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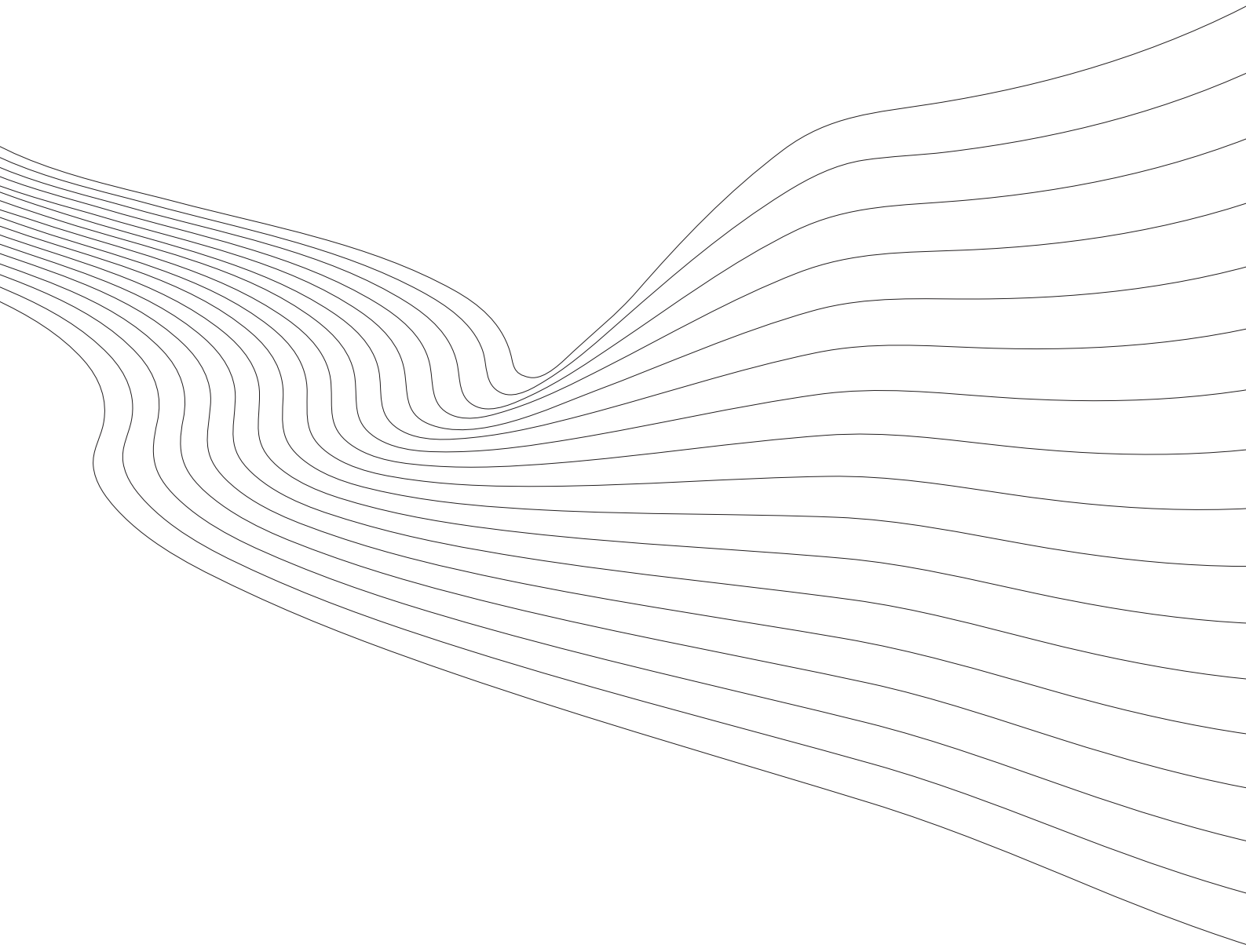

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Technology proximity between firms and universities and technology transfer*

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This paper investigates the technological orientation of firms and universities and their propensity to have knowledge and technology transfer (KTT) activities. This study looks at the technological potential for KTT and how it is used, emphasizing differences between smaller and larger firms. To this end we collected information about the technology activities of firms (patent statistics) and the technology activities of universities. Furthermore we used survey data on technology transfer activities. We combined the three datasets and found – especially for smaller firms – that great technology proximity fosters transfer activities with different universities (case 1). The same is true, if proximity is low and expertise is considerable at universities in the respective technology field (case 2). In both cases additional transfer potential exists. In the second case firms engage in transfer activities in order to update and modifying their knowledge base and as a consequence improve "competitiveness" in certain technology fields. Furthermore firms show a tendency to diversify their contacts with universities in order to avoid knowledge lock-in.

Key words: Innovation, Knowledge and Technology Transfer, Technology Proximity, Universities, Firms

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1. Introduction

With this study we aim at a comprehensive mapping of the technology activities of private firms and the public research sector (i.e. universities) for Switzerland. We want to identify the collaboration potential or knowledge and technology transfer potential between the private and the public research sector. The well known concepts of "inert areas" (see Leibenstein 1989), "satisfying behaviour" (see Simon 1956), "bounded rationality" and technological competences and knowledge (see Nelson and Winter 1982), "absorptive capacity" of a firm (see Cohen and Levinthal 1989), the resource based view of a firm (Penrose, 1995; Wernerfelt, 1984, Barney, 1991) or technology trajectories (see Dosi 1982) are used in economic literature to describe the ability of a firm to perceive, process and apply external knowledge and/or to change its innovation behavior in order to further develop the technology base of a firm or to develop and commercialize new products. We learnt from these concepts that collaboration among actors with similar technology/knowledge bases are more likely than among partners with a very different knowledge background. Thus, technology proximity matters. It is desirable that private enterprises know about the technology activities at universities and can make use of such activities in order to provide timely solutions (through new products) to urgent public need, e.g. in the energy sector. Here it is also very likely that technology proximity matters. This has to be shown in this paper.

Technology proximity between the two sectors (private and public research) indicates their collaboration potential. It tells us whether they "speak a similar language". Thinking in the above mentioned concepts it would be rather unwise to force collaborations without some knowledged about the potential. However, it would be also unwise to force universities into more applied fields of technology just to create collaboration potential. We have to be aware of and respect the two different goal setting mechanisms of applied (mostly private) research and basic (mostly public) research and their different goals from a public point of view (see Hall 2001, Beise et al. 1995 for different goal dimensions). Intensified interactions lead to goal harmonization between the actors; that could be caused by mutual adaptation (see Beise et al. 1995) or through an improved absorptive capacity of private enterprises (see Izushi 2002). As a consequence the character of universities is changing (see Gibbons et al. 1994).

With the study at hand we look at the potential for KTT and how it is currently used. To this end we collected information about the technology activities of firms (patent statistics) and the technology activities of universities (technology fields were assigned; see chapter on data). Furthermore we used data on technology transfer activities between the two sectors. We combined the three datasets for the purpose of this study. Chapter two discusses technology orientation and KTT with universities. In chapter three we discuss the components of an empirical model and formulate the hypotheses. Chapter four explains the empirical strategy in order to answer the hypotheses. Chapter five introduces the different sources of data. Chapter six shows the results and answers the hypotheses and chapter seven concludes.

2. Technological Orientation and Knowledge and Technology Transfer with Universities

Since technology (knowledge) proximities are intuitively very important for transfer activities, it is very surprising that so far, we did not find a single broad empirical investigation that relates technology transfer to technology proximity (see chapter on data below). Lack of adequate data may be one reason for it. Instead, there are several investigations that allocate patent classification to industries (see Broekel 2007, Verspagen et al. 1994, Schmoch et al. 2003) in order to trace the technology development of industries, to identify technology convergence or divergence between industries (e.g. nanotechnology; see Lee and Song 2007, Igami and Okazaki 2007, OECD 2007)1

Looking at the literature of knowledge and technology transfer between private enterprises and universities (KTT) we get a good understanding about the characteristics of the transfer process. We know for Switzerland that about 28% of firms with more than 5 employees have transfer contacts[2] with universities. Large firms and firms in the high-tech sector are significantly more likely to have transfer compared to

[1] Technology fields according to the patent classification should also be assigned to the university sector. Why such a trial should make sense? If we can match the technology activities of private enterprises with the technology activities of universities, we would be able to identify unused collaboration and transfer potential. Furthermore a "complete" technology mapping of a country would significantly improve the knowledge base for policy measures and reduce complexity of decision making. Why? Technology priorities and competitive differences to other countries can be easier detected.

