Energy Policy 102 (2017) 7–15

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Promoting clean energy technology entrepreneurship: The role of external context

Joel Malen[a,*], Alfred A. Marcus[b]

[a] Institute of Innovation Research, Hitosubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8603, Japan

[b] Department of Strategic Management & Entrepreneurship, Carlson School of Management, University of Minnesota, 3-406 CarlSMgmt, 321 19th Avenue South, Minneapolis, MN 55455, USA

ARTICLE INFO

Keywords:
Environmental entrepreneurship
Clean energy technology
Venture capital funding
Environmental policy

ABSTRACT

This study examines how political, social and economic factors influence clean energy technology entrepreneurship (CETE). Government policies supporting clean energy technology development and the development of markets for clean energy create opportunities for CETE. However, the extent to which such opportunities lead to the emergence of new clean energy businesses depends on a favorable external context promoting CETE. This study employs a novel dataset combining indicators of the policy and social context of CETE with information on clean energy technology startup firms in the USA to provide empirical evidence that technological and market conditions supporting clean energy induce more extensive CETE under contexts where local attention to clean energy issues and successful firms commercializing clean energy technologies are more prominent. By establishing that CETE is contingent upon a supportive local environment as well as technology and market opportunities, the study holds relevance for policy makers and clean energy technology firms.

1. Introduction

Advances in clean energy technology development are important to address contemporary environmental challenges such as global warming and air pollution that stem from the current reliance of the energy system on fossil fuels. By themselves, however, these advances are not sufficient to address these challenges. Technologies that facilitate the use of renewable energy or reduce energy consumption and pollution also must be commercialized and successfully diffused before they can precipitate positive environmental outcomes (Marcus, 2015). Clean energy technology entrepreneurship (CETE) concerns the discovery, evaluation and exploitation of goods and services that incorporate novel clean energy technologies to reduce harmful environmental externalities associated with conventional energy production, distribution, and consumption (Eckhardt and Shane, 2003; Venkataraman, 1997). Entrepreneurship in this domain involves identifying a market opportunity for a clean energy technology and developing a viable business model to exploit it (Teece, 2010). CETE is an essential step in the adoption and diffusion of the advanced technologies upon which a clean energy future depends.

Understanding CETE requires comprehending why some opportunities for clean energy technology are recognized and developed whereas others are not. While research on entrepreneurial opportunity development once tended to focus mainly on characteristics of the entrepreneur (Short et al., 2010), recent studies have begun to examine the influence of the external environment (Tolbert et al., 2011). In relation to CETE, market failures associated with knowledge externalities are compounded by the additional challenges of addressing the negative externalities of environmental pollution (Jaffe et al., 2005) and those that arise from policy uncertainty (Marcus et al., 2011). Because government and broader societal actors play an important role in helping to mitigate these challenges, the external context is particularly germane to CETE. Accordingly, this study examines how the external context of entrepreneurs influences clean energy technology entrepreneurship.

The objective of the study is to assess to the extent to which CETE is contingent on a favorable external context. Favorable political, social and economic factors play a role in not only creating opportunities for entrepreneurs to develop into new businesses, but in creating conditions supportive of that development. The study explores the extent to which technological opportunities and market opportunities, which promote CETE, vary across locations depending on contextual factors, specifically local attention to clean energy issues and evidence of clean energy business viability. The central claim is that local attention to clean energy and evidence of the viability of clean energy technology businesses positively moderate the relationship between the existence

* Corresponding author.
E-mail address: malen@iir.hit-u.ac.jp (J. Malen).

http://dx.doi.org/10.1016/j.enpol.2016.11.045
Received 30 March 2016; Received in revised form 22 November 2016; Accepted 27 November 2016
0301-4215/

of clean energy entrepreneurial opportunities in a location and the extent of CETE in that location. This argument is tested using a novel dataset combining indicators of the policy and social context of CETE with information on clean energy technology startup firms in U.S. states that received VC investment funding between 2000 and 2006.

Focusing on local attention to and verification of the viability of clean energy businesses contributes to research on the role of institutions in promoting entrepreneurship. Entrepreneurship research highlights the role of entrepreneurs and their social networks in commercializing technologies (Short et al., 2010). However, while inward-looking factors such as the traits and social networks of entrepreneurs themselves have received ample attention, the influence of the external environments in which entrepreneurs are embedded has been relatively understudied (Tolbert et al., 2011). The present study helps to fill this gap by leveraging the clean energy context to identify two important contextual influences on clean energy technology entrepreneurship. At the same time, this study highlights the salience of US states as relevant units of analysis for understanding how differences in institutional environments impact local CETE. It aligns with recent arguments from researchers delving into organizations and the natural environment who have emphasized the importance of jurisdictional differences at sub-national levels as change incubators for sustainable development (Hoffman and Jennings, 2015).

Increased understanding of how the external context influences CETE is also relevant to policy makers concerned with promoting the adoption of clean energy solutions. The importance of technological advance has led governments around the world to implement policy measures aiming to promote the development and diffusion of clean energy. Prominent examples include the provision of subsidies for clean energy research and development and the creation of market demand for such technologies through the use of such policy mechanisms as feed-in-tariffs and renewable portfolio standards. Some policies have been successful in promoting clean energy technology development (Johnstone et al., 2010). However, the results of policy adoption have not everywhere lived up to expectations with respect to the hoped for diffusion of those technologies nor the associated environmental benefits to the energy system (Marcus et al., 2011). Greater attention to the role of external context in promoting CETE necessary to realize societal gains can provide some insights into the reasons for such failures and help to guide future policy initiatives toward where they can have a more meaningful impact.

2. Literature review

2.1. Technological and market opportunities

Entrepreneurship in any domain is contingent on the presence of opportunities that entrepreneurs discover (Eckhardt and Shane, 2003) and transform into realized products and services (Alvarez and Barney, 2007). This process consists of a number of distinct steps (Ardichvili et al., 2003). Entrepreneurs must be aware of both technological potential and market need. They have to identify a match between potential and need and must develop business models to capitalize on that match (Casson, 1982; Eckhardt and Shane, 2003; Shane and Venkataraman, 2000). The existence of clean energy technologies and market opportunities, therefore, are necessary conditions for clean energy technology entrepreneurship to emerge (Shane, 2003). However, such supportive conditions do not exist everywhere to the same extent. In particular, local policy and social conditions can create important differences in the degree to which there are technological and market opportunities across geographic and political boundaries.

The diffusion of technological knowledge tends to be geographically constrained (Jaffe et al., 1993). Because technological entrepreneurship involves incorporating technologies into novel products and services offered by new enterprises, entrepreneurship is more extensive in regions where potentially relevant technologies are more abundant. The benefits of local technological development in promoting local entrepreneurship are well-established (Dosi, 1982; Malerba and Orsenigo, 1997; Siegel et al., 2003, 2004; Van de Ven et al., 1999). Beyond the quantity of locally available technology, the ability to understand that technology is perhaps just as important. Novel technologies often consist of a substantial amount of tacit knowledge. As such, the ability to understand and apply technologies is contingent on the ability to connect with local actors who can transmit this tacit knowledge (Jaffe et al., 1993). Moreover, greater levels of local scientific research help to distinguish between promising and unpromising future research areas (Fleming and Sorenson, 2004), which can further improve the odds of local entrepreneurial success. In short, local knowledge development has the potential to improve the quantity and quality of startup businesses that can develop these technologies into viable enterprises. Accordingly, CETE is likely to be more extensive in the presence of greater technological opportunities.

