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Municipal demand-side policy tools and the strategic management of technology life cycles

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ABSTRACT

This research is particularly concerned with public policy instruments which may help to accelerate the development and diffusion of sustainable innovations and support local economic development. While sustainable technology sectors are in high demand, firms still face significant barriers in developing and diffusing their technologies in regions throughout the world (Hoff, 2012). This area has been less explored in the extant research yet recent experiences suggest that supply side tools may not always have positive benefits for supporting clean technology evolution, or for taxpayers. Leveraging innovation policy and technology life cycle literature, we develop a model of demand-side policy instruments which could be applied at different stages of the technology s-curve in order to accelerate the adoption of sustainable technologies. Implications for managers, public policy actors and researchers are considered.

1. Introduction

This research is concerned with public policy instruments which may help to accelerate the development and diffusion of sustainable innovations (for example clean technologies) and support local economic development. Leveraging extant research on innovation policy and the diffusion of innovation, this work seeks to extend current understanding regarding the potential role for demand-side policy in stimulating local sustainable innovation. Aside from the contribution to theory extension, the results of this research generate insights for local government policymakers and for sustainable technology practitioners. This research suggests that different demand-side policy tools may be more impactful in influencing the development and eventual diffusion of sustainable innovation depending on the life cycle of the technology.

Rogers (1962) seminal work introducing a five-step process for the diffusion of innovation has survived more than 50 years of academic scrutiny. A vast research tradition in technology life cycles has been developed over the decades since Rogers (1962) presented the s-curve trajectory of diffusion of innovations. Within the management and technology literature, diffusion of innovation has been explored from a variety of perspectives ranging from marketing and new product development (Henard and Szymanski, 2001) to technology strategy development (Kim, 2003).

In the past few decades public policy scholars have also begun to explore the application of diffusion of innovation to the public realm. In most cases this research has focused on the diffusion of policy innovation (e.g. Mintrom, 1997; Hays and Glick, 1997). In recent decades, scholars have also sought to explore what role government policy can have in stimulating private sector innovation (Kneese and Schultze, 1978; Parry, 1998). The majority of the research in this area, conducted by public policy, management and technology scholars, has focused on the potential role for supply side policies to stimulate local economic development. Yet the extant research has been inconclusive with respect to the impacts supply-side tools such as technology parks, incubators and government grants have had on local economic development and job growth (Audretsch et al., 2008; Capelleras et al., 2008; Storey, 2005).

While sustainable technology sectors are in high demand, firms still face significant barriers in developing and diffusing their technologies in regions throughout the world (Hoff, 2012). This area has been less explored in the extant research yet recent experiences suggest that supply side tools may not always have positive benefits for supporting clean technology evolution, or for taxpayers. A recent, high profile failure of a supply-side intervention was the U.S. government's support of Solyndra, a solar technology company based in California. As part of the American Recovery and Investment Act, the U.S. developed a Clean Energy Package worth $90 billion in combined public spending and tax expenditures. The program's support of Solyndra through a series of low-interest loans, cost the U.S. taxpayers $500 million and left pie on the face of the program's administrators and President

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Obama as well. “The federal clean-energy loan guarantee program that gave you Solyndra wasn’t just a multibillion-dollar political debacle – it also didn’t create jobs, didn’t reduce carbon emissions and ran up financial risk for taxpayers.” (Tankersley, 2013).

In light of the mixed results for supply-side tools in promoting sustainable local economic development, the objective of this research is to develop a conceptual framework that helps to understand how local governments might develop demand-side policy tools that stimulate the development and diffusion of sustainable-driven innovations that enhance local economic development.

In the area of sustainable development, municipalities are increasingly becoming a focal point as an alternative to the perceived failure of national governments and multi-lateral efforts to mitigate global environmental challenges such as climate change (Rosenzweig et al., 2011). Cities are on the front line when it comes to major weather events, flooding and effects of climate change. Cities represent only 2% of the earth's surface but represent more than 50% of the world's population and nearly 80% of the world's energy consumption and carbon emissions (Lovins and Cohen, 2011).

As cities continue to experience increased migration from rural areas, they can become major engines of economic growth that spill over to the region (Venkataraman, 2004) and to other cities (Jacobs, 1984). While innovation in municipalities has been the domain of public policy scholars (e.g., Ihrke et al., 2003; Bartlett and Dibben, 2002), we argue here that the role of municipalities in providing the enabling conditions for private sector innovation should also be within the domain of the innovation and technology literature, where there is a dearth of research exploring how local governments such as municipalities foster, support and aid in the creation and diffusion of innovation opportunities (Lember et al., 2011).

This research explores three distinct demand-side tools: (1) procurement, (2) voluntary standards and incentives, and (3) regulations in the context of technology life cycles (Kim, 2003) providing a model for conceptualizing the utility of these different instruments and their technology objectives to achieve a municipal sustainability agenda, and how this agenda can be aligned with private sector business.

The rest of the manuscript is structured as follows: we provide a summary of innovation policy with a focus on supply and demand-side policy tools. We then provide an in-depth analysis of three demand-side policy tools which have the potential to support sustainable technology development and diffusion. Next we develop a model based in the technology life-cycle literature which explores the relationship between those three demand-side tools, procurement for innovation, voluntary standards and regulation, and private sector innovation throughout the life-cycle of new sustainable technology. By integrating innovation policy and technology life cycle theories, the model we have developed supports further theoretical understanding of the role for demand-side innovation policy in the development and diffusion of new technologies.

2. Different approach of innovation policy: supply-side versus demand-side policy.

Extant research has been inconclusive in regards to how and under what circumstances governments can positively influence innovation and entrepreneurship activity (Dolfsma and Seo, 2013; Parker, 2007; Capelleras et al., 2008; Shane, 2009). Innovation policy is concerned with promoting the development and diffusion of new products and services (Lundvall and Borras, 1999) and to support local economic and societal development.

A useful lens to explore innovation policy is to distinguish between supply-side and demand-side instruments. In the 1990s public policy scholars began exploring the relationship of public policy entrepreneurs and the diffusion of policy innovation (Mintrom, 1997; Hays and Glick, 1997). Yet only recently have researchers begun to explore the differential impacts of supply-side versus demand-side innovation policy on job creation (Kandil, 2009) and the development of technology innovations (Edler and Georghiou, 2007). Below we provide a review of the extant literature related to innovation policy and technology diffusion. Later we construct a model to explore how different demand-side policy tools might be used, in collaboration with the private sector, across the s-curve for supporting the development and diffusion of sustainable innovation.

2.1. Supply side innovation policy

Research on the effects of prevailing supply-side tools has shown mixed results with respect to desired outcomes of job growth and stimulating local economic development. Existing research on the municipal role in stimulating innovation has primarily focused on supply-side policy tools such as tax breaks, grants and technology parks creation (e.g., Edler and Georghiou, 2007). Unfortunately researchers have found that in many cases these tools have failed to achieve the desired innovation and economic development objectives.

Tamasy, 2007, illustrated results suggesting that incubators have primarily failed instruments for stimulating local innovation and economic development. Neck et al. (2004) demonstrated through a review of prior initiatives that many if not most planned silicon valley replications fail to live up to expectations. Through a study of the Boulder, Colorado ecosystem, Neck et al. (2004) found that numerous factors such as the quality of life, quality of local research universities, the presence of large technology firms and others all have an impact on the development of local technology ecosystems and that some of these factors are difficult if not impossible for innovation policy to influence.

