AEGIS

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| **Deliverable Title** | **D7.3.2 "Currents trends in patenting and technological capabilities of firms in emerging and fast growing economies"** |
| Deliverable Lead: | UB |
| Related Work package: | WP7.3 "Data generation: Patent analysis" |
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| Dissemination level: | Public |
| Due submission date: | 30/04/2011 |
| Actual submission: | 31/05/2001 |
| Version | Final |
| Project Number | 225134 |
| Instrument: | Collaborative Project (Large-scale integrating project) |
| Start date of Project: | 01/01/2009 |
| Duration: | 36 months |


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| Abstract | This report analyses empirically the nature of patenting activity in a selected number of large emerging economies countries (Brazil, China, India, Mexico, Russian Federation, and South Africa) using two databases: the USPTO and the EPO patent database. It is shown that international patenting is growing but it's not a pervasive and diffused activity across all the countries. Technological position in the world and its dynamic is also analyzed. |



SEVENTH FRAMEWORK PROGRAMME

*Project co-funded by the European Commission under Theme 8 "Socio-Economic Sciences and Humanities" of the 7th Framework Programme for Research and Technological Development.*

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# EXECUTIVE SUMMARY

This report analyses empirically the nature of patenting activity in a selected number of large emerging economies countries (Brazil, China, India, Mexico, Russian Federation, and South Africa) using two databases: the USPTO and the EPO patent database. It shows that international patenting is growing but it's not a pervasive and diffused activity across all the countries. If China and India experienced an growth rate in patenting activity almost always above the 200% in the 3 periods considered (1990-1994, 1995-1999, 2000-2004), on the other side South Africa - which was the country with more patent applications in the first period at the USPTO, is the country with the lowest growth rate.

Then, at the company level, it is observed to some extent a low level of turbulence: 5 applicants out of 15 are listed among the Top 3 domestic applicants in all the period considered. This is particularly evident for Brazil, where Petrobras and Embraco are the two applicants with more patent applications in the both periods. Clearly, top applicants in different countries patent in different sectors.

Hence technological position of emerging countries in the world is analyzed. It shows that the emerging shares of world patent are extremely low, even though it is increasing in almost all sectors. Focusing on single macro sectors, in the 2000-2004, apart from Electronics and Instruments, where all countries seems performing better, Brazil seems performing better in Pharmaceutical and Chemicals and Industrial Process; China in Consumer Goods; India in Chemicals; Mexico in Industrial Processes, Mechanical and Consumer Goods; South Africa in Chemicals, Pharmaceutical and Industrial Processes.

# 1 INTRODUCTION

The protection of intellectual property is an extremely important issue in developing and emerging countries. Following the Schumpeterian growth theory, technological innovation, as well as the accumulation of production and technological capabilities, plays a central role in the process of long-run economic prosperity. Thus, countries increasing the share of technology-intensive sectors in their economic structures benefit more technological learning and innovation (Cimoli et al. 2008). In this report we want emphasize the weight of some large emerging economies on the worldwide production of technology, looking in particular at their specialization and technological dynamics.

We consider data from US Patent and Trademark Patent Office (USPTO) and European Patent Office (EPO) for 6 Emerging Countries (ECs): Brazil, China, India, Mexico, Russian Federation and South Africa. The following questions are under scrutiny:

- Which is the picture of the patenting activity in the ECs?
- Which are the main actors?
- Which are the technological (absolute and relative) advantages of the ECs?
- Do ECs follow similar pattern of technological catching-up?

# 2 PATENT DATA DESCRIPTION

Patent data are an extremely valuable source of information. Because patents can be used to analyze the technological activities of countries, regions, firms and inventors and show a high level of correlation with R&D at the firm level many scholars have assessed the use of patents as economic indicators (Pavitt 1988, Griliches 1990). However the use of patents at the aggregate level to study innovative activity should be based on the consciousness of the limits of such an indicator.

First of all, because patents are not considered as a major source of appropriability (Levin et al. 1987, Cohen et al. 2000) many inventions are not patented. Second, the use and the effects of patents vary considerably across industries (Orsenigo and Sterzi 2010). Third, large firms are over-represented because they have in many sectors a higher number of patents than the small firms given the scale economies in the patenting activity. Finally, due to the increase in the internationalization of research and development activity, this may be conducted in one location but the protection for the invention might be sought in a different one (WIPO 2008).

