Exploring the Knowledge Filter: How Entrepreneurship and University-Industry Relations Drive Economic Growth

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Abstract:

Knowledge is recognized as a crucial element of economic growth in addition to physical capital and labor. Knowledge can be transformed into products and processes and is herewith exploited commercially. The ability to produce, identify, and exploit knowledge depends on the existing knowledge stock and the absorptive capacity of actors like employees at firms and researchers at universities and research institutions. The existing knowledge stock might not be commercialized to its full extent, therefore, knowledge spillovers must occur and other transmission channels are needed. Entrepreneurship and university-industry relations contribute to knowledge spillovers and thus spur economic growth. This paper tests the contribution of new ventures and university-industry relations to economic growth on the regional level empirically. The results support that entrepreneurial activity and universities are essential transmission channels for knowledge spillovers and have a positive impact on economic growth.

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1 Introduction*

Why do regions post different growth rates and differences in technological progress? The growth rates of labor and physical capital are not the only sources of economic growth; in fact, knowledge creation and knowledge spillovers are an important element in stimulating economic development. Recent empirical studies (Plummer & Acs, 2004; Varga & Schalk, 2004; Acs & Varga, 2004; Audretsch & Keilbach, 2004) have shown that knowledge spillovers positively affect technological change and economic growth.[1] Other studies have shown that knowledge spillovers do not occur automatically (i.e. Anselin, Varga & Acs, 1997 and 2000; Audretsch & Feldman, 1996). Hence, it is less clear which mechanisms facilitate and foster knowledge flows.

This paper focuses on the exploitation of opportunities and commercialization of knowledge, namely the transformation of knowledge into products, processes and organizations and their contribution to regional economic growth. Why does the degree of knowledge exploitation differ across regions? One reason might be that the level of research and development activities varies largely across regions. A high level of research and development leads to innovations and facilitates the ability to identify, absorb, and exploit inside and outside knowledge (i.e. knowledge created by other firms or research institutions) (Cohen & Levinthal, 1989). The other reason might be that incumbent firms might not exploit new opportunities to the full extent, and new knowledge generated in research institutions and universities is not commercialized at all. A critical part of knowledge may lie idle and thus, knowledge spillovers are necessary for its diffusion. Mechanisms are needed in order to support the exploitation of opportunities. This paper introduces entrepreneurship and university-industry relations as mechanisms for knowledge spillovers and determinants of economic growth.

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework and links channels for knowledge spillovers to economic growth. The methodology and database is described in section 3. It is empirically

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[1] Audretsch & Lehmann (2005) have shown that knowledge spillovers from universities affect firm growth. Firms that are closely located to the next university experience higher growth rates.

tested if entrepreneurship and university-industry relations are mechanisms facilitating the spillover of knowledge and affect economic growth in section 4. Section 5 provides a summary and a conclusion.

2 The Exploitation of Opportunities: The Significance of Knowledge Spillovers and the Knowledge Filter

Although knowledge is understood as an essential driver of economic growth, knowledge is hardly linked to economic growth in empirical analyses. Within new growth theory knowledge stimulates technological progress and thus increases productivity.[2] New knowledge generates innovations and is commercialized by transforming it into new products, processes and organizations. Private businesses and research establishments (i.e. universities and research institutions) generate new knowledge through research and development activities. The created knowledge may be exploited by them, the knowledge-producer, or by other businesses. These other businesses can be in the same industry or discipline, or in related or different industries or disciplines. However, the possibility to exploit knowledge from the environment (external knowledge) requires the flow of knowledge, i.e. knowledge spillovers. Through knowledge spillovers other economic actors may also exploit opportunities, resulting in an acceleration of economic growth.

Cohen & Levinthal (1989) argue that research and development activities not only generate innovations but also increase the firm's ability to identify, assimilate, and exploit externally created knowledge.[3] Applied on the regional level, this would indicate that the higher the level of research and development activities in a region are, the more opportunities are exploited by the knowledge-creator and also by other businesses. In other words the regional level of R&D characterizes the region's absorptive capacity. However, knowledge may be subject to various constraints preventing knowledge spillovers; namely legal, cost, and geographical constraints. Patenting, the protection of intellectual property, may be one legal constraint (Cohen, Nelson & Walsh, 2002) and a financial constraint since other firms need to pay license fees. The deployed technology, the