A recent, high profile failure of a supply-side intervention was the U.S. government's support of Solyndra, a solar technology company based in California. As part of the American Recovery and Investment Act, the U.S. developed a Clean Energy Package worth $90 billion in combined public spending and tax expenditures. The program's support of Solyndra through a series of low-interest loans, cost the U.S. taxpayers $500 million and left pie on the face of the program's administrators and President Obama as well. “The federal clean-energy loan guarantee program that gave you Solyndra wasn’t just a multibillion-dollar political debacle – it also didn’t create jobs, didn’t reduce carbon emissions and ran up financial risk for taxpayers.” (Tankersley, 2013).

Reviewing the mixed results in the literature, it is far from certain that supply-side tools are successful in facilitating sustainable local economic development. The strategic and smart use of public funds for stimulating innovation and sustainable local economic development is critical. The mixed results on supply-side tools suggests that research and policy makers may need to explore alternative approaches in order to obtain the desired results of increased sustainable local economic development and enabling the growth of a local sustainable and clean technology sector.

2.2. Demand side innovation policy and sustainable development

In the face of fiscal and political pressures, governments tend to rely on macroeconomic policies (e.g., monetary and fiscal policy), framework conditions (e.g., competition, tax or entrepreneurship policies) and to support market demand. In order to address

market and system failures in areas in which social needs are pressing, nations and regions have increasingly been turning to demand-side instruments (OECD Publishing, 2011). Demand-side innovation policy is defined as "all public measures to induce innovations and/or speed up diffusion of innovations through increasing the demand for innovations, defining new functional requirement for products and services or better articulating demand" (Edler and Georghiou, 2007, 952).

Lessons learned from the U.S. Clean Energy Package provide anecdotal support for the potential of demand-side innovation policy to support sustainable innovation and economic development objectives. Disputing Tankersley (2013) prior critique, Aldy (2013) found that the U.S. Clean Energy Package yielded nearly 720,000 clean energy jobs primarily in the areas of energy efficiency (179,000), renewable energy generation (192,900) and transit (158,200). The Package was also estimated to have generated $100 billion in private investment and led to the installation of more than 12,000 MW of renewable energy generation capacity (Aldy, 2013). Interestingly, Aldy (2013) notes that the grant program which provided subsidies for new renewable energy capacity (a demand-side approach) was substantially more effective than the loan guarantee program which focused on supporting clean technology development (a supply-side tool) which was employed in the Solyndra case.

Comparing innovation data in 15 countries in the European Union, Tokumasu and Watanabe (2008) found evidence suggesting institutions should focus more attention on demand-side instruments in order to further induce technology innovation. Further evidence was provided by a study of innovations commercialized in Finland between 1984 and 1998 where public procurement or regulation (public demand-side instruments) drove 48% of the successful innovations (Palmberg, 2004). Yet the usefulness of demand-side instruments such as public procurement, voluntary standards and incentives and regulation in supporting sustainable innovation and development has yet to be explored significantly in the sustainability, technology and policy research domains.

Under certain conditions, demand-side tools could complement supply side tools in enabling and diffusing sustainable innovation, while also improving the quality and efficiency of public services. We explore the use of demand-side instruments in municipalities to promote the adoption and diffusion of environmentally friendly technologies. This research explores three distinct demand-side tools: (1) procurement, (2) voluntary standards and incentives, and (3) regulations in the context of technology life cycles (Aschhoff and Sofka, 2008; Kim, 2003) providing a model for conceptualizing the utility of these different instruments to achieve municipal, corporate and technology strategy objectives in the context of the s-curve.

3. Demand side innovation policy tools: procurement for innovation, voluntary standards and regulations

In this section we will provide a review of emerging research and practice pertaining to the use of three demand-side innovation policy tools: procurement for innovation, voluntary standards and regulation. Later we incorporate these policy tools into a technology life cycle model designed for understanding which tools may be most appropriate at different stages of sustainable technology evolution.

3.1. Procurement for innovation

There is a growing movement in the procurement literature, and in practice, to begin expanding the role and influence of the procurement function (Snider, 2006). Edler and Georghiou (2007) suggest that "public demand, when oriented towards innovative solutions and products, has the potential to improve delivery of public policy and services, often generating improved innovative dynamics and benefits from the associated spillovers" (p. 949). Procurement for innovation has emerged as a unique way of considering the role and potential impact of procurement practices (Edler and Georghiou, 2007) and in particular at the municipal policy level (Lember et al., 2011).

The procurement function in municipalities has historically been associated with tactical, means-based approaches to acquiring products and services (Snider, 2006). The role of the procurement function in this context is to predetermine requirements for vendors to meet. It is not hard to understand why procurement has often been seen as the "Rodney Dangerfield" of municipal activities, wielding little respect from other professions due to the perception that the role is limited and mundane (Gordon et al., 2000).

Rothwell and Zegveld (1981) compared the impacts of research and development (R&D) subsidies (supply-side support) with state procurement contracts. They found that, over the long run, state procurement resulted in more innovation in the region than R&D subsidies. Given the sizable budgets municipalities have today (Table 1), it is clear that municipalities can have a big influence on markets.

In recent years, researchers have explored more innovative forms of procurement including strategic procurement (Snider, 2006) and procurement for innovation (Lember et al., 2011). That is, procurement for products and services that require some form of customization (Lember et al., 2011). Lember et al. (2011) conducted empirical research on six European cities in order to uncover customized procurement practices in each of these cities. Combining surveys and interviews, the researchers found innovative examples in each of these cities. In some cases, like Helsinki, as much as 40% of the total procurement budget was allocated to this type of procurement.

In fact, cities and their elected officials regularly spend nearly $5 trillion dollars on infrastructure projects and technology investments as a percentage of total expenditures is rising (Haselmeyer, 2012). Together, these projects already account for a substantial size of city budgets and resource allocation – a trend that seems to increase as cities grow. For example, the municipal water filtration and separation market is currently worth about $6 billion and Dow Chemical is predicting an annual growth of 15–20% for most of the major water filtration and treatment markets through 2015 (Dow Water & Process Solutions, 2011). Municipal

Table 1
Sample of Annual Municipal Budgets.

City/Country	Annual Budget $ (year)	Source
Barcelona	$4.164 billion (2010)	Ajuntament de Barcelona (2010): 2010–2013 Economic and financial plan of the City of Barcelona
New York/USA	$65 billion (2010)	The City of New York, Financial Plan Summary, 2010
Sao Paolo/Brazil	$15.134 billion (2010)	Rede Nossa São Paulo: Our Sao Paulo, 2009
Seattle/USA	$3.85 billion (2010)	City of Seattle, 2010
Tokyo/Japan	$84.83 billion (2009)	Tokyo Metropolitan Government, 2009

waste-to-energy systems, with $3.7 billion in revenues in 2010, are expected to grow $13.6 billion by 2016 (Pike Research, 2010).

Smart city solutions represent an emerging area of significant private sector interest with companies like Siemens restructuring to create an entire division dedicated to solutions which allow cities to utilize emerging information technologies to increase efficiency and access to real-time data regarding energy consumption and traffic patterns. The global spending on smart city technology is expected to grow to a total of $39.5 billion annually by 2016 (ABIResearch, 2011), including, in some cases, private money for public infrastructure projects. For example, the Carbon War Room, a non-profit think-tank formed by Virgin's CEO and founder Richard Branson recently assisted two counties in the U.S., Miami-Dade (Florida) and Sacramento (California) in securing $650 million in private capital for local government building energy retrofits (Carbon War Room, 2011).

