8-2021

Multinationality and the value of green innovation

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ABSTRACT

When do multinational corporations (MNCs) derive the most from internalizing the transfer of proprietary technological knowhow? We revisit this question, which lies at the core of theories on multinationality and performance, from the perspective of corporate strategy involving the mix of green versus non-green innovation effort and a foreign operations focus on countries with high-versus-low environmental standards. We find that high exposure to foreign markets with more stringent environmental regulations stimulates MNCs' green patent applications. Predictably, this long-run advantage produces higher economic rents when MNC's home countries rely on more clean energy for power generation, have more developed economy, and have more effective government. We further show that MNCs' environmental competitive advantage obtained through green innovation activities, coupled with exposure to MNCs' host countries with high long-term and femininity orientation, increases firm value in the long run. Finally, the pursuit of green (or even non-green) innovation while competing in polluting manufacturing industries is positively associated with market value. Overall, our study highlights that green technology development is a main source of value creation for multinationals.

JEL classification: F23, Q32, Q51, Q55
Keywords: Multinationality, environmental regulations, corporate environmental strategy, green innovation, firm value;

1. Introduction

International business theory (e.g., see Caves, 1974; Buckley and Casson, 1976; Hennart, 1982; and among many others) posits that multinational corporations' (MNCs[1]) success in an increasingly global business environment stems from proprietary knowhow and expertise that offer a competitive advantage over local corporations in foreign markets.[2] By internally deploying firm-specific intangible assets into their foreign market's operations, MNCs can increase efficiency, avoid costs of external contracting, and therefore accrue economic rents. An increasingly important challenge associated with international business are the costs that accrue to firms from a flurry of regulations aimed at environmental preservation.[3] Thus, MNCs are forced to make strategic decisions on the optimal mix of multinationality and green innovation effort. Yet, the value implications of these MNC strategies have not been directly or adequately addressed in the extant literature. We fill this gap by investigating whether and under what conditions green technology development is a significant source of value creation for multinationals.

[1] Multinational corporations are defined as if their foreign sales account for more than 20% of total sales (Denis *et al.*, 2002). Among firms listed in Worldscope, about 25.1% of firms (15.8% of U.S. firms) are classified as multinational corporationsin 1995, and the proportion increases to 51.3% (40.6%) in 2014..

[2] Corporate business is becoming increasingly global. According to the S&P 500 Dow Jones Indices, over 40% of total sales of companies in S&P 500 have been generated from foreign markets over the last decade. See, https://us.spindices.com/indexology/djia-and-sp-500/sp-500-global-sales

[3] Worldwide efforts to preserve the environment (e.g., Kyoto Protocol and the Paris Climate agreement) along with local government anti-pollution policies aimed to recover the previously underestimated social costs of pollution resulted in a set of environmental regulations that demand enhanced corporate social responsibilities. As such, observing those environmental rules and regs becomes more costly for firms than before. Local governments policies to reduce pollutions are especially aimed at heavy polluters. For instance, about 85% of total greenhouse gas emissions in California are generated by 450 businesses such as refineries, power plants, and other manufacturers. Since 2013, the CA legislature has enforced a cap-can-trade program, which puts a limit on the total amount of emission per business and requires businesses to purchase permits when they exceed assigned amounts of emission. This program has actually reduced greenhouse gas emission by 13% compared to its peak in 2004. See, https://www.yesmagazine.org/environment/2020/11/20/california-pollution-cap-trade/

Environment-friendly regulations can have debasing influences on a firm's productivity, profitability, or financing costs[4]. Over the years, costs of compliance with new environmental regulations have rapidly risen as global environmental standards have become increasingly stringent. Therefore, it is important for multinational corporations to adjust their environmental strategies to meet not only their home country's environmental standards, but also the country-specific environmental standards of current and potential business partners (or host countries). In this paper, we further explore the source of value creation in corporate multinationality from a perspective of corporate strategy involving the mix of foreign market focus and green technology development.

We first investigate whether MNCs adjust their green technology development based on their degree of exposure to foreign markets with more (less) stringent environmental regulations. Inspired by the extant literature on environmental pressure, we broadly sort corporate environmental strategies coping with global environmental pressure into two groups. The first group of MNCs consists of those that undertake more evasive strategies aimed at minimizing the costs of environmental regulations. Those firms primarily attempt to exploit cross-country differences in environmental regulations costs by shifting facilities manufacturing toxic products to countries where environmental regulations are less strict than in their home country (i.e., pollution haven hypothesis) and by somewhat overlooking green innovation.[5] Such strategy can have dual benefits. MNCs could not only save compliance costs by avoiding tight environmental regulations, which could result in attracting

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[4] For instance, Gollop and Robert (1983) show that regulation on sulfur dioxide (SO2) emission significantly reduces the rate of productivity growth in electric power industries. Similarly, Gray (1987) finds that environmental regulations enforced by the Environmental Protection Agency (EPA) hurt U.S. manufacturing firms' productivity growth in the 1970s. Fard et al. (2020) document evidence paralleling to early studies by showing that banks charges higher interest rate for borrowing firms facing stronger domestic environmental regulations.

[5] For example, a 1991 U.S. General Accounting Office survey documents that 2,675 wood furniture companies in Los Angeles moved their facilities to other areas in the United States or to Mexico to lower labor and environmental compliance costs. Keller and Levinson (2002) show that the state level pollution abatement costs are negatively associated with the inflow of foreign direct investment (FDI), implying that foreign investment favors places where expenditures necessary to meet environmental requirements are lower.

foreign investors (Xing and Kolstad, 2002), but could also avoid risky (going-green) projects embedded in high uncertainty about future cash flows.

Some environmental advocates, however, warn that, ultimately, the above-described strategy may cause reputational damage for MNCs, which could be depicted as the main culprits that create the negative externality (i.e., aggravating pollution) that lowers social welfare in spite of the financial benefits of investing more in countries with less strict environmental regulations (i.e., "race to the bottom" in environmental quality). Accordingly, there exists a second group of MNCs consisting of firms more likely to take a proactive approach in preserving the environment, based on the expectation that corporate environmental performance can boost firm value or perhaps partly due to social pressure. Indeed, both anecdotal and empirical evidence support the notion of a positive relation between corporate environmental performance and profitability.[6] This line of research, overall, shows that those MNCs that self-regulate their global businesses are more environmentally friendly and strive to develop green innovation.

Our empirical method accounts for the aforementioned degree of environmental pressure, by differentiating between the percentage of foreign sales in countries whose environmental regulations are more stringent ($Foresale^{HIGH}$) and in countries where environmental pressure is low ($Foresale^{LOW}$). To

[6] For example, the Guardian (see hyperlinks below) reports that DuPont reduced 65% of its greenhouse gas emissions over a recent 10-year period, resulting in $2.2 billion annual saving due to energy efficiency. Toyota has already started implementing an environmental action plan aiming to reduce vehicle emissions and improve fuel efficiency. The British Petroleum (BP)'s oil spill into the Gulf of Mexico and its failure to address environmental issues in a timely manner became an enormous financial liability. Recent studies also argue that MNCs can often conform to social pressure and become motivated to maintain a high level of environmental performance. Christmann and Taylor (2001) show that the level of foreign ownership and the percentage of sales to developed countries are positively associated with the adoption of ISO 14000, a family of standards related to environmental management. Eskeland and Harrison (2003) find that foreign firms pollute less than domestic firms in developing countries. Christmann (2004) show that social pressure from corporate external stakeholders (e.g., government, industry, and customers) improves quality of internal corporate environmental management.

https://www.theguardian.com/sustainable-business/environmentally-friendly-sustainable-business-profitable
https://www.theguardian.com/environment/2016/apr/04/bp-oil-spill-judge-grants-final-approval-20-billion-dollar-settlement

gauge a firm's the relative importance of foreign markets, we create a *FS Ratio* as $Foresale^{HIGH}$ divided by $Foresale^{LOW}$. Green innovation activities involve multidimensional plans and actions aimed at achieving a competitive advantage in product market (i.e., through green product development), along with preserving the environment in terms of energy savings, pollution reduction, and waste recycling (Arundel and Kemp, 2009). To quantify corporate environmental strategy in terms of efforts to develop green innovation, we count patent applications associated with environmental protection (i.e., green patents). Focusing on the economic effect[7] of corporate green innovation, a growing body of literature has shown a positive link between good environmental management and market valuation (e.g., Klassen and McLaughlin, 1996; Eichholtz, Kok, and Quigley, 2010; Guenster *et al.*, 2011)[8].

We find that the percentage of foreign sales in countries with stronger (weaker) environmental regulations than those of the MNC's home country is positively (negatively) associated with MNC green patent applications. We further show *FS Ratio* is positively associated with a firm's green patent applications. This finding supports the notion that MNCs' exposure to markets with more environmental pressure can drive green innovation effort and is broadly consistent with Calel and Dechezleprêtre (2016) who show that European firms increase the number of patent applications related to low-carbon technology by 36% compared with non-European matched peers after the initiation of the 2005 European Union Emissions Trading System (EU ETS). The positive effect is more pronounced for firms headquartered in more economically developed countries and countries relying on cleaner energy productions.

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7 Rugman and Verbeke (1998) show that the corporate response to environmental policies primarily depends on its expected economic benefits.

8 Moreover, Fernando, Sharfman, and Uysal (2017) document that firms with low environment risk exhibit higher firm value than other matched firms by attracting environment-sensitive institutional investors. Russo and Fouts (1997) further argue that new investments aimed at transitioning to clean technology can lead to the redesign of the manufacturing process or final products and eventually to improved upward product market competitiveness. Han, Yu, and Kim (2019) find that strong environmental performance increases corporate brand image and, thus, customers' loyalty in the airline industry.

We next test whether MNCs' environmental competitive advantage (obtained through patent stocks related to environmental protection) becomes capitalized, resulting in higher market value, and under what conditions.[9] We report a positive, long-term value impact of green innovation measured by environmental patent counts when coupled with a focus in countries with stronger environmental regulations than those of the MNC home country (i.e., business with high environmental pressure). This finding is consistent with prior research documenting the notion that good environmental performance is slowly incorporated into firm value (Derwall *et al.*, 2005). Our results further indicate that environmental competitive advantages are creating value in the long run when MNCs use them to penetrate foreign markets with strong environmental regulations.

We also investigate to a what extent the value impact from green innovation development differs by the MNC's home or host country characteristics. We first find that the effect of green innovation on firm value is coupled in countries (i.e., countries more relying electricity production on clean energy resources such as nucleus and waterpower) or industries (i.e., polluting industries) with environmental pressure and therefore where there is greater demand for green innovation. In addition, the value impact from green innovation's coupling with environmental pressure only materializes if the MNC home country has an effective government and a developed economy, which is consistent with the notion that institutional development help firms translate green innovation into firm value. Lastly, we show that the combination of green innovation and MNC exposure to high environmental regulation standards creates higher value when host countries have more long-term or femininity orientation, i.e. where there is a higher likelihood that shareholders or customers in such countries appreciate corporate green innovation efforts.

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[9] A voluminous amount of research shows that corporate research and development intensity or innovation is positively associated with earnings and stock returns (e.g., Chan, Lakonishok, and Sougiannis, 2001; Sood and Tellis, 2009). In addition, a large number of studies provide evidence that multinationality enhances the value relevance of intangibles [e.g., Morck and Yeung (1991), Allen and Pantzalis (1996), and Pantzalis (2001)].

To mitigate concerns about endogeneity due to omitted variable(s), we run a test that exploits the 2005 launching of the European Union Emissions Trading System (EU ETS), the cornerstone of EU's environmental policy aimed at reducing greenhouse gas emissions.[10] Effectively, the ETS raised the environmental compliance costs associated with doing business in the European Union. To isolate the effect of EU ETS on home and host countries, we focus on non-EU countries for this test. We compare firm value between two groups of sample firms in three years surrounding 2005. The first group (i.e., treatment group) consists of non-EU firms that have a high percentage of European foreign sales (i.e., whose European foreign sales are in the top tercile of our sample's European foreign sales); the other group (i.e., control group) consists of non-EU firms that have little foreign sales (i.e., whose European foreign sales are in the bottom tercile of our sample's European foreign sales). We find that green patents significantly increase treated group firms' long-term value after the enforcement of the EU ETS.