However, even the most advanced technologies are of little use if potential entrepreneurs are unable to identify customers willing to pay for novel products and services. In the absence of potential markets, entrepreneurs can neither create nor capture value from the provision of new technologies (Teece, 2010). In the case of clean energy technologies, the development of market opportunities is particularly challenging because traditional energy industries and technologies are heavily subsidized. Throughout the value chain, from extraction to production to consumption, fossil fuels receive considerable government support. According to Aldy (2011) subsidies for oil, gas, and coal production activities from the US federal government amount to over US$ 4 billion annually. These and other forms of support for the use of fossil fuels tilt the playing field against clean energy entrepreneurs.

Governments around the world have played an important part in balancing the playing field by creating the markets for clean energy technologies. Legislation intended to provide assistance to US manufacturers producing their own electricity, particularly the Public Utilities Regulatory Policies Act of 1978, created the opening for the emergence of US renewable energy production (Russo, 2001). In the transportation sector, fuel economy standards played a critical role in the use of fuel-efficient technologies (Lee et al., 2011). Policies such as feed-in-tariffs for electricity generated from renewable sources in several European countries and tax credits for wind energy production in the US have been instrumental in creating potential customers for products and services incorporating clean energy technologies. Accordingly, by generating such market opportunities for clean energy technologies these and similar government actions can be expected to increase the extent of local CETE.

The above background suggests that the presence of clean energy technology and market opportunities in the local environment are necessary conditions for CETE. In this sense, the factors supporting CETE align with research on innovation diffusion that emphasizes how factors that promote the development of new technologies and factors that promote the creation of commercial markets for those technologies are both critical components for fostering innovation (Bonaccorsi and Thoma, 2007; Dosi and Nelson, 2010). However, to the extent that entrepreneurship plays a major role in bridging the gap between the development of new technologies and their successful commercial deployment, the presence of technologies and the existence of markets may not be sufficient for promoting adoption and diffusion of clean energy technologies. Attending to how the presence of an external context that is conducive to entrepreneurial activity can explain why (Tolbert et al., 2011). Local attention to clean energy and evidence of clean energy business viability are two particularly salient features of the external context to CETE this study explores.

2.2. Local attention to clean energy issues

Opportunity awareness is an essential feature of the entrepreneurship process of technological development (Alvarez and Barney, 2007;

Shane, 2003). Even if potential entrepreneurs are surrounded by local market and technological opportunities to commercialize clean energy technologies, they will not create viable entrepreneurial firms if they lack awareness of those opportunities. A reason why awareness differs across potential entrepreneurs is the exposure of the entrepreneurs to the relevant information (Kirzner, 1997; Shane, 2000). To develop opportunities, entrepreneurs must recognize previously unseen connections between ideas (Baron, 2006). Scholars have shown that opportunity development is more prominent when potential entrepreneurs possess greater access to information (Siegel and Renko, 2012). Increased exposure to information increases the likelihood that entrepreneurs recognize potentially profitable connections between unrelated ideas. Greater awareness increases their potential for developing opportunities even when entrepreneurs do not actively search for this information (Shane, 2000). Awareness then increases the likelihood that potential entrepreneurs become actual entrepreneurs.

Exposure to information is particularly important in the case of clean energy technology development. Direct experience of potential entrepreneurs with clean energy may be lacking because relevant technologies in this domain often lie outside their everyday activities and awareness (Shane, 2000). Potential entrepreneurs with experience in other technological domains like computer software often are unaware of the clean energy technology opportunities for which their skills may be relevant.

The extent to which information regarding clean energy issues and technologies is part of everyday discourse varies by location. This variance exists for many reasons including the degree of local dependence on fossil fuels, the quality of the local natural environment, and the extent to which local residents prioritize maintaining or improving that quality (Matisoff, 2008). Local media play a critical role in stimulating awareness of new opportunities among market actors (Rindova et al., 2006). Through persistent patterns of selection, emphasis, and interpretation, the media direct awareness and recognition of new opportunities. Besides increasing awareness of new opportunities (Pollock and Rindova, 2003), the flow of media discourse also enhances the movement of information to market participants and supports inferences of quality. The more that media attention to clean energy exposes potential entrepreneurs to information pertaining to opportunities, the more likely they are to perform the critical task of discerning valuable connections between previously unrelated ideas (Baron, 2006). In sum, the positive effect of technological opportunities and market opportunities on clean energy technology entrepreneurship will be augmented when there is greater local attention to clean energy.

2.3. *Evidence of clean energy business viability and clean energy technology entrepreneurship*

Entrepreneurship is an inherently risky endeavor. Successful entrepreneurs must overcome technological and market challenges associated with the commercialization of new technologies (Lazonick, 2007; Van de Ven et al., 1999). Indications that entrepreneurial ventures are capable of surmounting the many challenges are therefore an important influence on entrepreneurship. Local availability of information, expertise, and social and professional networks plays an important role in enabling entrepreneurs to overcome the relevant challenges. The presence of successful local firms commercializing clean energy technologies can help to stimulate CETE by demonstrating that requisite resources are sufficiently available in the local environment and, in so doing, increase the legitimacy of clean energy entrepreneurial business activities (Aldrich and Fiol, 1994). In this sense, the presence of successful local firms commercializing clean energy technologies provides clear evidence that CETE presents a viable entrepreneurial opportunity.

Beyond demonstrating the sufficient local availability of requisite resources, the presence of successful entrepreneurial firms commercializing clean energy also demonstrates the potential for financial rewards. Because the negative financial consequences of failure constitute perhaps the most significant constraint on entrepreneurship, indications that entrepreneurial success can produce financial reward are perhaps the most important form of entrepreneurial business verification. Indeed, the overall extent of entrepreneurial activity in a given location derives in large part from the extent to which the local environment creates the conditions for financial rewards (Baumol, 1990).

Demonstrable prospects for financial success are particularly salient in the case of CETE. Competing with incumbents unconcerned with environmental performance is likely to put entrepreneurs offering clean energy products and services at a cost disadvantage (McWilliams and Siegel, 2001). The potential of a new business to produce financial returns becomes increasingly important as uncertainty surrounding the likelihood of customer acceptance increases (Choi and Shepherd, 2004). As such, the higher costs and lack of discernible, non-environmental, benefits for clean energy technologies are likely to be particularly discouraging for CETE in the absence of successful local firms indicating that clean energy technology businesses are viable.

In sum, the presence of successful local firms indicates not only that ample financial returns are possible but that critical resources such as local information, expertise, and networks are sufficiently available to realize those returns. The positive effects of technological opportunities and market opportunities on clean energy technology entrepreneurship will therefore be augmented when the opportunities are supported by the presence of successful clean energy businesses.

