



The impact of policy consistency on technological competitiveness: A study on OECD countries



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ABSTRACT

This study investigates the impact of policy consistency on technological competitiveness using patent citation analysis. Policy support plays a key role in promoting firms' investment in research and development (R & D) activities, especially in emerging sectors. Policy consistency increases technological competitiveness, since it encourages firms to invest in R & D activities. Although previous studies argue policy design and characteristics, few deal with policy consistency, and they lack a quantitative measure of policy consistency and explanation of its effects. Therefore, this study proposes the quantitative indexes for policy consistency and potential technological competitiveness.

The indexes are applied to the case of renewable energy sector since energy sector is highly dependent on the government policy and thus needs high policy consistency. The result shows that renewable energy technology development is affected by policy and the higher the policy consistency especially in emerging sectors. It also shows that countries of high policy consistency tend to achieve higher technological competitiveness and thus are likely to secure higher technological competitiveness in the future. The findings of this study can be used in designing policy for sustainable technological competitiveness and will be a corner stone for researches on assessing policy consistency.

1. Introduction

Governments play a key role in the research and development (R & D) of emerging technologies (Kim, 1997). They provide financial support, such as tax incentives and subsidies, and, thus, agents in both public and private sectors are encouraged to innovate (Abdmouleh et al., 2015; White et al., 2013). Although most policies that support R & D investment have positive effects on innovation, it is important for these policies to be consistent (Bürer and Wüstenhagen, 2009; Chung, 2013; Haley and Schuler, 2011) in order to achieve high performance in emerging sectors (White et al., 2013). Firms invest on R & D activity in order to acquire technological advantage. In order for firms to concentrate on technology development activity, their business environment has to be stable. One of the major factors that reduce market uncertainty is consistent and continuously implemented policy goals (Yoon and Sim, 2015) since constantly changing policies will lead to reluctant investors (Pan et al., 2015). Among various sectors, the energy sector is affected by the consistent and long-term policy since the government drives development of energy related technologies (ACORE, 2015).

Renewable energy, one of the most representative emerging technology fields, is essential for sustainable growth of nations and, thereby, a number of countries increase innovation activities at national level (Chen et al., 2009; Dincer, 2000; Lee and Lee, 2013). Since the dominant technology or R & D strategy has not been settled, numerous governments attempt to take advantage of the future renewable energy industry. Due to this global efforts, since 2004, global new investment in renewable energy has increased from 46.6 billion US dollars to 285.9 billion US dollars (McCrone et al., 2016).

While performing R & D in the renewable energy sector, it is important to maintain policy consistency. Despite its importance in achieving technological competitiveness, some governments are still following trends rather than developing technologies consistently. For instance, Martinot et al. (2005) point out that the inconsistency of the United States' (US) renewable energy policy may have led to its overtaking by Japan and EU during 2001–2004. However, the US government reorganized the national renewable plan and announced the Energy Policy Act of 2005 and Solar America Initiative in 2008, thus succeeding in becoming the technology leader in solar photovoltaic technology (Haley and Schuler, 2011). Moreover, Abdmouleh

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et al. (2015) identify that the limitation of India's renewable energy growth comes from infrastructure, financial support, and policy inconsistency. Conversely, China's success in renewable energy is based on the policy consistency given by the 2006 Renewable Energy Law (UNESCAP, 2012).

Despite the importance of policy consistency, previous researches such as White et al. (2013) and Yoon and Sim (2015) have conducted qualitative analyses without discussions on the measurement for policy consistency. In order to compare the relative competitiveness of countries, the index for policy consistency is necessary to be developed.

In this study, we propose indexes for policy consistency and potential technological competitiveness. Previous researches such as Lee and Lee (2013) and Polzin et al. (2015) compares innovation activities and performance based on R & D expenditures and number of patents statistics. Unlike these researches, our suggested indexes are based on patent citation analysis and reflect the qualitative evaluation of innovations. We apply our proposed index to OECD countries and China, and compare technological development activities and technological innovation performances in the renewable energy sector during 1990–2010. This index application could provide a framework for the evaluation of technological development activities and emphasize the consistency of a government's R & D policy.

The remainder of this paper consists of four sections. Section 2 reviews extant literatures. Section 3 provides data and methodology. Section 4 describes the empirical results. Section 5 briefly concludes the study.

2. Literature review

Policy support from government plays a significant role in technological innovation (Kim, 1997). The government directly influences R & D activity through funding or, indirectly, by making the institutional environment friendly (Hryckiewicz, 2013). These efforts resolve underinvestment in R & D on the free market, which is caused by externalities (Arrow, 1962; Nelson, 1959) or information issues (Greenwald et al., 1984; Hall and Lerner, 2010). The direct effort of the government is towards promoting R & D activities by funding the R & D of private sectors (Kaplan, 1988; Löf and Heshmati, 2005). On the other hand, the indirect role of the government policy support is to give a signal to the market and, thus, induces firms' investment in R & D.

