Scientific Research Publishing

Theoretical Economics Letters, 2023, 13, 1121-1130
https://www.scirp.org/journal/tel
ISSN Online: 2162-2086
ISSN Print: 2162-2078

Does Market Competition Affect Environmental Innovation? Some International Evidence

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How to cite this paper: Chasiotis, I., Georgakopoulos, G., & Touda, K. (2023). Does Market Competition Affect Environmental Innovation? Some International Evidence. *Theoretical Economics Letters, 13,* 1121-1130.
https://doi.org/10.4236/tel.2023.135061

Received: June 29, 2023
Accepted: August 28, 2023
Published: August 31, 2023

Abstract

This study explores whether market competition affects firms' propensity for environmental innovation. The sample is an international panel of 25,833 firm-year observations from international, non-financial, listed firms, between 2002 and 2022. Using a binary logistic regression model and several measures of market competition, we document that firms in competitive markets are more likely to engage in environmental innovation. Our findings support the "escape the competition effect", where companies, vis-à-vis market competition, strive to form competitive advantages.

Keywords

Market Competition, Innovation, Environmental Innovation, Schumpeter, Logistic Regressions

1. Introduction

Innovation can be defined as the process through which individuals or organizations conceptualize and develop novel products, processes, and ideas. Over the course of history, innovation was crucial against critical risks and threats while facilitating the progress and development of society. Considering its importance, economists have strived to understand its determinants. In this respect, the effect of competition on innovation has been the focus of economists and policymakers since Schumpeter (1950). Nevertheless, the theoretical and empirical evidence from the industrial organization literature is conflicting. Specifically, a number of studies show that a competitive environment stimulates innovation while others stand diametrically opposed. In this study, we explore whether market competition affects firms' propensity for environmental innovation.

We believe that our research objective is worthwhile for several reasons. Tha-

kor and Lo (2022) underline that theoretical and empirical findings on the relationship between market competition and innovation are contradictory. Thus, our study which uses an international sample drawn from a recent period, enriches extant empirical findings. Moreover, in this study we focus on a specific type of innovation, environmental innovation. Considering the adverse effects of climate change on a global scale, environmental innovation is of fundamental importance to society. Furthermore, numerous studies show that environmental innovation is value and performance relevant (Dyck et al, 2019; Liang et al, 2022; Chasiotis et al., 2023). Thus, understanding the determinants of green innovation is a worthwhile endeavor. In this respect, research on the effect of market competition on environmental innovation is generally limited. Hence, further research in this direction is called for. Accordingly, our study adds further insight into the determinants of environmental innovation by focusing on the relevant role of market competition.

The remainder of this study is organized as follows: Section 2 reviews the literature and develops testable hypotheses, Section 3 presents our sample and methodology, Section 4 discusses our results and Section 5 concludes.

2. Literature Review and Hypotheses Development

Schumpeter (1950) suggests that perfect competition does not favor innovation. The reasoning is that innovation is driven by profitability which is higher in monopolies. In this respect, Schumpeter (1950) proposes that innovation can be augmented by short-term restrictions on competition. Grossman and Helpman (1993) underline further, that competitive markets pose a higher risk that innovation will be copied or replaced. This in turn reduces firms' incentives to engage in innovation endeavors. Mulkay (2019) provides supportive empirical evidence. The author's analysis of French firms shows a negative effect of market competition on the propensity for innovation. In summary, part of the literature suggests a negative relationship between market competition and innovation. However, a number of empirical studies suggests otherwise.

Findings by Geroski (1990) show a negative relationship between market power and innovation, robust to alternative measures of market power. In a similar vein Nickell (1996) argues that market competition and research and development expenditures are positively related, and this in turn augments firm performance. Blundell et al. (1999) show that within firms, higher competition leads to higher innovation. Moreover, the authors state that within industries market competition appears to also boost innovation. Nevertheless, within industries market power was positively related to the commercialization of innovation. Aghion et al. (2005) propose a theoretical model that predicts an inverted-U shaped relationship between market competition and innovation. The authors state that the positive relationship stems from firms' incentive to "escape the competition". That is, firms that operate in competitive markets will need to improve their efficiency to survive; which translates into efforts towards gaining

and maintaining competitive advantages via innovation. Considering the discussion in this section we develop the following two competing hypotheses:

H_{1a}: Market competition increases the propensity for environmental innovation

H_{1b}: Market competition decreases the propensity for environmental innovation

3. Sample and Methodology

3.1. Sample

We construct our sample utilizing two commonly employed databases, the Compustat Global Database and Thomson's Reuters Refinitiv Eikon. We use the Compustat Global database to collect financial data for globally listed firms. To measure environmental innovation, we obtain the Environmental Innovation Score from Thomson's Reuters Refinitiv Eikon database, (indicatively see, Kyaw, 2022 and Albitar et al., 2023). Since data for this score are available since 2002, our sample period is 2002-2023. We merge the two datasets and remove financial firms and utility sectors (SIC codes 6000 - 6999 and 4900 - 4999, respectively), as well as, observations with missing values. Our final sample, is an unbalanced panel of 25,833 firm-year observations, from 2152 firms across 50 countries. Table 1, shows the distribution of our sample's firm-year observations across countries. We retain the unbalanced form of our panel to mitigate selection

Table 1. Number of firm-year observations per country, (N = 25,833).

