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Indicator-Based Reporting on the Chinese Innovation System 2010

– The Regional Dimension of Science and Innovation in China –

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1 Introduction

As regularly stated by both international scholars and confirmed by the Chinese government itself socio-economic development in China remains highly uneven both sociologically and regionally.

Conventional wisdom holds that the prevailing economic trend remains one of divergence rather than convergence. While the world-market oriented coastal provinces develop dynamically, the inland and certainly the Western provinces keep lagging behind. Nonetheless, after a number of years with increasing government proclamations regarding the objective of a harmonious society and efforts to develop the inland provinces there is no longer a unanimous trend, particularly with regard to activities under the direct or indirect control of government.

Hence, it appears reasonable to analyse to what extent these general trends with regard to the regional distribution of socio-economic development affect the different dimensions of relevance to science and innovation.

Consequently, it will be a key aspect of this study to focus on the development of the regional concentration [1] of different R&D activities, thus addressing the question whether the Chinese innovation system is becoming more heterogeneous or less so.

The following sections will follow the R&D process through from R&D-related investments to its eventual possible effects on the national export performance. In detail, it will analyse the regional dimension of R&D activities with regard to the four following key topics:

- Financial and Human Capital Input into R&D Processes,
- Scientific Output,
- Technological Output,
- Export Performance in Technology Related Fields.

Ultimately a brief conclusion will aim at a synthesis of all findings with regard to these different dimensions and its implications for our overall understanding of the regional distribution of R&D-related activities in China.

1 As a measure for regional concentration this study will use the Gini-Coefficient known from studies about the distribution of wealth in society. It is defined mathematically as the ratio of the area that lies between the line of equality and the Lorenz Curve. A low coefficient indicates a more equal distribution, with 0 corresponding to complete equality, while higher coefficients indicate more unequal distribution, with 1 corresponding to complete inequality. A detailed explanation is given in the Annex.

2 R&D Efforts and Input into the Process of Knowledge Generation

General Findings

In very general terms, a regionalised analysis of expenditure for R&D in China results in two main findings.

Firstly, R&D expenditure is concentrated in the coastal provinces (with the exception of Fujian[2]) as well as Beijing. A second tier of R&D spending provinces includes Hubei, Shaanxi, and Sichuan. Most of the former industrial centres in the north-east of China, in contrast, do no longer play a substantial role. Of the three regions only Liaoning matches the second tier. Expectably, R&D expenditures are next to absent in the autonomous regions and the provinces west of Shaanxi/Sichuan. Likewise, they remain low in the peripheral provinces of Yunnan, Guizhou, Guangxi and Hainan (cf. Figure 1).

Secondly, the share of public expenditure exceeds 50% in Beijing (where much of the Chinese Academy of Science's activities are accounted for), Shaanxi and Sichuan (with their traditionally strong defence complexes), whereas in most economically strong coastal provinces it remains below 20%. In the regions with significant activities in R&D, therefore, most R&D is performed in the enterprise sector. Beyond Beijing and central China, municipal Shanghai and Hubei are the only other regions where the share of public expenditure amounts to more than one third (cf. Figure 1).

Similar findings are obtained from an analysis of the regional distribution of FTE R&D personnel (cf. Figure 2). Again the focus lies on Beijing and the coastal provinces. With regard to employment, however, the group of second tier provinces appears broader, including Shanxi, Henan, Anhui and Hunan and it lags less behind the leading group.

As with regard to R&D expenditure, Beijing, Shanghai, Shaanxi, Hubei, and Sichuan are characterised by a high degree of public employment in the R&D sector, whereas in most other regions with a significant number of R&D personnel, the enterprise sector is the dominant employer. As with regard to expenditure, Beijing sticks out less through its high share of employment in the higher education sector than through the high number of R&D personnel in public research. Again, the accounting procedures of the Chinese Academy of Sciences appear a likely reason (cf. Figure 2).

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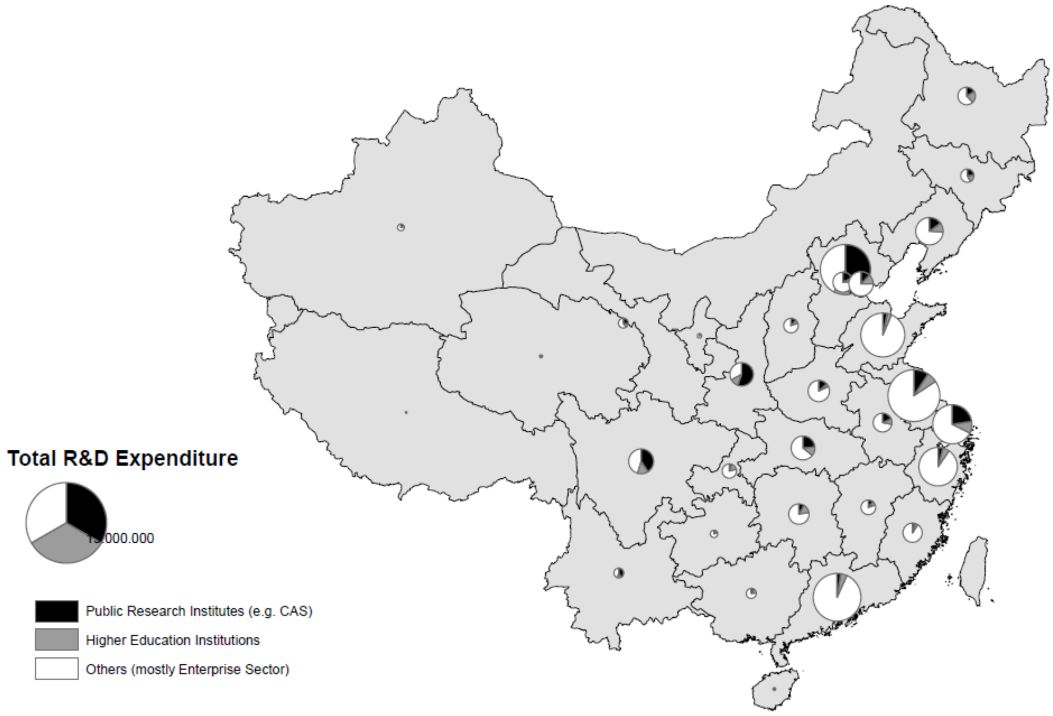
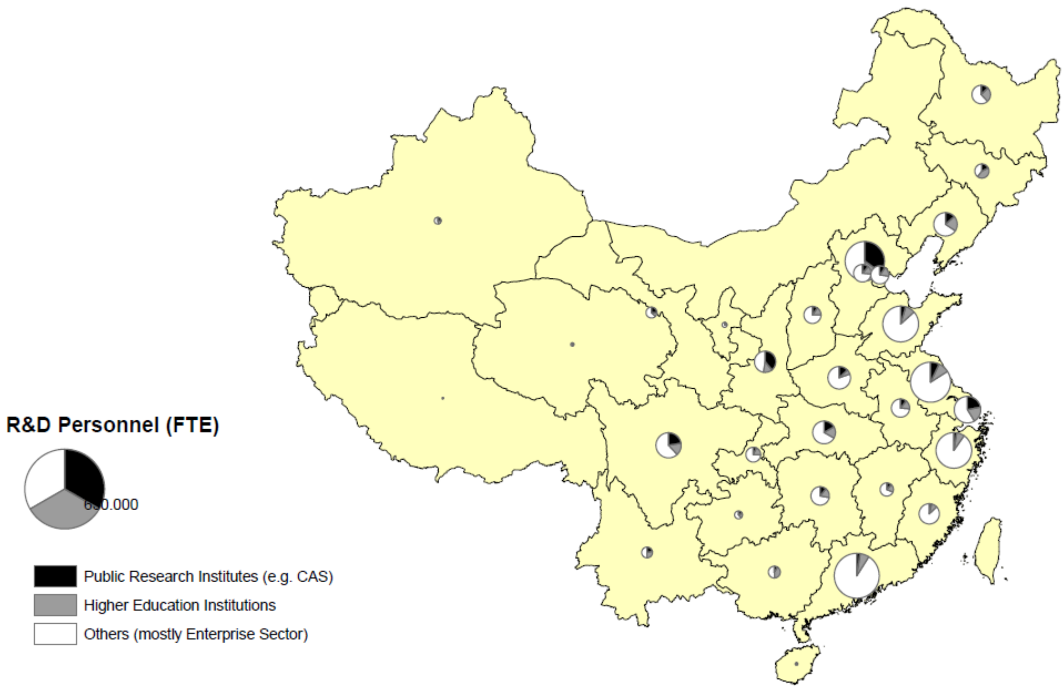
2 With the term "coastal provinces this report will in the following refer to the provinces on the coastline from Shandong to Guangdong. Hainan, Guangxi, Jilin and Liaoning, even though technically coastal, are not considered part of this group.

Figure 1: R&D Expenditures by Performing Actor (2008)



Source: Own map, based on China Statistical Yearbook on Science and Technology 2009

Figure 2: R&D Personnel by Type of Employing Organisation (2008)



Source: Own map, based on China Statistical Yearbook on Science and Technology 2009

Regional Distribution

Table 1 illustrates that the regional concentration of R&D Expenditure in China is not extraordinarily high. In fact, it is substantially lower than in the EU27, when considering the Member States as units of analysis. It is comparable to that of the EU15 and to that of Germany when considering the Länder as constitutive units. As in the European case, it clearly exceeds the degree of the concentration of the population.

Among the performers of R&D activities the degree of concentration is highest with regard to the expenditure of public research institutes, whilst it is lowest with regard to the expenditure of higher education institutions. Moreover, it seems noteworthy that the degree of R&D spending in private and foreign owned enterprises is more concentrated than that of state-owned firms. The pattern for employment in the R&D sectors follows the same differentiation by performers on an overall lower level of concentration.

With regard to the sources of funding, however, differences in concentration are less clear cut. Interestingly, government funding appears to be somewhat more concentrated than private funding, underlining the picture that much government spending on public research is concentrated on a number of selected regions, whereas private spending to a stronger degree follows the pattern of economic development along the coast. In most cases the patterns of funding and expenditure are relatively coherent with a slight tendency towards regional de-concentration with regard to funding (i.e. the government spends more on R&D outside Beijing than it actually performs there). The most obvious case in this respect is the province of Guangdong, where the share of publicly financed R&D clearly outranks the share of R&D which is publicly performed (even though both shares are quite low) (cf. also Figure 3).

Table 1: Degree of Regional Concentration of Expenditure on R&D and R&D Personnel

Field	Gini-Coefficient 2003	Gini-Coefficient 2008
Total Expenditure	0.567	**0.558 (POP: 0.357)**
EU 27 (Country Level)	0.745	**0.716 (POP: 0.599)**
EU 15 (Country Level)	0.579	**0.550 (POP: 0.527)**
Germany (Länder Level, 2007 for 2008)	0.573	**0.583 (POP: 0.459)**
By Performer		
Large and Medium-Sized Enterprises (BERD)	0.565	0.578
thereof State-Owned Enterprises	*n/a*	*0.469*
Public Research Organisations (GOVERD)	0.702	0.664
Higher Education Institutions (HERD)	0.548	0.512
By Source of Funding		
Government Funding	0.571	0.571
Self-Raised Funding by Enterprises	0.545	0.542
Credits from the Bank Sector	0.571	0.568
Total R&D Personnel	0.461	**0.498**
Large and Medium-Sized Enterprises	0.491	**0.538**
Public Research Organisations	0.563	**0.560**
Higher Education Institutions	0.416	**0.400**

Source: Own calculations based on China Statistical Yearbook 2009 on Science & Technology

Structure of Expenditure

A second possible perspective for analysis is to investigate the different purposes to which public R&D expenditure is allocated (cf. Figure 4). Typically, about 10% of R&D expenditure is dedicated to basic research. Notable exceptions with a higher share of basic R&D efforts are Guangdong, Shanghai, and Heilongjiang, i.e. three very different provinces which share a relatively low importance of experimental development as a second common trait. With regard to experimental development, however, this situation is not unique. The only province in which it makes up more than a half of overall expenditure is defence-driven Shaanxi. Furthermore, experimental development comes close to a 50% share in Sichuan, Hubei and Jiangsu. With a view on regional concentration Table 2 illustrates that expenditure on basic research and applied research is less concentrated than in experimental development. Likewise, it shows that the overall regional concentration of activities has visibly decreased during the last five years.

Based on the known diversity of the regional innovation systems that display similar characteristics with regard to the purpose to which R&D is allocated it appears questionable if the differentiation between applied research and experimental development can always be clearly drawn in practice. Nonetheless, it is a striking finding that the relative share of expenditure allocated to experimental development is reported to be quite low in the close-to-market regional economies of Guangdong, Zhejiang and Shanghai. Instead, it is high in the more government driven economies of the central provinces (see above).

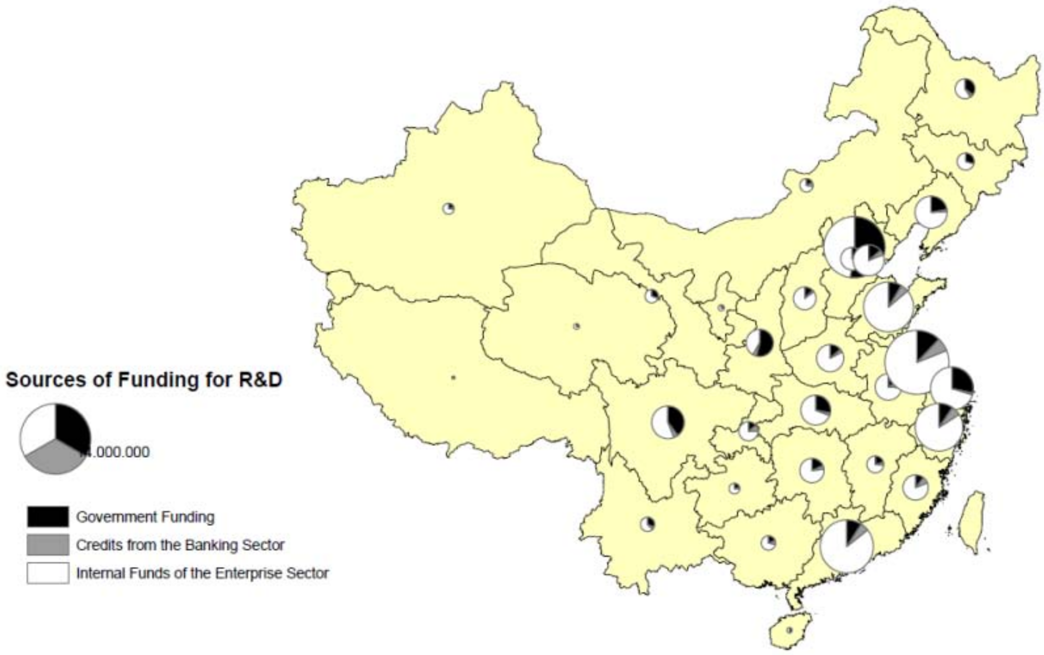
A possible conclusion from this pattern is that the public research system remains out of touch with the overall economic development so that a connection between the degree of application orientation in the public and the patterns of technological activity in the enterprise sector can neither be detected – nor expected. Instead, "experimental development" appears to mainly relate to R&D activities of publicly owned laboratories. Moreover, contrary to what general wisdom might suggest expenditure for basic research is regionally less concentrated than expenditure for research of the more applied type.

Table 2: Degree of Regional Concentration of Expenditure on R&D by Type of Research

Field	Gini-Coefficient 2003	Gini-Coefficient 2008
Basic Research	0.643	**0.576**
Applied Research	0.636	**0.580**
Experimental Development	0.692	**0.676**

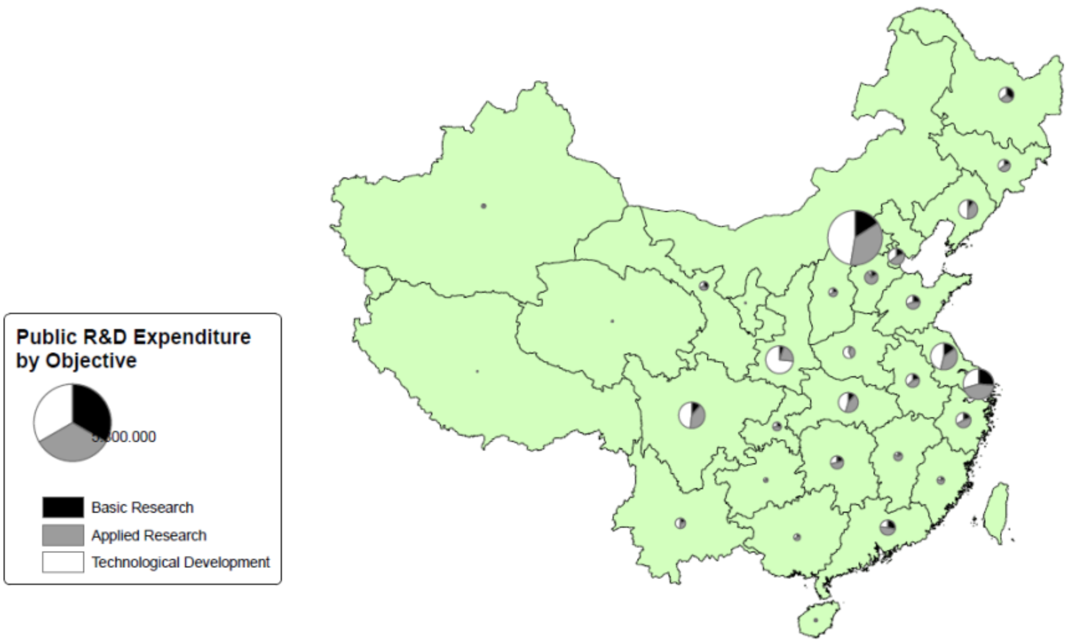
Source: Own calculations based on China Statistical Yearbook 2009 on Science & Technology

Figure 3: R&D by Source of Funding (2008)



Source: Own map, based on China Statistical Yearbook on S&T 2009

Figure 4: Public R&D Expenditure by Objective (2008)



Source: Own map, based on China Statistical Yearbook on S&T 2009

Relations between Funding and Performance

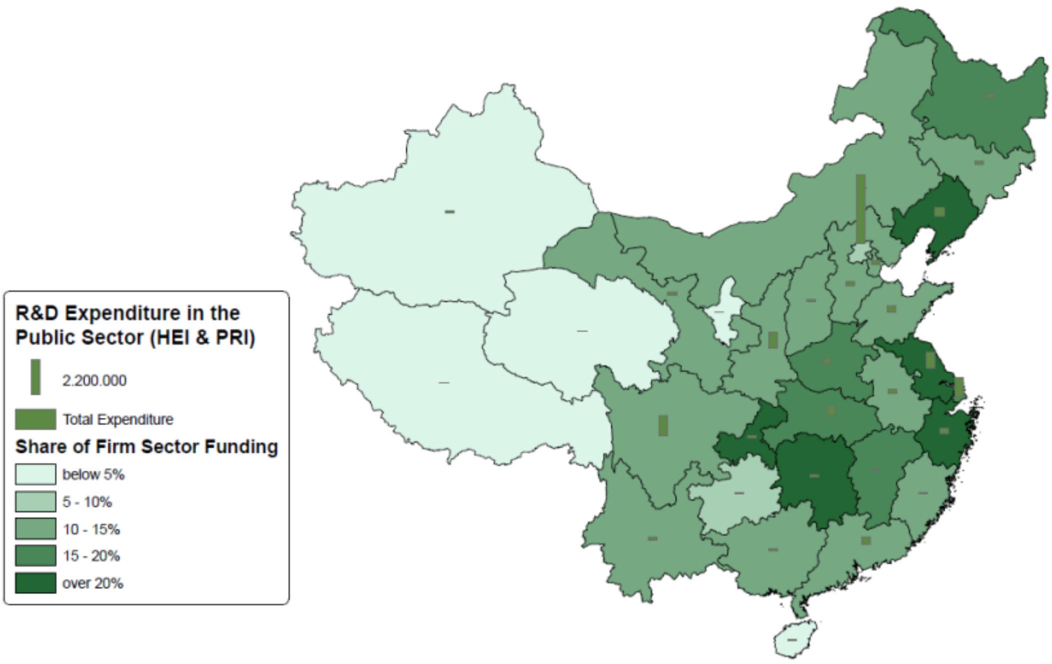
To further explore the above claim of the mutual isolation between the enterprise and the public research sector and to better understand the existing relations between them the following section will illustrate to what degree these sectors tend to finance R&D for the benefit of the respectively other sector (cf. Figure 6 and Figure 5).

Consequently, a first section will explore the degree to which public R&D is financed from the enterprise sector whereas a second will elaborate on the prevalence of public funding for R&D in the enterprise sector.

With regard to the first issue the findings clearly suggest that the Yangtze Delta is the region where contract research is most common – with enterprise funds constituting more than 20% of overall R&D funding in Zhejiang and Jiangsu and only slightly less in Shanghai. Neither in Guangdong nor in Beijing can any similar effect be observed. Among the regions with significant expenditures only Liaoning reaches a level similar to that common in the Yangtze Delta. That the central provinces with their defence related complexes only display a medium level of enterprise sector engagement does not come as a surprise. For both Beijing and Guangdong, in contrast, the findings testify to an absence of linkages that could in theory be established – and thus opportunities foregone. The preceding sections, however, illustrate that the conditions causing this bottleneck in both provinces need to be considered as quite different. Precisely therefore, however, it appears remarkable that they appear to have had the same detrimental effect – thus delimiting a corridor of desirable development for the coming years.