3.2. Voluntary standards and incentives

Researchers have begun to consider other demand-side tools for stimulating innovation at a municipality's disposal, such as regulation and standards (Aschhoff and Sofka, 2008). We want to differentiate between voluntary standards and mandatory standards as the latter we address below under regulation. The U.S. Environmental Protection Agency (EPA) defines voluntary standards as: "sets of rules, conditions or requirements concerned with the definition of terms, classification of components; delineation of procedures; specification of dimensions, materials, performance, design or operations; measurement of quality and quantity in describing materials, products, systems, services or practices; or descriptions of fit and measurement size." (EPA, 1995)

Contrary to prior research suggesting market-based mechanisms are more useful in incenting innovation (e.g. Jung et al., 1996), Montero (2002) found that in certain contexts, environmental standards provide better incentives for R&D innovation than do market-based approaches. It has been noted that standards may be difficult for certain levels of government to encourage or enforce, particularly as it relates to product-based standards (OECD, 2011). However, at the municipal level, certain standards can indeed be leveraged as a tool to support innovation. This is of course particularly true as it pertains to standards for municipal infrastructure since a city has more direct control over those facilities. It is also possible for municipalities to leverage voluntary standards to move the market in a desired direction by coupling voluntary standards with incentives. For example, numerous municipalities in the U.S. have embraced Leadership in Energy and Environmental Design (LEED) green building standards and are leveraging them for municipal and private sector building projects. LEED is the preeminent green building standard in North America which has subsequently been adopted by nearly 50 other countries around the globe. Gainesville and Sarasota Florida have implemented mandatory LEED standards for municipal projects while leveraging voluntary standards on private sector developers providing fast-track building permits and reduced fees for developers who meet the minimum LEED standards (USGBC, 2009).

3.3. Regulations

Governments create and regulate the playing ground for innovation and entrepreneurship (Minniti, 2008) by exercising varying degrees of economic and political control to stimulate technological innovation in their jurisdictions (Mahmood and Rufin, 2005). Regulation is one tool that governments can use when markets are not performing well or are resulting in negative externalities on citizens. Many economists and practitioners view regulation as a last resort, and particularly see regulation as a potential barrier to innovation (Rothwell, 1992). Fiorino (1999), p. 451 suggested that "we have exchanged market failure (the original justification for government intervention) for bureaucratic failure (limits in central regulatory capacities)".

Ashford (2002) however refutes the assumption that regulation is intuitively detrimental to innovation. For example, there is substantial evidence that market imperfections continue to generate significant environmental degradation (Cohen and Winn, 2007). However an appropriate regulatory environment can actually support the transformation towards a more sustainable economy. Yet research has also identified how innovation from the private sector can profitably address market environmental imperfections (Cohen and Winn, 2007). Investors representing $15 trillion of capital, at the end of 2010, urged the international community to commit to strong regulation on climate change and the issued a statement suggesting that "Strong government policies that reward clean technologies and discourage dirty technologies are essential for closing the climate investment gap and building a low-carbon global economy" (IGCC 2010).

4. Demand-side policy and sustainable technology life cycle

The extent literature on technology life cycle and diffusion of innovation is substantial. Rogers's (1962) pioneering work helped lay the foundation for a vast array of research in a range of academic disciplines design to understand the applicability of diffusion theory in contexts ranging from consumer goods to the medical device industry. While several scholars have identified limitations of innovation diffusion theory, the bulk of empirical research has found support for the evolution and adoption of new innovations (MacVaugh and Schiavone, 2010).

A useful lens to consider the applicability of different demand-side policy tools in encouraging sustainable technology innovation and diffusion is the technology life cycle as opposed to product life cycle introduced by Kim (2003). Technology life cycles are concerned with the life cycles of generations of technology from the perspective of the economy and society as a whole as opposed to the life cycle of a specific product (Kim, 2003). Like Rogers (1962) and Christensen (1997) before him, Kim explores the evolution of technologies, beyond the evolution of specific products. Kim draws from the product life cycle (PLC) literature to explore two common patterns of technology life cycle: concave and s-curve. In both instances, new technologies go through stages of their life cycle from introduction, growth, and maturity to eventual decline. Of course the decline is often precipitated by a disruptive innovation which starts the life cycle all over again.

While the s-curve has been challenged because in reality, products and technologies rarely travel through a smooth curvilinear evolution (Doyle, 1976), it is still a widely used concept to depict product and technology evolution including in the sustainable technology arena such as water treatment (Parker, 2011), building integrated photovoltaic systems (Hammond, 2012) and broadly applied to various technologies associated with industrial sustainability (Paramanathan, et al., 2004).

Having explored the potential for three demand-side tools to address municipal sustainability challenges, we will now present a model for developing municipal, private and technology strategies in the context of the tools at the different stages of the technology life cycle, summarized in Table 2. Furthermore, at the end of each subsection, we provide a concrete example currently being employed in cities around the globe. These examples have been mapped in Fig. 1, demonstrating where the example fits on the technology life cycle curve.

Table 2
A comparison of sustainable municipal and business agendas, technology strategies aligned with municipal demand-side tools and technology life cycle.

	Procurement for innovation	Voluntary standards and incentives	Regulation
Stage of Technology Life Cycle	Introduction	Growth	Maturity
Customer Types	Pioneering cities	Early adopters	Early majority
Municipal agenda	Urban competitiveness (Lember et al., 2011)	Increased competition for accelerated adoption (Langniss and Wiser, 2003);	Political ideology (Carley and Miller, 2012);
	Early adopter economic development	Citizen activism (Carley and Miller, 2012); Cluster development	Perceived failure to regulate at national level (Lovins and Cohen, 2011)
Corporate agenda	Accelerate procurement process;	Crossing the chasm (Moore, 1991; Almeida and Fernando, 2008)	Obtain sociopolitical regulatory legitimacy (Hunt and Aldrich, 1996)
	Legitimacy through manipulation (Suchman, 1995; Zimmerman and Zeitz, 2002)	Local green dynamic capability (Rugman and Verbeke, 2000)	
Technology strategy	Urban laboratory (Liauw, 2008) Switching costs (Tsoutsos and Stamboulis, 2005)	Influencing technology standards (Krozer and Nentjes, 2008)	Establishing Best Available Technology Krozer and Nentjes, 2008

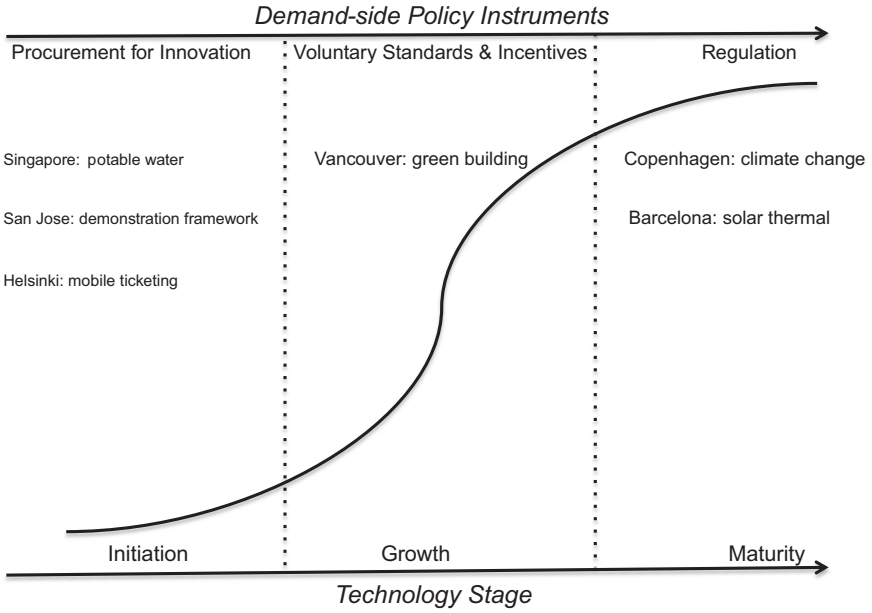

Fig. 1. A model of demand-side policy instruments, municipal and business agendas and technology life cycle.