[2] Broad definition of transfer activities: Knowledge and technology transfer between academic institutions and the business sector is understood in this study as any activities aimed at transferring knowledge or technology that may help either the company or the academic institute – depending on the direction of transfer – to further pursue its activities.

smaller firms and firms in any other sector. Informal, personal contacts and KTT through graduates or the education activities of the universities are the most important forms of KTT in Switzerland (see Arvanties et al. 2007). Similar studies for other countries and regions also emphasis the importance of human capital and more informal transfer forms (see OECD 2002, Blume and Fromm 2000, Lessmann and Rossner 2004, Salter et al. 2000, Arundel et al. 1995). Furthermore we know that especially through publications, patent/licenses, and spin-offs university knowledge flows into the entrepreneurial world as well (see Arvanitis et al. 2007; for the importance of transfer offices see also Kaufmann and Tödtling 2001). Access to human capital or problem solving capabilities (tacit knowledge), access to new research or development of new products are among the important motivations for transfer activities (see Schartinger et al. 2000, Hall 2004, Arvanitis et al. 2007). Important hindering factors are related to "firm deficiencies" (e.g. firm's questions being not interesting for science institutions or lack of interest for scientific projects). Similar results are found for Austria (see Schibany et al. 1999, Arvanitis et al. 2007). In general KTT and innovation and firm performance are positively related (see Arvanitis et al. 2008a, 2008b).

With the study at hand we will combine our knowledge about KTT and the technology proximity between the actors in order to identify unused transfer potentials and improve the knowledge base for policy making.3

3. Empirical Model and Hypotheses

Whether a firm identifies information or knowledge as important for its innovation activities depends very often on firm's knowledge base. Cohen and Levinthal (1989) called the ability to make use of knowledge from other institutions or firms, the absorptive capacity of a firm. The absorptive capacity is quite often approximated through R&D activities or the skill-level of the employees. We learnt from broad empirical studies that the absorptive capacity (measured by the skill-level of employees or R&D activities) is an important determinant for KTT activities (see Arvanitis et al. 2007; for Switzerland).

[3] In order to capture the technology orientation of firms and universities we refer to the international patent classification (see http://www.wipo.int/classifications/ipc/en/). Patents can be assigned to more than one sub-class. Subclasses are aggregated to more than 100 classes and 8 sections. We assigned technology fields only to firms that

Laursen and Salter (2004) investigated for the UK the types of firms that use universities as a source of innovation. They found also that variables related to the absorptive capacity of a firm such as R&D intensity and long-term R&D show a positive correlation with KTT activities. However, the absorptive capacity is measured in a very general way (skill-level, R&D activities). In order to choose co-operation partners we need to know more concretely the technology orientation of a firm, since a high skill-level you find in a bank as well as in a pharmaceutical company – nevertheless there is no reason to assume that they have a higher probability to co-operate in R&D, since their technology base is too different.

Firms are not anymore the sole actors in their innovation processes (see Malerba 2007). Research co-operations or informal contacts with universities, suppliers, or customers essentially modified the innovation behavior of firms. The partner choice or their perception of what are interesting partners is directed by the technology base of a firm, their working routines, or their quest for new application areas for existing knowledge or technology within the firm (see Dosi 1988). The technology proximity between partners is one important driver for collaboration. Only in rare cases firms seek collaborations in order to "radically" change their technology base, like it was the case with the rise of molecular biology (biotechnology) in pharmaceuticals; from an ex-post point of view the (chemical based) pharmaceutical companies enlarged their knowledge base rather than substituted it. The technology base of a firm is defined as cumulated knowledge, learning, or capabilities from past experiences. It is expressed in the assigned patent fields in case firms filed patents.

In understanding that firms try to continue working in the same technology field and applying similar working routines, they will try to diversify their external linkages, not only between different types of knowledge partners, e.g. suppliers, customers, and universities, but also within one type of partner. Why should they do so? Firstly, they can create a greater amount of "incoming spillovers" (see Shapiro and Willig, 1990; Greenlee and Cassiman, 1999) to modify their knowledge base and to update knowledge and to enlarge their research networks. Secondly, such contacts make it easier to recruit graduates or re-

filed patent(s). In case of universities we assigned technology fields according to their research activities presented on their websites (see chapter on data).

searchers. Thirdly, contacts with different university institutes help firms to "escape" from knowledge lock-in. Fourthly, funding schemes force firms to collaborate with (different) universities (that is the case in Switzerland)

Against this background we want to test the following four hypotheses:

H1: Technology proximity between universities and private enterprises increases the probability of transfer activities and makes it more likely to have more than one university link.

With this hypothesis we emphasis the importance of a firm's absorptive capacity (Cohen and Levinthal 1989, Schmidt 2008). It should be easier for them to assess the relevance of university research in known areas. In case universities are doing research in those fields, KTT with different universities should be likely. To elaborate on this hypothesis we will look at technology fields that are important in both sectors and estimate the probability of transfer activities (see equation 1 below)

H2: There are not transfer activities in technology fields that are not important for both private enterprises, and universities.

What we can learn from the concept of absorptive capacity and from a resource-based view perspective, it is very unlikely to see transfer activities in technology fields where both partner are not experts. Thus, we would assume that technology transfer does not take place in those technology fields and insignificant or negative signs are expected (see equation 2 below).

H3: Firms do not have transfer activities with universities in technology fields that are frequently researched by private enterprises and not frequently researched at universities.

It is very unlikely that firms have transfer activities with universities in technology fields that are unimportant in the academic world and thus not well researched at universities (see equation 3 below). Thus, we expect no significant results in those technology fields.

H4: Firms that want to change or essentially modify their technology orientation are having transfer relations with different partners form universities.

With this hypothesis we emphasize a more resource (capability)-based view of a firm (see Penrose, 1995; Wernerfelt, 1984, Barney, 1991; Barney et al., 2001). From a resource-based point of view firms

are heterogeneous as to their resource endowments and capabilities. Thus, the resource endowment is firm-specific and relatively difficult to transfer or to modify. Teece et al. (1997) mention several reasons for the persistence of firm behaviour due to the specificity of resource endowment: firms lack the organisational 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. In this context, the "sticky" character of the resource endowment makes it difficult to change the knowledge base of a firm even when market conditions urge them to do so. Useful strategies are necessary to change or modify the resource endowment and thus improve firms' performance (see Wernerfelt, 1984; Kor and Mahoney, 2004). KTT with universities is one feasible way to essentially modify the knowledge base of firms. This is confirmed by firm assessments of the main motives for KTT activities with universities. Firms are motivated, firstly, to get better access to human capital (see Geisler and Rubinstein, 1989; Schartinger et al., 2001; Onida and Malerba, 1989; Arvanitis et al., 2005a). Secondly, to have better access to new knowledge and technology for improving the firm's knowledge base (see Lee, 2000; Santoro and Chakrabarti, 2002; Schmoch, 2003; Arvanitis et al., 2005a). Thirdly, KTT is used to built-up new fields of research (see Onida and Malerba, 1989; Lee, 2000; Schibany and Schartinger, 2001). To elaborate on this hypothesis we look at technology fields that are frequently researched at universities and not frequently researched in private enterprises. It is assumed that firms have this type of transfer activities in order to essentially modify or change their knowledge base. Thus we would expect a positive correlation between number of transfer activities and those technology fields at least in some cases (see equation 4 below). A negative correlation would be against this hypothesis.

