The Policy Mix's Influence on Inventor Networks in Renewable Energies

[Special Session: "Renewable Energy Technologies, Innovation, and Policy Mix – first results from the GRETCHEN project"]

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(1) Overview

During the last decades, electricity production by renewable sources increased constantly, especially in Germany (IEA 2010). This increase is mainly driven by high subsidies and increased innovative activities in the specific technologies. Several studies show that policies and environmental regulations are an important driver of innovative activity in environmental technologies, especially in renewable energies (Johnston et al. 2010, Dechezleprêtre and Glachant 2012, Grau et al. 2012, Peters et al. 2012). Some of the policy instruments in place affect innovative activities indirectly by creating demand for renewable energies (e.g. feed-in tariffs, tax credits), while others directly affect innovative activities, e.g. by means of R&D subsidies. Innovative output, however, depends not only on the quantity of the inputs but also on the interaction structure between the actors that constitute the system. Innovation is a cumulative process in which novelty is created by combining knowledge from a diverse set of actors. Cooperation and the resulting networks of knowledge transfer and learning constitute one important driver of innovation (Dosi 1988, Powell et al. 1996, Ahuja 2000).

The aim of this research is to understand how different policy instruments interact with each other and form a policy mix which influences the intensity and interaction structure of innovative activity at the meso level. The identification of the effect of single policy instruments and the policy mix on networks of cooperation is studied by mapping co-inventor networks in the photovoltaic and wind industries in Germany. Our focus is on Germany because of the strong political support for renewable energies and the high share of German inventors in these specific industries.

We assume that the policy mix needs to offer sufficient incentives and has to be consistent and credible for the actors to take innovative action. Del Rio and Bleda (2012) show that a mix of different policy instruments is most successful in supporting innovation. Therefore, the following hypothesis arise:

H 1: A policy mix that lacks positive features like credibility and sufficient incentives will have no significant influence on (or even decrease) both size of and connectivity in the inventor network.

We define different categories of policy instruments, according to how direct the influence on the inventor network is. Instruments directly affecting the networks are those specifically designed to support R&D and cooperation. Other instruments, like feed-in tariffs (FITs) and tax credits, have only an indirect influence. From this, a second hypothesis can be derived:

H 2a: Direct instruments mainly increase the connectivity inside the network.

H 2b: Indirect instruments mainly increase the size of the network.

While in the long run policy instruments which support renewable energies are assumed to have a positive influence on the size and connectivity of the network, this must not be true in the short run. Hoppmann et al. (2013) argue that a strong increase in demand induced by political support can discourage innovative activities, since sparse labour and capital will be invested into expansion of production capacity. This leads to the third hypothesis:

H 3: Strong political support for diffusion of renewable energy will affect the growth of the network negatively in the short run.

To test these hypotheses, we will proceed in two steps. First, we analyse the evolution of the co-inventor networks for photovoltaic and wind energy in Germany. Second, we analyse the influence of certain policy indicators on the evolution of the networks.

(2) Methods

Patent data is used to identify cooperation at the inventor level. The dataset for the analysis is retrieved from the Patstat database. Subsets for the relevant technologies are extracted by a combination of technology specific IPC and keyword searches close to the suggestions of the WIPO. The considered time frame spans from 1985 until 2008 covering the emergence of these technologies and substantial changes in the political support they faced over time (Hoppmann et al. 2012).

For the reconstruction of inventor networks, we link inventors via collaborative patents (co-invention). If two inventors are named one the same patent, we assume that they have collaborated and exchanged knowledge during that process (Breschi and Lissoni 2004). Networks are constructed using 5-year moving windows to account for persistence while also allowing for decay of the linkages (Fleming et al., 2007; Schilling and Phelps, 2007). Information about the patent applicants is used to assign inventors to companies within the specific industry.

We construct policy indicators to capture the influence of the policy mix on the network structure. First, we look at particular policy instruments, which are assumed to have a strong influence on innovation in these sectors (e.g. R&D support, the EEG and investment supports). Second, to capture more general influences of political support on the expectations of inventors and innovators, we also construct indicators at the policy mix level. These indicators try to capture features like consistency, strength or credibility of the whole mix, which go beyond the influence of single instruments (Rogge and Reichardt 2012). An important challenge in measuring the influence of policies on structural properties of the inventor networks concerns the time span between R&D activities being affected by a policy and patenting of the inventive output. Furthermore, information on prices for fossil fuels, market structure, and capacity installed of the technologies are used to control for external influences.

(3) Results

Our results show that the size of the inventor networks in the photovoltaic and wind industries increase over time. For photovoltaics, the number of inventors increases over the whole period of observation, but growth rates vary considerably. There are periods of strong growth during the end of the 1980s, the end of the 1990s and from 2004 onwards, whereas throughout the remaining periods the size of the network stagnates or even decreases. The number of connections shows a similar pattern and the number of connections per actor increases from 0.8 in the first period to 1.4 in the last one. In contrast, the wind industry shows continuous growth without any phases of stagnation. The number of connections increases steadily, but the number of connections per actor is lower than for photovoltaics: 0.3 in the first period and 1 in the last one. Regarding the component distribution, we observe sharp differences: While the photovoltaic sector has a high number of relatively small, independent components, there are, from the middle of the 1990s on, three big network components in the wind network, consisting mainly of inventors from powerful players in the market.