4.1. Procurement for innovation and technology life cycle: public and private agenda

Procurement for innovation has different forms, from municipalities co-creating new solutions with the private sector, to allowing the private sector latitude to compete with innovative solutions to sustainability challenges and opportunities in the city. Regardless of the approach, procurement for innovation seeks to originate new solutions, thus we consider procurement for innovation to be a demand-side tool at the start of the s-curve.

4.1.1. Municipal agenda and procurement for innovation

Through innovative procurement policies, municipal governments could foster the highly important formative context that is necessary for the emergence of new, innovative thinking and problem-solving technologies. Lember et al. (2011) suggest that urban competitiveness drives municipalities to engage in procurement for innovation.

Furthermore, sustainability challenges such as those discussed throughout this paper are not usually isolated to one city. Thus, municipalities leveraging procurement for innovation to allow the local private sector to gain early expertise in a technology platform has the potential to serve as a new type of local economic development. By using government resources (facilities, procurement dollars) to co-create solutions to municipal challenges, the region may eventually obtain a competitive advantage beyond its municipal borders, leading to job and economic growth.

Singapore is a city-state which has impressively transformed itself from a developing country context to fully developed in the span of just a few decades. Yet it has faced many challenges in its transition. One of them was a lack of potable water, requiring Singapore to import the majority of its water from neighboring Malaysia. Yet the proactive government realized their long-term growth and sustainability was at risk if they did not address the solution locally. The government has been actively utilizing procurement for innovation in the water space, “experimenting with reservoirs, recycled water known as NEWater, and desalination as it aims to become self-sufficient in water by 2061” (Danubrata, 2013).

As a result of Singapore's pioneering efforts to solve its own potable water challenges, it has helped create a vibrant water technology industry in the region with 100 companies generating annual revenues of $370 million. These companies since 2006 have secured more than $7 billion worth of international projects, leading local water technology companies to believe that

"Singapore should be one of the world's dominant players in water. It should be the Silicon Valley of water" (Danubrata, 2013).

4.1.2. Private sector agenda and procurement for innovation

So why would the private sector encourage municipalities to embrace procurement for innovation? Firstly, this policy tool allows the possibility for expediting or even bypassing the traditional, bureaucratic procurement processes normally associated with formal request for proposal processes. A recent report by InterTrade Ireland noted that public procurement practices were too onerous for small and medium sized enterprises (SMEs). At the same time though, the market to supply to different levels of government, valued at £21 billion per year, was just too big to ignore for these SMEs (InterTradeIreland, 2011). Finally, given the potential size of this market, early collaboration with a recognized municipality can lead to enhanced legitimacy for the technology company participating in procurement for innovation. Suchman (1995) defines legitimacy as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (p. 574). Zimmerman and Zeitz (2002) developed a model illustrating how legitimacy assists new ventures in acquiring key resources for survival. Zimmerman and Zeitz (2002) also summarized and elaborated extant legitimacy research to demonstrate how new ventures may utilize four unique strategies (conformance, selection, manipulation and creation) in order to achieve one of three previously established types of legitimacy: sociopolitical regulatory, sociopolitical normative and cognitive (Hunt and Aldrich, 1996).

We suggest that private firms or organizations can develop strategies for engaging in municipal procurement for innovation programs is reflective of the manipulation legitimacy strategy. Manipulation legitimacy is utilized by firms to make changes in the environment to achieve consistency between the organization and its environment (Zimmerman and Zeitz, 2002, p. 424). While a new venture by itself is unlikely able to manipulate its environment on its own, it may do so through cooperation with an existing, larger legitimate entity (Zimmerman and Zeitz, 2002). Thus, in the context of procurement for innovation, a technology venture, may be able to obtain legitimacy via collaboration with the municipality in the co-creation of a new technology solution. If such a collaboration can lead to increased legitimacy and improved opportunities in the sizable municipal market, this would justify entering into a procurement for innovation contract with a municipality, even if the contract yields little to no profit.

In 2001, Plusdial, a Finnish technology startup, participated with Helsinki local government in a procurement for innovation initiative designed to facilitate public transit access by developing a mobile ticketing solution. Helsinki sought a new solution which would improve customer satisfaction and increased use of its public transit system through the use of a mobile SMS based system for transit ticket delivery. At the time, there were no available off-the-shelf tools, so the city turned to a local startup to co-create the first solution. The first test of the mobile ticketing system was delivered on international car-free day in 2001. Plusdial leveraged this early experience with Helsinki to get a jump start in a new market for m-commerce and mobile transit ticket delivery. By 2012, Plusdial had customers in more than 50 cities around the globe resulting in the sale of more than 100,000,000 mobile transit tickets.

4.1.3. Technology strategy and procurement for innovation

Procurement for innovation allows the private sector to co-create solutions to municipal sustainability challenges. It is not always easy for technology-based firms to find clients willing to experiment with technology at the introduction stage of the technology life cycle due to the perceived or realized costs and risks of technology failure (Bunduchi et al., 2011). And governments at all levels, including municipalities have to be considered with the political risks inherent with investments in new technologies (Tsoutsos and Stamboulis, 2005).

Therefore technology companies need to find clients willing to take the risks associated with being an early adopter of a new technology introduction (Rogers, 1962). By collaborating with a city to co-create a technology solution, a technology company can improve the likelihood their first client will actually use the solution and will have a vested interest in providing ongoing feedback to the development team regarding product enhancements.

Furthermore, if the municipal client commits to the technology at this stage, it can create substantial switching costs for the city later. This is particularly true with investments in renewable energy technologies because of the path dependence associated energy technology systems (Tsoutsos and Stamboulis, 2005). Rather than traditional R&D conducted internally at the introduction stage of technology evolution, a company can work with the city as a living laboratory like the Special Economic Zones (SEZ) in China (Liauw, 2008).

A recent municipal example we uncovered is in San Jose, California. In order to give local sustainable technology ventures a leg up locally and internationally, the city of San Jose created and passed legislation in 2008 entitled, Framework for Establishing Demonstration Partnerships in order –"to create a framework for engaging in and evaluating demonstration partnerships with the aim of developing, testing and demonstrating innovative solutions in San José in support of the City's Economic Development Strategy and City operations."– (San Jose Council Policy, 2008). Essentially San Jose seeks to use this demonstration framework to bypass onerous procurement processes and to enable the local private sector to gain access to city facilities as a living urban laboratory. The hope is that these projects will stimulate innovation in the municipality while giving local ventures a showcase for their emerging technology solutions, and to grow local jobs and the economy. The Framework is clearly not seeking to predict the future, but rather provide the means (i.e. city facilities) for local ventures to introduce unforeseen innovations.