Our study contributes to the literature that focuses on the merits of corporate internationalization by presenting empirical evidence that green technology development is a core source of value creation from multinationality.[11] Our study highlights that technological knowhow offers MNCs a competitive advantage in foreign markets, and that this advantage translates into excess value when environmental compliance costs reduce the level of competition. We further show that

[10] The EU ETS is applied to more than 11,000 manufacturing facilities and power stations residing in 31 European countries (28 EU members plus Iceland, Liechtenstein, and Norway). The primary purpose of the EU ETS is limiting carbon emissions and imposing a cap for emission with heavy fines if firms produce emissions over their allowance. See this website: https://ec.europa.eu/clima/policies/ets_en

[11] Desai, Foley, and Forbes (2008) find that MNCs increase capital expenditure compared with domestic firms upon a currency crisis. In a similar vein, Jang (2017) shows that MNCs are less likely to be financially constrained than single-nation firms, especially when facing a financial crisis. Rego (2003) finds that MNCs are better able to pay lower taxes than domestic firms. Further, Morck and Yeung (1991) demonstrate that MNCs with high levels of proprietary knowhow experience positive firm performance.

proactive environmental technology development is one of the mechanisms through which MNC intangibles can create value.

Our findings also contribute to the literature that studies the impact of the environmental regulation stringency of corporate foreign markets on corporate innovation. Consistent with Porter (1991), Jaffe and Palmer (1997), and Calel and Dechezlepretre (2016), we find that stringency of domestic environmental policies is positively associated with green patent development. Our study further adds to the line of research (e.g., Hitt et al., 1997) documenting that the structure of foreign sales can affect the value impact of firms' green patenting activities.

Last, our research adds to the growing corporate social responsibility (CSR) literature in the sense that environmental sustainability is a part of CSR. Extant literature has shown mixed evidence on the effect of CSR on firm value. One line of research views (e.g., Frideman, 1970; Cheng, Hong, and Shue, 2013; Masulis and Reza, 2014; Kruger, 2015) CSR as a waste of shareholders' resources, which are often disbursed by managers' interests, whereas another line of research supports the notion that corporate social commitment (e.g., protecting the environment) not only increases short-term profit maximization (e.g., Flammer, 2013; Flammer, 2015) but also is a good long-term investment to build corporate reputation. Overall, our results are broadly consistent with the latter group of research studies in line with Jensen's stakeholder theory (2001).

The remainder of the paper is organized as follows. Section 2 discusses the related literatures. Section 3 describes the data and the sample. Section 4 presents the empirical results. Section 5 concludes.

2. Hypotheses Development

There are several theoretical and practical underpinnings for international expansion besides the economies of scale argument. First, expansions to foreign markets allow firms to diversify their operational risks. Since economic cycles are heterogenous across countries, firms doing business in multiple countries could reduce earnings volatility. Second, multinational firms could benefit from tax-motivated income shifting, especially when firms hold considerable intangible assets (Dischinger and Riedel, 2011). For instance, Google shifted $22.7 billion of patent rights to one of Google's holding companies in Bermuda to save its foreign tax liability[12] in 2017. Third, international market operations could enable firms to access to foreign resources such as talented human capital or idiosyncratic resources available in specific countries (Porter, 1990). Fourth, institutional arbitrage theory (Hall and Soskice, 2001) advocates the view that globalization offers firms to exploit arbitrage opportunities across institutional differences. North (1991) defines an institution as constraints "devised by human beings to create order and reduce uncertainty in exchange," which informal constraints involve customs, traditions, and codes of conduct where the latter refers to constitutions, laws, and property rights. Along with this institutional framework, much of the international literature has attempted to explain patterns of foreign investment flows. For instance, Houston et al. (2012), Carbo-Valverde et al. (2012), and Karolyi and Taboada (2015) show that a cross-country variation in banking regulations influences a direction of the fund flow or a location of the foreign merger in a banking sector, respectively.

However, foreign expansions do not always render profits to companies. The liability-of-foreignness view (Zaheer, 1995) posits that a cross-border business requires additional costs to become familiar with local laws, culture, and customers compared to domestic business, which could surpass the benefits arising from international business. Furthermore, certain country and firm characteristics in a junction with the degree of foreignness could definitely play a role in explaining the relation between internationalization and firm performance. For instance, firms exposed to high

[12] https://www.theverge.com/2019/12/31/21044662/google-end-tax-loophole-double-irish-dutch-sandwich-2020

agency costs may decrease firm performance. Perhaps a physical distance increase coordination costs between headquarters and subsidiaries.

As mixed theoretical predictions have provided, empirical tests of this multinationality theory have also yielded a broad range of findings (Martin and Sayrak, 2003). For instance, Denis, Denis, and Yost (2002) show that firms with geographical diversified segments underperform relative to firms with a single-nation segment. A possible driver of the negative relation between geographical diversification and firm value is that the multinationality is also associated with higher monitoring costs and more severe agency problems as reflected in differences in MNC and domestic firms' capital structure. Errunza and Senbet (1981) is an early study that established a positive link between corporate internationalization (i.e., multinationality) and firm value. Kim, Hwang, and Burgers (1989) find a positive relation between global diversification and profitability, especially when diversification takes place across unrelated industries. Morck and Yeung (1991) show that the interaction of multinationality and R&D spending is positively associated with firm value, implying that intangible assets that MNCs possess are a source of value creation. Overall, albeit with rich evidence studying on this filed, multinationality literature needs for improvement to identify an alternative source of value creation or destruction for multinationality as international markets are more complicated and new business mechanisms emerge.

In particular, there is ongoing debates as to how environmental regulations influence a firm's productivity, competitiveness, and profitability in environmental economic literature. Since environmental regulations are distinct across countries and have developed over time as each country sees fit, environmental economic literature has evolved with international scope of research. Until 1990s, early environmental economic literature has documented the negative effect of environmental regulation on a firm's productivity, competitiveness, and profitability (e.g., Gollop and Robert, 1983 and Gray, 1987). Porter (1991) and Porter and van der Linde (1995), however, challenge the traditional view by contending that more stringent domestic environmental regulations could encourage firms to be more innovative to compete with their rival firms in international markets. Products and services based on green innovation may thus potentially create a competitive advantage for MNCs over peers not equipped with ecofriendly mindsets in new foreign markets. This (Porter) hypothesis has induced a voluminous amount of follow-up research and the debate is still going on.

In this paper, we extend Morck and Yeung's work (1991) (i.e., multinationality and valuation effect of its innovation) by looking into an aspect of environmental pressure arising in international business and corporate environmental strategy from a perspective of green innovation development to deal with environmental pressure. We therefore investigate the value implications of green and non-green innovation that MNCs choose to adopt under varying degrees of global environmental pressure. Accordingly, we first examine whether the structure of foreign sales after conditioning on foreign market stringency of environmental standards is correlated with the intensity of MNCs' green innovation activities. Subsequently, we test the hypothesis that foreign market location choice in conjunction with a firm's innovation activities can have market value implications. Since environmental outperformance is only slowly incorporated into firm value (Derwall *et al.*, 2005), we also check the time horizon over which green and non-green technology development coupled with a geographic focus (in high versus low environmental regulation compliance cost countries) is eventually capitalized into MNCs' valuation.

3. Data

3-1) Environmental databases

We construct our sample by combining information from several sources. First, we obtain the country-level environmental policy stringency (EPS) index from the OECD website.[13] The index

[13] https://stats.oecd.org/Index.aspx?DataSetCode=EPS

aggregates information on 6 domestic environment-related policies (i.e., environment-related taxes, trading schemes, feed-in-tariff, deposit refund scheme, emission limits, and R&D subsidy) for 29 countries (all 23 OECD countries plus Brazil, China, India, Indonesia, Russia, and South Africa) from 1990 to 2012. For instance, for variable expressed with nominal values such as emission limit, each country is categorized given emission limit on NO2 emission (e.g., score=6 if emission limit is greater than 0 and less than 150 mg/nm^3, score=5 if emission limit is between 150 and 200, score=4 if emission limit is between 200 and 250, …, score=1 if emission limit is greater than 350 and score =0 for no emission limit). Some regulatory elements (e.g., deposit and refund schemes) are measured as an indicator (zero or one) based on the existence of related laws. While each element of the index is measured in various ways, all elements are equally weighted and scored on a 0 (least stringent) to 6 scale (most stringent). This stringency of environmental policies generally implies the strength of signal on the cost of environmentally harmful behavior such as pollution (Botta and Kozluk, 2014). Using this EPS index, many researchers have tested how EPS influences economic outcomes such as innovation (De Santis and Lasinio, 2015), CO_2 emissions (Probst and Sauter, 2015), and productivity growth (Albrizio et al., 2014), respectively. We use this EPS index score to mainly measure the difference in the strength of environmental policies between the headquarters and foreign sales countries (Javier *et al.*, 2012). Alternatively, we also use the environmental performance index from Yale Center for Environmental Law & Policy (Wendling et al., 2020)[14] as a robustness check.

To identify places where foreign sales take place, we obtain corporate sales information by geographic segment (e.g., the dollar value of sales per country) since 2002 from Factset.[15] Because the main interest of our study is testing the effect of MNCs' environmental performance on firm value,

[14] While this EPI index covers 180 countries, its time series information is limited to 2000 to 2010.

[15] The Factset database provides geographically segmented corporate sales information for international firms since 2003. The Worldscope database by Thomson Financial also reports segmented corporate sales information since 1990, but about half of that is at the regional level.

we limited our analysis to firms residing in those countries and delete corporate foreign sales outside the 29 countries. Based on the information compiled, we follow Dyreng and Lindsey (2009) and create *Foresale-high* (or *Foresale-low*), which is the percentage of foreign sales that incur sales in countries whose environmental stringency is higher (or lower) than that of corporate's home country. These variables allow us to distinguish different level of environmental regulations and identify the extent of the MNCs' foreign sales associated with the stringency of environmental regulations. In addition, we also create two additional variables, namely *FS Ratio* and *FS Ratio-std*, as the proxies for company's relative foreign sales encompassing stringency of environmental regulations. Specifically, *FS Ratio* is constructed as *Foresale-high* divided by *Foresale-low*. We also use *FS Ratio-std* in the sensitivity tests, which is the alternative firm's relative foreign sales measured as (*Foresale-high* - *Foresale-low*)/ (*Foresale-high* +*Foresale-low*), and this variable is bounded between -1 and 1. In general, a higher value in *FS Ratio* (or *FS Ratio-std*) indicates that a focal firm has a relatively higher foreign sales in countries whose environmental regulations are more stringent than those of home country, comparing to its foreign sales in countries with less stringent environmental regulations.

To measure MNCs' green technology development, we use the patent applications reported in the Patent Network Dataverse managed by Harvard University.[16] The database includes a patent's applicant name, date, location, and class number for both U.S. and non-U.S. corporations for 26 years from 1975 to 2010. We conduct fuzzy matching, merging two databases by company names and locations, to link the unique patent number with GVKEY from Global Compustat. For ambiguous company names, we go through the matching manually. Thereafter, we classify patents as environment-related (or green) patents based on the primary class numbers[17] as was done by Carrion-

[16] https://dataverse.harvard.edu/dataverse/patent

[17] The following patent class numbers indicate classification as an environmental patent; wind energy (242, 073, 180, 440, 340, 343, 422, 280, 104, 374), solid waste prevention (137, 435, 165, 119, 210, 205, 405, 065), water pollution (405, 203, 210), Recycling (264, 201, 229, 460, 526, 106, 205, 425, 060, 075, 099, 100, 162, 164, 198, 210, 216, 266, 422, 431, 432, 502,

Flores and Innes (2010), Popp and Newell (2012), and Amore and Bennedson (2016). We then proxy environmental innovations by counting the total number of granted green patent applications and using in our tests their log-transformed value in year *t+1*, *t+2*, and *t+3*, namely, $Ln(GreenPat)_{t+1}$, $Ln(GreenPat)_{t+2}$, and $Ln(GreenPat)_{t+3}$, respectively. In our sample of firms, about 88.2% of all patents (or 87.1% of green patents) are filed by MNCs in the corporate headquarters' country. Most innovation studies suffer from truncation problems, which involve the significant lag (average two to three years) between the year of the application and the year the patent was granted. Therefore, around the end of the sample period, the number of patents reported in the data set might be underreported compared to the actual number of patents, since many patent applications filed during those years would still be under review and not yet granted. To address this problem, we adjusted the number of patents using a "weight factor," i.e., by scaling the number of patents with the mean value of green patents in a given year and country (Hall, Jaffe, and Trajtenbert, 2001, 2005). After deleting firms in the financial industry and those with missing financial information, our final sample consists of 37,092 firm-year observations[18], across 29 developed and developing countries spanning the period from 2002 to 2010.