Our hypotheses can be tested in estimating the following equations.

$$(1)\quad \text{intense}_i = \beta_1(techfield\_hp_i) + \beta_2(pat_i) + \beta_3(educ_i) + \beta_4(foreign_i) + \beta_5(size_i) + \beta_6(dind1-25) + \varepsilon_i$$

$$(2)\quad \text{intense}_i = \beta_1(techfield\_lp_i) + \beta_2(pat_i) + \beta_3(educ_i) + \beta_4(foreign_i) + \beta_5(size_i) + \beta_6(dind1-25) + \varepsilon_i$$

$$(3)\quad \text{intense}_i = \beta_1(techfield\_ls_i) + \beta_2(pat_i) + \beta_3(educ_i) + \beta_4(foreign_i) + \beta_5(size_i) + \beta_6(dind1-25) + \varepsilon_i$$

$$(4)\quad \text{intense}_i = \beta_1(techfield\_np_i) + \beta_2(pat_i) + \beta_3(educ_i) + \beta_4(foreign_i) + \beta_5(size_i) + \beta_6(dind1-25) + \varepsilon_i$$

Here we assume that the number of transfer contacts (intense) with different universities is significantly correlated with the absorptive capacity of a firm, the number of patent assignments to a technology field, patent activities (yes/no), foreign ownership (yes/no), firm size, and we also control for industry affiliation of a firm (25 industries). We identify four types of technology fields, i.e. techfield_hp (high potentials), techfield_lp (low potentials), techfield_np (not used potentials), and techfield_ls (lone stars). The absorptive capacity is approximated through the skill-level in a firm (educ) and patent activities (pat). "Foreign" (binary variable) controls for the fact that foreign owned firms have may have predominantly transfer activities in their home countries and thus the probability of contacts with Swiss universities may be somehow different. "Size" controls for the firm size and "Dind1–Dind25" are further controls for the size and industry affiliation of a firm (see table 3 and 4).

4. Empirical Strategy

In the following we describe the necessary (preparative) steps and estimation procedures in order to estimate our equations 1 to 4 (see above).

a) Firm side: we sorted the technological fields (class level) according to the number of firms' patent field inscriptions.

b) University side: we sorted the technology fields (class level) according to the number of technology fields assigned to universities.

c) We compared the 20 most important (frequently researched) technology fields on part of private enterprises with the 20 most important technology fields on part of the university sector and looked for similarities and dissimilarities. In the same way we investigated the 20 least important technology fields in both sectors public universities, and private enterprises.

d) As a result we could identify four quadrants (see figure 1 to 3), i.e.

- 'high potentials': technology fields frequently found in private enterprises and in universities;
- 'low potentials': technology fields not frequently found in private enterprises and in universities

- 'not used potentials': technology fields frequently found at universities and not frequently found in private enterprises
- 'lone stars': technology fields frequently found in private enterprises and not frequently found in universities

e) High potentials, low potentials, not used potentials, and lone stars could be identified for three different groups of private enterprises, i.e. all firms, firms with less than 500 employees, and for firms with less than 300 employees.

f) In order to identify if the technological orientation of a firm has an impact on the propensity and intensity (diversification) of transfer activities with universities, we estimated our equations (1 to 4; see above). The number of transfer contacts with different universities/research institutions is the dependent variable (see table 3). In case a firm does not have transfer activities we assigned a zero. This means we inflated zeros which suggests a zero inflated estimator for count data. Using STATA software we applied the "zinb" (zero inflated negative binomial) procedure with heteroscedasticity robust standard error. All estimations passed the "voung test" for the zero inflated negative binomial estimator. The first stage was estimated with two instruments, i.e. "frage" and "info" (see list of independent variables; table 4).

In addition to the number of patent field inscriptions on a class level (see table A1) we controlled for patent activities (pat) of firms. Furthermore we control for the education level of the employees (educ), foreign ownership (foreign), firm size (size), and sector affiliation of the firm (25 industry dummies (two-digit)).

g) We added the information of significant technology fields to our quadrants by highlighting the respective technological classification (see figure 1 to 3).

5. Data

For this study we used two data sources. Firstly, and in co-operation with NetBreeze[4] we assigned technology fields to R&D active Swiss firms and Swiss universities based on patent data (1904-2008).

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

On the firm side, we used the information on "esp@cenet (patent application and granted patents around the world - www.espacenet.com). We assigned technology fields according to the patent classification to single firms. Thus we only assigned technology fields to firms with patent activities (920 firms). R&D active firms without patent activities or non R&D active firms had no technological assignment. We did not assign the patent fields manually; instead we used a software program developed by NetBreeze5. Technology fields were assigned on the subclass level. Information on the subclass level was aggregated on the clas 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 classes6. It is possible that one patent is assigned to different classes (technology fields). We found 34048 patents (1904-2008; see table 1) for 5693 Swiss firms (Swiss Innovation Panel; 18 manufacturing industries, construction, and selected services). The 34048 patents were assigned to 68533 patent fields7. We collected information on all patent classification levels. However, the information on the subclass level was not used for this study, since it increases the complexity of the results without providing much more insight.

On the university side, we also assigned technology fields to science institutions of Swiss universities (ETH Zurich (including research institutes), EPF Lausanne, cantonal universities, and universities of applied sciences). Since patent applications are not sufficient in order to identify the technology fields of research activities at universities we used the information on the websites about the research activities of institutes. More concretely, we used classificators that allow us to assign patent classifications to universities' research activities based on "terms" that could be found on the respective websites. The parameters

[5] 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.
[6] 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.
[7] It is likely that one patent is assigned to different patent fields.

of the classificator were developed and trained based on 150'000 patent description (see Lang 2008).8 For the results of the technology field assignment to universities see table 2.

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 the patent information on the firm-level and received a combined data set of 2132 observations.

6. Results

The main results are presented in tables 5 to 7 and figures 1 to 3. The overlap of technology fields between private enterprises and universities is considerable. Depending on the size classes between 12 and 14 (out of 20) technology fields are considered to be important for private enterprises and universities. Furthermore it was found that the technological activities of universities and the technological orientation of firms are an important factor for knowledge and technology transfer. This fact is mostly neglected in related studies. In table 10 we see the technological fields with a significant impact on firms' propensity and intensity to have transfer activities with universities. We present the results for "all firms", for "firms

[8] Technological fields are assigned based on a binary classificatory that follows a "cascade structure". For a detailed

with less than 500 employees", and for "firms with less than 300 employees".9 For "all firms" we see that 10 technology fields are significant (see table 8), for smaller than 500 employees we see that 12 technology fields are significant (see table 9), and for firms with less than 300 employees we see that 7 technology fields are significant (see table 10).

Combining our findings about the overlap of technology fields with the econometric estimations enables us to answer our hypothesis (see table 5 to 7 and figure 1 to 3).

With hypothesis 1 (H1) we refer to "high potentials". Looking at the category "all firms" we see that especially RD activities in the following fields are found in private enterprises as well as universities (high potentials; see figure 1):

- human necessities, i.e. agriculture (a01), medical or veterinary sciences or hygiene (a61)
- performing operations/transporting, i.e. physical or chemical processes (b01), hand tools, workshop equipment, manipulators (b23), vehicles in general (b60)
- chemistry, i.e. organic chemistry (c07), organic macromolecular compounds (c08), biochemistry, microbiology (c12)
- physics, i.e. measuring (counting), testing (g01), computing, calculating, counting (g06)
- electricity, i.e. basic electric elements (h01), and electric communication technique (h04)

Comparing these results with the results from the econometric analysis (see table 5 and figure 1) we see that private enterprises patenting in the field a01 have a significant greater propensity to conduct technology transfer activities with different universities (greater intensity), while firms that emphasize c12 have a relatively low transfer propensity. Especially firms in the machinery industry and chemical industry as well as metal products were filing patents in a01. C12 is mainly researched by firms in the chemical industry. All other fields are not significant.

