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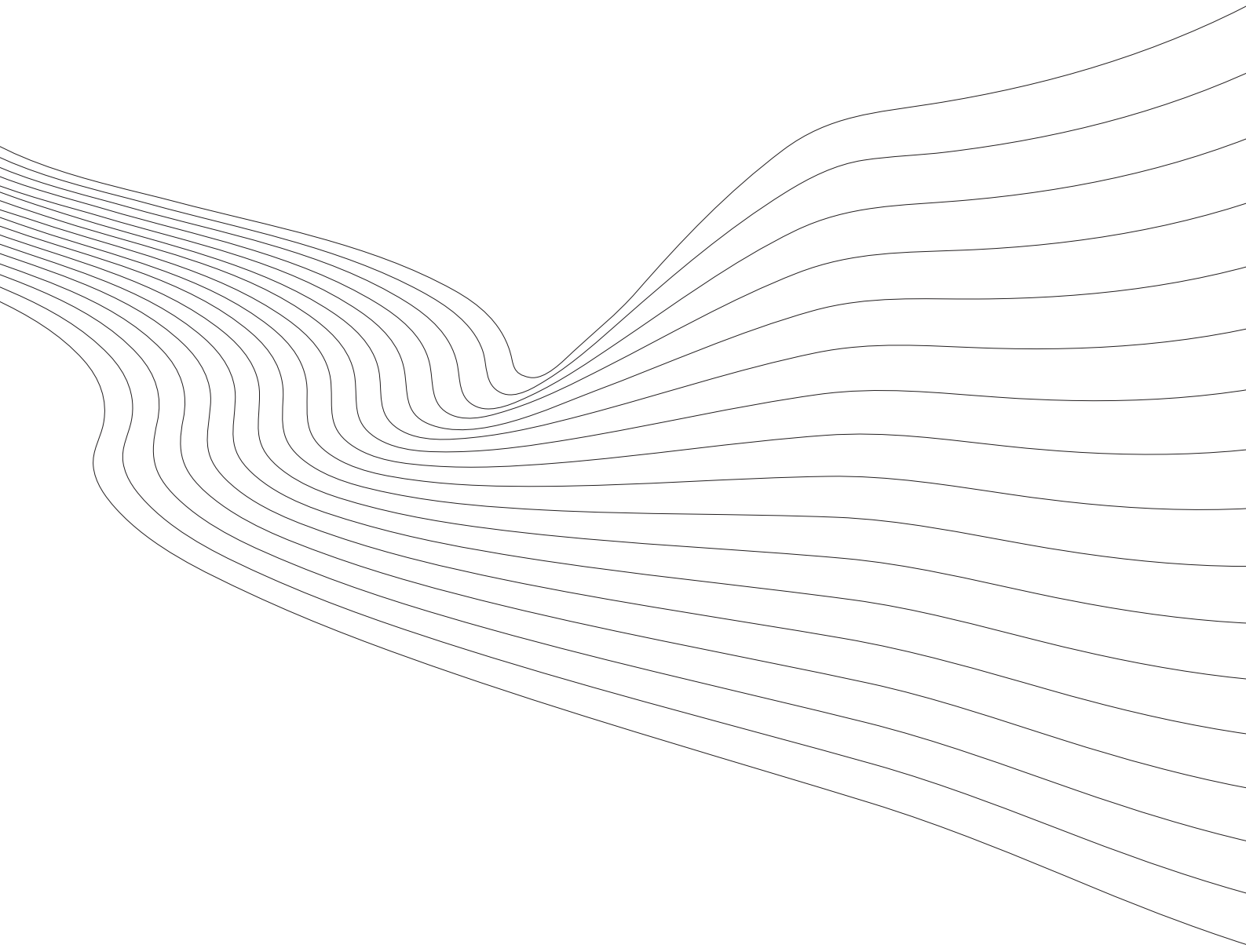

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Technology diversification, product innovations, and technology transfer *

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This paper investigates the relationship between technology specialization and innovation performance of firms emphasizing technology transfer activities with universities as an important knowledge source in order to attenuate the opportunity costs of technological specialization. Based on an econometric analysis combining patent data and survey data on technology transfer activities of firms it was found that technology transfer is positively related with the sales share of innovative products. Following the "technology trajectory (path)" increases the probability of an above average innovation performance. Taking into account the combined effects of transfer activities and technological specialization and in this way approximating the idea that transfer activities enable a firm to be specialized and keep the knowledge base broad and up-to-date, we detect a significant positive relationship between the combined effect (transfer and specialization) and the innovation performance of a firm. Smaller firms tend to benefit more from the combination of technology specialization and transfer activities with universities compared to larger firms.

Key words: Innovation, Knowledge and Technology Transfer, Specialization, Diversification, Firms

History:

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1. Introduction

This investigation looks at the relationship between technology specialization and innovation performance of firms emphasizing technology transfer activities with universities as an important knowledge source in order to attenuate the opportunity costs of technological specialization.

To this end we combine patent data and firm-level data related to the transfer activities of firms. Based on this data …

a) … we want to look at the relationship between firm's innovation performance and knowledge and technology transfer activities with universities. From earlier studies we know that transfer activities with universities or public research institutions are positively related to the innovation performance of firms. This was particular the case for RD (research and development) collaboration with universities and other public research institutions in European countries (see Becker 2003, Fritsch and Franke 2004 for Germany; Monjon and Waelbroeck 2003 for France; Lööf and Broström 2006 for Sweden; Arvanitis et al. 2008a for Switzerland; Mohnen and Hoareau 2003 based on pooled data for several countries). Looking at the USA, Adams et al. (2003) found that cooperative research and development agreements (CRADAs) have stimulated industrial patents and company-financed R&D in the industrial labs of 200 major U.S. companies.

b) … we want to investigate if technological specialization and technology path dependency (see Antonelli 1997) or following a technology trajectory (see Dosi 1982) is a profitable behavior of RD active firms. Profitable means whether there is a positive relationship between technological specialization and the share of innovative products on total sales. The efficiency gains resulting from following the technology trajectory combined with 'localized learning' are expected to narrow the technological flexibility of a firm, since the opportunity costs for alternative technologies are increasing. In the longer run such innovation behavior is likely to narrow future possibilities for innovation (see Forey 1997) and causes inefficiencies on a makro-level, unless firms succeed to adapt their knowledge or technology base to meet new

requirements. How to reach the goal, i.e. to focus on a technology trajectory and remain flexible for alternative technologies?

A redefinition of 'firm boundaries' (see Brusoni et al. 2001) or more concretely (formal or informal) RD networks[1] or transfer activities between private enterprises and public research institutions are possible organizational measures in order to reduce technology ignorance and thus lower the risk of missing the application potential of promising newer technologies. This leads us to the next question.

c) … we further want to investigate if the combination of technological specialization and technology transfer – in our case access to university sources and knowledge – enables a firm to be technologically specialized and to maintain or even enlarge their knowledge base through technology transfer with universities. While the relationship between the knowledge base of a firm and external knowledge has been researched from different angles, the role of technological specialization has been not considered in this context so far. For example, Cohen and Levinthal (1989, 1990) emphasize the importance of the 'absorptive capacity' of a firm for the ability to make use of external knowledge sources efficiently. Leiponen (2005) related the depreciation rate of knowledge to the investment affinity in the internal knowledge base or external knowledge resources. Freeman (1991) argues that the contribution of scientific institutions tends to be predominant in the early stages of more radical innovation, while the experiences of users are very important for the incremental type of innovation at later stage; literature on lead-user behavior (see von Hippel and Urban 1998) somehow questions that general statement.

d) … we want to investigate if our results hold for large firms and/or SMEs (small and medium sized firms) as well. Firm size in general is a very important factor for transfer activities (see Arvantitis et al 2005), the innovation behavior of firms (see Schumpeter 1943, Acs and Audretsch 1987), and technological specialization (see Woerter 2008). We want to see if we get some size implications for the econometric setting at hand as well.

