Financing, Institutional Environments, and Transitions to Clean Technology

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Strategic Management and Organization

Faculty of Business
University of Alberta

ABSTRACT

This dissertation provides an analysis of financing and institutional environments in sustainable innovation. I argue that to understand the drivers influencing technological innovations addressing new societal values, it is useful to study variations in financing innovation and how institutional environments structuring the nature of innovation shape the linkage between financing and innovation. Theoretical developments in this dissertation focus on the interactive mechanisms between financing and institutional environments to explain the emergence of clean technology innovation in the 1990s and 2000s.

I undertake three empirical studies with different levels of analysis, investigating multiple ways of how financing and institutional environments interact. My first paper shows how different nations' financial markets and renewable energy policies contribute to the rates of renewable energy innovation and production. My second paper examines how the rise of a shareholder value orientation, as evidenced by the growth of institutional ownership, impacts clean technology innovation under various contingencies. My third paper examines the influence of bank financing and environmental institutional pressures on clean technology innovation by individuals and private firms.

This dissertation contributes to the intersection of innovations, institutions, and sustainability by showing that the emergence of a new industry is embedded in the broader market and institutional dynamics and that the interactive mechanisms between financing and institutional environments fundamentally shape the fate of innovative projects designed to achieve particular social or environmental objectives.

ACKNOWLEDGMENTS

I am deeply indebted to my advisor, P. Devereaux Jennings, and to the other members of my dissertation reading committee, Michael Lounsbury, Tony Briggs, and Joel Gehman. Their advice, support, and encouragement during my graduate years have had a great impact on my work. I would also like to thank Zhenyu Wu, an external member, for his helpful comments on my dissertation.

I am grateful for the institutional support of both the Department of Strategic Management & Organizations and the PhD Office at the Alberta School of Business. I appreciate Jennifer Jennings and Tony Briggs for their support during the early stage of my graduate years. I also would like to thank Debbie Giesbrecht for her constant moral support from the beginning of my PhD study. Financial support from the Alberta School of Business and Future Energy Systems is gratefully acknowledged.

As I navigated my way through my doctoral studies, many fellow graduate students and colleagues were helpful. I especially thank Daniel Armanios, Yi Fang, Shilo Hills, Abiodun Ige, Anna Kim, Chang Lu, Evelyn Micelotta, Onnolee Nordstrom, Manely Sharifian, Dasha Smirnow, Myungjune Song, Muyu Wei, and Rengong Zhang.

I would like to thank Isabelle Le Breton-Miller for her generous support. Danny Miller taught me a great deal about research through our conversations. He has contributed significantly to my growth as a researcher. I would be forever grateful.

Finally, I am grateful to my family for imbuing me with scholarly perspectives. They have given me their constant support, understanding, and suggestions. The academic journey is as much theirs as it is mine. This thesis is dedicated to my family.

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CHAPTER 1: INTRODUCTION

Over the past decades, innovative projects designed to achieve particular social or environmental objectives that extend beyond functional needs have gained attention from both scholars and practitioners. Like other types of technological innovations, such innovative projects require substantial financing (e.g., Drover et al., 2017; Kerr & Nanda, 2015; Schumpeter, 1934). Canonical findings about the positive influence of financing on innovation are based on the assumption of the positive alignment between equity investment and incentives for launching innovative projects (Hall & Lerner, 2010; Levine, 1997). Although several scholars have recently suggested that potentially more nuanced relationships between financial ownership and innovation exist (e.g., Davis, 2009; Kerr & Nanda, 2015), the dominant approach to studies of financing and innovation is to probe and demonstrate the various positive linkages between financial ownership and innovation.

However, the argument that equity investment positively shapes the fate of innovation encounters significant challenges when explaining the financing of innovative projects that aim to address new societal values. Recently, many economic sociologists and organizational theorists have suggested the potential negative implications of the increasing dominance of finance in various real economic activities, the so-called "financialization of the economy" (e.g., Davis, 2009; Davis & Kim, 2015; Dore, 2008; Lounsbury & Hirsch, 2010; Lin & Tomaskovic-Devey, 2013; van der Zwan, 2014). Financialization influences the attention of decision makers toward meeting the interests of investors, leading toward a shareholder value orientation (Epstein, 2005; Fligstein, 2001; Krippner, 2011; Useem, 1996). Furthermore, some financial economists and strategy scholars have suggested that financialization generates managerial myopia and poor corporate governance practices (Admati, 2017; Greve, Palmer, & Pozner, 2010; Laverty, 1996; Porter, 1992; Stein, 1989). Hence, the relationship between financing and innovation requires a more nuanced understanding, particularly for innovative projects addressing social values that may not be well aligned with shareholder values.

By focusing on the nature of innovation, this dissertation advocates for the more complete theorization of institutional environments in order to better account for the full spectrum of mechanisms for financing socially beneficial innovation. In particular, I highlight the sociological notion that innovations with new social values are institutionally embedded or contingent (e.g., Fligstein & Dauter, 2007; Granovetter, 1985; Thornton, 2004). By emphasizing the role of institutional forces that has been investigated in the diffusion of administrative and non-technological innovations and the emergence of new industries (e.g., Abrahamson, 1991; Ansari, Fiss, & Zajac, 2010; Dobbin, 2009; Hoffman & Ventresca, 2002; Weber, Heinze, & DeSoucey, 2008), I consider how this applies to a particular type of technological innovations addressing new societal values. Toward this end, I engage both economic and sociological literatures to address the inherent complexities underlying financing within particular institutional environments for technological innovations and new industry regimes (e.g., Chandler, 1977; Dobbin, 1994; Levine, 1997; Nelson, 1994; Roy, 1999; Schumpeter, 1934).

In this dissertation, I study how clean technology innovation is shaped by the interaction of financing mechanisms and institutional environments. Among the various types of innovative projects that address both new societal norms and functional needs, the rise of clean technology innovation represents one of the most remarkable changes in many technology sectors, targeting a diverse range of products, services, and processes such as climate change mitigation, hazardous waste and emission reduction, energy efficiency improvement, and renewable energy generation (Hart, 2005; Pernick & Wilder, 2008). Clean technology innovation involves multiple market participants such as government agencies implementing regulations, environmentally sensitive citizens and communities, and consumers interested in new environmental and societal values. It also creates market opportunities by spanning across various spheres of industry norms, consumers, and various stakeholders (Hoffman, 1999; Hoffman & Ventresca, 2002; Russo, 2003; Vogel, 1995). Thus, innovative projects in clean technology potentially contain two intrinsic values: one is sustainable development for greener economy, which pertains to broader institutional demands, and the other is technological innovation for profitability, which helps to meet shareholder demands.

Clean technology innovation, thus, can be viewed as a particular category of social innovation. As the capability of the nation-state to define social values in the market space has been diminishing over time, firms have increasingly engaged in creating the "market for virtue" (e.g., Porter & Kramer, 2006; Vogel, 2005) by blending social and market values. Drawing on the sociological insight that innovations with new social values are institutionally embedded or contingent (e.g., Fligstein & Dauter, 2007; Rao et al., 2003; Weber et al., 2008), the scholarly endeavor in this stream of research has emphasized the institutional embeddedness of the origins of various social innovations such as microfinance (Battilana & Dorado, 2010; Cobb, Wry, & Zhao, 2016), organic foods (Besharov, 2014; Weber et al., 2008), and renewable energy projects (Georgallis, Dowell, & Durand, 2018; Sine & Lee, 2009). Consistent with the prior research, I propose that such sociological insight emphasizing the role of institutional forces in the emergence of new industries and practices is useful to explain transitions to clean technology in reducing pollutions and mitigating climate change.

I argue that, compared to other types of social innovations, the grand challenges that innovative projects in clean technology target are balanced configurations of environmental, social, and economic benefits. Fully balancing these three dimensions becomes indeed quite challenging, due to the dual goals of benefiting society and the environment, while also satisfying the market (e.g., Hahn et al., 2014; Jennings & Hoffman, 2017). The distinctive feature of clean technology innovation versus other types of social innovations is that it requires substantial financing such that various kinds of high technology projects need (e.g., Garud & Karnoe, 2003; Hargadon & Kenney, 2012; Mowery, Nelson, & Martin, 2010). Thus, as the nature of innovation is generally linked to that of financing, the fate of clean technology project is likely determined by the proper acquisition of financing. In attempting to balance the need to carve out the market space for broader institutional constituents as well as meeting financiers' demands, many cases of clean technology projects may fall under a particular value, whether economic or environmental/social. In the chapters that follow, I will discuss the specific cases of innovative projects in clean technology to identify their current and likely mix as a social innovation.

The analysis of transitions to clean technology engages with a broader issue of the rejection of socially efficient innovations that are less likely to diffuse compared to various stakeholders' expectations for its robust advancement (e.g., Abrahamson, 1991; Ferraro, Etzion, & Gehman, 2015; George et al., 2016). The nature of innovative projects in clean technology, satisfying broader institutional demands for sustainable development as well as requiring the substantive amount of financing for continuation, create grand challenges, potentially impacting transitions to clean technology. Thus, this dissertation focuses on the interactive role of financing mechanisms and institutional environments to explain transitions to clean technology. This leads to the following general research question (RQ) for this thesis*: Under varying and dynamic institutional environments, how does financing enable (and constrain) transitions to clean technology?*

Approaches

To address this question, I undertake three empirical studies on the emergence of clean technology innovation with a focus on the interaction of financing and institutional environments. Table 1.1 presents the overview of the three studies, developed in subsequent chapters, and Table 1.2 shows the approach of each empirical study. Each study tackles the question at a different level of analysis and is distinctively different from the other study in terms of approach; i.e., theoretical issue and empirical design. Overall, I examine the interaction effect of financing and institutional environments at the cross-country level and then explore how this interaction affects various outcomes at the organizational and jurisdictional levels, respectively. By working across levels (global-nation, nation-region-firm, and state-firm), I am able to investigate the varying linkages between the institutional environment, financing and clean technology transitions. Within each paper, I then develop specific explanations of the financing of clean technology in that context in order to provide more nuanced insights of how the relationships generated by the configuration of financing and various institutional forces shape the fate of technological innovation addressing new societal norms.

Insert Tables 1.1 & 1.2 about here

More specifically, my first paper (Chapter 2) examines the worldwide transition towards clean technology, with a focus on financing and policy. In particular, I examine how a nation-state's financing environment and its types of policies, particularly as configuration, contribute to the rates of renewable energy production and innovation. Using a sample of 73 countries from 1991 to 2013, I show the positive influence of credit market development on the transition to renewable energy production and innovation, and the complementary role of regulatory policies and credit market development on such transition. By presenting the value of long-term and stable financing in concert with command-and-control policies in the renewable energy sector, this paper highlights the potential limitations to market-based approaches such as equity market and incentive-based policies in the worldwide transition to renewable energy.

My second paper (Chapter 3) examines how the rise of a shareholder value orientation, driven by the financialization of the economy, impacts corporate environmental innovation. Specifically, I investigate whether the growth of institutional investor ownership undermined ongoing managerial efforts to enhance clean technology innovation. Drawing on variations in ownership structure, industry, and regional characteristics, I investigate under which conditions the relationship between institutional ownership and clean technology innovation were attenuated or amplified. I formulate several hypotheses that I tested using data from a universe of U.S.-listed firms that participated in clean technology innovation from 1990 to 2004. This paper highlights the potential limitations to market logics in corporate environmentalism by presenting the paradox of institutional investor ownership: There are somehow fundamental tensions between 'save for the future' and 'innovate for the future.' By bridging the gap between the complex institutional demands of specific sectors or fields with a more general view of these dynamics, this paper contributes to an understanding of how dominant cultural forces affect the stability and transformation of particular markets.

My third paper (Chapter 4) examines the effect of bank financing on innovation designed to achieve new societal norms. In particular, focusing on banking deregulation, I examine whether the enhanced financial market competition contributes to clean technology innovation output. Drawing on staggered events of state-level commercial bank branching deregulations in the United States, I find that banking deregulations positively influence clean technology innovation, particularly pronounced by private firms or individuals versus publicly listed corporations. Also, the positive effect of banking deregulations on clean technology innovation is stronger for entities located with greater institutional pressures. By presenting the influence of both institutional pressures and bank financing in clean technology innovation, this paper points to the value of non-market forces and the mitigation of continuation risks in the clean technology sector.

Contributions

Spanning multiple levels of analysis, the three empirical studies in my dissertation examine the determinants of clean technology innovation by focusing on the effects of financing and institutional infrastructure. In doing so, I offer new insights into the role of the institutional environments that structure competition, financing, and innovation, showing how the variation and dynamics of institutional environments play out when strategic orientations are contested or changing in the context of the emergence of clean technology innovation (e.g., Abrahamson, 1991; Ansari, Fiss, & Zajac, 2010; Davis, 2009; Fligstein & Dauter, 2007; Hoffman & Ventresca, 2002; Kerr & Nanda, 2015; Mowery et al., 2010). Focusing on the sector for renewable energy production and innovation, a key area of clean technology, my first paper (Chapter 2) presents the value of long-term and stable financing along with command-and-control policies in the worldwide transition to clean technology. To delve into the mechanism developed in my first paper, my second and third papers (Chapters 3 and 4), using the economy of the United States as a working laboratory, examine how interactions between financing and contextual institutional contingencies shape the evolution of the clean technology sector. My second paper (Chapter 3) shows how the growth of institutional investor ownership undermined ongoing managerial efforts to enhance clean technology innovation, presenting fundamental tensions between 'save for the future' and 'innovate for the future.' Alternatively, my third paper (Chapter 4) shows the positive influence of enhanced local bank financing conditions and the complementary role of environmental institutional pressures on the emergence of clean technology innovation, particularly for small firms and individuals, rather than publicly listed corporations.

Employing institutional perspectives as a toolkit, my approach herein contributes to the intersection of innovation, institution, and sustainability by showing that innovations with noble social and environmental objectives are embedded within the broader market and institutional dynamics and that the interactive mechanisms between financing and institutional environments fundamentally shape the fate of such innovative projects. The rest of the dissertation proceeds as follows. Chapters 2, 3, and 4 present each empirical study. Chapter 5 concludes with future research directions.

Table 1.1: Overview of Dissertation Chapters

	Financing	**Institutional environments**	**Clean technology innovation**
Chapter 2 (Paper 1)	Credit market Equity market	Regulatory policy Economic policy	Renewable production & patenting
Chapter 3 (Paper 2)	Institutional equity ownership	Party politics Business sectors	Clean technology patenting
Chapter 4 (Paper 3)	Commercial bank financing to private firms	Political support for environmental issues	Clean technology patenting

Table 1.2: Approach of Dissertation Chapters

	Level of analysis	**Sample**
Chapter 2 (Paper 1)	Country-level --- Country-level financial market & country-level renewable energy policy	Unit of analysis: 73 nation-states 1,370 country-year observations (1991 – 2013)
Chapter 3 (Paper 2)	Firm-level --- Subsample analyses on firm-, sector-, and regional heterogeneity	Unit of analysis: 856 publicly listed firms 6,875 firm-year observations (1990 – 2004)
Chapter 4 (Paper 3)	State-level within the U.S. --- State-level deregulation shock and policy support for environmental issues	Unit of analysis: 50 states in the U.S. 700 state-year observations (1990 – 2003)

CHAPTER 2: THE WORLDWIDE TRANSITION TO RENEWABLE ENERGY PRODUCTION AND INNOVATION: HOW FINANCIAL MARKETS AND POLICIES MATTER

INTRODUCTION

While sustainable development depends on the development and implementation of both financial markets and policies (e.g., Bergek et al., 2008; Mowery et al., 2010), the majority of empirical research in these fields has developed separately, implicitly treating financial market and policy components independently. In most situations, however, the actions that governments take in a particular sector affect the path of technological innovation in that sector throughout the investment strategies undertaken in financial markets. The complementarity between policies and overall financial market development in a nation-state is particularly important for the field of environmental sustainability. Policy shapes sustainable technologies and financial development and acts as a crucial vehicle for the implementation of socially beneficial, yet inherently financially risky, technologies (e.g., Russo, 2001; Sine & Lee, 2009). In spite of the importance of these complementarities, only a small stream of sustainability research has investigated the combination of non-market and market elements (Bansal, 2005; Hoffman & Ventresca, 2002; Marcus, Malen, & Ellis, 2013). Hence, we know little about configurational dimensions of financial market development and policy implementation that focalize the alignments of common elements, tightly integrating them by orchestrating them around themes (e.g., Meyer et al., 1993; Miller, 1986; 1996), such as sustainable development.

In this paper, I conduct a cross-country study of the effect of these configurational dimensions, providing new evidence that both financial market development and policies, at least in the renewable energy field, influence the transition to low carbon economies. The worldwide renewable energy field, my empirical setting, has undergone considerable transformation through the participatory involvement of various stakeholders, and policies and regulations since the 1990s (Hoffman, 2005; Porter & van der Linde, 1995; Vogel, 1995). A frequently stated rationale for environmental policies is to encourage the market participants to invest on renewables in order to substantially reduce the environmental pollution. Governments, not only as policy creators, but also as financiers, have broad discretion to influence production and innovation in different technologies such as renewables, therefore, creating and mitigating regulatory risk for the relevant actors (Malerba, 2002; Marcus, Aragon-Correa, & Pinkse, 2011; Rivera et al., 2009). In accordance with government intervention via policy and direct involvement, the transition to renewable energy production and innovation requires substantial financial market development in the nation-state due to financially risky and long-term nature of projects in the renewable field (Hargadon & Kenney, 2012; Slawinski et al., 2017). As renewable technologies are still considered to be emerging technologies, investors have often required substantial social and economic returns for taking the risk of investing in this sector, thereby incorporating the expected gains from stakeholders into their investment calculations (Busch, Bauer, & Orlitzky, 2016).

Empirically, I examine if the development of the financial market, the implementation of policy, and configurations of financial development and policy enhance the rate of the transition to renewable energy production and innovation. Drawing on variations in financial market development, government spending, and policy characteristics, I investigate under which conditions the rate of the transition to renewable energy production and innovation is mitigated or enhanced. I develop my theoretical framework from the joint consideration of the institutional perspective of sustainability (Delmas & Toffel, 2004; Jennings & Zandbergen, 1995; Jennings, Zandbergen, & Martens, 2011) and the literature on finance and sustainable innovation (Busch et al., 2016; Schumpeter, 1934). By focusing on different renewable policy characteristics and the heterogeneity among the path of financial market development, I formulate several hypotheses that I tested using data on 73 countries from 1991 to 2013.

My findings indicate that financial market development and policy are sources of variations in the adoption of renewable energy production and innovation. I show that credit market development is positively associated with the transition, but such a relationship does not hold in the equity market. My findings suggest that the enactment of renewable energy policy is positively associated with renewable energy production, while such relationship does not hold for renewable energy innovation. Regarding the configuration of finance and policy in the renewable energy sector, I show that there is evidence of the complementarity between credit market development and regulatory policy implementation on the transition to renewable energy production and innovation. Additionally, I find that such a positive relationship also exists between government expenditure and regulatory policy implementation.

THEORY AND HYPOTHESES

Transition to Renewable Energy Production and Innovation

Over the past decades, strategic environmentalism dealing with climate change and associated environmental issues has been an increasingly important practical and scholarly concern (Hoffman, 2011; Howard-Grenville et al., 2014). One of the most remarkable technological changes related to climate change has to do with the emergence of the renewable energy field, which involves multiple players such as governments, established firms, and entrepreneurs who are endeavoring to commercialize a diverse range of non-fossil resources such as wind, solar, and biofuel to enhance the effective use of natural resources and reduce toxic waste and greenhouse gas (GHG) emissions. Directing business professionals' attention away from responding to radical social activism against the private marketplace to cultivating feasible market solutions supported by various stakeholders, the transition to renewable energy represents a manifestation of strategic environmentalism. Such transition leverages market opportunities through innovation and production backed by the government and the civil society within the flow of the industry's technologies and consumers (Bansal & Roth, 2000; Delmas, Russo, & Montes-Sancho, 2007; Hoffman & Ventresca, 2002).

Technological progress in the renewable energy sector requires cumulative processes of technological advancements based on prior innovations like other technological innovations as well as the robust government and policy support throughout the industry emergence process (Marcus et al., 2011; Spencer, Murtha, & Lenway, 2005; Vogel, 1995). Drawing from an institutional approach, theorizing sustainable innovation has mainly relied upon organizational responses to institutional pressures (Jennings & Zandbergen, 1995; Hoffman & Jennings, 2015; Rivera et al., 2009), although scholars have also focused on the role of the resource-supply side such as financing in sustainability innovation (Bansal & Clelland, 2004; Busch et al., 2016; Marcus et al., 2013). Thus, a more complete conceptualization of the emergence of the renewable energy sector requires theorization of how the dual process of market and policy embedded in such innovation interact with complex institutional environments (Dacin, Ventresca, & Beal, 1999; Fligstein, 1996; Garud & Gehman, 2012; Granovetter, 1985). It is important to investigate the degree to which the multiplicity of varying financing and policy characteristics may be configured to shape such technological progress towards a low carbon economy.

The transition to the renewable energy sector has exhibited the worldwide pattern of diffusion (Figure 2.1).[1] In 1990, the average rate of electricity generation from the wind, solar, and biofuel out of total electricity generation among 73 countries was around 2 percent, but in 2010, it was around 5 percent. The innovation in the renewable sector exhibits a similar pattern. The worldwide transition towards renewable energy production and innovation has been salient, and well aligned with the theories and findings from several scholars on worldwide diffusion (Dobbin, Simmons, & Garrett, 2007; Frank, Hironaka, & Schofer, 2000; Meyer et al., 1997). Yet, the patterns of the transition to renewable energy sector may look similar across all the countries; thus, as noted above, it is worthwhile to investigate potential drivers of variation in the rate of the transition (Bartley, 2007; Schneiberg & Bartley, 2008; Vogel, 1995), focusing on financing and policy characteristics.