4.2. Voluntary standards and technology life cycle: public and private agenda

Technology life cycle literature suggests that after introduction and early adoption, the evolution of the technology goes through a growth phase (Kim, 2003). We suggest here that cities could use voluntary standards and incentives as demand

4.2.1. Municipal agenda and voluntary standards and incentives

Significant research in the policy literature has explored the efficacy of voluntary environmental standards as a tool for engaging the private sector (Innes and Sam, 2008), although only recently have researchers begun to explore local government policy in the context of voluntary standards and incentives. Local governments are increasingly responsible for implementing environmental policy (Hughes, 2012). Voluntary environmental programs (VEP) from municipalities are seen as more politically palatable and are more flexible than environmental regulations (Hughes, 2012). While voluntary standards and incentives can be used to help urge the market towards improved environmental performance, the role these tools may have in serving as demand generators for technology innovation is also worthy of research in the policy and technology arenas.

In the case of renewable portfolio standards (RPS), local and regional governments have explored a range of policy instruments from flexible, voluntary standards to hard regulatory minimum quotas in order to increase renewable energy contribution as a percentage of total energy production (Carley and Miller, 2012).

Langniss and Wiser (2003) demonstrated that RPS programs in Texas resulted in enhancing competition in the wind industry and enabled the state to reach its targets earlier than expected. In a study of factors driving voluntary versus regulatory RPS throughout the U.S., Carley and Miller (2012) found that the primary driver for the introduction of voluntary RPS policy, as opposed to no state policy, was the presence of a strong liberal citizen ideology. That is, states with active citizens pushing a green agenda were more likely to adopt voluntary standards over states without a strong presence of liberal citizens.

It is important to note that signals from policy makers regarding the commitment period to voluntary standards and incentives are crucial. When governments have introduced incentive programs for renewable energy generation and then revoked the incentive programs, such as what occurred with the production tax credit (PTC) for wind energy in the U.S. and the feed-in-tariff (FIT) or solar production in Spain, the results have been disastrous for the renewable energy sectors (e.g. Metcalf, 2009). Spain's moratorium on the FIT issued in 2012 only affected projects under development or in planning stage, not live generating projects. Yet this policy change sent a negative signal to solar producers not only in Spain but around the globe by providing an unfortunate example of how such incentive programs may be pulled at any time, affecting investors in projects which had been started but not yet completed.

4.2.2. *Private sector agenda and voluntary standards and incentives*

Technology firms who have developed innovative environmental solutions and sold them to pioneering early adopters need to find mechanisms to reach early adopters. Finding the pioneering early adopters for new technology solutions is a sizeable challenge for established and new technology ventures (Rogers, 1962). Yet, continuing the evolution of the technology life cycle beyond the innovators in the introduction phase through the early adopters and the growth phase is arguably even more difficult. Geoffrey Moore articulated this challenge in his seminal book, Crossing the Chasm (1991). Moore suggests that the most difficult transition for technology companies is to go from the innovators and earliest adopters to the pragmatists (Moore, 1991).

Rationale for firms to participate in voluntary programs include: targeting green consumers, preempting regulatory standards, and avoiding future environmental liability (Innes and Sam, 2008). Additionally, Rugman and Verbeke (2000) suggest that some firms develop localized green capabilities in order to obtain competitive advantage in limited geographic areas where there is demand. In areas with a liberal citizen ideology or voluntary environmental standards and incentives in place, technology firms would be wise to develop a localized green dynamic capability. Technology firms have the potential to dominate a niche area by targeting the marketing and sales efforts in a specific niche area and then to use that position to expand to other segments (Moore, 1991; Almeida and Fernando, 2008).

We posit that technology firms with environmental solutions should collaborate with municipalities to encourage the introduction of voluntary standards and incentives as a mechanism to cross the chasm and begin to scale the market beyond the municipality. For example, a municipality can require or encourage that all municipal facilities meet energy efficiency or green building requirements and then find mechanisms to encourage the private sector to adopt similar technologies. This scenario has already played out in municipalities around the globe. Vancouver, Canada's approach to the green building market bears this out.

In 2004, the City of Vancouver, Canada became the first city in North America to mandate that all new municipal buildings over 500 meters squared achieve LEED Gold Green building credentials. LEED is an acronym for Leadership in Energy and Environmental Design and is the preeminent green building standard in North America. This policy also required that these LEED buildings achieve a 30% improvement in energy efficiency over the current building codes. Just one year later, in 2005, Vancouver's City Council mandated the private sector brownfield redevelopment of Southeast False Creek for the 2010 Olympics must also meet LEED Gold standards. (Cascadia Green Building Council, 2009). Thus, the new green building regulations required innovation over business as usual in the local building community in British Columbia.

On the heels of the success of the green building standards for municipal buildings, the city moved to encouraging private sector adoption of greener building standards. As an early step the city offered incentives to developers who committed to higher green building standards. These included priority, expedited review of building permits and offering additional square footage over existing zoning regulations for developments meeting green building and social housing targets.

These strategies helped spawn the growth of the local green building industry in Vancouver. This created opportunities for local LEED and green building consultancies (e.g. Recollective), non-profit green building education and services (e.g. Light House Sustainable Building Centre), new green building services from local engineering companies (e.g. Cobalt Engineering) and green building products (e.g. Greenworks Building Supply) among others. As a result, based on the authors' research of 50 of the largest cities in the U.S. using the LEED green building directory for the US and Canadian Green Building Council, Vancouver has the most amount of LEED certified buildings in North America (see Table 3).

Many of Vancouver's green building companies used Vancouver's urban laboratory not only to build traction locally but to leverage the Vancouver brand to sell their products and services throughout North America. Cities from Seattle to Guayaquil, Ecuador have visited Vancouver or paid for leading players in the green building space in Vancouver to share their expertise and technology solutions.

4.2.3. *Technology strategy and voluntary standards and incentives*

While crossing the chasm is a core construct of business strategy for technology firms seeking to reach beyond the pioneers and earliest adopters, it sheds less light on technology strategy in this early growth phase of the technology life cycle. If procurement for innovation allows for proof of concept in the urban laboratory, voluntary standards and incentives can allow technology-based firms to build and test the scalability of their technology to a broader local market.

While the transition from procurement for innovation to voluntary standards likely leads to increased competition for pioneering technology companies (Langniss and Wiser, 2003), early intervention from companies in influencing the voluntary environmental standards and incentives can also result in establishing technology standards compatible with the firm's technology strategy. This issue is of utmost importance to environmental technology companies. We say this because governments around the globe have pursued a range of policies some of which omit viable technologies that would achieve the real desired outcomes. For example, feed-in tariffs have primarily been tied to solar technology projects, leading to reduced demand for other renewables like geothermal, wind and hydro. This scenario also plays out

Table 3
LEED Certified Buildings: Municipalities with more than 100 LEED Buildings.

City	LEED Certified Buildings
Vancouver (Canada)	276
San Francisco, CA	188
San Diego, CA	141
Tucson, AZ	136
Washington, DC	132
San Jose, CA	129
Seattle, WA	127
Philadelphia, PA	110

with government incentive programs for the purchase of low-emitting vehicles. Many of these programs target hybrid vehicles or electric vehicles, instead of targeting vehicles meeting specific emission standards. The Mazda CX-5 for example, is considered the most efficient vehicle in its class even though it is not a hybrid or electric.

