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Shaping the national system of inter-industry knowledge exchange Vertical integration, licensing and repeated knowledge transfer in the German plastics industry☆

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Abstract

We will claim in this paper that it was in particular the above-average propensity to share innovative information with customers and competitors which caused the exceptional international competitiveness of the West German plastics industry including chemical firms, plastics fabricators and machine makers. The system of knowledge exchange of this national cluster was shaped in two main steps. In the first half of the 20th century, cartellization and mergers were first tolerated and then even supported by the German government. It was in this period when German chemical firms formed the vertically integrated I.G. Farben concern which provided an optimal organisational framework to explore the new technological path of plastics. After the breaking up of I.G. Farben the firms of the West German chemical firms had to find new ways to maintain inter-industry technological co-operation in the second half of the 20th century. It turned out that they became aware of both contractual and non-contractual solutions of bundling standard good and information which were often placed somewhere between "market" and "hierarchy". It seems to be no accident that all these different institutions did primarily encourage knowledge exchange between firms in geographical and cultural proximity. That is why the knowledge exchanging network of the plastics industry described in this paper has been in particular concentrated on German firms. Even so the question is still open whether this localisation is just a curiosity limited to a special industry cluster or part of a broader German system of knowledge exchange.

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1. The problem of knowledge exchange

Economic history is full of examples which suggest that technological creativity has been one of the most important sources of long-term economic growth (see, for example, Mokyr, 1990). However, like others gifts, this talent has not been equally distributed among people, firms or industries. What is more this kind of inequality often not even balances out on the level of states. Obviously some nations have done better than others in bringing forth particular industries dominating international markets by their comparatively superior capability to innovate. That is why, measured

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by economic standards, some countries have been forging ahead while others have been falling behind (see Abramovitz, 1986). Nevertheless, it would be wrong to conclude from these empirical observations that we have to accept such an uneven development in the future too. Instead politicians and managers of those nations lagging behind may be able to improve the technological creativity in their particular home market by changing the attributes of the legal, cultural and economic environment. To find out appropriate ways to do this recent studies analyse the respective merits and disadvantages of historical "national systems of innovation" (see Edquist, 1997; Freeman, 1995; Lundvall, 1992; Nelson, 1993; Porter, 1990).

The German system of innovation of the late 19th century, for example, is especially credited for its advanced education system, the variety of specialised research organisations sponsored by government and its industrial research laboratories. It is widely believed that the new products which emerged from these organisational innovations allowed German firms to overtake their British competitors in fields like steel, chemicals or electro technical products (see Keck, 1993). However, the diffusion of knowledge might be as important as the creation of knowledge to make a national system of innovation working effectively (see Lundvall, 1998). In this respect Lundvall (1988) emphasises the importance of inter-industry knowledge exchange between upstream and downstream firms. There are several channels through which innovative information can be transferred from one firm to another. Drejer (2000) focuses on the flow of information embodied in commodities. Mapping inter-industry interdependencies on the basis of input–output tables she gets the result that the chemical industry was and still is the major source of embodied technology in Germany. In this paper, we will concentrate on the channels of pure knowledge exchange between supplier and customer. New information can flow in both directions. Being informed about actual problems and future needs of their customers, upstream firms are better able to assess which kind of technological invention will also be economically successful. In this case, it is the downstream industry which determines the choice of R&D projects executed by the upstream producers. It is also possible that the latter shape the future direction of their customers' technological progress by independently developing a new product which can be profitably sold in downstream markets. Equipment manufacturers as well as commodity suppliers have incentives to create and transfer this kind of knowledge whenever they expect that the market success of such an innovation will also increase the demand for their own products which themselves are serving as inputs in the respective process of production (see VanderWerf, 1992). However, every exchange of goods bears the danger that the receiver of a particular good refuses the economic return. This is particularly true for transferring innovative knowledge since it is especially hard for the supplier to prove before court that an intangible piece of information has actually been delivered. We will elaborate this hypothesis using some techniques of game theory.

We will model knowledge exchange as a two-stage game with two players.[1] These are an upstream firm supplying commodities and a downstream firm processing these inputs to consumer goods. We further assume that the R&D department of the upstream firm additionally has the capability to develop ideas for product innovations which are supposed to be put up for sale at the market of the downstream firm. The transfer of this knowledge to the downstream firm can be carried out through product demonstrations and customer training. Since the downstream firm will be reluctant to pay for this kind of information before exactly knowing its contents the upstream firm is forced to reveal its knowledge first (see Carter, 1989). Then the downstream firm can decide either to take the knowledge transfer as a free lunch or to reward the upstream firm for creating and transferring the useful innovative information. Hence, the game of knowledge exchange has the extensive form shown in Fig. 1.

The upstream firm moving first has the choice between the two strategies "Do not transfer" and "Transfer". The strategy "Do not transfer" means that the upstream firm will not communicate any innovative information to the downstream firm. In this case, the upstream firm realises the zero payoff. The same is true for the downstream firm. Playing "Transfer" the upstream firm has costs which includes expenses both for R&D and for teaching the downstream firm how to manufacture the product innovation. The total payoff of the upstream firm depends on the reaction

[1] See Streb (1999). For a similar concept see also Greif (2000).