental regulations, such that firms may undertake environmental management approaches regardless of regulatory uncertainty.

The next section describes the role of the national level of innovation on the adoption of a firm's environmental management initiatives in contexts with high and low environmental regulatory uncertainty.

National level of innovation and the environmental approaches of firms

Innovation can involve either a hardware change (in a product, plant, or equipment) or a software change (in ideas, processes, or systems). We use the concept of the national level of innovation to indicate the overall sources of innovation at the country level.²⁶ According to Stern, Porter, and Furman,²⁷ the national level of innovation is the potential to produce a stream of commercially relevant improvements in terms of products and organizational processes. For instance, countries with a high level of innovation are those with a high research and development (R&D) governmental expenditure, a high percentage of capital-intensive industries, and a highly qualified labor force.

The literature suggests that the number of innovation trajectories developed within a country largely depends on the structural characteristics of the national economy.²⁸ The

composition of a nation's economic base affects the number of successful innovation activities enacted by its firms. This composition is reflected in the technology input and size distributions of firms and in the degree of innovation orientation among firms.²⁹ The successful introduction of product innovations also depends on several macro-economic conditions that shape prevailing market conditions, including the level of effective demand within the national economy³⁰ and the accessibility of foreign markets.³¹ Each of these market conditions enhances the demand for product innovations and the economies of scale realized in supply, production, and logistics, stimulating extra sales of product innovations via cost and price reductions.³²

In addition, other national conditions can also exert considerable influence on the national level of innovation and the innovation practices of firms.³³ These conditions include the infrastructure that regulates the inputs necessary to achieve the innovation activities carried out within a nation, such as the *accessibility of financial and human resources*³⁴. The *availability of highly educated and trained people on the labor market* affects a firm's propensity to innovate and to patent innovations.³⁵ Another condition of the national innovation infrastructure involves *public R&D expenditures*, which stimulate national innovation activities. Firms receive these expenditures as subsidies, matched funding, or revenues from public R&D contracts. Scientific research conducted at public and private universities comprises another public R&D expenditure. Finally, *the context of the entrepreneurial climate prevailing within a nation* must also be considered. In general, a stronger risk-taking attitude will lead more entrepreneurs to improve the competitive position of their business by increasing innovation activities, seeking market protection by patenting more innovations, and successfully introducing more product innovations to the market.³⁶

To analyze the national level of innovation, we used one of the measures of country innovation included in the World Energy and Climate Policy: 2009 Assessment. Data collection was facilitated by World Energy Council member committees through alliances with international institutions, such as the International Energy Agency and national energy institutes. The measure called “*innovation*” was calculated by the total R&D expenditure over the gross domestic product (GDP) (source: UN Human Development Index), the energy R&D/GDP (source: International Energy Agency), and the Innovation Index (source: World Bank).³⁷

Column 2 of Table 1 displays the different national levels of innovation for each country included in our sample. Japan, Finland, and Switzerland are the countries with the greatest national level of innovation, and India, Brazil and South Africa are the countries with the lowest national levels of innovation. To understand how firms address the challenge of regulatory uncertainty regarding the national level of innovation, we analyzed the effect of environmental regulatory uncertainty on corporate environmental performance.

Regulatory uncertainty, the level of national innovation, and corporate environmental performance

Environmental performance is incrementally important for firms and includes the effects of their processes and products on the ecosystem. These effects are expressed by measuring a range of different variables depending on the firm’s specific activity or the area of interest, such as pollutants, solid waste, energy consumption, and waste water.³⁸ Multiple stakeholders, including governments, media, customers, and environmental activists, are paying growing attention to the potential of the firms to improve their environmental performance.³⁹

To measure their environmental performance, we used the Bloomberg database, a financial services system that provides current and accurate financial, economic, and government information covering all market sectors worldwide. It also features analytics, company financials, historical market data, statistics, and current news reports. The Bloomberg database includes the variable “Environmental Rank” as part of its “*Environmental, Social and Corporate Governance data.*” This variable represents a numerical score that assesses the environmental performance of firms, allowing comparisons among them and ranking them on a 100-point scale. To develop this measure, the Bloomberg database considers the following data: greenhouse gas intensity per sales, greenhouse gas intensity per earnings before interest, taxes, depreciation and amortization (EBITDA), energy intensity per sales, energy intensity per EBITDA, water intensity per sales, and water intensity per EBITDA. Firms with relatively less energy and water consumption and less greenhouse gas emissions have better environmental performance considering their size (sales) and profitability (EBITDA).