3-2) Financial databases

523, 525, 902); alternative energy (204, 062, 228, 248, 425, 049, 428, 242, 222, 708, 976); alternative energy sources (062, 425, 222); geothermal energy (060, 436); air pollution control (123, 060, 110, 422, 015, 044, 423); solid waste disposal (241, 239, 523, 588, 137, 122, 976, 405); and solid waste control (060, 137, 976, 239, 165, 241, 075, 422, 266, 118, 119, 435, 210, 405, 034, 122, 423, 205, 209, 065, 099, 162, 106, 203, 431) (Carrion-Flores and Innes, 2010)

[18] In this paper, we have two research questions linked to following two research questions: 1) the effect of foreign sales on corporate green innovation development and 2) the joint effect of green innovation and foreign sales on firm value. In the revised manuscript, we first compile 37,092 firm-year observations that have non-missing values to address the second question, since we think that second research question is more important question than the first one. To question 1), we use 1-year forwarded, 2-year forwarded, and 3-year forwarded green patent variable, resulting in 28,573, 20,419, and 15,369 observations respectively. The lower number of observations in model (1) for green patent variables is due to the lack of information on patent applications after 2010. The singleton groups will be automatically dropped anyway by STATA program (for example, 27, 052 observations in Table 3), but observations being dropped could vary across regressions. Therefore, we will observe different number of observations in different tables.

We obtain financial and accounting information from Worldscope. Since much of extant multinationality literature use either excess value or Tobin's *q* as a proxy variable of firm value, we use the firm's excess value for our main analyses and Tobin's *q* for a robustness test. A firm's excess value, namely *ExcessVal*, is computed as market value of equity minus book value of equity divided by sales (Bodnar, Tang, and Weintrop, 1997), which is our tests' main dependent variable. As a robustness check, we also construct an alternative excess value measure, computed as the firm's actual value divided by its imputed value, followed by Berger and Ofek (1995) and Graham, Lemmon and Wolf (2002). More specifically, we calculate the imputed value of each segment for a focal firm by multiplying median value of total capital to total sales for a single-segment firm in the same industry, by the segment's level of total sales. We then aggregate the imputed value of all segments as a whole. In addition to excess value, we construct Tobin's *q* proxy for a focal firm's relative market value as the sum of market value of equity, the liquidating value of preferred stock, and the book value of debt divided by the book value of assets (Chung and Pruitt, 1994; Berger and Ofek, 1995).

We also include a set of control variables in our analysis. We follow extant literature and construct the following firm characteristics: 1) *Ln(MkCap)*, the natural logarithm of the market value of equity at the end of year to represent firm size; 2) *ROA*, earnings before interests and taxes divided by total assets as a proxy for profitability; 3) *Domsale* is the ratio of domestic sales to total sales; 4) *Leverage*, long-term debts plus debts in current liabilities divided by total assets; 5) *Tangibility*, the net amount of property, plant, and equipment divided by total assets; 6) *R&D*, R&D intensity measured by the research and development expenditure divided by total assets; 7) *HHI*, the Herfindahl index based on sales across the first two digits of SIC code and some country variables. We also create the following country-level control variables: 8) *Ln(GDPpa)*, log-transformed GDP per capita; 9) *Trade,* imports minus export divided by GDP; 10) *RuleLaw,* the index that measures quality of domestic laws; 11) *EPS*, environmental stringency index; 12) *PPindex*, intellectual property protection index; 13) *FDI* is the ratio of foreign direct investment in the GDP. In addition, $Ln(GpatStock)_{[t-1,t]}$, $Ln(GpatStock)_{[t-3,t]}$, and $Ln(GpatStock)_{[t-5,t]}$, are the log-transformed cumulative number of green patents from year *t-N* (*N*=1, 3, and 5) to year *t* by adding one. All variables are winsorized at their 1st and 99th percentile values.

3-3) Summary statistics

Table 1 provides detailed summary statistics. The median value of either excess value or adjusted Tobin's *q* is slightly above zero, which is consistent with the findings in most literatures (Berger and Ofek, 1995; Graham et al., 2002). The average percentage of foreign sales is close to 26% (*ForeSale-high* plus *ForeSale-low*) for a typical firm, with 12.2% of them contributed from the countries with stricter environmental protection laws and the remaining 13.7% from the countries with less stringent environmental protection laws. The mean value of *FS Ratio* is 0.643, indicating that a relatively higher foreign sales contributed from countries with less stringent environmental regulations for a typical firm. Our sample of firms on average exhibit 3% of ROA and 21 % of leverage. Those of firms spend about 3% of assets as a research & development expense and hold 0.105 of log-transformed value of green patents. About 83% of our sample is from developed countries. Average EPS score is close to 2.075, ranging between 1.3 (bottom 25%) and 2.68 (top 25%).

Insert Table 1 about here

In Table 2, we report mean values of the environmental stringency index, foreign sales, and green innovations across countries. In our sample of firms, the country with strictest environmental protection law is Denmark with a mean *EPS* score of 3.585. On the other end of the spectrum, the country with the worst environmental protection law is Brazil with a mean *EPS* score of 0.457. Generally, European firms are more heavily relying on foreign sales to grow in the development of globalization process. For example, firms from Switzerland, Denmark, and Ireland exhibit the highest level of average percentage of foreign sales (*ForeSale-high* plus *ForeSale-low*), summing up over 70% in their total sales. Whereas Danish firms' foreign sales come primarily (almost 69%) from countries with less stringent environmental protection, Irish firms' foreign sales are mostly (53%) from countries with more stringent environmental protection. Over 50% of our sample are firms headquartered at United States, with a mean value of 11.9% for *ForeSale-high* and a mean value of 8.4% for *ForeSale-low*. Finally, among those firms from the different countries in our sample, Japanese companies engage the most in green technology development with highest mean value of *Ln(Greenpat)*, however, the firms headquartered in countries such as Greece, Indonesia, Poland, Portugal, Russia, South Africa or Turkey produce zero green patent during our sample periods

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Insert Table 2 about here

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4. Empirical Results

4-1) Green technology developments

To initiate our empirical analyses, we first investigate a relation between the structures of foreign sales and corporate green patent development. Christmann (2004) proposes two competing hypotheses on MNCs' environmental strategies facing with environmental pressure in foreign businesses. As such, we examine the effect the structures of foreign sales on corporate green patent development two different level of pressures by splitting foreign sales into *ForeSale-high* and *ForeSale-low* and create *FS Ratio* to see the relative importance of foreign sales on green innovation development. To measure a firm's green innovation activities, we count the number of applied patent applications related to environmental protection[19] (Carrion-Flores and Innes, 2010; and others) and use it by log-transforming its value plus one, *Ln(GreenPat)*$_{t+1}$[20]. We also include a set of control variables as determinants of corporate innovation in extant literature. For instance, Tian and Wang (2014) show that firms with larger size, more profitable, less debts, and greater R&D spending tend to be more productive in innovation. Therefore, we include a logarithm of assets, ROA, leverage, and R&D intensity. Aghion et al. (2005) find that product market competition exhibits an inverted-U shaped relation with corporate innovation activities. To measure competition, we use the Herfindahl-Hirshchman index. Loung et al. (2017) find foreign ownership is positively associated with corporate patenting activities. Furman et al. (2002) find macro factors such as domestic product development (GDP) per capital, trading volume, the level of intellectual property protection are important to shape corporate innovation development. Therefore, we also include a logarithm of GDP per capita, a difference between export and import divided by GDP, quality of domestic laws, foreign direct investment divided by GDP, and intellectual property protection index, respectively.

We therefore construct the following model to test our hypothesis

$$Ln(GreenPat)_{t+1} = \alpha + Firm_i + Year_t + \beta_1 ForSale + \beta_4 X + \varepsilon_i \quad (1)$$

Table 3 reports the detailed results. In column (1), we find that the coefficients of both *ForeSale-high* is positively associated with green innovation development that is significant at the 1%

[19] Some examples on the patent applications associated with environment are as follows: 1) A process for the desulfurization of a sulfurous acid gas-containing waste gas by blowing the waste contact into an absorbing liquid through a plurality of sparger pipes is disclosed, wherein various operation conditions are specifically… (class:423); 2) The invention relates to a process for *ex situ* presulfurization of porous particles of a hydrocarbon hydroconversion catalyst that contains at least one metal or metal oxide, comprising bringing catalytic particles … (class:502); and 3) A refuse recycling system, which recycles municipal waste as energy, includes a shredder for shredding the waste and removing rejects via a feed pipe to a circulating fluidized bed reactor, the reactor producing flue gases. The reactor includes (class:110)

[20] We also examine the effect of foreign sales on green patent development at year t+2 and t+3, and find similar evidence to the results with green patent development at year t+1. To save space, we omit to report these results.

level. Economically speaking, a one standard deviation increase in *ForeSale-high* leads to 3.29% increase in green patent applications at year *t+1*. In contrast, in column (2) we find opposite results of *ForeSale-low*. That is, the coefficients of *ForeSale-low* is negative, suggesting that MNCs are less likely to engage in green innovation if a high percentage of their sales that take place in countries with less stringent environmental requirements than their home countries. The result supports the viewpoint that MNCs' green technology development is highly tied with the structure of their foreign sales. In column (3), we replace our key independent variable with *FS Ratio*. We find that the coefficient of *FS Ratio* is positive that is statistically significant at 1% level. These results further provide the evidence to support the viewpoint that MNCs are more actively devoting in promoting green patent applications if they have relative more clients from countries imposing higher requirements on environmental standards.

Moreover, MNCs' green technology development increases with capital expenditures (i.e., manufacturing firms) and trading volume and also when the MNCs' home countries have high quality of rule and legal system, high spending on R&D education, and domestic stringency of environmental policies. These findings imply that the most significant determinants of corporate green innovation are institutional [also see Carlsson (2006)] rather than firm-specific factors, which contrast the findings in Francis *et al.* (2018). Extant literature finds that typical utility patent development is mostly driven by a firm's need. Schumpeter (1942) argue that innovation is critical for a survival of firms. Innovation provides firms with long-term competitive advantages and thereby leading to higher stock returns (Grillches, 1981; Hall 1993). Hsu et al., (2015) show that corporate innovation activities significantly reduce default risks which causes a reduction in bond issuance costs.

However, operating clean business is not primary concern for entrepreneurs unless it is surely less expensive than just polluting. According to environmental economics literature, this pollution problem occurs since property rights are not defined with great delicacy. To fix this problem, it is too costly for individuals to directly negotiate with polluting firms. Therefore, economists suggest that governments must take actions to find a collective solution through regulations and taxes. The reduction in pollution primarily relies on how the government effectively implement its policies (Kneese, 1971). In this line, it can be understood that a firm's efforts to preserve common environmental resources is likely shaped by the government pressure that is highly tied with institutional characteristics such as economic development and stringency of environmental regulations.