[1] see Freeman 1991, Powell 1996, Powell et al. 1996, Chesbrough and Teece 1996; as to open innovation see Chesbrough 2003, as to 'symbiotic arrangements' see Schanze 1998

In sum we found that technology transfer is positively related with the sales share of innovative products. It also became obviously that a technological focus (based on patent data) increases the probability to have a better innovation performance. Taking into account the combined effects of transfer activities and technological specialization and in this way approximating the idea that transfer activities enable a firm to be specialized and keep the knowledge base broad and up-to-date, we see also a significant positive relationship between the combined effect (technological specialization and transfer) and the innovation performance of a firm. Furthermore one can see that smaller firms are tending to benefit even more from the combination of technology specialization and transfer activities with universities compared to larger firms.

In chapter two the conceptual approach, the empirical models and the variables are introduced. In chapter three we introduce the 'balance' measures in order to identify the technological specialization of a firm. Chapter four describes the data and chapter five shows the results. In chapter six some conclusions are presented.

2. Conceptual approach, empirical models, and variables

a) Conceptual approach

Firms can be seen as bundles of resources (Penrose 1995). Firms differ in their resource endowment (Penrose 1959, Wernerfelt 1984, Barney, 1991; Barney et al., 2001). Teece et al. (1997) mention several reasons for the persistence of firm behavior due to the specificity of resource endowment: firms lack the organizational capacity to develop new competences, some assets are not tradable (e.g. tacit knowledge), and needed inputs have to be bought at relatively high prices that reduce possible rents. Based on the resource endowment, firms' develop working routines in order to reduce environmental complexity (Nelson 1995). Routines result from successful behaviors in the past, from the successful combination of firm resources. They symbolize goal-oriented learning and selection and, thus, applied routines are the best available procedure from the perspective of the firm. Routines are bounded and can hardly be changed in the short-run. According to the "satisfying" principle of Simon (1956), routines are very seldom funda-

mentally questioned and remain unchanged even if the economic environment may suggest a different behavior. They are bounded to the firm's knowledge base, its technology and learning abilities, they are bounded to prevailing paradigms (see Dosi 1988) or focused on a dominant design (see Utterback 1996), thus limiting the firm's ability to react upon or adapt to new market circumstances (see e.g. Lazaric and Denis 2005 or Pentland and Feldman 2005 for difficulties to modify routines). The way the resource endowment of a firm and working routines are concerted is on the one hand the result of bounded perception and on the other hand a cause of bounded perception. A possible explanation for this can be found in the personal rule dependent perception as it is analyzed in Holland et al. (1986); resource endowment and working routines are essential components of "perception rules". Resource endowment, working routines and perception rules lead to the so-called "path-dependency" (see Dosi 1982, 1988) of technology and innovation behavior.

Once a firm decides for a technology path (e.g. combustion engines vs. electric engine) information is accumulated and learning takes place. Innovation behavior becomes more and more limited to the path, it becomes path dependent. In the course of time this process shows an inherent tendency to narrow the view on what seems possible or efficient in terms of innovation behavior. This way firms would tend to become more specialized and most probably get more innovative in a narrower sense, inside the trajectory. However, there is a great risk that these firms become blind to newer developments or promising alternative technologies are overseen (e.g. chemistry vs. microbiology in the traditional pharmaceutical industry). There are many examples from different industries showing that firms get more efficient and realize economies of scale but they lose momentum for newer technology development (see Utterback 1996)[2].

How to get out of this "narrowing" tendency in applied research and remain productive in the innovation behavior over a longer period in time? Following Cyert and March (1964) and March (1994) firms have to balance efficiency (to do things right) and effectivity (to do the right thing). Specialization in knowledge processing (following a technology path) contributes to efficient innovation behavior. More

diversified approaches in knowledge processing would minder the risk of missing essential technological developments but this is too costly for private enterprises. How to bridge this contradiction in organizational terms? Brusoni et al. (2001) analyses the knowledge production of a specialized industry and found that they co-ordinate loosely coupled networks of specialists and maintain (in-house) their capabilities of system integration. Science linkages are of considerable importance for the technology output of firms (Cassiman et al. 2008) as well as for their innovation performance (Arvanitis et al. 2008a and 2008b). Furthermore we know for Switzerland that 'access to specific skills in addition to internal know-how' (46 % of transfer active firms) is by far the most important motive for transfer activities (see Arvanitis et al. 2007). This means firms aim at maintaining their knowledge base or modify (up-date) their knowledge base through technology transfer with universities (see Rothaermel and Ku 2008). It also means that contacts to basic research or to the technology frontier enables a firm to broaden its knowledge base while focusing on the technology path and remain efficient in terms of innovative output.[3] *Transfer activities could be one important way to achieve both an efficient innovation behavior in terms of successful commercialized innovative products, and to be attentive to newer technologies and thus to comply with an effective behavior. This is empirically investigated in the paper at hand.* Since it is quite costly to maintain a broader knowledge base than it is immediately necessary, we would think that especially smaller firms should benefit more from knowledge contacts with universities while they remain focused on their technology path.

b) Empirical models and variables

In order to test this more theoretical explanation of firm behavior in relation to its innovation performance, technological specialization (path dependency), and transfer activities with universities, we go down the following research path:

Firstly, we should see that technology transfer is positively related with the innovation performance of firms and thus confirming the results of other studies (e.g. see Adams et al 2003, Arvantitis et al 2008a,

[2] See the history of the typewriter industry or the US-Ice-Industry in the 19th century. (see Utterback 1996)

Mohnen and Hoareau 2003). In the empirical model (1) we expect 'exknow' (transfer activities with universities)[4] to be positively correlated with 'innosales' (sales share of innovative products). The variables are defined in table 3 (dependent variable) and table 4 (independent variables).

$$innosales = \beta_0 + \beta_1 exknow + \beta_2 educ + \beta_3 foreign + \beta_4 size + \beta_5 rd + \beta_6 dind1-25 + u_i \qquad \textbf{(1)}$$

'Exknow' is suspect to be endogenous and multicollinear with 'RD'; in fact 'RD' and 'exknow' are strongly correlated (see correlation table 8). In Arvanitis et al. 2008a[5] we endogenized 'exknow' and the results remained very similar (the coefficient is different (1.372 (Arvanitis et al. 2008a) and 1.223 in the paper at hand (all firms; see table 5). We further control for the education level of the staff (educ), the firm size (size), research and development activities (rd), foreign ownership (foreign), and for industry affiliation (25 two-digit industries including the manufacturing sector, construction and service industries).