Constraining our sample to firms with less than 500 employees' leads to some important changes (see table 6 and figure 2); c12 switches to the category not used potentials and e04 (building – layered materi-

description of the classificator (classification procedures) and tests of robustness see Lang J. (2008).
[9] For a complete description of the technological fields please refer to table A1

als, layered products in general) is new among the high potentials. Furthermore firms with less than 500 employees have a greater probability to have intensive transfer activities in three out of 12 high potentials (h04, c08, a01). This indicates that "smaller" firms (<500) make more intensively use of academic research in these technological areas (high potentials). This shows that the concept of "absorptive capacity" is a necessary but clearly not a sufficient condition for transfer activities. Firms in the electronic/instruments industry, the electronic industry, and informatics/RD industry are mainly filing patents in h04. Firms in the chemical industry, machinery and electronic have the greatest number of patent field inscriptions in c08. Like in the category "all firms", the chemical industry, metal products and machinery are dominant in a01.

If we further constrain our firm sample to firms with less than 300 employees (see table 7 and figure 3) we not only find e04 and again c12 among the high potentials, but new g02 (optics, making optical elements or apparatus); three out of fourteen technological fields show a significant positive impact on the intensity of transfer activities (a01, c08, g02). These are relatively few compared to firms with less than 500 employees but clearly more than "all firms". Thus our result that smaller firms use high potentials more intensively still holds. However it should be noticed that there is a slightly shift in significance; g02 (optics) is only significant in the category "<300", while h04 (electric communication technique) is only significant in the category "<500". Only a01 remains significant in all three size categories. Machinery and chemical industry are among the dominant industries in c08 and in g02 mainly firms in electronics and machinery industry are filing patents.

With hypothesis 2 (H2) we refer to "low potentials". Starting again with the category "all firms" we see few patent field inscriptions on both sides private enterprises and universities, in the following fields (see figure 1):

- Human necessities, i.e. headwear (a42)
- performing operations/transporting, i.e generating or transmitting mechanical vibrations (b06)
- chemistry, i.e. manufacturing of fertilizers (c05), explosives, matches (c06), sugar industry – polysaccharides (c13), skins, hides, pelts, leader (c14), combinatorial technology (c40).

- Textiles, paper, i.e. robes, cables other than electric (d07)
- Mechanical engineering, i.e. storing or distributing gases or liquids (f17), steam generation – physical or chemical apparatus (f22)
- Physics, i.e. instrument details (g12)

Taking into account the econometric analysis (see table 5 and figure 1) we see that firms active in these technological fields refrain from transfer activities with universities by trend; for three classification we observe a negative sign (b06, c05, c40), one is positive (c13) and the rest is insignificant. Firms in the electronic and machinery industry are frequently filing patents in b06 and c05. In c40 and c13 we have only one (firm) observation respectively which does not make the results appear to be robust.

Looking at firms with less than 500 employees we have quite similar results (see table 6 and figure 2). The technological fields are identical only the significant sign switches to some extent; a46 (brushware), b06, and c40 are significant negative and c13 and c14 are significant positive. Again, we have very few observations (in brackets) in c13 (1) and c40 (1), but also in c14 (3). Again, machinery (b06) and electronics (a46, b06) are frequently filing patents in these technology fields.

The main results still holds if we restrain our sample to firms with less than 300 employees (see table 7 and figure 3). Only one new technological field (b04 – centrifugal apparatus and machines for carrying-out physical or chemical processes) can be observed. Also machinery and electronics remain important industries in terms of filing patents in significant technology fields (a46, f17). In sum it is obvious that we do not observe – like expected – transfer activities in "low potentials".

With hypothesis 3 (H3) we refer to "lone stars". Starting again with the results for "all firms" we see that private enterprises emphasis in their patent activities a number of technology fields that are not emphasized or less emphasized by universities, like follows (see figure 1):

- Human necessities, i.e. furniture, domestic articles and appliances, coffee mills, spice mills, suction cleaners in general (a47)

- Performing operations/transporting, i.e. working of plastics (b29), conveying, packing, storing, handling thin or filamentary material (b65), hoisting, lifting, hauling (b66)
- Chemistry, i.e. dyes, paints, polishes, natural resins, adhesives (c09)
- Mechanical engineering, i.e. engineering elements/units, measures for producing and maintaining effective functioning of machines or installations, thermal insulation (f16)
- Physics, i.e. horology (g04)
- Electricity, i.e. generation, conversion, or distribution of electric power (h02)

Considering the econometric estimations (see table 5 and figure 1) we see that private enterprises patenting in these technology fields do not have a tendency for or against technological transfer activities in general; none of these technological fields is significant. This result is quite intuitive if one considers that universities do few or no research in these technology fields. Firms might have problems to find adequate partners. Which industries are predominantly active in these technological fields? Machinery, other industries, electronics, chemistry, and the watch industry are mainly filing patents in these technological fields.

Focusing on firms with less than 500 employees the results change slightly (see table 6 and figure 2). Only one technological field (b65) has a significant negative sign. All other are insignificant and thus confirming the results for “all firms”. Furthermore b22 (casting, powder metallurgy) is substituting c09. The list of important industries for “lone stars” remains identical to “all firms”.

For firms with less than 300 employees we found fewer technological fields (see table 7 and figure 3). h02, g04, and b66 can not be found anymore among this group of fields and b05 (spraying or atomizing in general, applying liquids or other fluent materials to surfaces) is new. The composition of important industries for these technological fields does not change.

With hypothesis 4 we refer to “not used potentials”. This group and the group of “high potentials” are of special interest for policy makers. Here, universities show comprehensive research activities but firms seem to be less interested in such research or do not have the absorptive capacity. One would not expect

significant or positive significant results for "not used potentials". Referring to "all firms" the following technological fields are classified as "not used potentials" (see figure 1):

- Human necessities, i.e. sports, games, and amusements (a63)
- Fixed constructions, i.e. building - layered materials, layered products in general (e04)
- Physics, i.e. optics – making optical elements or apparatus (g02), controlling, regulating (g05), educating, cryptography, display, advertising, seals (g09), information storage (g11)
- Electricity, i.e. basic electronic circuitry (h03), electric techniques not otherwise provided for (h05)

Like expected we have predominantly significant positive or not significant results for "not used potentials" (see table 5 and figure 1). This indicates that firms' do not have comprehensive research activities in these fields but try to build in-house capabilities through transfer activities with universities or in case of not significant results or negative significant results they do not have the absorptive capacity to make use of public research activities or they simply do not want (e.g. because of security reasons) to have transfer activities in such technology fields. Referring to all firms we see only one technology field with a significant negative sign (g11). That means, although universities have considerable research activities in g11, private enterprises do not tend to have transfer activities; secrecy, different (time) priorities, or problems for commercializing results may be reasons for it. Firms from the machinery, metal products, electronics, and electrical engineering business are most frequently filing patents in these technological fields.

Looking at firms with less than 500 employees we see very similar results (see table 6 and figure 2). Only e05 is substituted by c12 (biochemistry, beer, spirits, wine, microbiology) and g11 is no longer significant. All other variables remain to be significant positive or not significant. Also in terms of active industries, we do not see considerable differences. Machinery, electrical engineering and electronics are still very important industries. In addition, chemistry and construction (in case of c12, and a63) gain some importance as well.

In the category “firms with less than 300 employees” we still get similar results compared to “less then 500 employees” and “all firms” (see table 7 and figure 3). The technological fields are significant positive (h05) or not significant. However, we find fewer technological fields (without c12, e04 and g02) and a63 is no longer positive significant. Again machinery, electronics and electrical engineering are mainly filing patents in these technological fields. Other industries and construction gain some importance.