The variable environmental rank is available for a universe of 2,046 firms from 45 countries. We have selected all countries that provide data on the minimum of 10 firms. As a result, our final sample consists of 1,912 firms from 10 different sectors and 19 different countries. Ten different industries are classified based on their economic function and internal characteristics: *utilities* (Sector 1), *basic materials* (Sector 2), *energy* (Sector 3), *consumer cyclical* (Sector 4), *industrial* (Sector 5), *communications* (Sector 6), *technology* (Sector 7), *consumer non-cyclical* (Sector 8), *financial* (Sector 9), and *diversified* (Sector 10). Our analysis covered Europe (Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom), North America (the United States and Canada), Japan, and other regions (Australia, Brazil, South Africa, South Korea, and India).

Thus, we consider the firm-level information obtained about the environmental performance and country-level information related to the environmental regulatory uncertainty and level of innovation. The analysis confirms that the national level of innovation moderates the influence that environmental regulatory uncertainty has on the environmental performance of firms.

Figure 1 indicates how the negative influence that environmental regulatory uncertainty has on the environmental performance of firms is attenuated by the national level of innovation. Specifically, this negative effect is more intense at a low national level of innovation. In contrast, a high level of national level of innovation points to firms maintaining relatively good environment performance, independent of the level of environmental regulatory uncertainty in that country. In Annex 1, we include the methods and tables that support this analysis.

INSERT FIGURE 1 about here

Consequently, the national level of innovation acts as an institutional complementary force that encourages firms to implement advanced environmental approaches. According to our results, firms operating in contexts characterized by a high level of innovation are able to achieve a high level of environmental performance in uncertain and certain environmental regulatory contexts.

Table 2 displays the combination of environmental regulatory uncertainty and national level of innovation for all the countries included in our sample. We distinguish four different scenarios in which firms develop their environmental activities, leading to different levels of environmental performance. We also indicate the average of environmental performance for firms in each of these institutional contexts.

INSERT TABLE 2 about here

Considering the important moderating role that the national level of innovation plays in the relationship between environmental regulatory uncertainty and corporate environmental performance, the different impacts that low and high national levels of innovation have on that relationship require further explanation.

1. Low national level of innovation

In this context, environmental regulatory uncertainty has a strong negative effect on the environmental performance of firms. Consequently, firms in this scenario are less willing to develop advanced environmental management practices because they are not able to predict the consequences of their investments. Moreover, due to the low level of national innovation, firms may find it difficult to obtain the resources and technology necessary to improve their environmental performance. The countries possess a set of inefficient mechanisms, policies, and incentives that limit innovation at the business and societal level. Finally, firms are less encouraged to support the costs of environmental behavior in public institutions and the business context. All these ideas explain the strong difference among the environmental performance of firms operating in countries with a low environmental regulatory uncertainty (58.45 on average), compared with those firms located in countries with a high environmental regulatory uncertainty (37.59 on average).

2. High national level of innovation

Although, in this context, firms prefer to improve their environmental performance when they are able to predict regulations, the negative influence of environmental regulatory uncertainty is less pronounced. A high level of innovation

situates firms in a better position to adopt environmental strategies and signals their environmental progress based on the guaranteed implementation of innovative and efficient processes in the region. Firms therefore access more-advanced technologies, and a more highly qualified labor force and may take advantage of the benefits derived from effective policies and institutional mechanisms used to undertake innovative approaches. In highly innovative contexts, firms can enrich their capacity to search for talent, technology, and ideas⁴⁰. In summary, this situation grants firms more opportunities to innovate and make the necessary investments to adopt an environmentally proactive approach. Stated differently, a high national level of innovation can substitute and even replace the effect of environmental regulatory uncertainty on the environmental progress of firms. This lower resistance to improve environmental performance is reflected in the diminished difference between firms operating in countries with low environmental regulatory uncertainty (61.18 on average) and those in countries with high environmental regulatory uncertainty (55.32 on average), compared with the difference analyzed in the context of low levels of national innovation (see Table 1).