Insert Table 3 about here

4-2) By home country characteristics

In their recent study, Ben-David et al. (2020), multination corporations headquartered in countries with strict environmental regulations tend to pollute abroad in countries with less strict environmental regulations than those of their home country. Ben-David et al. also find that multination corporations' polluting behavior is heavily influenced by their home countries' environmental regulation standards. Therefore, we evaluate the variation of green innovation production with respect to different home country characteristics of multinational corporations as our next inquiries and report findings in Table 4. First, it is generally believed that the institutional economic development is highly correlated with awareness on environmental preservation. Compared to developed economies, firms in developing countries are generally regarded as more heavy polluters. We therefore divide a sample of firms into developed and developing countries based on MSCI market indices and see a relation between the structure of foreign sales and green innovation development is distinct one from another. In column (1) and (2) of Panel A, we find that the positive impact of *FS Ratio* on green innovation only appears in sample of firms in developed countries. These results promulgate that MNCs in developing countries tend to be under less environmental pressure and thus exhibit lower green technology productivity. It is also equally plausible that the weakening proactive effect could be resulting from less demand of eco-friendly products from developing economies or deficiency of necessary technological knowhow to convert into green technology.

Furthermore, over 62% of our sample firms are from either the United States or Japan and the percentage of foreign sales for a typical firm from those countries is about 20%, which is relatively lower than firms in other countries. If there is an increasing awareness of eco-related issues in domestic markets raised from only these two countries, our finding on positive relation could be spurious. To rule out this possibility, we conduct a series of regressions by combining different groups of observations with or without US and Japan. In column (3), we only include the firm-year observations from United States in our sample and we find that coefficient of *FS Ratio* remains positive and significant at 1% level. In column (4), coefficient of *FS Ratio* becomes insignificant if we only include firms from Japan. In column (5), coefficient of *FS Ratio* is marginally significant at 10% level. Lastly in column (6) and (7), we find that coefficients of *FS Ratio* are positive and significant at 1% level for group of developed economies by excluding firms from Japan and United States. Overall, our results are robust to the cases with or without firms in US and Japan. Those results alleviate the concern that positive relationship between *FS Ratio* and green innovation is driven by domestic sales of MNCs located in Japan or United States.

Next, we further investigate whether a relation between the structure of foreign sales and green innovation development is heterogenous by the strictness of domestic environmental standard at the country and industry level. We first split our sample of firms based on EPS score. In column (1) and (2) of Panel B, we find that *FS Ratio* only has a positive and significant effect on green patent applications for the group of firms with an EPS score higher than median, indicating that firms from eco-friendly economies are more likely to pursuit green technology if higher relative foreign sales contributed from other eco-friendly economies. Next, we divide our sample based on the reliance of electricity production on clean energy or a ratio between clean and dirty energy. We define *Clean Energy*, as the sum of electricity produced from clean energy (i.e., nuclear, hydroelectric, and other renewable sources). *Dirty Energy* is the sum of electricity produced from dirty energy (i.e., oil, gas, and coal sources). *Clean/Dirty* is a relative clean energy measurement, calculated as *Clean Energy* divided by *Dirty Energy*. In column (3) to (8), we find that group of economics produce higher green innovation output if electricity production is constituted with a higher proportion of clean energy, compared with their peers from economies whereas they still largely rely on traditional resource for electricity production. Overall, the strictness of home country environmental policies moderates the positive effect of the structure of foreign sales on green innovation development.

Insert Table 4 about here

4-3) Effect of green innovation on firm value

In this section, we test whether and how MNCs' green innovation is translated into firm value. More specifically, we construct the following model:

$$ExcessVal_{t+1} = \alpha + Firm_i + Year_t + \beta_1 FR\ Ratio + \beta_2 Ln(GpatStock)_{[t-N,t]}$$

$$+ \beta_3 FR\ Ratio \times Ln(GpatStock)_{[t-N,t]} + \beta_4 X + \varepsilon_i \qquad (2)$$

where *i* and *t* denote firm and year, respectively. Furman et al. (2002) show that the country-level knowledge accumulation (i.e., patent stock) is one of key driver for innovation productivity, eventually resulting in higher productivity. Followed by a spirit of Furman et al. (2002), to capture long-term effect of innovation on firm value, we construct cumulative green or non-green patent stocks during the past 1, 3, 5, or 7 years, $Ln(GpatStock)_{[t\text{-}N,\ t]}$ ($N=1, 3, 5, 7$) at the firm level. We then regress the interaction term between *FS Ratio* and $Ln(GpatStock)_{[t\text{-}N,\ t]}$ on firm value to see the effect of green innovation conditioning on the level of relative foreign sale on firm value. Extant literature has documented the source of value creation for corporate internationalization if MNCs hold intangible assets that give a firm a competitive advantage in foreign markets (e.g., Morck and Yeung, 1991). To differentiate green innovation from general (or non-green) innovation, we also include the interaction term of *FS Ratio* and *Ln(NGpatStock)*$_{[t-N,t]}$, where *Ln(NGpatStock)*$_{[t-N,t]}$ is the log-transformed cumulative number of non-green patents from year *t-N* to year *t*. Table 5 provides the detailed results.

In Panel A, we start our analyses without any control variables to simply illustrate our findings. In Column (1), we first examine the effect of *RS Ratio* on firm value and find the coefficient of *FS Ratio* is negatively significant, meaning that foreign sales incurring in countries with more stringent environmental regulations than those of home countries are negatively associated with firm value. In Column (2), we separate a firm's innovation activities into green vs. non-green and test the effect of green and non-green innovations on firm value. While coefficients of green and non-green innovations are negatively associated with firm value, but are not statistically significant. In Column (3), we insert interacted terms between *FS Ratio* and green (and non-green) innovations and find that the coefficient of the interaction term between *FS Ratio* and *Ln(GpatStock)*$_{[t-1, t]}$ is 0.049, indicating that short-run green technology coupled with relatively higher foreign sales that occur in countries with high environmental standards, has a positive yet insignificant effect on firm value. We also find no meaningful evidence with non-green innovations in this setting.

However, innovation may not have an immediate effect on firm value due to grant time lag occurring in review process of patent office (Hall et al., 2001). To probe into the extant of long-run effect in technological advancing, we also construct a series of variables that capture 5-year cumulative numbers of patent applications, namely *Ln(GpatStock)*$_{[t-5,t]}$. In Column (4), we find that the coefficient of green innovation stocks (i.e., *Ln(GpatStock)*) is negatively associated with firm value, which is consistent with the " it-has-to-pay-to-be-green" view (e.g., Hart and Ahuja, 1996). In Column (5), we further find that the coefficient of *FS Ratio* x *Ln(GpatStock)*$_{[t-7, t]}$ is 0.192, which is statistically significant at a 5% level. Economically speaking, an increase by a standard deviation of $Ln(GpatStock)_{[t-7,\ t]}$ and *FS Ratio* for our average sample of firm leads to increase in excess value by 0.176 (=0.169*0.931*1.116) in five years.

In Panel B, we include a set of control variables and find consistent evidence with those in Panel A, indicating that green innovations coupled with exposure to strict environmental standards does not increase a firm's performance in the short run but in the long run, which is consistent with Derwall *et al.*'s view (2005). This is also consistent with stakeholder theory (Freeman, 1984), which highlights long-term value creation of corporate social engagement. However, the effect of non-green innovation (i.e., *NGpatstock*) is still not significant in the foreign markets with stringent environmental standards[21].

Insert Table 5 about here

4-4) Subsample analysis

In this section, we evaluate whether a firm's home country's common innovation infrastructures will enhance its long-run firm value. We begin our test by splitting our sample of firms into two groups of economics whether utilize a higher portion of reliance on clean energy to produce electricity. In Panel A of Table 6, we find long-run value addition of green innovation interacted with foreign ratio only appears for the group of firms in countries with high reliance on clean energy. However, the coefficients of interaction term between *FS Ratio* and $Ln(NGpatStock)_{[t-N,t]}$ are all insignificant for the group of firms that largely relies on traditional resources to produce electricity. In

[21] We test the change in foreign sales as another independent variable to see if the change in foreign sales matters for value creation. Overall, the result shows that firm value does not improve as the change in foreign sales increases, but the level of foreign sale, interacted with green patent development, matters for determining firm value.

similar to the results reported in Table 5, we find no significant evidence with relatively short-term innovation accumulation and thus omit those results.

Next, we examine two other factors that can be important in the way the MNC is pursuing innovation. First, according to the Furman, Porter, and Stern (2002), level of economic development captures a country's ability to translate technological knowhow into a realized long term economic development. Therefore, the benefit of green technology could be amplified when a MNC's host country equipped with technological accumulation and technological sophistication (Porter and Stern, 2001). As such, we recognize that level of economic development in home countries offers opportunities for a firm to grow at different speed by development of green technology. In this line, we investigate whether the level of GDP per capital exacerbates or alleviates the association between green innovation and firm value. Accordingly, we re-run the valuation regressions used in Table 5 by splitting our sample into firms headquartered in developed vs. developing countries. In Panel B of Table 6, we show that the positive association of green innovation and firm value only appears for firms in developed countries, whereas we find little relation among firms in developing countries. This finding corroborates with Hasan and Tucci (2010) and indicates that level of economic development in MNC's host country provides a springboard for long-term accumulation of economic rents from pursuing green innovation.

Furthermore, Christmann (2004) show that social pressure from corporate external stakeholders, such as governments, improves the quality of internal corporate environmental management. Accordingly, we expect the effect of green innovation to be better reflected in firm value when there is a higher level of effectiveness in implementing a government's policies. To test if the valuation effects we focus on vary by the degree of the MNC's home government effectiveness, we repeat our tests for subsamples of firms from countries of high and low government effectiveness, as shown in Panel C of Table 6. All countries are classified into one of two groups (i.e., countries with more effective and less effective government) based on the median value of worldwide governance indicators (WGI) score that measures each country's government effectiveness every year. We find that the positive association between green innovation with *FS Ratio* and firm value is more evident for MNCs headquartered in countries with high government effectiveness scores. Similar to Table 5, the combined effect of green innovation with *FS Ratio* on firm value turns positive, once a firm accumulates at least five years of green technology knowhow. However, the value enhancement effect is much weaker for MNCs from countries with low government effectiveness, when compared with their peers from countries with high government effectiveness. Our result suggests that the MNCs' home country government plays an important role in determining the quality of its corporate environmental strategies and consequences of its green innovation outcomes. Overall, our findings are consistent with the viewpoints found in the existing studies (e.g., Christmann, 2004; Kim *et al.*, 2019).

Insert Table 6 about here

4-5) By industry classification

While institutional characteristics is important to our study, environmental regulation costs are not equally applicable across industries. Since our study aims to examine how the structure of foreign sales in the light of host country's environmental standard influence corporate green innovation activities and thus eventually firm value, the explicit or implicit cost imposed by environmental policies must be higher for firms in polluting industries than those in non-polluting industries. Consistent with this view, Cohen et al. (2020) find that a majority of green patents are produced by firms in either manufacturing industries, especially in energy sectors (e.g., Exxon, Honeywell International, Royal Dutch, Chevron, and BP PLC). Motivated by Cohen et al.'s work, we examine our inquiries in 7 different industries that are classified base on the Standard Industrial Classification (SIC) code: Mining, Oil and Construction (1000≤SIC≤1800), Light Manufacturing (2000≤SIC≤2700), Energy (2800≤SIC≤2999), Heavy Manufacturing (3000≤SIC≤3999), Transportation (4000≤SIC≤4799), Wholesale & Retail trade (5000≤SIC≤5999), and Service industries (7000≤SIC≤8999)[22].

First, we test the effect of FS Ratio on green innovation and present this result in Panel A of Table 7. We find a positive relation is more evident for firm in coal, oil, construction and manufacturing industries than those in other industries. Next, we investigate the joint effect of *FS Ratio* and green innovation on firm value and report the findings in Panel B of Table 7. Again, we find that 5- and 7-year green patent stocks in conjunction with expanding operations in countries with high environmental standards yield long-term value in polluting industries than in non-polluting industries. The value addition of *FS Ratio* and green innovation is more pronounced in firms in coal, oil, construction and manufacturing industries, especially for those in energy industries. While we only report the result with $Ln(GpatStock)_{[t-5,t]}$, we find a similar pattern with $Ln(GpatStock)_{[t-7,t]}$, but omit to report the result. Consistent with our prediction, empirical findings suggest that green innovation is more valuable to firms in polluting industries than nonpolluting industries, i.e., when environmental pressure becomes more binding.