Country	Obs.	%	Country	Obs.	%	Country	Obs.	%
USA	6369	24.65%	ITA	346	1.34%	ARG	61	0.24%
TWN	2466	9.54%	TUR	289	1.12%	BMU	56	0.22%
AUS	2330	9.02%	IDN	281	1.09%	SGP	49	0.19%
JPN	1350	5.23%	NOR	281	1.09%	PER	46	0.18%
DEU	1234	4.78%	NLD	248	0.96%	EGY	37	0.14%
FRA	1218	4.71%	MEX	236	0.91%	ISR	36	0.14%
KOR	1078	4.17%	NZL	204	0.79%	HUN	35	0.13%
IND	944	3.65%	AUT	183	0.71%	THA	31	0.12%
HKG	882	3.41%	IRL	173	0.67%	SWE	30	0.12%
CHE	765	2.96%	POL	160	0.62%	CYM	30	0.12%
ZAF	749	2.90%	PHL	132	0.51%	JEY	28	0.11%
GBR	557	2.15%	GRC	129	0.50%	ARE	23	0.09%
FIN	531	2.06%	CHL	113	0.44%	BEL	23	0.09%
MYS	442	1.71%	RUS	97	0.37%	KEN	22	0.08%
ESP	439	1.70%	PRT	94	0.37%	CYP	13	0.05%
DNK	428	1.66%	CHN	82	0.32%	ZMB	6	0.02%
BRA	412	1.59%	LUX	71	0.28%			

and survivorship bias. To reduce the potential effect of outliers, we follow common practice and winsorize all variables at the 1st and 99th percentiles.

3.2. Methodology

Our research objective is to investigate how market competition affects firms' propensity for environmental innovation. Hence, we construct the indicator variable *EnvInnov* (see, Equation (1)) which takes the value of 1 if a firm has a positive environmental innovation score (*EnvInnovScore*) and zero otherwise.

$$EnvInnov = \begin{cases} 1, & \text{if } EnvInnovScore > 0 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

Consequently, we use a binary logistic regression model and regress *EnvInnov* on market competition (*MarketCompetition*), a vector of control variables (*Z*), year (*Year*) and country (*Country*) dummies. Specifically, we estimate Equation (2), below:

$$EnvInnov_{i,t} = a_0 + a_1 MarketCompetition_{i,t} + a_2 Z_{i,t} + a_3 Year_t + a_4 Country_i + \varepsilon_{i,t} \quad (2)$$

We estimate Equation (2) using robust standard errors, clustered at the firm-level. A positive (negative) coefficient and statistically significant a_1 will support H_{1a} (H_{1b}) suggesting that market competition increases decreases (decreases) the likelihood for firms to engage in environmental innovation.

3.2.1. Measure of Environmental Innovation

Refinitivs's Enironmental Innovation Score reflects a company's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes, or eco-designed products (Refinitiv, 2022). The database collects data points on a wide range of concepts related to firm environmental innovation from various publicly available information sources, ranging from company reports such as the annual reports, corporate social responsibility reports, and so on, to news media and NGO websites. The collected data points are then converted into environmental innovation score using percentile rank scoring approach. Therefore, the environmental innovation score quantifies a firm's performance regarding environmental innovation. The environmental innovation score ranges from 0 to 100. A higher environmental innovation score, indicates that a firm is more innovative in tackling climate change and promoting environmental sustainability.

3.2.2. Measures of Market Competition

For robustness purposes, we use three alternative measures of market competition. To construct, the market competition measures, we first stratify firms into industries according to their respective three-letter SIC code. Consequently, we calculate for each industry and on an annual basis the Herfindahl-Hirschman Index of sales (HHI), as well as, the percentage of total sales of the top four firms in the industry.

$$\mathrm{HHI} = -\sum_{i=1}^{N_i}\left(\frac{Sales_{i,j}}{\sum_{i=1}^{N_J}\left(Sales_{i,j}\right)^2}\right)$$

where $Sales_{i,j}$ is the sales of firm i in industry j. Higher values of the Herfindahl–Hirschman Index correspond to lower competition. We multiply the Herfindahl–Hirschman Index by minus one and construct HHI, so that higher values of HHI indicate more competitive markets. Additionally, we calculate TOP4 as the percentage of total sales of the top 4 firms in each industry, and multiply by −1. As with HHI, higher scores of TOP4 indicate higher market competition. Finally, at the firm level we calculate the Lerner Index (LernerIndex) also known as the price cost margin. Specifically, we calculate the ratio of sales minus cost of goods sold to sales. A higher ratio indicates monopoly power while ratios close to zero perfect competition. We multiply by minus so that a higher LernerIndex corresponds to less market power and thus higher competition.

