



# Concentration on the few: mechanisms behind a falling share of innovative firms in Germany

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## ABSTRACT

Innovation activities in the German business sector showed two opposing trends over the past two decades: While total innovation expenditures grew substantially, the number of firms conducting innovation activities fell sharply. In this paper, we explore the mechanisms behind the declining trend in the share of innovation active firms. Considering both input (R&D activities) and output (introduction of innovations), we model innovation decisions as a multi-stage process using continuous-time Markov chain analysis. We base our analyses on a 14-year panel from the German part of the Community Innovation Survey. Our results show that smaller firms and firms in sectors with less innovation competition are more likely to stop innovating. We also show that better financial situation and public funding can mitigate the trend towards a falling share of innovating and R&D-performing firms.

## 1. Introduction

Innovation expenditures in Germany have increased impressively in the course of the last two decades. Between 1995 and 2013, firms in Germany raised their spending for developing and introducing new products and new processes from €60.7bn to €145.2bn resulting with a compound annual growth rate of 5.0 percent (Rammer et al., 2016). While the growth rate of innovation expenditures suggests that German firms have become ever more focused on innovation, it hides away that the rise in innovation expenditures was mainly driven by large firms with more than 500 employees (annual growth 6.6 percent), compared to only 1.6 percent for small firms. Consequently, the share of innovation expenditures of large firms increased from 58 to 76 percent. One important reason for the increasing concentration of innovation expenditures in large firms is a growing share of firms that refrain from innovation altogether. The share of firms having introduced at least one product or process innovation peaked in 1999 at 55.5 percent and more or less steadily dropped to 37.1 percent in 2013.<sup>1</sup> The falling share of innovative firms has alarmed innovation policy makers in Germany because of a fear that the firm base upon which much of the country's international competitiveness rests appears to be in decline.

The observed trend of a falling share of innovative firms is to some

degree in contrast to the findings in the literature on the persistency of innovation, which emphasises that transition rates between innovative firms and non-innovative firms are low (Clausen and Pohjola, 2013, Latham and Le Bas, 2006, Peters, 2009, Tavassoli and Karlsson, 2015). The main theoretical explanations for persistency in innovation include the path-dependent nature of technological progress (Colombelli and von Tunzelmann, 2011), the cumulateness of the knowledge required for innovation (Nelson and Winter, 1982, Crespi and Scellato, 2015), the self-reinforcing effect of past innovation successes by providing successful innovators with market power and larger financial resources ('success breeds success'; Phillips, 1971, Flaig and Stadler, 1994), the broadening of future technological opportunities through innovation (Mansfield, 1968), the presence of sunk costs of innovation (Sutton, 1991), and the role of market structure and competition (Woerter, 2014).

The declining trend in the share of innovators challenges the persistency perspective and calls for an extended view of the reasons when and why firms continue or discontinue innovation. To extend the theory of persistency in innovation we focus on the three aspects firm size, changes in the technological opportunities by sector, and the firm's financial situation, which can affect the degree of persistency. First, we argue that smaller firms face higher difficulties when conducting

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<sup>1</sup> A similar decline in the innovation share is also found in other European countries, though changes in survey methodologies and the lack of annual surveys limit the possibilities for long-term comparisons. For 12 European countries reporting innovation data for all Community Innovation Surveys from 1996 to 2012, the share of innovators fell from 45 percent in 1996–37 percent in 2012.

innovation (Acs and Audretsch, 1987, Cohen and Klepper, 1996). When the economic situation of a small firm worsens, quitting innovation may be a rational option. But restarting innovation activities often turns out to be very challenging owing to fixed costs and the need to invest in specific capabilities. Second, if opportunities for innovation are scarce and the level of innovation-based competition is low, larger firms have a relative innovative advantage over smaller firms, deterring small firms from innovation (Acs and Audretsch, 1987). We argue that in some sectors of the German economy, innovation opportunities diminished and competitive advantages shifted from innovation to costs, explaining why in particularly small firms withdrew from innovation over the course of the last decade. Third, we stress the mediating role of the firm's financial situation. Firms with larger internal funds and firms receiving public support for innovation can easier cope with the disincentives regarding innovation and hence are more likely to remain innovative or enter into innovation activities.

The paper contributes to the literature in a number of ways. On the one hand, we enrich the persistency discussion with insights on the discontinuities of firms' innovation behaviour, where, so far, most studies focused on the factors that drive persistency. On the other hand, while most studies focused on either the input (R&D) or the output side of innovation (successfully introduced products or processes) we consider both simultaneously. Third, we conceptualise a firm's choice to conduct innovation not as a binary (yes/no) decision as done in many other studies, but as a stage-process where stages represent different levels of innovative inputs and outputs. Fourth, we consider the role of policy intervention for counteracting the declining trend in innovation activity.