Alternatively, we obtain toxic-chemical-release data from the U.S. Environmental Protection Agency[23] and calculate the total amount of toxic chemical omission per industry, where industry is defined based on four-digit SIC codes.[24] We split our sample of firms in accordance with the level of industry pollution, whether or not a firm's industry membership belongs to the top decile industries

[22] We obtain the SIC classification at https://mckimmoncenter.ncsu.edu/2digitsiccodes/.

[23] https://www.epa.gov/toxics-release-inventory-tri-program/tri-basic-data-files-calendar-years-1987-2017

[24] The rationale for this classification scheme is the following: if U.S. firms in a certain industry are more likely to pollute, non-U.S. firms in a given industry are also more likely to pollute, which is rooted on the idea of Rajan and Zingales (1998) who measure both U.S. and non-U.S. firms' external financial dependence based on U.S. industry characteristics.

based on the total amount of toxic releases in a given calendar year. Simply put, we find a similar pattern indicating firms in polluting industries generate greater green patents, and the joint effect of *FS Ratio* and green innovation is more positively associated with firm value. This result is included in Appendix 1.

Insert Table 7 about here

4-5) By host country characteristics

In this subsection, we study how host country characteristics influence the value creation effect of *Foreign Ratio* and green technology, especially concentrating to cultural value.[25] MNCs' host countries are the place where products are sold or services are rendered. Therefore, the value creation effect of *Foreign Ratio* and green technology is more relevant for those of customers, one of primary stakeholders, who have higher value on environment protection or are willing to pay premium on those green products or services. Extant CSR literature show that stakeholder awareness (Servaes and Tamayo, 2013) or pressure (La Perez-Batres et al., 2012) is a critical determinant of CSR engagement and thus its value implication. Among others, we create two sets of indicator variables to represent MNCs' host country culture: long-termism or femininity. We first split all countries into high and low countries with long-term orientation score and femininity score based on Hofstede's cultural measures, given ample evidence showing long-term-oriented customers (e.g., Leonidou et al., 2010) or female customers are more eco-friendly (e.g., Loureiro et al., 2002) than other counterparts. This high and low classification is based on the median value of long-term orientation or femininity score, respectively. We then split countries into foreign sales- high or -low (to constrict *FS Ratio*), by

[25] We obtain country's cultural measures from https://geerthofstede.com/research-and-vsm/dimension-data-matrix/.

comparing home and host country's environmental strictness, within groups in this high and low long-term orientation or femininity score, respectively. Therefore, *FS Ratio-High* represents *FS Ratio* of the firms in countries with above-median long-term orientation or femininity scores. On the contrary, *FS Ratio-Low* is *FS Ratio* of the firms the firms in countries with below-median long-term orientation or femininity scores. In addition to create interacted terms between *FS Ratio- High* (or *Low*) and *Ln(GpatStock)*, we also include interacted terms between *FS Ratio- High* (or *Low*) and *Ln(NGpatStock)* to separate the effect of non-green innovation. The variables of our primary interest are *FS Ratio- High × Ln(GpatStock)* and *FS Ratio- Low × Ln(GpatStock)*. More specifically, the variable of *FS Ratio- High × Ln(GpatStock)* captures the valuation effect green innovation interacted with foreign ratio that occurs in countries with either higher long-term orientation or femininity culture. The variable of *FS Ratio-Low × Ln(GpatStock)* captures the valuation effect green innovation interacted with foreign ratio that occurs in countries with either less long-term orientation or femininity culture. In column (1) to (3), we find that green technological activities prompt long-run firm value if a MNC's host country in preference of long-term horizon. In column (4) to (6), this relationship is more evident for group of countries possessing higher femininity score. Taken together, host country's cultural value also influences the valuation effect of green innovations.

Insert Table 8 about here

4-6) Empirical identification

To this point, we find empirical evidence supporting the notion that green technology development increases firm value, particularly when MNCs have a high percentage of foreign sales in countries with strict environment standards. However, there is a possibility that our result is driven by omitted variables in the sense environmental policy strictness is correlated with other institutional characteristics (e.g., the case that some unobservable factor(s) other than environmental regulation may encourage firms to be innovative and profitable). To mitigate this endogeneity concern, we design a difference-in-differences regression around the time of a structural shift in the environmental regulations' compliance costs in the European Union as follows. The European Union Emissions Trading System (EU ETS) was launched in 2005 and is the cornerstone of the European environmental policy geared toward reducing green gas emissions. By exploiting the launching of EU ETS as an exogenous shock that resulted in externally strengthening environmental regulations, we compare green innovations' effect on firm value between two groups of U.S. firms in the years surrounding 2005. The first group (i.e., treatment group) consists of U.S. firms that have a high percentage of European foreign sales (i.e., whose European foreign sales are greater than the median value of European foreign sales among our sample of firms each year), and the other group (i.e., control group) includes U.S. firms that have no foreign sales.[26] Our testing window spans the three years before, on, and after 2005, the year the EU ETS is launched. We then investigate how this heightened environmental regulation affects firm value association with corporate green technology knowhow. In untabulated results, we conduct a parallel trend test and do not discover systematic differences existing in green innovation and firm value between treated firms and control firms.

Table 9 reports the detailed results of our analysis. We find that green patent stocks increase firm value, especially for the treatment group after the enforcement of the EU ETS. The long-term nature of this effect is reflected in that the positive effect becomes statistically significant when the firm accumulates green technology knowhow over five years or more. Calel and Dechezlepretre (2016) show that European firms increased low-carbon patenting after 2005, the enforcement year of the EU

[26] We drop U.S. firms that have a low percentage of European foreign sales (i.e., whose European foreign sales are less than the median value of the European foreign sales) and European firms that have cleaner treatment and control groups for our test.

ETS. Overall, we conclude that the pursuit of green technology development adds value to MNCs when environmental regulations in the MNCs' foreign markets become tighter.

Insert Table 8 about here

4-7) Sensitivity analyses

As a last set of tests, we conduct a sequence of sensitivity tests to detect whether potential measurement errors would bias our results which can lead to spurious conclusions. First, we construct alternative *FS Ratio*, which is *FS Ratio-std*. A difference between *FS Ratio* and *FS Ratio-std* is that, while *FS Ratio* is unbounded and skewed, *FS Ratio-std* is standardized and bounded by -1 (when total foreign sale is equal to *Foresale-low*) and +1 (when total foreign sale is equal to *Foresale-high*). Therefore, higher *FS ratio* and *FS Ratio-std* values represent that a firm's foreign sale is relatively greater in countries whose environmental regulations are more stringent than countries whose environmental regulations are less stringent compared to those of home country. In Panel A of Table 10, we report the result that rerun the regressions in Table 4 and 5 with *FS Ratio-std*. The result indicates that the positive relation between relative foreign sales and green innovation outputs still holds, and value creation effect of green technology remains significant in the long-run.

In Panel B of Table 10, we reconstruct the *FS Ratio-epi* based on the environmental performance index developed by Yale Center for Environmental Law & Policy. [27] The EPI index measures the government's 32 environmental-related policies form general environmental issue involving air quality, water resources, climate change to specific industries such as heavy metal, fisheries, agriculture across 180 countries. The EPI index is conceptually similar to the EPS index and

[27] We obtain environment performance index from https://epi.yale.edu/.

a correlation between two indexes are approximately 60%. Overall, our findings are robust to using an alternative environmental policy index.

Lastly, we use alternative firm-value variables: industry-adjusted Tobin's *q* and *Alternative ExcessVal*. We find that the relation among green patent stocks, foreign sales, and firm value still exists and exhibits a similar pattern, as shown in previous sections. We conclude that our findings are not subject to potential measurement errors that could possibly twist our findings in the value-based measures of firm performance.

Insert Table 10 about here

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5. Conclusion

We empirically investigate whether and how MNC geographic scope and corporate environmental strategy can combine into generating economic rents. We find that a relatively high exposure to foreign markets with more (less) stringent environmental regulations stimulates (stymies) MNCs' green patent applications. MNCs' environmental competitive advantage obtained through green innovation activities enhances firm value in the long-run when pursued in conjunction with higher relative foreign involvement in countries with stricter environmental standards than those of home countries. This effect is more profound for firms operating in polluting industries, firms from countries where a higher percentage of clean resources is utilized to produce electricity, firms headquartered at developing countries or when the MNC's home country legal system is more effective in implementing policies that support the adoption of sound policies of technology development. Moreover, the value enhancement of green technology development is strengthened if the MNC's host country culture is characterized by long-term orientation and femininity. Overall, our study highlights that green technology development is at the core of multinationality's effect on corporate valuation.

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Table 1
Descriptive Statistics

This table presents descriptive statistics on 37,092 firm-year observations for this study. *Foresale-high* (or *Foresale-low*) is the percentage of foreign sales that incur sales in countries whose environmental stringency is higher (or lower) than that of corporate home country. *FS Ratio* is a firm's relative foreign sales measured as *Foresale-high* divided by *Foresale-low*. *FS Ratio-std* is a firm's relative foreign sales measured as (*Foresale-high* - *Foresale-low*)/ (*Foresale-high* +*Foresale-low*) *FS Ratio-std* is bounded by -1 and +1. *Domsale* is the percentage of domestic sales. *ExcessVal* is computed as the market value of equity minus book value of equity divided by sales. *TobinQ* is industry-adjusted Tobin's *q,* computed as the sum of market value of equity, the liquidating value of preferred stock, and the value of debts divided by the book value of assets (Chung & Pruitt, 1994). *Ln(MkCap)* is the U.S. dollar denominated market value of equity at the end of year. *ROA* is earnings before interests and taxes divided by assets. *Leverage* is long-term debts plus debts in current liabilities divided by assets. *Tangibility* is the net amount of property, plant, and equipment divided by asset. *R&D* is R&D expenditure divided assets. *HHI* is the Herfindahl index based on sales across the first two digit of SIC code. *Ln(GDPpa)* is log-transformed GDP per annum. *Trade* is imports minus export divided by GDP. *RuleLaw* is the index that measures quality of domestic laws. *EPS* is the home country's environmental stringency index. *PPindex* is intellectual property protection index. *Developed* is a dummy variable that takes the value of one if a home country belongs to the MSCI developed market indexes and zero otherwise. *Pollute* is a dummy variable that takes the value of one if a firm's industry membership belongs to one of top 10 polluting industries based on the total amount of toxic releases per year and zero otherwise. Toxic release data are available at https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-and-tools. *Goveffect* is the value of worldwide governance indicators (WGI) score that measures each country's government effectiveness score that quantify its ability to implement its policies every year. *Masculine* is the Hofstede's cultural measure that represents a preference in country for either Masculinity. High (Low) value of *Masculine* means that the country is more leaning to masculinity (Femininity) that emphasizes achievement and material rewards for success (cooperation, modesty, caring for the weak, and quality of life). The data is available at https://geerthofstede.com/research-and-vsm/dimension-data-matrix/. *Clean Energy* is the sum of electricity produced from clean energy (i.e., nuclear, hydroelectric, and other renewable sources). *Dirty Energy* is the sum of electricity produced from dirty energy (i.e., oil, gas, and coal sources). *Clean/Dirty* is *Clean Energy* divided by *Dirty Energy*. Electricity production data from the World Bank that is available at https://data.worldbank.org/indicator/EG.ELC.FOSL.ZS. $Ln(GreenPat)_{t+N}$ is the log-transformed number of green patents plus one applied in a given year at *t*+*N* (*N*=1, 2, and 3) (Carrion-Flores and Innes, 2010). $Ln(GpatStock)_{[t-N,t]}$ ($Ln(GpatStock)_{[t-N,t]}$) is the log-transformed cumulative number of green (or nongreen) patents plus one from year *t-N* (*N*=1, 3, 5, and 7) to year *t* (Furman, Porter, and Stern, 2002).