Our preliminary descriptive results indicate that the German policy mix has a positive influence on the number of inventors and on network connectivity. Since political support for renewable energies, and therefore the credibility and strength of the policy mix, increased over time, there is some initial support for H 1.Given the stagnation of inventor numbers and connectivity in the early 1990s and 2000s in the photovoltaic network, there seems to be support for H 3. The phases of stagnation follow the introduction of the 1000-roofs program in 1990 and the introduction of the EEG in 2000, which both created strong demand for photovoltaic installations compared to the situation prior to their introduction. The continuous growth of the network in the wind sector, where demand-side policy support was more stable, matches with this interpretation. These preliminary results indicate that policy instruments can cause unintended structural breaks in the evolution of the inventor networks of an industry. Also, the mix of policy instruments is important. While there were strong demand-side instruments in place at the beginning of the 2000s, the direct support for R&D was much below the values in the 1990s. However, the strong effect of the EEG and the strong political support for renewable energy indicate a stronger support at the policy mix level in the 2000s than in the 1990s for photovoltaics. For wind energy, where the EEG did not increase demand as much, changes in the policy mix were weaker and did not induce a structural break in the inventor network.

(4) Conclusions

We show that inventor networks in renewable energies are specific for each industry. Characteristic differences can, at least to some extent, be traced back to market structure and firm size. Furthermore, we show that a credible and incentive rich policy mix has a positive influence on the evolution of inventor networks. However, analytical difficulties arise with respect to the time structure of the policy impact on innovation networks. Even though we observe a long run exponential increase in network size triggered by the introduction of demand side policies, they seem to slow down the growth of the network in the short run. Apparently, changes in single policy instruments seem to be sufficient to alter innovative activities and certain instruments could dominate others. Due to the strength of the EEG, this may be the case for the German policy mix. These specific effects of indirect policy instruments inside a policy mix will be elaborated in more detail in the next step of this analysis. In addition to this analysis, there is further space for research by looking at the policy mix in other countries and its influence on the respective inventor networks.

References

Ahuja, G. (2000): "Collaboration networks, structural holes, and innovation: A longitudinal study", Administrative Science Quarterly, Vol. 45, No. 3, pp. 425-455.

Breschi, S.; Lissoni F. (2004): "Knowledge networks from patent data: methodological issues and research targets", in: Moed, H.; Glänzel, W.; Schmoch, U. (ed.): "Handbook of quantitative science and technology research: the use of publication and patent statistics in studies on S&T systems", Springer.

Dechezleprêtre, A.; Glachant, M. (2011): "Does foreign environmental policy influence domestic innovation? Evidence from the wind industry", November 2012, http://personal.lse.ac.uk/dechezle/Dechezlepretre_Glachant_Nov2012.pdf

del Rio, P.; Bleda, M. (2012): "Comparing the innovation effects of support schemes for renewable electricity technologies: A function of innovation approach", Energy Policy, Vol. 50, pp. 272-282.

Dosi, G. (1988): "The nature of the innovative process", in: Dosi, G.; Freeman, C.; Nelson, R.; Silverberg, G.; Soete, L. (ed.): "Technical Change and Economic Theory", Pinter, pp. 221-238.

Fleming, L.; King, C.; Juda, A. I. (2007): "Small Worlds and Regional Innovation", Organization Science, Vol. 18, No. 6, pp. 938-954.

Grau, T.; Huo, M.; Neuhoff, K. (2012): "Survey of photovoltaic industry and policy in Germany and China", Energy Policy, Vol. 51, December 2012, P. 20 - 37.

Hoppmann, J.; Huenteler, J.; Girod, B. (2012): "Compulsive Policy-Making – The Evolution of the German Feed-In Tariff System for Solar Photovoltaic Power" Paper presented at the International Schumpeter Society Conference 2012, Brisbane.

Hoppmann, J; Peters, M; Schneider, M.; Hoffmann, V. H. (2013): "The two faces of market support – How deployment policies affect technological exploration and exploitation in the solar photovoltaic industry", Research Policy 2013, http://dx.doi.org/10.1016/j.respol.2013.01.002.

IEA (2010): "World Energy Outlook", International Energy Agency, Paris.

Peters, M.; Schneider, M.; Griesshaber, T.; Hoffmann, V. H. (2012): "The impact of technology-push and demand-pull policies on technical change – Does the locus of policies matter?", Research Policy, Vol. 41, No. 8, pp. 1296 - 1308.

Powell, W. W.; Koput, K. W.; Smith-Doerr, L. (1996): "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology", Administrative Science Quarterly, Vol. 41, No. 1, pp. 116-145.

Rogge, K.; Reichardt, K. (2012): "Towards a conceptualization of the policy mix: the case of renewable power generation technologies", Draft Paper, December 19th, 2012.

Schilling, M. A.; Phelps, C. C. (2007): "Inter-firm Collaboration Networks: The Impact of Large-Scale Network Structure on Firm Innovation", Management Science, Vol. 53, No. 7, pp. 1113-1126.