7. Conclusions

This study tries to map the technology activities of private enterprises and the technology activities of universities in Switzerland in order to detect collaboration potential or knowledge and technology transfer potential between private enterprises and universities. This way we can improve the knowledge base for policy making in the country. For this study we used two data sources. Firstly, and in co-operation with NetBreeze10 we assigned technology fields to R&D active Swiss firms and Swiss universities based on patent data (1904-2008). Secondly, we collected data in the course of a survey among Swiss enterprises about their transfer activities with universities. We received answers from 2582 firms, i.e. 45.4% of the firms in the underlying sample.

Looking at the technology proximity between private enterprises and universities we can identify four areas. Firstly, “high potentials” (technology fields frequently found in private enterprises and in universities). Secondly “low potentials” (technology fields not frequently found in private enterprises and in universities). Thirdly, “not used potentials” (technology fields frequently found at universities and not frequently found in private enterprises). Fourthly “lone stars” (technology fields frequently found in private enterprises and not frequently found in universities).

We saw that great technology proximity between universities and private enterprises increases the probability of transfer activities and makes it more likely to have more than one university link. This was observed in several technology fields, like a01 (agriculture), c08 (organic macromolecular compounds), g02 (optics), and h04 (electric communication technique) and especially in smaller firms (less than 500 em-

ployees or less than 300 employees). These finding are very in line with the concept of absorptive capacity and/or a resource based motivation of an enterprise for transfer activities.

We also found that there are not transfer activities in technology fields that are not important (not frequently researched) from both private enterprises, and universities. Here, we mainly observed - independent of the size class - not significant or negative significant relationships between the respective technology fields and the probability to have transfer activities. This result is quite coherent, if we think that both sides do not emphasize research in these fields and thus do not accumulate considerable knowledge.

Furthermore it became obvious that firms do not have transfer activities with universities in technology fields that are frequently researched by private enterprises and not frequently researched at universities. We did not observe significant transfer activities in those fields (one exception) independent of the size class. It is understandable that private enterprises refrain from transfer activities if they have "better" knowledge compared to potential partners at universities.

We also found that firms want to change or essentially modify their technology orientation with different partners form universities. These findings refer to technology fields in the category "not used potentials". As expected we saw predominantly significant positive or not significant transfer relationships in those fields. The significant positive technology fields also indicate that private enterprises recognize the relevance of transfer activities to change or essentially modify their knowledge base. This shows a "technology-push" effect from universities to the private sector contributing to the long-term competitiveness of the transfer partner.

Since we know that transfer activities support the innovativeness and productivity of firms, it is useful to develop policy measures to ease the transfer by taking into account the different functions of private enterprises and universities in the society. From a policy point of view all four fields are of great interest. A lack of transfer activities in some fields of "high potentials" poses a communication/information challenge to transfer policy makers. Firms may not be well informed about research activities in related fields

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

at universities or research goals, time schedules, or the research questions are too different and thus firms refrain from transfer activities. Secrecy may be a further problem, especially in very market related research. A lack of transfer activities in “low potentials” is quite understandable. “Low potentials” pose long-term strategic challenges, in case the government aims at strengthening the capabilities in such technology fields. “Lone stars” may have problems to find adequate national academic partners for their research activities, which would pose an information challenge to policy makers or a research strategy challenge to universities. “Not used potential” indicates a lack of absorptive capacity or lack of commercial potential

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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)	Number of transfer contacts with universities (KOF)				R&D active firms (NetBreeze)	No. of Patents (NetBreeze)	No. of patent field inscriptions (NetBreeze)
Industries			**1**	**2**	**3**	**4+**			
Food/beverage	127	34	7	11	8	7	48	1219	2372
Textile	30	9	2	2	2	3	19	247	417
Clothing/leather	11	0	3	3	2	3	0	37	55
Wood processing	56	9	6	1	2	1	12	45	98
Paper	31	9	8	5	2	4	28	175	336
Publishing	91	17	2	10	4	14	20	278	488
Chemicals	93	37	3	2	3	5	106	4683	11448
Plastics/rubber	58	13	2	2	3	4	50	581	1105
Other non metallic mineral products	47	13	4	2	1	3	29	276	510
Metal	39	9	18	6	10	11	21	345	788
Metalworking	173	37	6	23	23	38	98	1769	3397
Machinery	269	116	14	5	10	11	240	7767	15034
Electrical machinery	87	33	1	9	10	26	64	2421	4780
Electronic/instruments	152	67	3	1	1	4	144	4522	8857
Watches	54	6	2	3	2	4	46	900	1618
Vehicles	29	9	7		5	3	24	550	1151
Other manufacturing	54	12	14	2	9	6	40	1075	2115
Energy/water	49	15	4	5	6	6	0	40	65
Construction	271	32	4	8	1	6	58	815	1554
Wholesale	215	35	3	9	6	5	109	2726	5485
Transport	154	21	13	7	5	14	32	565	911
Banking/insurance	179	35	2	6	11	11	68	968	1704
Computer services	79	28	7	12	1	23	40	671	1347
Business services	216	67	2	11	8	2	74	1166	2527
Telecommunication	18	6	3	2	2	7	10	207	371
Total	2582	669	128	138	127	214	1388	34048	68533

Base: Swiss Innovation Panel (SIP) with 5693 firms. KOF Survey: 2582 answers (response rate 45%); NetBreeze Survey (based on SIP): 1388 R&D active firms and 920 firms with patent activities. 62 firms do not tell us the cooperation partner(s) or do not have transfer activities with national universities. No. of patents and patent field inscriptions between 1904 and May 2008.

Table 2: Technological fields of Universities / science institutions

Institution	websites searched	hits	Technology fields (sections)							
			A	B	C	D	E	F	G	H
University of Applied Sciences Bern	737	537	12	85	8	1	12	3	199	217
Engineering School of Changins	103	56	5	10	7	0	4	5	19	6
Swiss Federal Institute of Technology Lausanne	15811	9940	853	942	1357	98	571	404	2908	2807
Swiss Federal Institute of Technology Zurich	22699	14143	836	767	922	95	334	554	8363	2272
Swiss Federal Institute of Aquatic Science and Technology	253	168	18	18	30	7	33	3	44	15
Swiss Federal Institute for Forest, Snow and Landscape Research	271	168	26	9	45	0	25	0	53	10
University of Applied Sciences Northwestern Switzerland	28	15	2	2	2	1	2	0	3	3
University of Applied Sciences western Switzerland	275	166	16	0	0	0	2	2	133	13
Interstate University of Applied Sciences of Technology Buchs	22	12	0	0	0	0	0	0	8	4
University of Applied Sciences Rapperswil	648	431	21	42	25	14	48	12	131	138
College of Technology Zurich	249	129	3	7	7	1	14	1	80	16
University of Applied Sciences of Southern Switzerland	309	279	25	62	20	5	22	26	32	87
University of Lugano	555	291	41	10	16	4	9	42	107	62
University of Basel	2589	1571	376	169	225	50	52	39	447	213
University of Bern	7853	5318	1492	441	535	73	440	158	1216	963
University of St. Gallen	17	5	3	0	0	0	0	0	2	0
University of Zurich	8969	6199	1097	713	1160	161	418	270	1485	895
University of Fribourg	127	80	4	14	20	0	3	0	5	34
University of Lausanne	247	115	9	5	7	0	19	3	52	20
University of Neuchatel	2	2	0	0	2	0	0	0	0	0
Zurich University of Applied Sciences Winterthur	978	568	41	63	73	8	50	16	190	127

"hits" shows us the number of websites related to technological fields found on the servers of the respective university/science institution. We only searched servers related to science institutes (economics, humanities, or law have been excluded). Technological fields (see http://depatisnet.dpma.de/ipc/ipc.do): 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). A to H - technological assignments for the respective technological field.

Table 3: Dependent variable

Dependent Variables	Description
intense	Number of transfer activities with different universities; no transfer activities equal 0.