	N	Mean	Median	Std. Dev.	25th Pctl	75th Pctl
ForeSale-high	37092	0.122	0.042	0.178	0.000	0.182
ForeSale-low	37092	0.137	0.022	0.227	0.000	0.169
FS Ratio	37092	0.643	0.134	0.931	0.000	1.037
FS Ratio-std	37092	0.067	0.000	0.535	-0.128	0.503
DomSale	37092	0.702	0.840	0.330	0.459	1.000
ExcessVal	37092	2.450	0.007	12.651	-0.336	0.851
TobinQ	36014	0.406	0.001	1.417	-0.342	0.623
Ln(MkCap)	37092	6.187	6.166	2.008	4.843	7.520
ROA	37092	0.030	0.063	0.196	0.014	0.112
Leverage	37092	0.210	0.174	0.201	0.027	0.325
Tangibility	37092	0.268	0.211	0.221	0.089	0.392
R&D	37092	0.038	0.000	0.091	0.000	0.029
HHI	37092	0.162	0.091	0.183	0.054	0.194
Ln(GDPpa)	37092	10.514	10.852	0.706	10.540	10.905
Trade	37092	-0.016	-0.027	0.039	-0.048	0.010
EPS	37092	2.075	2.130	0.806	1.300	2.680
RuleLaw	37092	1.269	1.546	0.666	1.319	1.612
PPindex	37092	4.628	4.880	0.365	4.540	4.880
FDI	37092	0.023	0.018	0.040	0.010	0.024
Developed	37092	0.833	1.000	0.373	1.000	1.000
Goveffect	37092	1.365	1.573	0.569	1.461	1.645
Masculine	37092	63.131	62.000	15.317	62.000	66.000
Clean Energy	37092	0.396	0.323	0.231	0.316	0.357
Dirty Energy	37092	0.448	0.490	0.194	0.280	0.505
Clean/Dirty	37092	2.614	0.521	10.097	0.503	0.694
$Ln(GreenPat)_{t+1}$	28573	0.105	0.000	0.490	0.000	0.000
Ln(GpatStock)	37092	0.107	0.000	0.499	0.000	0.000
$Ln(GpatStock)_{[t-3,t]}$	37092	0.234	0.000	0.792	0.000	0.000
$Ln(GpatStock)_{[t-5,t]}$	37092	0.337	0.000	0.984	0.000	0.000
$Ln(GpatStock)_{[t-7,t]}$	37092	0.414	0.000	1.116	0.000	0.000
Ln(NGpatStock)	37092	0.248	0.000	0.854	0.000	0.000
$Ln(NGpatStock)_{[t-3,t]}$	37092	0.479	0.000	1.240	0.000	0.000
$Ln(NGpatStock)_{[t-5,t]}$	37092	0.641	0.000	1.463	0.000	0.000
$Ln(NGpatStock)_{[t-7,t]}$	37092	0.751	0.000	1.603	0.000	0.693

Table 2
Sample Distribution by Country

This table shows the mean value of *EPS*, *Foresale*, *Foresale-high, Foresale-low*, *FS Ratio,* and *Ln(GreenPat)* by country. The time-varying EPS index score is obtained from the OECD website (https://stats.oecd.org/Index.aspx?DataSetCode=EPS).

	N	EPS	*ForeSale-high*	*ForeSale-low*	*FS Ratio*	*Ln(Greenpat)*
Australia	1002	2.439	0.164	0.113	0.480	0.002
Austria	83	3.120	0.115	0.562	0.217	0.042
Belgium	154	2.440	0.445	0.195	1.311	0.130
Brazil	256	0.457	0.143	0.018	0.057	0.014
Canada	1380	3.046	0.038	0.412	0.095	0.046
China	3064	1.106	0.086	0.017	1.076	0.003
Denmark	120	3.585	0.077	0.685	0.154	0.179
Finland	172	3.137	0.118	0.526	0.215	0.059
France	897	3.090	0.083	0.426	0.159	0.057
Germany	1021	2.867	0.139	0.333	0.368	0.191
Greece	86	2.129	0.193	0.055	1.097	0.000
India	1276	1.191	0.178	0.028	1.245	0.005
Indonesia	229	1.116	0.121	0.014	0.833	0.000
Ireland	80	2.157	0.531	0.168	1.728	0.077
Italy	295	2.682	0.205	0.207	0.615	0.043
Japan	4264	1.876	0.106	0.125	0.528	0.212
Netherlands	223	3.254	0.098	0.535	0.205	0.160
Norway	170	2.944	0.212	0.426	0.426	0.054
Poland	147	2.946	0.092	0.110	0.301	0.000
Portugal	55	2.413	0.328	0.099	1.052	0.000
Russian Feder	94	0.600	0.198	0.008	1.648	0.000
South Africa	281	1.589	0.134	0.094	0.686	0.000
South Korea	657	3.480	0.023	0.255	0.067	0.085
Spain	187	2.815	0.130	0.247	0.440	0.007
Sweden	381	3.112	0.175	0.481	0.399	0.019
Switzerland	236	3.032	0.151	0.546	0.287	0.077
Turkey	201	1.777	0.167	0.054	1.091	0.000
United Kingdom	1345	2.755	0.227	0.268	0.702	0.017
United States	18736	2.003	0.119	0.084	0.673	0.133

Table 3
Internationalization and Green Innovation

The table presents OLS results where the dependent variable is *Ln(GreenPat)*$_{t+N}$, the log-transformed number of green patents at year *t+1*. *Foresale-high* (or *Foresale-low*) is the percentage of foreign sales (in total sales) that incur sales in countries whose environmental stringency is higher (or lower) than that of corporate home country. *FS Ratio* is a firm's relative foreign sales measured as *Foresale-high* divided by *Foresale-low*. All regressions include firm and year fixed effects. The numbers shown in parentheses are *t*-statistics clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
		Dependent variable: In(GreenPat)$_{t+1}$	
Foresale-high$_t$	0.295***		
	(6.45)		
Foresale-low$_t$		-0.293***	
		(-6.16)	
FS Ratio$_t$			0.034***
			(6.81)
DomSale$_t$	0.260***	0.034	0.166***
	(6.72)	(1.05)	(5.63)
Ln(MkCap)$_t$	-0.001	-0.002	-0.002
	(-0.20)	(-0.35)	(-0.52)
ROA$_t$	-0.012	-0.010	-0.020
	(-0.48)	(-0.39)	(-0.90)
Leverage$_t$	0.001	0.002	0.005
	(0.04)	(0.06)	(0.21)
Tangibility$_t$	0.123***	0.121***	0.112***
	(3.05)	(3.01)	(3.11)
R&D$_t$	-0.029	-0.036	-0.028
	(-0.39)	(-0.49)	(-0.43)
HHI$_t$	0.197	0.209	0.177
	(1.51)	(1.59)	(1.43)
Ln(GDPpa)$_t$	0.797***	0.788***	0.723***
	(7.73)	(7.63)	(7.17)
Trade$_t$	1.067***	1.045***	1.276***
	(2.79)	(2.73)	(3.53)
EPS$_t$	0.240***	0.238***	0.214***
	(6.20)	(6.12)	(5.72)
RuleLaw$_t$	0.174*	0.171*	0.186**
	(1.81)	(1.78)	(1.99)
Ppindex$_t$	0.062*	0.064*	0.061*
	(1.75)	(1.83)	(1.78)
FDI$_t$	-0.139**	-0.134*	-0.111*
	(-2.02)	(-1.95)	(-1.67)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
N	27,052	27,052	27,052
Adj. R^2	0.635	0.638	0.634

Table 4
By Home Country Characteristics

The table presents OLS results where the dependent variable is *Ln(GreenPat)*$_{t+1}$, the log-transformed number of green patents at year *t+1*. *FS Ratio* is a firm's relative foreign sales measured as *Foresale-high* divided by *Foresale-low*. Panel A divides sample firms into two groups of firms based on the home country's economic development: developed vs. emerging markets. The classification on developed and emerging markets is based on the MSCI developed and emerging market indices. Panel B splits sample firms into high vs. low environmental strictness of the home countries. *EPS* is the home country's environmental stringency index. *Clean Energy* is the sum of electricity produced from clean energy (i.e., nuclear, hydroelectric, and other renewable sources). *Dirty Energy* is the sum of electricity produced from dirty energy (i.e., oil, gas, and coal sources). All regressions include firm and year fixed effects. The numbers shown in parentheses are *t*-statistics clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A. By Economic Development

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Developed	Emerging	Only US	Only Japan	Without US and Jap	Developed without US	Developed without US and Jap
			Dependent variable: *In(GreenPat)*$_{t+1}$				
FS Ratio	0.042***	-0.008	0.049***	-0.004	0.012*	0.042***	0.050***
	(7.42)	(-1.37)	(7.80)	(-0.10)	(1.75)	(2.62)	(3.05)
Controls	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
N	24,107	2,945	16,986	2,531	7,535	7,121	4,590
Adj. R^2	0.646	0.353	0.647	0.706	0.538	0.642	0.581

Panel B. By Environmental Strictness

	(1)	(2)	(3)	(4)	(5)	(6)
	EPS		Clean Energy		Clean /Dirty	
	High	Low	High	Low	High	Low
			Dependent variable: *In(GreenPat)*$_{t+1}$			
FS Ratio	0.028***	0.007	0.047***	0.028***	0.044***	0.010***
	(4.11)	(1.47)	(5.35)	(6.54)	(2.99)	(2.71)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	10,737	14,762	11,540	13,435	13,342	12,361
Adj. R^2	0.498	0.832	0.603	0.671	0.579	0.861

Table 5

Green Innovation and Firm Performance

This table presents OLS results where the dependent variable is *ExcessVal*, industry-adjusted excess value computed as the market value of equity minus book value of equity divided by sales. *FS Ratio* is a firm's relative foreign sales measured as *Foresale-high* divided by *Foresale-low*. $Ln(GpatStock)_{[t-N,t]}$ (or $Ln(NGpatStock)_{[t-N,t]}$) is the cumulative number of green (non-green) patents from year *t-N* (*N*=1, 3, 5, and 7) to year *t* and log-transformed after adding one. All regressions included firm and year fixed effects, but coefficients are omitted to report. The numbers shown in parentheses are t-statistics clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Without control variables

	(1)	(2)	(3)	(4)	(5)
			Dependent variable; $ExcessVal_{t+1}$		
		N=1	N=1	N=5	N=5
FS Ratio	-0.347***		-0.335***		-0.346***
	(-4.05)		(-4.11)		(-4.42)
$Ln(GpatStock)_{[t-N,t]}$		-0.116	-0.168	-1.118***	-1.260***
		(-0.53)	(-0.46)	(-2.62)	(-2.78)
FS Ratio x $Ln(GpatStock)_{[t-N,t]}$			0.049		0.192**
			(0.25)		(2.21)
$Ln(NGpatStock)_{[t-N,t]}$		-0.079	-0.015	0.511	0.603
		(-0.53)	(-0.07)	(1.25)	(1.37)
FS Ratio x $Ln(NGpatStock)_{[t-N,t]}$			-0.042		-0.067
			(-0.47)		(-1.48)
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	36,270	36,270	36,270	36,270	36,270
Adj. R^2	0.632	0.632	0.632	0.632	0.632