Insert Figure 2.1 about here

Nation-State Financing Environment and the Transition to Renewable Energy

Equity market development versus credit market development. The sustainability

[1] For source, see Data and Methods section.

literature emphasizes that the match of temporal orientations between the long-term objective in sustainable innovation and the short-term objective in financial profitability (Laverty, 1996; Porter, 1991), as the resultant trade-offs, are likely to produce paradoxes that hamper the rate of sustainable innovation (Hahn et al., 2014; Van der Byl & Slawinski, 2015). The importance of a long-term orientation in sustainability and its implications on corporate performance have been put forward in different ways, such as the notion of intertemporal tensions (Slawinski & Bansal, 2015), resilience (Ortiz-de-Mandojana & Bansal, 2016), and organizational inaction on climate change (Slawinski et al., 2017). Such a perspective has also emphasized the contrasting effect between the long-term value orientation of a stakeholder perspective and the short-term value orientation of a shareholder perspective. I suggest that equity and credit markets could play out differently in relation to temporal and stakeholder value orientations (Levine, 2005), thereby influencing the transition to renewable energy in different ways.

I argue that credit markets are more likely to have a positive effect on production and innovation in the renewable energy field for two reasons. First, bank-based financial systems could offer relatively long-term and stable financing, which is well aligned with the notion that renewable energy innovation and production require a substantial time horizon to become profitable and commercialized (Busch et al., 2016; Hargadon & Kenney, 2012; Marcus et al., 2013). Second, professionals in credit markets are more oriented towards stakeholders and consider various external environmental factors beyond profitability, as they are community oriented and socially embedded (Almandoz, 2014; Mizruchi, Stearns, & Marquis, 2006). Since renewable energy sectors possess multiple socially and environmentally noble objectives, and are highly dependent on long-term financing, developed credit markets should fund renewable energy production projects and innovations more to achieve more socially effective resource allocation.

Equity markets, by contrast, are less likely to promote innovation and production in renewable energy sectors that are dependent on long-term financing and possess multiple social purposes for two reasons. First, as Porter (1991) and Laverty (1996) argued, there are fundamental trade-offs between short-termism in equity investments and long-term orientation in innovative projects. In developed equity markets, there are competitions among profitable technology innovators in terms of their growth opportunities, hence, environmentally beneficially yet economically less profitable renewable energy production and innovation projects are likely to be neglected (Garud & Karnøe, 2003). Second, equity market systems are dependent upon relatively clear objectives of shareholder value maximization (Fligstein, 2001), and investment-banking professionals are less engaged with communal and societal objectives.

These arguments suggest that credit, rather than equity, issues are the main source of financing for entities that engage in renewable energy production and innovation. Although the selection of sustainable investment projects is likely driven by the logic of appropriateness, emphasizing stakeholder identification and broader social obligation in the credit market, financiers in the equity market are likely to choose investment projects based on the logic of consequences, focusing on financial utility and economic reality (March & Olsen, 1989). Thus, I posit that, while equity market development with the emphasis of economizing and short-term horizon is likely to work negatively towards the transition to renewable energy production and innovation, credit market development is positively associated with renewable development due to the emphasis on greening and long-term horizon (Hoffman & Ventresca, 1999; Marcus & Fremeth, 2009; Sigel, 2009). Hence,

> ***Hypothesis 1A***. *There is a positive relationship between the credit market development and the transition to renewable energy production and innovation.*
> ***Hypothesis 1B***. *There is a negative relationship between the equity market development and the transition to renewable energy production and innovation.*

The role of government as a financier. As the transition towards sustainable production and innovation is not entirely driven by the market, sustainability research emphasizes on the role of the state (Delmas et al., 2007; Jennings & Zandbergen, 1995; Short & Toffel, 2010). I posit that a strong state, in which the government's share controls substantial financing of private economic activities, is likely to promote the transition to the renewable energy sector throughout coercive and intervening roles (Hamilton & Sutton, 1989; Spencer et al., 2005; cf., Dobbin & Sutton, 1998). Financing innovative projects in the renewable energy sector is likely to benefit citizens in nation states, thus it is more likely that a strong state's policy agenda. In such case, governments are likely to provide such projects with financial support throughout their control of private market activity shares. Government size indeed matters when governments provide financing a certain economic project (Chandler, 1977; Dobbin, 1994). I postulate governments as financiers in the worldwide transition to the renewable energy sector and suggest that, like the case of credit market development, government size matters positively for the capacity of financing renewable energy projects. Therefore,

> ***Hypothesis 1C***. *There is a positive relationship between government size and the transition to renewable energy production and innovation.*

Policy and the Transition to Renewable Energy

Economic policies versus regulatory policies. Like other fields, the field of sustainability is intimately linked with public policy (For reviews, see Jennings, Zandbergen, & Martens, 2011; Rivera et al., 2009; Schneiberg & Bartley, 2008). There are different types of policies among nation states (Dobbin, 1994); some countries are more likely to implement command-and-control (regulatory) policies, and other countries are more likely to implement incentive-based (economic) policies. It is inconclusive which types of policies are more effective for the transition, as some scholars discuss the potential benefits of deregulations (Delmas et al., 2007) and discretion over rules (Majumdar & Marcus, 2001), while others argue about the limitations of self-regulation and emphasize on the potential benefits of regulation (Jennings & Zandbergen, 1995; King & Lenox, 2000). Yet, scholars largely agree that cumulative rule setting processes in the sustainability field encourage economic entities to be more ecologically responsive (Dowell, Hart, & Yeung, 2000; Edelman & Suchman, 1997; Jennings et al., 2005). Thus, as a baseline hypothesis, I propose that both regulatory and economic policies promote the transition to renewable energy. Hence,

> ***Hypothesis 2***. *There is a positive relationship between the cumulative number of regulatory and economic policies created and the transition to renewable energy production and innovation.*

Complementarities between Financing Environment and Policy

Credit market development and regulatory policy. The field of sustainability is not driven by a single factor; rather, it is enhanced by the agglomeration of several forces. I postulate that potential complementarities between financing and policy are shaped by the temporal orientation and types of policy. I argue that credit market developments ameliorate the potential trade-offs between short-termism in financing and long-term orientation for sustainable innovation, hence resolving resultant paradoxes in sustainability (Hahn et al., 2015; Slawinski et al., 2017; Van der Byl & Slawinski, 2015). As credit market developments reduce short-term pressures on long-term sustainability (Slawinsky & Bansal, 2015), I suggest that regulatory policies provide a robust platform for credit markets as a driver for the transition to renewable energy (Jennings & Zandbergen, 1995; Jennings et al., 2011; Marcus & Fremeth, 2009; Garud & Karnoe, 2003).

The complementary role of command-in-control (regulatory) policies and credit market development on the transition to renewable energy production and innovation is shaped by the configuration of the regulatory environment and the value of long-term and stable financing. Aligned with regulatory policies that implement stringent standards requiring economic entities to be more responsible ecologically, the long-term and stable financing provided by credit markets is more likely to facilitate renewable development. Thus, I posit that the logic of appropriateness (March & Olsen, 1989), the socially embedded nature of credit markets in the investment in the renewable sector (Dacin et al., 1999; Granovetter, 1985), may positively interact with regulatory environment set by command-in-control (regulatory) policies to promote the transition to renewable energy. Hence,

> ***Hypothesis 3.*** *There is a positive complementarity between the credit market development and cumulative regulatory policies on the transition to renewable energy production and innovation.*

Equity market development and economic policy. Compared to credit markets, equity markets are more likely to respond to economic policies as such incentive-based policies provide entrepreneurial opportunities for economic entities. While I posit that equity markets are not likely to trigger positive effects towards the transition to sustainability, it is accepted that equity markets are standard instruments for entrepreneurial growth (York & Lenox, 2014). Hence, economic policies are likely to positively interact with equity market developments in promoting the transition. Aligned with the incentive-based policies facilitating economic entities to search for entrepreneurial opportunities within the renewable energy field, the dynamic and timely financing provided by equity markets is more likely to facilitate renewable development. Thus, I posit that the logic of consequences (March & Olsen, 1989), attending to financial utility and economic reality in the investment in the renewable sector (Siegel, 2009), may positively interact with the facilitative environment set by incentive-based policies to promote the transition to renewable energy. Hence,

> ***Hypothesis 4.*** *There is a positive complementarity between the equity market development and cumulative economic policies on the transition to renewable energy production and innovation.*

Government size and regulatory policy. In accordance with my argument positing the complementary relationship between credit market and regulatory policy, I argue that there is a positive interaction effect between government size and regulatory policy on the rates of renewable energy production and innovation. Like the case of credit market development, the government as a financier is likely to facilitate renewable development because the government provides stable and long-term financing to renewable energy projects. A similar case is the railway development, one of key modern economic infrastructure, which was largely shaped by government financing (Chandler, 1977; Dobbin, 1994; Roy, 1999). The government as a financier, and the regulatory policy as a stringent yardstick, together will establish a robust platform for the transition. Intuitively for the renewable energy sectors, the simultaneous existence of the big government and the regulatory regime may complement the relatively strenuous private sector's support for the transition. As a corollary for the complementary relationship between credit market development and regulatory policies on renewable development,

> ***Hypothesis 5***. *There is a positive complementarity between the government size and cumulative regulatory policies on the transition to renewable energy production and innovation.*

DATA AND METHODS

Sample and Data Collection

To test my hypotheses, I assembled country-level data from a variety of sources. My main data source was the World Development Indicator (WDI). WDI data are reliable and have been used widely in cross-country research (Givens & Jorgenson, 2011; Guillén & Capron, 2016; Henisz, Guillén, & Zelner, 2005) and provide comprehensive information about various sectors (technology, energy, environment, and public sectors) that is standardized and comparable across countries. I constructed several core variables from multiple secondary sources. I collected renewable energy (wind, biofuel, and solar) patents data from CleanTech PatentEdge (e.g., Malen & Marcus, 2017). The PatentEdge database has an advantage over the USPTO as a patent data source in that PatentEdge is based on the use value (the basic and applied science and commercial uses) of the patent (CleanTech, 2014; Nanda et al., 2014). Hence, solar, wind, and biofuel patents are actually used for renewable energy production. I supplemented credit and equity market data from the Global Financial Development (GFD) database. For data on renewable energy policies, I used International Energy Agency (IEA.gov) data.

I tested my hypotheses in the renewable sector by studying countries that patented in biofuel, solar, and wind sectors between 1991 and 2013, inclusive. The year 1991 was the earliest that some of my indicators of policy and financial markets were available for both transitional and developed countries, which was essential for me to analyze interaction effects feasibly. I concluded the sample selection with the year 2013 to prevent the potential right censoring issue in terms of patenting activity and data availability. Due to the lack of systematic data by country for all the years involved, yet the need for temporal and endogeneity controls, I limited my analysis to countries with which comprehensive data were available for greater than five years of observations of each country during my sample period. In my sample, the minimum and maximum observation per country is eight and 23 respectively. The baseline sample for my analyses contained 1,370 country-year observations on 73 countries, including both developed and developing countries. Seventy-three countries is a very large number of country units relative to other studies in this area of cross-national patenting (e.g., Costantini, Crespi, & Palma, 2017), and, thus, it is a major advantage of my study.

Dependent Variables

I used two dependent variables in my analyses, measured at the country-year level: (1) the transition to renewable energy production and (2) the transition to renewable energy innovation. To gauge the transition to renewable energy production, I measured the percentage of the electricity production from renewable sources, excluding hydroelectric, out of total energy production. Data for this variable were collected from WDI.

For my measure of the transition to renewable energy innovation, I linked the total number of successful patent applications by residents in a country, obtained from CleanTech PatentEdge, with the entire successful patent applications by residents in that country obtained from WDI to construct the ratio of renewable energy patents over total patents. In particular, for each country, I identified biofuel, solar, and wind patents separately for each year and then summed them to create the total successful renewable patent applications. They were the number of patents that were filed in USPTO, European Patent Office (EPO), and World Intellectual Property Organization (WIPO). I used the residence of the first inventor to identify the origin country of the patent. Biofuel patents comprised of patents for algae, biodiesel, biogas, biomass, ethanol, and microbes. Wind patents comprised of patents for wind farms, measurement and forecasting, and turbines and components. Solar patents consist of patents for concentrators, solar cells, panels, and systems, and thin films. I divided the total successful renewable patent applications by total successful total patent applications in an entire sector filed in USPTO, EPO and WIPO. The two dependent country-level variables are annually updated.

Independent variables

I collected annual financial market development data from the WDI/GDF database. The proxy for the credit market development is Bank credit/GDP. The proxy for the equity market development of a country is Stock market capitalization/GDP. To gauge government size, I used general government final consumption expenditure (% of GDP), taken from WDI database.

I collected data on policy variable from the International Energy Agency (IEA.org) website. I counted the number of renewable policies that were introduced each year per country. To capture the cumulative nature of policies, I added a new policy to existing ones when it was created. Since my goal was to understand how economic and regulatory policies in renewable sectors interact differently with financial market variables to influence a country-level innovation activity in renewable sectors, I constructed two separate empirical proxies. To code renewable economic and regulatory policies for each country, I used data on the International Energy Agency (IEA.org). IEA classifies policies that provide financial incentives to market participants as economic policies, such as grants and subsidies, R&D supports, and tax relief. Following the classification by IEA, I coded policies such as codes and standards, mandatory requirements, and obligation schemes, as regulatory policies. For example, the Renewable Fuel Regulations in Canada require an average 5% renewable fuel content for gasoline, and 2% renewable fuel content in most diesel fuel. The proxy for the total renewable energy policy of a country was the sum of measures for the economic and regulatory policies in renewable energy sectors.

To test Hypotheses 3, 4, and 5 using mean-centered values, I interacted credit market, equity market, and government size with the regulatory and economic policy variables. All these proxies were annual, country-level variables.

Control variables

To control for the potential relationship between country-level factors and renewable energy production and innovation throughout my analyses, I entered GDP per capita (logged), GDP growth rate (%), energy intensity (ton of oil equivalent consumption per capita), urbanization (% of total population in urban area), FDI inflow (% of total GDP), and oil rent (the difference between the value of crude oil production at world prices and total costs of production). These are standard controls in the literature (Givens & Jorgenson, 2011; Guillén & Capron, 2016; Henisz, Guillén, & Zelner, 2005).

Analytic Method

I used Feasible General Least Squares (FGLS) regressions with country-wise heteroscedasticity in my analyses. This model allows observations within a country to be influenced by common unobservable country-level factors (Kmenta, 1986), thus it is appropriate for my data. To address potential sample selection biases, I adopted the Heckman two-stage selection model (Heckman, 1979). The first-stage model used the same independent and control variables in main analyses to predict whether each country-year observation would be included in my sample. The inverse Mills ratio generated by the first-stage selection model was then included in all regressions to address potential sample biases. In line with the causal mechanism set forth by my framework, all the independent and control variables were lagged by one year. In my analyses, a full set of country and year dummies were included to control for time-invariant country-specific characteristics and overall temporal trends.[2]

RESULTS

Table 2.1 provides descriptive statistics and correlations for the variables. I note that several of the variables exhibit significant correlations. However, all the variance inflation factors (VIFs) of individual variables are below five, indicating that multicollinearity is not a problem. Tables 2.2 and 2.3 present the results for the transition to renewable energy production and innovation. To facilitate comparison, the models are presented in the same sequence.

[2] I also ran FGLS regressions without including country dummy and/or Inverse Mills Ratio. Results are virtually identical with results presented in the paper. Concerning a potential multicollinearity issue that dependent variables are constructed using raw GDP as a denominator and that logged (yet lagged) GDP is used as a control, I ran analyses without logged GDP and got consistent results with ones presented in the paper.

Insert Tables 2.1, 2.2, & 2.3 about here

Models 1 through 6 summarize the results for the transition to renewable energy production. Model 1 presents the baseline model of control variables. Model 2 examines the effects of financial market and government. The coefficient for the credit market variable is positive and significant; thus, Hypothesis 1A is supported. The coefficient for the equity market variable is negative and significant, but it loses significance in some subsequent models, lending partial support for Hypothesis 1B. Although the coefficient for the government size variable is insignificant in the main model, its positive effect becomes significant in Models 4 and 5, lending partial support for Hypothesis 1C.

Model 3 examines the effects of renewable energy policy. The coefficients for economic policy and regulatory policy are positive and significant, and maintain overall significance in subsequent models (except for regulatory policy in model 4), thereby lending support for Hypothesis 2.

Models 4 through 6 demonstrate interaction effects between financial market and policies. Model 4 examines interaction effects between credit market development and different types of policies. The coefficient for the credit market and regulatory policy interaction variable is positive and significant, lending support for Hypothesis 3. Contrary to the positive complementarity between credit market development and regulatory policy, the interaction effect between credit market and economic policy is negative and significant.

Model 5 examines the interaction effects between equity market development and policies. Contrary to my prediction, the coefficient for the equity market and economic policy interaction variable is negative and significant; thus, Hypothesis 4 is not supported. The coefficient for the equity market and regulatory policy interaction variable is also negative and significant; hence, equity market development is overall incongruent with both economic and regulatory policy in transition to renewable energy production. Model 6 examines interaction effects between government size and industry policy. The coefficient for the government size and regulatory policy interaction variable is positive and significant, lending support for Hypothesis 5.

Models 7 through 12 contain the results for the transition to renewable energy innovation. The findings exhibit overall similar patterns with those reported in the transition to renewable energy production. Model 7 presents the baseline model of control variables, indicating that overall significance of control variables is weaker than Model 1. Model 8 examines the effects of financial market and government. The coefficient for the credit market variable is positive and significant; thus, Hypothesis 1A is supported. The coefficient for the equity market variable is negative but insignificant; hence, Hypothesis 1B is not supported. Contrary to my prediction, the coefficient for the government size variable is negative and significant; hence, Hypothesis 1C is not supported. Model 9 examines effects of policy. The coefficient for the economic policy variable is positive and significant, but it does not maintain significance in subsequent models. Further, the regulatory policy variable is not significant; thus, Hypothesis 2 is not supported.

Models 10 through 12 enter interaction effects between financing and policy. Model 10 examines interaction effects between credit market development and policy. The coefficient for the credit market and regulatory policy interaction variable is positive and significant, reinforcing support for Hypothesis 3. Model 11 examines interaction effects between equity market development and policy. Consistent with my prediction, the coefficient for the equity market and economic policy interaction variable is positive and significant; thus Hypothesis 4 is supported. The coefficient for the equity market and regulatory policy interaction variable is negative and significant, indicating that equity market development is incongruent with regulatory policy in transition to renewable energy innovation. Model 12 examines interaction effects between government size and policy. The coefficient for the government size and regulatory policy interaction variable is positive and significant, reinforcing support for Hypothesis 5. The summary of results is presented in Table 2.4.

Insert Table 2.4 about here

Supplementary Analyses

I conducted two supplementary analyses to enhance the overall confidence of results presented in the paper. First, to see if the patters are held with a greater number of countries, I ran analyses with a sample including any country with greater than one complete observation during the sample period, presented in Tables 2.5 and 2.6. In this case, the sample contained 1411 country-year observations on 83 countries. The patterns of results presented in Tables 2.5 and 2.6 are virtually identical, in terms of significance and magnitude, with results from a sample with a sufficient number of observations per country.

Insert Tables 2.5 & 2.6 about here

Second, to check potential multicollinearity, I also ran analyses that entered only a hypothesized variable for each equation, presented in Tables 2.7 and 2.8. In the main analyses (Tables 2.2 and 2.3), since I am interested in how policy is aligned with financing, I entered both a hypothesized variable (e.g., credit market x regulatory policy) and a non-hypothesized variable (e.g., credit market x economic policy) and compared them. The patterns presented in the supplementary analyses are virtually identical in terms of significance and magnitude, enhancing confidence in the overall results presented in the paper.[3]

Insert Tables 2.7 & 2.8 about here

DISCUSSION

There has been substantial support for the notion that sustainable development is situated and embedded within heterogeneous institutional forces. Accordingly, I unpack a finer-grained mechanism of how such efforts for sustainability are bounded and instantiated by broader structural configurations among financial market development, policy, and general government capacity. Efforts to bridge the gap between the domain of policy approaches (Delmas et al., 2007; Majumdar & Marcus, 2001; Prakash & Potoski, 2006) and emerging institutional complexity approaches have important implications for sustainability research (Greenwood, Jennings, & Hinings, 2015; Hoffman & Jennings, 2015; Lee & Lounsbury, 2015). By unbundling the effects of financial development and policy on the adoption of renewable energy production, I touch upon the kind of

[3] To spell out results more clearly, I used three-decimal points in presenting supplementary analyses. While not presented, I also entered the direct effect of financing (H1A – H1C) to check potential multicollinearity. The results are virtually identical with ones presented in the paper.

institutionally oriented behaviors driven by the logic of appropriateness/consequentiality (March & Olsen, 1989).

Given the surprising lack of research conducted on cross-national study of institutional and economic sources of innovations in the renewable energy field, this study raised and examined a fundamental overarching question for emergent work at the intersection of relevant literatures: How does the heterogeneous nature of institutional characteristics within a nation-state influence the rate of environmentally sustainable production and innovation? From the simultaneous consideration of overall financial market development in a nation-state and policy implementation in a renewable energy sector, I argue that the relationship between the development of country-level financial resource environment and the nation-state level transition to renewable energy is not univariate, due to complex institutional mechanisms inherent in the congruence of regulatory styles towards the renewable energy field and overall nation-state resource environment within each country.

To test the multiple dimensionalities of cross-national variations in production and innovations associated with these financial market and policy characteristics in the renewable energy field, I analyzed a cross-national panel dataset consisting of 73 countries over the 23-year period. My analysis reveals that the production and innovation rates in the renewable energy field are associated with causal mechanisms in my framework. More specifically, countries with more developed credit markets and more regulatory policies generate more productions and innovations in renewables. Yet, countries with stronger equity market development and economic policy implementation tend to be more innovative in the renewable energy sector. These findings set forth the systems perspective on sustainability (Bansal & Song, 2017; Hahn et al., 2015; Hoffman & Jennings, 2015), emphasizing interconnected and interdependent elements in understanding drivers of sustainable development. My findings also offer corroboration of the comparative study reported by Dobbin (1994) for heterogeneous paths of innovations in railways in different countries—as well as those reported by Hoffman (2001) for different alignments of organizational responses to institutional environments.

By presenting the value of long-term and stable financing in concert with command-and-control policies in the renewable energy field, this paper highlights the potential limitations to market-based approaches such as equity market and incentive-based policies in the worldwide transition to renewable energy. Thus, beyond a shareholder value orientation, stakeholder identification that aligns with regulatory policy regime facilitates the development of renewables, as stable and long-term financing with command-and-control policy implementation, in tandem, provides the robust platform for the transition to renewable energy production and innovation. My research extends the lessons from the case study of Denmark and the United States on wind turbines (Garud & Karnøe, 2003), by demonstrating the potential value of the long-term and stable relationship between financing environment and economic entities, complemented with stringent environmental standards, as an alternative mechanism to standard market-based approaches.