Table 4: Independent variables

Determinants	Description
Educ	Share of employees with tertiary-level vocational education (universities, universities of applied sciences, other business and technical schools at tertiary level)
Foreign	Dummy variable; 1 if a firm is foreign owned, 0 if the firms is not foreign owned
Pat	Dummy variable; 1 if the firm filed patent(s). 0 if the firm did file patent(s).
Size	The size of firms is measures through the number of employees expressed in full-time equivalents (log)
Technology fields (see also Appendix Table A1)	
Techfield_hp (Technology fields frequently found in private enterprises and in universities (see figure 1 to 3; category: high potentials)	
… a01	Number of technology field inscriptions in a01 (agriculture, forestry, animal husbandry, hunting, trapping, fishing)
… c12	Number of technology field inscriptions in c12 (biochemistry, beer, spirits, wine, vinegar, microbiology, enzymology, mutation of genetic engineering)
… c08	Number of technology field inscriptions in c12 (organic macromolecular compounds, their preparation or chemical working-up, compositions based thereon)
… g02	Number of technology field inscriptions in g02 (optics)
… h04	Number of technology field inscriptions in h04 (electric communication technique)
Techfield_lp (Technology fields not frequently found in private enterprises and in universities (see figure 1 to 3; category: low potentials)	
… a46	Number of technology field inscriptions in a46 (brushware)
… b06	Number of technology field inscriptions in b06 (generating or transmitting mechanical vibrations in general)
… c05	Number of technology field inscriptions in c05 (fertilisers, manufacture thereof)
… c13	Number of technology field inscriptions in c13 (sugar industry)
… c14	Number of technology field inscriptions in c14 (skins, hides, pelts, leather)
… c40	Number of technology field inscriptions in c40 (combinatorial technology)
… f17	Number of technology field inscriptions in f17 (storing or distributing gases or liquids)
Techfield_np (Technology fields frequently found at universities and not frequently found in private enterprises (see figure 1 to 3; category: not used potentials)	
… a63	Number of technology field inscriptions in a63 (sports, games, amusements)
… g02	Number of technology field inscriptions in g02 (optics)

… g11	Number of technology field inscriptions in g11 (information storage)
… h05	Number of technology field inscriptions in h05 (electric techniques not otherwise provided for)
Techfield_ls (category: lone stars)	Technology fields frequently found in private enterprises and not frequently found in universities (see figure 1 to 3;
… b65	Number of technology field inscriptions in b65 (conveying, packing, storing, handling thin or filamenary material)
Control variables	
Dind1 to 25	25 industry dummies (two-digit)
Instruments in order identify the 0/1 decision to have transfer activities	
Info	Obstacle: difficulties to get information about the research activities at universities. Firms assessed the importance of this obstacle based on a five-point Likert scale (1 not important … 5 very important).
Frage	Obstacle: our research and development questions are not interesting for universities (from a firm point of view). Firms assessed the importance of this obstacle based on a five-point Likert scale (1 not important … 5 very important).

Table 5: Regression results "all firms" (dependent variable "intense")

	1	2	3	4	5	6	7	8	9	10
Educ	0.137***	0.137***	0.137***	0.136***	0.137***	0.137***	0.135***	0.138***	0.136***	0.136***
	6.52	6.51	6.49	6.5	6.51	6.43	6.51	6.52	6.47	6.51
Foreign	-0.017	-0.019	-0.02	-0.02	-0.017	-0.018	-0.018	-0.02	-0.016	-0.014
	-0.4	-0.46	-0.48	-0.47	-0.41	-0.41	-0.42	-0.45	-0.39	-0.31
Size	0.147***	0.148***	0.149***	0.147***	0.148***	0.149***	0.147***	0.15***	0.149***	0.145***
	11.65	11.62	11.62	11.61	11.63	11.61	11.62	11.58	11.6	11.53
Pat	0.297***	0.299***	0.296***	0.299***	0.299***	0.3***	0.295***	0.302***	0.3***	0.296***
	6.98	7	6.94	7.06	7.04	7.03	6.99	7	7.03	7.04
Techfield_hp										
a01	0.004*									
	1.94									
c12		-0.003**								
		-2.27								
g02			0.001***							
			2.66							
Techfield_lp										
b06				-0.092**						
				-2.31						
c05					-0.203*					
					-1.64					
c13						1.066**				
						2.34				
c40							-0.292***			
							-12.33			
Techfield_np										
a63								0.001**		
								2.09		
g11									-0.023*	
									-1.84	
h05										0.038**
										2.03
Wald chi2 (29)	6044.66***	6064.16***	5912.05***	6427.51***	6061.07***	372.94***[1]	6767.82***	5288***	6158.57***	5996.77***

No. of observations 2132. Table shows marginal effects and z-values. Dependent variable "intense". Heteroscedasticity robust standard errors. Estimation procedure: zero inflated negative binomial estimator (0/1 decision for technology transfer is controlled for (variable "info" and/or "frage"). *, **, *** indicate significance level of 90%, 95%, and 99% respectively. [1] indicates that the LR (chi2) figure comes from the not "robust" estimation. C13 has only one observation in the estimation. The "robust" estimation does not show a chi2 figure.

Table 6: Regression results “firms with less than 500 employees” (dependent variable “intense”)

	1	2	3	4	5	6	7	8	9	10	11	12
Educ	0.113***	0.113***	0.114***	0.113***	0.113***	0.113***	0.113***	0.113***	0.113***	0.114***	0.115***	0.114***
	6.41	6.45	6.44	6.42	6.39	6.34	6.45	6.4	6.42	6.39	6.45	6.43
Foreign	-0.032	-0.03	-0.032	-0.031	-0.034	-0.032	-0.031	-0.032	-0.034	-0.035	-0.03	-0.034
	-0.99	-0.95	-0.99	-0.95	-1.05	-0.98	-0.96	-1	-1.05	-1.06	-0.9	-1.04
Size	0.115***	0.113***	0.114***	0.115***	0.116***	0.116***	0.113***	0.115***	0.115***	0.117***	0.113***	0.117***
	9.27	9.15	9.18	9.23	9.24	9.21	9.18	9.23	9.18	9.23	9.06	9.3
Pat	0.227***	0.226***	0.226***	0.229***	0.231***	0.231***	0.231***	0.228***	0.23***	0.229***	0.229***	0.234***
	6.48	6.4	6.42	6.47	6.55	6.52	6.55	6.48	6.5	6.43	6.54	6.6
Techfield_hp												
a01	0.004***											
	2.74											
c08		0.007***										
		2.89										
h04			0.006**									
			2.18									
Techfield_lp												
a46				-0.121***								
				-3.77								
b06					-0.074**							
					-2.49							
c13						0.723**						
						2.08						
c14							0.27***					
							3.28					
c40								-0.221***				
								-11.00				
Techfield_np												
a63									0.001**			
									2.41			
g02										0.001**		
										2.46		
h05											0.034**	
											2.02	
Techfield_ls												
b65												-0.003***
												-2.89
Wald chi2	9436.52***	9375.18***	9048.72***	9374.1***	9196.21***	273.28	9395.35***	9651.5***	9298.89***	8690.58***	8863.44***	8859.77***

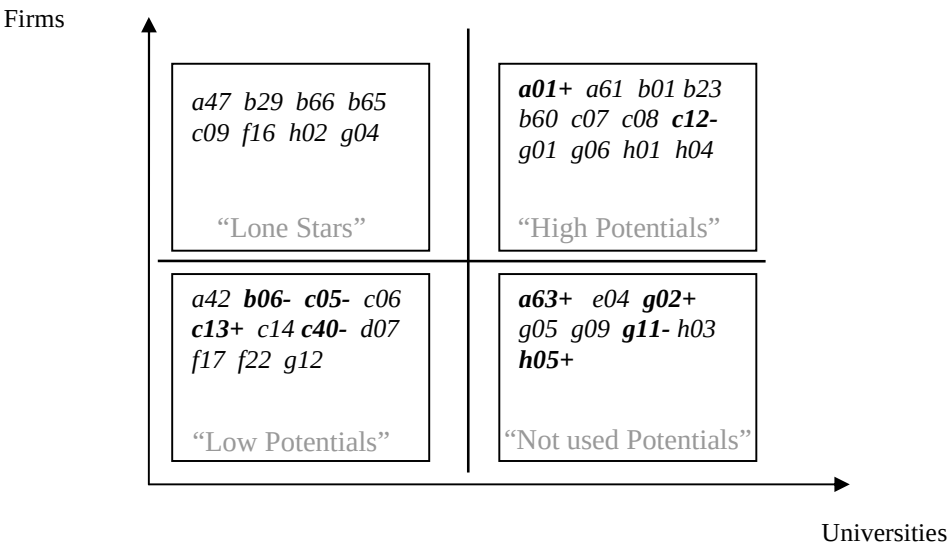
No. of observations 2010. Table shows marginal effects and z-values. Dependent variable “intense”. Heteroscedasticity robust standard errors. Estimation procedure: zero inflated negative binomial estimator (0/1 decision for technology transfer is controlled for (variable “info” and/or “frage”). *, **, *** indicate significance level of 90%, 95%, and 99% respectively. [1] indicates that the LR (chi2) figure comes from the not “robust” estimation. C13 has only one observation in the estimation. The “robust” estimation does not show a chi2 figure.