Panel B. With control variables

	(1)	(2)	(3)	(4)
	Dependent variable; $ExcessVal_{t+1}$			
	N=1	N=3	N=5	N=7
$FS\ Ratio_t$	-0.338***	-0.318***	-0.345***	-0.352***
	(-3.83)	(-3.71)	(-4.07)	(-4.16)
$Ln(GpatStock)_{[t-N,t]}$	-0.104	-0.949**	-1.179***	-1.101**
	(-0.28)	(-2.05)	(-2.62)	(-2.15)
$FS\ Ratio_t$ x $Ln(GpatStock)_{[t-N,t]}$	0.026	0.224	0.188**	0.169**
	(0.13)	(1.34)	(2.24)	(2.15)
$Ln(NGpatStock)_{[t-1,t]}$	0.034	0.742**	0.645	0.134
	(0.16)	(2.11)	(1.49)	(0.32)
$FS\ Ratio_t$ x $Ln(NGpatStock)_{[t-1,t]}$	-0.053	-0.165*	-0.076*	-0.051
	(-0.58)	(-1.65)	(-1.65)	(-1.36)
$DomSale_t$	1.313	1.340	1.359	1.332
	(1.18)	(1.20)	(1.22)	(1.20)
$Ln(MkCap)_t$	0.135	0.129	0.136	0.140
	(0.76)	(0.73)	(0.76)	(0.79)
ROA_t	-4.882***	-4.823***	-4.837***	-4.846***
	(-3.03)	(-3.00)	(-3.01)	(-3.00)
$Leverage_t$	-1.788	-1.812	-1.808	-1.770
	(-1.48)	(-1.50)	(-1.50)	(-1.46)
$Tangibility_t$	-5.940***	-5.920***	-5.874***	-5.872***
	(-3.42)	(-3.41)	(-3.38)	(-3.38)
$R\&D_t$	-3.105	-3.027	-3.063	-3.021
	(-0.53)	(-0.52)	(-0.52)	(-0.52)
HHI_t	-0.700	-0.671	-0.717	-0.815
	(-0.49)	(-0.47)	(-0.50)	(-0.57)
$Ln(GDPpa)_t$	-3.195***	-3.331***	-3.109***	-2.913**
	(-2.78)	(-2.97)	(-2.77)	(-2.57)
$Trade_t$	1.026	1.264	1.450	1.718
	(0.15)	(0.18)	(0.21)	(0.25)
EPS_t	-0.413*	-0.411*	-0.383	-0.387
	(-1.68)	(-1.67)	(-1.57)	(-1.60)
$RuleLaw_t$	-0.084	-0.074	0.023	0.018
	(-0.09)	(-0.08)	(0.02)	(0.02)
$Ppindex_t$	-1.205	-1.213	-1.205	-1.155
	(-1.31)	(-1.32)	(-1.30)	(-1.24)
FDI_t	0.219	0.265	0.139	0.131
	(0.32)	(0.38)	(0.20)	(0.19)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	36,270	36,270	36,270	36,270
Adj. R^2	0.634	0.634	0.634	0.634

Table 6
Subsample Analysis by Home Country Characteristics

This table presents the results of subsample analyses based on the home country's characteristics. This table presents OLS results where the dependent variable is *ExcessVal*, industry-adjusted excess value computed as the market value of equity minus book value of equity divided by sales. *FS Ratio* is a firm's relative foreign sales measured as *Foresale-high* divided by *Foresale-low*. $Ln(GpatStock)_{[t\text{-}N,t]}$ (or $Ln(NGpatStock)_{[t\text{-}N,t]}$) is the cumulative number of green (nongreen) patents from year *t-N* (*N*=1, 3, 5, and 7) to year *t* and log-transformed by adding one (Furman, Porter, and Stern, 2002). All regressions include the same set of control variables used in Table 5, firm and year fixed effects, but coefficients are omitted for brevity. Panel A splits sample firms into two groups of firms in countries more or less dependent on clean energy sources for electricity production. *Clean Energy* is the sum of electricity produced from clean energy (i.e., nuclear, hydroelectric, and other renewable sources). Panel B divides sample firms into two groups of firms based on the home country's economic development: developed vs. emerging markets. The classification on developed and emerging markets is based on the MSCI developed and emerging market indexes. Panel C presents subsamples formed based on the MNC home country's government effectiveness score. We distinguish between high (above median) and low (below median) government effectiveness subsamples based on the median value of worldwide governance indicators (WGI) score that measures each country's government effectiveness score to quantify its ability to implement its policies every year.

Panel A. More Clean Energy vs. Less Clean Energy

	(1)	(2)	(3)	(4)
	Dependent variable; $ExcessVal_{t+1}$			
	More Clean Energy		Less Clean Energy	
	N=5	N=7	N=5	N=7
FS Ratio	-0.331***	-0.370***	-0.329***	-0.314***
	(-2.79)	(-3.08)	(-3.17)	(-3.06)
$Ln(GpatStock)_{[t\text{-}N,t]}$	-1.196**	-1.202**	-0.890	-0.928
	(-2.37)	(-2.00)	(-1.29)	(-1.45)
FS Ratio x $Ln(GpatStock)_{[t\text{-}N,t]}$	0.163**	0.166**	0.158	0.112
	(2.05)	(2.10)	(1.49)	(1.16)
$Ln(NGpatStock)_{[t\text{-}N,t]}$	0.723	0.285	0.322	0.003
	(1.24)	(0.50)	(0.64)	(0.01)
FS Ratio x $Ln(NGpatStock)_{[t\text{-}N,t]}$	0.001	0.039	-0.152**	-0.140**
	(0.02)	(0.99)	(-2.23)	(-2.52)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	15,480	15,480	19,814	19,814
Adj. R^2	0.694	0.693	0.636	0.636

Panel B. Developed vs. Emerging markets

	(1)	(2)	(3)	(4)
	Dependent variable; $ExcessVal_{t+1}$			
	Developed Markets		Emerging Markets	
	N=5	N=7	N=5	N=7
FS Ratio	-0.464***	-0.472***	-0.049	-0.060
	(-4.36)	(-4.45)	(-0.61)	(-0.75)
$Ln(GpatStock)_{[t-N,t]}$	-1.209***	-1.129**	-1.003	0.163
	(-2.65)	(-2.18)	(-1.15)	(0.36)
FS Ratio x *$Ln(GpatStock)_{[t-N,t]}$*	0.191**	0.170**	0.363	0.013
	(2.25)	(2.14)	(1.09)	(0.09)
$Ln(NGpatStock)_{[t-N,t]}$	0.619	0.112	1.444	0.426
	(1.41)	(0.27)	(1.07)	(0.74)
FS Ratio x *$Ln(NGpatStock)_{[t-N,t]}$*	-0.051	-0.028	-0.067	0.146*
	(-1.12)	(-0.74)	(-0.38)	(1.86)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	30,405	30,405	5,865	5,865
Adj. R^2	0.632	0.632	0.776	0.776

Panel C. High vs. Low Government Effectiveness

	(1)	(2)	(3)	(4)
	Dependent variable; $ExcessVal_{t+1}$			
	Higher Government Effectiveness		*Lower Government Effectiveness*	
	N=5	N=7	N=5	N=7
FS Ratio	-0.468***	-0.483***	-0.268***	-0.259***
	(-3.16)	(-3.28)	(-2.79)	(-2.69)
$Ln(GpatStock)_{[t-N,t]}$	-1.784***	-1.343*	-0.065	-0.189
	(-2.72)	(-1.80)	(-0.13)	(-0.43)
FS Ratio x *$Ln(GpatStock)_{[t-N,t]}$*	0.235*	0.252*	0.035	0.024
	(1.67)	(1.79)	(0.57)	(0.44)
$Ln(NGpatStock)_{[t-N,t]}$	0.929	-0.338	-0.207	-0.354
	(1.25)	(-0.49)	(-0.50)	(-0.84)
FS Ratio x *$Ln(NGpatStock)_{[t-N,t]}$*	-0.110*	-0.098	-0.031	-0.035
	(-1.65)	(-1.45)	(-0.71)	(-0.99)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	13,315	13,315	22,092	22,092
Adj. R^2	0.647	0.647	0.664	0.664

Table 7
By Industry Classification

This table presents the results of subsample analyses based a firm's industry membership. *Mining & Oil* is the firm's industry membership is either mining or oil industry (i.e., the first digit of the SIC code equal to one). *Light Manu* is the firm's industry membership is one of light manufacturing industries (i.e., the first two digit of the SIC code is from 20 to 27). *Energy* is the firm's industry membership is one of energy industries (i.e., the first two digit of the SIC code is from 28 to 29). *Heavy Manu* is the firm's industry membership is one of light manufacturing industries (i.e., the first two digit of the SIC code is from 30 to 39). *Transport* is the firm's industry membership is one of transportation industries (i.e., the first two digits of the SIC code is between 40 and 47). *Wholesale & Retail* is the firm's industry membership is one of wholesale or retail trade industries (i.e., the first digit of the SIC code equal to five). *Service* is the firm's industry membership is one of service industries (i.e., the first digit of the SIC code equal to 7 or 8).

Panel A. Green Innovation Development

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: In(GreenPat)$_{t+1}$						
	Mining & Oil	Light Manu	Energy	Heavy Manu	Transport	Wholesale & Retail	Service
FS Ratio	0.043**	0.035**	0.030*	0.024**	0.003	0.006	0.007
	(2.58)	(2.44)	(1.90)	(2.13)	(0.42)	(1.49)	(1.21)
Controls	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
N	2,287	2,230	2,903	8,270	1,057	3,017	5,060
Adj. R^2	0.549	0.555	0.668	0.660	0.252	0.491	0.656

Panel B. Firm Value

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: *Excess Value*$_{t+1}$						
	Mining & Oil	Light Manufact	Energy	Heavy Manu	Transport	Wholesale & Retail	Service
FS Ratio	-0.305*	-0.138	-1.307***	-0.244	0.050	-0.010	-0.304*
	(-1.76)	(-1.50)	(-3.02)	(-1.62)	(0.59)	(-0.31)	(-1.73)
Ln(GpatStock)$_{[t-5,t]}$	-0.733	-0.209	-7.392***	-0.245	-0.017	2.024	0.133
	(-1.46)	(-1.13)	(-3.78)	(-0.62)	(-0.05)	(1.02)	(0.11)
FR Ratio-epi x *Ln(GpatStock)*$_{[t-5,t]}$	0.297**	0.036**	0.712**	0.093	0.525	-0.644	-0.193
	(1.98)	(2.05)	(2.48)	(1.54)	(1.26)	(-0.96)	(-0.74)
Ln(NGpatStock)$_{[t-5,t]}$	0.098	0.067	5.108**	-0.115	0.086	-0.432	-0.979**
	(0.27)	(0.44)	(2.34)	(-0.33)	(0.46)	(-0.80)	(-2.02)
FR Ratio x *Ln(NGpatStock)*$_{[t-5,t]}$	-0.250**	-0.000	-0.155	-0.042	-0.401**	0.199	0.086
	(-2.13)	(-0.01)	(-0.57)	(-1.04)	(-1.98)	(1.09)	(0.94)
Controls	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
N	3,427	3,185	4,183	11,287	1,511	4,096	7,035
Adj. R^2	0.628	0.638	0.587	0.633	0.819	0.902	0.691

Table 8
Subsample Analysis by Host Country Characteristics

This table presents the results of subsample analyses based on the host country's long-term orientation and femininity-masculinity inclination. Column (1) – (3) use *FS Ratio-high or FS Ratio-low* (or *FS Ratio-long or FS Ratio-short*) from the Hofstede's cultural measure that represents a preference in country for the long-term time horizon. A high (above median) and a low (below median) long-term horizon is based on the median value of the long-term time horizon score. Column (4) – (6) use *FS Ratio-high or FS Ratio-low* (or *FS Ratio-fem or FS Ratio-mas*) from the Hofstede's cultural measure that represents a preference in country for femininity or masculinity. A high (above median) and a low (below median) femininity is based on the median value of the femininity score, which is the reverse value of masculinity score. All regressions include the same set of control variables used in Table 5, firm and year fixed effects, but coefficients are not reported.