Globally, numerous governments support the renewable energy sector due to its significance as a new growth engine. The main goal of the government's support policies is to help firms acquire technological competitiveness and lead the market (Kaplan, 1988). Lipp (2007) compares renewable energy policies among Denmark, Germany, and the United Kingdom, and draws that policy design and intensive execution from government are key factors to the success of renewable energy technology development. Moreover, Johnstone and Haščič (2011) show that flexible policies lead to higher quality innovation by analyzing patent data. Other previous studies focus on the impact of types and characteristics of policies, such as tax credit, subsidy, public procurement, and demand-side subsidy, mainly discussing the effect of recent policies, but not their design.

One of the most important issues in policy design is to keep the policy consistent. Researches in policy science considered policy consistency as consistency between policies. Brehmer (1974) and Brehmer and Kostron (1973) argued that if policies that the subject designed were not consistent, it would make other subjects hard to understand the designed policy. These researches analyzed policy consistency by the correlation between policies. May et al. (2006) suggested that policy consistency can be shown by the compatibility of the goals and the intent between policies. Several researches redefined the concept of policy consistency by combining time consistency. White et al. (2013) used the concept of policy consistency and insisted that policy inconsistency stifled long term investment since it makes uncertainty higher. Similarly, Yoon and Sim (2015) analyzed both

policy continuity and consistency at the same time. In line with White et al. (2013) and Yoon and Sim (2015), this research defines policy consistency as the dynamic consistency of policy over time.

Among various policy support issues, policy consistency affecting technological innovation has been widely dealt with (Groba and Breitschopf, 2013; Reichardt and Karoline, 2014; Uyarra et al., 2016). These researchers agree on the importance of giving consistent signals to economic agents, especially firms, regardless of the types of policy. Frequent policy changes can cause risk-return perception for economic actors and also increase uncertainty (Wüstenhagen and Menichetti, 2012). Therefore, policy consistency is a key factor to the firms' decision-making processes for reducing uncertainty. Nybakk et al. (2011) investigate that policy measures are important for firms' innovation performance in the bioenergy sector. Regarding renewable energy policies, Miranda (2010) also argues the significance of clarity and consistency for these policies. According to Miranda (2010), policy consistency is key to reducing uncertainty on R & D investments and is illustrated when firms decide on large investments in renewable energy projects. If policy is not predictable, firms can suffer contracting loans and can even be deterred to continue investment on their R & D activities.

As such, Bürer and Wüstenhagen (2009) show that policy consistency has a positive impact on investment by interviewing investors. They also find that investors agree on the need of a policy mix and the fact that consistency is the most important characteristic a well-designed policy contains. In this sense, unstable and unpredictable policies may give firms more negative signals than no policy at all (Mallon, 2006). Negative effects of the collapse of R & D projects exceed the positive effect led by the projects not depending on governmental support. White et al. (2013) show the negative effect of unexpected changes in decision-making on investment by analyzing the case of Norway and Ontario.

Overall, it is obvious that technological innovation is critically affected by policy consistency. Despite its importance, numerous researchers regard policy consistency as just one factor among various other factors influencing technological competitiveness. For instance, White et al. (2013) only focus on the case studies of certain technologies and their diffusion, without considering technology development activities. Furthermore, they deal with short-term policy consistency and, thus, do not analyze the accumulated effect of long-term policy consistency. The accumulation of policy consistency can be discussed with the accumulation of competitiveness, since policy consistency indirectly influences R & D activity and, thus, consistent support for R & D activities enhances technological competitiveness.

One of the best practices in explaining the relationship between policy consistency and competitiveness is the case of the German government (Wüstenhagen and Bilharz, 2006). The German renewable energy support system is based on two laws, the feed-in law (StREG) of 1991 and the renewable energy law (EEG) of 2000. This consistent policy support plays a key role in driving renewable investment in Germany. However, the US wind industry suffered from inconsistent policy during the early 2000s (Swisher and Porter, 2006). The US tax credit rate for renewable energies is too low to support and investment in contrast to high cost of renewables. Moreover, the Renewable Portfolio Standard succeeded at the state level, not at national level. These policies failed to give constant signals to the industry and the market, and the US wind industry was overtaken by European countries. The amendment of the FIT system of the Austrian Ökostromgesetz (Eco-electricity Act) of 2009 affects investment in biogas plants (Kulisic et al., 2011). In line with this, Raven and Gregersen (2007) illustrate the setback of biogas plants in Denmark, which is caused by environmental and energy policy changes. China also lacks policy consistency in the wind energy sector, since no policies have been announced in 1996, 1998, 2004, and 2010 (Liao, 2016). Although the Chinese government had not announced a wind energy policy, if it supported the policy, wind energy sector in China would be developed further by overcoming the lack of investment.

Numerous government officers have also acknowledged the importance of policy consistency in terms of avoiding the boom-bust cycle and

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