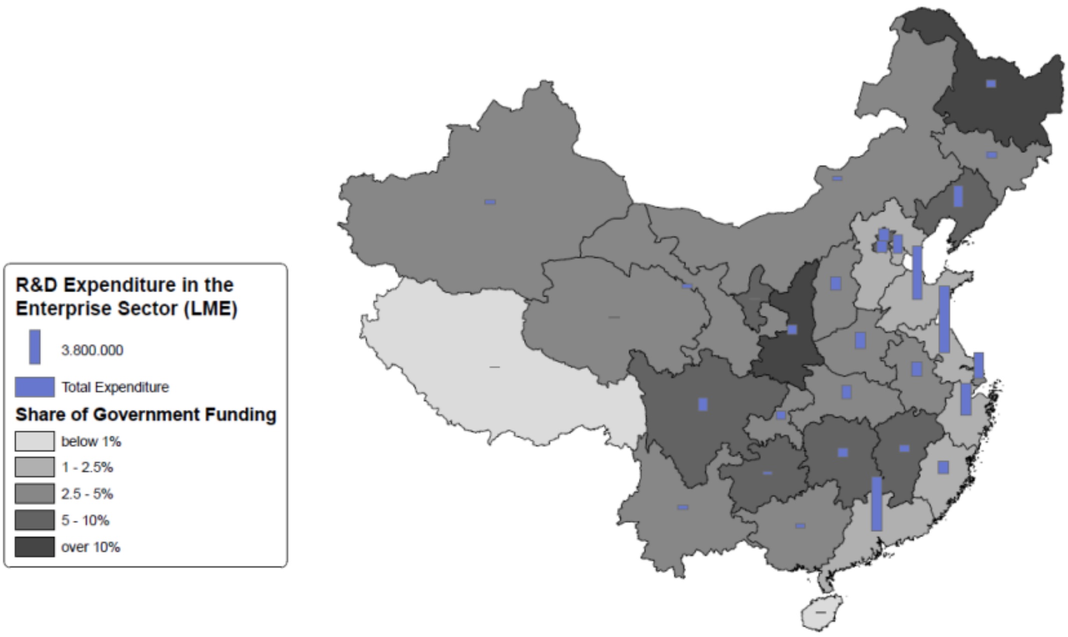
The second perspective (Figure 5) additionally illustrates that the role of the government sector in financing private research becomes less and less important with the rising degree of development of the province. Next to all coastal provinces display a very low share of state funding in R&D performed by enterprises. The main reason for this, of course, is the generally much higher extent of privately sourced expenditure in those regions, which has not been matched with a comparable amount of public funding. The only notable exceptions from this rule are Shanghai and, to a far higher extent, Beijing. Both thus stand in contrast to the general connection between high economic development and a low degree of public R&D funding. In the capital's regional research system over 10% of R&D expenditure in the firm sector is directly financed from public sources – a situation only otherwise found in Shaanxi and Sichuan, the central periphery (Guizhou, Hunan, Jiangxi) or the old industrial centres of the north-east.

Figure 5: R&D Expenditure of the Public Sector (2008)



Source: Own map, based on China Statistical Yearbook on S&T 2009

Figure 6: R&D Expenditure of the Enterprise Sector (2008)

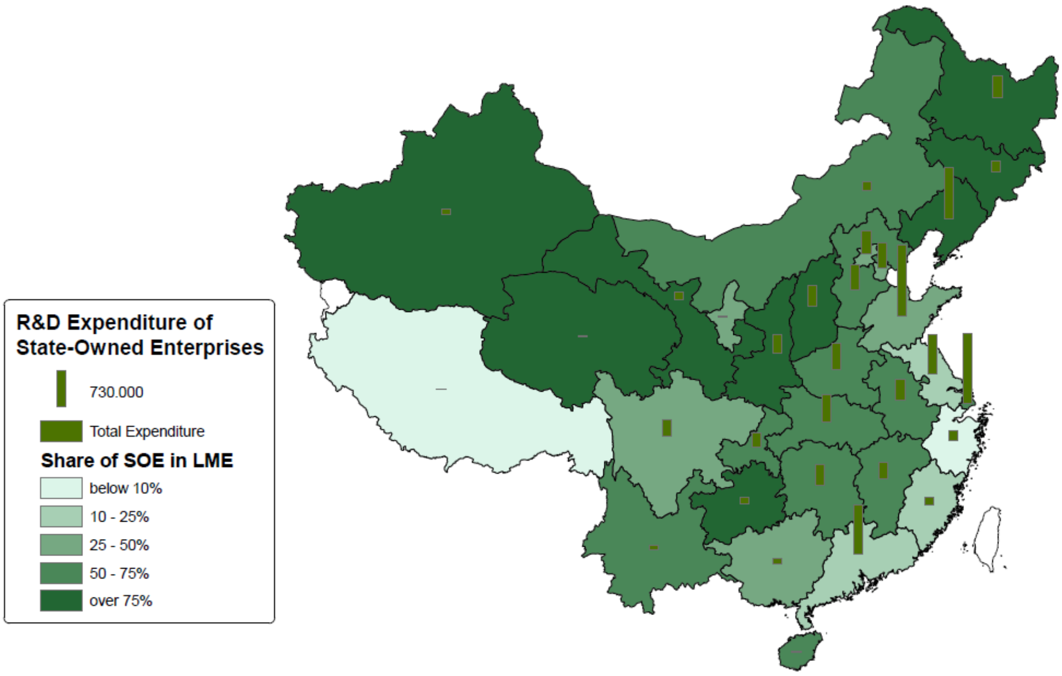


Source: Own map, based on China Statistical Yearbook on S&T 2009

A similar picture results with a view on the relative share that state-owned firms contribute to the overall R&D expenditure of the firm sector (cf. Figure 7). Unsurprisingly, this share is low in the coastal provinces, whereas it is high in Shaanxi, the old industrial centres of the north-east (Liaoning, Jilin, Heilongjiang) and the western periphery. Remarkably, however, Shanghai falls into the second highest class as well, whereas Beijing does not. While, apparently, Beijing is characterised by a high degree of government funding for R&D in the enterprise sector, Shanghai is characterised by a high share of R&D performed by state-owned enterprises. Whether these are to different models to the same effect constitutes an interesting follow-up question.

Finally Figure 8 illustrates the share of expenditure in Chinese-Foreign Joint Ventures that is spent on different types of technical activities. It shows that the absorption of external technology plays a decisive role in Beijing, Tianjin, Shanghai and Guangdong, whilst its importance outside these centres of economic and innovative activity remains comparatively low. To some extent, therefore, these findings can be interpreted as an indication that Beijing, Tianjin, Shanghai and Guangdong constitute the main points of entry of foreign technology to the Chinese market.

Figure 7: R&D Expenditures of State-Owned Enterprises (2008)



Source: Own map, based on China Statistical Yearbook on S&T 2009

Figure 8: R&D Expenditure of Foreign-Invested Joint-Ventures (2008)

Source: Own map, based on China Statistical Yearbook on S&T 2009

3 Scientific Output

Methodological Remarks

The scientific output of an innovation system can typically best be measured by means of publication analysis. The use of publications as an indicator in this respect, however, is subject to some limitations that have to be taken into account. Most importantly, the publications analysed have to have been published in peer-reviewed journals to avoid counting junk articles. In this respect, two major journal databases can be consulted: those of the Science Citation Index listed journals on Web of Science and the Scopus database provided by Elsevier. The regional part of this study is based on the Scopus database since it provides a broad coverage of journals beyond the natural sciences (on which the SCI concentrates) and it permits an easy and relatively straightforward regionalisation of the data.

In terms of measurement approaches, this study will concentrate its comments on the total number of publications (2005-2007). Additionally, it will take into account the specialisation of a region in a certain scientific field. Specialisation is represented by a well known relation: the share that a certain scientific field holds in overall scientific activities in a region in relation to the share that it holds on the global level[3].

$$\text{specialisation index} = [pub_{\text{field, region}}/pub_{\text{total, region}}]/[pub_{\text{field, international}}/pub_{\text{total, international}}]$$

Regional Distribution

A first general finding with regard to scientific activities in China is that, while following the general distribution of the population, they are relatively evenly distributed across the nation (cf. Figure 9). Overall, their degree of concentration is similar to that for total R&D expenditures. While the spread of academic activities across the country is somewhat higher than in Germany it is clearly lower than in the EU 27. As a tendency, the degree of concentration in China comes closest to that of the EU 15 (cf. Table 3). Contrary to the EU and Germany, however, it exceeds the corresponding degrees of concentration of the population and it has visibly decreased in the past five years.

Among scientific fields, the spread is highest for Arts-, Humanities and Social Sciences, Computer Sciences and Environmental Engineering and lowest for Physics and

3 The regional part of this study aims to benchmark the activities of scientific authors in China. The relevant point of reference, therefore, is the global scientific community. In most of the studied scientific fields a ‘national scientific community’ could not meaningfully be defined.

Mathematics, Life Sciences, and Chemistry. Overall, however, the field specific degrees of regional concentration do not differ much (Gini-Coefficients between 0.644 and 0.535). As will be shown later, it remains well below that of technological activities.

Table 3: Degree of Regional Concentration of Activities by Scientific Field

Field	Gini-Coefficient 2000-02	Gini-Coefficient 2005-07
Total	**0.604**	**0.557 (POP: 0.357)**
Arts, Humanities and Social Sciences	0.725	0.644
Computer Science	0.678	0.626
Environmental Engineering	0.625	0.578
Energy	0.613	0.572
Engineering and Materials	0.631	0.567
Physics, Mathematics and Earth Sciences	0.634	0.565
Life Sciences	0.627	0.551
Chemistry	0.556	0.535
EU 27 (Country Level, 2000, 2006)	0.680	**0.653 (POP: 0.599)**
EU 15 (Country Level, 2000, 2006)	0.547	**0.509 (POP: 0.527)**
Germany (Länder Level, excl. ST, 2000, 2005)	0.475	**0.451 (POP: 0.459)**

Source: Own analysis and calculations based on Elsevier Scopus

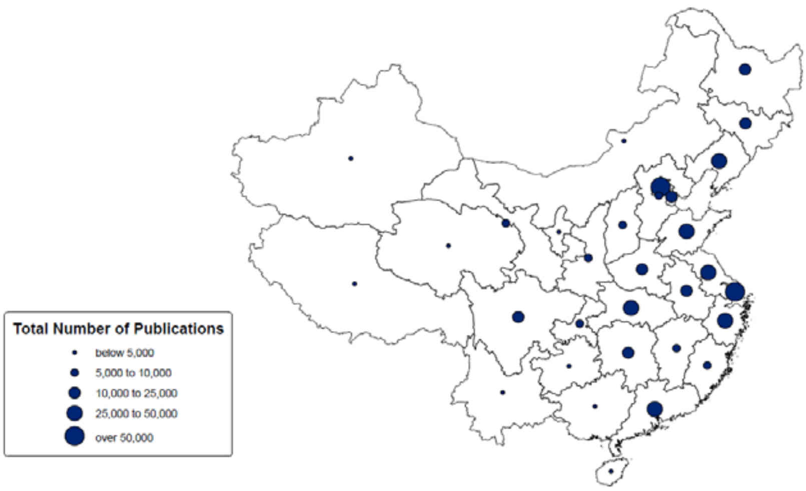
General Findings

A key general finding from the regional analysis of scientific publications is that, in global comparison, all Chinese regions display an above average specialisation on the natural sciences and engineering (Figure 9 to Figure 17). With regard to Physics and Mathematics specialisation is above average in all regions but Guangdong and Hainan. Likewise, an above average specialisation on Engineering and Materials Sciences is found in all provinces but those in the Far West, in many of them with specialisation indices above 2. The distribution of publications in the field of energy follows a similar pattern, except for the activities in the western provinces. Finally, publications in Chemistry play an above average role in all provinces but Hubei and Shaanxi. In line with the above findings, in contrast, the degree of specialisation in Computer Science and Environmental Engineering varies notably from province to province. While it is well above world average in some provinces, it remains clearly below in others. While activities in Computer Sciences are concentrated on the Eastern provinces, specialisations in Environmental Engineering can also be found in the west, although on a low absolute level.

Moreover, the degree of specialisation in Life Sciences remains below the worldwide average in most regions. Despite a significant amount of activities that in terms of the total number of publication match those in the fields of Engineering or Physics, the relative share of such publications in total publication activities cannot life up to world standards. Interestingly, a strong specialisation – and a significant amount of activities – can be found in the region of Yunnan where activities in next to all other fields are low.

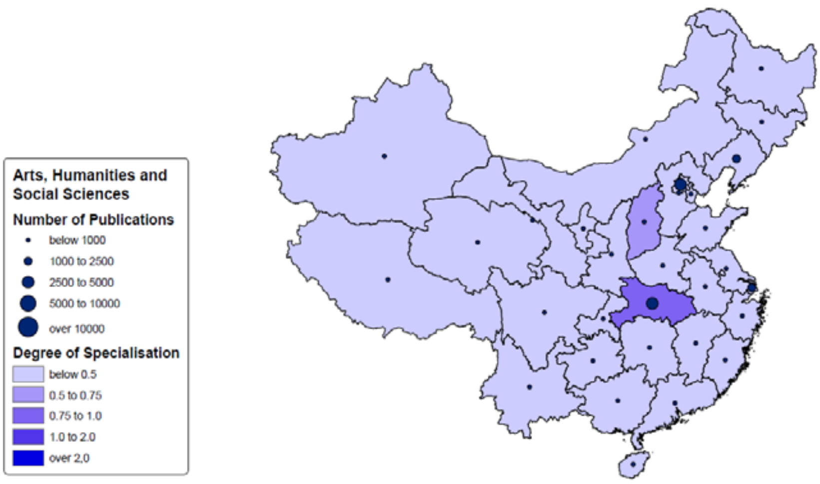
The relative importance of Arts, Humanities and Social Sciences, finally, remains far below average in all provinces but Hubei. While, partially, this can be explained by the fact that the Scopus database does not yet provide full coverage of Chinese journals in these fields a mere methodological explanation alone can no longer be regarded as sufficient to explain the degree of deviation observed.

Figure 9: Publications in China (2005-2007)



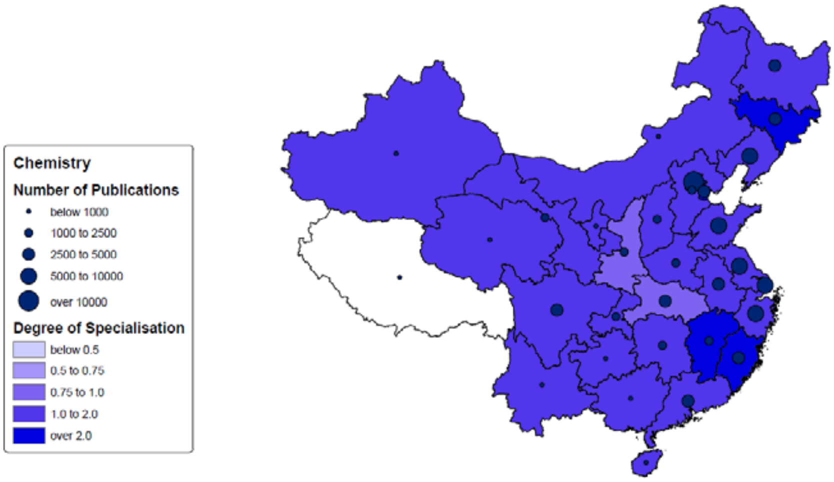
Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 10: Chinese Publications in Arts, Humanities and Social Sciences (2005-2007)



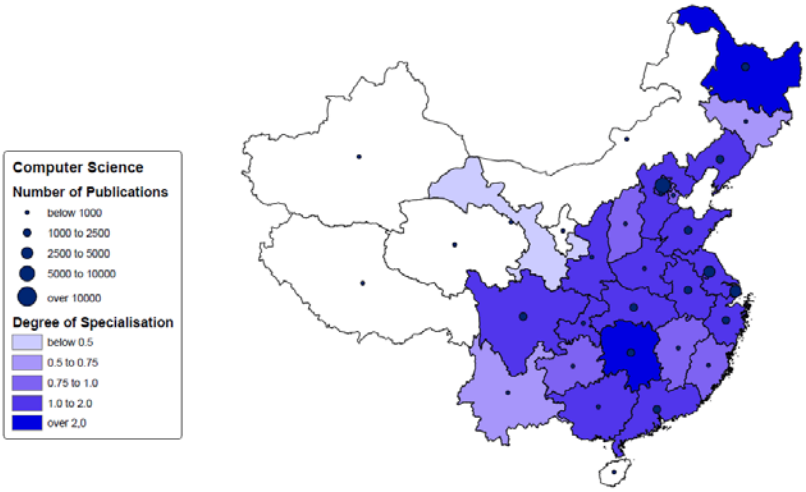
Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 11: Chinese Publications in Chemistry (2005-2007)



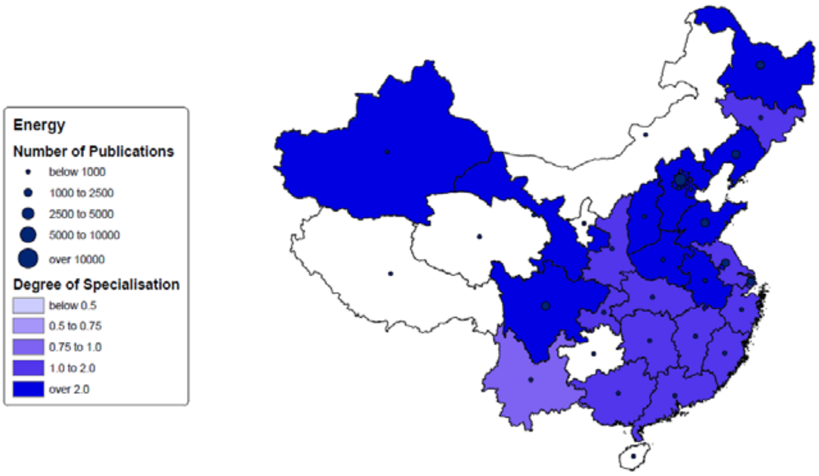
Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 12: Chinese Publications in Computer Sciences (2005-2007)



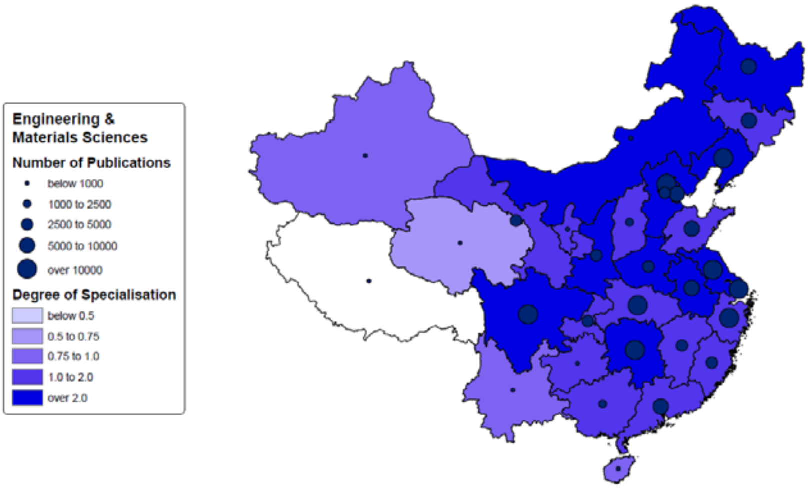
Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 13: Chinese Publications in Energy Sciences (2005-2007)



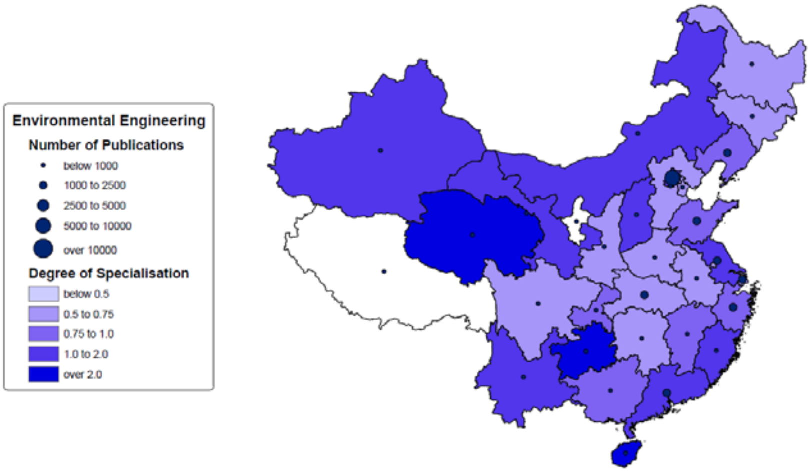
Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 14: Chinese Publications in Engineering & Material Sciences (2005-2007)



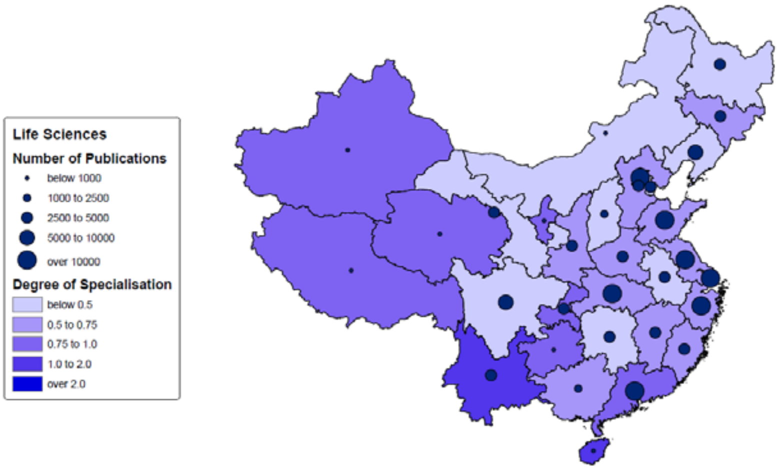
Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 15: Chinese Publications in Environmental Engineering (2005-2007)



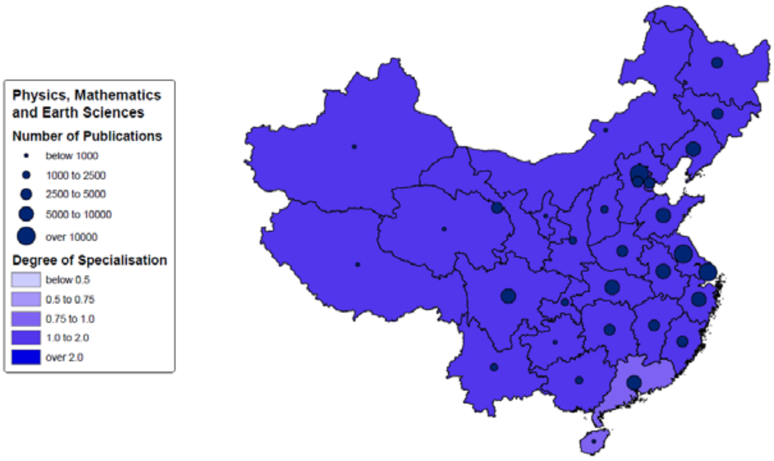
Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 16: Chinese Publications in Life Sciences (2005-2007)



Source: Own map, own calculations, based on Elsevier SCOPUS

Figure 17: Chinese Publications in Physics, Mathematics, and Earth Sciences (2005-2007)



Source: Own map, own calculations, based on Elsevier SCOPUS

4 Technological Output

Methodological Remarks

The technological output of an innovation system can typically best be measured by means of patent analysis. The use of patents as an indicator in this respect is subject to some limitations with regard to validity and reliability, a point that can in particular be made with a view on transforming economies. Nonetheless, the fact that a patent application stipulates both "a significant inventive step" and "applicability" makes it the ideal indicator for knowledge generation with economic relevance and recent analysis of the Chinese patent data have shown that many common concerns may in fact be unsubstantiated.