Secondly, we should see that a more specialized technology output promotes the innovation performance of a firm. Actually we apply three different measures for technological specialization (see following chapter), i.e. Bpbalance (see Berger and Parker 1970), Simpson (see Simpson 1949), Stirling (see Stirling 1998) (see table 4).

$$\begin{aligned} innosales &= \beta_0 + \beta_1 Bpbalance + \beta_2 exknow + \beta_3 educ + \beta_4 foreign + \beta_5 size + \beta_6 dind1-25 + u_i \\ innosales &= \beta_0 + \beta_1 Simpson + \beta_2 exknow + \beta_3 educ + \beta_4 foreign + \beta_5 size + \beta_6 dind1-25 + u_i \\ innosales &= \beta_0 + \beta_1 Stirling + \beta_2 exknow + \beta_3 educ + \beta_4 foreign + \beta_5 size + \beta_6 dind1-25 + u_i \end{aligned} \qquad \textbf{(2)}$$

Following our reasoning above, we would expect that our proxies for the technology specialization of a firm are positively correlated with 'innosales'. This would show that firms following a technology path

[3] A good impact of public knowledge on a firm-level assumes efficient knowledge and technology provision through Technology Transfer Offices (see Siegel et al. 2008)

[4] Under knowledge and technology transfer we understand very broadly any activities targeted at transferring knowledge and technology that may help a company or a research institution – depending on the direction of the transfer – to further promote its activities. We asked the survey respondents to report on the importance of 19 different forms of knowledge and technology transfer activities. The 19 items were pooled into 5 main groups, i.e. informal contacts related to informational activities, utilization of infrastructure, forms related to university education, research co-operation and consulting.

[5] There we used the same transfer data.

and cumulate knowledge in a certain technology area are more innovative compared to less specialized firms.

Thirdly, we should see that firms following a certain technology path (specialised) and cultivate their technology base through collaborations with universities, they should have a better performance compared to specialised firms without collaborations with universities …

$$\begin{aligned} innosales &= \beta_0 + \beta_1 Bpbalance\_1 + \beta_2 Bpbalance\_0 + \beta_3 educ + \beta_4 foreign + \beta_5 size + \beta_6 dind1-25 + u_i \\ innosales &= \beta_0 + \beta_1 Simpson\_1 + \beta_2 Simpson\_0 + \beta_3 educ + \beta_4 foreign + \beta_5 size + \beta_6 dind1-25 + u_i \\ innosales &= \beta_0 + \beta_1 Stirling\_1 + \beta_2 Stirling\_0 + \beta_3 educ + \beta_4 foreign + \beta_5 size + \beta_6 dind1-25 + u_i \end{aligned} \quad \textbf{(3)}$$

Thus, we would expect that Bpbalance_1, Simpson_1, and Stirling_1 are positively correlated with the innovation performance. Bpbalance_0, Simpson_0, and Stirling_0 should be not significant or negative significant. This would indicate that specialized firms with transfer activities show a better innovation performance compared to specialized firms without transfer activities. This in turn would indicate that firms that "cultivate" their knowledge base through university contacts are performing better by following their technology path compared to firms without university contacts. 'Bpbalance_1' identifies 'Bpbalance' measure for transfer active firms. 'Bpbalance_0' identifies 'Bpbalance' for firms without transfer activities (see table 4).

Fourthly, assuming that smaller firms have less financial means to maintain a broader knowledge base in-house, we should see that contacts with universities are more important and thus the relationship between innovation performance and the balance-measures and transfer activities are more essential. This would mean that the coefficients of 'Bpbalance_1', 'Simpson_1', and 'Stirling_1' should be greater the smaller firms are, in tendency.

c) Estimation procedure

All models are estimated using a tobit estimator (STATA Software). Our dependent variable (innosales) is very right skewed (zero censored), since we included non-innovative firms by giving them a zero in the 'innosales' variable. Furthermore we calculated heteroscedasticity robust standard errors. 'exknow' and

'rd' are expected to be endogenous. For 'exknow' please refer to the comments in *b) empirical models*. 'rd' is a binary variable and expresses structural information that is not subject to change in the shorter run. Thus, we assume 'rd' to be stable over time and thus the model (1) it is not affected by "endogeneity".

3. Measuring technology specialization

There are a number of possibilities measuring technology specialization. Fai (2003) or Patel and Pavitt (1997) apply the RTA (revealed technological advantage) measure on an industry level. Also concentration measures like the very well know "Herfindahl-index" or an "entropy" measure (see Jacquemin and Berry 1979, Zander 1997) could be applied.[6] Following Jacquemin and Berry (1979, p. 4) empirical usefulness is an adequate criteria for choosing a good measure, since we have no axiomatic analysis or general model which suggests the advantage of any single index. Looking at the results (table 5, 6, and 7) we see that we get very similar results for the three chosen measures. This shows that our measures performing well empirically.

In the investigation at hand we refer to the patent field inscription of patenting firms (see chapter on data) in order to measure technology specialization. Following the IPC (International Patent Classification) we have 8 sections, more than 100 classes and several hundred subclasses. The specialization or "balance" measures refer to the class and section levels. They look at the allocation of firms' patent field inscription among sections. The more equally allocated the patent activities of a firm among sections, the more "balanced" is its technology portfolio and the less "specialized" are its activities. Based on firms' patent activities we can say that the applied measures describe the technology path (accumulated knowledge) of a firm.[7] In order to have robust results we applied three measures.

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[6] For an overview of non-parametric measures out of ecological research please refer to Stirling (1998, p. 47).

[7] In the course of the time firms may change their names, exit or merge with other firms. How did we address this issue when collecting patent information? We used the name of firms in 2005. If there have been mergers or a change in the company name in between the last ten years then this changes are considered. We checked the results ‚manually' for the larger companies. In case there have been changes earlier than 1995 we consider them as not important, since we proxi the technology capabilities of a firm and not counting patents. Thus, it is not so important what 'parts' of the merged firms where doing earlier. Actually there are only 19 firms in our sample that are younger than 10 years.

'Bpbalance' (Berger and Parker 1970) is formulated in the following way:

$$\frac{N_{\max}}{N} \qquad \textbf{(4)}$$

N identifies the number of patent field inscriptions and N_{max} equals the number of patent field inscription in the most populous patent field. The values are between 0 and 1. The greater the value, the more specialized are the technology activities of the firm.

'Simpson' (Simpson 1949) is formulated as follows:

$$\sum_i p_i^2 \qquad \textbf{(5)}$$

p_i is the proportion of patent field inscription in patent field i. The greater the sum of squared p_i, the less balanced or more specialized are the firm's technology activities. The values are between 0 and 1.

'Stirling' (Stirling 1998) is formulated as follows:

$$\frac{1}{v}\sqrt{\sum_i (p_i - \frac{1}{v})^2} \qquad \textbf{(6)}$$

p_i is the proportion of patent field inscription in patent field i and v represents the number of patent fields. Also this formula indicates a greater specialization in case the value is greater and a more balanced technology orientation is indicated if the value approximates 0. The values are between 0 and 1.

4. Data

For this study we used two data sources. Firstly, and in co-operation with NetBreeze[8] we assigned patent fields (section, classes, subclasses) to patenting Swiss firms (1904-2008).