2.4. *Hypotheses derived from the literature review*

Fig. 1 summarizes the following six hypotheses derived from the prior literature:

Hypothesis 1. Clean energy technology entrepreneurship is likely to be more extensive in the presence of greater technological opportunities.

Hypothesis 2. Clean energy technology entrepreneurship is likely to be more extensive in the presence of greater market opportunities.

Hypothesis 3. Increased local attention to clean energy augments the positive effect of technological opportunities on clean energy technology entrepreneurship.

Hypothesis 4. Increased local attention to clean energy augments the positive effect of market opportunities on clean energy technology entrepreneurship.

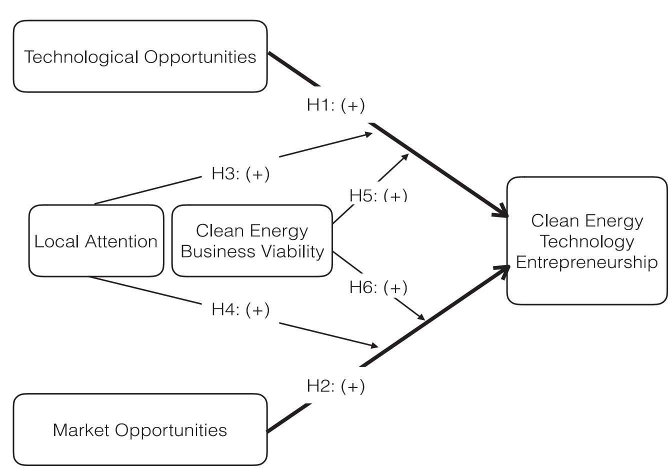

Fig. 1. Moderating effect of local attention to clean energy issues and viability of clean energy business viability on the relationship between technological and market opportunities and clean energy technology entrepreneurship.

Hypothesis 5. Increased evidence of clean energy business viability augments the positive effect of technological opportunities on clean energy technology entrepreneurship.

Hypothesis 6. Increased evidence of clean energy business viability augments the positive effect of market opportunities on clean energy technology entrepreneurship.

3. Methodology

3.1. Sample and variables

The dependent variable of the study is clean energy technology entrepreneurship. This variable is measured by examining venture capital (VC) investment in startup firms developing clean energy technologies. Venture capitalists are sophisticated investors who specialize in being able to identify when entrepreneurs have identified a promising business opportunity by linking a new technology to a potentially substantial market opportunity (Gompers and Lerner, 2001). In order for firms to receive VC support, they must not only possess unique technological capabilities and ideas, they must also demonstrate a potential plan for profitably deploying those ideas in (frequently new) markets. The skills of venture capital investors are therefore particularly relevant to identifying viable startups developing clean energy technologies (Lerner, 2011). The approach this study takes to measuring technology entrepreneurship has been employed in prior studies (Audretsch, 2012) and accords with the Schumpeterian logic whereby *success* in identifying novel combinations of ideas defines entrepreneurial activity (Schumpeter, 1934).

Venture capital investments in firms commercializing environmental technologies are measured using data collected by the Cleantech Group. The Cleantech Group is a private research firm specializing in providing information about firms developing technologies related to environmentally sustainable innovation. The Cleantech Group's emphasis enables identification of specific instances of venture capital investment in clean energy *technology* firms. Its focus is on firms developing technologies related to energy efficiency and renewable energy generation such as wind and solar electricity. For example, the sample includes Miasole, a California-based producer of lightweight and flexible solar cells capable of being used across a range of devices ranging from solar panels to mobile devices. The firm was founded and received its first venture capital investment in 2004. For a period of time it emerged to become a world leader in thin film solar panel efficiency. Another example is Enernoc. Located in Massachusetts, VC investment supported this provider of software to manage energy consumption and demand since its 2003 inception.

Clean energy technology entrepreneurship: is measured as the total number of firms in a state receiving venture capital investment in a given year. Aggregate state-level investment data is used to create a longitudinal dataset of clean energy technology entrepreneurship across the United States between 2000 and 2006. This period coincides with important increases in both policy attention to the challenge posed by climate change as well as entrepreneurial interest in developing clean energy technologies. Accordingly, focusing on this period provides variance in our main independent variables necessary for testing our arguments. The final sample consists of 660 VC investments in clean energy firms spread across 329-state years for 47 US states[1] for which complete data were available.

To measure the level of technology opportunities available to potential clean energy entrepreneurs the study uses patent data. Patents provide a clear and objective indicator of technological activity in a given location and have been used for that purpose in prior studies (e.g. Fleming et al., 2007; Jaffe et al., 1993). The patent data come from the CleanTech PatentEdge database provided by IP Checkups, a private research firm specializing in identifying patents covering technologies that address harmful environmental externalities. Clean energy technology patents are defined as those patents in the CleanTech PatentEdge database granted by the US Patent and Trademark Office that are related to renewable energy and energy efficiency (i.e. the same criteria used to identify clean energy investments).

The set of clean energy technology patents from the CleanTech Patent Edge database is then used to identify clean energy patents in the NBER patent data file provided by the NBER Patent Data Project (Hall et al., 2001). The NBER patent data includes information on the geographic location of each clean energy patent assignee, which is used to ascertain the US state in which the assignee is located. This location data is then aggregated annually at the US state level to create a measure of *Technological Opportunities* defined as the total number of clean energy patents granted in a given year to assignees residing in the state, including public entities such as universities and research institutes, private sector firms and individuals.

Market opportunities are measured by focusing on state level adoption of a renewable portfolio standard (RPS). A state RPS mandates that a set percentage of energy generated or purchased in the state be produced from renewable sources and sets targets for when those levels must be achieved. RPS also stipulate substantial penalties for non-compliant utilities, providing strong indication that the targets they mandate are accurate indicators of not only future market size but when that size will be realized as well. By mandating levels of clean energy production, the adoption of an RPS has been the most practically substantial policy adopted by US states over this time period in terms of influence on market creation (Matisoff, 2008). Moreover, because how production targets will evolve over time is clearly spelled out, they provide more accurate and reliable guidance into potential future market than alternative indicators such as installed renewable energy capacity. This characteristic is likely important to entrepreneurs contemplating the commencement of a clean energy technology commercialization process that is likely to take time to realize. Finally, RPS adoption is also a general indicator of the overall level of state policy support for clean energy market development (Matisoff, 2008). *Market Opportunities* is a dummy variable, set to 1 if the state had adopted an RPS in the given year and 0 otherwise. This measure, varied substantially over the time period of the study. Only 6 states had an RPS in 2001 but this increased to 19 states having adopted a standard by 2006, the final year of the study. Data for RPS come from the office of Energy Efficiency and Renewable Energy of the U.S. Department of Energy.

Local attention to clean energy is captured by referencing local print media, specifically the total number of articles appearing in print publications located within the state in a given year that reference any of a set of terms pertaining to clean energy and which indicate the topic is a primary focus of the article. This measure, *Local Attention*, is the total number of such articles appearing in a year (divided by one thousand to avoid coefficient estimates of zero when reporting results). Data come from the Dow Jones Factiva database.