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[2] Romer (1986, 1990) and Lucas (1988) explain in their models economic growth through the accumulation and spillover of technological knowledge.
[3] See also Cohen & Levinthal (1990) and Zucker, Darby & Brewer (1998) for more details on absorptive capacity.

factual production capacity, and the employed human capital affect the exploitation of knowledge as well. Results of various empirical analyses show that knowledge spillovers are spatially bounded (Anselin, Varga & Acs, 1997 & 2000; Audretsch & Feldman, 1996 & 2004; Audretsch & Lehmann, 2005)[4]. Knowledge spillovers seem to depend on a strong regional component, taking advantage of spatial proximity to research facilities, universities, industry specific agglomeration and of course using face-to-face contacts. One reason for geographic boundaries could be the tacit nature of knowledge. It can be distinguished between a codified and a tacit part of knowledge. Whereas codified knowledge is published in books, scientific papers or in patent documentations, the tacit part is firm and individual specific because it is embodied in employees.[5] Due to its tacit dimension, knowledge cannot be easily transferred over large distances, manifesting its spatial dimension and its geographic boundaries. Due to these constraints, knowledge spillovers do not occur costless and automatically.

Furthermore, knowledge may not be fully applied and exploited. One reason could be that incumbent firms do not want to take the risk combined with new products or processes. They might focus on exploiting the profit possibilities of their given product program and are not interested in searching for new opportunities and realizing them (Audretsch, 1995; Geroski, 1995, 431). Internal constraints (i.e. financial manner) might also hinder the commercialization of knowledge in these firms. Another reason might be that the work of universities and research institutions, in particular, is hardly translated into new products or services (Pavitt, 2001). The assignment of universities is to carry out fundamental and applied research and not to commercialize their generated knowledge. University-industry interaction is needed to facilitate the exploitation of opportunities. Mansfield (1991 and 1998) and Beise & Stahl (1999) point out that many new products and processes would not have been developed without academic research or only with substantial delay and without technology transfer. Therefore, it may be argued that a kind of filter exists, functioning as a barrier and limiting the total conversion of knowledge into new products, processes and

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[4] See also Jaffe, Trajtenberg & Henderson, 1993; Audretsch, Lehmann & Warning, 2004.
[5] See Gorman, 2002 for an overview of the different types of knowledge. See also Romer, 1990 for details and Varga & Schalk, 2004 for an overview.

organizations – the knowledge filter (for details, see Acs, Audretsch, Braunerhjelm & Carlsson, 2003).[6]

The permeability of the knowledge filter determines to what extent knowledge is exploited, and the permeability may be increased by a greater pool of economic actors possessing the ability and willingness to take the risk and exploit opportunities. Knowledge needs to flow before it can be applied and commercialized externally; hence, knowledge transmission channels are needed. New business formation and university-industry relations are possible transmission channels which penetrate the filter and stimulate knowledge flows.

Entrepreneurial activity, taking the opportunity and setting up a business, can be assumed as a mechanism by which knowledge spillover occurs. Founders of the new ventures might have worked for incumbent firms or research establishment before they realized the opportunity (spin-offs), they might have already been entrepreneurs, or the new ventures might be new branches of existing firms.[7] Through their innovative activity, new ventures may introduce new products or even create new markets. Many radical innovations have been introduced by new firms rather than by incumbents (Audretsch, 1995). This phenomenon may be explained that the set-up of one's own business might be the most promising – sometimes the only – possibility to commercialize knowledge (Audretsch, 1995). Shane & Venkataraman (2000) point out that entrepreneurship is not only the presence of (profitable) opportunities but also the presence of enterprising individuals. Therefore, it may be expected that in those regions where entrepreneurial spirit is more developed, new business formation activity is more pronounced, hence facilitating knowledge flows stronger.

University-industry relations may be another mechanism facilitating the exploitation of knowledge and the flow of ideas (c.f. Mansfield & Lee, 1996; Fritsch & Lukas, 2001; Fritsch, 2001). Many governments try to obtain an

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[6] Acs, Audretsch, Braunerhjelm and Carlsson (2003) developed a model in which knowledge is transformed into economically useful knowledge by either incumbent firms or start-ups. Incumbent firms learn, increase their absorptive capacity and incorporate new knowledge into their firm-specific knowledge, thus absorb knowledge spillovers. New ventures are assumed to be the mechanism to transmit knowledge and transform it through knowledge spillovers into economically relevant knowledge. However, for Acs et. al. knowledge spillovers cannot occur without new ventures, and hence, there is no economic growth