We used the information on esp@cenet (patent application and granted patents around the world - www.espacenet.com). We assigned technology (patent) fields according to the patent classification to single firms. Thus we only assigned technology fields to firms with patent activities (920 firms). RD active firms without patent activities or non RD active firms had no technological assignment and have been

[8] NetBreeze is an ETH spin-off that developed an internet search engine (http://www.netbreeze.ch/index.php?id=23)

excluded from our "balance" measures. We did not assign the patent fields manually; instead we used a software program developed by NetBreeze[9].Technology fields were assigned on the subclass level (see Lang 2008). Information on the subclass level was aggregated on the class level, and the section level. The estimations were made on the class level. On the section level we have 8 different sections, and on the class level we found patent inscription of Swiss firms on 109 different classes[10]. It is possible that one patent is assigned to different classes (technology fields). We searched 5693 Swiss firms (Swiss Innovation Panel; 18 manufacturing industries, construction, and selected services) and found 34048 patents (1904-2008; see table 1). The 34048 patents were assigned to 68533 patent fields[11] (see table 2 for the allocation of patents to patent fields).

Secondly, we collected data in the course of a survey among Swiss enterprises about their transfer activities with universities. From this survey we used the information about the intensity of transfer activities, the industry affiliation of firms, firm size, patent activities, education level of the employees, and whether a firm is foreign-owned. The survey was based on a (with respect to firm size) disproportionately stratified random sample of firms with at least 5 employees covering all relevant industries of the manufacturing sector, the construction sector and selected service industries (excluding industries with an expected very low propensity of KTT activities such hotels/catering, retail trade, real estate/leasing, personal services). Answers were received from 2582 firms, i.e. 45.4% of the firms in the underlying sample. The response rates do not vary much across industries and size classes with a few exceptions (over-representation of wood processing, energy industry and machinery, under-representation of clothing/leather industry). The non-response analysis (based on a follow-up survey of a sample of the non-respondents) did not indicate any serious selectivity bias with respect to the incidence of transfer activities with universities/science institutions. In a further step we matched the information from the survey with

[9] Based on the developed software we searched the espacenet.com website for the name of the firm and related patent information and saved the assigned patent classifications. For more information please see also http://www.netbreeze.ch/index.php?id=28 on open source software.

[10] Sections: human necessities; performing operations, transporting; chemistry, metallurgy; textiles paper; fixed constructions; mechanical engineering, lighting, heating, weapons, blasting; physics; electricity. For the class level please refer to the Annex, table A1.

the patent information on the firm-level and received a combined data set of 2512 observations if we look at the qualitative (0/1) transfer variable and we received 445 observations if we look at the "balance" measures (only firms with patent activities that have answered our survey).

5. Results

The main results are presented in table 5, table 6, and table 7 for "all firms", "firms with less than 300 employees", and for "firms with less than 150 employees", respectively.

The most important result of this study is that more technologically specialized firms are more likely to increase their sales through new and/or essentially modified products compared to firms with more equally allocated patent field inscriptions among patent sections. This shows that - although a more interdisziplinary approach might be helpful for new discoveries – more concentrated research activities along a technological path more likely result in an above average sales share of innovative products compared to less directed research activities. We know that following a technology path runs the risks of missing application potential of alternative promising technologies. It could make a firm blind for new developments (see Utterback 1996). Thus we have been asking if access to more basic knowledge or (personal) contact with the technological frontier (university research) ameliorates the risk of becoming technologically outdated and thus loose innovative power. In fact technology transfer activities of a firm and a technology path dependent research focus are positively related to the innovation performance of that firm. *This indicates that a focus on a technological path*[12] *not necessarily blinds a firm for alternative knowledge and methods if contact to basic research institutions is maintained.* As a consequence, one might see that it is quite profitable that private enterprises focus on a technological path in order to develop new and innovative products. However, we saw that they on the one hand reduce their risk of be-

[11] It is likely that one patent is assigned to different patent fields. Patent classes found for Swiss firms can be seen in the appendix (table A1).

[12] Since we can only run a cross-section econometric analysis due to data limitations, it sounds strange to talk about "technology path". However, we collected the patent activities of firms over a very long period of time and it is assumed that all patent activities of one firm together give a quite good picture about its accumulated knowledge. In case the accumulated knowledge is focused we suggest a great path-dependency. In case the accumulated knowledge is broad (in terms of patent field inscriptions) we suggest that a firm is technologically less focused. Thus the observed knowledge endowment is a consequence of past patent activities – therefore "technological path".

coming technologically outdated and on the other hand increase the likelihood of product innovation if they simultaneously collaborate with universities. These results are valid for all size groups (all firms, less than 300 employees, and less than 150 employees). This shows that our results are not a question of firm size and related economies of scale notions. In sum, these results are supported by the fact that 'exknow', our proxy for technology transfer, is positively correlated in equation 1 (table 5, 6, and 7). Furthermore we see that all three variables for the technological specialization/balance or path dependency ('Bpbalance', Simpson', and 'Stirling') are positively related to 'innosales' (see equation 2, 3, and 4 in table 5, 6, and 7 respectively). Also our proxies for the interaction between transfer activities and the balance-measures, i.e. 'Bpbalance_1', 'Simpson_1', and Stirling_1' are significant related to 'innosales' independently of firm size.

6. Conclusions

Using data on the technology transfer activities of private enterprises (2582 observations) and patent information from 920 patenting firms we found that firms are more productive in terms of innovation output if they are following a so called "technology path" and having transfer activities with public research institutions. This means that firms can ameliorate the risk of technology specialization through transfer activities. These results are robust in terms of different firm sizes. In fact smaller firms tend to benefit more from the combination of technology specialization and transfer activities compared to larger firms.

Thinking in some broader implications of these findings, then one could consider public research activities not only as a possibility for firms to decrease performance risks related to a technological specialization, but also from a more general, evolutionary point of view, public research may ease the risk of technology "lock-in" of a society and thus make it more likely that we find technology solutions to urgent societal (vital) problems in case dominant technologies used in the industry are not likely to provide far-reaching solutions (e.g. environment pollution). Thus public research essentially contributes to more sus-

tainable behavior in terms of technology use. Transfer contacts with public research could enable firms to be efficient and effectively.[13]

Further research could look at the time dimension of transfer activities, technological orientation of a firm and innovation performance by using panel data. Furthermore the implication of technology specialization and transfer activities on firm productivity or price-cost-margin should be investigated as well.

[13] Just thinking in the automotive industry it appears that the large car producing companies are not able to change or modify their "core technologies" in order to address new societal needs of more environmental adequate transport. In the 1930s of the last century electric engines, combustion engines, and steam engines were on the same development status. Nowadays it looks like that knowledge about alternative engine technologies is not sufficiently available in the car industry. Public research could essentially contribute to shorten the way for alternative engines, in a way that we do not have to start alternative research based on the knowledge base of the 1930s.