Evidence of clean energy business viability, *CEB Viability*, is measured as an annual count of the total number of clean energy technology firms based in the state that were acquired by or merged with another firm or that held an initial public offering in a given year. These events indicate that local firms have been successful in commercializing clean energy technologies. These events are also the most prominent means by which entrepreneurial founders obtain the financial rewards that factor into their decision to become entrepreneurs. Accordingly, acquisitions of and IPOs held by local firms provide strong evidence of the viability of CETE to potential clean energy technology entrepreneurs. Data for *CEB Viability* come from the CleanTech Group investment database.

In order to address potentially confounding effects and alternative

[1] The actual number of US states is 46 (all US states except Alaska, Iowa, Montana and New Mexico), however, the District of Columbia is included as a 47th "state." For simplicity, subsequent references to the sample refer to "47 US States".

explanations, five additional variables are included as control in the estimations. The first two control variables address potential confounding affects associated with the time and location of venture capital investment. Venture capital investment tends to be cyclical. Beyond general fluctuations in VC investment levels, VC investing also tends to be characterized by bandwagon effects where VCs become enamored with new and fashionable investment categories (Gompers and Lerner, 1999, 1998). Fashion is important driver of investment in activities, such as clean energy technology development, where information is incomplete and difficult to access, future market conditions are hard to predict, and performance is hard to track (Abrahamson and Fairchild, 1999; Strang and Macy, 2001). Because what is fashionable at one point in time strongly influences what is fashionable in the subsequent period, *Lagged CETE*, controls for the possibility that current levels of interest in clean energy, broadly conceived, influence both opportunities as well as entrepreneurship.

VC investing is a predominantly local activity that varies substantially across regions of the US (Chen et al., 2010). Prospective entrepreneurs are likely to be aware of these local differences. If entrepreneurs believe they possess valuable ideas that will require venture capital to realize their full potential, they may seek to establish their firms in locations where VC financing is more widely available. A measure of the size of the local VC community is included to control for such effects. *State VC* is an annual count of all prior VC investments in the state (from 1990 onward) in sectors other than clean energy. State-level data on VC investment comes from the Thomson One Banker database.

In addition to VC cycles, the availability of financing and interest in establishing new ventures may also track the local economic climate. Two measures of state-level economic activity are therefore included to control for such effects. Change in gross state product (GSP), *GSP Change*, is measured as the percentage change in GSP between the previous and current years. The size of the state economy may influence levels of both the independent and dependent variables. Therefore a measure of *State GDP* in millions of US Dollars is also included. Data for both *State GSP* and *GSP Change* come from the US Bureau of Economic Analysis.

The cost of purchasing electricity in a state may also influence both local entrepreneurship and the extent of entrepreneurial opportunities. O'Rourke (2009) maintains energy prices are a fundamental driver of clean energy technology investments. *Electricity Price* is the average retail price per kilowatt hour (in US Dollars). In her study, she found that VC investments have been related to rising energy prices.

In order to separate the opportunities created by an RPS from existing clean energy opportunities, a control measure for renewable energy generation is included. *RE Generation* is the annual total amount of electricity generated in the state from renewable energy sources (excluding hydro-based energy generation). Data for *Electricity Price* and for *RE Generation* come from the US Energy Information Administration.

Finally, the environment for clean energy in the US as a whole underwent substantial change over the time period of study. Therefore, a set of six dummy variables indicating years 2001–2006 (2000 is the referent year) is included to address variation resulting from time-specific influences common across the US.

3.2. Estimation strategy

The Arellano-Bond dynamic panel general method of moments (GMM) difference estimator (Arellano and Bond, 1991) is employed to evaluate the six hypotheses of the study. This estimator is appropriate for several reasons. First, it addresses potential bias stemming from the inclusion of the lagged dependent variable (*Lagged CETE*) in estimations (Nickell, 1981). *Lagged CETE* acts as a control for any unobserved past state-level influences on current levels of clean energy technology entrepreneurship. Including the lagged dependent variable addresses the possibility that current levels of VC attention to and support for clean energy technology entrepreneurship are influenced by prior-year levels. Including the lagged dependent variable also addresses the possibility that unobservable state-level factors influence other explanatory variables as well as clean energy technology entrepreneurship.

Second, a dynamic panel estimator addresses the possibility that the extent of technological and market opportunities may be endogenously determined by other characteristics of the local environment. The estimator uses a measure of the difference between current and prior year values as instruments for any potentially endogenously-determined explanatory variables. The differencing approach combined with the inclusion of the lagged dependent variable address the problem of potential unobserved state-level heterogeneity. For the present analysis, all available lagged differences (years two through seven) are used as instruments for the lagged dependent variable and the two measures of entrepreneurial opportunities. This addresses the possibility that *Technological Opportunities* and *Market Opportunities* may be endogenous. The robust two-step procedure correcting for panel-specific heteroskedastacity as well as autocorrelation is used (Windmeijer, 2005). Finally, a dynamic panel estimator is also appropriate for panel data sets with relatively few years but many groups, such as the dataset used in the present study which includes 7 years of observation and 47 states (groups).

4. Results

Table 1 reports descriptive statistics and pairwise correlations for all variables used in the analyses. There was substantial variation in the extent of clean energy opportunities and entrepreneurship over the time period of the study. While some states (primarily early in the sample period) had no activity in terms of opportunities or entrepreneurship, both opportunities and entrepreneurship were extensive in other states. For example, although the average state saw approximately 18 clean energy patents granted to local entities, some states saw as many as 241 patents granted, while others saw none.

Results of Arellano-Bond dynamic panel difference GMM analyses are reported in Columns 1–6 of Table 2. Table 2 reports statistics for several tests of the validity of the Arellano-Bond difference GMM estimates. First, as a general rule, the number of instruments used for the potentially endogenous variables should not exceed the number of groups (Roodman, 2009). Table 2 reports that 31 instruments were used in all estimations, comfortably below the maximum threshold of 47 (the number of groups being the 47 US states in the sample). Second, test results indicate that autocorrelation in the error structure is not a problem. The test for second-order, AR(2), autocorellation is not significant. Also insignificant are all Hansen test results for whether the instruments are overidentified, indicating that the use of all sixed lagged differences as instruments is not problematic. An additional Hansen test for the exogeneity of the instruments was not significant for any of the reported estimations. Together these tests support the validity of the instruments used as well as the reliability of the results.

Column 1 of Table 2 reports results of Arellano-Bond dynamic panel difference GMM estimation for a model including the control and moderator variables only. The coefficient estimate for *Lagged CETE* is positive and statistically significant (2.06, significance level $p < 0.05$). As expected, previous levels of VC investment lead to more investment in subsequent periods. Inclusion of a lagged dependent variable typically absorbs a substantial fraction of variance in the remaining explanatory variables. This appears to be the case in the present analysis as none of the other control variables included in Column 1 are statistically significant. Interestingly, the direct effects of both contextual variables (*CEB Viability* and *Local Attention*) are not statistically significant in Columns 1 or 2 of Table 2. This finding that a favorable external context for CETE does not, *by itself*, promote such entrepreneurship is very important.