3.2.3. Control Variables

The choice of control variables is based on Zhang and Zhao (2022). In our initial estimation of Equation (2) we choose a more parsimonious model and include leverage (Leverage), capital investment (Capex), profitability (ROA), firm size (Size) and growth opportunities (GrowthOpportunities). Leverage proxies for financial constraints which may hamper innovation expenditures. Profitability and size are expected to have the opposite effect as they proxy, for the ability of a firm to fund investment internally and externally (i.e., borrowing ability). Capital expenditures can be considered as a competing use of funds (McCabe, 1979; Gugler, 2003), and sales growth proxies for growth opportunities.

3.3. Descriptive Statistics

Variable definitions and descriptive statistics are provided in **Table 2** and **Table 3**, respectively. The average firm in our sample has a mean environmental score ratio of 25.6. It exhibits a 12.6% profitability ratio, a leverage ratio of 50%, while 27.9% of its assets are tangible. Moreover, it has a 4.5% ratio of capital expenditures to total assets (Capex), and exhibits an average annual increase of 8.1% in sales. Moreover, net working capital represents 17.3% of its assets, while it holds 15.3% of its assets in cash.

4. Results

Table 4 presents results from estimating Equation (2) using logistic regressions with year, and country dummies and robust standard errors clustered at the firm-level. Results indicate that market competition increases firms' propensity for environmental innovation. This relationship holds across all measures of market competition. Specifically, the coefficient of HHI is 0.081, the coefficient for Top4 is 0.109 and for the LernerIndex is 0.073, all statistically significant at the 1% level. Results support H_{1a} and are in line with previous evidence (see

Table 2. Variable definitions.

Variable	Definition	Source
EnvInnovScore	The Environmental Innovation Score from the Refinitiv database.	Refinitiv
EnvInnov	An indicator variable that takes the value of 1 if a firm's Environmental Innovation Score is positive and zero otherwise.	Refinitiv
HHI	Herfindahl-Hirschman Index of sales classified using the 3-letter SIC code and multiplied by −1. Higher scores indicate higher market competition.	Compustat
Top4	The % of total sales of the top 4 firms in the industry, classified using the 3-letter SIC code and multiplied by −1. Higher scores indicate higher market competition.	Compustat
ROA	EBITDA divided by total assets	Compustat
Size	The natural logarithm of total assets	Compustat
Tangibility	Fixed assets to total assets	Compustat
Growth	Sales growth from year $t-1$ to year t	Compustat
Leverage	The book value of short- and long-term liabilities dividend by the sum of the book value of equity plus the book value of short- and long-term liabilities.	Compustat
Capex	Capital expenditures to total assets	Compustat
Cash	Cash and cash equivalents to total assets	Compustat
NWC	Current assets minus current liabilities to total assets	Compustat

Table 3. Descriptive Statistics. Variable definitions are provided in Table 2.

	N	Mean	p25	Median	p75
EnvInnovScore	25,833	25.156	0.000	0.00	50
HHI	25,833	−0.481	−0.664	−0.427	−0.27
TOP4	25,833	−0.883	−0.990	−0.935	−0.829
LernerIndex	25,833	−0.103	−0.255	−0.191	−0.138
Size	25,833	10.308	8.039	9.85	12.675
Tangibility	25,833	0.279	0.121	0.244	0.395
Leverage	25,833	0.500	0.368	0.509	0.637
ROA	25,833	0.126	0.075	0.113	0.162
Cash	25,833	0.153	0.062	0.120	0.210
GrowthOpportunities	25,833	0.081	−0.012	0.060	0.151
Capex	25,833	0.045	0.018	0.035	0.059
NWC	25,833	0.173	0.049	0.155	0.280

Table 4. Logit estimations of the relationship between market competition and environmental innovation (Equation (2)).