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Table 1: Composition of the data set – number of observations according to industries

	Obs. Survey (KOF)	No. of transfer firms (KOF)	No. of firms with patents (Net-Breeze)	No. of Patents (Net-Breeze)	No. of patent field inscriptions (Net-Breeze)
Industries					
Food/beverage	127	34	31	1219	2372
Textile	30	9	15	247	417
Clothing/leather	11	0	2	37	55
Wood processing	56	9	9	45	98
Paper	31	9	17	175	336
Publishing	91	17	13	278	488
Chemicals	93	37	78	4683	11448
Plastics/rubber	58	13	41	581	1105
Other non metallic mineral products	47	13	24	276	510
Metal	39	9	15	345	788
Metalworking	173	37	78	1769	3397
Machinery	269	116	188	7767	15034
Electrical machinery	87	33	48	2421	4780
Elec-tronic/instruments	152	67	103	4522	8857
Watches	54	6	32	900	1618
Vehicles	29	9	14	550	1151
Other manufacturing	54	12	35	1075	2115
Energy/water	49	15	4	40	65
Construction	271	32	38	815	1554
Wholesale	215	35	72	2726	5485
Transport	154	21	11	565	911
Banking/insurance	179	35	12	968	1704
Computer services	79	28	17	671	1347
Business services	216	67	17	1166	2527
Telecommunication	18	6	6	207	371
Total	2582	669	920	34048	68533

Base: Swiss Innovation Panel (SIP) with 5693 firms. KOF Survey: 2582 answers (response rate 45%); NetBreeze Survey (based on SIP): 920 firms with patent activities. No. of patents and patent field inscriptions between 1904 and May 2008.

Table 2: Number of patent field inscriptions and patent fields

Industries	Number of Patent field inscriptions							
	A	B	C	D	E	F	G	H
Food/beverage	677	531	775	68	26	65	122	108
Textile	26	75	24	190	11	35	19	37
Clothing/leather	41	6	0	3	2	0	1	2
Wood processing	3	57	13	0	4	19	2	0
Paper	24	244	15	0	11	12	30	0
Publishing	175	149	104	0	11	6	17	26
Chemicals	4268	881	5449	256	106	88	357	43
Plastics/rubber	109	439	80	14	264	69	63	67
Other non metallic mineral products	22	102	121	12	101	4	118	30
Metal	139	259	237	7	36	41	28	41
Metalworking	316	1154	321	57	600	479	217	253
Machinery	561	8191	577	1493	691	2084	716	721
Electrical machinery	475	764	513	79	135	424	922	1468
Electronic/instruments	2000	743	328	15	112	564	3494	1601
Watches	272	215	37	7	7	94	915	71
Vehicles	9	629	3	2	132	76	95	205
Other manufacturing	1066	338	223	15	86	168	131	88
Energy/water	2	40	0	0	4	11	8	0
Construction	229	348	252	46	186	161	206	126
Wholesale	1543	1493	485	54	89	547	579	695
Transport	248	114	400	0	20	21	78	30
Banking/insurance	243	196	89	11	49	113	764	239
Computer services	57	195	114	7	294	354	174	152
Business services	485	934	600	16	62	141	238	51
Telecommunication	129	71	15	0	31	10	33	82
Total	**13119**	**18168**	**10775**	**2352**	**3070**	**5586**	**9327**	**6136**

Number of patent field inscriptions for manufacturing, construction and several service industries, respectively. Patent fields according to the International Patent Classification: A (human necessities), B (performing operations, transporting), C (chemistry, metallurgy), D (textiles, paper), E (fixed constructions), F (mechanical engineering, lighting, heating, weapons, blasting) G (physics), H (electricity)

Table 3: Dependent variable

Dependent Variables	Description
Innosales	Share of innovative products on total sales (log transformed).

Table 4: Independent variables

Determinants	Description
Exknow	Binary variable;1 if a firm has knowledge and technology transfer activities; 0 if a firms has not knowledge and technology transfer activities.
Educ	Share of employees with tertiary-level vocational education (universities, universities of applied sciences, other business and technical schools at tertiary level)
Foreign	Binary variable; 1 if a firm is foreign owned; 0 if the firms is not foreign owned
RD	Binary variable; 1 if a firm has research and development activities; 0 if not.
Size	The size of firms is measures through the number of employees expressed in full-time equivalents (log)
Control variables	
Dind1 to dind25	25 industry dummies (two-digit)
Variables to measure 'balance' of technology field inscriptions	
Bpbalance (Berger and Parker 1970)	$\frac{N_{max}}{N}$; N = Total number of patent field inscriptions; N_{max} = Number of patent field inscription in the most populous patent field
Simpson (Simpson 1949)	$\sum_i p_i^2$; pi = proportion of patent field inscription in patent field i
Stirling (Stirling 1998)	$\frac{1}{v}\sqrt{\sum_i (p_i - \frac{1}{v})^2}$; pi = proportion of patent field inscription in patent field i; v = number of patent fields
'Balance' and' transfer' - combined variables	
Bpbalance_1	Values of 'bpbalance' if 'exknow' equals 1; 0 otherwise
Bpbalance_0	Values of 'bpbalace' if 'exknow' equals 0; 0 otherwise
Simpson_1	Values of 'simpson' if 'exknow' equals 1; 0 otherwise
Simpson_0	Values of 'simpson' if 'exknow' equals 0; 0 otherwise
Stirling_1	Values of 'stirling' if 'exknow' equals 1; 0 otherwise
Stirling_0	Values of stirling' if 'exknow' equals 0; 0 otherwise

Table 5: Regression results “all firms” (dependent variable “Innosales”)

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Exknow	1.223***	2.091***	2.090***	2.089***			
	5.46	6.37	6.37	6.37			
Bpbalance		1.352**					
		2.04					
Simpson			1.111*				
			1.93				
Stirling				12.488**			
				2.04			
Bpbalance_1					2.415***		
					3.5		
Bpbalance_0					0.147		
					0.2		
Simpson_1						2.250***	
						3.73	
Simpson_0						-0.099	
						-0.15	
Stirling_1							22.260***
							3.5
Stirling_0							2.356
							0.36
Educ	0.527***	0.153	0.154	0.149	0.207	0.228	0.194
	4.02	0.6	0.61	0.59	0.81	0.89	0.76
Foreign	-0.151	-0.184	-0.192	-0.192	-0.159	-0.163	-0.176
	-0.57	-0.52	-0.55	-0.55	-0.44	-0.45	-0.5
Size	0.501***	0.517***	0.524***	0.521***	0.569***	0.593***	0.566***
	7.02	4.22	4.28	4.26	4.64	4.85	4.63
RD	3.235***						
	13.49						
No.obs.	2512	445	445	445	445	445	445
left-cens.	1267	117	117	117	117	117	117
right-cens.	34	6	6	6	6	6	6
uncens.	1211	322	322	322	322	322	322
F	44.32***	165.78***	165.48***	165.88***	154.14***	151.28***	156.32***
R2	0.09	0.08	0.08	0.08	0.08	0.08	0.08

Table shows marginal effects and t-values. Dependent variable “innosales”. Heteroscedasticity robust standard errors. Estimation procedure: tobit regression. *, **, *** indicate significance level of 90%, 95%, and 99% respectively. All models include 25 industry dummies (two digit-level); some are significant (reference construction).