Table 1
Descriptive statistics and pairwise correlations.

	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8
1. Clean Energy Technology Entrepreneurship	1.426	3.957	0	53	1							
2. Technological Opportunities	20.361	35.463	0	241	0.69	1						
3. Market Opportunities	0.226	0.419	0	1	0.32	0.35	1					
4. Local Attention	0.215	0.311	0	2.854	0.73	0.74	0.31	1				
5. CEB Viability	0.346	1.177	0	11	0.51	0.4	0.24	0.58	1			
6. State VC	656.033	1455.294	1	11,961	0.88	0.83	0.36	0.72	0.41	1		
7. Electricity Price	7.529	2.473	4.17	20.72	0.32	0.41	0.53	0.38	0.23	0.35	1	
8. State GSP	226.198	269.449	17.047	1800.7	0.68	0.91	0.28	0.73	0.44	0.83	0.3	1
9. GSP Change	0.055	0.026	−0.005	0.171	0.03	−0.07	0.09	0	0.1	−0.01	0.05	−0.02

N=329. Table 1 reports means, standard deviations, minimum and maximum values, and pair-wise correlations of dependent and independent variables used in Arellano-Bond dynamic panel difference generalized method of moments (GMM) estimation for CETE in 47 US States observed from 2000 to 2006. Multicollinearity diagnostics reveal a condition number of 15.76 for the dataset, well below the threshold value of 30 where multicollinearity may be problematic (Belsley et al., 1980).

Column 2 tests Hypotheses 1 and 2 by adding to the explanatory variables included in Column 1 the two independent variables: *Technological Opportunities* and *Market Opportunities*. Based on these hypotheses, coefficient estimates for both variables are expected to be positive and significant. As reported in Column 2, the coefficient estimate for *Technological Opportunities* is positive and significant at the ten percent level (coefficient estimate=0.093, significance level $p < 0.1$). Because this effect is only weakly significant statistically speaking, it is important to interpret the practical impact of this result. This can be done by estimating the effect of a one standard deviation increase in *Technological Opportunities* (an increase of 35 clean energy patents in the state) on clean energy technology entrepreneurship. Such an increase would be associated with approximately three additional successful clean energy technology firms in the state. To put this value

Table 2
Results of Arellano-Bond dynamic panel difference GMM estimation of clean energy technology entrepreneurship on technological and market opportunities.

Hypothesis Tested→	1	2 H1/H2	3 H3	4 H4	5 H5	6 H6
Lagged CETE	2.0557*	1.7625	1.4304	1.1482	0.8546	1.5931
	(0.999)	(1.572)	(1.114)	(0.832)	(0.899)	(1.686)
Technological opportunities **(H1)**		0.1237†	0.0930†	0.1152	0.1605*	0.1194
		(0.071)	(0.052)	(0.080)	(0.075)	(0.077)
Market opportunities **(H2)**		−0.0996	−0.5686	−1.0436	−0.9772	−0.7867
		(3.803)	(1.945)	(2.051)	(1.772)	(4.250)
CEB viability	−0.0163	0.0343	−0.048	−0.0024	−0.824	−0.4822
	(0.431)	(0.459)	(0.447)	(0.205)	(0.631)	(1.424)
Local attention	−0.3765	−0.8697	−7.6172†	−4.0998	−0.0928	−0.571
	(0.003)	(3.012)	(4.590)	(3.463)	(3.470)	(3.218)
State VC	−0.0016	−0.0005	0.0005	0.0002	0.0016	0.0000
	(0.002)	(0.004)	(0.003)	(0.002)	(0.002)	(0.005)
Electricity price	0.0197	−0.2386	−0.2746	−0.473	−0.3857	−0.5655
	(0.299)	(0.639)	(0.255)	(0.373)	(0.253)	(1.150)
State GSP	0.0044	−0.016	−0.0137	−0.014	−0.0257*	−0.0155
	(0.010)	(0.016)	(0.013)	(0.018)	(0.012)	(0.021)
GSP change	−4.7216	1.7327	−1.1081	1.1894	4.2993	4.4812
	(6.656)	(13.387)	(6.788)	(7.165)	(6.075)	(13.608)
Technological opportunities×local attention **(H3)**			0.0492**			
			(0.018)			
Market opportunities×local attention **(H4)**				6.2999**		
				(2.152)		
Technological opportunities×CEB viability **(H5)**					0.0101*	
					(0.004)	
Market opportunities×CEB viability **(H6)**						0.6817
						(0.965)
Constant	−0.3912	2.6368	3.4359*	4.4185*	4.1963*	4.6124
	(1.428)	(3.651)	(1.601)	(2.247)	(1.629)	(6.412)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	329	329	329	329	329	329
Number of states	47	47	47	47	47	47
R-squared	0.609	0.632	0.723	0.680	0.615	0.640
Number of Instruments	31	31	31	31	31	31
AR(1)	−2.16	−1.43	−1.35	−1.78	−1.82	−1.8
AR(2)	1.37	1.24	1.14	1.18	0.92	1.26
Hansen test overidentification	17.34	16.15	16.1	8.93	10.13	6.59
Hansen test of instrument exogeneity	8.27	8.05	8.61	4.38	5.65	6.1

Columns 1–6 of Table 2 report coefficient estimates, standard errors (in parentheses) and related output from Arellano-Bond dynamic panel difference generalized method of moments (GMM) estimation for CETE in 47 US States observed from 2000 to 2006. Post-estimation assessment of instrument exogeneity is based on a Hansen test rejecting the null hypothesis of instrument exogeneity as a group. Post-estimation assessment of second-order autocorrelation is based on the Arellano–Bond (AB) test rejecting the null hypothesis of no second-order autocorrelation. Neither the Hansen test null hypothesis of group exogeneity for instruments generated, nor the null hypothesis of no second-order autocorrelation are rejected.

* $p < 0.05$.
† $p < 0.10$.
** $p < 0.01$.

in perspective, the sample mean level of new clean energy technology firms is approximately 1.4 such firms in a state per year. Accordingly, a one standard deviation increase in *Technological Opportunities* would triple the level of clean energy technology entrepreneurship in an average state. Thus Hypothesis 1 is supported. By contrast, the coefficient estimate *Market Opportunities* is not statistically significant (significance level p=0.979). Adopting an RPS does not, by itself, encourage potential entrepreneurs to develop new clean energy technology businesses. Hypothesis 2 is not supported.

The fact that the presence of market opportunities is not, by itself, a sufficient condition for CETE suggests the importance of considering other external factors that might work in conjunction with market as well as technological opportunities to influence levels of CETE. Considering other external factors is precisely the purpose of the remaining estimations reported in Columns 3–6 of Table 2. Hypotheses 3–6 imply that the effects of technological and market opportunities on CETE will be stronger where the local context is more supportive of such entrepreneurial activity as indicated by local attention to clean energy issues and evidence of the viability of clean energy businesses. The four estimations reported in Columns 3–6 of Table 2 report results of Arellano-Bond dynamic panel difference GMM estimations identical to those used to produce the results in Column 2, with the sole difference being that each estimation includes one of four different interaction terms that capture the moderating effects of *Local Attention* and *CEB Viability* on the two types of entrepreneurial opportunities, *Technological Opportunities* and *Market Opportunities*, respectively. Determining the extent to which the external context influences CETE requires attending to whether the coefficient estimates for each of these four interaction terms are both statistically significant as well as practically meaningful.