Conclusions and Discussion

Environmental regulatory uncertainty has received extraordinary attention among scholars, managers, and society, and yet conclusions about the effect of regulatory uncertainty are not consistent. Some scholars argue that environmental regulatory uncertainty leads firms to adopt a proactive environmental strategy, but others find that it negatively affects their environmental approaches. Environmental regulations are not the only mechanism that enables firms to develop advanced environmental approaches. A high national level of innovation may substitute for the effectiveness of environmental regulations. Concretely, a high national level of innovation encourages

firms to achieve a high level of corporate environmental performance, reducing the negative impact that environmental regulatory uncertainty has on their environmental approaches.

According to our results, regulatory uncertainty must be analyzed in the context where the regulation is applied. The effects of regulatory uncertainty are very high when there is not a high level of national innovation, but this effect is low when there is a high level of national innovation. This analysis is extremely useful for understanding local firm behavior in the national context. Consequently, the national level of innovation complements and replaces the effect of environmental regulations, to the extent that firms can develop advanced environmental approaches independently of the level of environmental regulatory uncertainty.

Our analysis suggests that firms facing environmental regulatory uncertainty are unwilling or hesitant to invest in advanced environmental management approaches.⁴¹ We contribute to this line of argument by stating that the context of national innovation promotes firms to reduce their negative environmental impact and complement the effectiveness of environmental regulations to the extent that firms may undertake environmental management approaches regardless of environmental regulatory uncertainty.

This result may have important implications for managers and policy makers. First, managers should pay special attention to this issue when they internationalize their activities in countries and regions with different institutional profiles to understand better the behavior of competitors and design their entry strategy. Managers should be able to acquire valuable environmental knowledge from highly innovative countries and integrate it within their internal organizational network. In addition, managers who interact in innovative regions can undertake important investments in terms of

environmental issues because competitors, stakeholders, and the regional society will appreciate all these advances. Consequently, the risk of investment would be considerably reduced in those circumstances. From a governmental point of view, regulators and policy makers should be able to promote initiatives and create incentives (i.e., subsidies and tax benefits) related to the improvement of the national level of innovation. As a result, firms and the agents that interact in that social context will be able to develop innovative environmental postures beyond what is required by the law.

Finally, although this analysis has focused on the environmental reactions of firms rather than on the consequences of these reactions, those firms following a proactive environmental approach, regardless of the degree of environmental regulatory uncertainty, gain international legitimacy, transparency, a good reputation, and preferential treatment from consumers and stakeholders⁴². Managers must understand all of these circumstances because they may affect the environmental strategy of their firms. The simultaneous study of the effects of regulatory uncertainty and the national level of innovation facilitates the understanding of different competitive scenarios and may serve as a tool for analysis prior to environmental strategy design.

APPENDIX 1

Summary of Empirical Analysis

To assess the moderating effects of the national level of innovation on emission performance, we use a moderated regression model. The dependent variable is emission performance, and the independent variable is environmental regulatory uncertainty. The moderator is national innovation capability.

In addition, we considered sector financial performance and firm size. Profitability may be associated with the attention given to environmental issues. We use the *return*

on assets (ROA), frequently cited in the literature as an indicator of a company's financial performance. *Firm size* is also one of the structural determinants of corporate environmental behavior. We control for firm size by using the logarithm of total revenues as reported on the balance sheet in 2008.

Table 3 reports descriptive statistics and correlations for the variables examined in our study. To reduce potential problems of collinearity, we centered the variables for the moderation regressions. We also calculated the variance inflation factor (VIF) after each regression to understand whether the results were subject to multicollinearity. Values were within acceptable limits, indicating that our calculations were free of any significant multicollinearity bias.

Table 4 shows the result of the regression analysis.