Table 6: Regression results “firms with less than 300 employees” (dependent variable “innosales”)

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Exknow	1.415***	2.419***	2.405***	2.407***			
	5.48	6.08	6.06	6.07			
Bpbalance		2.100***					
		2.63					
Simpson			1.693**				
			2.48				
Stirling				19.351***			
				2.62			
Bpbalance_1					3.314***		
					3.89		
Bpbalance_0					0.770		
					0.91		
Simpson_1						2.999***	
						4.08	
Simpson_0						0.392	
						0.53	
Stirling_1							30.692***
							3.91
Stirling_0							8.403
							1.09
Educ	0.545***	0.124	0.133	0.121	0.215	0.253	0.196
	3.63	0.37	0.39	0.36	0.64	0.75	0.58
Foreign	-0.092	-0.129	-0.146	-0.141	-0.136	-0.154	-0.150
	-0.29	-0.29	-0.33	-0.32	-0.3	-0.34	-0.33
Size	0.531***	0.676***	0.686***	0.681***	0.770***	0.799***	0.761***
	5.04	3.22	3.28	3.26	3.72	3.88	3.69
RD	3.390***						
	12.42						
No.obs.	2215	349	349	349	349	349	349
left-cens.	1185	104	104	104	104	104	104
right-cens.	27	5	5	5	5	5	5
uncens.	1003	240	240	240	240	240	240
F	36.47***	119.38***	118.80***	119.52***	108.57***	106.00***	110.60***
R2	0.09	0.08	0.08	0.08	0.07	0.07	0.07

Table shows marginal effects and t-values. Dependent variable “innosales”. Heteroscedasticity robust standard errors. Estimation procedure: tobit regression. *, **, *** indicate significance level of 90%, 95%, and 99% respectively. All models include 25 industry dummies (two digit-level); some are significant (reference construction).

Table 7: Regression results “firms with less than 150 employees” (dependent variable “innosales”)

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Exknow	1.291***	2.970***	2.962***	2.952***			
	4.07	5.66	5.64	5.64			
Bpbalance		2.684**					
		2.45					
Simpson			2.099**				
			2.25				
Stirling				24.249**			
				2.41			
Bpbalance_1					4.451***		
					3.67		
Bpbalance_0					1.296		
					1.13		
Simpson_1						3.978***	
						3.78	
Simpson_0						0.725	
						0.74	
Stirling_1							40.659***
							3.71
Stirling_0							12.929
							1.25
Educ	0.591***	0.147	0.148	0.144	0.244	0.275	0.223
	3.43	0.35	0.36	0.35	0.58	0.66	0.54
Foreign	-0.050	-0.146	-0.161	-0.175	-0.136	-0.155	-0.175
	-0.13	-0.23	-0.25	-0.27	-0.21	-0.24	-0.27
Size	0.562***	0.661*	0.667**	0.673**	0.747**	0.769**	0.739**
	3.94	1.95	1.97	1.99	2.22	2.3	2.2
RD	3.703***						
	11.54						
No.obs.	1889	249	249	249	249	249	249
left-cens.	1077	89	89	89	89	89	89
right-cens.	26	5	5	5	5	5	5
uncens.	786	155	155	155	155	155	155
F	28.62***	89.19***	88.51***	89.18***	80.84***	78.67***	82.66***
R2	0.08	0.08	0.08	0.08	0.08	0.07	0.08

Table shows marginal effects and t-values. Dependent variable “innosales”. Heteroscedasticity robust standard errors. Estimation procedure: tobit regression. *, **, *** indicate significance level of 90%, 95%, and 99% respectively. All models include 25 industry dummies (two digit-level); some are significant (reference construction).

Table 8: Correlation matrix for “all firms”

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Exknow	1													
(1)														
	449													
Bpbalance	-0.082	1												
(2)	0.085													
	449	449												
Simpson	-0.094	0.980	1											
(3)	0.046	0.000												
	449	449	449											
Stirling	-0.082	0.987	0.988	1										
(4)	0.085	0.000	0.000											
	449	449	449	449										
Bpbalance_1	0.919	0.192	0.169	0.184	1									
(5)	0.000	0.000	0.000	0.000										
	449	449	449	449	449									
Bpbalance_0	-0.915	0.371	0.381	0.371	-0.841	1								
(6)	0.000	0.000	0.000	0.000	0.000									
	449	449	449	449	449	449								
Simpson_1	0.871	0.253	0.244	0.252	0.990	-0.797	1							
(7)	0.000	0.000	0.000	0.000	0.000	0.000								
	449	449	449	449	449	449	449							
Simpson_0	-0.864	0.432	0.454	0.439	-0.794	0.990	-0.753	1						
(8)	0.000	0.000	0.000	0.000	0.000	0.000	0.000							
	449	449	449	449	449	449	449	449						
Stirling_1	0.931	0.167	0.151	0.166	0.997	-0.852	0.988	-0.805	1					
(9)	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000						
	449	449	449	449	449	449	449	449	449					
Stirling_0	-0.923	0.353	0.368	0.360	-0.849	0.998	-0.804	0.989	-0.860	1				
(10)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000					
	449	449	449	449	449	449	449	449	449	449				
Educ	0.243	0.024	0.023	0.035	0.224	-0.199	0.210	-0.178	0.229	-0.198	1			
(11)	0.000	0.616	0.630	0.456	0.000	0.000	0.000	0.000	0.000	0.000				
	448	448	448	448	448	448	448	448	448	448	448			
Foreign	0.079	0.054	0.061	0.063	0.081	-0.047	0.083	-0.035	0.087	-0.050	0.173	1		
(12)	0.096	0.254	0.201	0.186	0.086	0.322	0.078	0.455	0.067	0.297	0.000			
	447	447	447	447	447	447	447	447	447	447	446	447		
Size	0.333	-0.017	-0.046	-0.028	0.313	-0.306	0.291	-0.298	0.311	-0.308	0.080	0.028	1	
(13)	0.000	0.714	0.335	0.556	0.000	0.000	0.000	0.000	0.000	0.000	0.090	0.551		
	449	449	449	449	449	449	449	449	449	449	448	447	449	
RD	0.498	-0.040	-0.058	-0.047	0.432	-0.431	0.395	-0.402	0.438	-0.439	0.262	0.068	0.254	1
(14)	0.000	0.402	0.224	0.319	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.153	0.000	
	449	449	449	449	449	449	449	449	449	449	448	447	449	449

Table show the correlation coefficients, significance level and number of observations.

Appendix:

Table A1: Patent classes found for Swiss firms

class	Description
a01	AGRICULTURE; FORESTRY; ANIMAL HUSBANDRY; HUNTING; TRAPPING; FISHING
a22	BUTCHERING; MEAT TREATMENT; PROCESSING POULTRY OR FISH
a23	FOODS OR FOODSTUFFS; THEIR TREATMENT, NOT COVERED BY OTHER CLASSES
a24	TOBACCO; CIGARS; CIGARETTES; SMOKERS' REQUISITES
a42	HEADWEAR
a43	FOOTWEAR
a44	HABERDASHERY; JEWELLERY
a46	BRUSHWARE
a47	FURNITURE (arrangements of seats for, or adaptation of seats to, vehicles B60N); DOMESTIC ARTICLES OR APPLIANCES; COFFEE MILLS; SPICE MILLS; SUCTION CLEANERS IN GENERAL (ladders E06C)
a61	MEDICAL OR VETERINARY SCIENCE; HYGIENE
a62	LIFE-SAVING; FIRE-FIGHTING (ladders E06C)
a63	SPORTS; GAMES; AMUSEMENTS
b01	PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL (furnaces, kilns, ovens, retorts, in general F27)
b02	CRUSHING, PULVERISING, OR DISINTEGRATING; PREPARATORY TREATMENT OF GRAIN FOR MILLING
b03	SEPARATION OF SOLID MATERIALS USING LIQUIDS OR USING PNEUMATIC TABLES OR JIGS; MAGNETIC OR ELECTROSTATIC SEPARATION OF SOLID MATERIALS FROM SOLID MATERIALS OR FLUIDS; SEPARATION BY HIGH-VOLTAGE ELECTRIC FIELDS (separating isotopes B01D 59/00; crushing or disintegrating B02C; centrifuges or vortex apparatus for carrying out physical processes B04)
b04	CENTRIFUGAL APPARATUS OR MACHINES FOR CARRYING-OUT PHYSICAL OR CHEMICAL PROCESSES
b05	SPRAYING OR ATOMISING IN GENERAL; APPLYING LIQUIDS OR OTHER FLUENT MATERIALS TO SURFACES, IN GENERAL (domestic cleaning A47L; cleaning in general by methods essentially involving the use or presence of liquid B08B 3/00; sand-blasting B24C; coating of articles during shaping of substances in a plastic state B29C 39/10, B29C 39/18, B29C 41/20, B29C 41/30, B29C 43/18, B29C 43/28, B29C 45/14, B29C 47/02; for further classification of forming layered products, seeB32B; printing, copying B41; conveying articles or workpieces through baths of liquid B65G, e.g. B65G 49/02; handling webs or filaments in general B65H; surface treatment of glass by coating C03C 17/00, C03C 25/10; coating or impregnation of mortars, concrete, stone or ceramics C04B 41/45, C04B 41/61, C04B 41/81; paints, varnishes, lacquers C09D; enamelling of metals, applying a vitreous layer to metals, chemical cleaning or degreasing of metallic objects C23; electroplating C25D; treating of textile materials by liquids, gases or vapours D06B; laundering D06F; treating roads E01C; apparatus or processes for the preparation or treatment of photosensitive materials G03; apparatus or processes, restricted to a purpose fully provided for in a single other class, see the relevant class covering the purpose)
b06	GENERATING OR TRANSMITTING MECHANICAL VIBRATIONS IN GENERAL
b07	SEPARATING SOLIDS FROM SOLIDS; SORTING (separation in general B01D; wet separating processes, sorting by processes using fluent material in the same way as liquid B03; using liquids B03B, B03D; sorting by magnetic or electrostatic separation of solid materials from solid materials or fluids, separation by high voltage electric fields B03C; centrifuges or vortex apparatus for carrying out physical processes B04; sorting peculiar to particular materials or articles and provided for in other classes, see the relevant classes)
b08	CLEANING

b09	DISPOSAL OF SOLID WASTE; RECLAMATION OF CONTAMINATED SOIL (treatment of waste water, sewage or sludge C02F; treating radioactively contaminated solids G21F 9/28) [3, 6]
b21	MECHANICAL METAL-WORKING WITHOUT ESSENTIALLY REMOVING MATERIAL; PUNCHING METAL (casting, powder metallurgy B22; shearing B23D; working of metal by the action of a high concentration of electric current B23H; soldering, welding, flame-cutting B23K; other working of metal B23P; punching sheet material in general B26F; processes for changing of physical properties of metals C21D, C22F; electroforming C25D 1/00)
b22	CASTING; POWDER METALLURGY
b24	GRINDING; POLISHING
b25	HAND TOOLS; PORTABLE POWER-DRIVEN TOOLS; HANDLES FOR HAND IMPLEMENTS; WORKSHOP EQUIPMENT; MANIPULATORS
b26	HAND CUTTING TOOLS; CUTTING; SEVERING
b27	WORKING OR PRESERVING WOOD OR SIMILAR MATERIAL; NAILING OR STAPLING MACHINES IN GENERAL
b29	WORKING OF PLASTICS; WORKING OF SUBSTANCES IN A PLASTIC STATE IN GENERAL
b30	PRESSES
b31	MAKING PAPER ARTICLES; WORKING PAPER (making layered products not composed wholly of paper or cardboard B32B; handling thin material, e.g. sheets, webs, B65H)
b32	LAYERED PRODUCTS
b41	PRINTING; LINING MACHINES; TYPEWRITERS; STAMPS (reproduction or duplication of pictures or patterns by scanning and converting into electrical signals H04N) [4]
b42	BOOKBINDING; ALBUMS; FILES; SPECIAL PRINTED MATTER
b43	WRITING OR DRAWING IMPLEMENTS; BUREAU ACCESSORIES
b44	DECORATIVE ARTS
b60	VEHICLES IN GENERAL
b62	LAND VEHICLES FOR TRAVELLING OTHERWISE THAN ON RAILS
b63	SHIPS OR OTHER WATERBORNE VESSELS; RELATED EQUIPMENT
b64	AIRCRAFT; AVIATION; COSMONAUTICS
b65	CONVEYING; PACKING; STORING; HANDLING THIN OR FILAMENTARY MATERIAL
b66	HOISTING; LIFTING; HAULING
b67	OPENING OR CLOSING BOTTLES, JARS OR SIMILAR CONTAINERS; LIQUID HANDLING (nozzles in general B05B; packaging liquids B65B, e.g. B65B 3/00; pumps in general F04; siphons F04F 10/00; valves F16K; handling liquefied gases F17C)
b81	MICRO-STRUCTURAL TECHNOLOGY (NANO-TECHNOLOGY)
b82	NANO-TECHNOLOGY
c01	INORGANIC CHEMISTRY (processing powders of inorganic compounds preparatory to the manufacturing of ceramic products C04B 35/00; fermentation or enzyme-using processes for the preparation of elements or inorganic compounds except carbon dioxide C12P 3/00; obtaining metal compounds from mixtures, e.g. ores, which are intermediate compounds in a metallurgical process for obtaining a free metal C21B, C22B; production of non-metallic elements or inorganic compounds by electrolysis or electrophoresis C25B)
c02	TREATMENT OF WATER, WASTE WATER, SEWAGE, OR SLUDGE (settling tanks, filtering, e.g. sand filters or screening devices, B01D)
c03	GLASS; MINERAL OR SLAG WOOL
c04	CEMENTS; CONCRETE; ARTIFICIAL STONE; CERAMICS; REFRACTORIES (alloys based on refractory metals C22C)
c05	FERTILISERS; MANUFACTURE THEREOF (processes or devices for granulating materials, in general B01J 2/00; soil-conditioning or soil-stabilising materials C09K 17/00) [4]
c06	EXPLOSIVES; MATCHES
c07	ORGANIC CHEMISTRY
c08	ORGANIC MACROMOLECULAR COMPOUNDS; THEIR PREPARATION OR CHEMICAL WORKING-UP; COMPOSITIONS BASED THEREON (manufacture or treatment of artificial threads, fibres, bristles or ribbons D01)