[7] Shane & Venkataraman (2000, 219) also argue that entrepreneurship does not necessarily require the creation of new organizations, it could also occur within existing organizations, i.e. the set-up of branches. See also Amit, Glosten & Mueller (1993) and Casson (1982).

increase in the interaction between university and industry (Cohen; Nelson & Walsh, 2002) because these interactions are recognized to ascend the rate of innovation in the economy (Spencer, 2001 and Laursen & Salter, 2004). Public research hardly results in ready-to-produce innovations, however, if the generated knowledge is transferred via research partnerships it may accelerate technology transfer and enable firms to develop new products and process (Cohen, Nelsen & Walsh, 2002 , Spencer, 2001, Mansfield 1991 and 1998). Adams, Chiang & Starkey (2001) find evidence that industry-university cooperative research centers are conducive to industry-university technology transfer. Both large firms and small enterprises may seek collaboration with universities in order to realize specific research and development projects. Some firms that have downsized their research and development facilities benefit from linkages with universities as well (Adams, Chiang & Starkey, 2001). Especially some small ventures only obtain access to R&D inputs via cooperation (Audretsch & Feldman 2004). Research partnerships expand the absorptive capacity of the cooperative firm because otherwise the firms may only benefit from spillovers of new knowledge generated by other firms in a particular technology area if it does R&D in this specific area, as well (Scott, 2003). Therefore, university-industry research partnerships are transmission channels for both small and large firms to generate, receive, apply and commercialize knowledge.

Based upon these assumptions, the commercialization of knowledge depends on research and development activities of firms and research facilities (the knowledge stock and absorptive capacity), entrepreneurship and university-industry relations. This paper puts forward that the contribution of entrepreneurial activity and university-industry partnerships may spur economic growth and explain why regions post different growth rates. Regional differences in economic growth may also be determined by agglomeration externalities i.e. the concentration of firms in same or related industries, universities and research facilities, and (qualified) labor provide a pool of technical knowledge (Feldman & Florida, 1994; Acs&Varga,2004).[8] The role of spatial proximity of knowledge creators and users is especially important when technical knowledge is informal or tacit in nature. The regional entrepreneurial climate may also affect growth;

[8] See also Glaeser, Kallal, Scheinkaman & Shleifer (1992) and Jaffe, Trajtenberg & Henderson (1993) and others.

empirical studies have found that people who have developed useful information for entrepreneurship from previous employment have a higher propensity to exploit opportunities themselves and become entrepreneurs (Cooper, Woo & Dunkelberg, 1989, Wagner, 2005).[9]

3 Methodology, Data and Measurement

Are entrepreneurship and university-industry relations transmission channels for knowledge spillovers which penetrate the knowledge filter, facilitate the commercialization of knowledge, and thus stimulate economic development? The purpose of the paper is to develop a regional model of economic growth for West German districts between 1992 and 2000. Economic growth is measured by the annual growth rate of economic output and the growth rate of Total Factor Productivity (TFP). The analysis is restricted to West Germany because East Germany can be regarded as a special case with very specific conditions not comparable to the West in the 1990s (for detail see, Brixy & Grotz, 2004; Fritsch, 2004).

The starting point is a neoclassical production function, $Y(t) = A(t)\, K^{\alpha} L^{\beta}$, economic output is determined by physical capital *K*, labor *L* and the level of technology *A(t)* (also called total factor productivity, TFP). The growth rate of aggregate output is broken down into the contributions from the growth of capital and labor. The growth rate of aggregate output can be written as $\dot{Y}/Y = \dot{A}/A + \alpha(t) \cdot \left(\dot{K}/K\right) + \left[1 - \alpha(t)\right] \cdot \left(\dot{L}/L\right)$.[10] Regional aggregate output *Y* is measured by regional gross value added of all industries (at constant 1995 prices). The physical capital stock *K* is calculated from gross fixed capital formation (investment) (at constant 1995 prices) following the perpetual inventory method (for details see, Mueller, 2004). The number of employees measures labor *L*. All data on regional gross value added and gross fixed capital formation (investments) are from various publications of the federal statistical office and statistical offices

[9] See also Shane & Venkataraman (2000) for an overview.
[10] See Barro & Sala-i-Martin (1995) for an overview of growth accounting.

of each state (*Bundesländer*).[11] The number of employees in each region is from the establishment file of the German Social Insurance Statistics. All public and private employees must be reported to the Federal Employment Office for enrollment in the social insurance system.[12]