According to Hypothesis 3, the positive effect of technological opportunities on CETE will be stronger where there is more extensive local attention to clean energy issues. Tests of this hypothesis are conducted by including a term representing the interaction between *Technological Opportunities* and *Local Attention* (*Technological Opportunities x Local Attention*) in the estimates reported in Column 3 of Table 2. The coefficient estimate for this interaction term is positive and statistically significant (coefficient estimate=0.049, significance level $p < 0.01$). This results provides statistical support for the argument of Hypothesis 3 that the positive effect of technological opportunities on CETE is stronger in those states where there is greater local attention to clean energy issues.

A meaningful technique to interpret whether this result is practically meaningful is to compare the effect of a one standard deviation increase in *Technological Opportunities* across states with high and low levels, respectively, of local attention to clean energy. In a state with *low* levels of *Local Attention* (defined as a state with zero articles addressing clean energy) a one standard deviation increase in *Technological Opportunities* (that is, an increase of 35 clean energy patents) would be associated with three additional VC investments in entrepreneurial clean energy technology firms. However, the same, one standard deviation increase in *Technological Opportunities* is substantially stronger in states with *high* levels of local attention. Defining a high level of *Local Attention* as 558 articles on clean energy (i.e. roughly the 90th percentile level of *Local Attention* for the sample), a one standard deviation increase in *Technological Opportunities*, would lead to more than four additional instances of CETE. In other words, the effect of *Technological Opportunities* is 33% stronger in states where there is more extensive local attention to clean energy issues. Taken together, the results reported in Column 3 provide statistical support for Hypothesis 3 while also demonstrating that this effect is practically meaningful.

Hypothesis 4 implies that more extensive local attention to clean energy will also strengthen the positive effect of *Market Opportunities* on CETE. Results of empirical testing of Hypothesis 4 are reported in Column 4 of Table 2. Here, the coefficient on the interaction term between *Market Opportunities* and *Local Attention* (*Market Opportunities×Local Attention*) is positive and statistically significant (coefficient estimate=6.299, significance level $p < 0.01$). The moderating effect of *Local Attention* on *Market Opportunities* is also practically meaningful. In a state at the sample mean level of local attention to clean energy (215 articles), the adoption of an RPS has essentially no effect on increased clean energy technology entrepreneurship. However, in a state where local attention to clean energy is strong (i.e. a state with 558 articles, again roughly the 90th percentile level of clean energy articles for the sample) the adoption of an RPS would be predicted to produce an additional two entrepreneurial firms in the state. Compared to the sample mean level of CETE of 1.4 new clean energy technology firms annually per state, an increase of two firms would constitute a practically meaningful increase in CETE. Accordingly, the results reported in Column 4 of Table 2 indicate support for Hypothesis 4.

Column 5 of Table 2 reports results for empirical tests of Hypothesis 5. Here, the coefficient estimate for the interaction term representing the moderating effect of *CEB Viability* on *Technological Opportunities* (*CEB Viability×Technological Opportunities*) is positive and statistically significant (coefficient estimate=0.010, significance level $p < 0.05$). Whether this result is practically meaningful can again be interpreted by examining the effect of a one standard deviation increase in *Technological Opportunities* on *Clean Energy Technology Entrepreneurship* in states with high and low levels of *CEB Viability*. In a state with *low CEB Viability* (defined as zero mergers, acquisitions and IPOs involving clean energy firms based in the state) a one standard deviation increase in *Technological Opportunities* (again an increase of 35 patents) is associated with less than six additional instances of CETE. By contrast, the same (35 patent) increase is associated with nearly 7 additional cases of CETE in states with *high* levels of *CEB Viability* (defined as three mergers, acquisitions and IPOs, approximately the 90th percentile of the distribution for *CEB Viability*). These results indicate that the positive effect of technological opportunities on CETE is stronger (roughly 17% stronger in the above example) in those states where CEB Viability is more firmly established, in line with Hypothesis 5.

Hypothesis 6 is not supported. The interaction term representing the moderating effect of *CEB Viability* on *Market Opportunities* (*CEB Viability×Market Opportunities*), reported in Column 6 of Table 2, is not statistically significant at commonly accepted levels (coefficient estimate=0.6817, significance level p=0.480). Thus empirical tests provide no evidence that the effect of market opportunities is stronger in locations where the viability of clean energy businesses is more clearly apparent.

5. Conclusions and policy implications

This study examined how the external environment in which entrepreneurs operate influences clean energy technology entrepreneurship. Empirical investigation of entrepreneurial firms developing clean energy technologies in US states revealed that more extensive technological opportunities, measured as local clean energy technology patenting activity, increased clean energy technology entrepreneurship. This positive effect was magnified in states where attention to clean energy, measured as the number of local print media articles addressing clean energy, was more substantial and where there were more successful local firms commercializing clean energy technologies, that is, local firms that underwent acquisition or held an IPO. Market opportunities, in the form of a state-level renewable portfolio standard, also promoted CETE, but only where the local environment was attentive to clean energy issues.

These findings build upon and extend prior research into clean energy technology entrepreneurship. Previous studies have emphasized the importance of social forces in the local environment in promoting the establishment of clean energy businesses, such as green building developers or wind farm operators (e.g. Sine and Lee, 2009; York and Lenox, 2013). The present study provides evidence about the extent to which such social forces drive local attention to clean energy issues that become the focus of local media discussion. By documenting evidence that local priorities motivate clean energy *technology* entrepreneurship specifically, as opposed less technologically oriented clean energy entrepreneurship generally, the present study contributes to this stream of research by refining the domain of entrepreneurial research with respect to clean energy. This study documents the importance of socioeconomic factors as well, namely the role that success among local clean energy technology firms plays in encouraging CETE. Such demonstrable instances of commercial success are particularly important in the context of CETE, given the extensive business and technological risks involved in creating such markets.

The study's findings contribute to research on the role of policies that promote technology development and market creation in supporting innovation. Researchers generally agree that "technology push" and "market pull" are both necessary elements of technological advancement (Bonaccorsi and Thoma, 2007; Dosi and Nelson, 2010; Mowery and Rosenberg, 1979). Both are critical in the context of diffusing clean energy technologies that must compete with fossil fuel-based alternatives that do not fully internalize the costs of the harmful environmental externalities they generate. In various political jurisdictions, government policies have helped to create market conditions that incentivize the development of clean energy technologies (Burer and Wustenhagen, 2009). Government policies have also promoted the development of scientific knowledge upon which such technologies are based (Jaffe et al., 2005; Johnstone et al., 2010). Nonetheless, results of such policy initiatives have not at all times and in all places lived up to expectations (Marcus et al., 2011). Our results provide a possible explanation for why. Attention must be paid to the role entrepreneurs play in connecting technologies to markets and bringing about their adoption and not only on the provision of subsidies for clean energy technology R & D and the creation of market incentives such as feed-in-tariffs (Ardichvili et al., 2003; Schumpeter, 1934). For new energy technologies to gain widespread acceptance and adoption, CETE is needed in response to government action (Teece, 2010; Van de Ven et al., 1999).