	(1)	(2)	(3)	(4)	(5)	(6)
	Long-Term Orientation Score			Femininity Score		
			Dependent variable: *ExcessVal*$_{t+1}$			
	N=1	N=3	N=5	N=1	N=3	N=5
FS Ratio-high	-0.003*	-0.004**	-0.004**	-0.033***	-0.032***	-0.033***
	(-1.87)	(-2.10)	(-2.47)	(-3.13)	(-3.06)	(-3.08)
Ln(GpatStock)$_{[t-N,t]}$	-0.093	-0.851**	-1.133**	-0.072	-0.924**	-1.207**
	(-0.32)	(-2.13)	(-2.41)	(-0.22)	(-2.11)	(-2.39)
FS Ratio-high x *Ln(GpatStock)*$_{[t-N,t]}$	0.012	0.011**	0.009*	0.014	0.031*	0.024*
	(1.34)	(1.99)	(1.77)	(0.61)	(1.90)	(1.64)
Ln(NGpatStock)$_{[t-N,t]}$	0.023	0.690**	0.648	-0.057	0.668*	0.626
	(0.12)	(2.14)	(1.48)	(-0.27)	(1.92)	(1.36)
FS Ratio-high x *Ln(NGpatStock)*$_{[t-N,t]}$	-0.002	-0.003	-0.002	-0.003	-0.015	-0.011
	(-0.66)	(-1.23)	(-1.01)	(-0.31)	(-1.53)	(-1.28)
FS Ratio-low	-0.051***	-0.046***	-0.045***	-0.081***	-0.077***	-0.082***
	(-3.08)	(-2.84)	(-2.84)	(-3.73)	(-3.45)	(-3.60)
FS Ratio-low x *Ln(GpatStock)*$_{[t-N,t]}$	-0.009	0.029	0.022	-0.039	0.009	0.006
	(-0.27)	(1.06)	(0.91)	(-0.69)	(0.19)	(0.14)
FS Ratio-low x *Ln(NGpatStock)*$_{[t-N,t]}$	-0.016	-0.036*	-0.028	0.014	-0.015	-0.004
	(-0.82)	(-1.84)	(-1.58)	(0.47)	(-0.49)	(-0.14)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	36,270	36,270	36,270	36,270	36,270	36,270
Adj. R^2	0.634	0.634	0.634	0.633	0.634	0.634

Table 9
Empirical Identification

This table presents OLS results, where the dependent variable is *Excess value*, industry-adjusted excess value computed as the market value of equity minus book value of equity divided by sales. *Treated* is a dummy variable that takes a value of 1 if the firm is with high foreign sales in countries affected by the European Union Emissions Trading System (EU ETS) and zero for a single-nation firm without European sales. High foreign sales are defined as if non-EU firms' average European foreign sales in the top tercile of foreign sales that occurred in the EU territories during 2002–2004. *Post* is a dummy variable that takes value of one if years fall in 2005–2007 and zero if years fall in 2002–2004. $Ln(GpatStock)_{[t\text{-}N,t]}$ (or $Ln(NGpatStock)_{[t\text{-}N,t]}$) is the cumulative number of green (non-green) patents from year *t-N* (*N*=1, 3, 5, and 7) to year *t* and log-transformed it after adding one (Furman, Porter, and Stern, 2002). All regressions include firm and year fixed effects, but coefficients are omitted. The numbers shown in parentheses are *t*-statistics clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
	Dependent variable; $ExcessVal_{t+1}$			
	N=1	N=3	N=5	N=7
$Ln(GpatStock)_{[t\text{-}N,t]} \times Treated \times Post$	3.866	2.808	1.018**	0.777**
	(1.28)	(1.47)	(2.50)	(2.29)
$Ln(GpatStock)_{[t\text{-}N,t]} \times Post$	-3.613	-2.650	-0.940*	-0.695*
	(-1.19)	(-1.37)	(-1.96)	(-1.71)
$Ln(GpatStock)_{[t\text{-}N,t]} \times Treated$	-5.782**	-3.198	0.761	2.087
	(-2.07)	(-1.31)	(0.29)	(0.60)
Post × Treated	0.681	0.620	0.738	0.786
	(1.08)	(1.01)	(1.23)	(1.32)
Treated	-6.340**	-6.362**	-6.834**	-7.064**
	(-2.03)	(-2.01)	(-2.17)	(-2.25)
$Ln(GpatStock)_{[t\text{-}N,t]}$	4.928*	1.145	-1.696	-2.936
	(1.70)	(0.45)	(-0.62)	(-0.81)
$Ln(NGpatStock)_{[t\text{-}N,t]}$	0.466	2.416**	0.770	-0.691
	(0.75)	(2.27)	(0.68)	(-0.69)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	8,479	8,479	8,479	8,479
Adj. R^2	0.699	0.699	0.698	0.699

Table 10
Sensitivity Analyses

This table presents the results of robustness tests with alternative proxy variable of the firm value. Panel A employs an alternative ratio of foreign sales, *FS Ratio-std* is measured as (*ForeSale-high - ForeSale-low)/ (ForeSale-high + ForeSale-low)*. Panel B uses an alternative ratio of foreign sales (i.e., *FS Ratio-epi*) based on the environmental performance index developed by Yale Center for Environmental Law & Policy. Panel C reports the OLS results with alternative firm value measure: *Tobin's Q* is computed as sum of market value of equity, the liquidating value of preferred stock, and the value of debts divided by the book value of assets *Alternative ExcessVal* is computed as the firm's actual value divided by its imputed value (Berger and Ofek, 1995). All regressions included the same set of control variables used in Table 3, firm and year fixed effects, but coefficients are omitted to report. The number shown in parentheses are t-values clustered at the firm level. ***, **, and * indicate significance at the 1% 5%, and 10% levels, respectively.

Panel A. Alternative Foreign Sales Ratio

	(1)	(2)	(3)	(4)	(5)
	$In(GreenPat)_{t+1}$	Dependent variable: $ExcessVal_{t+1}$			
		N=1	N=3	N=5	N=7
FS Ratio-std	0.068***	-1.078***	-1.085***	-1.073***	-1.052***
	(7.04)	(-5.09)	(-5.17)	(-5.12)	(-5.06)
$Ln(GpatStock)_{[t-N,t]}$		-0.094	-0.756**	-1.029**	-0.957*
		(-0.42)	(-2.19)	(-2.44)	(-1.94)
FS Ratio-std x $Ln(GpatStock)_{[t-N,t]}$		0.136	0.183	0.288**	0.334**
		(0.72)	(1.01)	(1.99)	(2.38)
$Ln(NGpatStock)_{[t-N,t]}$		0.024	0.628**	0.621	0.127
		(0.15)	(2.17)	(1.52)	(0.31)
FS Ratio-std x $Ln(NGpatStock)_{[t-N,t]}$		-0.123	-0.140	-0.142	-0.160*
		(-0.85)	(-1.00)	(-1.43)	(-1.71)
Controls	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	27,052	36,270	36,270	36,270	36,270
Adj. R^2	0.635	0.634	0.634	0.634	0.634

Panel B. Alternative Environmental Policy Index

	(1)	(2)	(3)	(4)	(5)
	In(GreenPat)$_{t+1}$	Dependent variable: *ExcessVal*$_{t+1}$			
	N=1	N=1	N=3	N=5	N=7
FS Ratio-epi	0.018***	-0.279**	-0.253**	-0.303***	-0.332***
	(4.64)	(-2.51)	(-2.21)	(-2.59)	(-2.86)
Ln(GpatStock)$_{[t-N,t]}$		-0.310	-1.335**	-1.565**	-1.237*
		(-0.59)	(-2.24)	(-2.42)	(-1.80)
FS Ratio-epi x *Ln(GpatStock)*$_{[t-N,t]}$		0.222	0.633**	0.538*	0.237
		(0.64)	(2.02)	(1.84)	(0.90)
Ln(NGpatStock)$_{[t-N,t]}$		0.122	0.918**	0.753	0.084
		(0.40)	(2.12)	(1.41)	(0.17)
FS Ratio-epi x *Ln(NGpatStock)*$_{[t-N,t]}$		-0.148	-0.368**	-0.211	-0.024
		(-0.85)	(-2.02)	(-1.30)	(-0.18)
Controls	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	27,052	36,270	36,270	36,270	36,270
Adj. R^2	0.633	0.634	0.634	0.634	0.634

Panel C. Alternative Firm Value

	(1)	(2)	(3)	(4)
	Dependent variable; *Alternative ExcessVal*$_{t+1}$			
	N=1	N=3	N=5	N=7
FS Ratio	-0.022**	-0.020**	-0.019*	-0.019*
	(-2.20)	(-2.02)	(-1.88)	(-1.81)
Ln(GpatStock)$_{[t-N,t]}$	0.017	-0.021	-0.059**	-0.043
	(0.70)	(-0.81)	(-2.20)	(-1.46)
FS Ratio x *Ln(GpatStock)*$_{[t-N,t]}$	-0.037**	-0.023*	0.021**	0.018**
	(-2.11)	(-1.73)	(2.31)	(2.38)
Ln(NGpatStock)$_{[t-N,t]}$	-0.004	0.040*	0.051**	0.026
	(-0.27)	(1.95)	(2.03)	(0.99)
FS Ratio x *Ln(NGpatStock)*$_{[t-N,t]}$	0.009	0.003	-0.013**	-0.011**
	(0.93)	(0.39)	(-2.10)	(-2.10)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	32,486	32,486	32,486	32,486
Adj. R^2	0.774	0.774	0.774	0.774
	(5)	(6)	(7)	(8)
	Dependent variable; *Tobin's Q*$_{t+1}$			
	N=1	N=3	N=5	N=7
FS Ratio	-0.009	-0.011	-0.009	-0.007
	(-0.68)	(-0.76)	(-0.63)	(-0.52)
Ln(GpatStock)$_{[t-N,t]}$	0.015	-0.018	-0.060	-0.079*
	(0.42)	(-0.48)	(-1.58)	(-1.76)
FS Ratio x *Ln(GpatStock)*$_{[t-N,t]}$	-0.050**	-0.035*	0.014	0.029***
	(-2.12)	(-1.76)	(1.47)	(3.55)
Ln(NGpatStock)$_{[t-N,t]}$	0.005	-0.010	-0.032	-0.055
	(0.23)	(-0.35)	(-0.91)	(-1.28)
FS Ratio x *Ln(NGpatStock)*$_{[t-N,t]}$	0.026*	0.023*	0.002	-0.005
	(1.81)	(1.80)	(0.23)	(-0.79)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	36,270	36,270	36,270	36,270
Adj. R^2	0.634	0.634	0.634	0.634

Appendix A
By Industry Pollution

This table present a subsample test by the level of industry pollution. Industry pollution is the industry level amount of toxic chemical releases, where the industry is based on the four digits of the SIC code. An industry is classified as the high polluting industry if amount of toxic chemical releases is in top decile in a given calendar year and non-polluting industry if outside top10. Panel A report the result of the analysis that examine the effect of *FS ratio* on green innovation. Panel B shows the valuation effect of *FS Ratio* and green innovation.

Panel A. Green Innovation Development

	(1)	(2)
	Industry Pollution	
	High	Low
FS Ratio	0.032***	0.027***
	(3.48)	(4.86)
Controls	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
N	9,157	16,829
Adj. R^2	0.652	0.623

Panel B. Firm Value

	(1)	(2)	(3)	(4)
	Dependent variable; ExcessVal$_{t+1}$			
	High Industry Pollution		*Low Industry Pollution*	
	N=5	N=7	N=5	N=7
FS Ratio	-0.603***	-0.595***	-0.174**	-0.189**
	(-3.27)	(-3.29)	(-2.08)	(-2.23)
Ln(GpatStock)$_{[t-N,t]}$	-1.531**	-1.460*	-0.944*	-0.824
	(-2.13)	(-1.94)	(-1.79)	(-1.22)
FS Ratio x *Ln(GpatStock)$_{[t-N,t]}$*	0.225*	0.214*	0.125	0.087
	(1.93)	(1.92)	(1.18)	(0.84)
Ln(NGpatStock)$_{[t-N,t]}$	0.626	-0.021	0.750	0.335
	(0.82)	(-0.03)	(1.60)	(0.76)
FS Ratio x *Ln(NGpatStock)$_{[t-N,t]}$*	-0.046	-0.043	-0.109*	-0.058
	(-0.65)	(-0.69)	(-1.93)	(-1.44)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	12,978	12,978	23,292	23,292
Adj. R^2	0.632	0.632	0.638	0.638