Contributions

My study offers several main contributions and associated implications. First, drawing from the tradition of the institution-based view emphasizing institutional heterogeneity (Hamilton & Biggart, 1988; Dobbin, 1994; Fligstein, 1996), I contribute to the understanding of sources of variations in the transition to the renewable energy sector. In doing so, I follow past calls for a stronger theorization of the state and policy to understand complexities in financing and policy in the emergence of sustainability field (Garud & Karnøe, 2003; Hoffman & Jennings, 2015; Rivera et al., 2009). I thus extend applications of variations of policy effects within sustainability research (Delmas & Montes-Sancho, 2011; Majumdar & Marcus, 2001; Russo 2001), as well as contribute to recent research on exploring the impacts of paradoxes inherent to temporal orientations (Hahn et al., 2014; Slawinski & Bansal, 2015; Van der Byl & Slawinski, 2017).

Second, I identify a potential positive driver for the transition to the renewable energy production and innovation. By taking the integrative approaches to financing and policy for understanding cross-national variations in the renewable energy field, I add to the body of literature examining the antecedents of proactive environmental strategies. Despite the potential importance of social implications of systematic coordination in renewable energy dealing with climate change in the globe, almost all notable recent studies that have unpacked potential limitations to such moves (Ansari, Wijen, & Gray, 2013; Schüssler, Rüling, & Wittneben, 2014) lack the identification of positive drivers for such coordination for the transition. This relative neglect reflects upon both challenges in theorization in the cross-country setting and inherent empirical challenges in research on proactive environmental strategies drawing from large-scale, macro-level data. The dearth of such work is unfortunate, considering the prevalence and potential social and economic impact of the renewable energy sector. My research suggests that credit market developments, regulatory policies, and configurations between long-term and stable financing and command-and-control (regulatory) policies are substantive elements of cross-national innovations in the renewable energy field, unlike standard approaches to innovations such as equity market development and incentive-based (economic) policies.

A third contribution of my study is that it is one of a few attempts to investigate multiple dimensions of innovative and production activities in the worldwide renewable energy field. To capture the sources of heterogeneity in the transition towards renewable energy field, I endeavored to construct multidimensional measures of financial markets, states, and policies. Overall, my findings are consistent with previous sustainability research, but my observation of the configuration between financing and policy is intriguing, providing preliminary evidence that calls for multidimensional approaches in cross-country studies.

Limitations and Future Directions

There are limitations of my study that provide fruitful opportunities to advance future research. I acknowledge that there are alternative institutional mechanisms that might explain cross-national variations in production and innovation in the renewable energy field. In this paper, I tend to conceptualize macro-level institutional variables in a large sample of countries. Thus, some of my empirical measures are relatively coarse proxies for micro-level institutional mechanisms at practice. An in-depth comparative case study (Dobbin, 1994; Guillén, 2001; Vogel, 1986) or an intensive case study of a single country (Hoffman, 1999) may contribute to a more fine-grained theorization of the transition to renewable energy, yet there are inherent trade-offs. One of these is likely to be external validity. Although I incorporated two proxies to gauge the worldwide transition to renewable energy, one with renewable energy production out of total electricity production and the other with patenting activity in the renewable energy sector out of total patenting activity in a nation-state, I agree that I hinge upon generalizability over contextualization. Thus, I believe future insights could be gained from research investigating micro aspects of production and innovations shaped by financing activity in the renewable energy field, such as linking individual and organizational practices with microfinance in the informal economy. Related to my empirical findings, it would be intriguing to unpack how the rates of innovations, led by different entities such as university scientists and corporate R&D that are shaped by financiers' heterogeneous temporal and risk orientations influence the evolution of renewable energy.

Although my study shows varied configurations between financing and policy in the renewable energy field, future research would benefit from a finer-grained investigation of the temporal dynamics of renewable energy sectors (Bansal & DesJardine, 2014; Lawrence, Winn, & Jennings, 2001). For instance, future researchers might want to consider varied business responses to policy implementation under different stages of transition (Garud & Gehman, 2012; Jennings et al., 2011; Rivera et al., 2009). In a related manner, it would be interesting to know how the different objectives of financing and policy embedded in profession and state in an earlier stage impact differently the transition towards sustainable development compared to a later stage as the renewable energy sector evolves (Baron, Dobbin, & Jennings, 1986; Delmas & Montes-Sancho, 2010; Ioannou & Serafeim, 2015). The explicit consideration of temporal dynamics may yield potential paradoxical mechanisms nested in competing societal demands in financing and policy (Hahn et al., 2014; Smith & Lewis, 2011; Van der Byl & Slawinski, 2015). For example, how do financial market development and renewable energy policy impact the evolutionary process of renewable energy sectors and potential buffering mechanisms against the withdrawal of renewable energy projects under certain market and institutional conditions (e.g., Garud & Gehman, 2012; Lawrence et al., 2001)?

I acknowledge that it is difficult to completely discern the direct and indirect effects of policies on innovations in the renewable field. There are several potential mechanisms that are likely to influence policy creations (e.g., Georgallis, Dowell, & Durand, 2018) and regulatory styles (e.g., Vogel, 1986) and then impact innovation and production in the renewable energy sector. These could be social movement organizations (Bertels, Hoffman, & DeJordy, 2014; Pacheco, York, & Hargrave, 2014), voluntary environmental regulations (Barnett & King, 2008; Prakash & Potoski, 2006) and organizational learning from prior innovation experiments (Russo, 2003; York & Lenox, 2014). I hope that future research will continue to unpack these causal linkages in the worldwide transition towards a low carbon economy.

Figure 2.1: Transition to Renewable Energy Production & Innovation

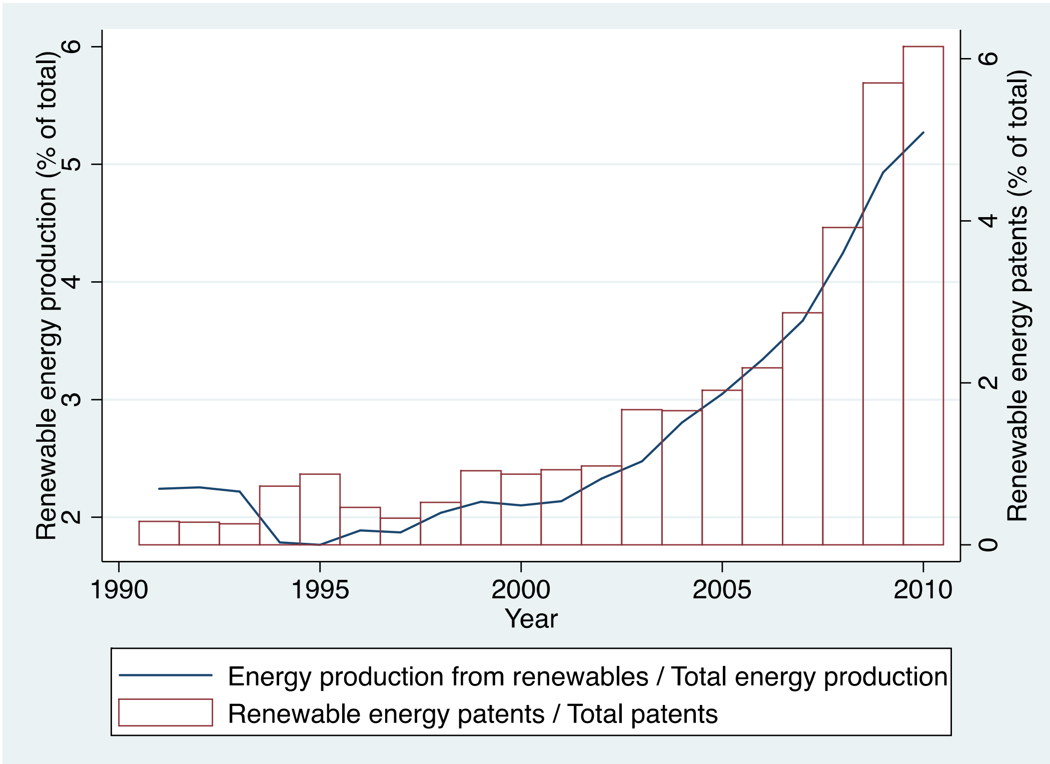

Table 2.1: Descriptive Statistics and Pearson Correlation Coefficients (N = 1,370)

	Variable	Mean	S.D.	1	2	3	4	5	6
1	Renewable energy generation	3.36	5.63						
2	Renewable energy patenting	2.03	5.20	0.30					
3	Credit market	65.37	44.55	0.31	0.32				
4	Equity market	60.23	91.25	-0.02	0.20	0.42			
5	Government size	16.65	4.84	0.19	0.18	0.17	-0.11		
6	Economic policy	1.66	3.51	0.23	0.23	0.33	0.29	0.13	
7	Regulatory policy	0.76	1.64	0.28	0.17	0.19	0.11	0.08	0.71
8	GDP per capita (ln)	9.72	0.82	0.14	0.28	0.55	0.32	0.44	0.35
9	GDP growth	2.65	3.73	-0.19	-0.14	-0.16	0.01	-0.21	-0.12
10	Energy intensity	2.84	2.18	0.23	0.15	0.40	0.19	0.46	0.29
11	Urbanization	67.72	18.46	0.08	0.23	0.32	0.30	0.36	0.23
12	FDI inflow (% of GDP)	5.30	20.19	-0.01	0.15	0.11	0.13	0.04	0.08
13	Oil rent	2.49	6.52	-0.17	-0.05	-0.20	-0.09	-0.08	-0.11

	Variable	7	8	9	10	11	12
7	Regulatory policy						
8	GDP per capita (ln)	0.25					
9	GDP growth	-0.12	-0.19				
10	Energy intensity	0.18	0.74	-0.13			
11	Urbanization	0.16	0.73	-0.16	0.55		
12	FDI inflow (% of GDP)	0.06	0.12	0.02	0.05	0.15	
13	Oil rent	-0.10	0.00	0.04	0.02	-0.03	-0.04

Coefficients are significant at the 0.05 level when absolute values are greater than 0.05.

Table 2.2: Results on Transition to Renewable Energy Production

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Credit market		0.04***		0.04***	0.04***	0.03***
		(0.00)		(0.00)	(0.00)	(0.00)
Equity market		-0.00**		-0.00**	0.00	0.00
		(0.00)		(0.00)	(0.00)	(0.00)
Government size		0.03		0.03*	0.05***	0.03
		(0.02)		(0.02)	(0.02)	(0.02)
Economic policy			0.11***	0.23***	0.09***	0.01
			(0.02)	(0.04)	(0.02)	(0.02)
Regulatory policy			0.40***	0.02	0.45***	0.30***
			(0.05)	(0.06)	(0.05)	(0.05)
Credit market				-0.14***		
X Economic policy				(0.02)		
Credit market				0.37***		
X Regulatory policy				(0.04)		
Equity market					-0.02***	
X Economic policy					(0.01)	
Equity market					-0.05***	
X Regulatory policy					(0.01)	
Government size						0.03
X Economic policy						(0.03)
Government size						0.70***
X Regulatory policy						(0.06)
GDP per capita (ln)	-3.38***	-4.91***	-2.80***	-4.51***	-4.21***	-2.90***
	(0.41)	(0.47)	(0.36)	(0.44)	(0.43)	(0.44)
GDP growth	0.06**	0.06**	0.03	0.04	0.07***	0.03
	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
Energy intensity	-0.32**	-0.15	0.05	0.09	0.11	0.33**
	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Urbanization (%)	-0.04**	0.13***	-0.03	0.10***	0.10***	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FDI inflow (% of GDP)	-0.01*	0.01	-0.00	0.01*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Oil rent (% of GDP)	-0.13***	-0.07**	-0.08***	-0.05*	-0.08***	-0.06**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Inverse Mills Ratio	3.94***	0.93	1.99**	0.26	2.27*	1.07
	(1.05)	(1.28)	(0.98)	(1.22)	(1.19)	(1.15)
Constant	34.49***	34.09***	27.85***	32.26***	28.95***	21.91***
	(4.61)	(5.03)	(4.03)	(4.66)	(4.56)	(4.70)
Country and year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Countries	73	73	73	73	73	73
Country years	1370	1370	1370	1370	1370	1370

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses. $p < 0.001$ for all models based on Wald chi-squared test.

Table 2.3: Results on Transition to Renewable Energy Innovation

Variable	(7)	(8)	(9)	(10)	(11)	(12)
Credit market		0.02***		0.02***	0.02***	0.02***
		(0.00)		(0.00)	(0.00)	(0.00)
Equity market		-0.00		-0.00	-0.00	-0.00
		(0.00)		(0.00)	(0.00)	(0.00)
Government size		-0.06**		-0.07***	-0.06***	-0.07***
		(0.02)		(0.02)	(0.02)	(0.02)
Economic policy			0.06***	-0.06*	-0.04**	-0.03
			(0.02)	(0.04)	(0.02)	(0.02)
Regulatory policy			-0.05	0.04	0.08**	0.03
			(0.04)	(0.05)	(0.04)	(0.04)
Credit market				0.03		
X Economic policy				(0.02)		
Credit market				0.08***		
X Regulatory policy				(0.03)		
Equity market					0.05**	
X Economic policy					(0.02)	
Equity market					-0.13***	
X Regulatory policy					(0.05)	
Government size						-0.01
X Economic policy						(0.04)
Government size						0.21***
X Regulatory policy						(0.07)
GDP per capita (ln)	-2.72***	-4.45***	-2.67***	-3.70***	-4.44***	-4.03***
	(0.46)	(0.52)	(0.47)	(0.53)	(0.52)	(0.54)
GDP growth	0.05	0.02	0.04	0.03	0.02	0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Energy intensity	-0.11	-0.06	-0.02	-0.10	0.01	0.07
	(0.11)	(0.15)	(0.12)	(0.16)	(0.16)	(0.16)
Urbanization (%)	-0.09***	-0.02	-0.09***	-0.03	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
FDI inflow (% of GDP)	0.01	0.02**	0.01	0.02**	0.02**	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Oil rent (% of GDP)	-0.01	0.04	0.00	0.03	0.05	0.04
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Inverse Mills Ratio	2.73**	-0.03	2.24*	0.39	-0.27	0.05
	(1.28)	(1.49)	(1.28)	(1.53)	(1.48)	(1.50)
Constant	31.62***	43.35***	31.40***	37.31***	42.92***	39.48***
	(4.83)	(5.32)	(4.92)	(5.43)	(5.40)	(5.61)
Country and year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Countries	73	73	73	73	73	73
Country years	1370	1370	1370	1370	1370	1370

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses. $p < 0.001$ for all models based on Wald chi-squared test.

Table 2.4: Summary of Results (Transition to Renewable Energy Sector)

Theorized variables	Hypothesized direction	Empirical support	
		Production	Innovation
Credit market development	H1A (+)	Yes	Yes
Equity market development	H1B (–)	Yes	No
Government size	H1C (+)	Yes	No
Economic & regulatory policy	H2 (+)	Yes	No
Credit market X Regulatory policy	H3 (+)	Yes	Yes
Equity market X Economic policy	H4 (+)	No	Yes
Government size X Regulatory policy	H5 (+)	Yes	Yes

Table 2.5: Supplementary Analysis 1: Renewable Energy Production

Variable	(1)	(2)	(3)	(4)	(5)
Credit market	0.045***		0.038***	0.039***	0.028***
	(0.002)		(0.003)	(0.002)	(0.002)
Equity market	-0.002**		-0.002**	0.001	-0.000
	(0.001)		(0.001)	(0.001)	(0.001)
Government size	0.044***		0.045***	0.058***	0.033**
	(0.017)		(0.015)	(0.015)	(0.015)
Economic policy		0.114***	0.233***	0.095***	0.012
		(0.020)	(0.038)	(0.023)	(0.023)
Regulatory policy		0.390***	0.028	0.439***	0.312***
		(0.046)	(0.058)	(0.052)	(0.045)
Credit market			-0.137***		
X Economic policy			(0.022)		
Credit market			0.366***		
X Regulatory policy			(0.039)		
Equity market				-0.024***	
X Economic policy				(0.008)	
Equity market				-0.045***	
X Regulatory policy				(0.015)	
Government size					0.034
X Economic policy					(0.028)
Government size					0.676***
X Regulatory policy					(0.057)

N = 1411 (83 countries). Control variables and year dummies are included.
*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses. $p < 0.001$ for all models based on Wald chi-squared test.

Table 2.6: Supplementary Analysis 1: Renewable Energy Innovation

Variable	(8)	(9)	(10)	(11)	(12)
Credit market	0.016***		0.008***	0.015***	0.011***
	(0.00)		(0.00)	(0.00)	(0.00)
Equity market	0.003***		0.004***	0.002*	0.006***
	(0.00)		(0.00)	(0.00)	(0.00)
Government size	0.029**		0.020	0.029**	0.006
	(0.01)		(0.01)	(0.01)	(0.01)
Economic policy		0.018	-0.146***	-0.057***	-0.045***
		(0.02)	(0.03)	(0.02)	(0.02)
Regulatory policy		0.183***	0.221***	0.217***	0.118***
		(0.04)	(0.05)	(0.04)	(0.03)
Credit market			0.076***		
X Economic policy			(0.02)		
Credit market			0.066*		
X Regulatory policy			(0.04)		
Equity market				0.078***	
X Economic policy				(0.02)	
Equity market				-0.191***	
X Regulatory policy				(0.05)	
Government size					0.079**
X Economic policy					(0.03)
Government size					0.290***
X Regulatory policy					(0.07)

N = 1411 (83 countries). Control variables and year dummies are included.
*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses. $p < 0.001$ for all models based on Wald chi-squared test.

Table 2.7: Supplementary Analysis 2: Renewable Energy Production

Variable	(1)	(2)	(3)	(4)	(5)
Credit market	0.021***		0.018***	0.019***	0.016***
	(0.002)		(0.002)	(0.002)	(0.002)
Equity market	-0.006***		-0.006***	-0.004***	-0.003***
	(0.001)		(0.001)	(0.001)	(0.001)
Government size	0.074***		0.072***	0.082***	0.036**
	(0.016)		(0.015)	(0.016)	(0.015)
Economic policy		-0.060**		0.190***	
		(0.025)		(0.027)	
Regulatory policy		0.752***	0.537***		0.450***
		(0.064)	(0.062)		(0.052)
Credit market			0.140***		
X Regulatory policy			(0.038)		
Equity market				-0.024**	
X Economic policy				(0.009)	
Government size					0.669***
X Regulatory policy					(0.057)

N = 1,370 (73 countries). Control variables and year dummies are included.
*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses. $p < 0.001$ for all models based on Wald chi-squared test.

Table 2.8: Supplementary Analysis 2: Renewable Energy Innovation

Variable	(6)	(7)	(8)	(9)	(10)
Credit market	0.016***		0.010***	0.015***	0.012***
	(0.002)		(0.002)	(0.002)	(0.002)
Equity market	0.004***		0.004***	0.002	0.005***
	(0.001)		(0.001)	(0.001)	(0.001)
Government size	0.034***		0.026*	0.036***	0.007
	(0.013)		(0.014)	(0.014)	(0.014)
Economic policy		0.035		0.019	
		(0.022)		(0.017)	
Regulatory policy		0.178***	0.036		0.062**
		(0.047)	(0.033)		(0.026)
Credit market			0.153***		
X Regulatory policy			(0.026)		
Equity market				0.027	
X Economic policy				(0.018)	
Government size					0.498***
X Regulatory policy					(0.058)

N = 1,370 (73 countries). Control variables and year dummies are included.
*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses. $p < 0.001$ for all models based on Wald chi-squared test.

CHAPTER 3: FINANCIALIZATION OF THE ECONOMY AND CLEAN TECHNOLOGY INNOVATION: THE PARADOX OF INSTITUTIONAL OWNERSHIP

INTRODUCTION

Over the past three decades, financial markets have had an increasingly dominant impact on the structure and strategy of corporations (Davis & Kim, 2015; Fligstein, 1990; Useem, 1996). Scholars increasingly recognize that the rise of a shareholder value orientation embedded in the financialization of the economy transforms corporate activities as well as the field of finance professions. Accordingly, organizational research on financialization of the economy has generated an extensive body of research on various topics such as shifts in corporate strategy from diversification to refocusing on core competence (Davis et al., 1994; Zuckerman, 2000), the espousal of the shareholder value orientation (Fiss & Zajac, 2004), the adoption of compensation and management practices tailored for shareholder value maximization (Westphal & Zajac, 1994; 2001), and workforce downsizing (Ahmadjian & Robbins, 2005), as well as the rise of institutional investors (Davis & Thompson, 1994) and the professionalization of the field of finance (Lounsbury, 2002). An important development in this stream of the literature is that strategic change is increasingly seen as not only organizational reorientation to technological evolution (Christensen & Bower, 1996; Tushman & Anderson, 1986), but also as organizational responses to broader institutional demands that shape heterogeneous effects on its constituent members (Oliver, 1991; Thornton et al., 2012).

Despite the fact that many business scholars suggest that there is a fundamental tension between the managerial short-term orientation embedded in a shareholder value orientation and broader societal demands for the long-term orientation of corporate activities (e.g., Davis, 2009; Porter, 1991), organizational scholars have tended to focus on the cases of how organizations comply with such market demands. Hence, it is not surprising that organizational research on the conception of shareholder value has tended to focus on cases of how organizational generic strategies are well aligned with the demands of shareholders (Zajac & Westphal, 2004; cf. Ioannou & Serafeim, 2015). Research that has emphasized an understanding of conflicting institutional sources and dynamics of inherent heterogeneity, on the other hand, has tended to provide exemplary cases of tensions and competitions among particular cultural values (Marquis & Lounsbury, 2007; Reay & Hinings, 2009; cf. Greenwood et al., 2010). Therefore, more scholarly efforts to bridge the gap between complexities in institutional demands in specific sectors or fields and a more general view of these dynamics can enhance the understanding of how dominant cultural forces affect the origins, stability, and transformation of particular markets (Lounsbury et al., 2003; Pacheco et al., 2014; York & Lenox, 2014).