It is also important to consider that in many cases, voluntary standards evolve into regulation over time (Carley and Miller, 2012). Therefore technology firms developing environmental technologies should ensure that their solutions are entrenched in local systems prior to formalized regulations enter the local market.

4.3. Regulations and technology life cycle: public and private agenda

4.3.1. Municipal agenda and regulation

Environmental regulations have been among the fastest growing policy instruments across all ranges of government for the past few decades (Rugman and Verbeke, 2000). As discussed local governments are now getting into the act. This is especially true when the local government has a liberal ideology. Carley and Miller (2012) found that states were more likely to implement RPS regulations, as opposed to voluntary standards, in the presence of liberal political ideology. Local governments have been increasingly engaging in environmental regulation, particularly in the absences of federal policy which aligns with local government objectives.

Climate change legislation, for example has been slowed at the national level in countries around the globe so states and cities have taken up the charge (Lovins and Cohen, 2011). Cities like Copenhagen and Stockholm have established bold targets and regulatory programs designed to achieve carbon neutrality by 2025 and 2050 respectively. Frustrated with the lack of federal regulation regarding climate change, the previous Mayor of Seattle, Greg Nickels, launched the U.S. Conference of Mayors' Climate Protection Agreement for which more than 1000 U.S. Mayors have signed on to, binding them to reduce emissions below 1990 levels.

Barcelona, Spain offers a good example of the use and success of local government regulation to stimulate environmental technology adoption. For instance, in 2000, Barcelona, Spain became the first known municipality in the world to require that all new buildings (and all major retrofits) over a certain size must use solar thermal energy to supply at least 30% of its hot-water needs. Just as in the case of Vancouver's green building initiatives, this regulation spawned innovation and opportunity in the private sector from technology providers to solar thermal installers. A summary of the program's impact in Barcelona alone was created by ICLEI (2011):

"The Barcelona Energy Agency's evaluation program monitors and further promotes the effective implementation of the Solar Thermal Ordinance. Since its enforcement licenses for the installation of a total of 14,028 m^2 of solar panels have been requested, compared to a total of 1650 m^2 of panels before the ordinance was in place. This increase in the installation of solar panels has resulted in annual energy savings of 11,222 MWh and a corresponding reduction in eCO_2 emissions of 1973 t per year."

The perceived success of this solar thermal ordinance led to the adoption of similar ordinances in more than 50 other municipalities in Spain alone (solarordinances.eu). Madrid, for example followed suit in 2003. From 2003 to 2005, 424 permits were submitted to the municipality of Madrid which included solar thermal components (ESTIF, 2006).

4.3.2. Private sector agenda and regulation

While corporations may have historically viewed environmental regulation as a burden, many companies now recognize that getting ahead of and supporting the passage of environmental regulation can be leveraged to achieve strategic objectives (Rugman and Verbeke, 2000). Just as consumers of technologies can be classified as ranging from early adopters to laggards, so can corporate responses to environmental regulation. "Since environmental protection is a public good that is undervalued by individual consumers, regulations are a means of giving it a value, by rewarding technology leaders and penalizing technology laggards." (Ng, 2006, p. 31).

Earlier we discussed the role of legitimacy as a driver for technology firm involvement in procurement for innovation. Hunt and Aldrich, 1996 introduced sociopolitical regulatory legitimacy as legitimacy associated with adhering to regulations and laws of the region where the venture is operating. Zimmerman and Zeitz (2002) extended the application of sociopolitical regulatory legitimacy across all four types of legitimacy strategies: conformance, selection, manipulation and creation. In the context of this research, creation approaches to sociopolitical regulatory legitimacy are associated with "creating rules and regulations that benefit the new venture." Thus we suggest here that environmental technology firms may seek to support the creation of regulations which benefit their firm as a means of acquiring, or creating, sociopolitical regulatory legitimacy.

4.3.3. Technology strategy and regulation

In most jurisdictions, environmental policy has focused on best available technology as a means for setting the bar for mandatory regulations (Krozer and Nentjes, 2008). Krozer and Nentjes (2008) articulate the potential benefits for technology firms to invest in research and development which allows their technology to surpass existing regulations. They suggest that by doing so, technology firms can develop patented innovations which demonstrate the reasonable ability to achieve environmental benefits such as emission reductions, allowing the innovation to be incorporated into regulation as the best available technology. This can allow the firm to gain entrepreneurial rents for a period of time while their competitors seek to catch up to the new technology standard.

5. Discussion

This research has sought to develop a grounded theoretical model for the integration of innovation policy and diffusion of innovation theory. Particularly, the model developed herein provides a theoretical extension technology life cycle research by suggesting that specific demand-side innovation policy tools may uniquely support technology diffusion at different stages of the technology life cycle. Furthermore, we sought to provide support for corporate and technology strategies which could be most appropriate with the three demand-side policy tools addressed

in the model: procurement for innovation, voluntary standards and regulation. Finally, we framed the model and our research in the context of sustainable technology development.

As the urbanization trend sweeping the globe continues, cities are going to be increasingly challenged to sustain and improve the quality of life of their citizens. While density is often associated with potential benefits to the environment and to citizens it also poses major stresses on city infrastructure. Municipalities have the potential to serve as an urban laboratory and a creator of new opportunities for the private sector leveraging sizable procurement budgets. As municipalities face an increasing share of the environmental burden, they are also beginning to increase their involvement in environmental policy making. Technology-based firms would be wise to pay attention to the evolution of government policy and to collaborate with municipalities in developing demand-side policies to exploit opportunities at different stages of the technology life cycle.

Despite challenges in its implementation, municipal demand-side tools offer significant opportunities for addressing urban sustainability challenges while also supporting private sector innovation. In a time when big part of the global economy is in a recession and federal and regional governments are cash-strapped, the world has begun to re-examine the role of cities in providing opportunities for job and economic growth. Supply-side solutions such as tax breaks, investments in technology parks, and grants have their place but may not be enough to stimulate innovation and create opportunities for new goods and services. Municipalities are starting to show they actually can drive new opportunities through demand-side tools such as procurement for innovation, voluntary standards and incentives and regulation.

This research offers a number of practical contributions for policy makers and municipal leaders. We have shown that the private sector is paying attention to growing municipalities more than ever and that recent initiatives indicate that private sector-municipal cooperation for innovation is on the rise. For example, Code for America was recently created to stimulate interest from entrepreneurs and citizens to re-imagine how cities in the U.S. govern, and innovate, in the 21st century. Similarly, Barcelona recently launched the Smart City Campus in an attempt to turn the city into a living laboratory for new technology innovations in smart cities. It is important to note the shift of mindsets, where the administration no longer specifies solutions (as would have been the case in tactical, strategic and even market escalation forms of procurement for innovation), but instead opts to co-create the next wave of innovations in smart city technology. Moreover, Barcelona has opened up the campus to other municipalities around the globe in an effort to support the diffusion of the best solutions that emerge. With more research on entrepreneurial procurement, possibly stemming from our research agenda, these practices may become more commonplace. Taking into account that entrepreneurship policy may be oriented to stimulate "more entrepreneurial behavior in a region or country" (Lundström and Stevenson, 2001, p 19), there is enough space for policies that enhance demand-side innovative solutions. As other growing cities follow suit, sustainable development through demand-side tools may just become one of the most important innovation frontiers in the 21st century.

