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Innovation Effects of Science-Related Technological Opportunities

Theoretical Considerations and Empirical Findings for Firms in the German Manufacturing Industry

Innovationseffekte von technologischen Möglichkeiten aus dem Wissenschaftsbereich

Theoretische Analyse und empirische Evidenz für das Verarbeitende Gewerbe in Deutschland

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Summary

This paper investigates the innovation effects of science-related technological opportunities. Against the background of theoretical considerations about the interrelation of innovation process and adaptation of external (knowledge) resources, the impacts of technological opportunities stemming from scientific institutions on firms' innovation input and output are empirically analyzed for the German manufacturing industry. The investigations focus on the question of whether science-related technological opportunities are used as complements or substitutes in the innovation process.

The estimations indicate complementary relationships between firms' innovation input and technological opportunities stemming from scientific institutions. The adaptation of science-related knowledge resources has stimulating effects on the intensity of in-house R&D. The results for the innovation output effects are ambiguous. On the one hand, empirical evidence for complementary impacts on the realization of process innovations could be found. On the other hand, science-related technological opportunities have no enhancing effects on the probability of realizing product innovations. Obviously, knowledge from universities and research institutes stimulates the development of new products more indirectly by increasing in-house capacities and enhancing R&D efficiency.

Zusammenfassung

In diesem Beitrag werden die von technologischen Möglichkeiten aus dem Wissenschaftsbereich induzierten Innovationseffekte analysiert. Vor dem Hintergrund theoretischer Überlegungen zum Zusammenhang zwischen betriebsinternen FuE-Aktivitäten und der Nutzung externer Wissensquellen wird der Einfluss technologischer Möglichkeiten aus dem Wissenschaftsbereich

auf den betrieblichen Innovationsinput und -output im Verarbeitenden Gewerbe der Bundesrepublik Deutschland empirisch untersucht.

Die ökonometrischen Schätzungen zeigen, dass sich die Nutzbarmachung von wissenschaftlichen Erkenntnissen stimulierend auf die Intensität betriebsinterner FuE-Anstrengungen auswirkt. Zwischen dem betrieblichen Innovationsinput und der Nutzung technologischer Möglichkeiten aus Hochschulen und Forschungsinstituten besteht insofern ein komplementäres Verhältnis. Die Ergebnisse auf der Seite des Innovationsoutputs fallen ambivalent aus. Die ökonometrischen Schätzungen weisen einen positiven Zusammenhang zwischen der Entwicklung verbesserter Produkte und der Adaption wissenschaftlicher Erkenntnisse aus. Bezogen auf die Entwicklung grundlegend neuer Produkte finden sich dafür aber keine empirischen Belege. Technologische Möglichkeiten aus dem Wissenschaftsbereich fördern demnach die Entwicklung von Produktinnovationen mehr indirekt, indem betriebsintern vorhandene Kapazitäten erweitert und die Forschungseffizienz erhöht werden.

process (Peters/Becker 1999, Fritsch/Lukas 2001, Kaiser 2002), the dynamics of knowledge flow from science to technology as reflected in patent indicators (Grupp 1996, Schmoch 1993), the role of universities in the technology transfer especially for small and medium-sized firms (Beise/Licht/Spielkamp 1995, Meyer-Krahmer/Schmoch 1998, Schmoch/Licht/ Reinhard 2000, Wagner 1990), the importance of regional science and research infrastructure on the formation of new firms (Fritsch/Meyer-Krahmer/Pleschak 1998, Licht/Nerlinger 1998, Harhoff 1997), or the relevance of public and university research in high-tech industries (Beise/Stahl 1999, Grupp 1992, Peters/Becker 1998, Wagner 1987). A summary of the state of the art reveals two noteworthy points:

- Empirical investigations have concentrated on the effects of scientific research on the intensity of firms' innovation input activities (e.g., R&D intensity, R&D employment intensity).
- The impacts of external (knowledge) resources stemming from universities and research institutes on the realization of innovations (the innovation output side) are hardly analyzed.

This paper picks up these points and tries to enlarge the findings on the role of science-related technological opportunities in the innovation process. Analysis concentrates on the effects – in context with other exogenous factors – both on the innovation input and output of firms. Furthermore, it investigates whether internal R&D and external knowledge resources stemming from scientific institutions are used as complements or substitutes in the innovation process.

The paper is organized as follows: In section 2, we discuss the relationship between firms' innovation behaviour and the adaptation of external (knowledge) sources from a *theoretical* point of view. Section 3 describes the data set, variables used and estimation methods. In section 4, the importance of science-related technological opportunities for the innovation input and output activities of firms in the German manufacturing sector are investigated from an *empirical* point of view. Section 5 summarizes the main findings and gives an outlook on further research.

2. Theoretical Considerations: Innovation Process, External (Knowledge) Resources and Science-Related Technological Opportunities

The development of new products and technologies is a well-directed search and learning process which involves technical as well as economic uncertainties. Successful innovations are determined by different and related factors (Flaig/Stadler 1998, Kleinknecht 1996, Martin 1994). These factors can be divided into *firm-specific* determinants (R&D intensity, firm size, etc.) and *external* influences, such as technological opportunities, market structures, industrial technology level, etc.

Concerning firm-specific determinants, *in-house* R&D³ plays a major role in the development of new products and technologies. Basic reasons for R&D can be seen in the expansion of know-how and the increasing probability of realizing product and process

³ R&D is a part of firms' activities to develop new products and technologies. *Innovation activities* include also expenditures for product design, trial production, purchase of patents and licences, and employee training, etc. In this paper, the discussion centres on R&D as the *main* part of firms' innovation activities.