Similarly, the regionalisation of patent applications is not necessarily a straightforward procedure. Ideally, the home address of the inventor(s) should be used to localise a patent while avoiding that all patents of large companies are attributed to their headquarters. For Chinese patent data, however, inventor address data is not currently available. Consequently, patents have to be localised based on the known location of the applicant. Moreover, patents filed by individual persons, which currently amount to about 23.7 percent of Chinese applications, cannot be covered.

Conceptually, in this section, the issue of technological output will be addressed from two perspectives using two main measures. Those two perspectives relate to the patent office at which the patents are applied for. Naturally, most Chinese applicants will first apply for IPR protection on the national market (and in the specific Chinese case legally even have to do so). Additionally, however, it is relevant to see to what extent patent protection is looked for on global, such as the European, markets.

In terms of measurement approaches, this study will concentrate its comments on the total number of applications (2005-2007). Additionally, it will take into account the specialisation of a region in a certain technological field. Specialisation is represented by the well known location quotient relation the share that a certain technological field holds in overall applications in a region to the share that it holds on the national level[4].

$$\text{specialisation index} = [pat_{\text{field, region}}/pat_{\text{total, region}}]/[\ pat_{\text{field, national}}/pat_{\text{total, national}}]$$

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4 As the regional part of this study aims to compare the specialisation of Chinese applicants in a certain province in comparison to the overall activities of Chinese national, "national total" refers to the national total of Chinese applications. Moreover, a calculation of specialisations based on a comparison with the structure of all transnational applications would result in only slightly different pattern.

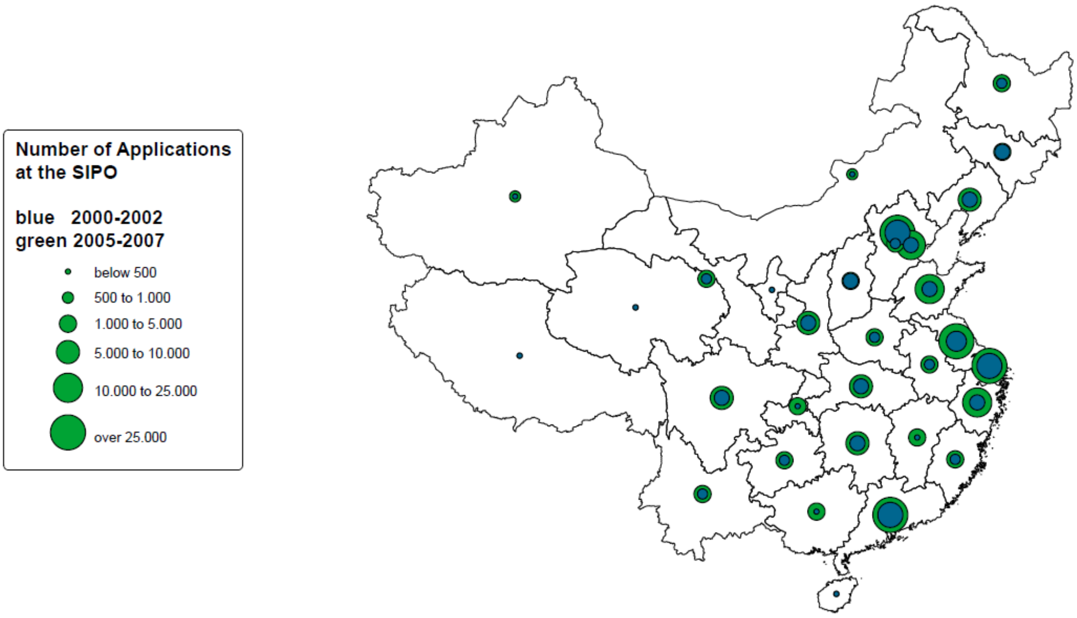
General Findings

Unsurprisingly, Figure 18 illustrates that most patent applications at the national office originate from the three main economic centres of China: the Greater Bohai Region, the Greater Yangtze Delta, and Guangdong province. The only province in the coastal belt that features a surprisingly small number of applications is Fujian. Former laggards such as Shandong, Tianjin and Zhejiang have substantially caught up in the course of the last 5 years. Despite this visible activity on the coastline, however, applicants from the central provinces and the north-eastern belt are far from inactive. Leaders among this second tier are Sichuan, Shaanxi, Hubei and Hunan even though growth has not been as impressive as in the coastal areas. Remarkably, some of the formerly nearly inactive regions such as Guangxi, Jiangxi, and Chongqing have caught up with the middle field. A true absence of technological activity is today thus limited to the periphery of Ningxia, Qinghai, Tibet, Inner Mongolia, Hainan, and Xinjiang. In conclusion, it appears that although technological activities have somewhat expanded in the second tier regions, they are not substantially less concentrated today than they were five years ago. The Gini Coefficient is 0.673 for both periods.

With regard to applications at the European Patent Office (EPO), in contrast, the picture is somewhat different (cf. Figure 20). Technological activities, the results of which are seen as meriting IPR protection on the European market, are far more concentrated on the countries three economic engines: Beijing/Tianjin, the Greater Yangtze Delta and Guangdong province. Effectively, 90% of EPO applications filed by Chinese applicants originate from these three regions. During the last five years, growth was most evident in the Greater Yangtze Delta and Guangdong province, whilst the number of applications from Beijing and Tianjin remained more or less stable. Overall the concentration of activities has increased as evidenced in the Gini coefficient rising from 0.782 for 2000-02 to 0.849 for 2005-07. A second point worth noting is that the relation of patents applied for at the European office to those applied for at the Chinese national office is highest in the southern regions with their more world-market-oriented economies (Zhejiang, Fujian, Guangdong, Jiangxi) – irrespective of the overall extent of regional patenting. Some other cases in point are the international cities of Beijing, Shanghai and, interestingly, Chongqing.

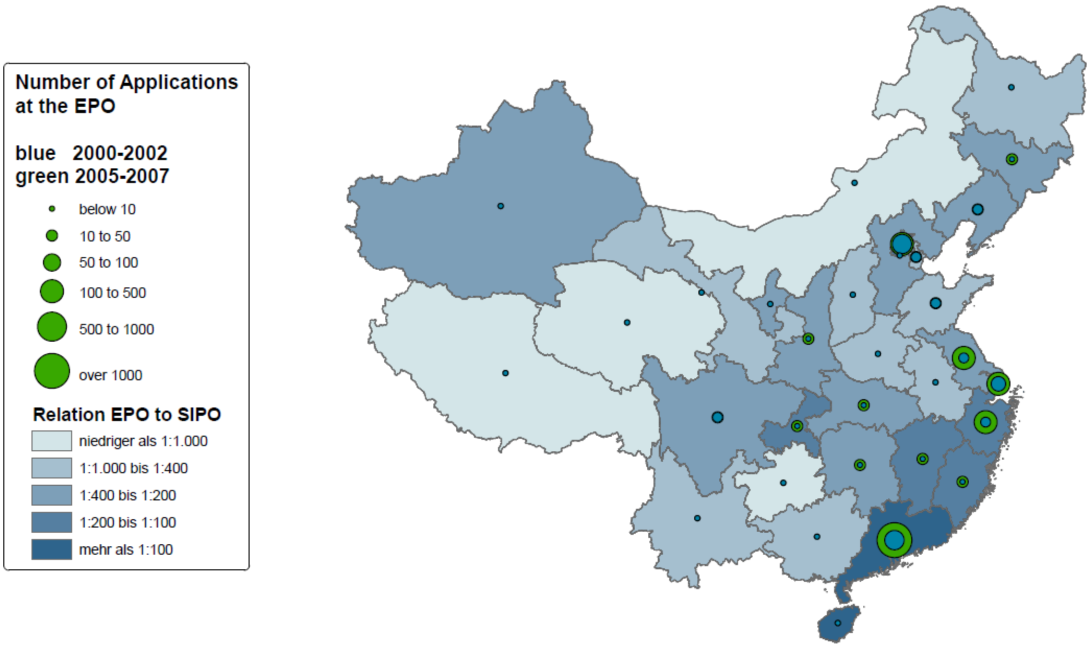
The pattern of patent intensity, i.e. patent applications per inhabitant does on average follow the distribution of overall activities so that it is not commented on separately here. The only exception from the general logic is Liaoning were the patent intensity is somewhat higher than could be expected based on the overall extent of activities.

Figure 18: Chinese SIPO Patent Applications (2000-2002 and 2005-2007)



Source: Own map, based on EPO Worldwide Patent Statistical Database (PATSTAT)

Figure 19: Chinese EPO Patent Applications (2000-2002 and 2005-2007)



Source: Own map, based on EPO Worldwide Patent Statistical Database (PATSTAT)

Specialisation by Technological Field

Currently, most of the high-tech activities remain strongly concentrated on the three key areas, i.e. Beijing/Tianjin, the Greater Yangtze Delta and Guangdong province. The technological specialisation profiles of the leading provinces (Beijing, Guangdong, Shanghai, Zhejiang, Jiangsu, Shandong) are displayed in detail in Figure 20 to Figure 25.

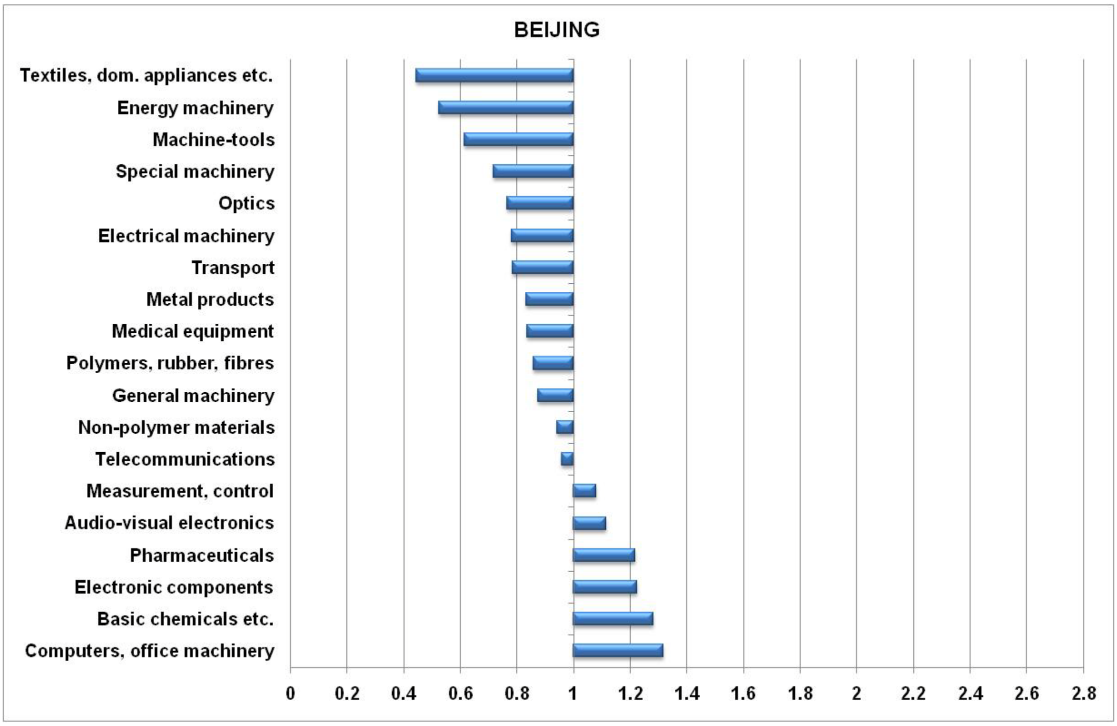
A detailed analysis of Chinese patent applications by technological field reveals the following key patterns: On the one hand, the regional pattern of activities in most fields tends to follow the overall regional distribution of patent applications, i.e. the general centre-periphery structure of China. Few fields do substantially deviate from this (cf. FigureAnnex 2 to FigureAnnex 18). On the other hand, the degree of concentration of activities differs quite substantially (cf. Table 4).

Table 4: Degree of Regional Concentration of Activities by Technological Field

Field	Gini-Coefficient		
	EU Reference	**2000-2002**	**2005-2007**
Total	**0.775**	**0.673**	**0.673**
Telecommunications	0.752	0.848	0.874
Audio-visual electronics	0.756	0.776	0.826
Computers, office machinery	0.768	0.779	0.805
Optics	0.781	0.766	0.766
Electronic components	0.791	0.756	0.752
Electrical machinery, apparatus, energy	0.809	0.673	0.698
Measurement, control	0.797	0.672	0.663
Medical equipment	0.758	0.681	0.658
Polymers, rubber, man-made fibres	0.775	0.707	0.654
General machinery	0.778	0.682	0.651
Energy machinery	0.827	0.738	0.646
MICROBIOLOGY, GENETICS		0.855	0.635
Transport	0.834	0.608	0.631
BIOTECHNOLOGY		0.827	0.627
Basic chemicals, paints, soaps, petroleum products	0.786	0.651	0.625
Metal products	0.801	0.867	0.625
Textiles, clothes, dom. appliances, wood, paper, furniture, food	0.767	0.585	0.613
Machine-tools	0.833	0.641	0.601
Special machinery	0.791	0.530	0.600
Pharmaceuticals	0.750	0.759	0.588
Non-polymer materials	0.793	0.606	0.571
EU 27 (Country Level)			**0.801**
EU 15 (Country Level)			**0.664**
Germany (Länder Level)			**0.642**

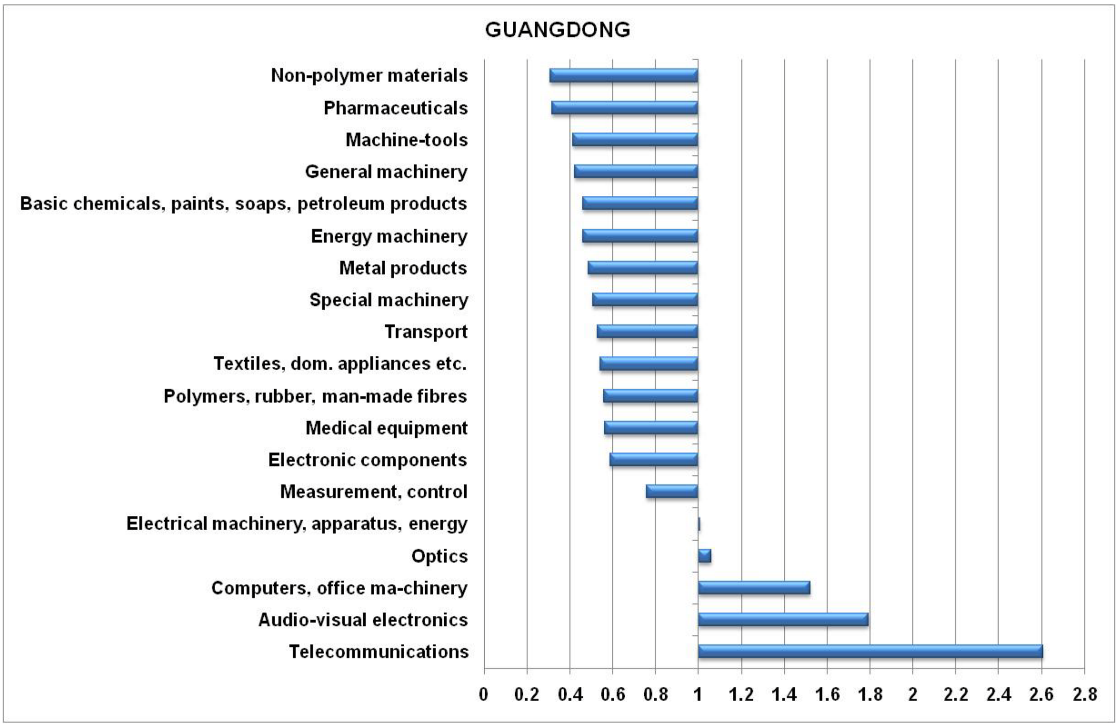
Source: Own analysis and calculations based on EPO Worldwide Patent Statistical Database (PATSTAT)

Figure 20: Technological Specialisations in Selected Regions in Comparison (Beijing)



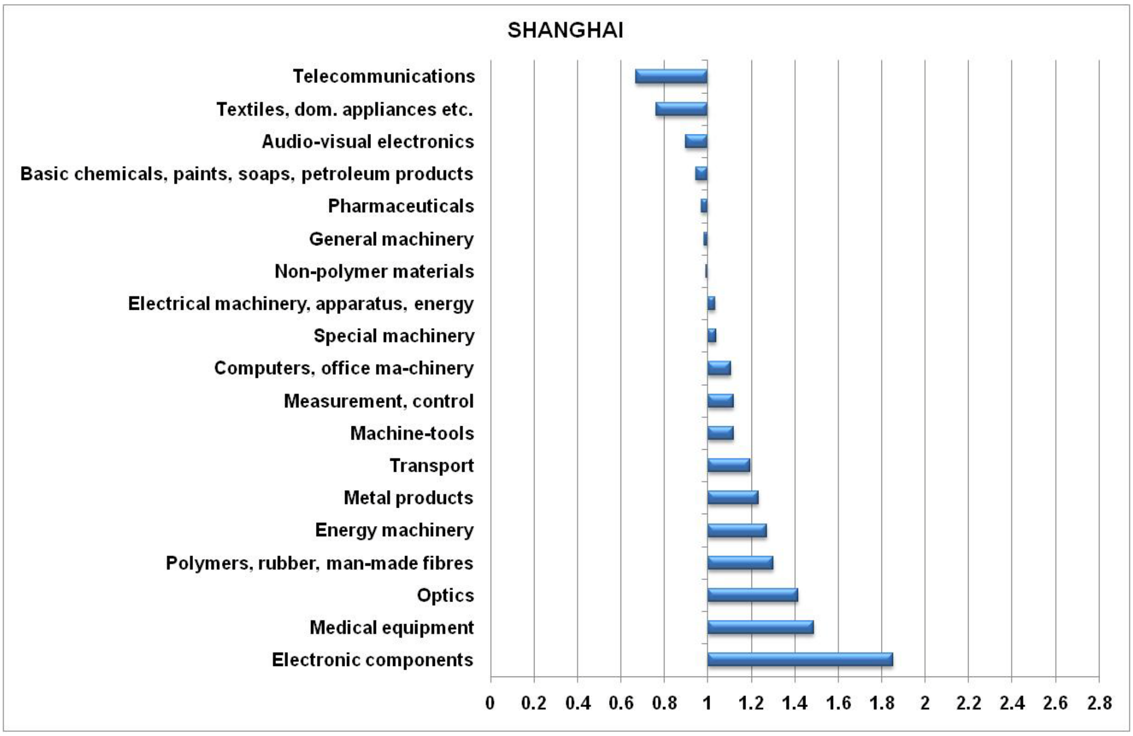
Source: Own figure, based on own calculations, based on EPO PATSTAT.

Figure 21: Technological Specialisations in Selected Regions in Comparison (Guangdong)



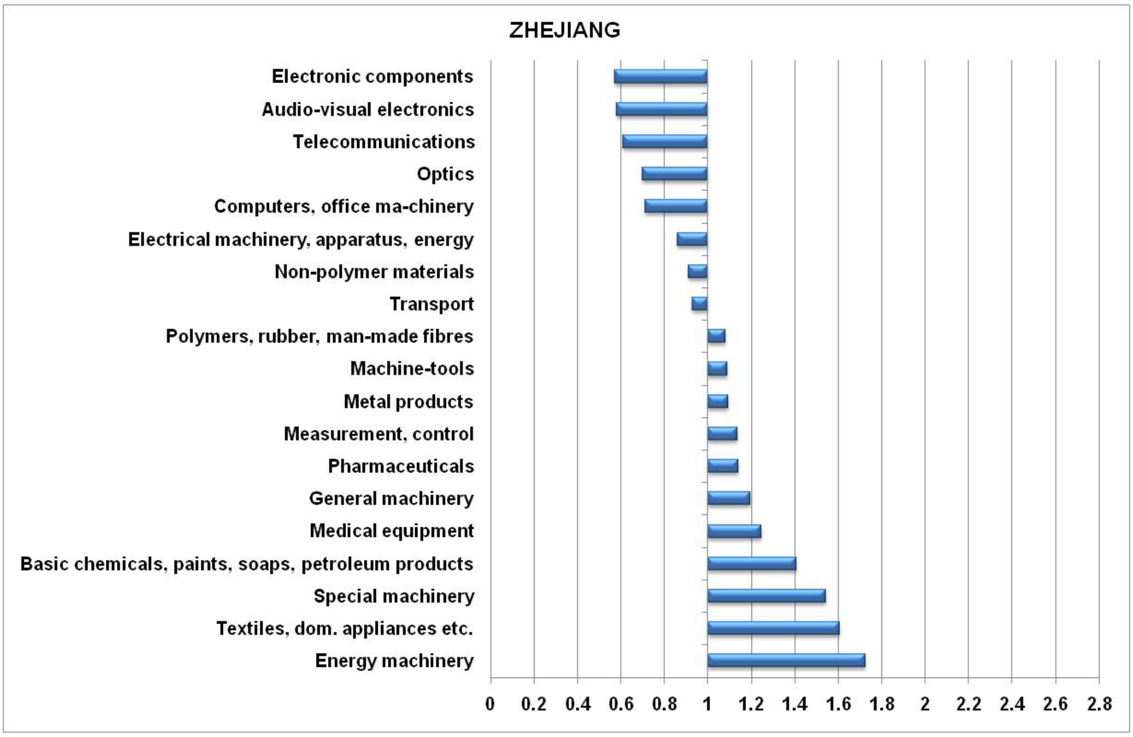
Source: Own figure, based on own calculations, based on EPO PATSTAT.