The empirical modeling framework develops a regional model of economic growth.[13] In order to test the hypothesis if economic growth depends on the region's absorptive capacity, entrepreneurship and university-industry relations, the following model is developed. Entrepreneurship and university-industry relations shall test the permeability of the knowledge filter and analyze if they function as possible transmission channels for the flow of knowledge and spur economic growth.

$$(1)\quad \ln\left(Y(t)/Y(t_0)\right) = \alpha_1 \ln\left(K(t)/K(t_0)\right) + \alpha_2 \ln\left(L(t)/L(t_0)\right) + \alpha_3\left(RDI_{i,t}\right) + \alpha_4\left(RDP_{i,t}\right) + \alpha_5\left(E_{i,t}\right) + \alpha_6\left(UI_{i,t}\right) + \alpha_7\left(AGG_{i,t}\right) + \varepsilon_{i,t}$$

In equation (1), in addition to the growth rate of physical capital and labor regional economic growth, it is affected by research and development activities in private enterprises *RDI* and the generation of knowledge in universities *RDP*, entrepreneurship activity *E*, and university-industry relations *UI*, as well as by agglomeration externalities *AGG*. The subscript *i* refers to the respective West German districts, t runs from 1992 to 2000 and t_0 is the initial value in 1992. The regional knowledge stock and the region's absorptive capacity are measured by R&D activities in the private sector and in universities. The share of employees devoted to R&D in the private sector out of all employees measures RDI, and RDP is measured by the number of researcher at universities per overall employees in the respective district. Regional entrepreneurship *E* is measured by

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[11] Data on gross fixed capital formation (investment) are annually published by each statistical office of the German federal states (series E I 6). Data on regional gross value added are published by the working group of the Statistical Offices of the German Federal States, Volkswirtschaftliche Gesamtrechnung der Länder (VGR d L) every other year between 1976 and 1990 and annually since 1992.

[12] Civil servants, army personnel, self-employed etc. are not obliged to contribute to the social insurance system and are therefore not listed (for details see Fritsch & Brixy, 2004).

[13] The basis is the Romer (1990) model, $\dot{A} = \delta H_A^{\chi} A^{\varphi}$, in which the change in technological knowledge is affected by the number of knowledge workers (H_A) and the total stock of knowledge (A) available at a certain point in time. However, this model assumes that knowledge spillovers occur automatically, contradicting the idea of an existing knowledge filter. For more details see Romer (1990), and Varga & Schalk (2004) for an overview

the region's start-up rate, the number of new businesses formed per employees in the respective district. The regional level of university-industry relations *UI* is measured by the amount of grants given from firms in the private sector to universities. The data on new businesses and the business stock are provided by the establishment file of the German Social Insurance Statistics (for details see, Fritsch & Brixy, 2004). All establishments with at least one employee who is subject to obligatory social insurance are listed in this file. Therefore, firms consisting only of owners are not included. The information is available on the regional level (districts) and for a relatively long time period, between 1983 and 2002, for West Germany. The number of employees engaged in research and development in private businesses are also from the German Social Insurance Statistics. The database comprises information on education and occupation of the listed employees. Information is existent for the years 1987 – 2000. The number of researchers at universities is from the Federal Statistical Office. All other data about academia-like students, graduates, staff and financial resources (grants, revenues and expenses) are from the Federal Statistical Office as well. The information is available on the level of university entities and has been aggregated on the district level.

The descriptive statistics are presented in Table 1. The number of employees devoted to research and development in private industries range from 31 to 33,765 employees for all districts between 1992 and 2000; the share from below 1% to about 16%. The skewness of the distribution of researcher and scientist at universities is quite obvious, ranging from zero to 11,684 per district and from 0% to 12.49%. The district with the fewest start-ups has 62 new ventures; the maximum of new businesses constitutes 6,134. The start-up rate, new businesses per 1,000 employees, ranges from 1.92 to 20.64; there are on average 8 new businesses per 1,000 employees. On the district level, differences regarding grants from firms to universities are highly distinct; it ranges from zero Euro to 104,478,000 Euro (in constant 1995 prices). The distribution is heavily skewed, while the district received on average 1,593,550 Euros, 50 percent of the districts obtained no grants at all. The reason for the heterogeneity is that many universities in Germany are located in cities, and these cities are also organized as

districts. Hence, some districts around cities have not received grants.[14] Nevertheless, adjacent districts of university cities may benefit from research activities of universities. The total amount of grants from private businesses to universities increased from 389 million Euros in 1992 up to 651 million Euros in 2000 in West Germany. The strong rise indicates that technology transfer from universities increased over the 1990s. The descriptive statistics of the variable population density shows strong differences as well; at the minimum 42 inhabitants per square kilometers and at the maximum 4038 inhabitants per square kilometers.