To the extent that CETE poses a constraint on the effectiveness of policy instruments, results of the study hold implications for government officials. We found that an RPS does not, by itself, precipitate increased CETE. It also requires favorable conditions in the external environment, specifically substantial local attention to clean energy. Similarly, we found that the effect of government induced technological opportunities in promoting CETE was stronger when local attention to clean energy was more pronounced and there were more successful local clean energy startups. The implication is that governments concerned with promoting the adoption and diffusion of clean energy technologies should consider how the external entrepreneurial context, specifically local attention to clean energy and successful local clean energy startups, stimulate clean energy entrepreneurial activity.

Policy makers interested in encouraging the incorporation of cutting edge clean energy technologies into new products and services are likely to be more effective if they can bolster these conditions that support local clean energy technology entrepreneurship in addition to providing a supportive policy environment. If local conditions are not sufficiently supportive, the best policies that government officials devise to create new clean energy opportunities are unlikely to realize their full potential. Directing efforts toward enhancing the external environment by increasing the amount of attention devoted to clean energy and encouraging clean energy startup success therefore are important complementary activities for governments to carry out in order to promote the diffusion of novel clean energy technologies.

Governments can focus on generating the publicity needed to create clean energy awareness as this aspect of the external environment is one they can productively influence. While it is difficult for public officials to promote the success of specific local businesses, generating public interest in clean energy through active public relations campaigns that, for example, land articles in newspapers is a task governments can reasonably carry out. Promoting media attention to clean energy is a role that is often not adequately considered in the policy recommendations on what it takes to build new business clusters of entrepreneurial firms. By contrast, tax credits and economic tools or coercive command and control policies tend to get the most mention. Our findings therefore are important in that they highlight this crucial role that the government can play in building awareness through active public relations efforts that improve the context in which entrepreneurial activity in clean energy is played out.

The fact that policy works in conjunction with a supportive external environment is important to policy makers for another reason. Generating public support for new policies that promote clean energy remains a challenge. To justify the costs of such policies and to overcome opposition from the purveyors of conventional energy is not easy. Public officials often tout jobs and economic development (Anadon, 2012). Results of this study provide some empirical support for such contentions by demonstrating the importance of policy initiatives in promoting the emergence of new clean energy technology firms. The emergence of such firms can support local economic growth as well as the development of industrial clusters based on clean energy (Pitelis, 2012; Spencer et al., 2010). However, our study suggests that new clean energy technology firms are unlikely to emerge in locations where government does not promote the development of technology and market opportunities with supportive policy. Neither of the study's external contextual variables (*CEB Viability* and *Local Attention*) were statistically significant in terms of their direct effects on CETE. That is, a supportive external context does not, by itself, support CETE. Government policy is also necessary. In this light, results of this study highlight the role of policy in creating local economic "wins" that are essential to maintaining public support for government action promoting clean energy.

This study also has implications for potential entrepreneurs considering establishing new businesses focused on development of new products and services incorporating clean energy technologies. Understanding the combinatorial effects of policy support for clean energy and a munificent local entrepreneurial context can guide potential entrepreneurs as to where new industries and industrial clusters based around clean energy technology are likely to emerge. Knowing where jurisdictional advantages for the location of business activities may lie is advantageous for prospective entrepreneurs (Feldman and Martin, 2005). Such advantages are even more pronounced for firms in emerging industries, such as those based on clean energy technologies, that are more fragile as a result of their inherent newness (Aldrich and Fiol, 1994).

The evidence documented in this study suggests that the entrepreneurial pursuit of clean energy technology development is contingent upon both the presence of government induced opportunities and supportive external conditions. Should the opportunities dry up, the local population lose interest in clean energy, or newly established firms run into headwinds from an increasingly challenging business environment, the desire among potential entrepreneurs to turn opportunities into viable clean energy businesses will recede. Thus, policy makers face difficult challenges beyond simply providing support for technology development or market creation (Wustenhagen and Bilharz, 2006). While the adoption of these policies constitutes a critical first step, it also is necessary to maintain public interest in clean technology businesses and to reinforce this interest through the encouragement of entrepreneurial success.

References

Abrahamson, E., Fairchild, G., 1999. Management fashion: lifecycles, triggers, and collective learning processes. Adm. Sci. Quart. 44, 708–740.