Figure 22: Technological Specialisations in Selected Regions in Comparison (Shanghai)



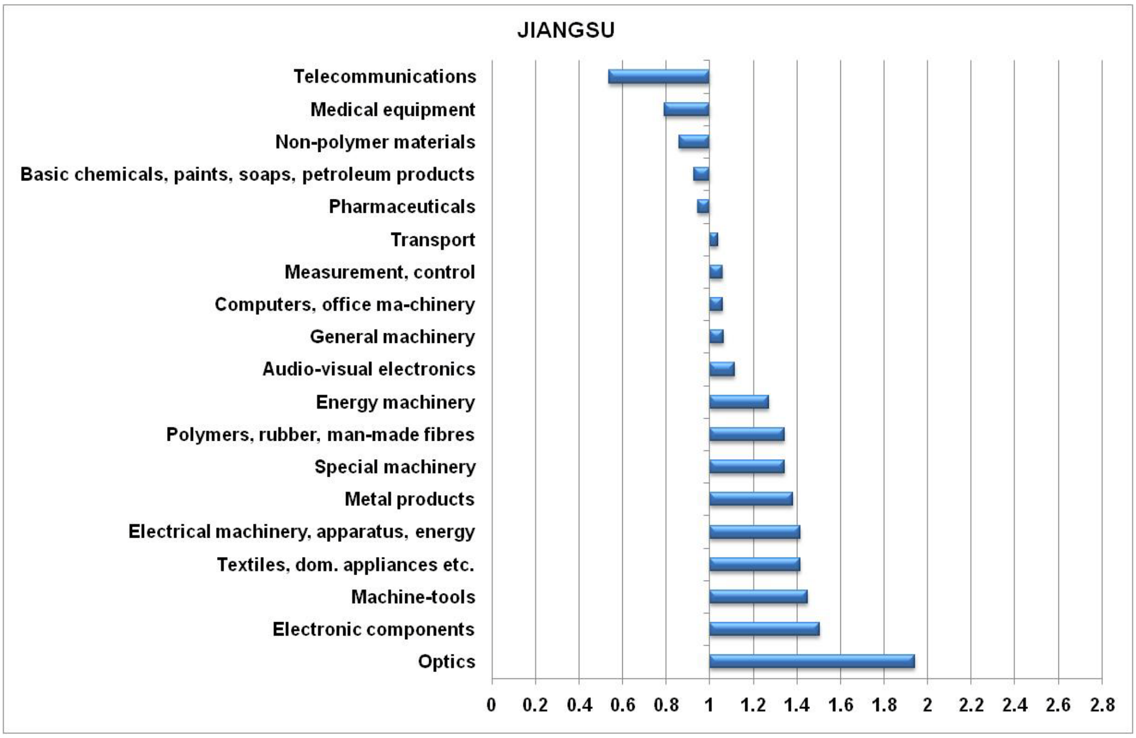
Source: Own figure, based on own calculations, based on EPO PATSTAT.

Figure 23: Technological Specialisations in Selected Regions in Comparison (Zhejiang)



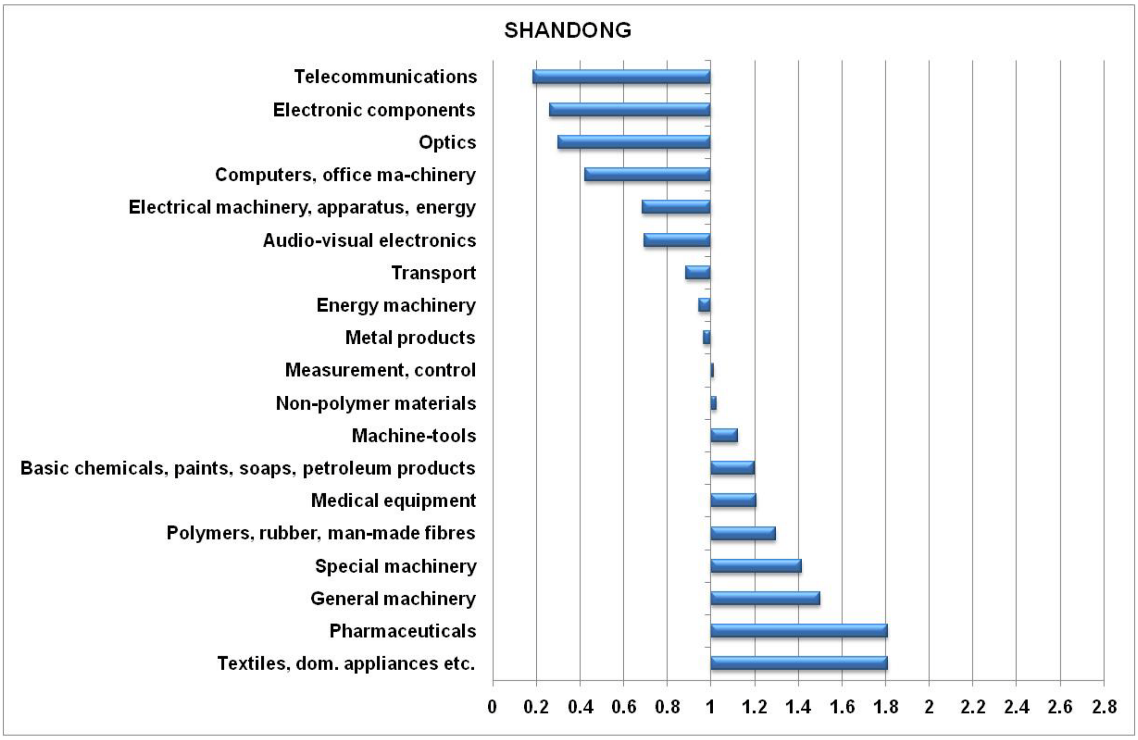
Source: Own figure, based on own calculations, based on EPO PATSTAT.

Figure 24: Technological Specialisations in Selected Regions in Comparison (Jiangsu)



Source: Own figure, based on own calculations, based on EPO PATSTAT.

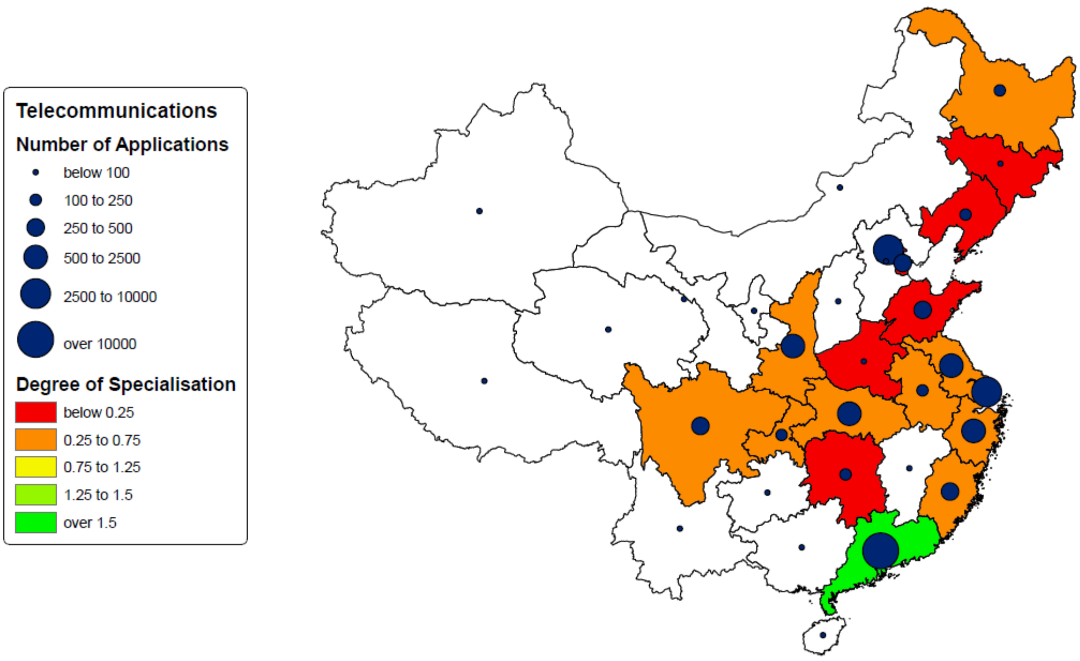
Figure 25: Technological Specialisations in Selected Regions in Comparison (Shandong)



Source: Own figure, based on own calculations, based on EPO PATSTAT.

In some technological fields, a high level of activities can also be detected in Hubei and Shaanxi due to the clustering of strong technical universities in Xi'an and Wuhan (cf. e.g. Figure 26). Guangdong's strong specialisation and outstanding national role in the fields of 'Telecommunication', 'Audio-visual electronics', and 'Computers' (cf. e.g. Figure 26) gives evidence of the activities of large firms such as Huawei and ZTE/ZhongXing, although, with regard to SIPO applications, it cannot be explained by them alone. The prominent focus on this one province is also the reason why the overall degree of regional concentration is highest in these three fields. Non-high-tech activities, in contrast, are distributed more evenly across the country, even though, in many of them, the degree of specialisation differs from province to province. The central and north-eastern provinces, for example, are in many cases specialised and relatively active in various forms of mechanical engineering, including transport technologies. The western provinces, in contrast, tend to concentrate their limited activities on the chemical and pharmaceutical industry. Finally, most provinces are to some degree engaged in activities subsumed under the remaining category 'Textiles, wearing, leather, wood, paper, domestic appliances, furniture, and food'. While the fact that many provinces appear "specialised" in this field is mostly due to the sheer breath of this category, it still conveys an important message with regard to the overall regional distribution of low-tech patent application in China. In the past five years the overall pattern of specialisation has not changed drastically. Nonetheless, certain shifts are clearly visible in next to all fields and in many of the provinces (cf. FigureAnnex 1).

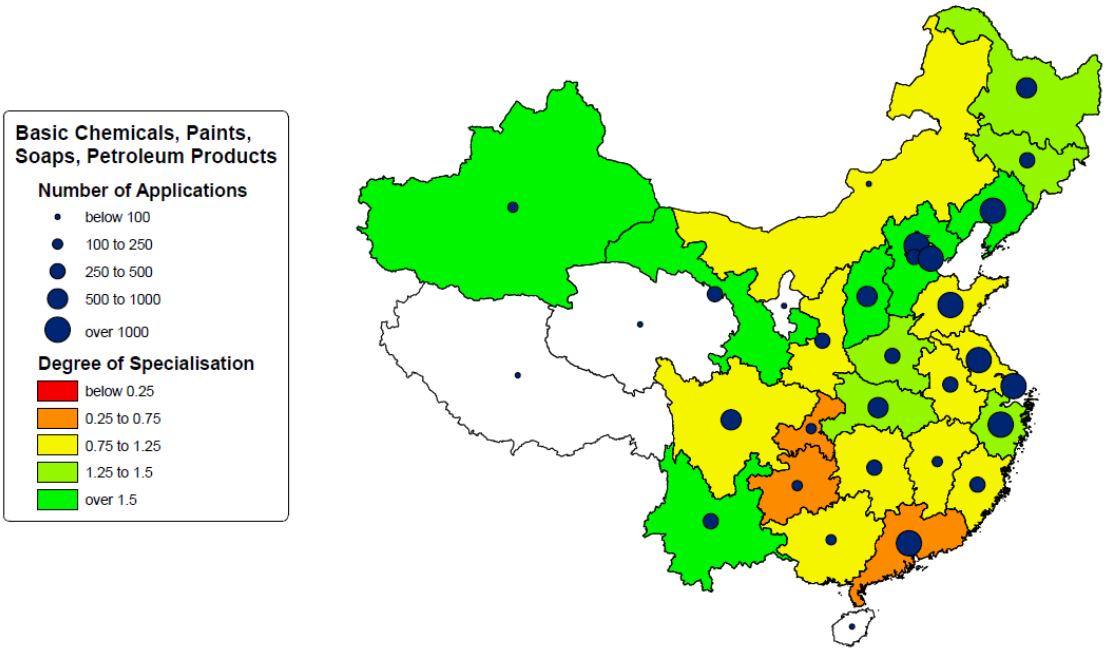
Figure 26: SIPO Patent Applications in Telecommunications



Source: Own map, own calculations, based on EPO Worldwide Statistical Database

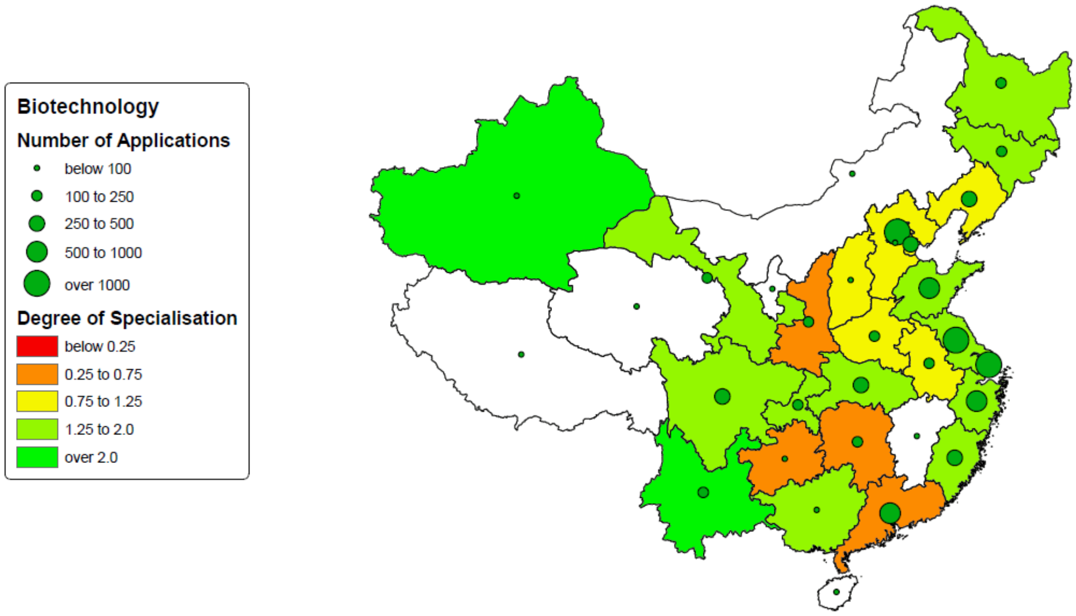
The following paragraph will describe the regional pattern of technological specialisation in some more detail for two technological fields: biotechnology and microbiology/genetics. Expectably, the absolute amount of activities in these as in many other fields is concentrated according to the general centre-periphery structure of China. The centres of activities are thus to be found in the Greater Bohai Area, the Greater Yangtze Delta and Guangdong. While this pattern is relatively clear cut with regard to microbiology/genetics it is somewhat less pronounced for biotechnology in general where significant activities can be detected in next to all coastal provinces. In both fields, moreover, significant activities can be detected in Hubei and Sichuan, whereas more technically oriented regions such as Shaanxi do not feature prominently. Instead, regions like Yunnan or even Xinjiang that typically, beyond a certain account in chemistry (cf. Figure 27), do not display a lot of activities at all show a high relative specialisation irrespective whether they are measured by the broad (biotechnology) or the narrow (microbiology/genetics) concept (cf. Figure 28 and Figure 29).

Figure 27: SIPO Patent Applications in Basic Chemicals, Paints, Soaps, Petroleum Prod.



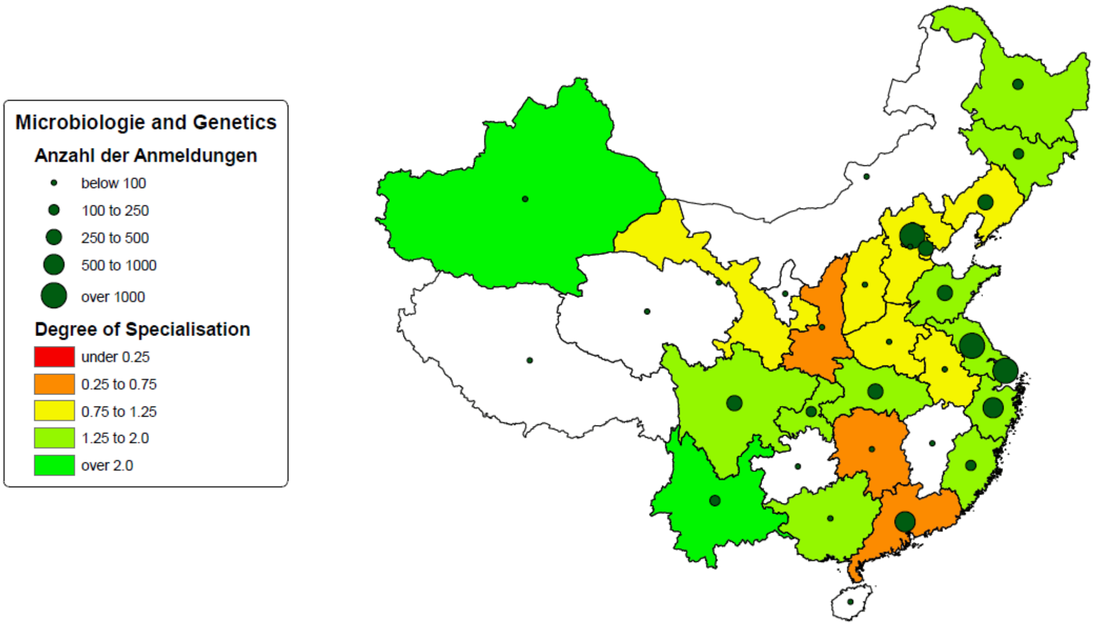
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

Figure 28: SIPO Patent Applications in Biotechnology



Source: Own map, own calculations, based on EPO Worldwide Statistical Database

Figure 29: SIPO Patent Applications in Microbiology and Genetics



Source: Own map, own calculations, based on EPO Worldwide Statistical Database

Considerations on the Productivity of R&D in China

Figure 30 to Figure 32 illustrate that it is not a straightforward task to draw conclusions about the degree of efficiency of research & development activities in China. As little is known about the actual degree of inter-connectedness of activities on a regional level and there is a large amount of anecdotal evidence on cross-regional science-industry co-operations all "productivity-related" considerations have to be treated with a high degree of caution. Nonetheless, a cautious attempt in this direction will be undertaken in the following section.

With regard to "scientific productivity" (Figure 31), the results mostly illustrate the distribution of public and private activities. The coastal provinces where activities of the private sector raise R&D expenditures but not publications, "productivity" is low. In Beijing, the central regions of Hubei and Gansu as well as the north-eastern provinces of Jilin and Heilongjiang the share of public sector activities translating into publications is higher and forms the basis for a higher "scientific productivity".

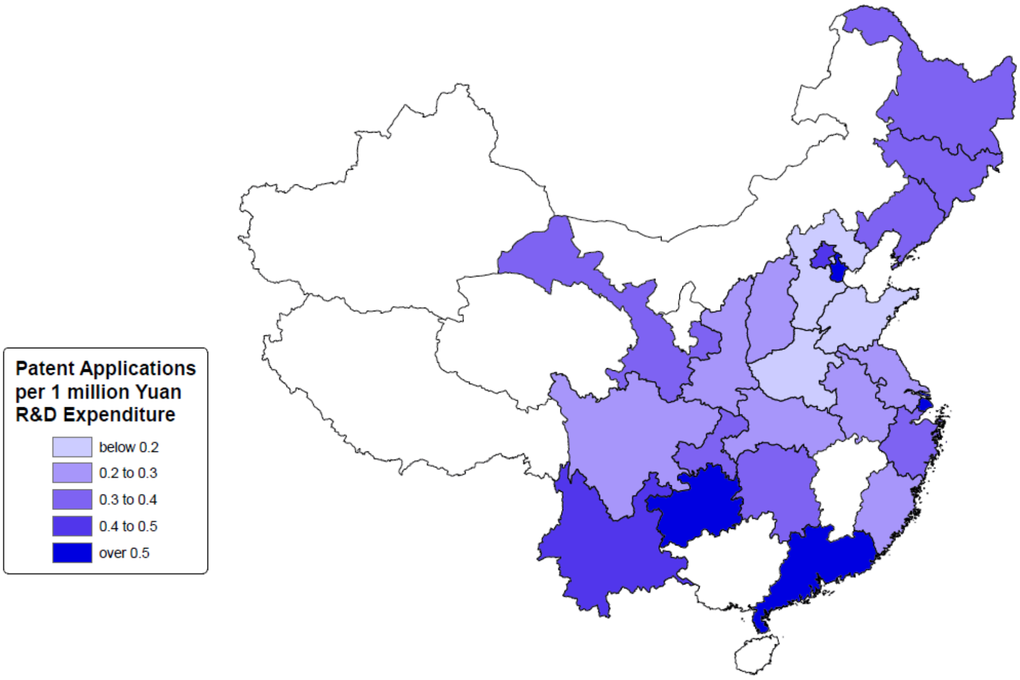
With regard to "patent productivity" (Figure 30) the urban centres of Beijing, Tianjin, Shanghai and Guangdong stick out as places where a lot of R&D activities finally translate into patent applications (the case of Guizhou can be attributed to an overall low level of input). Those likely candidates are followed by Zhejiang province as well as by the traditional industrial centres of the north-east and some of the central regions. This highly diverse group suggests that a number of different reasons can lie under high values in "patent productivity". That the defence-oriented centres of Shaanxi and Sichuan do not feature prominently conforms to expectations. Noteworthy, in contrast, remains the "low-productivity" situation in the core of the broader Bohai Region: Hebei and Shandong.

Finally, one can attempt to juxtapose publications and patent applications to try to assess the regional degree of science-industry interactions or at least the potential for such endeavours. In most fields, this relation is, as a tendency, highest in the coastal provinces where the number of patent applications is highest (cf. Figure 32).

For IT/Computer Science, the by far highest relation is found in Guangdong. A secondary relative centre exists in Shaanxi and Ningxia.