Table1: Descriptive Statistics

	Mean	Std. dev.	Min.	Max.
Number of employees in R&D in private industries	1,505.03	2,850.50	31	33,765
Share of employees in R&D in private industries to all employees (%)	2.10	1.45	0.32	16.03
Number of researcher and scientists in universities	526.29	1324.62	0	11,684
Share of researcher and scientists in universities to all employees (%)	0.67	1.53	0	12.49
Number of start-ups	432.12	458.46	62	6,134
Start-up rate (start-ups per 1,000 employees)	8.60	2.65	1.92	20.64
Grant from firms in private industries (thousand Euro, constant 1995 prices)	1,593.55	6382.10	0	104,478
Population density (inhabitants per square kilometer)	565.95	696.22	41.18	4037.37

Note: All data on the regional level (districts) are within the time period of 1992-2000.

4 Entrepreneurship and University-Industry Relations: Empirical Evidence of the Knowledge Filter

If entrepreneurship and university-industry relations do penetrate the knowledge filter, knowledge flows are facilitated and a positive impact on economic growth can be expected. The empirical estimations employ panel regressions with fixed effects. A statistically positive relationship between economic growth and the growth rate of labor and capital is always found (Table 2). The region's absorptive capacity – the region's knowledge stock – is measured

[14] One could argue that universities of applied science (*Fachhochschule*) are located in moderately congested areas and rural areas and will absorb this imbalance, but universities of applied science do not have a high amount of grants from firms in private industries.

by the share of R&D employees in private industries and the share of researchers and scientists at universities. The estimates imply a strong positive impact research and development in private industries on the growth rate of economic output, the higher the level of absorptive capacity in the region the higher economic growth (model II-IV).

Table 2: Impact of entrepreneurship and university-industry relations on regional economic growth

	Regional technological progress			
	(I)	(II)	(III)	(IV)
Growth rate capital	0.088**	0.023	0.041**	0.036**
	(5.65)	(1.64)	(3.08)	(2.68)
Growth rate labor	0.358**	0.464**	0.513**	0.495**
	(13.89)	(19.50)	(22.91)	(21.33)
R&D in private industries	–	0.111**	0.085**	0.084**
		(26.46)	(20.63)	(20.32)
R&D in universities	–	0.017**	0.010*	0.011*
		(3.00)	(1.99)	(2.16)
Start-up rate	–	–	0.013**	0.013**
			(18.47)	(18.57)
University-industry relations (ln)	–	–	0.002**	0.002**
			(4.85)	(4.97)
Agglomeration	–	–	–	0.0002**
				(2.97)
Constant	0.033**	-0.205**	-0.267**	-0.389**
	(22.82)	(22.87)	(29.89)	(9.22)
R^2-adj. (within)	0.0885	0.3070	0.4011	0.4033
R^2-adj. (overall)	0.2298	0.0087	0.0397	0.0022
F	123.75	267.32	269.23	232.78
Observations	2871	2732	2732	2732

Note: * significant at 5%-level, ** significant at 1%-level, t-values in parentheses, panel regressions with fixed effects.

The relationship between research employed in universities and economic growth is less distinctive. One reason could be that the knowledge generated in universities still needs to be applied, and its commercialization depends on additional knowledge transfer channels. Nevertheless, researchers in private industries and universities seem to be a necessary condition for economic growth. The two proposed transmission channels for knowledge spillovers enter the regression in the predicted positive way (model III). While entrepreneurs exploit opportunities, they penetrate the knowledge filter and stimulate economic growth. University-industry relations also confirm their ability to penetrate the knowledge filter, hence spurring growth. The region's population density might be one

indicator of agglomeration externalities (Table 2, model IV). Regions benefit from a higher pool of inhabitants, employees, firms or students as well as from the proximity to firms, universities and research institutions. Firms have better access to their demanded labor force, and the interchange of employees between firms is easier due to spatial proximity. Businesses might cluster in a specific region; hence, industry-specific knowledge is more accessible and might diffuse easier.