Recently, sustainability scholars have begun focusing on inconsistencies in temporal orientations and inherent paradoxical natures in the generic business domain and the particular sustainability domain (Bansal & DesJardine, 2014; Hahn et al., 2014; Smith & Lewis, 2011). In line with the rise of corporate environmentalism, the notion of sustainability has been incorporated into one of the core objectives in corporate environmental strategy as organizations respond to broader institutional demands (Delmas & Toffel, 2004; Hoffman, 2001; Jennings & Zandbergen, 1995). At the organizational level, sustainability has shaped the focal attention of managers concerned with issues such as financial risks (Bansal & Clelland, 2004), social evaluation (Walls et al., 2012), and environmental management practices (Delmas & Toffel, 2008).

Researchers have noted that proactive corporate environmental initiatives face higher risk of failure and require a longer time horizon for commercialization compared to other strategic initiatives (Hargadon & Kenney, 2012; Marcus et al., 2013), advancing recent scholarly attention to the nature of competing market demands embedded in shareholders' short-term orientation and the long-term nature of corporate environmental strategy (Laverty, 1996; Ortiz-de-Mandojana & Bansal, 2016; Slawinsky & Bansal, 2015). Hence, by focusing on the tension between corporate practices meeting shareholder demands and ongoing efforts for environmentally beneficial strategies, this paper aims to gain a deeper understanding of the fundamental tension between the managerial short-term orientation, embedded in the dominant market norm of the shareholder value conception, and the long-term orientation for proactive corporate environmental strategies, embedded in the broader societal demands on corporate environmentalism.

In this paper, I investigate how the rise of the shareholder value orientation driven by the financialization of the economy impacts corporate environmental innovation. Empirically, I study whether the growth of institutional ownership instantiates managerial short-termism, undermining ongoing efforts to enhance clean technology innovation. Under which conditions, is the relationship between institutional ownership and clean technology innovation attenuated or amplified? To answer these questions, I formulate several hypotheses that I tested using data from a universe of U.S.-listed firms who participated in clean technology innovation from 1990 to 2004.

I draw my theoretical framework from the joint consideration of institutional complexity in organizational environments (Friedland & Alford, 1991; Greenwood et al., 2011; Thornton et al., 2012) and socially embedded and constituted agency as a carrier of cultural values (Rao et al., 2003; Scott, 1995; Westphal & Zajac, 2013). Following recent advances in the notion of institutional complexity that explicitly recognizes organizational environments as a multiplex of heterogeneous institutional demands and resultant dynamics in the alignment of the environment and the internal structure (Greenwood et al., 2010; Pache & Santos, 2013; Raffaelli & Glynn, 2014), I aim to enhance understandings of corporate sustainability in the broader institutional dimensions (Greenwood et al., 2015; Hoffman & Jennings, 2011; Lee & Lounsbury, 2015). To complement the institutional complexity approach, I conceptualize actors as socially situated and constructed agency (Fligstein, 1990; Palmer et al., 1993; Thornton, 2002). Recent scholarly advances in institutional analyses have engaged with incorporating both accounts of institutional complexity in organizational environments and actors as a carrier of cultural values (Almandoz, 2014; Greve & Zhang, 2017; Marquis & Lounsbury, 2007). I employ this combinative approach as I build on the tradition of eclecticism in corporate sustainability research (Bansal, 2005; Delmas & Toffel, 2008; Lewis et al., 2014; Lounsbury, 2001; Walls et al., 2012).

THEORY AND HYPOTHESES

Institutional Investor Ownership & Shareholder Value Orientation

In the 1970s and 1980s, large US firms were under severe international competition, particularly due to increased oil prices and the rise of Japanese firms. As a result, the returns of financial investors became much more unstable, and a substantial proportion of large US corporations underwent takeovers and di-diversification processes (Davis et al., 1994; Zuckerman, 2000). Triggered by the poor financial performance of large US firms, the active involvement of financial investors into managerial behavior around the 1980s replaced the 'firm-as-portfolio' model with the shareholder value orientation model, particularly focusing on scalable financial indicators such as stock price and dividend (Fligstein, 2001). The emergence of the shareholder value orientation in the 1970s and 1980s was carried through the rise of institutional investor ownership in large US corporations, and meeting the demands of such investors became one of the main concerns of the top management team (Davis & Thompson, 1994; Jung & Dobbin, 2012; Useem, 1996).

The emergence of the shareholder value orientation carried by institutional investors substantially influenced corporate behavior in the 1990s, such as corporate social performance (David et al., 2007), international diversification (Tihanyi et al., 2003), and R&D investments (David et al., 2001). The cumulative evidence suggests that managerial behaviors that are aligned with the shareholder value orientation carried by institutional investors improve financial performance, advancing the positive side of shareholder monitoring. However, because professional investment companies have tended to focus on the scalable financial indicators with visible time horizons, the focus on managerial short-termism manifested itself in workforce downsizing (Ahmadjian & Robbins, 2005; Jung, 2016), corporate malfeasance (Dobbin & Zorn, 2005), and potential conflicts with other stakeholders (Jung & Dobbin, 2012). The rise of a shareholder value orientation produced diverse consequences and generated heterogeneities among institutional investors as the field of finance industry has become more diverse.

Clean Technology Innovation and Corporate Environmentalism

Over the past decades, innovation with particular social or environmental objectives has been an increasingly important practical and scholarly concern. One of the most remarkable technological changes has to do with the recent rise of clean technology innovation, which involves multiple players such as governments, established firms, and entrepreneurs who are endeavoring to commercialize a diverse range of products, services, and processes that aim to harness renewable materials and energy sources, enhance the efficient use of natural resources, and reduce emissions and wastes (Hart & Dowell, 2011; Pernick & Wilder, 2008). Directing attention away from radical social activism against the private marketplace and deregulatory policy regime, clean technology innovation represents a manifestation of strategic environmentalism, which leverages market opportunities through innovation within the flow of an industry's technologies and consumers (Bansal & Roth, 2000; Hoffman, 1999; Hoffman & Ventresca, 2002).

Clean technology innovation, therefore, like other technological innovations, requires cumulative processes of technological advancements based on prior innovations (Murray & O'Mahony, 2007). Despite the fact that scholars have speculated that clean technology innovation is driven by financial motivation as well as social licensing (Hart & Dowell, 2011), theorizing clean technology innovation has mainly assumed it is an organizational response to institutional pressures (Delmas & Toffel, 2008). Thus, a more complete conceptualization of clean technology innovation requires theorization of how the dual purposes of social/environmental objectives and a shareholder value orientation embedded in such innovation interact within complex institutional environments. That is, it is important to investigate the degree to which the multiplicity of varying market and institutional factors may be configured to shape such innovation.

Institutional Investor Ownership and Clean Technology Innovation

I conceptualize institutional investors as carriers of the shareholder value orientation (Fligstein, 2001) and argue that they hold a short-term orientation, conflicting with the long-term horizon embedded in clean technology innovation. Attending to the actor as a carrier of a certain institutional force, sustainability research has demonstrated variations in recycling staffing (Lounsbury, 2001), environmental management practices (Delmas & Toffel, 2008) and firm environmental disclosure (Lewis et al., 2014). Several sustainability scholars have noted that clean technology innovation may require a longer time horizon in order to be profitable, and have a greater tolerance for failure than other innovations (Hargadon & Kenney, 2012; Marcus et al., 2013). Thus, institutional investors are less likely to welcome such financially risky innovation, as these financial investors are under pressure being financially profitable in a visible time horizon. Hence, I predict:

> ***Hypothesis 1.*** *Institutional ownership has a negative relationship with clean technology innovation.*

Ownership Structure

A common theme of institutional complexity and socially-situated agency approaches is that the organizational orientation is shaped by broader socially constituted and embedded guiding principles, and that such strategic positioning is influenced by actors carrying heterogeneous institutional orders such as the market, family, professions, and state (Fiss & Zajac, 2004; Greenwood et al., 2010; Miller et al., 2011; Palmer & Barber 2001). Hence, it would be valuable to focus on an ownership dimension to investigate how varied combinations of institutional demands mitigate and instantiate the potential negative relationship between the conception of shareholder value and proactive corporate environmentalism. When a firm is controlled by diverse institutional investor ownership, to meet diverse demands the firm is likely to invest in financially less risky projects with visible time horizons, amplifying the potential negative relationship between the shareholder value orientation and proactive corporate environmentalism. Hence, this negative relationship is likely to be weaker when a firm is controlled by relatively concentrated institutional investor ownership.

Like the case of concentrated institutional ownership, family ownership and control is likely to mitigate the relationship between the market logic of a shareholder value orientation and clean technology innovation. When a firm is controlled by families, family control is likely to provide greater managerial discretion and less oriented to the market logic (Berrone et al., 2010; Gomez-Mejia et al., 2007). As a family-controlled firm is more discretionary, it is less likely to engage in a shareholder value orientation, and is less likely influenced by institutional ownership, making the tension between the short-term orientation of institutional investors and the long-term orientation of proactive corporate environmentalism less salient. Hence, I predict:

> ***Hypothesis 2.*** *The negative relationship between institutional ownership and clean technology innovation is weaker, when (a) institutional ownership is concentrated or (b) a firm is owned by families.*

Industry Variations

At the market institutional level, two key factors affect both the extent to which a firm faces public expectations about clean technology innovation and the extent to which it is sensitive to such expectations: governmental regulations of its primary sector

(Chatterji & Toffel, 2010; Cho & Patten, 2007) and the consumer orientation of its primary industry (Lev et al., 2010; Tilcsik & Marquis, 2013). Chatterji & Toffel (2010) showed that for firms operating in heavily regulated sectors poor environmental ratings were associated with future pollution reduction. Clean technology innovation is more likely profitable in environmentally regulated sectors; as such, innovation is more likely to mitigate pollution expenses and reputational concern, enhancing competitive advantage. I suggest that for firms operating in environmentally regulated sectors, the pursuit of clean technology innovation is well aligned with a shareholder value orientation because such innovation is likely to mitigate financial risks for these firms. Hence, the potential negative influence of institutional investor ownership on clean technology innovation is likely to be mitigated for these firms.

Prior research suggests that firms operating in consumer goods and personal services are more concerned about their image to public perception, and are hence more likely to involve corporate philanthropy activity (Lev et al., 2010; Tilcsik & Marquis, 2013). This line of argument also applies for clean technology innovation because such innovation is likely to enhance reputational benefits (e.g., Gehman & Grimes, 2017). However, Business-to-Business (B2B) firms are more likely to be attended to their core domains of technological innovations, much less likely to engage in clean technology innovation under a shareholder value orientation. Thus, I propose that institutional investor ownership is less likely to trigger the reduction in clean technology innovation for firms operating in B2C sectors. Hence, I predict:

> ***Hypothesis 3.*** *The negative relationship between institutional ownership and clean technology innovation is weaker, when a firm's focal domain operates in (a) an environmentally regulated sector or (b) an individual consumer focus (B2C).*

Regional Variations

I attend to two non-market institutional factors: community cultures (Saxenian, 1994) and inter-state political regimes (Vogel, 1995). Extending previous studies on geographic communities which demonstrated the enduring and profound effects of shared local beliefs and values on organizations (Greve & Rao, 2012; Marquis et al., 2007; Marquis et al., 2013), I consider the varying effects of community logics on locally headquartered corporations by attending to potential tensions between the dominant market conception of shareholder value and the eco-friendly norms embedded in local communities. I posit that, under such competing cultural demands, it is likely that such a negative influence of institutional ownership is amplified.

That is, as the local cultural forces where a firm's headquarters is located are eco-friendly, the influence of shareholder value conception on clean innovation is likely more salient as institutional investors want organizational attention to turn away from such innovation to focus on more financially profitable opportunities. Consistent with findings in prior research on saliency of tensions between dominant market norms and local cultures (Gehman & Grimes, 2017; Greenwood et al., 2010; Jennings et al., 2013; Marquis & Lounsbury, 2007), I posit that if a firm's headquarters are located where community members appreciate the intrinsic environmental value and support a firm's initiative for clean technology innovation, its propensity for clean technology innovation is more likely influenced by the shareholder value orientation. While the community logic may support clean technology innovation through providing entrepreneurial environments, the conception of shareholder value may impede clean technology innovation by attending to the market logic.

Building on the scholarly work on the tension between community culture and the shareholder value orientation, I argue that, in pursuing clean technology innovation, firms headquartered in Democratic states are more likely bounded by a shareholder value orientation. Communities governed by a politically progressive logic place much greater emphasis on good environmental management with moral imperatives (Lee & Lounsbury, 2015). Hence, I suggest that for firms located in Democratic states, institutional investors more likely to influence corporations to shift attention away from socially beneficial, yet risky innovations, such as clean technology innovation, while for firms located in Republican states strong market emphases through deregulatory political regimes are likely to overlap with a shareholder value orientation. Thus, inter-state political variations regarding proactive corporate environmentalism predict that for firms located in politically progressive communities, the conception of shareholder value carried by institutional investors may trigger scaling down clean technology innovation.

As clean technology innovation is likely more acceptable in eco-friendly or Democratic states, firms located in democratic or embedded in eco-friendly communities may experience greater conflict with the shareholder value orientation regarding the pursuit of clean technology innovation. Thus, the potential negative relationship will be instantiated. Hence, I predict:

> ***Hypothesis 4.*** *The negative relationship between institutional ownership and clean technology innovation is stronger, when a firm's headquarters is located in (a) an eco-friendly state or (b) a Democratic state.*

Heterogeneities in Institutional Investor Ownership

Financial institutions are indeed heterogeneous; hence, I may expect that different classifications and types of institutional owners impact clean technology innovation in different manners. Researchers noted that the heterogeneities among institutional investors influence corporate diversification strategy, workforce downsizing, and strategic and tactical repertoires in different directions (Connelly et al., 2010; Hoskisson et al., 2002; Jung, 2016). An important implication of this stream of research is that time horizons of different managerial behaviors tend to be matched with those of different institutional investors, consistent with the shareholder value orientation. Bushee (1998) classified transient (e.g., investment firms using high-frequency trading strategy), quasi-index (e.g., index funds, CalPERS), and dedicated institutions (e.g., Berkshire Hathaway). It is likely that ownership stakes by transient and quasi-index funds are more likely to negatively affect clean technology innovation as such innovation is deemed to be less financially profitable in the short-run. In particular, transient investors are pursuing visible short-term returns from investment, contradicting with the nature of clean technology innovation.

Regarding the types of institutional ownership, independent investment advisory and investment companies are more likely to be engaged in short-term financial returns, compared to bank trusts, insurance companies, and foundations. The field of finance in the US had been transformed to active investment management from passive investment management, led by investor advisors and mutual funds (e.g., Davis, 2009; Lounsbury, 2007; Useem, 1996). These two groups had a predominant status in the 1990s and hence these two groups are likely more influential in clean technology innovation than other types. Thus, I predict:

> ***Hypothesis 5.*** *The negative relationship between institutional ownership and clean technology innovation is stronger for (a) transient institutional ownership or (b) predominant institutional ownership (investor advisor & mutual funds).*

DATA AND METHODS

Sample

I used firm-level data on clean technology innovation and institutional ownership from a variety of sources. My starting point for the sample construction was from Compustat, which contains industry classification (Hypothesis 3), headquarter location (Hypothesis 4) and accounting information (control variables). I linked clean technology patents data obtained from CleanTech PatentEdge with the NBER Patent Project data and the Harvard Patent Dataverse data to match these data with Compustat. My data contained US clean technology and non-clean technology patents granted between 1980 and 2010. Institutional ownership data are from Thomson Reuters.

My sample period began in 1990 because information on firm-level variables and clean technology innovation is less comprehensive in the 1980s. Also, complications and dynamics in financial and sustainability sectors in the 1980s have been well demonstrated in prior research (Fligstein, 2001; Hoffman, 2001). My sample period ended in 2004, to mitigate the potential biases of right censoring in my patent data and shifts and complications in market environments driven by substantial increases in oil prices. As I employed fixed-effects models, I required a firm to have at least one successful clean technology patent application in my sample period, which is the main restriction from the overall Compustat database. The baseline sample for my analyses contained 6,875 observations on 856 firms.

Variables

Dependent variable. My dependent variable was calculated using the total annual successful clean technology patent applications by a firm. Firms patented in a wide variety of clean technology categories such as renewable energy, air pollution reduction, and energy efficiency. Hence, a wide range of firms participated in clean technology innovation. Figure 3.1 plots the annual aggregate number of clean technology applications eventually patented in my sample. Compared to overall patenting activities with a stable increasing trend, clean technology patenting activities stagnated in the late 1990s but a dramatic increase in the early 2000s.

Insert Figure 3.1 about here

Independent variables. For my main independent variable, I used the percentage of institutional investor ownership. Thus, I used the percentage of total institutional ownership out of total outstanding equity. Following Bushee (1998), to measure institutional ownership in the middle of the second half of the fiscal year, when the fund manager is likely to have an accurate expectation of annual earnings and begin to consider revising investment decisions, I calculated the percentage from the end of the firm's third fiscal quarter. Institutional ownership variables were annually updated.

To test Hypothesis 2, I required ownership dispersion (H2a) and family firm (H2b) variables. For the ownership dispersion variable, I used the institutional ownership Herfindahl-Hirschman Index (HHI) from Thomson Reuters. I took the median value of institutional ownership HH index to split the sample for the subsample analyses. For the family firm variable, following from Anderson & Reeb (2004) for the 1990s and Anderson et al (2009; 2012) for the 2000s, I classified "family firms" as those where at least 5% of the shares are held by the family blockholders such as founder or heir families.

To test Hypothesis 3, I needed to classify sectors under environmental regulations (H3a) and with an individual consumer focus (H3b). For environmentally regulated sectors, following Chatterji & Toffel (2010) and Cho & Patten (2007), I classified industries with a primary two-digit SIC code of 13 (oil exploration), 26 (paper), 28 (chemical and allied products), 29 (petroleum refining), or 33 (metals) as environmentally regulated sectors. For sectors with an individual consumer focus (B2C), following Flammer (2015) and Tilcsik & Marquis (2013), for classifying B2C sectors, I followed a classification by Lev and colleagues (2010: 188). The classification is based on firms' primary four-digit SIC codes.

To test Hypothesis 4, I needed to classify eco-friendly states (H4a) and Democratic states (H4b). For eco-friendly states, I consulted with several sources and triangulated them.[4] Connecticut, Massachusetts, Minnesota, New Hampshire, New York, Oregon, Rhode Island, and Washington are deemed as eco-friendly states. For Democratic states, I treated a state as a Democratic state where average margins of victory in the five presidential elections from 1992 to 2008 are greater than ten percentage points for Democrat candidates. Democratic states are California, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, Massachusetts, New Jersey, New York, Rhode Island, Vermont, and Washington. For robustness check, I also used margins exceeding twenty percentage points (Hawaii, Massachusetts, New York, Rhode Island, and Vermont). The information was taken from the Federal Election Commission websites.[5]

[4] Drawing from the several sources such as Forbes, Fox Business, and Wallethub, I focused on the propensity to support for eco-friendly initiatives, environment quality, and overall support for environmental activities.

[5] http://www.fec.gov/pubrec/electionresults.shtml

To investigate heterogeneities in institutional ownership (Hypothesis 5), I constructed the classification (H5a) and investor type (H5b) variables by matching Thomson Reuters data with the classifications and types data constructed by Brian Bushee.[6] For classifications, I constructed transient (e.g., investment firms using high-frequency trading strategy), quasi-index (e.g., index funds, CalPERS), and dedicated institutions (e.g., Berkshire Hathaway). For institution types, I constructed three categories: bank and insurance (bank trust and insurance company), investment company (mutual fund company and investment advisor), and pension and endowments (public & corporate pension funds, university endowments, and other miscellaneous funds). Figure 3.2 presents the annual trends of institutional ownership types during my sample period. It is evident that investment companies are the predominant type of institutional investors.

Insert Figure 3.2 about here

Control variables. To control potential relationship between firm-level factors and clean technology innovation, throughout my analyses I controlled relevant financial variables. Following Berrone et al (2013), I entered both research & development expenses (logged) and blank R&D (coded 1 if a firm did not report R&D expenses and 0 if reported). To control firm-level financial conditions, I entered ROA (operating income before depreciation over total assets), cash (logged), sales (logged), capital intensity (logged capital expenses/employment), and plant, property and equipment expenses (logged).

[6] Available at http://acct.wharton.upenn.edu/faculty/bushee/IIclass.html

Analyses

I used negative binomial regressions, as my dependent variable is skewed. All of the independent and control variables were lagged by one year. In my analyses, a full set of four-digit SIC dummies and year dummies were used for controlling industry and time effects. Following innovation research (Aghion, van Reenen, & Zingales, 2013; Blundell et al., 1999; Cameron & Trivedi, 2013), for firm-fixed effect controls, I employed pre-sample mean scaling estimators. Throughout my analyses, taking into an account of potential autocorrelation and heteroscedasticity, I clustered standard errors at the firm level. To test H2 – H4, I performed subsample analyses (Berrone et al., 2010; Connelly et al., 2010; Miller et al., 2015; Short & Toffel, 2010), and the results are presented in Tables 3.3 and 3.4.

RESULTS

Table 3.1 displays descriptive statistics and correlations, and Table 3.2 presents regression results for the 856 firms from 1990 to 2004. Model 1 tests Hypothesis 1. As predicted, the coefficient for the institutional ownership variable is negative and statistically significant. I also conducted a series of analyses that control for additional variables that may be related to clean technology innovation. These analyses, displayed from Model 2 to Model 7, controlled for institutional investor ownership concentration (HHI %), family control (binary variable), environmentally regulated sectors (binary variable), sectors with customer orientation (binary variable), eco-friendly states (binary variable), and Democratic states (binary variable). Because some of these variables were highly correlated with one another and with the independent variable of my interest, I entered them separately into the equations. In Model 4, as the family control variable was coded for disproportionately large firms, the sample size is reduced. Across all these models, the negative coefficients on institutional ownership remain statistically significant. These findings provide strong support for Hypothesis 1.

In Model 8, I checked whether the negative relationship between institutional ownership and clean technology patenting activity also holds for overall patenting activity. Contrary to my findings from Model 1 to Model 7, Model 8 shows that the relationship between institutional ownership and overall patenting activity is positive yet insignificant, suggesting that the negative effect of institutional ownership on clean technology innovation is driven by the particularistic nature of clean technology.