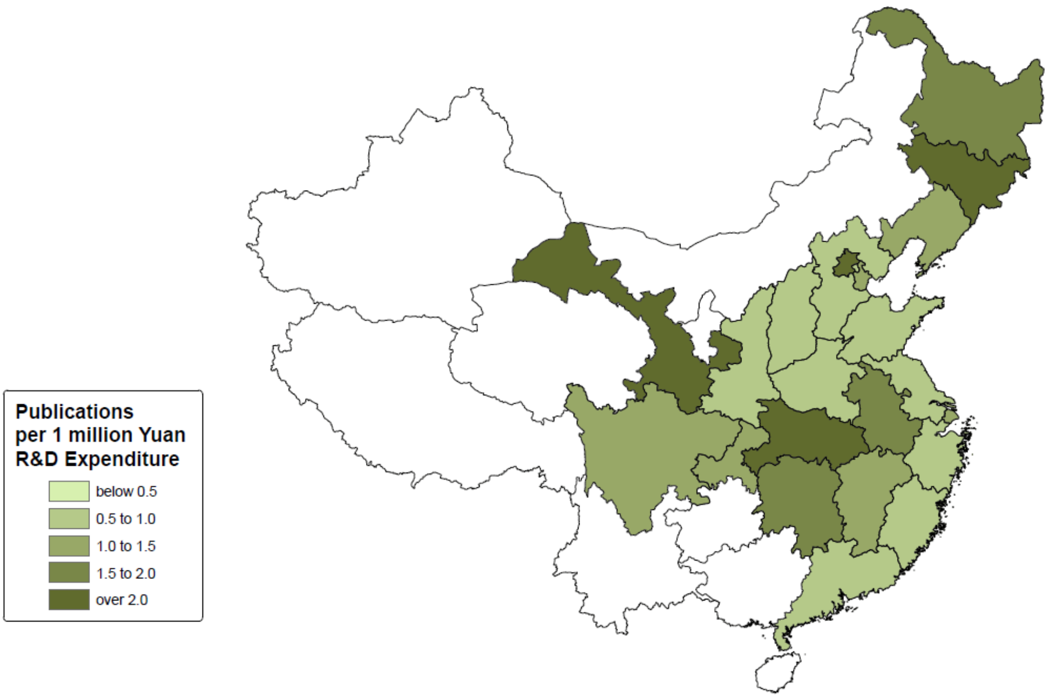
Like IT/Computer Science, the pattern for Biotech/Life Sciences shows high relations in the coastal provinces, even though, in this case, the highest relation is found in Tianjin. Moreover, a higher number of central regions display relations similar to that of the coastal provinces.

Figure 30: Patent Applications per R&D Expenditure



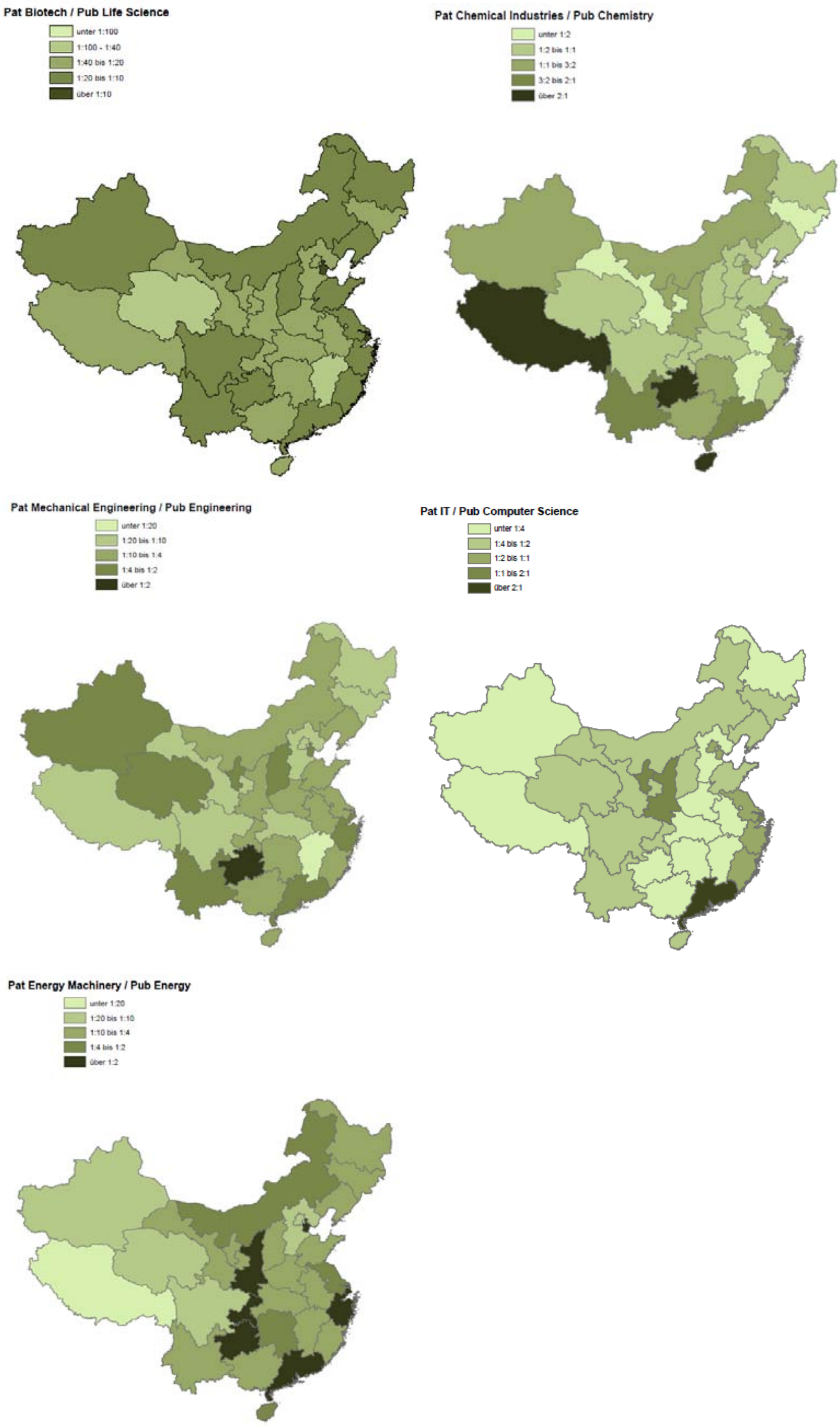
Source: Own map, based on China Statistical Yearbook on S&T 2009 and EPO PATSTAT

Figure 31: Publications per R&D Expenditure



Source: Own map, based on China Statistical Yearbook on S&T 2009 and Elsevier SCOPUS

Figure 32: Field Specific Relations between Patents and Publications



Source: Own maps, own calculations, based on EPO PATSTAT and Elsevier SCOPUS

With regard to Mechanical Engineering, activities are quite evenly distributed across the country. Apart from the statistical artefact of Guizhou, no region stands out as particularly prominent. According to expectations, a lower level of emphasis is found in Tianjin, Shanghai, Zhejiang and Guangdong but also in some central areas.

With regard to Energy Machinery, the pattern is comparatively similar with an even clearer focus on Tianjin, Shanghai, Zhejiang and Guangdong. Other provinces that stand out are Shaanxi, Chongqing and (at a low absolute level) Guizhou.

Finally, with regard to the Chemical Industries, relations are no more concentrated than with regard to Mechanical Engineering. As a statistical artefact, relations are highest in the peripheral regions of Guizhou, Hainan and Tibet. Despite of this, among the regions with significant activities the patterns correspond to general wisdom. The Greater Yangtze River Delta as well as Guangdong stand out as regions with both a high number of patent applications and a high number of publications.

In summary, the juxtaposition of patent applications and publication activities does not yield an overly clear picture. Those patterns that we find among the provinces with a significant scope of activities, however, conform to expectations. The analysis demonstrates that the relation of patent applications to publications is highest in those regions which are known to possess the most functional regional innovation system in a certain field (e.g. Yangtze River Delta in IT and Chemical Industries). This is not to say, of course, that these innovation systems do not leave ample room for improvement (as suggested by past OECD reports in 2008 and, more recently, 2010).

Moreover, the very high relation of patents to publications in some and the high relations of publications to patents in many other cases suggest that many regional innovation systems remain highly unbalanced (e.g. the ratio of IT patents to IT-related publications reaches over 2:1 in Guangdong, whereas even among the most patent active regions in Europe it is uncommon that the regional number of patent applications exceeds the number of regional publications).

5 Export Performance

General Findings

As a final perspective this section of the report will analyse the regional distribution of export activities in China. While a regional co-location of scientific centres and centres of export is not necessarily expectable a certain regional overlap between technological strengths and technology based export performance can be expected – if the export performance of an economy is based on its technological capabilities.

In spatial terms, export performance is the most concentrated of all activities analysed in this section of the report. Moreover, the export of technology-related[5] products (e.g. electronic products) is even more regionally concentrated than that of other non-technology products (e.g. toys or fabrics) (cf. Table 5).

Among the technology-related products (HS 30, HS 84-90) pharmaceutical products are the only successfully exported from a larger number of provinces, both coastal and inland (cf. also Figure 33). Likewise, the exports in the field of vehicles (cf. also Figure 37) are regionally somewhat more distributed than on national average. In both fields, however, China is a net importer and the existing national exports do not make a substantial contribution to the overall total.

Table 5: Degree of Regional Concentration of Export Activities by Selected HS Classes

Field	2005	2009
Total	0.7532	0.7560
HS 30 – Pharmaceutical products	0.6902	0.7258
HS 84 – Nuclear reactors; boilers; machinery and mechanical appliances; parts thereof	0.8496	0.8224
HS 85 – Electrical machinery and equipment and parts thereof; sound recorders and reproducers; television image recorders and reproducers; and parts and accessories of such articles	0.8467	0.8391
HS 86 – Railway or tramway locomotives; rolling-stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical traffic signalling equipment of all kinds	0.8046	0.7403
HS 87 – Vehicles other than railway or tramway rolling-stock; and parts and accessories thereof	0.7237	0.6810

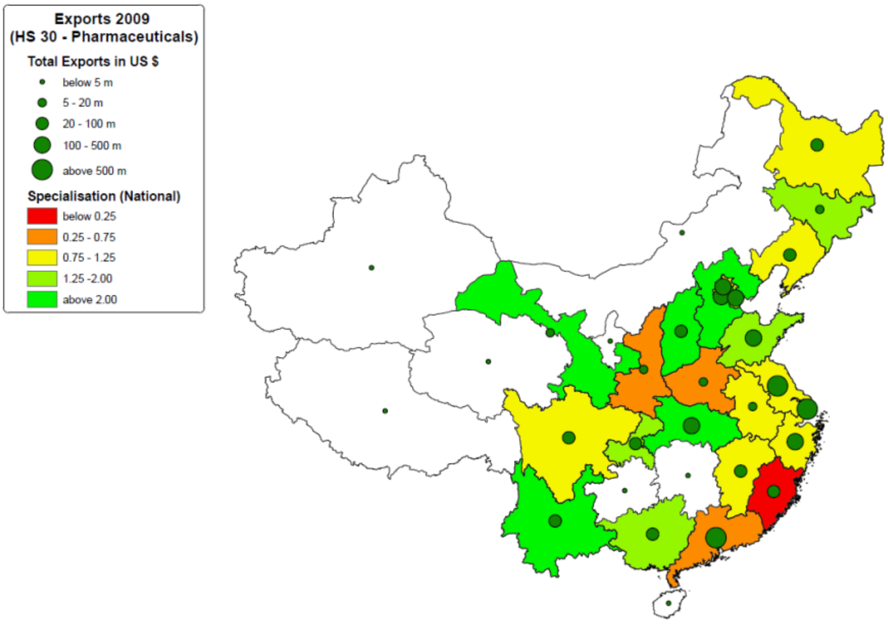
5 As from mere trade figures it is not directly possible to conclude on the actual amount of domestic technology content (exports could be based on mere assembly and re-export, cf. OECD, 2010), we speak of technology-related, rather than technology products.

Field	2005	2009
HS 88 – Aircraft; spacecraft; and parts thereof	0.8648	0.7143
HS 89 – Ships; boats and floating structures	0.7981	0.8355
HS 90 – Optical; photographic; cinematographic; measuring; checking; precision; medical or surgical instruments and apparatus; parts and accessories thereof	0.8633	0.8349
Other Goods and Services		

Source: Own Calculations, based on China Customs Statistics

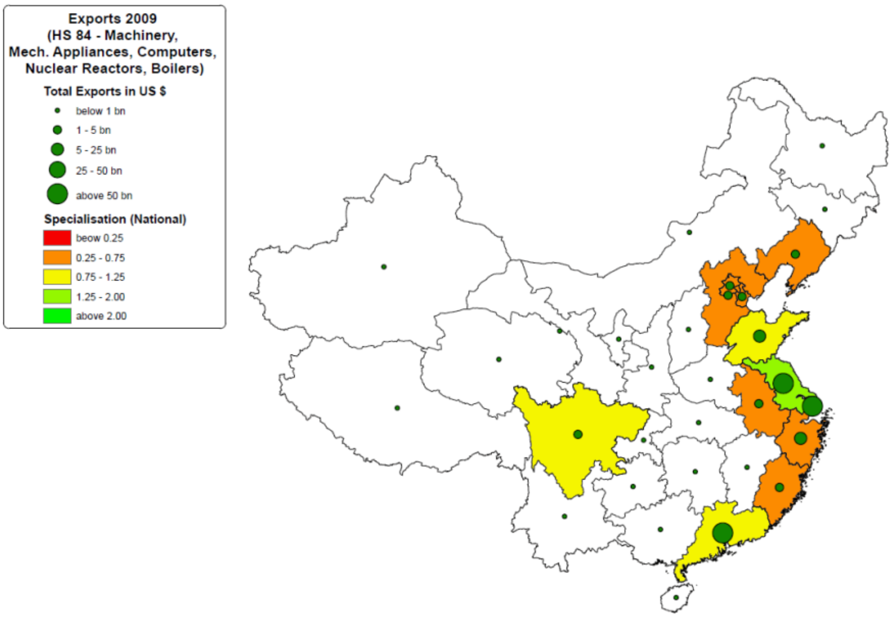
In those technology-related fields that contribute significantly to overall exports and in which China is a substantial net exporter (HS 84 – Machinery and HS 85 – Electronics) the regional distribution is far more uneven than on national average (Table 5). With regard to machinery (HS 84) the strongest focus is on the Yangtze River Delta with regard to electric machinery and electronics (HS 85), the strongest focus is on Guangdong (cf. Figure 34 and Figure 35).

Figure 33: Exports of Pharmaceuticals (HS 30)



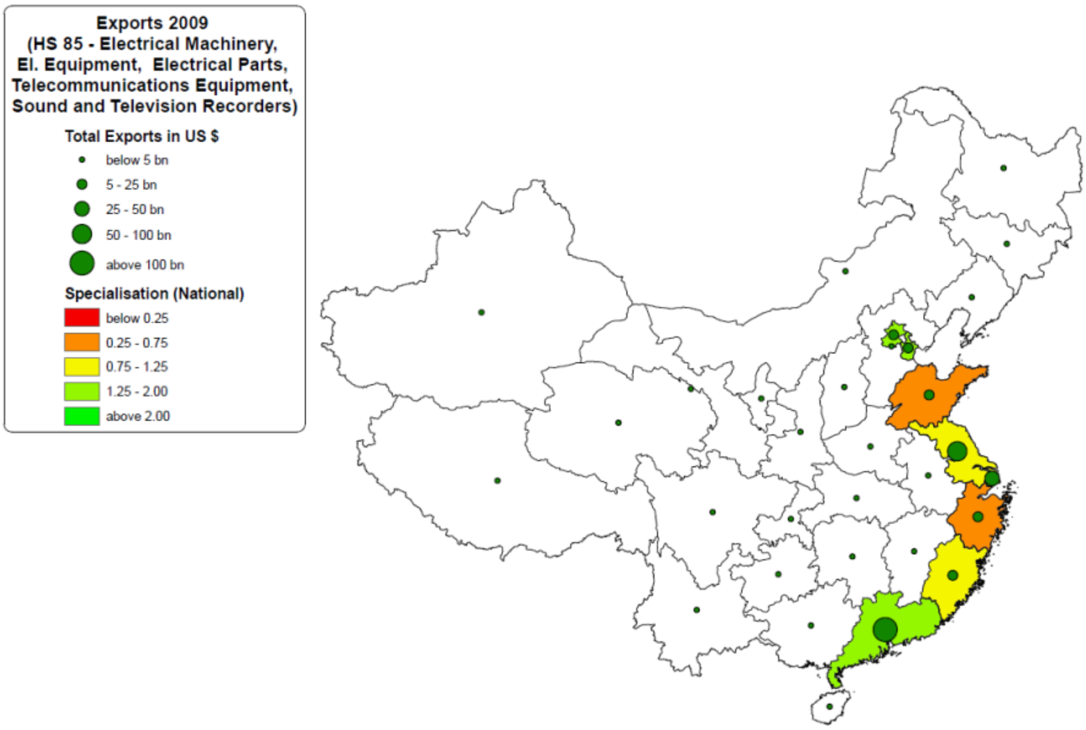
Source: Own map, own calculations, based on China Customs Statistics

Figure 34: Exports of Machinery and Computers (HS 84)



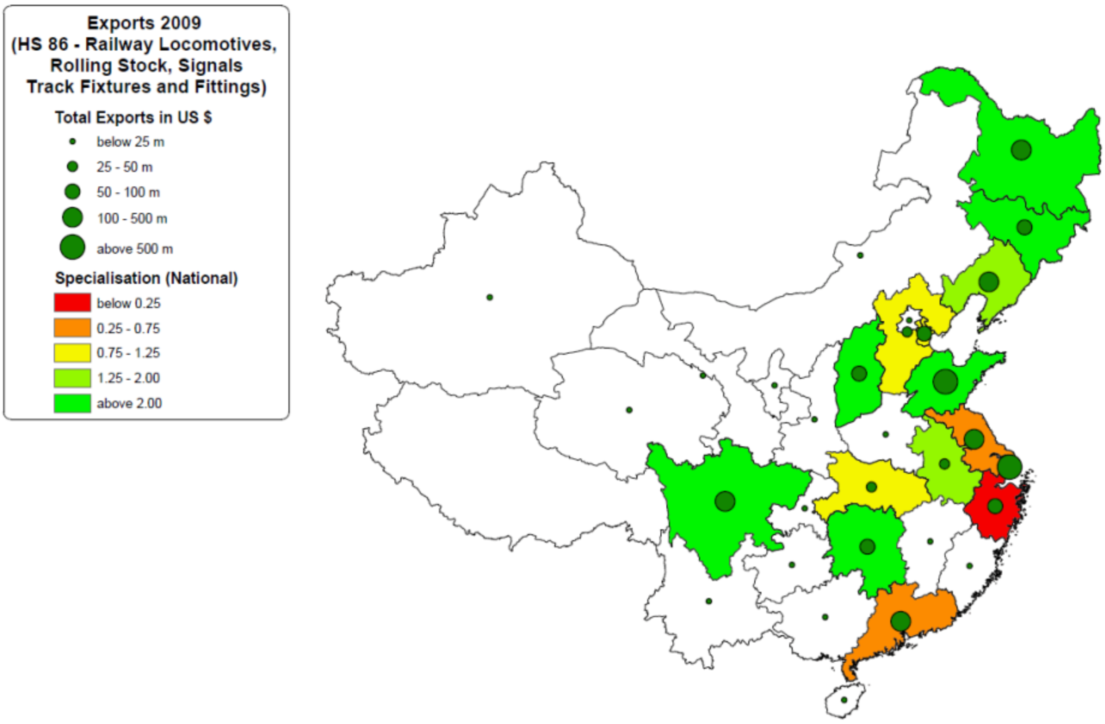
Source: Own map, own calculations, based on China Customs Statistics

Figure 35: Exports of Electrical Machinery and Communications (HS 85)



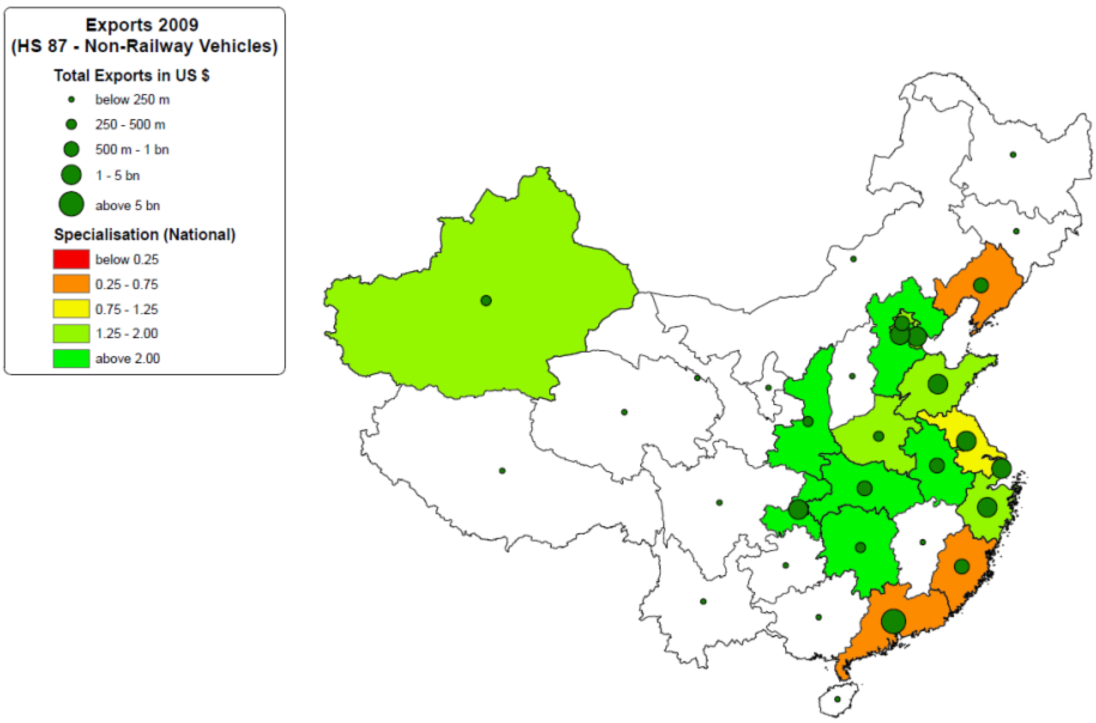
Source: Own map, own calculations, based on China Customs Statistics

Figure 36: Exports of Railways and Related Products (HS 86)