c09	DYES; PAINTS; POLISHES; NATURAL RESINS; ADHESIVES; COMPOSITIONS NOT OTHERWISE PROVIDED FOR; APPLICATIONS OF MATERIALS NOT OTHERWISE PROVIDED FOR
c10	PETROLEUM, GAS OR COKE INDUSTRIES; TECHNICAL GASES CONTAINING CARBON MONOXIDE; FUELS; LUBRICANTS; PEAT
c11	ANIMAL OR VEGETABLE OILS, FATS, FATTY SUBSTANCES OR WAXES; FATTY ACIDS THEREFROM; DETERGENTS; CANDLES (edible oil or fat compositions A23)
c12	BIOCHEMISTRY; BEER; SPIRITS; WINE; VINEGAR; MICROBIOLOGY; ENZYMOLOGY; MUTATION OR GENETIC ENGINEERING
c13	SUGAR INDUSTRY (polysaccharides, e.g. starch, derivatives thereof C08B; malt C12C) [4]
c14	SKINS; HIDES; PELTS; LEATHER
c21	METALLURGY OF IRON
c22	METALLURGY (of iron C21); FERROUS OR NON-FERROUS ALLOYS; TREATMENT OF ALLOYS OR NON-FERROUS METALS
c23	METALLURGY (of iron C21); FERROUS OR NON-FERROUS ALLOYS; TREATMENT OF ALLOYS OR NON-FERROUS METALS (general methods or devices for heat treatment of ferrous or non-ferrous metals or alloys C21D; production of metals by electrolysis or electrophoresis C25)
c25	ELECTROLYTIC OR ELECTROPHORETIC PROCESSES; APPARATUS THEREFOR (electrodialysis, electro-osmosis, separation of liquids by electricity B01D; working of metal by the action of a high concentration of electric current B23H; treatment of water, waste water or sewage by electrochemical methods C02F 1/46; surface treatment of metallic material or coating involving at least one process provided for in class C23 and at least one process covered by this class C23C 28/00, C23F 17/00; anodic or cathodic protection C23F; single-crystal growth C30B; metallising textiles D06M 11/83; decorating textiles by locally metallising D06Q 1/04; electrochemical methods of analysis G01N; electrochemical measuring, indicating or recording devices G01R; electrolytic circuit elements, e.g. capacitors, H01G; electrochemical current or voltage generators H01M) [4]
c30	CRYSTAL GROWTH (separation by crystallisation in general B01D 9/00)
c40	COMBINATORIAL TECHNOLOGY [2006.01]
d01	NATURAL OR ARTIFICIAL THREADS OR FIBRES; SPINNING (metal threads B21; fibres or filaments of softened glass, minerals, or slag C03B 37/00; yarns D02)
d02	YARNS; MECHANICAL FINISHING OF YARNS OR ROPES; WARPING OR BEAMING
d03	WEAVING
d04	BRAIDING; LACE-MAKING; KNITTING; TRIMMINGS; NON-WOVEN FABRICS
d05	CONTROLLING; REGULATING
d06	TREATMENT OF TEXTILES OR THE LIKE; LAUNDERING; FLEXIBLE MATERIALS NOT OTHERWISE PROVIDED FOR
d07	ROPES; CABLES OTHER THAN ELECTRIC
d21	PAPER-MAKING; PRODUCTION OF CELLULOSE
e01	CONSTRUCTION OF ROADS, RAILWAYS, OR BRIDGES (of tunnels E21D)
e03	WATER SUPPLY; SEWERAGE
e04	BUILDING (layered materials, layered products in general)
e05	LOCKS; KEYS; WINDOW OR DOOR FITTINGS; SAFES
f01	MACHINES OR ENGINES IN GENERAL (combustion engines F02; machines for liquids F03, F04); ENGINE PLANTS IN GENERAL; STEAM ENGINES
f02	COMBUSTION ENGINES (cyclically operating valves therefor, lubricating, exhausting, or silencing engines F01); HOT-GAS OR COMBUSTION-PRODUCT ENGINE PLANTS
f03	MACHINES OR ENGINES FOR LIQUIDS (for liquids and elastic fluids F01; positive-displacement machines for liquids F04); WIND, SPRING, OR WEIGHT MOTORS; PRODUCING MECHANICAL POWER OR A REACTIVE PROPULSIVE THRUST, NOT OTHERWISE PROVIDED FOR
f15	FLUID-PRESSURE ACTUATORS; HYDRAULICS OR PNEUMATICS IN GENERAL

f16	ENGINEERING ELEMENTS OR UNITS; GENERAL MEASURES FOR PRODUCING AND MAINTAINING EFFECTIVE FUNCTIONING OF MACHINES OR INSTALLATIONS; THERMAL INSULATION IN GENERAL
f17	STORING OR DISTRIBUTING GASES OR LIQUIDS (water supply E03B)
f21	LIGHTING (electric aspects or elements, see section H, e.g. electric light sources H01J, H01K, H05B)
f22	STEAM GENERATION (chemical or physical apparatus for generating gases B01J; chemical generation of gas, e.g. under pressure, Section C; removal of combustion products or residues, e.g. cleaning of the combustion contaminated surfaces of tubes of boilers, F23J; generating combustion products of high pressure or high velocity F23R; water heaters not for steam generation F24H, F28; cleaning of internal or external surfaces of heat-transfer conduits, e.g. water tubes of boilers, F28G)
f24	HEATING; RANGES; VENTILATING (protecting plants by heating in gardens, orchards, or forests A01G 13/06; baking ovens and apparatus A21B; cooking devices other than ranges A47J; forging B21J, B21K; specially adapted for vehicles, see the relevant subclasses of classes B60-B64; combustion apparatus in general F23; drying F26B; ovens in general F27; electric heating elements or arrangements H05B)
f26	Drying
f28	HEAT EXCHANGE IN GENERAL (heat-transfer, heat-exchange or heat-storage materials C09K 5/00; arrangement or mounting of heat-exchangers in air-conditioning, air-humidification or ventilation F24F 13/30)
g01	MEASURING (counting G06M); TESTING
g02	OPTICS (making optical elements or apparatus B24B, B29D 11/00, C03, or other appropriate subclasses or classes; materials per se, see the relevant places, e.g. C03B, C03C)
g03	PHOTOGRAPHY; CINEMATOGRAPHY; ANALOGOUS TECHNIQUES USING WAVES OTHER THAN OPTICAL WAVES; ELECTROGRAPHY; HOLOGRAPHY
g04	HOROLOGY
g05	CONTROLLING; REGULATING
g06	COMPUTING; CALCULATING; COUNTING (score computers for games A63B 71/06, A63D 15/20, A63F 1/18; combinations of writing implements with computing devices B43K 29/08)
g07	CHECKING-DEVICES
g08	SIGNALLING (indicating or display devices per seG09F; transmission of pictures H04N)
g09	EDUCATING; CRYPTOGRAPHY; DISPLAY; ADVERTISING; SEALS
g10	MUSICAL INSTRUMENTS; ACOUSTICS
g11	INFORMATION STORAGE
g21	NUCLEAR PHYSICS; NUCLEAR ENGINEERING
h01	BASIC ELECTRIC ELEMENTS
h02	GENERATION, CONVERSION, OR DISTRIBUTION OF ELECTRIC POWER
h03	BASIC ELECTRONIC CIRCUITRY
h04	ELECTRIC COMMUNICATION TECHNIQUE
h05	ELECTRIC TECHNIQUES NOT OTHERWISE PROVIDED FOR