6. Conclusion

Innovation policy is no longer the exclusive domain of national governments. Increasingly smart and sustainable cities are also seeking to support the growth of innovation districts and to attract the creative class (Florida, 2002). The high profile failure of firms receiving supply-side support such as Solyndra have led to a reconsideration of the role of public policy in supporting sustainable innovation. By shedding light on the potential for demand-side tools to stimulate local sustainable innovation based on the stages of the technology life cycle (Rogers, 1962), this research contributed to theory extension while also providing potential guidance for local policy-makers and practitioners regarding the potential for more effective innovation policy which not only stimulates sustainable technology development but also has the potential to influence local sustainable development.

References

ABIResearch, 2011. $39.5 Billion will be Spent on Smart City Technologies in 2016. Available from: ⟨http://www.abiresearch.com/press/3768-$39.5+Billion+Will+Be+Spent+on+Smart+City+Technologies+in+2016⟩ (retrieved 01.01.14).

Ajuntament de Barcelona, 2010. 2010–2013 Economic and Financial Plan of the City of Barcelona. Available from: ⟨http://w3.bcn.es/fitxers/ajuntament/pefenglishversionfinal2.315.pdf⟩ (retrieved 01.01.14).

Aldy, J., 2013. A preliminary assessment of the American Recovery and Reinvestment Act's Clean Energy Package. Rev. Environ. Econ. Policy, 1–20.

Almeida, S., Fernando, M., 2008. Survival strategies and characteristics of start-ups: an empirical study from the New Zealand IT industry. Technovation 28 (3), 161–169.

Aschhoff, B., Sofka, W., 2008. Innovation on demand—can public procurement drive market success of innovations, Center for European Economic Research Discussion Paper.

Ashford, N., 2002. Government and environmental innovation in Europe and North America. Am. Behav. Sc. 45, 1417–1434.

Audretsch, D.B., Bönte, W., Keilbach, M., 2008. Entrepreneurship capital and its impact on knowledge diffusion and economic performance. J. Bus. Ventur. 23 (6), 687–698.

Bartlett, D., Dibben, P., 2002. Public sector innovation and entrepreneurship: case studies from local government. Local Gov. Stud. 28 (4), 107–121.

Bunduchi, R., Weisshar, C., Smart, A., 2011. Mapping the benefits and costs associated with process innovation: the case of RFID adoption. Technovation 31, 505–521.

Capelleras, J., Kevin, M., Greene, F., Storey, D., 2008. Do more heavily regulated economies have poorer performing new ventures? Evidence from Britain and Spain. J. Int. Bus. Stud. 39 (4), 688–702.

Carbon War Room, 2011. Carbon War Room-brokered Consortium set to Unlock Multi-billion Dollar Global Commercial Property Retrofit Market. Available from: ⟨http://news.carbonwarroom.com/2011/09/19/carbon-war-room-brokered-consortium-set-to-unlock-multi-billion-dollar-global-commercial-property-retrofit-market/⟩ (retrieved 01.01.14).

Carley, S., Miller, C., 2012. Regulatory stringency and policy drivers: a reassessment of renewable portfolio standards. Policy Stud. J. 40 (4), 730–756.

Cascadia Green Building Council, 2009. Vancouver Mandates LEED Gold for all New Civic Buildings. Available from: cascadiagbc.org (retrieved 01.01.14).

Christensen, C., 1997. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business School Press, Boston, MA.

City of Seattle, 2010. 2010 Adopted Budget. Available from: ⟨http://www.seattle.gov/financedepartment/10adoptedbudget/default.htm⟩ (retrieved 01.01.14).

Cohen, B., Winn, M., 2007. Market imperfections, opportunity and sustainable entrepreneurship. J. Bus. Ventur. 22 (1), 29–49.

Danubrata, E., 2013. Singapore's water companies aim to quench China's $850 billion thirst, *Reuters*, June 2nd.

Dow Water & Process Solutions, 2011. Market Overview. Available from: ⟨http://www.dowwaterandprocess.com/docs/market_overview.pdf⟩ (retrieved 01.01.14).

Dolfsma, W., Seo, D., 2013. Government policy and technological innovation—a suggested typology. Technovation 33, 173–179.

Doyle, P., 1976. The realities of the product life cycle. Q. Rev. Mark. 1 (Summer), 1–6.

Edler, J., Georghiou, L., 2007. Public procurement and innovation: resurrecting the demand-side. Res. Policy 36, 949–963.

EPA, 1995. EPA Standards Network Fact Sheet. Available from: ⟨http://www.epa.gov/p2/pubs/standards.txt⟩ (retrieved 07.07.14).

ESTIF, 2006. The Bylaw for Solar Thermal use by the Madrid Town Council: Implementation and Results, European Solar Thermal Industry Federation.

Fiorino, D.J., 1999. Rethinking environmental regulation: perspectives on law and governance. Harv. Environ. Law Rev. 23, 441–469.

Florida, R., 2002. The Rise of the Creative Class: And How it's Transforming Work, Leisure, Community, and Everyday Life. Perseus Books Group, New York, NY.

Gordon, S.B., Zemansky, S.D., Sekwat, A., 2000. The public purchasing profession revisited. J. Public Budg., Account., Financ. Manag. 12 (2), 248–271.

Hammond, G., 2012. Whole systems appraisal of a UK Building Integrated Photovoltaic (BIPV) system: energy, environmental and economic evaluations. Energy Policy 40, 219–230.

Haselmeyer, S. 2012. 21 Cities Call for Solutions to Improve the Lives of 120 Million Citizens. Urban Times, February 10th.

Hays, S.P., Glick, H.R., 1997. The role of agenda-setting in policy innovation. Am. Politics Q. 25, 497–516.