Table 7: Regression results “firms with less than 300 employees” (dependent variable “intense”)

	1	2	3	4	5	6	7
Educ	0.106***	0.087***	0.105***	0.102***	0.105***	0.103***	0.104***
	6.22	6.21	6.22	6.15	6.15	6.15	6.2
Foreign	-0.052*	-0.04*	-0.051*	-0.049*	-0.05*	-0.051*	-0.047
	-1.83	-1.66	-1.79	-1.73	-1.74	-1.78	-1.6
Size	0.102***	0.083***	0.102***	0.099***	0.102***	0.1***	0.098***
	7.74	7.58	7.72	7.68	7.66	7.68	7.5
Pat	0.211***	0.175***	0.21***	0.208***	0.215***	0.208***	0.211***
	6.17	6.17	6.17	6.23	6.22	6.18	6.29
Techfield_hp							
a01	0.004***						
	2.76						
c08		0.006***					
		2.58					
Techfield_lp							
a46			-0.105***				
			-3.63				
c40				-0.195***			
				-10.11			
f17					0.02*		
					1.70		
Techfield_np							
g02						0.001***	
						2.71	
h05							0.029*
							1.77
Wald chi2	7524.69***	20144.85***	8152.48***	9223.84***	7578.18***	8844.68***	8150.6***

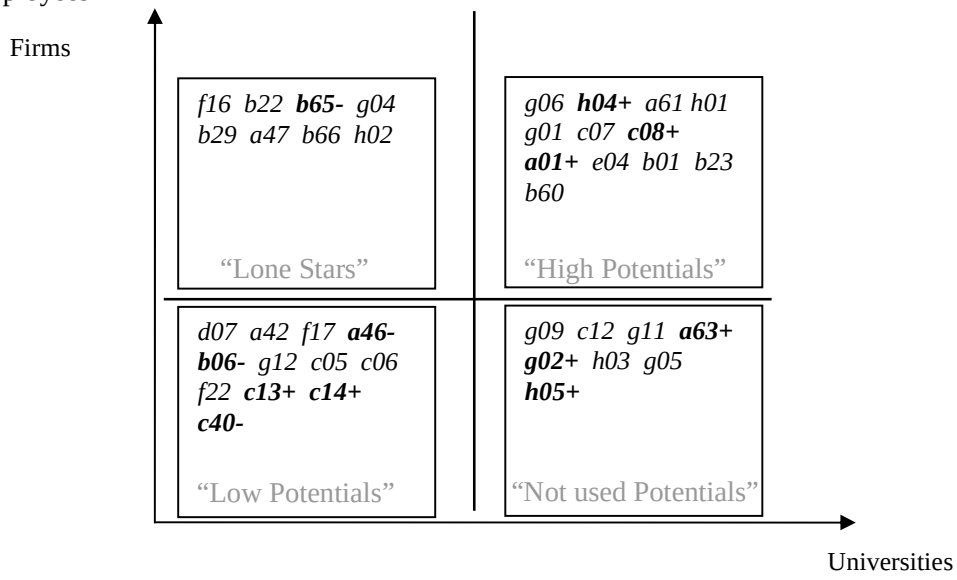
No. of observations 1903. Table shows marginal effects and z-values. Dependent variable “intense”. Heteroscedasticity robust standard errors. Estimation procedure: zero inflated negative binomial estimator (0/1 decision for technology transfer is controlled for (variable “info” and/or “frage”). *, **, *** indicate significance level of 90%, 95%, and 99% respectively.

Figure 1: Technological fields and the probability to have technology transfer. All firms



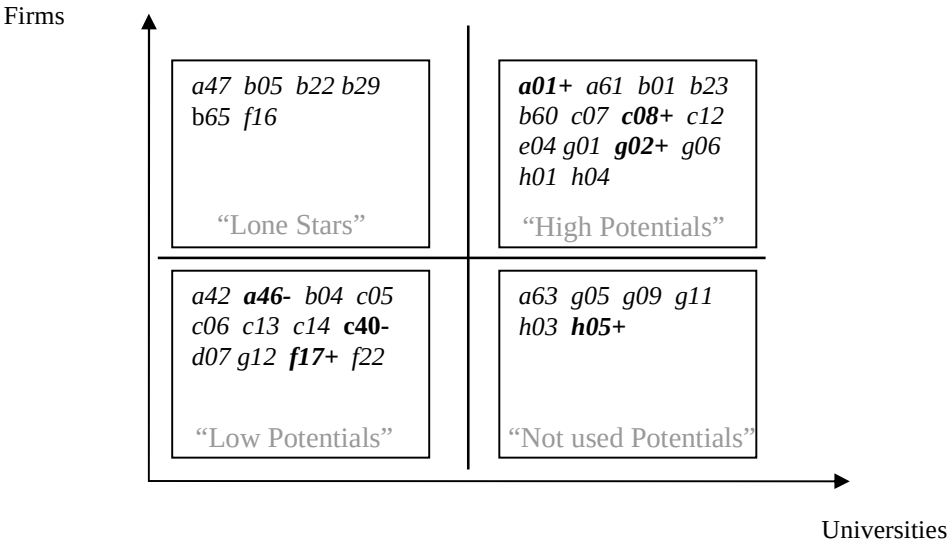
Note: **High potentials** - upper right corner (technological fields frequently found in private enterprises and in universities). **Low potentials** - lower left corner (technological fields not frequently found in both private enterprises and universities). **Not used potentials** - lower right corner (frequently found at universities and not frequently found in private enterprises). **Lone stars** - upper left corner (frequently found in private enterprises and not frequently found at universities). Frequency refers to the 20 most important (according to counts in the respective technological field) or 20 least important technological fields.

Figure 2: Technological fields and the probability to have technology transfer. Firms with less than 500 employees



Note: **High potentials** - upper right corner (technological fields frequently found in private enterprises and in universities). **Low potentials** - lower left corner (technological fields not frequently found in both private enterprises and universities). **Not used potentials** - lower right corner (frequently found at universities and not frequently found in private enterprises). **Lone stars** - upper left corner (frequently found in private enterprises and not frequently found at universities). Frequency refers to the 20 most important (according to counts in the respective technological field) or 20 least important technological fields.

Figure 3: Technological fields and the probability to have technology transfer. Firms with less than 300 employees



Note: **High potentials** - upper right corner (technological fields frequently found in private enterprises and in universities). **Low potentials** - lower left corner (technological fields not frequently found in both private enterprises and universities). **Not used potentials** - lower right corner (frequently found at universities and not frequently found in private enterprises). **Lone stars** - upper left corner (frequently found in private enterprises and not frequently found at universities). Frequency refers to the 20 most important (according to counts in the respective technological field) or 20 least important technological fields.