Insert Tables 3.1 & 3.2 about here

Table 3.3 reports the subsample test results of Hypotheses 2 (Models 1 – 4) and 3 (Models 5 – 8). For Models 1 and 2, the subsamples were defined by median bifurcation according to institutional investor ownership HHI. In Model 1, the institutional ownership coefficient is significant for firms with highly dispersed institutional ownership, while in Model 2 the coefficient is insignificant for firms with concentrated institutional investor ownership. For Models 3 and 4, the sample was split according to whether a firm is family controlled or not. Model 3 testing the non-family firm sample shows that the effect of institutional ownership is negative and significant, while Model 4 shows that the effect is not significant in the family firm sample. Hence, Models 1 to 4 confirm Hypothesis 2, suggesting that the negative relationship between institutional ownership and clean technology innovation is weaker, when (a) institutional investor ownership is concentrated or (b) a firm is owned by families.

Models 5 and 6 present subsample tests according to whether a firm's primary sector is environmentally regulated or not. Model 5 tests for firms operating in environmentally regulated sectors and the institutional ownership coefficient is insignificant. Model 6 tests the other case (firms are not environmentally regulated) and, the coefficient is negative and statistically significant. Models 7 and 8 provide subsample tests according to whether a firm's primary sector has an individual consumer focus (B2C) or not. Model 7 reports the subsample test result of B2C sectors and shows that the institutional ownership coefficient is insignificant. However, in Model 8 testing a firm's primary sector having a business-to-business (B2B) focus, the coefficient is negative and statically significant. Hence, Models 5 to 8 confirm Hypothesis 3, suggesting that the negative relationship between institutional ownership and clean technology innovation is weaker when a firm's focal domain operates in (a) an environmentally regulated sector or (b) an individual consumer focus (B2C).

Insert Table 3.3 about here

Table 3.4 reports the subsample test results of Hypotheses 4. For Models 1 and 2, the sample was split according to whether a firm's headquarters is located in an eco-friendly state or otherwise. Model 1 tests for eco-friendly states and Model 2 tests for other cases. The coefficient for institutional ownership variable in Model 1 is stronger negative effects with greater significance than in Model 2. From Model 3 to 5, the sample was split according to whether a firm's headquarters is located in a Democratic state or not. Model 3 tests for Democratic states and Model 5 tests for other states. The coefficient for institutional ownership variable in Model 3 is stronger negative effects with greater significance than in model 5. Also, Model 4 tests the case for Democratic states with the margin greater than twenty percentage points, and the result is consistent with Model 3. For Democratic states, R&D is not significantly associated with the clean technology patenting activity, but while not reported here it is indeed significantly associated with the overall patenting activity. Hence, the results presented in Table 3.4 confirm Hypothesis 4, suggesting that the negative relationship between institutional ownership and clean technology innovation is stronger, when a firm's headquarters is located in (a) an eco-friendly state or (b) a Democratic state.

Insert Table 3.4 about here

Table 3.5 reports the test results of H5. From Model 1 to Model 4, I test the differential effects of institutional ownership classes on the clean technology patenting activity. Model 1 enters the percentage of transient institutional ownership, and Model 2 enters the percentage of quasi-index institutional ownership, and both cases are negative and statistically significant. However, when Model 3 enters the percentage of dedicated institutional ownership, the coefficient is not significant. Model 4 enters all three classifications and shows that transient institutional ownership is negative and significant while quasi-index institutional ownership is insignificant due to potential multicollinearity. From Model 5 to Model 8, I tested the differential effects of institutional ownership types on clean technology innovation. Model 5 enters the percentage of bank trust and insurance company ownership, and the coefficient is not statistically significant. Model 6 enters the percentage of mutual fund and investment advisory ownership, and the coefficient is negative and statistically significant. When

Model 7 enters the percentage of pension and foundation ownership, the coefficient is not significant. Model 8 enters all three institutional ownership types and shows that investment company ownership is negative and significant. Hence, the results in Table 3.5 lend strong support for Hypothesis 5, suggesting that the negative relationship between institutional ownership and clean technology innovation is stronger for (a) transient institutional ownership or (b) predominant institutional ownership (investor advisor & mutual funds).

Insert Table 3.5 about here

While the negative relationship between institutional ownership and clean technology innovation holds consistently across a wide range of my models, one may wonder whether the negative relationship holds for operational dimensions of clean technology, and is less related to the patenting activity. Drawing from the environmental strength score constructed by KLD Research & Analytics, I explored the association between overall environmental proactivity and institutional investor ownership. As the environmental strength score is a count variable ranging from 0 to 3, I employed an ordered probit model. While not reported in this paper, the relationship is negative and significant, corroborating with my main results.[7] A Poisson model (Chatterji et al., 2009) provided the same results. In terms of environmental degradation, I did not find a clear association between environmental concern score and institutional ownership.

To check the representativeness of my sample and potential confluences between macroeconomic indicators and institutional ownership, I entered annual oil prices instead

[7] As a robustness check, I analyzed citations of clean technology patents over citations of total patents as a dependent variable with the fractional probit model, and found that results are consistent with my main results.

of year dummies. While not reported in this paper, the coefficient of institutional ownership is negative and statistically significant, and the coefficient of oil prices is positive and statistically significant, providing confidence in my overall results and corroborating with well-received wisdom that increases in commodity prices lead clean technology innovation.

DISCUSSION

In this paper, I examine how the rise of the shareholder value conception of the firm (Fligstein, 2001) may influence the rise of corporate environmentalism (Hoffman, 2001). Over the past decades, research on organizational theory has demonstrated various antecedents and consequences of the alignment of managerial behavior with the shareholder value orientation, while sustainability research has engaged with various cases of how organizations respond to institutional demands for corporate environmentalism. By focusing on tensions between the short-term horizon of the shareholder value conception and the long-term horizon of corporate environmentalism, I empirically demonstrate that institutional investor ownership, a surrogate of the shareholder value conception, is negatively associated with clean technology patenting activity, a proxy of hybridization of technological invention and corporate environmentalism.

In turn, I present how different situational contingencies amplify or mitigate such negative relationship. I suggest that regarding ownership structure, concentrated ownership is likely to mitigate the negative relationship between clean technology innovation and institutional investor ownership as concentrated ownership provides more managerial discretion and is less likely to be under varying shareholder pressures.

Empirically, I demonstrate that such negative relationship is mitigated under family control and relatively concentrated institutional investor ownership. Hence, in the context of clean technology innovation, the logic of family, valuing managerial discretion, is not coherently aligned with market logic, embedded within a shareholder value orientation (Berrone et al., 2010; Miller et al., 2011).

It is noteworthy that such a negative relationship between institutional ownership and clean technology does not unitarily hold. I show that when the firm's primary focus is an individual customer, and it operates in an environmentally regulated sector, the market value of clean technology innovation is well aligned with shareholder value, as clean technology is likely to enhance the firm's reputation and mitigate regulatory concerns. Hence, I empirically demonstrate that when a firm's focal domain is in a sector having an individual consumer or environmental regulations, the negative relationship between institutional investor ownership and clean technology innovation is likely to be mitigated.

In accordance with recent institutional analyses on local variations (Gehman & Grimes, 2017; Greve & Rao, 2012; Lounsbury, 2007; Tilcsik & Marquis, 2013), I take into account the local community where a firm is headquartered. I propose that such negative relationship between corporate environmentalism and the shareholder value orientation is amplified under eco-friendly states and Democratic states. While the local community is likely to appreciate the pursuit of clean technology innovation from the long-term orientation, it is likely to bring about substantial conflict with the shareholder value orientation. Empirically, I demonstrate that the negative relationship between institutional investor ownership and clean technology innovation is stronger for eco-friendly states or Democratic states than other cases. Hence, in the context of clean technology innovation, the community logic, valuing the pursuit of clean technology innovation of a locally headquartered firm, is competing with the market logic (Marquis & Lounsbury, 2007). Relatedly, I show that when a firm's headquarters is located in a community dominated by a politically progressive logic, such negative relationship between corporate environmentalism and a shareholder value orientation is amplified (cf. Lee & Lounsbury, 2015).

Given the heterogeneity among institutional investors, I take a deeper look at the relationship between institutional investor ownership and clean technology innovation. As noted, ownership by investors with short-term horizons (transient investors) is particularly negatively associated with clean technology innovation, corroborating with my main result. Regarding ownership types, the predominant types of institutional investors, which are mutual funds and investment advisors, are particularly negatively associated with clean technology patenting activity. Hence, I empirically demonstrate that institutional investors, as a carrier of the shareholder value conception, negatively influence clean technology innovation. In my paper, extending and complementing the approach that adopted an actor as a carrier of cultural values (e.g., Delmas & Toffel, 2008; Lewis et al., 2014; Lounsbury, 2001), I show that there are potential trade-offs in a firm's pursuit of clean technology innovation: while it is well aligned with broader institutional demands for proactive corporate environmentalism, it may not be well aligned with the relatively short-term horizon of financial investors.

Throughout the joint consideration of the complexity of multiple institutional demands (Friedland & Alford, 1991; Greenwood et al., 2011) and actors as carriers of institutional forces (Fligstein, 1990; Westphal & Zajac, 2013), I enhance the understanding of the antecedents of clean technology innovation. As both streams of the literature emphasize the socially embedded nature of managerial behavior (Marquis & Lounsbury, 2007; Palmer et al., 1993), recent scholarly efforts have focused on conceptualizing the socially constituted agency and institutional complexity under the broader array of organizational theory (Almandoz, 2014; Greenwood et al., 2010; Greve & Zhang, 2017; Lee & Lounsbury, 2015). My focus echoes these scholarly advances, highlighting that various forms of institutional rationality led by socially constituted actors shape innovation under different contingencies. Although sustainability research drawing from neoinstiutional approaches has made substantial progress by building on the notion of the cognitive, normative, and regulative pillars (Bansal, 2005; Berrone et al., 2013; Scott, 1995), my study emphasizes variegated cognitive dimensions embedded in situated contingencies, suggesting that there may be more mileage in investigating the configurations of competing and multiple institutional demands.

Scholarly research on configurations has focused on the alignment of internal and external components of strategy and structure, pointing to a potential contribution to complexity theory (Meyer et al., 1993; Miller, 1986; 1996). By showing how the direction of a firm's innovative activity is shaped by the multiplex of institutional demands, I enhance the configurational approach to institutional complexity. Hence, this research shows that the repertoire of a firm's technology positioning is socially nested by varied combinations of institutional logics, which are culturally embedded and constituted guiding principles for managerial behavior (Thornton et al., 2012). Empirically, I demonstrate that even firms that are well aware of the rise of corporate environmentalism and capable of conducting innovation in clean technology sectors may not be motivated to do so if they are well aligned with a shareholder value orientation. Hence, it is noteworthy that the simplicity of a firm's competitive repertoire (Miller & Chen, 1996) can be driven by broader institutional sources and the inherent dynamics of such heterogeneous forces as well as organizational resources and past performance.

My research complements previous research about the influence of a shareholder value orientation on a firm's competitive behavior. Drawing from agency theory, scholars have demonstrated that there are positive relationships between monitoring by shareholders and managerial efforts for competitive actions in large US firms (Connelly et al., 2010; Hoskisson et al., 2002; Tihanyi et al., 2003). I concur. Regarding overall competitive behavior, the effect of institutional investors' monitoring may shape managerial efforts for innovation in a positive manner (Aghion et al., 2013). While not thoroughly analyzed in my paper, but consistent with prior research, I find evidence of positive associations between institutional ownership and overall patenting activity. In the context of clean technology innovation, I show how a particular direction of managerial behavior is bounded by a shareholder value orientation. Corporate focusing strategies in favor of shareholders (Davis et al., 1994; Zuckerman, 2000) may impede clean technology innovation in my sample period, as such innovation is considered exploratory and financially risky.

Above all, efforts to bridge the gap between the general domain of organizational theory on financialization and institutional complexity approaches have important implications for sustainability research. There has been substantial progress on the notion that managerial behavior is situated and constituted by heterogeneous institutional forces, yet I need a finer-grained mechanism of how managerial efforts for sustainability are bounded by broader tensions over temporal orientations among market players, bringing paradoxical dimensions in such efforts. Despite the fact that several scholars suggest that there are fundamental conflicts between the short-term horizon of a shareholder value orientation and the long-term horizon for a broader stakeholder value orientation (Davis, 2009; Porter, 1991), sustainability researchers have not yet built up sufficient knowledge about this paradoxical processes (Smith & Lewis, 2011; Smith & Tracey, 2016). In particular, focusing on the fundamental tension in temporal orientations between proactive environmental strategy and shareholder value maximization, in the context of clean technology innovation, I advance the notion of the means-ends decoupling embedded in heterogeneous institutional demands (Bromley & Powell, 2012; Wijen, 2014). Related, such issue touches upon the fundamental tension between the logic of appropriateness and the logic of consequences (March & Olsen, 1989).

Interestingly, the origin and evolution of institutional investors were driven by the individual's motivation for saving for the future (Davis, 2009; Dobbin, 1992; Jung & Dobbin, 2012), leading financialization of the economy and emphasizing the shareholder value orientation such as the explicit focus on the stock price and future growth opportunity for a firm. Ironically, such market forces are negatively associated with clean technology innovation, which is nested in broader institutional demands for innovating for the future (Hoffman & Jennings, 2015). Hence, my empirical case highlights the potential limitations to market logics in corporate environmentalism by presenting the paradox of institutional investor ownership: there are somehow fundamental tensions between 'save for the future' and 'innovate for the future.'

Figure 3.1: Annual Trends of Clean Technology Innovation, 1990 – 2004

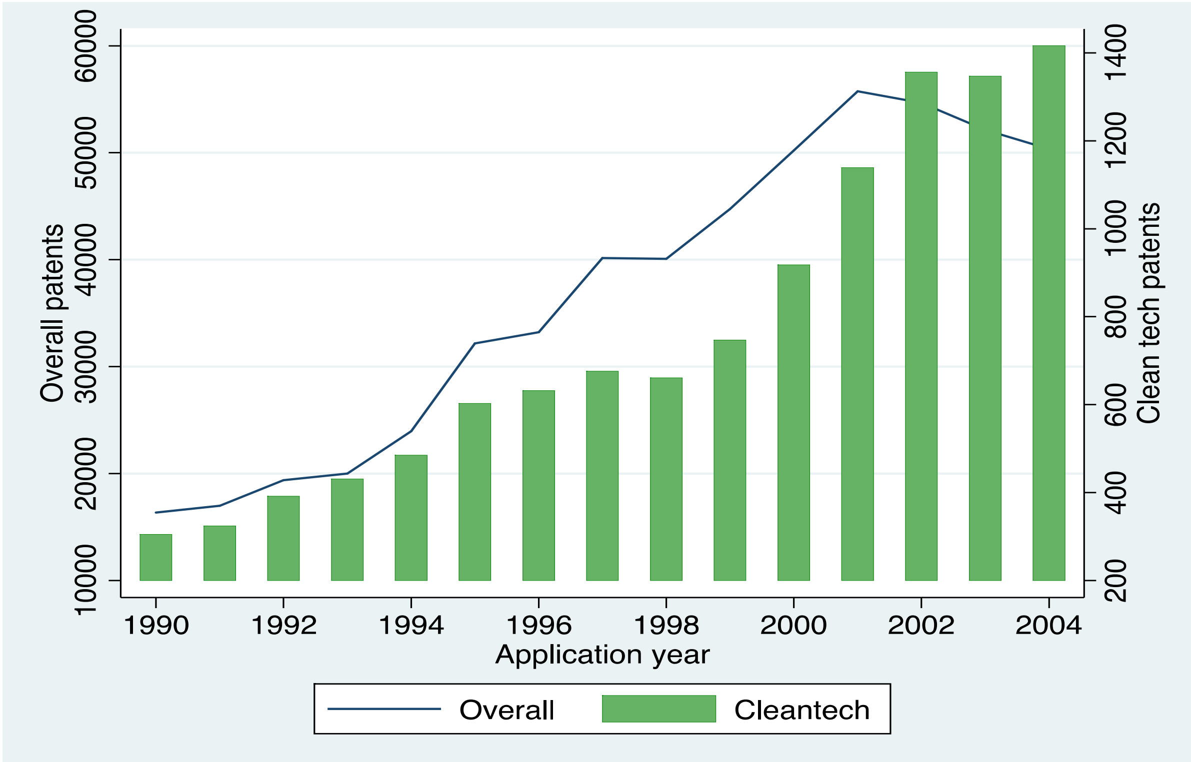

Figure 3.2: Annual Trends of Institutional Investor Ownership

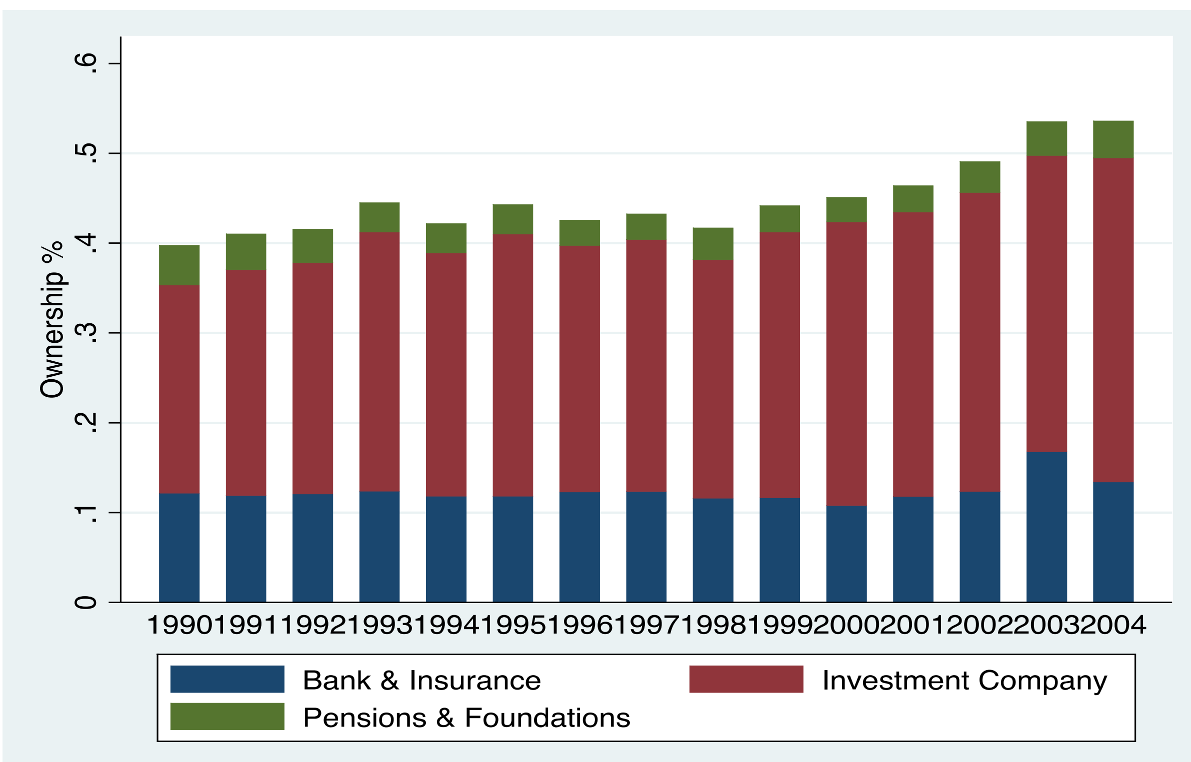

Table 3.1: Descriptive Statistics and Correlations

	Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1	Clean tech patents	1.29	5.33										
2	Overall patents	66.82	252.83	0.6									
3	Environmental strength	0.32	0.56	0.19	0.06								
4	Institutional ownership	0.44	0.26	-0.11	-0.07	-0.07							
5	Transient	0.12	0.12	-0.07	-0.04	-0.18	0.69						
6	Quasi-index	0.23	0.16	-0.07	-0.04	0.03	0.81	0.35					
7	Dedicated	0.1	0.1	-0.09	-0.08	0.06	0.54	0.11	0.21				
8	Bank & insurance	0.13	0.1	-0.03	0.01	0.08	0.75	0.35	0.8	0.34			
9	Investment firm	0.3	0.19	-0.13	-0.1	-0.13	0.91	0.75	0.64	0.55	0.46		
10	Pension & foundation	0.03	0.04	-0.05	-0.02	0.02	0.55	0.28	0.56	0.25	0.47	0.35	
11	Ownership HHI	0.14	0.18	0.03	-0.01	-0.03	-0.61	-0.41	-0.56	-0.25	-0.49	-0.53	-0.4
12	Family firm	0.26	0.44	-0.02	-0.04	-0.08	-0.34	-0.19	-0.2	-0.19	-0.13	-0.31	-0.16
13	Env regulated sector	0.21	0.4	0.01	-0.04	0.2	0.15	0.02	0.2	0.06	0.23	0.07	0.14
14	B2C sector	0.32	0.47	-0.03	-0.06	0.02	-0.08	-0.1	-0.01	-0.07	0.01	-0.11	-0.03
15	Eco-friendly state	0.22	0.41	-0.05	-0.01	0.05	0.04	0.01	0.04	0.03	0.05	0.02	0.05
16	Democrat state (>10%)	0.45	0.5	-0.06	0	-0.08	0.13	0.13	0.07	0.06	0.04	0.14	0.05
17	Democrat state (>20%)	0.12	0.32	-0.03	0.02	0.04	0	0	0.01	-0.01	0.02	-0.01	0.03
18	ln(R&D)	2.81	2.3	0.33	0.44	0.13	0.22	0.18	0.23	0.02	0.26	0.14	0.19
19	Blank R&D	0.15	0.36	-0.08	-0.1	-0.07	-0.03	-0.07	0	0	0	-0.04	0
20	ROA	0.12	0.2	0	0.03	0.05	0.17	0.07	0.17	0.1	0.19	0.13	0.07
21	ln(Cash)	3.46	2.35	0.31	0.39	0.08	0.26	0.22	0.25	0.03	0.3	0.17	0.23
22	ln(Sales)	5.95	2.2	0.3	0.34	0.2	0.27	0.09	0.34	0.07	0.39	0.13	0.26
23	Capital intensity	2.19	1.02	0.14	0.18	0.1	0.17	0.16	0.15	0.04	0.18	0.12	0.14
24	ln(PP&E)	5.04	2.44	0.28	0.33	0.25	0.29	0.1	0.37	0.08	0.42	0.14	0.29
25	Oil price	18.27	4.81	0.07	0.05	-0.15	0.08	0.23	0.02	-0.03	0.07	0.11	0.01

	Variable	11	12	13	14	15	16	17	18	19	20	21	22
12	Family firm	0.13											
13	Env regulated sector	-0.15	-0.13										
14	B2C sector	0.02	0.03	0.01									
15	Eco-friendly state	0	0.04	-0.05	-0.03								
16	Democrat state (>10%)	-0.11	-0.02	-0.06	-0.1	0.33							
17	Democrat state (>20%)	0.02	-0.03	-0.03	0.03	0.69	0.4						
18	ln(R&D)	-0.27	-0.13	0.14	0.01	-0.07	0.08	-0.02					
19	Blank R&D	0.04	-0.01	0.03	0.1	-0.02	-0.16	-0.02	-0.51				
20	ROA	-0.26	0.05	0.02	0.06	0	-0.05	-0.01	0.13	0.01			
21	ln(Cash)	-0.32	-0.17	0.17	0.02	-0.1	0	-0.03	0.7	-0.14	0.18		
22	ln(Sales)	-0.34	-0.1	0.25	0.13	-0.14	-0.17	-0.1	0.6	0.02	0.28	0.73	
23	Capital intensity	-0.25	-0.11	0.31	-0.1	-0.09	0	-0.06	0.34	-0.03	0.12	0.42	0.3
24	ln(PP&E)	-0.37	-0.13	0.35	0.1	-0.15	-0.15	-0.09	0.63	0.01	0.25	0.74	0.93
25	Oil price	0.01	-0.03	0	-0.01	-0.01	-0.01	-0.01	0.12	-0.02	-0.05	0.18	0.09

	Variable	23	24
24	ln(PP&E)	0.48	
25	Oil price	0.01	0.08

Correlations greater than or equal to 0.03 are significant at the 0.05 level.