Using firm-level panel data from the German Innovation Survey covering the period from 2001 to 2013 and adopting a Markov Chain approach, we indeed find that SMEs are less likely to enter into higher states of innovativeness and more likely to fall back. Most importantly, we show that the lower probability for innovativeness amplified over time. While this holds for SMEs in all sectors, the withdrawal from innovation is most pronounced in low-tech manufacturing, while SMEs in high-tech manufacturing and in services are less affected. Finally, we show that both public innovation support and better financial capabilities increase the SMEs' chances of moving to higher levels of innovativeness and reduce the probability of falling back. We conclude that strengthening public innovation support in Germany can be an important economic policy to mitigate the risk of a permanent withdrawal of German SMEs from innovation.

## 2. Theory

The main purpose of this paper is to investigate the mechanisms driving the steady decline in the share of innovative firms in Germany, which led to a concentration of innovation activities on ever fewer firms. While many works have focused on persistency of innovation (Deschryvere, 2014, Johansson and Löf, 2010, Crespi and Scellato, 2015 for a review), we are instead interested in the mechanisms driving discontinuities in the firms' innovation behaviour. We introduce three factors leading to discontinuities. The first factor refers to the role of size of the firm. Because smaller firms control fewer resources, they need to prioritise their investments much stronger in comparison to larger firms with typically better resource endowments (Acs and Audretsch, 1987). Lower resource endowment first affects the input side of innovation in terms of R&D, because in order to conduct R&D firms need specific skills such as human capital and pre-existing technological knowledge as well as financial resources. Lower resource endowment also affects innovation outputs by at least two mechanisms. First, conducting R&D is itself a major driver of innovative output as it is a prerequisite for conducting innovation successfully in many sectors (Arora, 1997). Second, lower skills and inferior access to financing decrease the success rates of innovation. Thus, lower success rates imply higher risks for firms. A high level of risk means that investing a

significant share of the firm's resources in innovation may jeopardise the entire firm in case the innovation fails. This is particularly true if innovation requires a certain minimum investment and fixed costs (González and Pazó, 2004) typically giving rise to increasing returns to scale in innovation (Shefer and Frenkel, 2005). In small firms, fixed costs of innovation can be spread only over a smaller level of output, placing a competitive disadvantage on small as compared to large firms (Cohen and Klepper, 1996). Attracting external financing for innovation is also more complicated for small firms because of information asymmetries resulting in higher risks for lenders, particularly if the expected returns from innovation are low and hence unattractive for venture capital (Czarnitzki, 2006, Hall and Lerner, 2010).

In a static perspective, these factors contribute to a lower share of innovators among small firms. In a dynamic perspective, the factors contribute to a lower degree of innovation persistency. In line with that argument, the literature shows that large firms are often more successful in their innovation activities as they profit more from increasing returns to scale (Clausen and Pohjola, 2013, Lhuillery, 2014, Máñez et al., 2014, Flaig and Stadler, 1994), tend to possess more or more valuable complementary assets (Teece, 1986) and follow more elaborate protection strategies for intellectual property (Neuhäusler, 2012). If innovation competition becomes more intense, small firms face a disadvantage and are more likely to quit innovation, as they find it more difficult to enter into innovation activities. In addition, larger firms follow more complex innovation strategies making them less likely to discontinue innovation (Le Bas and Poussing, 2014). Empirical evidence of larger firms showing higher persistency over smaller firms is provided by Roper and Hewitt-Dundas (2008) and Antonelli et al. (2013).

*H1: Small firms are more likely to exit from and are less likely to enter into higher states of innovativeness both on the input (R&D) and the output side (introduced innovations).*

Our second hypothesis relates to the role technological opportunities for innovation and competition. If innovation opportunities and the expected returns from innovation are low, competition will be based on other factors, such as low prices or high degrees of customer specification. At the same time, spill-overs from innovation outside the firm are lower, increasing the cost of innovation for each firm. Investing in innovation will hence result in lower returns, making other investment more attractive. In this situation, entry into innovation will be lower than in other markets (see Schmoockler, 1966 for theoretical arguments and Malerba et al., 1997, Peters, 2009 for empirical support) and firms will gradually switch their competitive strategies to non-innovative ones. The intensity of competition in a market is another important determinant of firms' choices to enter or exit innovation. Baraldi et al. (2013) find that persistency is higher in oligopolistic markets (Schumpeter II industries). Woerter (2014) supports this finding showing that persistency is more pronounced for firms with few competitors. Acs and Audretsch (1987) demonstrated that the effects of size and market structure on the probability of innovation are inter-related. Large firms tend to have a relative innovative advantage in more capital-intensive and concentrated industries whereas small firms can be more successful with innovation in highly innovative and competitive industries.

In order to explain the declining share of innovative firms in Germany, technological opportunities and shifts in the type of competition can play a relevant part (Vega-Jurado et al., 2008, Robin and Schubert, 2013, Schubert, 2010). The decline started around the year 2000, which was the year of the introduction of the Euro as common currency. Since then, the German economy experienced a gradual but steady improvement of its cost competitiveness vis-à-vis other countries in the euro area, because higher productivity gains in Germany were not compensated by an appreciating currency inside the euro area (compare Dustmann et al., 2014). In addition, inflation in Germany was lower than in most other euro area countries, resulting in a lower increase in production costs. As the euro area is Germany's most

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