Table 8: Significant and not significant technological fields – all firms

Significant results		*Not significant results*	
High potentials			
a01+	machinery, chemicals, metalworking	a61	chemicals, electronics / instruments, machinery
c12-	chemicals, construction, food / beverage, machinery, electrical machinery	b01	machinery, chemicals, electronics / instruments
		b23	machinery, metalworking, electronics / instruments
		b60	machinery, electronics / instruments, electrical machinery
		c07	chemicals, machinery, electrical machinery, construction
		c08	chemicals, machinery, electrical machinery
		g01	machinery, electronics / instruments, electrical machinery
		g06	machinery, electronics / instruments, electrical machinery
		h01	electronics / instruments, machinery, electrical machinery
		h04	electronics / instruments, electrical machinery, machinery
Low potentials			
b06-	machinery, electronics / instruments, chemicals, electrical machinery	a42	
c05-	chemicals, machinery, electrical machinery, wholesale, banking/insurance	c06	machinery, chemicals, electrical machinery
c13+	food / beverage	c14	food / beverage, chemicals, metal, machinery
c40-	construction	d07	electrical machinery, metalworking, machinery
		f17	machinery, chemicals, metalworking, electronics / instruments, other manufacturing, construction, banks/insurance
		f22	machinery, metalworking, electrical machinery
		g12	electronics / instruments, metalworking, business services
Not used potentials			
a63+	machinery, metalworking, other manufacturing	e04	machinery, metalworking, construction
g02+	electronics / instruments, machinery, electrical machinery	g05	machinery, electronics / instruments, electrical machinery
g11-	electronics / instruments, machinery, electrical machinery	g09	machinery, electronics / instruments, watches, other manufacturing, paper, computer services
h05+	machinery, electrical machinery, electronics / instruments	h03	electronics / instruments, electrical machinery, machinery, computer services

Table to be continued - see next page.

Continued: Significant and not significant technological fields – all firms

Lone Stars		
	a47	machinery, other manufacturing, metalworking
	b29	machinery, chemicals, electronics / instruments
	b66	machinery, electronics / instruments, electrical machinery, construction, wholesale
	b65	machinery, electronics / instruments, chemicals
	c09	chemicals, machinery, electrical machinery, electronics / instruments
	f16	machinery, electronics / instruments, metalworking
	h02	machinery, electronics / instruments, electrical machinery
	g04	watches, electronics / instruments, machinery, electrical machinery

This table shows significant and not significant "technology fields" for transfer activities of firms separated into the four categories (high potentials, low potentials, lone stars, and not used potentials). Furthermore the important sectors are listed (according number of firms that filed patents in the respective technology field).

Table 9: Significant and not significant technological fields –firms with less than 500 employees

Significant results		*Not significant results*	
High potentials			
h04+	electronics / instruments, electrical machinery, computer services	g06	electronics / instruments, machinery, electrical machinery, computer services
c08+	machinery, chemicals, electrical machinery	a61	chemicals, electronics / instruments, machinery
a01+	machinery, metalworking, chemicals, electrical machinery, construction	h01	electronics / instruments, machinery, electrical machinery
		g01	machinery, electronics / instruments, electrical machinery
		c07	chemicals, machinery, electrical machinery
		e04	metalworking, machinery, food / beverage, electronics / instruments, other manufacturing, construction
		b01	machinery, chemicals, electronics / instruments
		b23	machinery, metalworking, electronics / instruments
		b60	machinery, electronics / instruments, metalworking, electrical machinery, other manufacturing, construction
Low potentials			
a46-	electronics / instruments, food / beverage, construction, transport / telecommunication	d07	electrical machinery, metalworking, machinery
b06-	machinery, electronics / instruments, electrical machinery	a42	
c13+	food / beverage	f17	machinery, chemicals, metalworking, other manufacturing, construction
c14+	food / beverage, metalworking, machinery	g12	electronics / instruments, metalworking, business services
c40-	construction	c05	chemicals, machinery, electrical machinery, wholesale, banking/insurance
		c06	chemicals, machinery, electrical machinery
		f22	machinery, metalworking, electrical machinery
Not used potentials			
a63+	machinery, other manufacturing,metalworking, construction	g09	machinery, electronics / instruments, paper, watches, other manufacturing, computer services
g02+	electronics / instruments, electrical machinery, machinery	c12	construction, chemicals, food / beverage, machinery, electrical machinery
h05+	electrical machinery, machinery, electronics / instruments	g11	machinery, electrical machinery, electronics / instruments, construction
		h03	electronics / instruments, electrical machinery, machinery, computer services
		g05	machinery, electronics / instruments, electrical machinery, computer services

Table to be continued - see next page.

Continued: Significant and not significant technological fields – firms with less than 500 employees

Lone Stars			
b65-	machinery, chemicals, electronics / instruments	f16	machinery, electronics / instruments, metalworking
		b22	machinery, electronics / instruments, synthetics, metal, metalworking, electrical machinery,other manufacturing, wholesale, computer services,
		g04	watches, electrical machinery, electronics / instruments
		b29	machinery, chemicals, electronics / instruments
		a47	machinery, other manufacturing, chemicals, metalworking
		b66	machinery, electronics / instruments, electrical machinery, construction, wholesale
		h02	machinery, electronics / instruments, electrical machinery

This table shows significant and not significant “technology fields” for transfer activities of firms separated into the four categories (high potentials, low potentials, lone stars, and not used potentials). Furthermore the important sectors are listed (according number of firms that filed patents in the respective technology field).

Table 10: Significant and not significant technological fields –firms with less than 300 employees

Significant results		*Not significant results*	
High potentials			
a01+	synthetics, metal, watches, transport / telecommunication, banking/insurance	a61	chemicals, electronics / instruments, machinery
c08+	machinery, chemicals, synthetics, computer services	b01	machinery, chemicals, electronics / instruments
g02+	electronics / instruments, machinery, construction	b23	machinery, metalworking, electronics / instruments
		b60	machinery, electronics / instruments, metalworking, construction
		c07	chemicals, machinery, construction
		c12	construction, chemicals, machinery
		e04	metalworking, machinery, electronics / instruments, construction
		g01	electronics / instruments, machinery, computer services
		g06	electronics / instruments, machinery, computer services
		h01	electronics / instruments, machinery, electrical machinery
		h04	electronics / instruments, computer services, food / beverage, machinery, electrical machinery
Low potentials			
a46-	electronics / instruments, food / beverage, construction, transport / telecommunication	a42	
c40-	construction	b04	machinery, metal, electronics / instruments
f17+	machinery, metalworking, other manufacturing, construction	c05	machinery, electrical machinery, wholesale, banking/insurance
		c06	chemicals, machinery
		c13	food / beverage
		c14	metal
		d07	metalworking, machinery, electrical machinery
		g12	electronics / instruments, metalworking
		f22	machinery, metalworking
Not used potentials			
h05+	machinery, electronics / instruments, electrical machinery	a63	machinery, other manufacturing, construction
		g05	machinery, electronics / instruments, computer services
		g09	machinery, electronics / instruments, computer services
		g11	machinery, electrical machinery, electronics / instruments, construction
		h03	electronics / instruments, computer services, machinery, electrical machinery

Table to be continued - see next page.

Continued: Significant and not significant technological fields – firms with less than 300 employees

Lone Stars		
	a47	machinery, other manufacturing, chemicals, metalworking
	b05	machinery, food / beverage, electrical machinery, electronics / instruments, other manufacturing, computer services
	b22	machinery, electronics / instruments, synthetics, metal, metalworking, electrical machinery, other manufacturing, construction, wholesale, computer services
	b29	machinery, electronics / instruments, chemicals
	b65	machinery, electronics / instruments, food / beverage, chemicals
	f16	machinery, metal, electronics / instruments

This table shows significant and not significant "technology fields" for transfer activities of firms separated into the four categories (high potentials, low potentials, lone stars, and not used potentials). Furthermore the important sectors are listed (according number of firms that filed patents in the respective technology field).

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