Table 3.2: Effects of Institutional Ownership on Clean Technology Innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Institutional ownership (%)	-0.58***	-0.70***	-0.78**	-0.71***	-0.80***	-0.60***	-0.58***	0.17
	(0.19)	(0.21)	(0.37)	(0.21)	(0.22)	(0.19)	(0.20)	(0.12)
Ownership concentration		-0.39						
		(0.27)						
Family control			0.02					
			(0.21)					
Environmentally regulated sector				-0.25*				
				(0.15)				
B2C					-0.17			
					(0.17)			
Eco-friendly states						0.13		
						(0.14)		
Democrat states							-0.00	
							(0.11)	
ln(R&D)	0.24***	0.24***	0.20*	0.27***	0.28***	0.25***	0.24***	0.44***
	(0.06)	(0.06)	(0.10)	(0.05)	(0.05)	(0.06)	(0.06)	(0.04)
Blank R&D	0.10	0.10	0.08	0.05	0.09	0.09	0.10	0.25
	(0.26)	(0.26)	(0.53)	(0.28)	(0.28)	(0.26)	(0.26)	(0.16)
ROA	-0.62***	-0.65***	0.17	-0.64*	-0.60*	-0.63***	-0.62***	-0.47***
	(0.23)	(0.22)	(0.80)	(0.33)	(0.33)	(0.23)	(0.22)	(0.12)
ln(Cash)	0.10**	0.10**	0.02	0.03	0.04	0.10**	0.10**	0.04**
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.02)
ln(Sales)	0.06	0.06	0.23	0.12	0.15*	0.06	0.06	0.09*
	(0.08)	(0.08)	(0.14)	(0.07)	(0.08)	(0.08)	(0.08)	(0.05)
Capital intensity	0.27***	0.27***	0.30***	0.29***	0.27***	0.27***	0.27***	0.19***
	(0.07)	(0.07)	(0.10)	(0.06)	(0.06)	(0.07)	(0.07)	(0.04)
ln(PP&E)	0.11	0.11	0.17	0.03	-0.02	0.11	0.11	0.19***
	(0.08)	(0.08)	(0.12)	(0.08)	(0.08)	(0.08)	(0.08)	(0.05)
Fixed effects	Y	Y	N	Y	Y	Y	Y	Y
Industry dummy	Y	Y	Y	N	N	Y	Y	Y
Year dummy	Y	Y	Y	Y	Y	Y	Y	Y
Firms	856	856	354	856	856	856	856	856
N	6875	6875	3696	6875	6875	6875	6875	6875

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by firm are reported in parentheses.

Table 3.3: Subsample Analyses: Governance (Institutional Ownership Concentration & Family Control) and Industry (Environmentally Regulated Sector & Business-to-Customer Sector) Characteristics

	H2a Concentration		H2b Family firm		H3a Regulated		H3b B2C	
	Low	High	No	Yes	Yes	No	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Institutional ownership (%)	-0.89***	-0.34	-1.16***	-0.11	-0.21	-0.44**	-0.36	-0.64***
	(0.29)	(0.28)	(0.42)	(0.64)	(0.42)	(0.20)	(0.35)	(0.22)
ln(R&D)	0.19**	0.25***	0.14	0.17	0.45***	0.16**	0.37***	0.20***
	(0.09)	(0.08)	(0.11)	(0.20)	(0.12)	(0.06)	(0.11)	(0.07)
Blank R&D	0.19	0.03	0.27	-1.41	1.25***	-0.19	0.71*	-0.18
	(0.41)	(0.29)	(0.56)	(1.07)	(0.47)	(0.27)	(0.38)	(0.36)
ROA	0.76	-0.64***	1.20	-2.07**	-0.36	-0.72**	0.71	-1.08**
	(0.62)	(0.24)	(0.98)	(0.87)	(0.46)	(0.31)	(0.84)	(0.44)
ln(Cash)	0.05	0.12***	-0.01	0.12	-0.02	0.13***	0.20***	0.05
	(0.06)	(0.05)	(0.07)	(0.08)	(0.07)	(0.05)	(0.07)	(0.04)
ln(Sales)	0.18	-0.05	0.29*	0.04	0.26*	-0.03	0.15	0.12
	(0.11)	(0.10)	(0.16)	(0.21)	(0.16)	(0.09)	(0.16)	(0.09)
Capital intensity	0.14	0.28***	0.32***	0.33**	0.26**	0.28***	0.43***	0.22***
	(0.10)	(0.08)	(0.12)	(0.16)	(0.12)	(0.07)	(0.11)	(0.07)
ln(PP&E)	0.11	0.17*	0.15	0.09	-0.03	0.17**	-0.39**	0.22***
	(0.11)	(0.09)	(0.13)	(0.19)	(0.17)	(0.08)	(0.17)	(0.09)
Fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Industry dummy	Y	Y	Y	Y	Y	Y	Y	Y
Year dummy	Y	Y	Y	Y	Y	Y	Y	Y
Firms	548	651	272	100	186	670	282	574
N	3437	3438	2734	962	1421	5454	2176	4699

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by firm are reported in parentheses.

Table 3.4: Subsample Analyses: Regional Characteristics (Eco-friendly States & Democratic States)

	H4a Eco-friendly states		H4b Democrat states		
	Yes	No	> 10%	> 20%	No
	(1)	(2)	(3)	(4)	(5)
Institutional ownership (%)	-1.44**	-0.42*	-0.58*	-1.56**	-0.37
	(0.60)	(0.22)	(0.35)	(0.77)	(0.31)
ln(R&D)	-0.03	0.31***	0.01	-0.24	0.38***
	(0.11)	(0.07)	(0.09)	(0.16)	(0.09)
Blank R&D	0.10	0.06	0.28	-0.79	0.23
	(0.49)	(0.29)	(0.45)	(0.49)	(0.33)
ROA	-0.92	-0.58**	-1.26**	-1.11	-0.61
	(0.70)	(0.24)	(0.57)	(1.32)	(0.58)
ln(Cash)	0.12*	0.09*	0.08	0.17*	0.12**
	(0.07)	(0.05)	(0.05)	(0.10)	(0.05)
ln(Sales)	0.43***	-0.01	0.08	0.18	0.05
	(0.15)	(0.09)	(0.09)	(0.14)	(0.13)
Capital intensity	0.22	0.28***	0.24***	0.15	0.30***
	(0.15)	(0.07)	(0.09)	(0.16)	(0.09)
ln(PP&E)	0.08	0.13	0.33***	0.15	0.00
	(0.15)	(0.09)	(0.11)	(0.23)	(0.12)
Fixed effects	Y	Y	Y	Y	Y
Industry dummy	Y	Y	Y	Y	Y
Year dummy	Y	Y	Y	Y	Y
Firms	171	685	372	95	484
N	1485	5390	3094	796	3781

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by firm are reported in parentheses.

Table 3.5: Heterogeneities in Institutional Ownership and Clean Technology Innovation

	H5a				H5b			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Transient	-1.36***			-1.23***				
	(0.37)			(0.35)				
Quasi-index		-0.67**		-0.28				
		(0.31)		(0.29)				
Dedicated			-0.22	0.13				
			(0.45)	(0.43)				
Bank & insurance					-0.69			0.00
					(0.52)			(0.60)
Investment company						-0.78***		-0.82***
						(0.24)		(0.25)
Pension & foundation							-0.85	0.58
							(1.49)	(1.60)
Firm-level controls	Y	Y	Y	Y	Y	Y	Y	Y
Fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Industry dummy	Y	Y	Y	Y	Y	Y	Y	Y
Year dummy	Y	Y	Y	Y	Y	Y	Y	Y
Firms	856	856	856	856	856	856	856	856
N	6875	6875	6875	6875	6875	6875	6875	6875

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by firm are reported in parentheses.

CHAPTER 4: DOES BANK FINANCING ENHANCE CLEAN TECHNOLOGY INNOVATION? EVIDENCE FROM INTERSTATE BANK BRANCHING DEREGULATION

INTRODUCTION

Over the past decades, the emergence of clean technology has gained significant practical and scholarly attention. Clean technology is a crucial vehicle for sustainable development such as climate change mitigation and hazardous waste reduction (Hart, 2005; Stern, 2008). Understanding the drivers of clean technology innovation is important because such innovations not only create companies' competitive advantages by generating new technological standards, but also replace conventional and polluting technologies (Porter & van der Linde, 1995). A growing body of literature takes up this task, documenting positive and negative empirical links between clean technology innovation and various firm, market, and institutional characteristics (Hart, 2005; Mowery, Nelson, & Martin, 2010; Popp, Newell, & Jaffe, 2010). However, this literature contains few empirical studies examining the link between capital market development and clean technology innovation output (Hargadon & Kenney, 2012; Kerr & Nanda, 2015; Nanda, Younge, & Fleming, 2015). In particular, although scholarly efforts have been focusing on unpacking the influence of the dramatic growth of equity and venture capital financing on innovation (for reviews, see Drover et al., 2017; Hall & Lerner, 2010), we know relatively little about the influence of changes in the banking sector on innovation (Kerr & Nanda, 2015). I contribute to this nascent literature by examining the effects of changes in state-level bank financing on the emergence of clean technology.

Although early research on financing innovation signalled that the incentive for innovation is well aligned with equity financing yet poorly aligned with bank financing (see Hall & Lerner, 2010), recent research has generated more nuanced findings. There is growing evidence that debt financing is an important source of capital, particularly for small firms engaged in innovation across a broad range of new industries (see Kerr & Nanda, 2015). Changes in the availability or cost of bank finance, thus, are likely to impact both the rate and nature of innovation by firms. Despite the dominant scholarly view on financing innovation that various forms of equity investment influence innovation positively (e.g., Brown, Fazzari, & Petersen, 2009; Kortum & Lerner, 2000), there is also substantive evidence that managerial myopia or short-termism influenced by the public equity markets can stifle innovation (e.g., Jacobs, 1991; Porter, 1992; Stein, 1989). This growing body of literature on financing innovation suggests bank-backed financing as a potential alternative of equity investment (Kerr & Nanda, 2015). This not only has important policy implications but also has potentially profound implications for the theory that suggests the linkage should be quite different.

Addressing the link between bank financing and clean technology innovation, this paper is one of the first studies in this body of literature. Although innovation projects are designed to achieve new societal norms as well as functional needs in the clean technology sector, such innovative projects are insufficiently funded because the capital and investment timeframe required for commercialization is so high (Hargadon & Kenney, 2012; Mowery et al., 2010; Nanda et al., 2015). Thus, the mismatch between equity investment and innovation in clean technology is likely more pronounced than other types of high technology projects (Ghosh & Nanda, 2014; Kerr & Nanda, 2015). It is an open question whether bank financing, as an alternative mechanism of equity investment, can effectively address additional continuation risks inherent in innovative projects in clean technology.

I also suggest that external institutional interests and concerns are critical vehicles for innovation, addressing new societal norms and enhancing the reputation of entities, such as clean technology innovation (Bansal & Clelland, 2004; Delmas, Russo, & Montes-Sancho, 2007; Tashman & Rivera, 2016). Although extant research in financing innovation has investigated internal functional needs such as financial dependence and corporate governance (Hall & Lerner, 2010; Kerr & Nanda, 2015), external institutional pressures are also important drivers of innovative projects designed to address normative value (Delmas & Montes-Sancho, 2010; Hoffman & Ventresca, 2002; Tashman & Rivera, 2016). I argue that, by reducing the additional continuation risks, such external institutional supports or pressures are likely to influence the relation between bank financing and clean technology innovation. Hence, by combining the emerging scholarly insight of bank financing on innovation with the well-established scholarly perspective on the role of institutional environments on sustainable development, this paper examines impacts of both institutional pressures and bank financing on clean technology innovation. More broadly, this paper addresses how the external institutional environment interacting with the financial sector shapes the rate and direction of innovation.

Empirically, I focus on the effect the banking deregulation on clean technology innovation. Then, I investigate how environmental institutional pressures influence this effect. A major hurdle in the empirical literature on financing innovation is that innovation could be endogenous with company and market characteristics, including state-level bank financing condition. In such case, a correlation between bank financing and innovation may tell us little about the causal effect of bank financing on innovation. I address such endogeneity concerns by exploiting the staggered deregulation of interstate bank branching laws in the United States. Although interstate bank branching was fully legalized after the passage of the Interstate Banking and Branching Efficiency Act (IBBEA) of 1994, each state retained the right to erect roadblocks to hamper interstate branching and the removal of such right was randomly implemented (Rice & Strahan, 2010). When states relax bank branching restrictions, more bank branches open and compete with one another, facilitating the availability of credit within a state and lowering the cost of capital (Rice & Strahan, 2010). Hence, the staggered deregulation of interstate bank branching laws in the United States is an ideal candidate for alleviating endogeneity as it pertains to both randomized timing and economic significance.

I construct tests using these deregulatory events as exogenous adjustments in state-level bank financing conditions. My empirical analysis uncovers three main findings. First, given the positive economic effects of these deregulatory events documented by extant research (Cornaggia, Mao, Tian, & Wolfe, 2015; Krishnan, Nandy, & Puri, 2015; Rice & Strahan, 2010), I expect state-level clean technology innovation to increase following the deregulation because economic entities located within deregulating states could take advantage of the more favourable bank financing condition to increase clean technology innovation output. Consistent with my intuition, I find robust evidence that increases in banking competition cause state-level clean technology innovation output to increase.

Second, I find an overall positive effect of deregulatory events on state-level clean technology innovation is driven by private firms or individuals located within deregulating states. Individuals or private firms could be more sensitive to local banking conditions than publicly listed corporations, so the effects of state-level banking competition could be different for these two groups. Thus, I decomposed state-level clean technology patents into patents produced by publicly listed corporations and other entities such as private firms or individuals. Indeed, relative to publicly listed corporations, private firms or individuals increase in clean technology innovation output following deregulatory events. However, I find no direct effect of deregulation on clean technology innovation outputs by publicly listed firms. These findings support the notion that individuals or private firms, more dependent upon bank financing than corporations, take advantage of the improved credit conditions to finance innovative projects designed to achieve new societal goals as well as functional needs.

Third, I find that the effect of deregulatory events on state-level clean technology innovation positively interacts with environmental institutional pressures. These results suggest that favorable local banking conditions driven by the deregulation of interstate bank branching laws complement the opportunity recognition of clean technology innovation in response to greater environmental institutional pressures. Taken together, my findings link a recent body of work (e.g., Kerr & Nanda, 2015) that unpacks the effect of bank financing on the rate and nature of innovative activities with an established body of work (Delmas & Montes-Sancho, 2010; Hoffman & Ventresca, 2002; Vogel, 1995) that emphasizes the role of institutional environments on sustainable development.

The rest of the paper proceeds as follows. The next section overviews the institutional context of the paper --- the rise of clean technology innovation and the interstate bank branching deregulation in the United States. Then, I describe how this paper relates to existing literature and develops testable hypotheses. The data and the empirical strategy follow. After presenting the results and discussing the underlying mechanisms of the results, the paper ends with concluding remarks.

INSTITUTIONAL CONTEXT

The Rise of Clean Technology Innovation

Over the past decades, scholars have long been interested in technological innovations addressing new societal or environmental norms. One of the most remarkable changes is the rise of clean technology innovation, targeting a diverse range of products, services, and processes such as climate change mitigation, hazardous waste and emission reduction, energy efficiency, and renewable energy (Hart, 2005; Pernick & Wilder, 2008). Clean technology innovation involves multiple market participants such as government agencies, environmentally sensitive citizens and communities, and customers valuing industry norms. By addressing across various spheres of an industry's norms, consumers, and various stakeholders (Hoffman & Ventresca, 2002; Vogel, 1995), clean technology innovation creates market opportunities for competitive advantage.

Although scholars have argued that the rise of clean technology innovation has both financial and social implications (Hart, 2005; Mowery et al., 2010; Porter & van der Linde, 1995), it has tended to be considered primarily as a response to non-financial institutional pressures. However, the speed of the rise of clean technology innovation does not seem to meet expectations of both business professionals and scholars (Ansari et al., 2013; Schüssler et al., 2014), leading scholars to investigate the potential financing barriers against clean technology innovation (Hargadon & Kenney, 2012; Mowery et al., 2010; Nanda et al., 2015).

Scholars have suggested that innovative projects in clean technology face additional continuation risks in financing, compared to those in other areas such as biotechnology or information technology where the long-term opportunity is more protected by a patent system, because clean technology innovations can face competition from both upstream and downstream such as all kinds of alternative sources of energy and final goods using polluting technology (Hargadon & Kenney, 2012; Kerr & Nanda, 2015; Mowery et al., 2010; Nanda et al., 2015). I argue that a more complete understanding of the drivers of such innovation designed to achieve new societal and environmental norms requires an analysis of both institutional pressures and financing conditions. Thus, I investigate the ways in which how institutional pressures and bank financing interact to enhance or impede clean technology innovation.

Interstate Bank Branching Deregulation

The US banking sector has gone through decades of regulatory changes regarding banks' geographic expansion (see Carruthers & Lamoreaux, 2016; Kroszner & Strahan, 2014).[8] States gradually dismantled these restrictions, and many states had laws in place allowing interstate banking by early 1990s, which primarily took the form of allowing out-of-state banks to buy in-state banks (Kane, 1996; Kerr & Nanda, 2009; Rice & Strahan, 2010). These state-level reforms culminated in the Riegle-Neal Interstate

[8] A few organizational scholars investigated the effect of the deregulation in the banking sector (e.g., Davis & Mizruchi, 1999; Haleblian, Kim, & Rajagopalan, 2006; Marquis & Huang, 2009; Marquis & Lounsbury, 2007). However, these studies tended to focus on various consequences of deregulations within the banking sector rather than how deregulations triggered changes across different sectors.

Banking and Branching Efficiency Act of 1994 (IBBEA). Interstate bank branching was still not allowed until the passage of IBBEA. The passage of IBBEA effectively permitted bank holding companies to operate branches across state lines without any formal authorization from state authorities (Johnson & Rice, 2008; Kane, 1996; Rice & Strahan, 2010).

According to Johnson & Rice (2008) and Rice & Strahan (2010), however, states were given the ability to erect roadblocks to branch expansion, effectively allowing states to dissuade interstate branching based on the following four dimensions: (1) the minimum age of the target institution, (2) de novo interstate branching restriction, (3) the acquisition of individual branches or other portions of an institution, and (4) the state-wide deposit cap branch acquisition. In most cases, deregulating states choose to lift several restrictions at once, so that the four components of deregulation are highly correlated. It is, in fact, impossible to distinguish their individual effects.

These provisions provided states with tools to effectively constrain interstate bank branching. The IBBEA was passed in 1994, but states had the discretion to set up their interstate bank branching regulations under the IBBEA anytime before 1997. Many states successfully utilized these provisions to bar out-of-state banks from setting up branches within their borders. It is noteworthy that, while economic and political factors are highly correlated with the timing of earlier banking deregulation across states (Kane, 1996; Kroszner & Strahan, 1999), such correlations have been found to be much weaker for the timing of interstate bank branching deregulation across states (Rice & Strahan, 2010). As a result, these deregulations were implemented in a staggered and random manner, thereby allowing us to exploit them to analyze how an increase in access to financing as a result of these deregulations affect the clean technology innovation by various economic entities.

BACKGROUND LITERATURE AND EMPIRICAL IMPLICATIONS

This paper addresses whether increased access to bank financing has a causal effect on clean technology innovation. Further, I unpack the role of environmental institutional pressures on such linkage. In this section, to develop testable hypotheses, I review three cognate literatures, which are the real effects of banking deregulation, bank financing and innovation, and the role of institutional environments. There is a vast literature that has looked at whether finance creates economic development (e.g., Levine, 1997; Schumpeter, 1934), but there has been insufficient scholarly attention to financing particular dimensions of economic development designed to achieve new environmental and societal norms, such as clean technology innovation. Also, since finance and development are likely determined endogenously, identifying the direction of causality has been a major challenge in this literature. I address this by exploiting the interstate bank branching deregulations as a natural experiment.