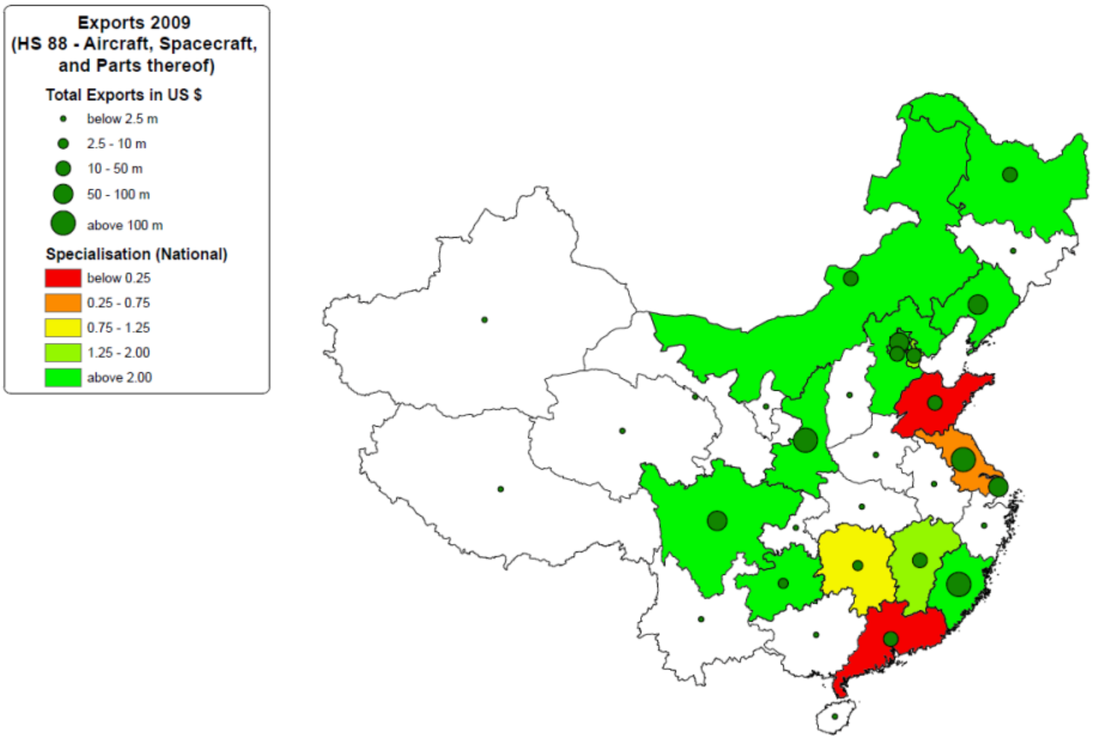
Source: Own map, own calculations, based on China Customs Statistics

Figure 37:Exports of Vehicles and Related Products (HS 87)



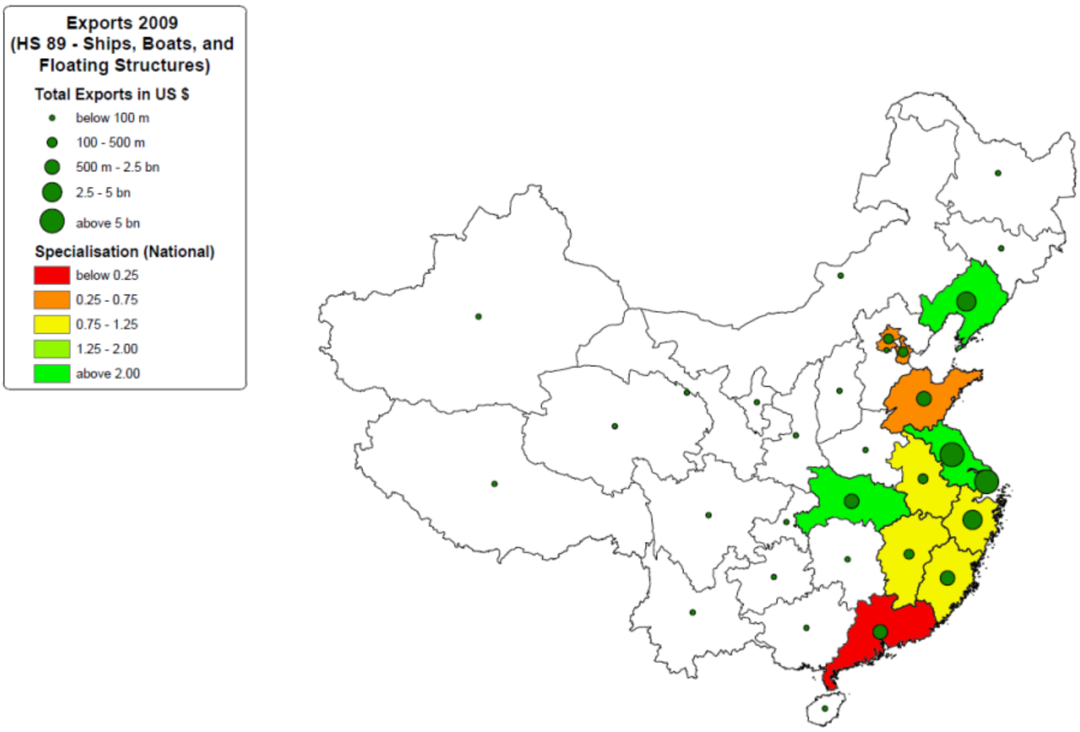
Source: Own map, own calculations, based on China Customs Statistics

Figure 38: Exports of Aircraft and Related Products (HS 88)



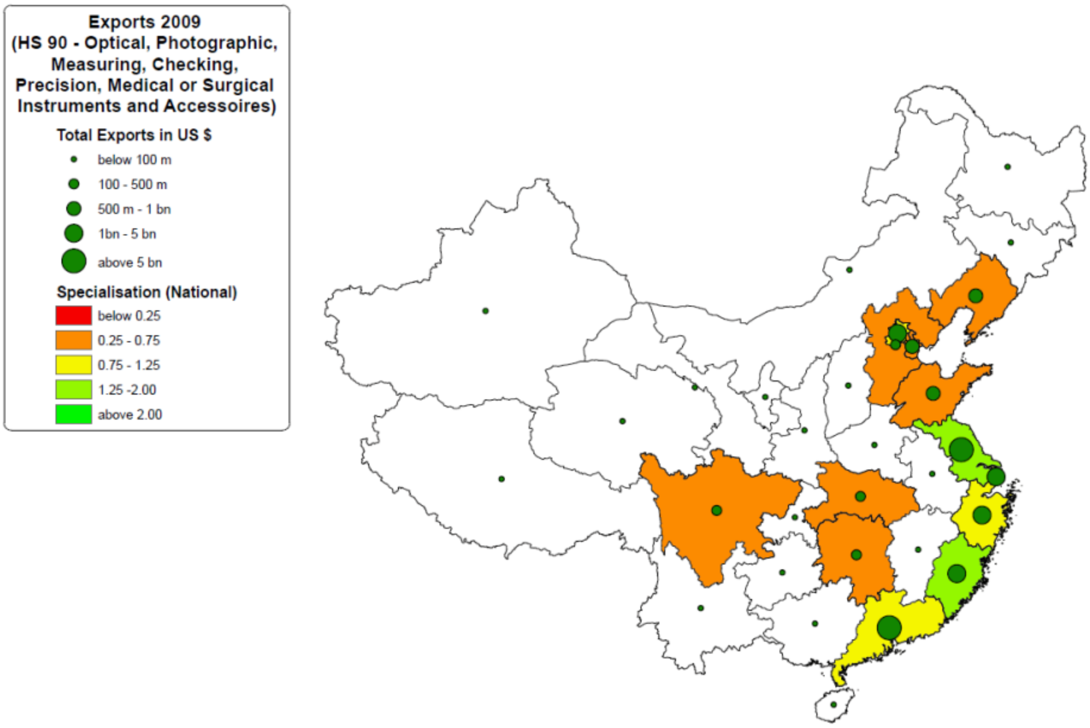
Source: Own map, own calculations, based on China Customs Statistics

Figure 39: Exports of Ships and Related Products (HS 89)



Source: Own map, own calculations, based on China Customs Statistics

Figure 40: Exports of Optical Products and Measuring Equipment (HS 90)



Source: Own map, own calculations, based on China Customs Statistics

These findings are confirmed by the trade specialisations of China's main economic centres as displayed in Figure 41 to Figure 43.[6]

The Bohai area, which in most technology related fields is a net importer, shows a specialisation in electronic machinery (the only field in which it is a net exporter), vehicles and aircraft (cf. Figure 41).

The Yangtze River Delta, a strong net exported particularly due to Zhejiang province, displays a visible specialisation in next to all fields except electric and electronic machinery/telecommunication and aircraft (cf. Figure 42).

Guangdong province, finally, displays a major specialisation in machinery/computers, electric and electronic machinery/telecommunication as well as optics/instruments. In all other technology-related fields it is under-specialised (cf. Figure 43).

6 To identify strengths and weaknesses within China, trade specialisations are calculated against the NATIONAL not the international average. The calculation formula is equivalent to that used for technological specialisations.

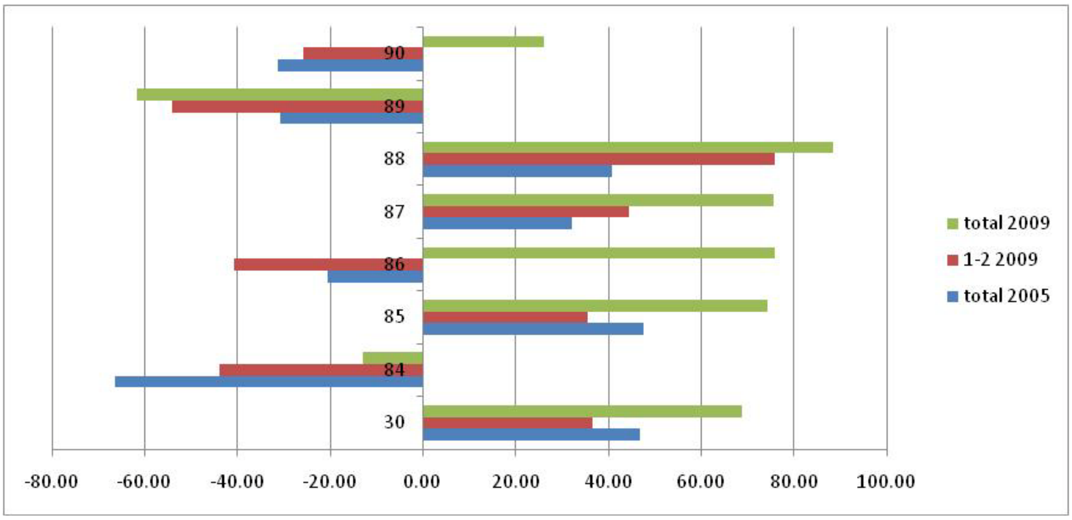
Effects of the 2008/2009 Economic Crisis

As in most major trading countries, Chinese exporters have been affected by the 2008/2009 economic crisis, even if, in relative terms, the impact was felt less than in e.g. Germany. Most exports only dropped to the level of 2006/2007.

Remarkably, the export of technology-related products has typically been affected less and, after February 2009, picked better or at least equal to that of low-tech products. Moreover, despite their different profiles of specialisation no province has - according to trade statistics – fared substantially better or worse than others. While the absolute impact was of course higher and more severely felt in more trade dependent provinces, the relative developments are remarkably similar (cf. Figure 44 to Figure 49). The only possible exception worth pointing out is that the export of technology-related products seems to be picking up more slowly in provinces in which it plays a less significant role to begin with (cf. Figure 48 to Figure 49). Finally, it seems that foreign-invested and private firms have recovered better than state-owned enterprises (Figure 50).

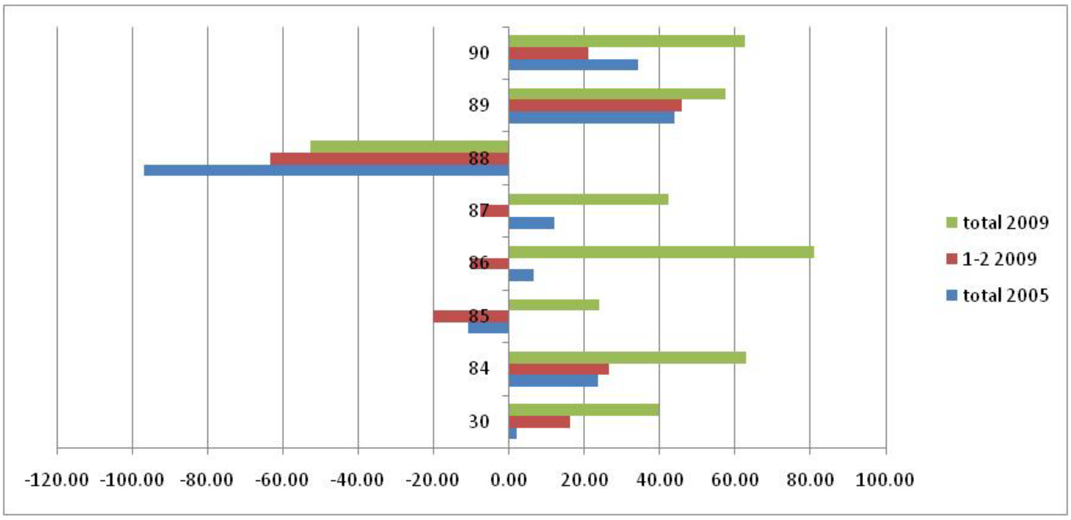
Impacts on regional specialisation patterns, in contrast, could in most cases not be identified, particularly not for the relevant groups of commodities (cf. Figure 44 to Figure 49). The general regional balance of export specialisation between the provinces does not seem to have been shifted by the crisis.

Figure 41: Regional Trade Specialisation of the Bohai Area (Against National Average)



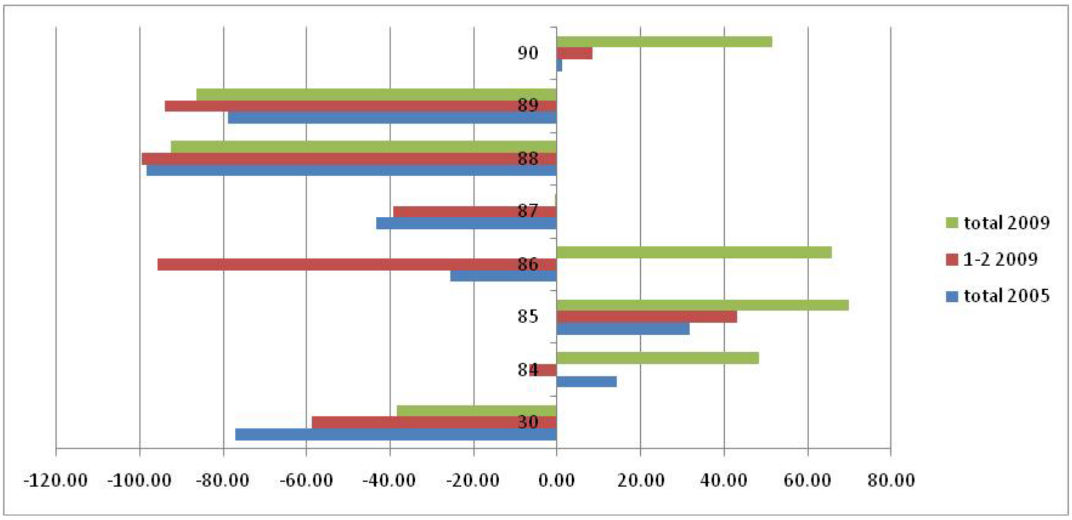
Source: Own figure and calculations, based on China Customs Statistics

Figure 42: Regional Trade Specialisation of the Yangtze River Delta (Against National Average)



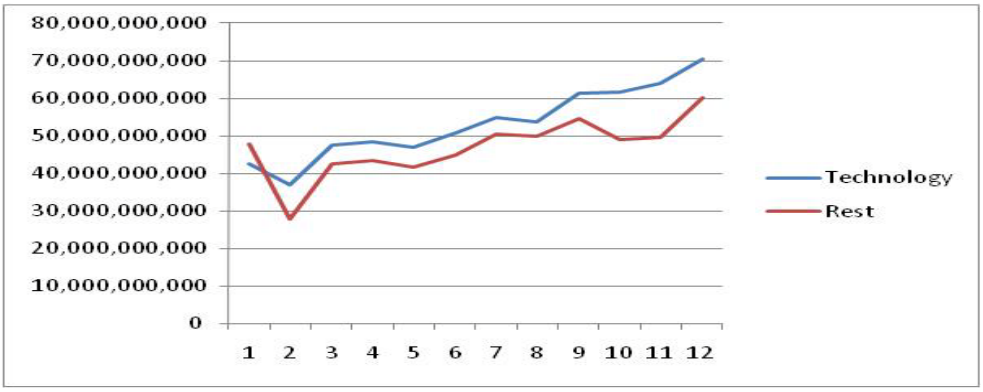
Source: Own figure and calculations, based on China Customs Statistics

Figure 43: Regional Trade Specialisation of Guangdong Province (Against National Average)



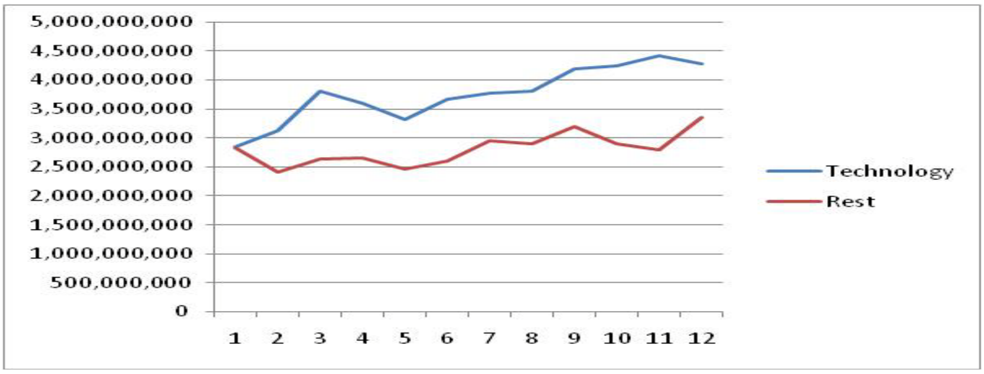
Source: Own figure and calculations, based on China Customs Statistics

Figure 44: Monthly Exports of Technology-Related and Other Goods in China 2009 (US$)



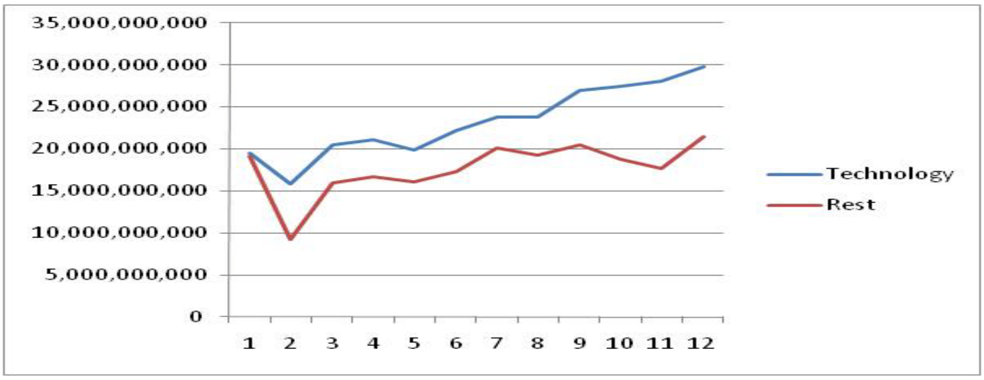
Source: Own figure, based on China Customs Statistics

Figure 45: Monthly Exports of Technology-Related and Other Goods in Bohai Area 2009 (US$)



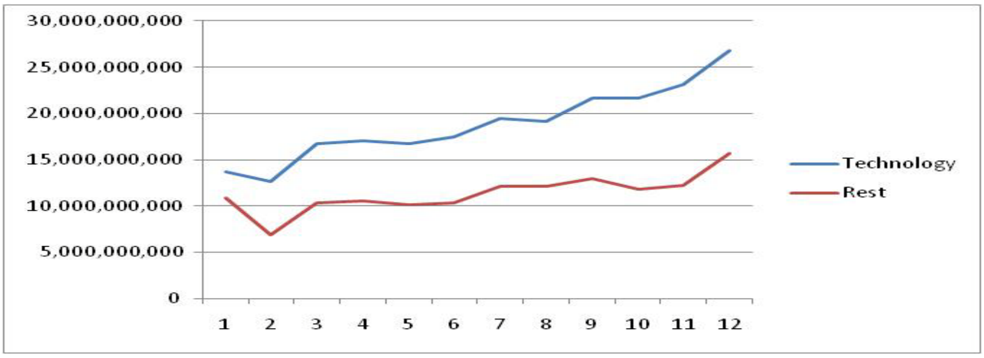
Source: Own figure, based on China Customs Statistics

Figure 46: Monthly Exports of Technology-Related and Other Goods in Yangtze RD 2009 (US$)



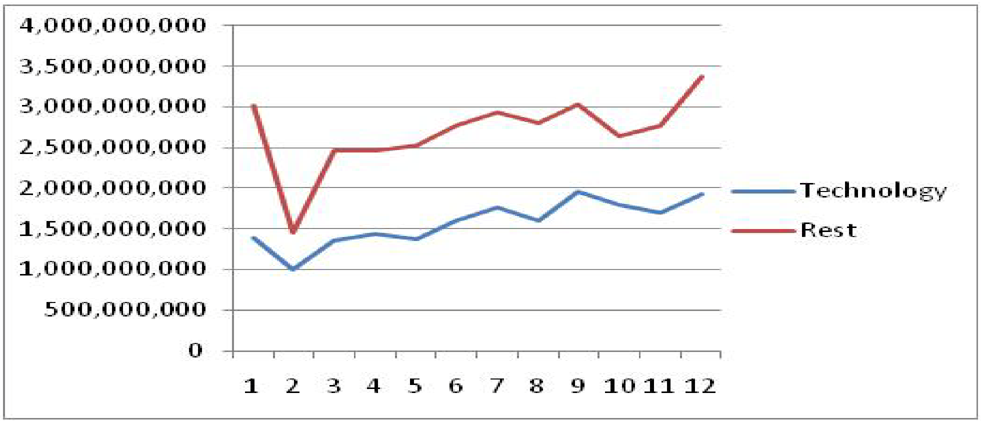
Source: Own figure, based on China Customs Statistics

Figure 47: Monthly Exports of Technology-Related and Other Goods in Guangdong 2009 (US$)