Henard, D., Szymanski, D., 2001. Why some new products are more successful than others. J. Mark. Res. 38 (3), 362–375.
Hoff, P., 2012. Greentech Innovation and Diffusion. Springer, New York, NY.
Hughes, S., 2012. Voluntary environmental programs in the public sector: evaluating an Urban Water Conservation Program in California. Policy Stud. J. 40 (4), 650–673.
Hunt, C., Aldrich, H. 1996. Why even Rodney Dangerfield has a home page: legitimizing the world wide web as a medium for commercial endeavors. In: Academy of Management, Annual Meeting, Cincinnati, OH.
ICLEI, 2011. Plan for Energy Improvement in Barcelona and Solar Thermal. Available from ⟨http://www.iclei.org/index.php?id=1156⟩ (retrieved 01.01.14).
IGCC, 2010. 259 Investors Representing US$15 Trillion Endorse National Action on Climate Change. Available from: ⟨http://www.igcc.org.au/Resources/Documents/MR_259%20Investors%20representing%20US$15%20trillion_101117_for%20release.pdf⟩ (retrieved 07.07.14).
Ihrke, D., Proctor, R., Gabris, J., 2003. Understanding innovation in municipal government: city council member perspectives. J. Urban Aff. 25 (1), 79–90.
Innes, R., Sam, A., 2008. Voluntary pollution reductions and the enforcement of environmental law: an empirical study of the 33/50 program. J. Law Econ. 51 (2), 271–296.
InterTradeIreland, 2011. Barriers Exist for SMEs in the €21 Billion Public Procurement Market. Available from: ⟨http://www.intertradeireland.com/newsevents/news/2011/name,7651,en.html⟩ (retrieved 01.01.14).
Jacobs, J., 1984. Cities and the Wealth of Nations: Principles of Economic Life. Random House, New York, USA.
Jung, C., Krutilla, K., Boyd, R., 1996. Incentives for advanced pollution abatement technology at the industry level: An evaluation of policy alternatives. J. Environ. Econ. Manag. 30, 95–111.
Kandil, M., 2009. Demand-side stabilization policies: what is the evidence of their potential? J. Econ. Bus. 61 (3), 261–276.
Kim, B., 2003. Managing the transition of technology life cycle. Technovation 23, 371–381.
Kneese, A., Schultze, C., 1978. Pollution, Prices and Public Policy. Brookings Institution, Washington, DC, pp. 1–125.
Krozer, Y., Nentjes, A., 2008. Environmental policy and innovations. Bus. Strategy Environ. 17 (4), 219–229.
Langniss, Ole, Wiser, R., 2003. The renewable portfolio standard in Texas: an early assessment. Energy Policy 31 (6), 527–535.
Lember, V., Kalvet, T., Kattel, R., 2011. Urban competitiveness and public procurement for innovation. Urban Stud. 48 (7), 1373–1395.
Liauw, L., 2008. Leaping forward, getting rich gloriously, and letting a hundred cities bloom. Archit. Des. 78 (5), 6–15.
Lovins, H., Cohen, B., 2011. Climate Capitalism: Capitalism in the Age of Climate Change. Hill and Wang, New York, USA.
Lundvall, B., Borras, S., 1999. The globalizing Learning Economy: Implications for Innovation Policy. Office for Official Publications of the European Communities, Luxembourg.
Lundström, A., Stevenson, A., 2001. Entrepreneurship Policy for the Future. Swedish Foundation for Small Business Research, Stockholm.
MacVaugh, J., Schiavone, F., 2010. Eur. J. Innov. Manag. 13 (2), 197–221.
Mahmood, I., Rufin, C., 2005. Government's dilemma: government's role in imitation and innovation. Acad. Manag. Rev. 30 (2), 338–360.
Metcalf, G., 2009. Investment in Energy and Infrastructure and the Tax Code. National Bureau of Economic Research. Working paper 15429.
Moore, G., 1991. Crossing the Chasm. HarperCollins, New York.
Minniti, M., 2008. The role of government policy on entrepreneurial activity: productive, unproductive, or destructive? Entrep.: Theory Pract. 32 (5), 779–790.
Mintrom, M., 1997. Policy entrepreneurs and the diffusion of innovation. Am. J. Political Sci. 41 (3), 738–770.
Montero, J.P., 2002. Permits, standards and technology innovation. J. Environ. Econ. Manag. 44, 23–44.
Neck, H.M., Meyer, G.D., Cohen, B., Corbett, A., 2004. An entrepreneurial system view of new venture creation. J. Small Bus. Manag. 42 (2), 190–208.
Ng, C., 2006. Shaping the Terms of Competition: Environmental Regulation and Corporate Strategies to Reduce Diesel Vehicle Emissions (MIT Dissertation).
OECD Publishing, 2011. Demand-side Innovation Policies.
Palmberg, C., 2004. The sources of innovations – looking beyond technological opportunities. Econ. Innov. New Technol. 13, 183–197.
Paramanathan, S., Farrukh, C., Phaal, R., Probert, D., 2004. Implementing industrial sustainability: the research issues in technology management. R&D Manag. 34 (5), 527–537.
Parker, D., 2011. Introduction of new process technology into the wastewater treatment sector. Water Environ. Res. 83 (6), 483–497.
Parker, S., 2007. Policy-makers beware!. In: Audretsch, D., Grilo, I., Thurik, R. (Eds.), The Handbook of Entrepreneurship Policy. Edward Elgar, Cheltenham, pp. 54–63.
Parry, I., 1998. Pollution regulation and the efficiency gains from technology innovation. J. Regul. Econ. 14, 229–254.
Pike Research, 2010. Waste-to-energy technology markets: thermal and biological processes for electricity and heat generation from municipal solid waste. Market Analysis and Forecasts. Pike Research, Boulder, USA.
Rogers, E.M, 1962. In: Rogers, E.M. (Ed.), Diffusion of Innovation. The Free Press, New York, p. 2003.
Rosenzweig, C., Solecki, W., Hammer, S., Mehrotra, S., 2011. Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network. Cambridge University Press, Cambridge, UK.
Rothwell, R., 1992. Industrial innovation and government environmental regulation: some lessons from the past. Technovation 12 (7), 447–458.
Rothwell, R., Zegveld, W., 1981. Government regulations and innovation—industrial innovation and public policy, London. In: Rothwell, R., Zegveld, W. (Eds.), Industrial Innovation and Public Policy. Frances Pinter Publishers, London, UK.
Rede Nossa,São Paulo 2009. Orçamento de SP em 2010 será de R$27 Bi. Available from ⟨http://www.nossasaopaulo.org.br/portal/node/9069⟩ (retrieved 01.01.14).
Rugman, A., Verbeke, A., 2000. Six cases of corporate strategic responses to environmental regulation. Eur. Manag. J. 18 (4), 377–385.
San Jose Council Policy, 2008. Framework for establishing demonstration partnerships. Policy, 1–40.
Shane, S., 2009. Why encouraging more people to become entrepreneurs is bad public policy. Small Bus. Econ. 33 (2), 141–149.
Snider, K., 2006. Procurement leadership: from means to ends. J. Public Procure. 6 (3), 274–294.
Storey, D., 2005. Entrepreneurship, small and medium sized enterprises and public policies. In: Acs, Z.J., Audretsch, D. (Eds.), Handbook of Entrepreneurship Research: An Interdisciplinary Survey and Introduction. Springer, New York, pp. 473–511.
Suchman, M.C., 1995. Managing legitimacy: strategic and institutional approaches. Acad. Manag. J. 20 (3), 571–610.
Tamasy, C., 2007. Rethinking technology-oriented business incubators: developing a robust policy instrument for entrepreneurship, innovation, and regional development? Growth Change 38, 460–473.
Tankersley, J. 2013. Solyndra Stunk. The green Stimulus didn't. Washington Post, January 9th.
The City of New York, 2010. Financial plan summary. Office of Management and Budget.
Tokyo Metropolitan Government, 2009. Tokyo's Finances. Available from: ⟨http://www.metro.tokyo.jp/ENGLISH/PROFILE/overview10.htm⟩ (retrieved 01.01.14).
Tokumasu, S., Watanabe, C., 2008. Institutional structure leading to the similarity and disparity in innovation inducement in EU 15 countries. J. Serv. Res. 8 (1), 5–42.
Tsoutsos, T., Stamboulis, Y., 2005. The sustainable diffusion of renewable energy technologies as an example of an innovation-focused policy. Technovation 25 (7), 753–761.
USGBC, 2009. Summary of government LEED incentives. Available from ⟨http://www.usgbc.org/Docs/Archive/General/Docs2021.pdf⟩ (retrieved 07.07.14).
Venkataraman, S., 2004. Regional transformation through technological entrepreneurship. J. Bus. Ventur. 19 (1), 153–167.
Zimmerman, A., Zeitz, G., 2002. Beyond survival: achieving new venture growth by building legitimacy. Acad. Manag. Rev. 27 (3), 414–431.