INSERT TABLE 3 and 4 about here

TABLES

TABLE 1. Environmental regulatory uncertainty and national level of innovation

Country	Environmental regulatory uncertainty	National level of innovation
AUSTRALIA	47.05	4.9
BRAZIL	58.52	2.5
CANADA	52.35	5.6
DENMARK	40.84	6.3
FINLAND	40.5	7.3
FRANCE	47.35	5.4
GERMANY	40.26	5.5
INDIA	65.87	1.6
ITALY	53.98	5.4
JAPAN	48.79	8.7
NETHERLANDS	43.04	5.6
NORWAY	44.16	5.5
SOUTH AFRICA	57.98	2.7
SOUTH KOREA	56.92	6.8
SPAIN	55.89	3.6
SWEDEN	40.44	6.8
SWITZERLAND	40.86	6.9
UNITED KINGDOM	47.05	4.7
UNITED STATES	48.83	6.1

TABLE 2. Environmental regulatory uncertainty, national level of innovation, and corporate environmental performance

		NATIONAL LEVEL OF INNOVATION	
		Low	High
ENVIRONMENTAL REGULATORY UNCERTAINTY	Low	<p>Australia United Kingdom</p> <p>Corporate environmental performance 58.45</p> <p>(n = 279)</p>	<p>Denmark Netherlands Finland Norway France Sweden Germany Switzerland Japan</p> <p>Corporate environmental performance 61.18</p> <p>(n = 1,090)</p>
	High	<p>Brazil India South Africa Spain</p> <p>Corporate environmental performance 37.59</p> <p>(n = 498)</p>	<p>Canada Italy South Korea</p> <p>Corporate environmental performance 56.19</p> <p>(n = 88)</p>

FIGURE 1. Environmental regulatory uncertainty, national level of innovation, and corporate environmental performance

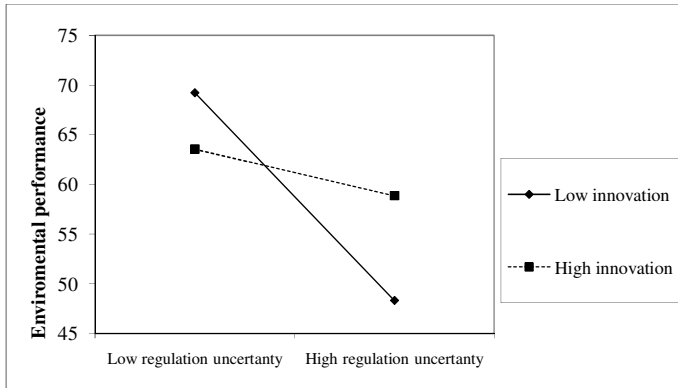


TABLE 3. Means, Standard Deviations and Correlations^a

Variable	Mean	S.D	1	2	3	4	5
1. Environmental performance	55.11	26.91					
2. Size	11.53	29.75	.19***				
3. Previous profitability	4.59	8.60	.03	.01			
4. Sector	4.88	2.47	.06**	.05*	-.07**		
5. Regulatory uncertainty	51.59	7.79	-.40***	-.18***	.10***	-.32***	
6. National level of innovation	5.66	2.57	.32***	.07**	-.14***	.19***	-.74***

^a n=1912. Table contains Pearson's correlation coefficient. Significant at the †.10; * .05; ** .01; *** .001 level.

TABLE 2. Regulatory uncertainty, level of national innovation and corporate environmental performance^a

	Model 1	Model 2	Model 3
Control variables			
Size	0.17*** (0.02)	0.11*** (0.02)	0.10*** (0.02)
Previous profitability	0.10 (0.07)	0.21** (0.07)	0.22** (0.07)
Sector	0.58** (0.25)	-0.74** (0.24)	-0.84*** (0.24)
Independent variables			
Regulatory uncertainty		-1.28*** (0.11)	-0.81*** (0.17)
National level of innovation		0.56† (0.33)	0.48 (0.33)
Regulatory uncertainty* National level of innovation			0.20*** (0.06)
Constant	49.88*** (1.41)	56.47*** (1.35)	59.99 (1.68)
R ² adjusted	.04	.18	.19
ΔF (dl)	25.86*** (3)	173.34*** (2)	12.50*** (1)

^an=1912. Table contains unstandardized regression coefficients. Standard errors are in parentheses. Significant at the †.10; * .05; ** .01; *** .001 level.

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