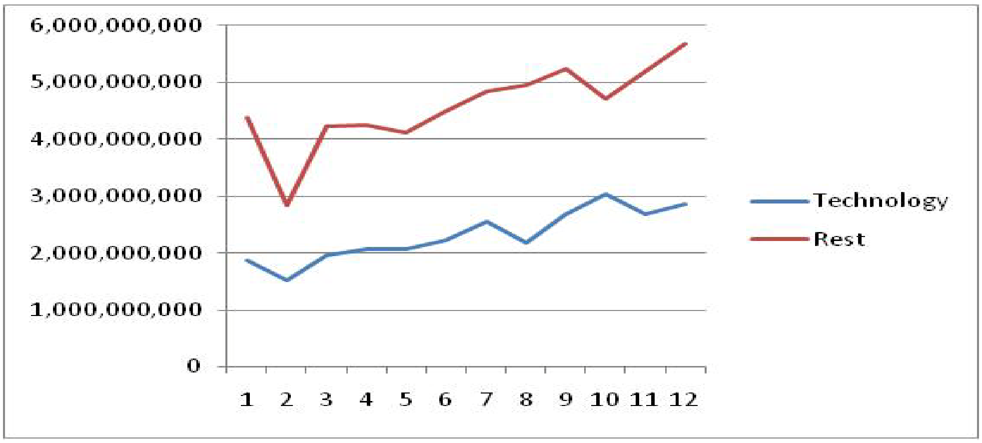
Source: Own figure, based on China Customs Statistics

Figure 48: Monthly Exports of Technology-Related and Other Goods in Fujian 2009 (US$)



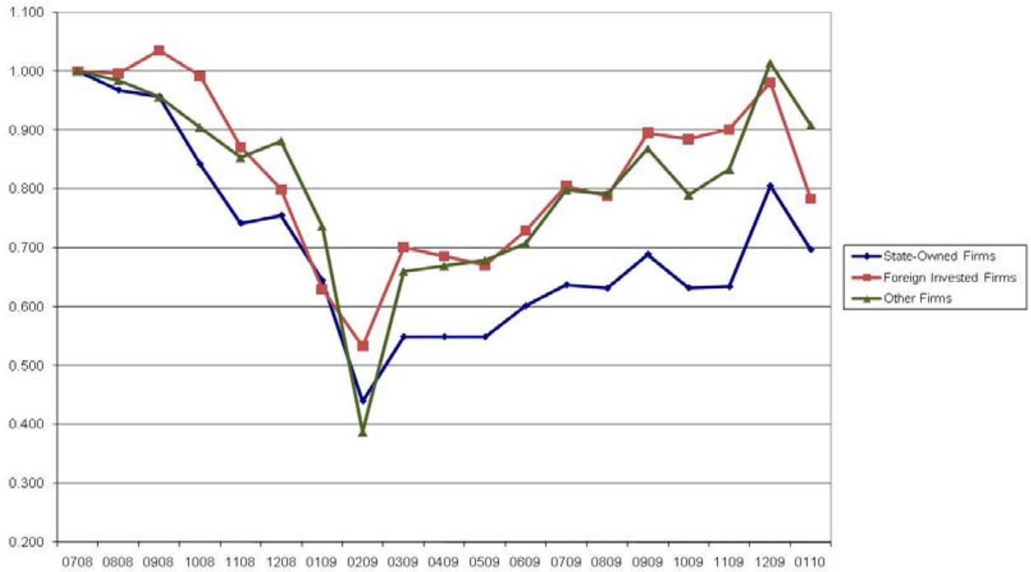
Source: Own figure, based on China Customs Statistics

Figure 49: Monthly Exports of Technology-Related and Other Goods in Shandong 2009 (US$)



Source: Own figure, based on China Customs Statistics

Figure 50: Monthly Exports by Type of Firm in China 2009 (US$)



Source: Own figure, based on China Customs Statistics

6 Summary

Our study of the regional dimension of China's innovation system has in essence yielded five main findings.

Firstly, contrary to what general wisdom may suggest at first sight, the regional concentration of R&D activities in China could not be found to be particularly stark. While they are indeed much stronger than the general disparities in economic development at the provincial level they more or less resemble those found in the former EU15 on a country level. Furthermore, the current disparities among the countries of the EU27 typically exceed those among the provinces of China.

As in most countries, regional disparities are lower for those expenditures more directly controlled by the state (e.g. by state owned firms or higher education institutions) and higher within the enterprise sector. The expenditures of the public research institutions, most prominently the CAS, which remain to a high degree concentrated on Beijing constitute an exception from this rule. Another aspect of this phenomenon is that the output of scientific activities (publications) is regionally more concentrated than the output of most technological activities (patents).

Secondly, while the concentration of scientific activities does not vary much across fields, the concentration of technological activities does so quite substantially, more so than for example in Europe. Remarkably, moreover, it does so differently than in the European Union. While in Europe applications in the classic technological fields tend to be more concentrated, China shows a strong regional concentration in the high-tech fields (Correlation between Chinese and EU Pattern of Concentration by Field: -0.41).

Thirdly, while the degree of regional concentration has diminished in all scientific fields, the picture is mixed with regard to technological activities. The strongest increases in regional concentration, in this context, can be attributed to the dominant role of Guangdong in certain fields such as telecommunications. Remarkably, in contrast, there has been a substantial decrease in regional concentration with regard to biotechnology and microbiology and genetics.

Fourthly, a juxtaposition of publications and patent applications yields an inhomogeneous picture. In some fields, such as telecommunications, the centres of academic activity are spatially quite separate from those of technological activity. In some others, such as Chemistry or Engineering, both activities are more synchronised. For the time being, however, there is little in our data that suggests strong linkages between academic and technological activities at the regional level. In contrast, the pattern of co-financing between public and private activity provides tentative evidence against it for many regions. Nonetheless the results suggest that the current regional pattern of distribution of scientific and technological activities in certain fields harbours potential to develop local linkages in the future. In other fields, substantial challenges continue to lie ahead.

Finally, the pattern of technology-related trade is the most concentrated of all activities analysed in this study – far more concentrated than regional GDP or regional S&T activities. Moreover, it cannot be found to be highly co-incident with scientific or technological activities on a regional level. Instead, it seems to reflect patterns of export processing and assembly in e.g. the electronics and telecommunications sector. Thus, our findings are in line with the findings of Linden et al. (2007) as well as Koopman et al. (2008), quoted in the last OECD report (OECD, 2010).

In summary, our regional analysis of the Chinese innovation system has painted the picture of a system in transition in which, despite substantial overall growth, disparities are not increasing but slowly decreasing – even though this decrease remains more evident for activities controlled by the state than for activities typically associated with the private enterprise sector. Moreover, it appears that while high-tech activities may still be concentrated on a number of key locations, activities in the medium-tech sectors are far more distributed. If there are strong linkages between scientific and technological activities at the regional level outside the prime locations, in contrast, remains questionable. If anything, the evidence collected for this study cautions against easily taking such assumptions and suggests to individually check on the micro level. Nonetheless, the current pattern of scientific and technological specialisation implies that potentials are present for the future development of knowledge driven clusters at a regional.

Annex I

FigureAnnex 1: Specialisations in Comparison Across Time

2000-2002

SIPO China	0.4%	0.8%	0.9%	0.3%	1.7%	0.8%	0.4%	0.4%	1.3%	0.7%	0.9%	6.2%	0.1%	0.3%	0.2%	0.4%	0.3%	0.1%	0.7%
2000-2002	19F01	19F02	19F03	19F04	19F05	19F06	19F07	19F08	19F09	19F10	19F11	19F12	19F13	19F14	19F15	19F16	19F17	19F18	19F19
ANHUI	1.60	0.81	0.76	3.18	1.01	1.36	0.45	0.46	0.94	0.79	0.74	0.68	0.70	0.62	1.35	0.56	1.99	0.41	1.70
BEIJING	0.45	0.91	0.60	1.02	0.83	0.97	0.60	0.57	1.26	1.09	0.60	0.61	0.23	0.73	0.69	0.47	0.31	0.94	0.21
CHONGQING	0.38	1.22	0.38	0.52	0.30	1.83	1.59	0.70	0.55	0.58	1.05	0.67	1.25	0.82	1.46	0.40	1.45	0.20	0.56
FUJIAN	1.05	0.25	1.15	1.45	0.32	1.22	0.96	1.21	0.87	0.70	0.95	0.43	0.25	0.62	0.29	0.92	0.55	0.05	0.62
GANSU	0.44	0.54	0.08	0.00	0.37	0.58	0.57	0.00	1.83	1.11	1.05	0.41	1.54	0.34	0.83	0.97	0.26	0.00	0.31
GUANGDONG	0.84	0.64	3.53	1.33	1.29	0.51	0.41	1.08	0.37	0.45	0.30	0.22	0.20	0.37	0.45	0.38	0.24	0.08	0.36
GUANGXI	0.34	0.16	0.14	0.00	0.31	0.81	0.29	0.42	1.22	0.19	1.26	0.57	0.21	1.15	0.75	0.80	0.47	0.14	1.13
GUIZHOU	0.29	0.10	0.26	0.00	0.23	0.36	0.56	0.13	0.78	0.24	0.59	1.35	0.14	0.51	0.16	0.96	0.70	0.03	0.61
HAINAN	0.00	0.00	0.29	0.00	0.44	0.52	1.56	0.89	0.76	0.53	0.26	0.88	0.91	0.38	0.53	1.18	0.67	0.10	1.64
HEBEI	0.69	0.45	0.05	0.17	0.17	0.49	0.33	0.46	1.03	0.77	1.06	0.49	0.59	0.64	4.15	2.03	0.53	0.13	0.80
HEILONGJIANG	1.27	0.40	0.28	0.00	0.23	1.17	0.18	0.34	1.04	0.47	0.74	0.32	0.53	0.48	2.06	1.74	0.59	0.16	0.57
HENAN	0.82	0.20	0.25	0.00	0.31	0.73	1.06	0.25	0.95	0.57	1.51	0.39	0.13	0.80	0.75	1.39	0.66	0.09	0.68
HUBEI	0.62	0.41	0.51	0.17	0.39	1.26	0.79	0.92	0.96	0.67	1.19	0.65	0.54	0.49	1.30	0.72	0.89	0.08	0.56
HUNAN	0.60	0.96	0.28	0.42	0.83	0.67	0.22	0.03	0.41	0.33	3.21	0.27	0.31	0.22	0.62	0.68	0.49	0.03	0.81
INNER MONGOLIA	0.37	1.05	0.00	0.50	0.00	0.13	0.00	0.00	0.74	0.40	2.28	0.35	0.00	0.71	0.00	1.15	0.25	0.15	1.53
JIANGSU	1.57	2.86	0.95	1.02	1.52	0.78	0.52	1.54	0.66	0.52	0.54	0.40	0.27	0.50	1.22	0.69	0.46	0.10	0.36
JIANGXI	1.32	0.38	0.16	0.00	0.48	0.47	0.51	0.49	0.62	0.58	0.75	0.62	0.00	1.14	0.58	0.28	0.73	0.61	1.06
JILIN	0.66	0.97	0.23	0.33	0.44	1.51	0.62	1.57	0.88	1.74	0.89	0.39	0.34	0.81	0.96	1.08	0.75	0.07	0.60
LIAONING	0.60	0.26	0.11	0.98	0.31	1.17	0.51	0.35	1.42	0.61	0.97	0.54	0.39	0.97	1.74	0.74	0.30	0.09	0.40
NINGXIA	0.16	0.23	0.06	0.00	0.43	0.34	0.62	0.29	1.46	0.70	0.85	0.70	0.60	0.62	0.00	1.78	0.44	0.00	0.98
QINGHAI	2.11	0.00	0.21	1.46	0.48	0.00	0.68	0.00	1.89	0.29	1.13	0.39	0.00	0.00	0.00	1.48	0.73	0.00	0.82
SHAANXI	1.00	1.66	0.86	1.19	1.81	1.44	0.63	1.73	0.54	0.63	0.95	0.29	0.61	1.01	0.83	0.62	0.52	0.10	0.23
SHANDONG	0.36	0.30	0.18	0.53	0.19	0.60	0.51	0.29	0.86	1.21	1.11	0.58	0.36	0.81	0.72	0.93	0.50	0.16	0.99
SHANGHAI	0.43	0.87	0.49	0.81	0.78	0.74	0.48	0.91	0.41	0.56	0.47	1.36	0.29	0.33	0.46	0.33	0.38	0.08	0.25
SHANXI	0.24	0.41	0.20	0.45	0.17	0.61	0.11	0.22	1.91	1.08	1.00	0.24	0.61	0.80	1.07	0.80	0.68	0.09	0.48
SICHUAN	0.62	0.47	0.36	0.81	0.25	0.98	0.78	0.37	0.98	1.25	0.61	0.85	0.28	0.63	0.52	0.83	0.15	0.05	0.71
TIANJIN	1.58	0.35	0.26	0.30	0.45	0.70	0.47	0.45	0.44	0.59	0.41	0.16	3.81	2.40	0.64	0.41	0.48	0.13	1.97
TIBET	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	2.28	0.00	0.00	4.03
XINJIANG	0.00	2.44	0.00	0.34	0.05	0.52	0.47	0.22	1.33	0.67	0.95	0.52	0.23	0.28	0.80	1.96	1.01	0.05	1.20
YUNNAN	0.21	0.18	0.05	0.47	0.13	0.63	0.49	0.00	0.88	0.14	0.83	1.19	0.00	0.40	0.19	1.15	0.35	0.09	0.89
ZHEJIANG	0.98	2.56	0.47	0.89	0.80	1.29	1.47	1.00	0.60	0.61	0.51	0.62	1.36	0.81	0.85	0.82	0.32	0.12	0.46

2005-2007

SIPO China	5.1%	4.8%	15.3%	3.2%	11.2%	7.9%	2.8%	2.5%	11.1%	5.1%	8.8%	14.3%	2.8%	4.4%	2.5%	6.7%	3.3%	2.7%	10.7%
2005-2007	19F01	19F02	19F03	19F04	19F05	19F06	19F07	19F08	19F09	19F10	19F11	19F12	19F13	19F14	19F15	19F16	19F17	19F18	19F19
ANHUI	1.62	1.19	0.41	0.97	0.66	1.45	1.00	0.86	0.78	0.84	1.21	0.74	1.41	1.11	1.83	1.06	5.26	2.41	1.01
BEIJING	0.78	1.22	0.96	1.12	1.32	1.08	0.84	0.77	1.28	0.86	0.94	1.22	0.52	0.88	0.61	0.72	0.78	0.83	0.44
CHONGQING	0.67	0.23	0.39	0.07	0.40	1.54	3.38	0.42	0.59	0.70	0.97	1.37	3.21	0.86	1.51	0.65	6.28	2.44	0.41
FUJIAN	1.20	1.30	0.69	0.51	0.71	1.05	1.19	0.72	1.19	1.32	1.38	1.27	0.36	1.24	0.60	0.98	0.63	1.31	1.36
GANSU	0.39	0.33	0.05	0.08	0.28	0.85	0.72	0.16	1.98	2.00	2.01	1.62	1.37	0.60	1.90	1.03	0.12	0.90	1.00
GUANGDONG	1.01	0.59	2.61	1.79	1.52	0.76	0.56	1.06	0.46	0.56	0.31	0.32	0.46	0.42	0.42	0.51	0.53	0.49	0.54
GUANGXI	1.21	0.40	0.15	0.10	0.26	0.89	0.98	0.38	1.19	1.43	1.45	2.39	0.43	0.69	0.83	1.32	1.33	1.56	1.49
GUIZHOU	0.89	0.26	0.07	0.02	0.06	1.06	0.43	0.00	0.75	0.61	2.58	2.68	0.94	1.92	1.31	1.28	0.42	1.09	1.05
HAINAN	0.11	0.12	0.10	0.00	0.28	0.21	1.19	0.00	1.12	0.96	0.43	4.79	0.47	0.89	0.00	1.05	0.43	0.00	0.95
HEBEI	0.69	0.52	0.10	0.08	0.24	0.85	0.99	0.54	1.55	1.01	1.89	1.37	1.24	1.22	2.49	1.76	0.87	1.81	1.41
HEILONGJIANG	1.54	0.52	0.28	0.18	0.46	1.45	1.48	0.91	1.34	1.05	1.40	0.97	1.84	1.22	2.31	1.40	1.93	0.92	0.78
HENAN	0.80	1.55	0.10	0.14	0.23	0.83	0.80	0.32	1.35	0.99	2.08	1.28	1.18	0.99	1.91	1.67	0.91	1.35	1.48
HUBEI	1.07	0.70	0.48	0.44	0.63	1.19	1.34	0.71	1.26	1.28	1.89	1.19	0.97	0.91	1.56	1.17	1.13	1.20	0.78
HUNAN	0.84	0.66	0.21	0.13	0.47	0.66	0.58	0.12	0.79	0.59	4.90	0.54	1.16	0.84	1.13	1.62	1.46	0.62	1.84
INNER MONGOLIA	0.79	0.29	0.01	0.07	0.23	0.81	0.47	0.00	0.96	0.61	2.26	1.25	1.26	0.37	0.84	1.16	0.53	0.84	3.63
JIANGSU	1.41	1.51	0.54	1.11	1.06	1.06	0.79	1.94	0.93	1.34	0.86	0.95	1.27	1.07	1.45	1.35	1.04	1.38	1.41
JIANGXI	0.36	0.84	0.09	0.07	0.14	1.06	1.14	0.17	1.21	0.69	1.46	2.68	1.17	0.57	1.19	1.44	0.86	0.90	1.02
JILIN	0.72	1.19	0.18	0.39	0.42	1.37	0.90	1.70	1.31	2.61	1.00	1.75	0.71	0.57	1.21	1.05	1.81	0.96	0.80
LIAONING	1.21	0.44	0.17	1.19	0.58	1.02	0.94	0.58	1.68	0.90	1.71	1.04	1.23	1.45	2.22	1.48	1.24	1.38	0.93
NINGXIA	0.82	1.69	0.34	0.28	0.48	0.38	1.22	0.21	1.18	0.39	1.88	1.70	0.96	0.65	0.22	1.88	1.10	1.39	2.35
QINGHAI	0.81	0.50	0.14	0.00	0.13	0.45	0.67	0.00	1.85	0.41	2.22	1.23	0.33	0.36	0.30	3.83	0.00	0.96	1.81
SHAANXI	1.32	2.41	0.65	0.81	1.24	1.41	1.65	2.38	0.77	0.86	1.21	0.68	1.27	1.15	1.28	0.73	1.15	0.68	0.72
SHANDONG	0.69	0.26	0.19	0.69	0.42	1.01	1.21	0.30	1.20	1.30	1.03	1.81	0.95	1.50	1.13	1.42	0.89	0.97	1.81
SHANGHAI	1.03	1.85	0.67	0.90	1.10	1.12	1.49	1.42	0.95	1.30	0.99	0.97	1.27	0.98	1.12	1.04	1.20	1.23	0.76
SHANXI	0.57	0.36	0.10	0.13	0.20	0.82	0.68	0.22	2.06	1.17	1.63	1.03	1.16	1.32	1.88	1.83	1.20	1.61	1.55
SICHUAN	0.63	0.71	0.37	0.80	0.59	0.96	1.44	1.23	1.15	1.59	1.20	1.66	0.72	0.73	1.19	1.58	1.18	1.29	1.03
TIANJIN	1.26	0.48	0.14	0.40	0.35	0.87	1.16	0.44	1.20	1.11	0.67	1.50	1.95	3.05	0.92	0.75	0.55	1.07	2.66
TIBET	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	5.35	0.00	0.00	0.00	0.42	0.00	0.00	5.88
XINJIANG	0.50	0.46	0.06	0.07	0.00	0.52	0.23	0.00	1.95	1.81	1.05	2.26	0.57	0.55	0.31	2.72	0.31	2.31	2.43
YUNNAN	0.25	0.12	0.03	0.06	0.19	0.75	0.73	0.18	1.64	0.42	1.72	2.52	0.31	1.23	0.40	1.98	0.35	0.94	2.13
ZHEJIANG	0.86	0.57	0.61	0.58	0.71	1.14	1.24	0.70	1.41	1.08	0.91	1.14	1.73	1.20	1.09	1.54	0.93	1.10	1.61

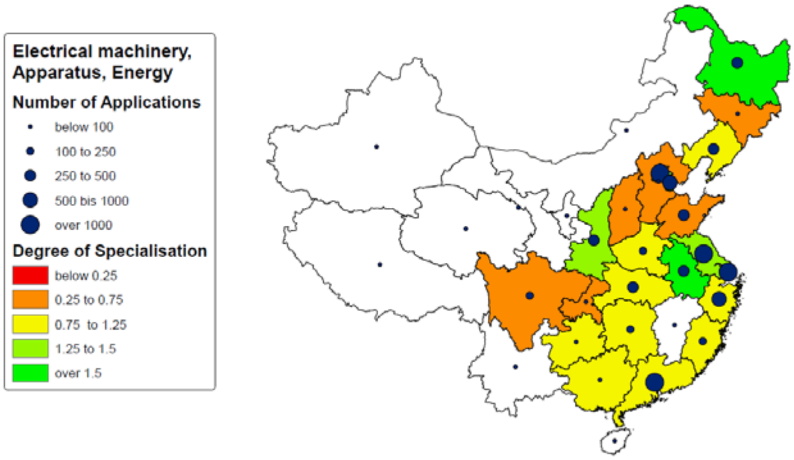
Technological Categories Used Above

19F01 Electrical machinery, apparatus, energy
19F02 Electronic components
19F03 Telecommunications
19F04 Audio-visual electronics
19F05 Computers, office machinery
19F06 Measurement, control
19F07 Medical equipment
19F08 Optics
19F09 Basic chemicals, paints, soaps, petroleum products
19F10 Polymers, rubber, man-made fibres

19F11 Non-polymer materials
19F12 Pharmaceuticals
19F13 Energy machinery
19F14 General machinery
19F15 Machine-tools
19F16 Special machinery
19F17 Transport
19F18 Metal products
19F19 Textiles, wearing, leather, wood, paper, domestic appliances, furniture, food