Aldrich, H.E., Fiol, C.M., 1994. Fools Rush in - the institutional context of industry creation. Acad. Manag. Rev. 19, 645–670.
Aldy, J., 2011. Promoting Clean Energy in the American Power Sector, Hamilton Project. Brookings Institution, Washington, DC.
Alvarez, S.A., Barney, J.B., 2007. Discovery and creation: alternative theories of entrepreneurial action. Strateg Entrep. J. 1, 11–26.
Anadon, L.D., 2012. Missions-oriented RD & D institutions in energy between 2000 and 2010: a comparative analysis of China, the United Kingdom, and the United States. Res. Policy 41, 1742–1756.
Ardichvili, A., Cardozo, R., Ray, S., 2003. A theory of entrepreneurial opportunity identification and development. J. Bus. Ventur. 18, 105–123.
Arellano, M., Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev. Econ. Stud. 58, 277–297.
Audretsch, D., 2012. Entrepreneurship research. Manag. Decis. 50, 755–764.
Baron, R.A., 2006. Opportunity recognition as pattern recognition: how entrepreneurs "connect the dots" to identify new business opportunities. Acad. Manag. Perspect. 20, 104–119.
Baumol, W.J., 1990. Entrepreneurship - productive, unproductive, and destructive. J. Polit. Econ. 98, 893–921.
Belsley, D.A., Kuh, E., Welsch, R.E., 1980. Regression Diagnostics: Identifying influential Observations and Sources of Collinearity. John Wiley and Sons, New York.
Bonaccorsi, A., Thoma, G., 2007. Institutional complementarity and inventive performance in nano science and technology. Res. Policy 36, 813–831.
Burer, M.J., Wustenhagen, R., 2009. Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international cleantech investors. Energy Policy 37, 4997–5006.
Casson, M., 1982. The Entrepreneur: An Economic Theory. Barnes & Noble Books, Totowa, N.J.
Chen, H., Gompers, P., Kovner, A., Lerner, J., 2010. Buy local? The geography of venture capital. J. Urban Econ. 67, 90–102.
Choi, Y.R., Shepherd, D.A., 2004. Entrepreneurs' decisions to exploit opportunities. J. Manag. 30, 377–395.
Dosi, G., 1982. Technological paradigms and technological trajectories - a suggested interpretation of the Determinants and directions of technical change. Res. Policy 11, 147–162.
Dosi, G., Nelson, R.R., 2010. Technical change and industrial dynamics as evolutionary processes. Handb. Econ. Innov. 1, 51–127.
Eckhardt, J.T., Shane, S.A., 2003. Opportunities and entrepreneurship. J. Manag. 29, 333–349.
Feldman, M., Martin, R., 2005. Constructing jurisdictional advantage. Res. Policy 34, 1235–1249.
Fleming, L., Sorenson, O., 2004. Science as a map in technological search. Strateg. Manag. J. 25, 909–928.
Fleming, L., King, C., Juda, A., 2007. Small worlds and regional innovation. Organ Sci. 18, 938–954.
Gompers, P., Lerner, J., 1999. The Venture Capital Cycle. MIT Press, Cambridge, MA.
Gompers, P., Lerner, J., 2001. The venture capital revolution. J. Econ. Perspect. 15, 145–168.
Gompers, P.A., Lerner, J., 1998. What drives venture capital fundraising. Brook. Pap. Econ. Act., 149–204.
Hall, B.H., Jaffe, A.B., Trajtenberg, M., 2001. The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools. National Bureau of Economic Research, Cambridge, MA.
Hoffman, A.J., Jennings, P.D., 2015. Institutional theory and the natural environment: research in (and on) the Anthropocene. Organ Environ. 28, 8–31.
Jaffe, A.B., Trajtenberg, M., Henderson, R., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. Q. J. Econ. 108, 577–598.
Jaffe, A.B., Newell, R.G., Stavins, R.N., 2005. A tale of two market failures: technology and environmental policy. Ecol. Econ. 54, 164–174.
Johnstone, N., Hascic, I., Popp, D., 2010. Renewable energy policies and technological innovation: evidence based on patent counts. Environ. Resour. Econ. 45, 133–155.
Kirzner, I.M., 1997. Entrepreneurial discovery and the competitive market process: an Austrian approach. J. Econ. Lit. 35, 60–85.
Lazonick, W., 2007. The US stock market and the governance of innovative enterprise. Ind. Corp. Change 16, 983–1035.
Lee, J., Veloso, F.M., Hounshell, D.A., 2011. Linking induced technological change, and environmental regulation: evidence from patenting in the US auto industry. Res. Policy 40, 1240–1252.
Lerner, J., 2011. Venture capital and innovation in energy. In: Henderson, R., Newell, R.G. (Eds.), Accelerating Energy Innovation: Insights from Multiple Sectors. University of Chicago Press, Chicago, IL, 225–260.
Malerba, F., Orsenigo, L., 1997. Technological regimes and sectoral patterns of innovative activities. Ind. Corp. Change 6, 83–118.
Marcus, A.A., 2015. Innovations in Sustainability: Fuel and Food. Cambridge University Press, Cambridge, U.K.
Marcus, A.A., Aragon-Correa, J.A., Pinkse, J., 2011. Firms, regulatory uncertainty, and the natural environment. Calif. Manag. Rev. 54, 5–16.
Matisoff, D.C., 2008. The adoption of state climate change policies and renewable portfolio standards: regional diffusion or internal determinants? Rev. Policy Res. 25, 527–546.
McWilliams, A., Siegel, D., 2001. Corporate social responsibility: a theory of the firm perspective. Acad. Manag. Rev. 26, 117–127.
Mowery, D., Rosenberg, N., 1979. The influence of market demand upon innovation: a critical review of some recent empirical studies. Res. Policy 8, 102–153.
Nickell, S., 1981. Biases in dynamic models with fixed effects. Économ.: J. Econom. Soc., 1417–1426.
O'Rourke, A., 2009. The Emergence of Cleantech. Yale University, New Haven, CT.
Pitelis, C., 2012. Clusters, entrepreneurial ecosystem co-creation, and appropriability: a conceptual framework. Ind. Corp. Change, dts008.
Pollock, T.G., Rindova, V.P., 2003. Media legitimation effects in the market for initial public offerings. Acad. Manag. J. 46, 631–642.
Rindova, V.P., Pollock, T.G., Hayward, M.L., 2006. Celebrity firms: the social construction of market popularity. Acad. Manag. Rev. 31, 50–71.
Roodman, D., 2009. How to do xtabond2: an introduction to difference and system GMM in Stata. Stata J. 9, 86–136.
Russo, M.V., 2001. Institutions, exchange relations, and the emergence of new fields: Regulatory policies and independent power production in America, 1978–1992. Adm. Sci. Quart. 46, 57–86.
Schumpeter, J.A., 1934. The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle. Transaction Books, New Brunswick, N.J.
Shane, S., 2000. Prior knowledge and the discovery of entrepreneurial opportunities. Organ Sci. 11, 448–469.
Shane, S., 2003. A General Theory of Entrepreneurship. The Individual-opportunity Nexus. Edward Elgar, Northampton, MA.
Shane, S., Venkataraman, S., 2000. The promise of entrepreneurship as a field of research. Acad. Manag. Rev. 25, 217–226.
Short, J.C., Ketchen, D.J., Shook, C.L., Ireland, R.D., 2010. The concept of "opportunity" in entrepreneurship research: past accomplishments and future challenges. J. Manag. 36, 40–65.
Siegel, D.S., Renko, M., 2012. The role of market and technological knowledge in recognizing entrepreneurial opportunities. Manag. Decis. 50, 797–816.
Siegel, D.S., Waldman, D., Link, A., 2003. Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. Res. Policy 32, 27–48.
Siegel, D.S., Waldman, D.A., Atwater, L.E., Link, A.N., 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. J. Eng. Technol. Manag. 21, 115–142.
Sine, W.D., Lee, B.H., 2009. Tilting at Windmills? The environmental movement and the emergence of the US wind energy sector. Adm. Sci. Quart. 54, 123–155.
Spencer, G.M., Vinodrai, T., Gertler, M.S., Wolfe, D.A., 2010. Do clusters make a difference? Defining and assessing their economic performance. Reg. Stud. 44, 697–715.
Strang, D., Macy, M.W., 2001. In search of excellence: fads, success stories, and adaptive emulation. Am. J. Socio. 107, 147–182.
Teece, D.J., 2010. Business models, business strategy and innovation. Long Range Plan. 43, 172–194.
Tolbert, P.S., David, R.J., Sine, W.D., 2011. Studying choice and change: the intersection of institutional theory and entrepreneurship research. Organ Sci. 22, 1332–1344.
Van de Ven, A.H., Polley, D.E., Garud, R., Venkataraman, S., 1999. The Innovation Journey. Oxford University Press, New York.
Venkataraman, S., 1997. The distinctive domain of entrepreneurship research: an editor's perspective. In: Katz, J., Borckhaus, R. (Eds.), Advances in Entrepreneurship, Firm Emergence and Growth. JAI Press, Greenwich, CT, 119–138.
Windmeijer, F., 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. J. Econ. 126, 25–51.
Wustenhagen, R., Bilharz, M., 2006. Green energy market development in Germany: effective public policy and emerging customer demand. Energy Policy 34, 1681–1696.
York, J.G., Lenox, M.J., 2013. Exploring the sociocultural determinants of de novo versus de alio entry in emerging industries. Strateg. Manag. J. 35, 1930–1951.