Table 3: Impact of entrepreneurship and university-industry relations on technological progress

	Regional technological progress		
	(I)	(II)	(III)
R&D in private industries	0.107**	0.082	0.080**
	(25.68)	(19.90)	(19.46)
R&D in universities	0.012*	0.004	0.006
	(2.24)	(0.75)	(1.18)
Start-up rate	–	0.013**	0.013**
		(18.13)	(18.40)
University-industry relations (ln)	–	0.002**	0.002**
		(3.89)	(4.18)
Agglomeration	–	–	0.0003**
			(11.24)
Constant	-0.232**	-0.291**	-0.458**
	(25.84)	(32.57)	(11.24)
R^2-adj. (within)	0.2250	0.3249	0.3298
R^2-adj. (overall)	0.0041	0.0162	0.0270
F	350.66	290.47	237.48
Observations	2732	2732	2732

Note: * significant at 5%-level, ** significant at 1%-level, t-values in parentheses, panel regressions with fixed effects.

Another way of growth accounting could be estimating technological progress, subtracting from the growth rate of economic output that part of growth rate that can be accounted for by the growth rate of the inputs capital and labor.[15] The residual is the TFP growth rate or the rate of technological progress. This allows analyzing the impact of entrepreneurship activity and university-industry relations on technological progress (Table 3). The results resemble those of Table 2. Those regions where the absorptive capacity or the knowledge stock is higher also experience a higher technological progress (model I). The statistical relationship between technological progress and research and development activities in private industries is again more distinct. The impact of research and

[15] See Barro & Sala-i-Martin (1995) for an overview of growth accounting.

development in universities is positive but hardly significant. This result indicates that R&D in private businesses is more valuable for technological progress and that a transfer channel for research employed in universities is needed. The regional start-up rate and university-industry relations facilitate knowledge flows and positively affect technological progress. The relationship between technological progress and agglomeration effects measured by population density are again positively statistically significant.

Comparing the results of Table 2 and Table 3 reveals that economic growth may be accounted for in both ways. No major differences can be found and the coefficients are stable in the different models and methods; and they even correspond approximately. This indicates that a high sensitivity does not exist between the used methods. Knowledge spillovers by means of new business activity and university-industry relations spur economic growth.

5 What is the role for public policy to promote knowledge transmission channels?

In this paper the determinants of economic growth and technological progress have been analyzed accounting for knowledge transmission channels, namely new business formation activity and university-industry relations. The results suggest that new ventures and partnerships between university and industry amplify the permeability of the knowledge filter, increase the flow of knowledge and thus spur economic growth. The empirical analysis also showed that the region's knowledge stock or absorptive capacity is another crucial element of economic growth. New knowledge needs to be generated in incumbent firms and in universities before it can be exploited, and firms need to have the ability to apply and assimilate knowledge.

Public policy can facilitate both, the generation of knowledge and the spillover of knowledge. The state may support universities and research institutions with federal R&D funds with the objective of technology transfer. In order to promote the knowledge transmission channel, entrepreneurship public policy programs should stimulate entrepreneurial awareness and develop entrepreneurial skills. Many universities have already incorporated entrepreneurship education into the curriculum, or they provide counseling to potential business founders. Most chamber of commerce and industry also offer counseling to individuals interested

in starting a business. Since new ventures are also subject to financial constraints, public policy programs may provide access to loan financing, i.e. the state may act as guarantor by bank loans (Storey, 2003). In Germany, the KFW SME Bank offers support with loans, mezzanine financing, equity capital and consulting services to entrepreneurs.

In order to promote university-industry relationships and stimulate technology transfer, incentives for universities need to be provided to cooperate with private businesses. The role of various public policy programs (i.e. InnoRegio or BioRegio in Germany) is to strengthen the role of research institutions in regional networks. The development of science parks might also be an instrument facilitating knowledge spillovers. Via science parks, clusters of new technology based firms can be promoted and since they are often adjacent to universities, spin-offs from research institutions may result. However, an appropriate legal infrastructure, i.e. intellectual property law, and standardized rules are an essential condition for efficient research partnerships. The co-operative businesses often claim all outcomes resulting from co-operative research.

Future research should also deal with the question if other knowledge transmission channels besides entrepreneurship and university-industry relations exist and stimulate economic growth. We know that entrepreneurship ‘capital’ is an essential resource for growth, but we still need to learn much more about the ways in which it can be created and enlarged.

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