Bank Financing and Clean Technology Innovation

My paper is related to the literature that examines the real effects of banking deregulation. Over the past two decades, a large literature has examined various consequences of the intrastate branching and interstate banking deregulation events that occurred in the U.S. in the 1970s and 1980s (e.g., Jayaratne & Strahan, 1996; Kroszner &

Strahan, 2014).[9] A major contribution has been to show that such deregulatory events tend to contribute positively to the real economy (Jayaratne & Strahan, 1996). This stream of literature shows that deregulation spurs entrepreneurship (Black & Strahan, 2002), allows greater firm entry and access to bank credit (Cetorelli & Strahan, 2006), and promotes creative destruction as well exits (Kerr & Nanda, 2009). Rice & Strahan (2010) demonstrated that the interstate bank branching deregulation occurred in the U.S. in the mid-1990s expanded credit supply by reducing the cost of credit, arguing that bank competition will generate greater efficiency in the banking sector and favourable borrowing conditions. Taking the same deregulatory event chronicled in Johnson & Rice (2008) and Rice & Strahan (2010), I advance this line of inquiry by investigating whether the reduced cost of credit allows driven by such deregulatory event enhances or impedes innovative projects in the clean technology sector, which pertains greater continuation risks and longer timeframe for commercialization than other high technology sectors.

Hence, this paper contributes to the emerging literature on bank financing and innovation, investigating nuanced relations between innovation and market characteristics (e.g., Kerr & Nanda, 2015). Four major contemporaneous studies make use of the state-level banking industry deregulations in the United States as identification strategies to explore the effect of bank credit supply on innovation. Amore, Schneider, & Zaldokas (2013) found that interstate banking deregulation in the 1980s had a positive effect on the innovative performance of public corporations, especially for those highly dependent on external capital and located closer to entering banks. Chava, Oettl, Subramanian, & Subramanian (2013) showed contrasting effects of intrastate branching

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[9] See Marquis & Huang (2009) for an institutional analysis of the banking sector. See Kroszner & Strahan (1999) for an analysis of political and economic drivers of banking deregulation. Herein, I focus on the product market consequences of banking deregulation.

and interstate banking deregulation on innovation by private firms. Focusing on the notion that small firms would have been more likely to be financially constrained, Chava et al (2013) found that state-level intrastate banking deregulation in the U.S., which enhanced the local market power of banks, has a negative effect on the innovation efforts made by young, private firms. In contrast, interstate banking deregulation in the U.S., which reduced the local market power of banks, promoted such firms' innovation. In a similar vein with Chava et al (2013), Hombert & Matray (2017) analyzed how relationship lending affected the financing of innovation. Using intrastate banking deregulation as a negative shock to relationships, they found that the shock had an adverse effect on small innovative firms, especially those that depended more on relationship lending.

Contrary to all three papers above that suggest economic activity responded directly to the deregulation episodes that preceded the IBBEA, Cornaggia et al (2015) analyzed the impact of the bank branching deregulations post-1994 on innovation. Taking the identification of deregulatory events based on Rice & Strahan (2010), Cornaggia et al. (2015) found that innovation by small private firms, which depend more on bank financing for capital than publicly traded firms, increased following the interstate deregulations, while innovation fell among publicly traded firms (for small-sized firms' total factor productivity, see Krishnan et al., 2015). By examining the effects of the same deregulatory event in Cornaggia et al (2015), I contribute to this line of inquiry by showing that the reduced cost of credit driven by bank competition allows individuals and private firms, more bank-finance dependent entities, to secure bank financing to fund innovative projects in the clean technology sector. To address whether increased access to bank financing has a causal effect on clean technology innovation, from the review of two cognate literatures, I set out two testable hypotheses:

> ***Hypothesis 1***. *Interstate bank branching deregulation led to an increase in the level of clean technology innovation.*
>
> ***Hypothesis 2***. *The hypothesized positive effect of interstate bank branching deregulation on clean technology innovation is driven by individuals or private firms.*

The Role of Environmental Institutional Pressures

Another stream of literature emphasizes the role of institutional environments in sustainable innovation. The strength of environmental institutional pressures may affect the relationship between bank financing and clean technology innovation. Here, I argue that robust environmental institutional pressures may help innovators to consider the strategic value of clean technology innovation (e.g., Delmas & Montes-Sancho, 2010; Hoffman & Ventresca, 2002; Vogel, 1995), in response to a more favourable condition in bank financing.[10]

In particular, I note that when environmentally friendly community members and policymakers exert institutional pressures on environmental agendas including climate change, reducing hazardous wastes, and enhancing energy efficiency, innovators are more likely attended to such issues as a response to improved local banking conditions. At the policy level, erecting regulations or supporting subsidies on environmental agendas mitigate the continuation risks of innovative projects in clean technology (Porter & van der Linde, 1995; Vogel, 1995), complementing favourable financing condition. At

[10] In this paper, among the various elements of institutional environments, I focus on a particular type, institutional pressures. See Dobbin & Dowd (1997) for a discussion of policy regimes in the emergence of a new industry and see Armanios et al (2017) for a recent discussion of institutional infrastructure in an emerging economy.

the community level, shared values and norms about the importance of environmental agendas, complemented by local economic condition, are likely to direct entities to launch innovative projects designed to achieve such shared values and norms (Hoffman & Ventresca, 2002; Marquis et al., 2007). Finally, combined with better financing conditions, shared expectations among innovators regarding environmental agendas increase clean technology innovations to create firms' competitive advantage by generating new technological standards replacing polluting technologies (Porter & van der Linde, 1995; Schumpeter, 1934). Thus, combined with favourable local banking conditions, environmental institutional pressures may promote expectations for firms to explore more opportunities throughout innovative projects in clean technology. Hence:

> ***Hypothesis 3.*** *The interaction between interstate bank branching deregulation and environmental institutional pressures led to an increase in the level of clean technology innovation.*

EMPIRICAL STRATEGY AND DATA

Methodology

My empirical strategy utilized a natural experiment approach. Hence, my main econometric model focused on the relationship between an indicator variable for interstate bank branching deregulation and the proxies for the level of clean technology innovation output. Then, I further examined how the relationship unfolds for private firms and individuals and for economic entities located in states with greater environmental institutional pressures. The baseline empirical specification I estimated is as follows:

$$E[y_{it}] = \exp(\beta^* \, Dereg_{it} + \eta_i + \delta_t)$$

where y_{it} is a proxy of clean technology innovation measured in state *i* in year *t*, η_i a set of state dummies, and δ_t represents a set of year dummies. The inclusion of state fixed effects results in the identification of solely from within state variation across time. Hence, all time-invariant characteristics of the state that may influence its clean technology innovation output are controlled. For example, in a specification without state fixed effects, a state's time-invariant features in innovative activity may influence the estimated effect of banking deregulation on clean technology innovation if the timing of deregulation is systematically correlated with such state-level unobserved factors. All state-invariant time trends were controlled for with the year dummies. Thus, any economic or political shock across states in innovation concurrent with the timing of banking deregulation was controlled by the year fixed effects.

$Dereg_{it}$ varies by state and year. As noted, because the implementation timing of deregulation events is quite random and states deregulated at different times, I was able to estimate a difference-in-differences. That is, I used states that had not deregulated at a point in time to control for confounding effects across states, capturing the effect of a deregulation event by comparing the difference in the level of innovation in a state before and after the deregulation with this difference for states that did not implement a deregulation during the same period.

Due to the count-based nature of the dependent variables, I employed a fixed-effects Poisson estimator unless noted otherwise (e.g., Hausman, Hall, & Griliches, 1984). The differences-in-differences model required the use of a full set of state and year dummies, which makes us using a negative binomial model less computationally straightforward. I reported robust cluster standard errors that are robust to over-dispersion, are valid under any variance assumption, and allow for arbitrary serial correlation (e.g., Wooldridge, 2003). The approach with the full set of fixed effects and robust cluster standard error is often found in difference-in-differences settings (e.g., Amore et al., 2013; Bertrand, Duflo, & Mullainathan, 2004; Chava et al., 2013).

When I tested the baseline effect, I considered four innovation indicators, clean technology patent count, clean technology patent citation, the proportion of clean technology patent applications out of total patent applications, and the proportion of clean technology patent citations out of total patent citations. To use both count and citation measures, I looked for consistent patterns. To use the proportion measure for applications and citations, I checked whether the interstate bank branching deregulation substantially enhances the direction of clean technology innovation compared to other types of technological innovation. By using multiple innovation indicators, I gained greater confidence and a more nuanced understanding of the effect of the deregulatory events on clean technology innovation.

Sample

I drew my state-level data on clean technology innovation and relevant variables from a variety of sources. I linked clean technology patent data obtained from CleanTech PatentEdge with the NBER Patent Project data and the Harvard Patent Dataverse data, and matched these with data from Compustat for identifying publicly-listed corporations. The baseline database included U.S. clean technology and non-clean technology patents granted between 1980 and 2010.

The sample period began in 1990 because prior to 1990 clean technology innovation is less comprehensive and less reliable before that date (Hart, 2005; Hoffman

& Ventresca, 2002) and because the passage of IBBEA is 1994, it gives a few years of observation before the staggered events of deregulations. Furthermore, the late 1980s was marked by other types of banking deregulations (e.g., Amore et al., 2013; Chava et al., 2013; Kerr & Nanda, 2009; Kroszner & Strahan, 1999). The sample period ended in 2003 to mitigate potential biases from right censoring and shifts in the market environments from increases in oil prices. Also, the enactments of interstate bank branching deregulation are completed by the mid 2000s. As I employed fixed-effects models, I indeed required a state to have at least one successful clean technology patent application in the sample period. The baseline sample for my analyses contained 700 observations on 50 states.

Clean Technology Innovation

The major dependent variable is the total number of annual successful clean technology patent applications by a state. Clean technology innovation consists of a wide variety of technology categories such as renewable energy, air pollution reduction, and energy efficiency. Hence, unlike other types of technological innovation with a limited number of participants, a broad range of economic entities participated in clean technology patenting activities.

Publicly listed corporations and others (individuals & private firms)

Following Chava et al (2013), I identified a patent assignee as a private firm or an individual if there is no GVKEY match for the assignee in the NBER/Harvard patent database. Indeed, clean technology patent applications by GVYKEY-matched firms are classified as those by publicly listed corporations. As the unit of analysis was state-year observation, based on the headquarter location of innovators and the application year of patents ultimately granted, I aggregated into two groups --- private firms/individuals and publicly listed corporations --- by state and year. Figure 4.1 plots the annual aggregate number of clean technology applications ultimately patented in my sample. Overall, the pattern of clean technology patent activities exhibits an overall stable increasing trend except some stagnation in the late 1990s.

Insert Figure 4.1 about here

Interstate bank branching deregulation: An independent variable

Dereg (Interstate bank branching deregulation) is a dummy variable that is either one or zero, depending on whether or not the focal state implemented interstate bank branching deregulation. I consulted with Johnson & Rice (2008) and Rice & Strahan (2010) for the identification of the timing of deregulations across states. If more than one deregulatory event are observed in a state, I chose one with the greater magnitude of deregulation.

Environmental institutional pressures: An interaction variable

I measured environmental institutional pressures using data from the League of Conservation Voters (LCV) that rates congressional support for environmental policies at the U.S. state level (e.g., Tashman & Rivera, 2016; Viscusi & Hamilton, 1999). The LCV is a nonprofit organization that, with a panel comprising the main U.S. environmental groups, selects environmental issues each year that constitute the environmental agenda (e.g., clean energy tax credits or global warming). The organization then creates an index by measuring the percentage frequency of each representative or senator in Congress votes in favor of such environmental agendas. The index varies by state and year, ranging from 0 to 1, with 1 representing a record of voting supportive for all of the environmental agendas (Delmas & Montes-Sancho, 2010; Tashman & Rivera, 2016). Consistent with the event of state-level interstate bank branching deregulations, states are largely responsible for designing and implementing environmental policy in the U.S., and their policy stances on environmental issues are well aligned with locally prevailing norms and values (Lubell et al., 2002; Viscusi & Hamilton, 1999). Following previous studies (e.g., Delmas & Montes-Sancho, 2010; Tashman & Rivera, 2016), I measured these pressures by averaging the LCV scores for each state's House of Representatives and Senate congressional delegation in each year.

RESULTS

State-level descriptive statistics

Table 4.1 presents state-level summary statistics of my key variables across states. Not surprisingly, California made the greatest number of successful applications in clean technology among states on average. The statistics of clean technology innovation output varies across states. Vermont and Massachusetts exhibit high levels of environmental institutional pressures. Table 4.2 presents descriptive statistics of variables. On average, each state made 46 successful applications in clean technology per year and received 550 citations to these clean technology patents. Private firms and individuals made more clean technology patent applications than publicly listed firms, but their clean technology patents received fewer citations.

Insert Tables 4.1 & 4.2 about here

Interstate bank branching deregulation

Table 4.3 provides a test of Hypothesis 1, whether interstate bank branching deregulation led to an increase in the level of clean technology innovation. Table 4.3 shows my baseline estimation, that across the four different proxies for clean technology innovation, the coefficients of interstate deregulation are positive and statistically significant at the 5% level or lower in all equations. This provides strong support for Hypothesis 1, interstate bank branching deregulation enhanced clean technology patenting activities.

The level and direction of clean technology patenting activity increased significantly after the interstate bank branching deregulation. Equations (1) and (2) present an analysis of the effect of the interstate bank branching deregulation on clean technology patent applications and citations. Quantitatively, clean technology patenting increased 14% [$e^{0.128}-1 = 0.14$] after the interstate banking deregulation and citation-weighted patenting increased 25% [$e^{0.225}-1 = 0.25$]. Using OLS estimation, equations (3) and (4) provide an analysis of the effect of the interstate bank branching deregulation on the proportion of clean technology patent count and citation out of total patent count and citation.[11] The interstate banking deregulation explains a 0.5% increase in the level of the proportion of clean technology patenting and a 0.9% increase in the level of the proportion of citation-weighted clean technology patenting out of total patenting and citation-weighted patenting, respectively.

Insert Table 4.3 about here
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[11] Throughout this chapter, when a dependent variable is a ratio variable, I used OLS estimation.

Individuals and private firms vs. Publicly listed firms

Table 4.4 provides an empirical analysis on patenting activity in clean technology by individuals/private firms versus publicly listed firms. As discussed earlier, because individuals and private firms depend primarily on bank debt for external financing, I expected the effects of interstate bank branching deregulation to manifest primarily for these entities. Table 4.4 compares the effects of banking deregulation on innovation by private firms and individuals (entities that do not have a Compustat GVKEY assigned in the NBER and Harvard patent databases) to publicly listed firms.

The results in Table 4.4 support Hypothesis 2 --- the hypothesized positive effect of interstate bank deregulation on clean technology innovation is driven by individuals or private firms. As noted in Equations (1) and (2), banking deregulation significantly affected the level of clean technology innovation output by individuals or private firms in terms of both patent applications and citations. Further, as shown in Equations (3) and (4), this positive effect does not hold for publicly listed firms. Such a pattern is consistently held for both clean technology patent applications and patent citations. The presence of a significant impact of the interstate bank branching deregulation on clean technology patent applications (increased 17%) and citation-weighted applications (increased 27%) by individuals and private firms, but for publicly-listed firms, provides support for the channels through which more favourable banking conditions support economic entities more dependent upon debt financing.

Insert Table 4.4 about here

Environmental institutional pressures

Tables 4.5 and 4.6 provide a test of Hypothesis 3, whether the interaction between interstate bank branching deregulation and environmental institutional pressures led to an increase in the level of clean technology innovation. Table 4.5 shows the interaction effect on the four different proxies for clean technology innovation. Repeating estimation techniques in Table 4.3, Equations (1) and (2) used Poisson estimation and Equations (3) and (4) used OLS estimation. Compared to the results in Table 4.3 presenting the positive and significant effect of the interstate bank branching deregulation, the coefficients of the interaction term exhibit weaker magnitude and statistical significance. For clean technology patent applications and the proportion of clean technology patent applications out of total patent applications, as shown in Equations (1) and (3), the coefficients of the interaction between bank deregulation and environmental institutional pressures are positive and statistically significant at the 10%. Given the established findings that economic values are correlated with patent citations (Hall, Jaffe, Trajtenberg, 2005; Trajtenberg, 1990), the interaction between bank deregulation and environmental institutional pressures may not lead an increase in clean technology innovation with greater economic values, while the interaction is likely to somewhat influence the level and the density of clean technology innovation.

Table 4.6 repeats Table 4.4, focusing on the interaction effect. The results in Table 4.6 partially support Hypothesis 3 --- the interaction between interstate bank branching deregulation and environmental institutional pressures led to an increase in the level of clean technology innovation. Hypothesis 3 only holds for individuals and private firms. As noted in Equations (1) and (2), I find that the interaction between bank branching deregulation and environmental institutional pressures significantly affected the level of clean technology innovation output by individuals or private firms in terms of both patent applications and citations. However, as shown in Equations (3) and (4), such a positive interaction effect does not hold for publicly listed firms. The patterns shown in Table 4.6 are consistent with that in Table 4.4. Yet, the direct effect of environmental institutional pressures led to an increase in clean technology patent applications by publicly listed firms, consistent with findings in sustainable development literature that visible firms are more responsive to institutional pressures. The presence of a significant impact of the interaction between the interstate bank branching deregulation and environmental institutional pressures on clean technology patent applications and citation-weighted applications by individuals and private firms, but for publicly-listed firms, provides an interesting avenue of the complementary relationship between greater institutional demands for environmentalism and favourable bank financing conditions for the emergence of clean technology.

Insert Tables 4.5 & 4.6 about here

Placebo tests

This section explores the impact of other exogenous events potentially relevant to clean technology innovation. Hence, this section presents useful "placebo" tests of my hypotheses to see if the results in this paper particularly hold with interstate bank branching deregulation events. To do so, I focused on two issues --- one was the timing of interstate bank branching deregulation events and the other was the regulatory dynamics in financing.

Regarding the timing of the exogenous shock, the interstate bank branching deregulation events were concentrated in the mid to late 1990s. To test whether a series of other exogenous events occurred in a similar period impacted clean technology innovation, I chose the staggered events of tariff cuts in the United States as exogenous shocks (Flammer, 2015; Fresard, 2010). If the impact of banking deregulation on clean technology innovation is not from the financing linkage but from the period effect, the staggered events of tariff cuts may positively impact clean technology innovation. To exploit the standard industry classification (SIC) of firms, I matched firms with and without tariff cut shocks. Tariff cut shocks are defined in the SIC 4-digit level (Fresard, 2010). By constructing SIC 4 digit – year observations with the same sample period used in the analysis of the bank branching deregulation, Table 4.7 presents the effect of tariff cut shocks on clean technology innovation, shown in a similar fashion to Table 4.3. The results in Table 4.7 indicate that the effect of tariff cut shocks are negative yet insignificant, confirming the evidence that the impact of the interstate bank branching deregulation is from the financing effect, not from the period effect.

Insert Table 4.7 about here

Regarding the regulatory dynamics in financing, the interstate bank branching deregulation events indicate changes driven by enhanced competition among banks. To test whether a series of other exogenous events occurred in the debtor side impacted clean technology innovation, I chose the staggered events of personal bankruptcy law enactments in the United States as exogenous shocks (Cerqueiro et al., 2017). Over time, the staggered events of personal bankruptcy law enactments provide stronger debtor protection (Cerqueiro et al., 2017). If the impact of banking deregulation on clean technology innovation is not from competition among banks but from stronger debt protection, the staggered events of personal bankruptcy law enactments may positively impact clean technology innovation, particularly for smaller firms. By exploiting the staggered events of personal bankruptcy laws using Cerqueiro et al (2017) with the same panel used in the analysis of the bank branching deregulation, Table 4.8 presents the effect of stronger debtor protection on clean technology innovation, in a similar fashion found in Table 4.4. The results in Table 4.8 indicate that there is no clear evidence of the effect of stronger debtor protection on clean technology innovation, confirming the evidence that the impact of the interstate bank branching deregulation is from enhanced competition among banks, not from stronger protection of debtors.

Insert Table 4.8 about here

CONCLUSION

In this paper, I examined how increased access to financing driven by bank competition affects clean technology innovation. By exploiting the exogenous shift in access to financing due to interstate bank branching deregulations that took place ranging from the 1990s to the early 2000s, I related these staggered deregulations of state-level branching laws to clean technology innovation output. I find that the overall state-level clean technology innovation increases subsequent to their states allowing out-of-state banks to establish local bank branches. This result is mainly driven by individuals or private firms within states that deregulate. Consistent with this result, I find no evidence that branching deregulation drives clean technology innovation by publicly listed firms, which are less likely dependent on bank financing. Branching deregulation expands access to credit for individuals or private firms, which relaxes their financial constraints and allows them to pursue innovative projects designed to achieve new societal goals. Thus, my result reinforces the idea that greater access to bank financing may increase bank-finance dependent economic entities' access to additional productive projects that they may otherwise not be able to take up. My result further emphasizes that the availability of bank financing is important not only for overall technological innovation, but also for innovative projects designed to achieve emerging societal and environmental values.

I also find that innovation increases among entities located in states with greater environmental institutional pressures. Firms located in the greater environmental sensitivity of the citizens, they are more likely to launch innovative projects in clean technology after branching deregulation. This finding reinforces the view that innovation designed to achieve new social norms may require both non-market support and financing reducing additional continuation risks. This study contributes to the existing literature by analyzing the real effects of increased access to bank financing and capitalizing how such effects interact with institutional environments.