VARIABLES	(1) *EnvInnov*	(2) *EnvInnov*	(3) *EnvInnov*
HHI	0.081***		
	(0.022)		
Top4		0.109***	
		(0.025)	
LernerIndex			0.073***
			(0.018)
Leverage	0.027	0.007	0.022
	(0.019)	(0.021)	(0.019)
ROA	−0.013	−0.021	−0.006
	(0.018)	(0.019)	(0.018)
Size	0.175***	0.180***	0.188***
	(0.030)	(0.034)	(0.030)
Capex	0.065**	0.077***	0.073***
	(0.025)	(0.028)	(0.025)
SalesGrowth	0.058***	0.052***	0.061***
	(0.013)	(0.014)	(0.013)
Constant	0.738	0.681	0.795
	(0.498)	(0.481)	(0.501)
Observations	25,833	25,833	25,833
Year dummies	YES	YES	YES
Country dummies	YES	YES	YES
Robust SE	YES	YES	YES

This table presents results on logit estimations of Equation (2). The dependent variable is *EnvInnov*, a dummy variable that takes the value of if a firm has a positive Environmental Innovation Score and zero otherwise. Market competitions is measured using the Herfindahl-Hirschman Index multiplied by −1 (*HHI*) in column 1, the sum of the sales percentage of the top four firms in the industry multiplied by −1 in column 2, and the inverse Lerner Index (*LernerIndex*) multiplied by −1 in column 3. All variables are standardized. Robust standard errors, clustered at the firm level are reported in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Variable definitions are reported in Table 2.

Geroski, 1990; Nickell, 1996; Blundell et al., 1999; Aghion et al., 2005) who argue for an "escape the competition effect" of market competition on innovation.

In terms of our control variables leverage and profitability do not have a statistically significant effect on environmental innovation. However, firm size seems to have a consistent positive effect on the likelihood for environmental

innovation. This suggests that larger firms are more able to finance environmental innovation, most likely due to their ability to generate internal funds and obtain external capital at a lower cost. Growth opportunities also show a consistent positive sign. Finally, capital expenditures (CAPEX) show a consistent negative coefficient, in line with the notion that it represents a competing use of funds (McCabe, 1979).

Nevertheless, to test the sensitivity of our results we repeat the estimations of Equation (2) while including additional control variables. Specifically, we further include cash (Cash), asset tangibility (Tangibility) and net working capital (NWC). Results are reported in Table 5 and similar to our baseline estimations. Results across columns 1 - 3 show a positive and statistically significant coefficient on all measures of market competition at the 1% level. This lends further support to hypothesis H_{1a} that market competition increases the likelihood for environmental innovation.

Table 5. Sensitivity test-Logit estimations of the relationship between market competition and environmental innovation (Equation (2)) using additional controls.

VARIABLES	(1) *EnvInnov*	(2) *EnvInnov*	(3) *EnvInnov*
HHI	0.081***		
	(0.022)		
Top4		0.108***	
		(0.025)	
LernerIndex			0.073***
			(0.018)
Leverage	0.029	0.008	0.025
	(0.020)	(0.022)	(0.020)
ROA	−0.012	−0.019	−0.005
	(0.018)	(0.020)	(0.018)
Size	0.175***	0.177***	0.188***
	(0.031)	(0.034)	(0.031)
Capex	0.066**	0.078***	0.076***
	(0.026)	(0.029)	(0.026)
SalesGrowth	−0.059***	−0.053***	−0.061***
	(0.013)	(0.015)	(0.013)
Cash	0.014	0.016	0.016
	(0.019)	(0.022)	(0.019)
Tangibility	−0.007	−0.012	−0.005
	(0.020)	(0.022)	(0.020)

Continued

NWC	−0.007	−0.013	−0.004
	(0.021)	(0.023)	(0.021)
Constant	0.741	0.684	0.796
	(0.499)	(0.483)	(0.502)
Observations	19,700	17,077	19,833
Year dummies	YES	YES	YES
Country dummies	YES	YES	YES
Robust SE	YES	YES	YES

This table presents results on logit estimations of Equation (2). The dependent variable is *EnvInnov*, a dummy variable that takes the value of if a firm has a positive Environmental Innovation Score and zero otherwise Market competitions is measured using the Herfindahl-Hirschman Index multiplied by −1 (HHI) in column 1, the sum of the sales percentage of the top four firms in the industry multiplied by −1 in column 2, and the inverse Lerner Index (LernerIndex) multiplied by −1 in column 3. All variables are standardized. Robust standard errors, clustered at the firm level are reported in parentheses, ***$p <$ 0.01, **$p < 0.05$, *$p < 0.1$, Variable definitions are reported in Table 2.

5. Conclusion

In this study, we explore whether firms that operate in competitive markets are more or less likely to engage in environmental innovation. We empirically test two competing hypotheses derived from the extant literature. We utilized a binary logistic regression model and a sample of international, non-financial, listed firms. We provide evidence that market competition increases the propensity for environmental innovation. Our findings our robust to several measures of market competition and insensitive to the inclusion of additional control variables. The positive relationship between market competition and the likelihood for environmental innovation is against the Schumpeterian hypothesis that market competition impedes innovation because it decreases corporate profitability. On the contrary, our findings support the "escape the competition effect" suggesting that firms operating in competitive markets are more likely to innovate to gain competitive advantages against their rivals.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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