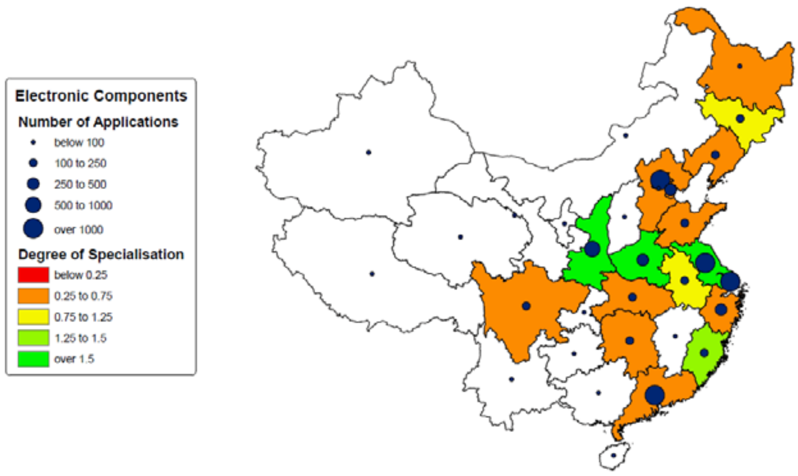
Source: Own figure, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 2: SIPO Patent Applications in Electrical machinery, Apparatus, Energy



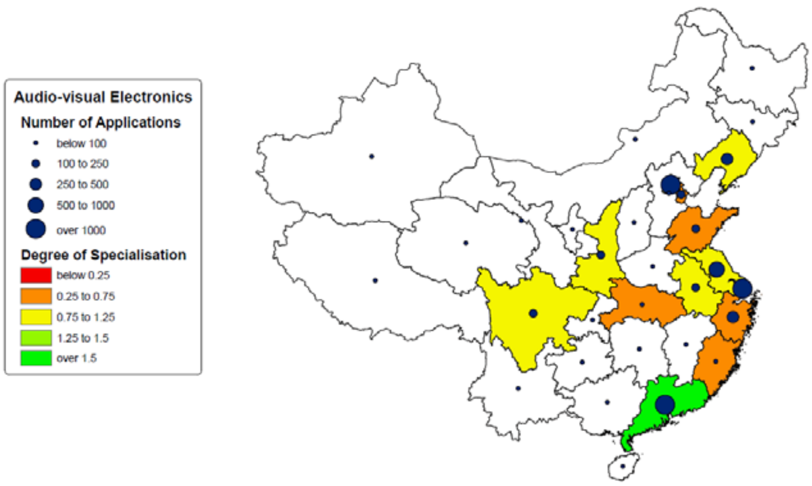
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 3: SIPO Patent Applications in Electronic Components



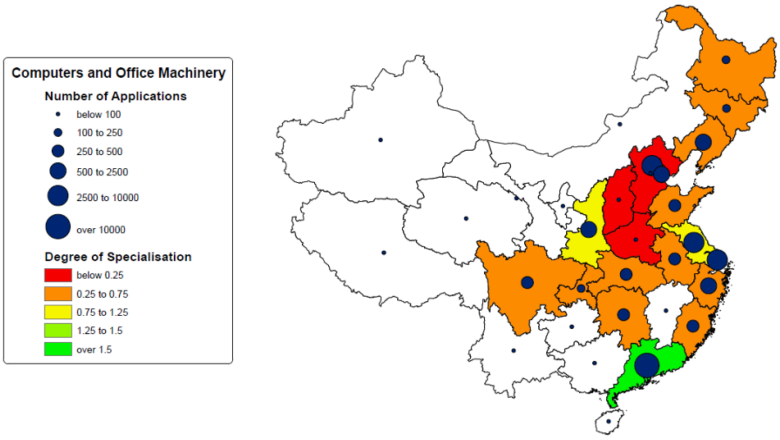
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 4: SIPO Patent Applications in Audio-visual Electronics



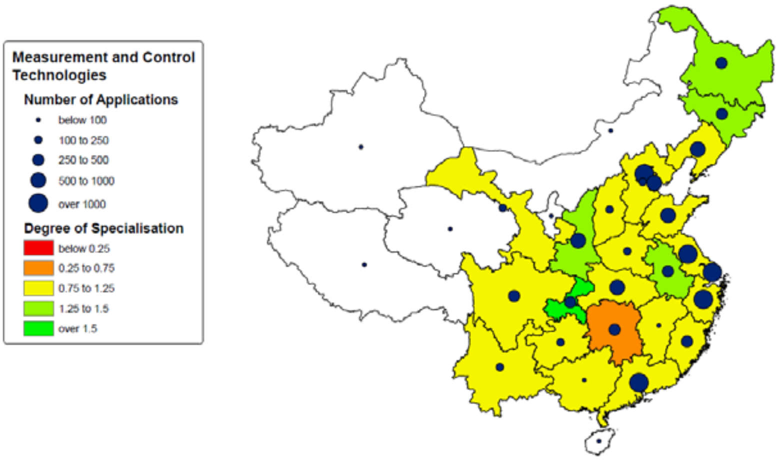
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 5: SIPO Patent Applications in Computers and Office Machinery



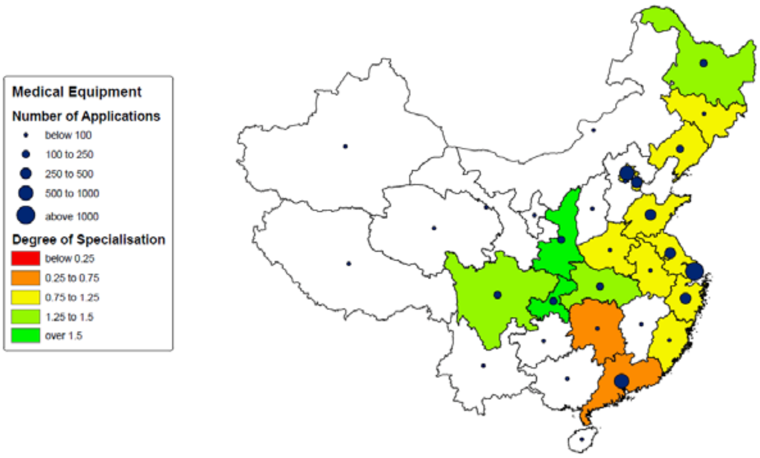
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 6: SIPO Patent Applications in Measurement and Control



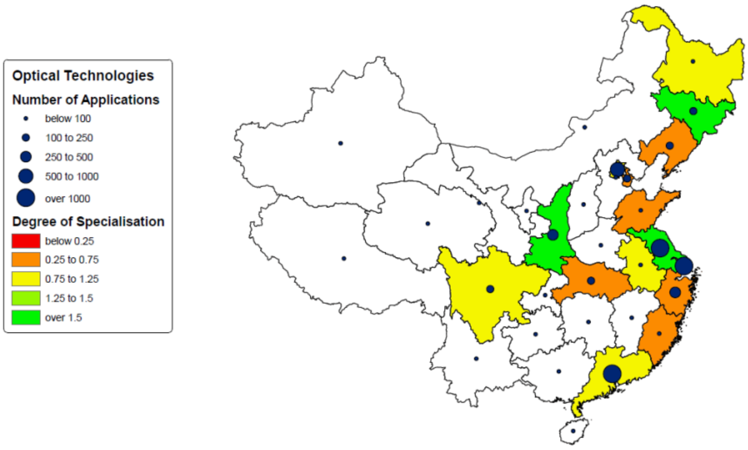
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 7: SIPO Patent Applications in Medical Equipment



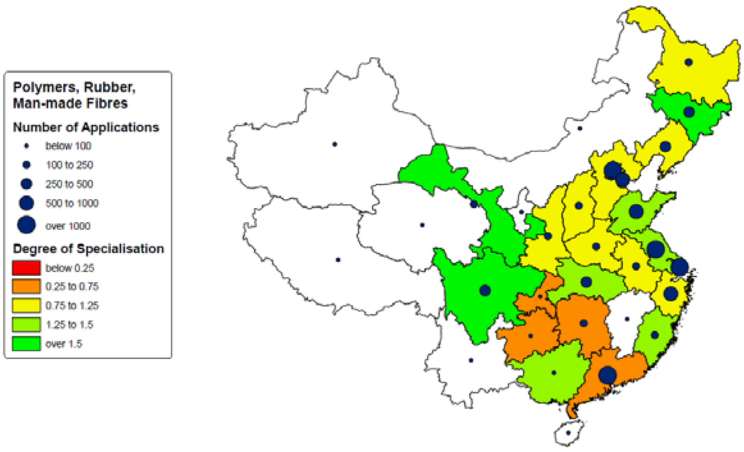
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 8: SIPO Patent Applications in Optical Technologies



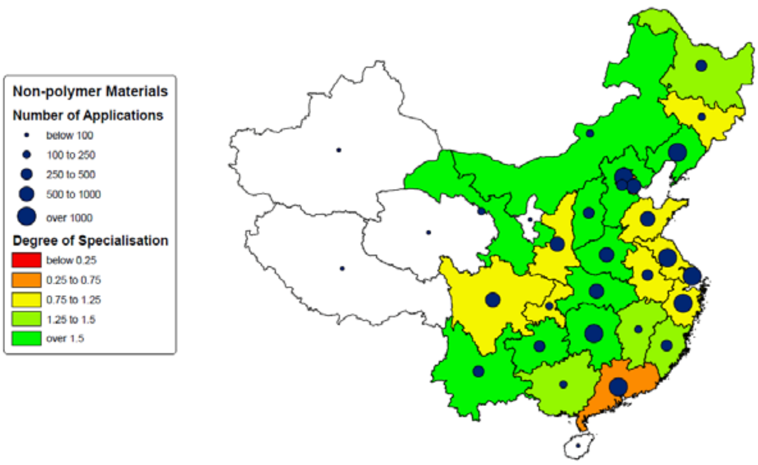
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 9: SIPO Patent Applications in Polymers, Rubbers, and Man-made Fibres



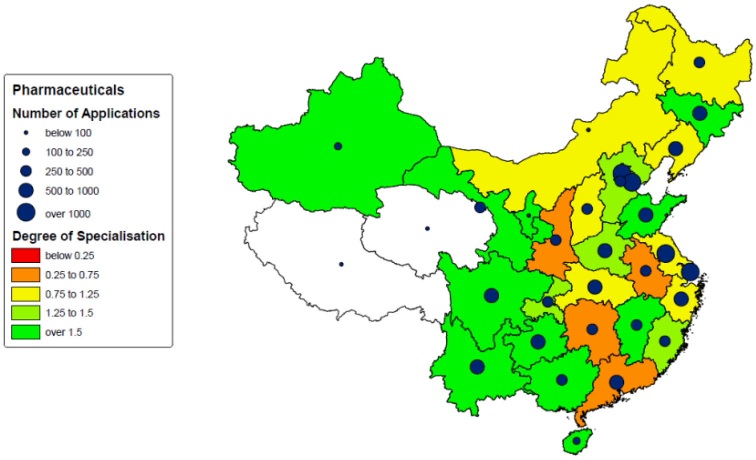
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 10: SIPO Patent Applications in Non-polymer Materials



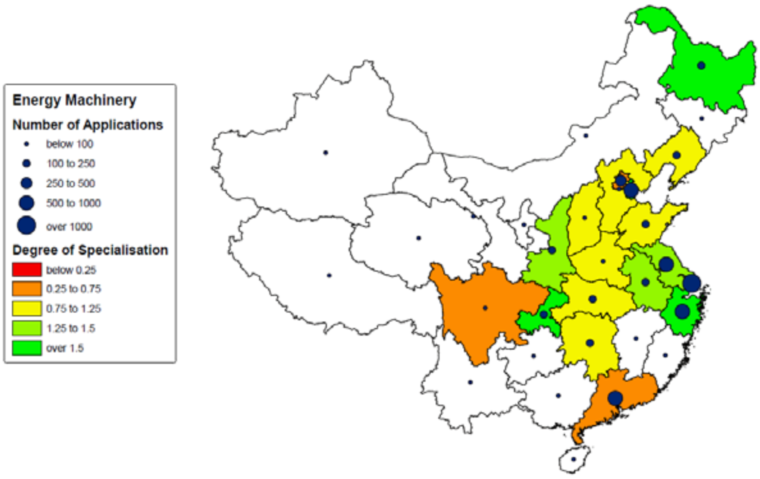
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 11: SIPO Patent Applications in Pharmaceuticals



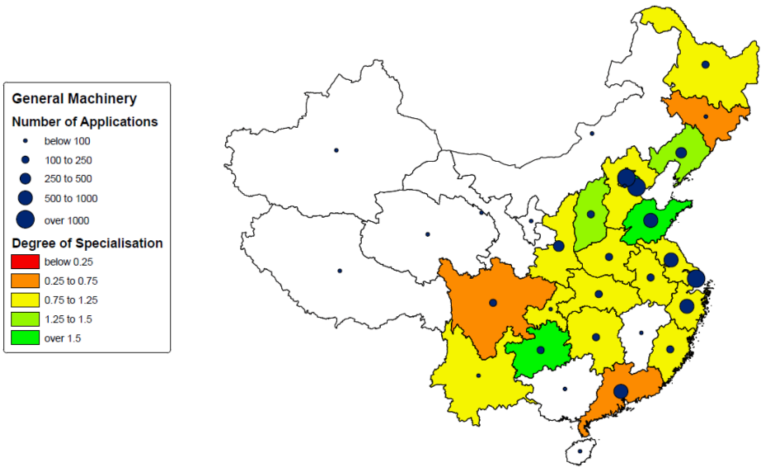
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 12: SIPO Patent Applications in Energy Machinery



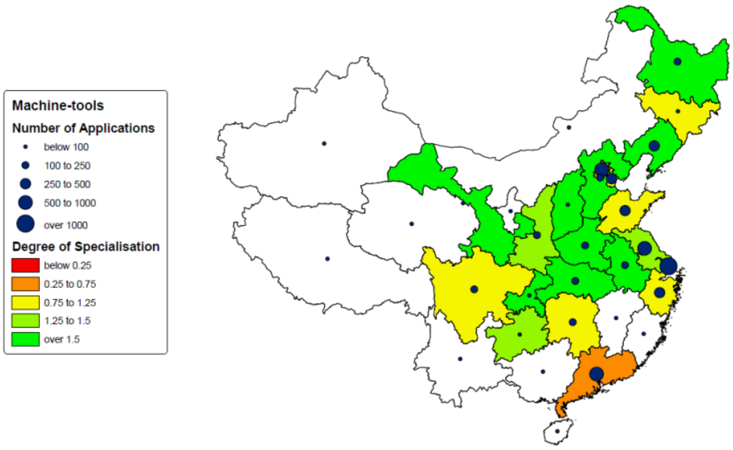
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 13: SIPO Patent Applications in General Machinery



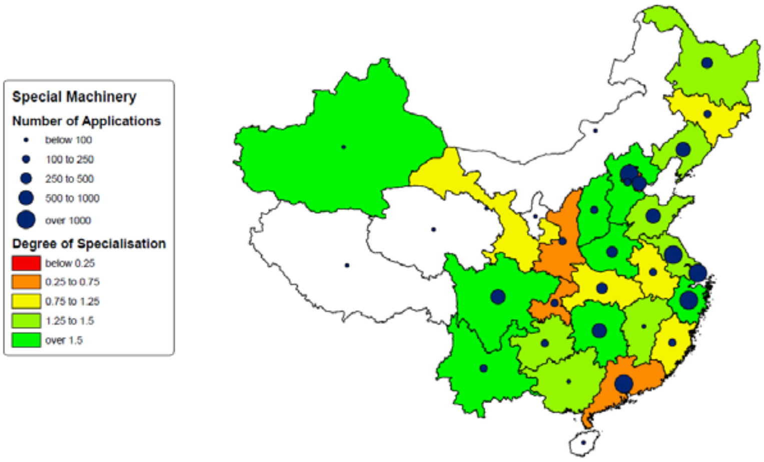
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 14: SIPO Patent Applications in Machine-tools



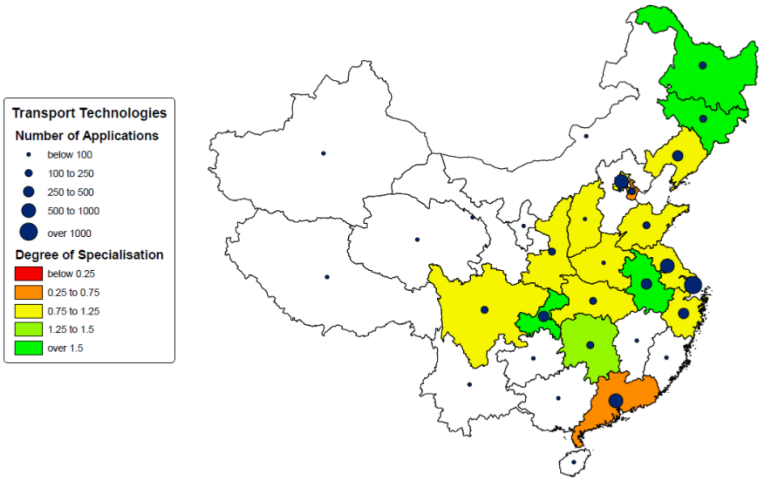
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 15: SIPO Patent Applications in Special Machinery



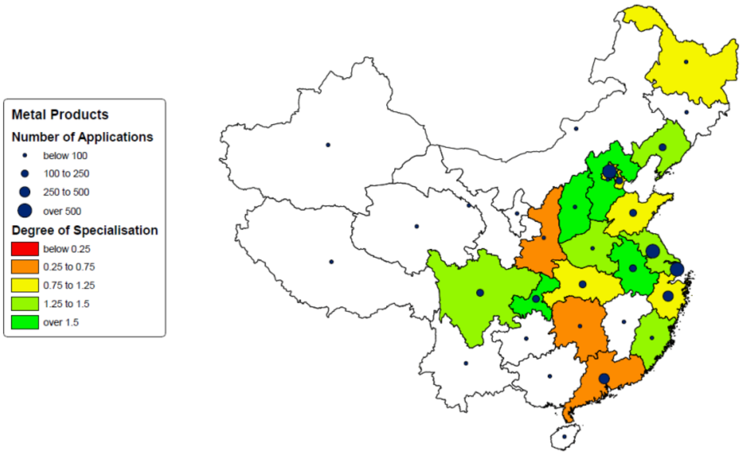
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 16: SIPO Patent Applications in Transport Technology



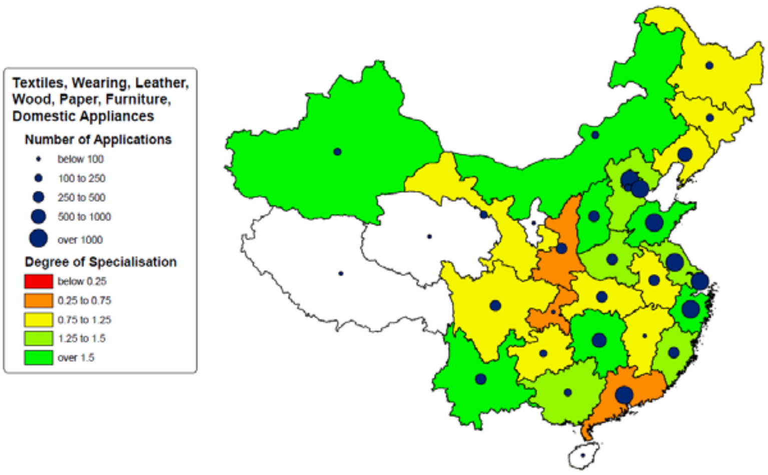
Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 17: SIPO Patent Applications in Metal Products



Source: Own map, own calculations, based on EPO Worldwide Statistical Database

FigureAnnex 18: SIPO Patent Applications in Textiles, Wearing, Wood, Paper, Dom. Appl., etc.



Source: Own map, own calculations, based on EPO Worldwide Statistical Database

Annex II

Calculation of the Gini Coefficient

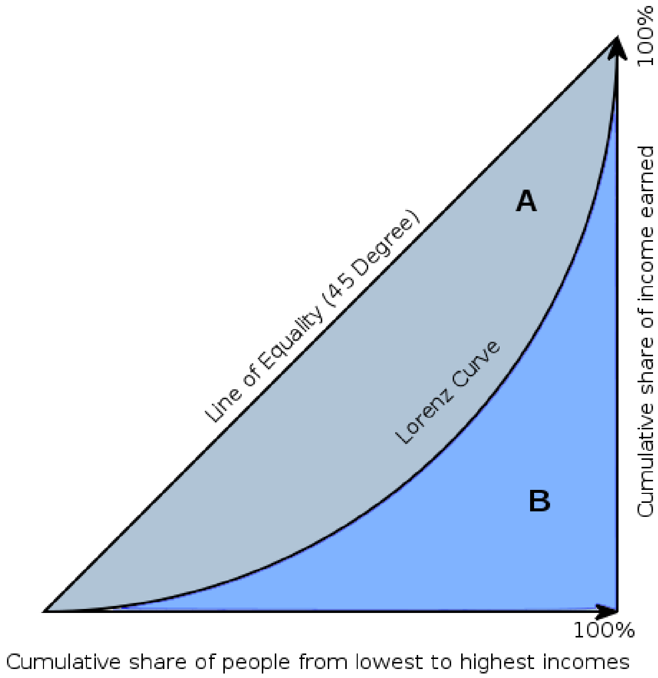
The Gini coefficient is defined mathematically based as the ratio of the area that lies between the line of equality and the Lorenz curve (marked 'A' in FigureAnnex 19) over the total area under the line of equality (marked 'A' and 'B' in FigureAnnex 19).

Mathematically, it is calculated as $G = 1 - 2\int_0^1 L(X)dX.$

The Gini coefficient can thus range from 0 to 1. A low Gini coefficient indicates a more equal distribution, with 0 corresponding to complete equality, while higher Gini coefficients indicate more unequal distribution, with 1 corresponding to complete inequality.

When used as a measure of regional disparities, a Gini Coefficient of 1 would thus describe a country in which 100% of activities are performed in a single region whereas activities in all other regions are absent. A Gini Coefficient of 0, in contrast, would describe a country in which the same amount of activities is performed in every region.

FigureAnnex 19: The Lorenz Curve



Literature

Linden, G., Kraemer, K., Dedrick, J. (2007): Who Captures Value in a Global Innovation System? The Case of Apple's iPod, Communications of the ACM, Vol. 52, No. 3.

OECD (2008): OECD Reviews of Innovation Policy, China, Paris.

Koopman, R., Wang, Z., Wei, S.-J. (2008): How Much of Chinese Exports is Really Made In China? Assessing Domestic Value-Added When Processing Trade is Pervasive, NBER Working Papers, No. 14109.

OECD (2010): OECD Economic Surveys, China, Paris.