Figure 4.1: Total Successful Clean Technology Patent Applications

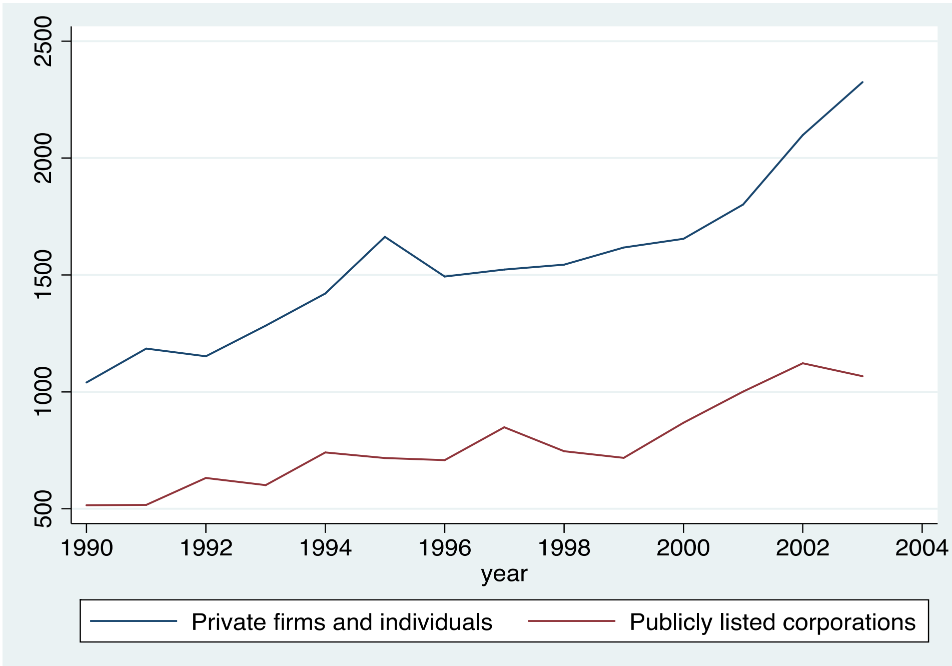

Table 4.1: State-level Summary Statistics

State	Event year	LCV	Total Application	Private firm application	Public firm application
Alaska	1994	0.05	2.64	2.57	0.07
Alabama	1997	0.16	12.29	11.00	1.29
Arkansas	1997	0.40	6.93	6.00	1.00
Arizona	2001	0.22	42.71	22.50	20.71
California	1995	0.68	393.50	299.07	94.43
Colorado	1997	0.30	55.29	46.79	8.50
Connecticut	1995	0.83	50.21	36.43	13.79
Delaware	1995	0.69	17.50	5.00	13.93
Florida	1997	0.47	81.36	63.86	17.50
Georgia	1997	0.38	37.64	24.93	12.86
Hawaii	2001	0.77	5.64	5.36	0.29
Iowa	1996	0.40	24.71	12.79	11.93
Idaho	1995	0.08	18.86	13.43	5.43
Illinois	2004	0.65	111.93	72.71	39.21
Indiana	1997	0.35	34.71	17.21	19.50
Kansas	1995	0.21	8.93	8.07	0.86
Kentucky	2000	0.18	9.50	7.64	2.57
Louisiana	1997	0.26	20.36	18.14	2.21
Massachusetts	1996	0.90	85.64	58.14	27.50
Maryland	1995	0.78	44.00	38.50	5.50
Maine	1997	0.75	4.71	3.57	1.64
Michigan	1995	0.59	138.86	57.50	81.36
Minnesota	1997	0.62	58.07	37.43	20.64
Missouri	1995	0.25	22.14	12.50	9.64
Mississippi	1997	0.15	8.86	8.29	0.57
Montana	2001	0.30	5.00	4.43	0.57
North Carolina	1995	0.32	42.21	33.29	8.93
North Dakota	2003	0.53	3.43	3.07	1.07
Nebraska	1997	0.36	7.00	5.00	2.07
New Hampshire	2000	0.37	14.86	12.43	2.43
New Jersey	1996	0.84	100.21	61.14	39.07
New Mexico	1996	0.36	23.21	22.07	1.14
Nevada	1995	0.54	12.50	11.71	0.79
New York	1997	0.67	175.36	101.07	74.29
Ohio	1997	0.45	92.64	50.00	44.00
Oklahoma	2000	0.13	22.79	17.57	5.21
Oregon	1997	0.56	26.93	14.43	12.50
Pennsylvania	1995	0.42	115.50	72.79	42.71
Rhode Island	1995	0.86	8.93	8.00	0.93

South Carolina	1996	0.39	16.00	10.50	11.93
South Dakota	1996	0.48	1.71	1.14	0.57
Tennessee	1997	0.32	28.36	21.36	7.07
Texas	1999	0.21	154.00	83.07	70.93
Utah	1995	0.14	18.50	16.00	2.50
Virginia	1995	0.37	38.50	32.64	5.86
Vermont	1996	0.89	5.07	5.00	0.07
Washington	2005	0.55	47.14	38.00	9.14
Wisconsin	1996	0.71	47.00	34.86	12.50
West Virginia	1997	0.63	6.86	5.79	1.86
Wyoming	1997	0.04	2.50	2.36	0.50

Table 4.2: Descriptive Statistics (N = 700)

Variable	Mean	Std. Dev.	Min	Max
Applications	46.26	68.25	0.00	617.00
Citations	550.27	913.97	0.00	7143.00
Clean tech /Total patent applications	0.03	0.02	0.00	0.17
Clean tech/Total patent citations	0.03	0.02	0.00	0.33
Applications by private firms	31.14	48.43	0.00	471.00
Citations to private firms	342.36	604.72	0.00	5678.00
Applications by public firms	15.43	26.58	0.00	199.00
Citations to public firms	215.40	421.79	0.00	4022.00
League of Conservation Voter	0.45	0.26	0.00	97.25
Bank Branch deregulation (y/n)	0.39	0.49	0.00	1.00

Table 4.3: Effect of Bank Branching Deregulation on Clean Technology Innovation

	(1) Clean tech Applications	(2) Clean tech Citations	(3) Clean tech/Total Applications	(4) Clean tech/Total Citations
Dereg	0.128**	0.225***	0.005**	0.009**
	(0.055)	(0.078)	(0.002)	(0.004)
Year FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
# of States	50	50	50	50
Observations	700	700	700	700

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by state are reported in parentheses.

Table 4.4: Effect of Bank Branching Deregulation on Clean Technology Innovation by Individuals and Private Firms and by Publicly Listed Firms

	(1) Private firm Applications	(2) Private firm Citations	(3) Public firm Applications	(4) Public firm Citations
Dereg	0.154**	0.240**	0.060	0.172
	(0.062)	(0.110)	(0.166)	(0.230)
Year FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
# of States	50	50	50	50
Observations	700	700	700	700

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by state are reported in parentheses.

Table 4.5: Bank Branching Deregulation X Environmental Institutional Pressures

	(1) Clean tech Applications	(2) Clean tech Citations	(3) Clean tech/Total Applications	(4) Clean tech/Total Citations
Dereg	0.033	0.224	0.000	0.004
	(0.072)	(0.248)	(0.003)	(0.006)
LCV	0.202	0.037	-0.009	-0.013
	(0.124)	(0.296)	(0.006)	(0.010)
Dereg X LCV	0.175*	-0.001	0.013*	0.013
	(0.098)	(0.391)	(0.007)	(0.015)
Year FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
# of States	50	50	50	50
Observations	700	700	700	700

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by state are reported in parentheses.

Table 4.6: Bank Branching Deregulation X Environmental Institutional Pressures --- Private Firms vs. Publicly Listed Firms

	(1) Private firm Applications	(2) Private firm Citations	(3) Public firm Applications	(4) Public firm Citations
Dereg	0.016	0.023	0.070	0.437
	(0.078)	(0.156)	(0.228)	(0.542)
LCV	-0.110	-0.178	0.806**	0.256
	(0.187)	(0.294)	(0.376)	(0.655)
Dereg X LCV	0.280***	0.400*	-0.071	-0.515
	(0.100)	(0.206)	(0.255)	(0.806)
Year FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
# of States	50	50	50	50
Observations	700	700	700	700

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by state are reported in parentheses.

Table 4.7: Effect of Tariff Cut on Clean Technology Innovation

	(1) Clean tech Applications	(2) Clean tech Citations	(3) Clean tech/Total Applications	(4) Clean tech/Total Citations
Dereg	0.110	-0.038	-0.008	-0.007
	(0.212)	(0.240)	(0.006)	(0.009)
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
# of Industries	142	142	142	142
Observations	1970	1970	1970	1970

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by industry are reported in parentheses. Industries are defined by the SIC 4-digit level.

Table 4.8: Effect of Personal Bankruptcy Law on Clean Technology Innovation

	(1) Private firm Applications	(2) Private firm Citations	(3) Public firm Applications	(4) Public firm Citations
Dereg	-0.054	0.095	-0.053	-0.093
	(0.072)	(0.102)	(0.295)	(0.329)
Year FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
# of States	50	50	50	50
Observations	700	700	700	700

*, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Robust standard errors clustered by state are reported in parentheses.

CHAPTER 5: DISCUSSION AND CONCLUDING REMARKS

Given the fact that the capability of the nation-state to define social values and business activities in the market space is diminishing (Strange, 1996; Vogel, 2008), business professionals and scholars have become increasingly attentive to innovative firm- and community-level solutions blending social and environmental values (Porter & Kramer, 2006; Porter & van der Linde, 1995; Vogel, 2005). Combined with the sociological insight that innovations with new social values are institutionally embedded or contingent (e.g., Fligstein & Dauter, 2007; Rao et al., 2003; Weber et al., 2008), the scholarly endeavor in this stream of research has delineated the institutional embeddedness of the origins of various sustainable innovations such as green building (York & Lenox, 2014), recycling (Lounsbury et al., 2003), and renewable energy (Pacheco et al., 2014). This dissertation shows that such sociological insight emphasizing the role of institutional forces in the emergence of new industries and practices (e.g., Ansari et al., 2010; Dobbin, 2009; Weber et al., 2008) can be applied to the emergence of clean technology innovation.

Further, extending the recent sociological line of thought in the scaling-up of innovative projects addressing social values (e.g., Jennings et al., 2013; Markman et al., 2016), this dissertation focuses on the interactive role of financing mechanisms and institutional environments, tackling the grand challenge of why socially efficient innovation is rejected and less likely to diffuse in relation to various stakeholders' expectations (e.g., Abrahamson, 1991; Ferraro, Etzion, & Gehman, 2015; George et al., 2016). To investigate the empirical issue of the new industry regime shifting to greener economy, this dissertation uses eclectic approaches to draw from various streams of literature addressing inherent complexities in financing and institutional environments for technological innovations and new industry regimes (e.g., Chandler, 1977; Dobbin, 1994; Hollingsworth & Boyer, 1997; Roy, 1999; Schumpeter, 1934).

Building on these insights, my dissertation argues that studying the evolution and interaction of financing and institutional environments has the potential to cultivate insight into the drivers influencing technological innovations that address new societal values. In this way, my effort is part of an ongoing move among organizational scholars to analyze the identification of the rationalization of finance on various organizational outcomes (Davis, 2009; Fligstein, 2001; Krippner, 2011). A handful of sociological studies have focused on the emergence of new categories or technological trajectories, but have concentrated on only institutional environments, neglecting the role of financing (Schumpeter, 1934). Economists focusing on financing and innovation tend to ignore the role of institutional environments and how particularistic technology is linked to financing. Yet, the rise and fall of many industries is fundamentally shaped by various financing and institutional environments, and this is particularly evident in dynamic contexts, such as nascent business models (Pahnke, Katila, & Eisenhardt, 2015; Yan, Ferraro, & Almandoz, 2018), high technology industries (Mowery et al., 2010; Saxenian, 1994), and large-scale infrastructure projects (Chandler, 1977; Dobbin, 1994). Despite the practical and theoretical importance of understanding how interactions of financing and institutional environments help or impede the growth of emerging sectors, we have little insight into how this occurs.

To help address this, I empirically investigated the interplay of financing and institutional environments in the emerging field of clean technology. Adapting insights from configuration theory, my first paper (Chapter 2) shows how different nations' financial markets and renewable energy policies contribute to the rates of renewable energy innovation and production. Results suggest that, with the positive influence of a credit market on the transition to renewable energy innovation and production, the configuration of regulatory renewable energy policies and a credit market significantly affect such transition. Narrowing down to a firm-level analysis, my second paper (Chapter 3) examines how the rise of a shareholder value orientation, evidenced by the growth of institutional ownership, impacts corporate environmental innovation. Whereas extant studies imply that under greater institutional ownership corporations are more likely to pursue innovation because they are punished for not doing so or that there may be potential complementary effects between external institutional demands and internal institutional ownership, I show that there are tensions between institutional ownership and clean technology innovation and that such tensions are amplified when external institutional demands for clean technology are high. As an alternative mechanism, my last empirical study (Chapter 4) shows the positive role of bank financing on individuals and private firms. Environmental institutional pressures complement such a positive influence. Hence, this dissertation questions the findings of extant literature on financing innovation by focusing on the emergence of a particular market space and suggests that the exercise of linking the unique nature of a particular innovation type and the nature of financing is valuable.

These results have important implications for research in sustainable development, and for economics of financing innovation and institutional theory. For research on sustainable development, this dissertation indicates that both financing-based and institutional arguments influence the emergence of clean technology innovation. In particular, regulatory policy implementations and environmental institutional pressures are closely related to the transition to clean technology. Of the financing-based drivers, contrary to extant research on financing innovation, I uncover the positive influence of bank financing and the negative influence of institutional ownership on clean technology innovation. Most research in the area of sustainable development has taken either an institutional (Delmas & Toffel, 2008; Hoffman, 1999) or a financing-based position (e.g., Hargadon & Kenney, 2012; Nanda et al., 2014). This study responds to the call for research that integrates cognate perspectives for a better theorization of sustainable development (e.g., Bansal, 2005; Berrone et al., 2010).

In sum, I highlight multiple ways in which financing and institutional environments can be interrelated in the growth of new industries and show how the potential interplay between them can shape innovation outcomes designed to achieve novel societal and environmental goals. Building on recent advances in diffusion research based on institutional perspectives (Ansari et al., 2010; Davis & Marquis, 2005; Dobbin et al., 2007), this dissertation provides an analysis of institutional alignments in a particular context. In each paper, by focusing on the intersection of sustainable development, economics of financing innovation, and institutional theory, I discuss the implications that my findings have for future research in specific domains such as cross-country perspectives on financing and policy (Paper 1), the conflicting nature between a shareholder value orientation and corporate environmentalism (Paper 2), and the socially embedded nature of financing innovation (Paper 3). Rather than reiterate these here, the remainder of my discussion focuses on three very broad future research agendas that my dissertation signals: 1) the institutional embeddedness of innovation; 2) the institutional embeddedness of financing innovation; and 3) analytic strategies for studying clean technology innovation and financing such innovation. To unpack these three issues, I employ a problem-based approach and institutional perspectives as a toolkit to understand the emergence of clean technology innovation (e.g., Ansari et al., 2010; Davis & Marquis, 2005; Dobbin, 2009; Fligstein, 2001; Hoffman, 2001; Hollingsworth & Boyer, 1997).

Institutional Embeddedness of Innovation

Although each paper in this dissertation focuses on a particular dimension of institutional environments, I acknowledge the importance of studying the variety of ways in which institutional elements in production systems are organized and coordinated (e.g., Campbell, Hollingsworth, & Lindberg, 1991; Fligstein, 1996; Hollingsworth & Boyer, 1997). Scholars in economic sociology and cognate disciplines have long recognized the importance of identifying the variety of trajectories that institutional elements coordinate with each other. This literature provides evidence that innovative projects are institutionally embedded and that identifying the ways of blending social values and market forces is the analysis of the methods of coordinating between various institutional elements. Herein, examining this literature emphasizes the value of two approaches: those related to the law and society literature, and those related to the comparative and international literature.

It is clear that the emergence of clean technology innovation is embedded in the dynamics of regulatory environments and social movements (e.g., Edelman & Suchman, 1997; Russo, 2001; Short & Toffel, 2010; Sine & Lee, 2009). Lessons from the law and society literature signal the intersection of regulatory dynamics and social movements in the emergence of new markets. It is well documented that the interaction between value-driven movements and regulatory dynamics fundamentally shapes the origins of new industry domains that blend social values and market forces (e.g., Lounsbury et al., 2003; Pacheco et al. 2014; Short & Toffel, 2010; Sine and Lee 2009; York & Lenox, 2014). Hence, the findings in this dissertation suggest that it is useful to delve into the ways how intertwined coordination mechanisms of social movements and public policies, as the source of substantial economic and social change, define the trajectories of the emergence of clean technology innovation.

In addition, my dissertation points to the utility of considering the cross-country variations from comparative perspectives. It is clear that the emergence of new industries exhibits heterogeneity in development trajectories as the product of configurations of various institutional elements among countries (Garud & Karnoe, 2003; Jepperson, 2002; Jepperson & Meyer, 1991; Spencer et al., 2005). Also, it is noted that the slow progress of sustainable development may be due to inherent difficulties in coordinating between different nation-state constituents (e.g., Ansari, Wijen, & Gray, 2013; Schüssler, Rüling, & Wittneben, 2014). Hence, moving beyond the world society literature that focuses on the isomorphic direction leading the institutionalization of practices and innovations (e.g., Meyer, 2010; Meyer et al., 1997; cf. Dobbin et al., 2007), this dissertation indicates that it is useful to investigate how variations within a sector configured with nation-states define the trajectory of clean technology innovation and how different styles of coordination between corporations and nation-states shape the paths for sustainable development (Bartley, 2007; Garud & Karnoe, 2003; Rugman & Verbeke, 1998; Schofer & Fourcade-Gourinchas, 2001; Vogel, 2008).

Institutional Embeddedness of Financing Innovation

Although each paper in this dissertation addresses a specific dimension of financing innovation, I acknowledge the importance of studying the variety of ways in which financing innovation is institutionally embedded, beyond the rational calculus of investors. Scholars of strategy and organizational theory have long recognized the importance of identifying the variety of ways that financial markets shape product markets (e.g., Davis, 2009; Fligstein, 2001; Porter, 1992). This literature shows that financing innovative projects is institutionally contingent, as the finance professionals are in a particular cultural domain (e.g., Davis, 2009; Useem, 1996). Herein, examining this literature signals the value of two approaches: those related to the financialization of the economy, and those related to financing new industry regime.

Recently, many economic sociologists and organizational theorists have suggested an increasing dominance of finance in various real economic activities (e.g., Davis & Kim, 2015; Dore, 2008; Epstein, 2005). Such financialization of the economy generates managerial myopia, targeting short-term profitability and distorting managerial incentives for long-term innovation (Admati, 2017; Laverty, 1996; Stein, 1989). The short-termism culture driven by financialization is problematic because financing innovative projects with social values is now in the hands of venture capitalists and institutional investors, rather than government agencies, leading companies to patent particular categories of technologies that meet shareholders' interests as they stay away from relatively risky projects like clean technology innovation. Hence, if clean technology innovation is deemed to be radical, fundamentally transforming an incumbent industry landscape, the findings in my dissertation indicate that it is useful to critically analyze how the culture of financial professionals may shape the emergence of socially beneficial industries. Further, drawing from the particular case of technological innovations with social values, clean technology innovation, this dissertation suggests that it would be useful to develop theoretical arguments on alignments of various institutional alignments to explain a new industry development, moving beyond incentive alignments between innovators and investors.

This dissertation signals the utility of considering financing clean technology innovation as infrastructure financing. For example, it is clear that the transformation of transportation technologies from waterways to railways involved complexities in institutional contexts (e.g., Chandler, 1977; Dobbin, 1994; Roy, 1999). Financing such infrastructure transformation is a basis of economic development and makes it possible to combine various economic elements in new ways (Gerschenkron, 1962; Schumpeter, 1934). For example, scholars investigating the evolution of the railway industry show that the variation in polity types across different countries and institutionally contingent complexities in relationships between financiers and companies fundamentally shape the trajectories of railway development (Chandler, 1977; Dobbin, 1994). Hence, institutional contexts shape financing innovation particularly those innovative projects that influence economic entities in multiple sectors. If we treat the shift to a less polluting and greener economy similarly to the shift from waterways to railways, this dissertation demonstrates that it is useful to investigate how the insights from financing the railway industry during its emergence can be applied to financing clean technology innovation under the condition of decreasing capacity of nation-states and increasing complexity between financiers and innovators. Indeed, such a historical comparative approach may shed light on how varieties of institutional forces intertwine with financing innovation to shape the worldwide transition to new industry landscapes.

Analytic Strategies for Studying Clean Technology Innovation

As clean technology becomes more commonplace as an alternative to polluting technology, there is an associated need to understand the drivers that influence this transition. It is important to understand how social and economic processes interact in order to answer questions of when and why economic entities, including firms, financiers, and stakeholders, commit to such transition toward sustainable development. This dissertation highlights the opportunity to investigate not only the relative merit of institutional and financing-based drivers, but also how such drivers reinforce each other, and the processes by which they affect such transition. Unpacking these motivations and goals can assist business professionals and government agencies to determine the relative efficacy of different sets of strategies and initiatives like building innovation ecosystems, implementing radical innovative projects beyond regulations, and coordinating industry-government. Such problem-oriented research makes it possible to develop public and business policies that are well aligned with the complexities of the market economy in order to enhance sustainable development.

Industries emerge, evolve, mature, and decline. Accounting for industrial dynamics and heterogeneities could benefit from a full spectrum of diverse analytical strategies, including micro-to-macro mechanisms and cross-fertilizations of cognate disciplines. Given the institutionally embedded and problematic nature of clean technology innovation, the empirical complexity in such contexts does not necessarily have to result in the convergence of analytical strategies (e.g., Ansari et al., 2010; Benner & Tushman, 2015; Davis & Marquis, 2005; Greenwood et al., 2011). An interesting empirical inquiry would rely on multiple analytical strategies, and renewed engagement with a diverse array of foundational research agendas (e.g., Chandler, 1977; Schumpeter, 1934; Scott, 1995) would enrich this emerging research program.

Concluding Remarks

My basic point in this dissertation is that the emergence of a new industry is embedded within the broader market and institutional dynamics. Industry evolution not only involves functional needs or incentive alignments within an organization, but also relies on broader institutional environments that structure competition, financing, and innovation. Hence, the emergence of a new industry depends upon how the variation and dynamics of institutional environments play out when strategic orientations are contested or changing in the context of struggles between incumbents and new entrants. As this dissertation demonstrates, the interactive mechanisms between financing and institutional environments fundamentally shape the fate of innovative projects designed to achieve particular social or environmental objectives. Hence, it is critical to investigate actual institutional alignments throughout cross-fertilizations of cognate disciplines.

Pragmatically, clean technology innovation pertains to two intrinsic values: sustainable development for greening and technological innovation for profitability. An innovative project necessitates figuring out the right balance between the value of greening and the value of profitability, and is a precarious task from the innovator's view. My dissertation shows that the business model for clean technology innovation may fundamentally differ from that for other types of technological innovation. Hence, collective efforts to unpack behavioral and institutional foundations for robust paths towards the greener economy are urgently needed in this important business domain.

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