The patent statistics published in this report are taken from the USPTO (United States Patents and Trademarks Office) and EPO (European Patent Office) Patstat Database. Each year KITeS (Bocconi University) collects patent statistics including the number of patent applications filed and patent granted, broken down by country of origin, date and technological classification. Moreover, for each patent application, we also collect information on inventors and applicants.

In this report we focus on a 6 large emerging economies (Brazil, China, India, Mexico, Russia Federation, and South Africa). The country of origin is chosen according to the residence of the inventor. Following this definition, a Brazilian patent is a patent with *at least* an inventor residing in Brazil. This choice is driven by the fact that patent statistics based on the country of residence of the inventor may reflect more directly the inventive activity of laboratories and researchers in a given country, while the residence of the applicant provides information about the owner of the patent at the time of the application (WIPO 2008).

# 3 GENERAL OVERVIEW

Table 1 shows the total number of patent at the EPO and USPTO by year (priority year). Top emerging countries at the USPTO in the period 2000-2004 are China, India and Russia Federation with, respectively, 7'762, 4'899, and 1'975 patent applications. These figures are also confirmed by looking at Table 2 which displays the number of patent application at the national patent offices.

However, if Russia Federation has begun to patent during the 80s, China and India have experienced an incredible growth rate in the last 10 years (530% and 339% respectively between the period 1995-1999 and 2000-2004). EPO statistics show similar figures.

It is also important to underline that a considerable share of patent applications of emerging countries is the result of collaborative activity with foreign laboratories, companies and inventors. Table 3 shows the share of patents with at least a foreign co-inventor: the less "internationalized" country is South Africa, where in the 2004 less than 20% of patents have a foreign inventors, while Russia Federation and China are those with an higher share of foreign co-inventors with, respectively, the 55% and 35% at the USPTO. Clearly geographical proximity and economic agreements play a very important role: for example if at the USPTO Brazil and Mexico have almost the same number of patents, at the EPO Brazil has a total number of patents which is almost three times that for Mexico.

Finally it is worthwhile to underline that this impressive growth in terms of number of patent applied in the last ten-fifteen years cannot clearly explained only by the increased propensity to patent worldwide. Patents in emerging countries are primarily driven by both demand factors (e.g. FDI) - which foster the creation of markets for goods - and general reinforcement of IPR legislation - which contributes to the creation of markets for technologies - (see Hu and Jefferson 2009 for the China's patent explosions).

# 4 FIRMS

If we look at the applicant name of the patent applications based on the country of residence of the inventors we find many multinational enterprises. This reflects the internationalization of the inventive activity: multinationals locate R&D laboratories in developing and emerging countries to reduce costs, access to large markets and benefit from knowledge spillovers available in the local system of innovation. However in order to measure the national innovative performance of a country it's better to rely on patents owned by domestic companies. For this reason in this Section we present some patent figures for domestic applicant.

Table 4 shows the Top 3 Domestic applicants at the USPTO for two different periods: 1990-1994 and 2000-2004.

First of all we observe to some extent a low level of turbulence: 5 applicants out of 15 are listed among the Top 3 domestic applicants in both periods. This is particularly evident for Brazil, where Petrobras and Embraco are the two applicants with more patent applications in the both periods. These two companies are international innovators in the energy and refrigeration industry respectively.

In China a crucial role is played by the Huawei Technologies with 251 patent applications. Moreover the third position of Tsinghua University is explained by the fact that Chinese academic institutions have taken the lead in the worldwide academic patenting: the first five universities are all Chinese (Luan et al. 2010).

The Council of Scientific and Industrial Research dominates the Top 3 list in India, followed by STMicroelectronics and Ranbaxy Laboratories – the India's largest pharmaceutical company.

In Mexico the number of patents owned by domestic companies is so small that a single inventor is ranked first in the 2000-2004 period.

Finally in South Africa CSIR and SASOL Technology – international integrated energy and chemical company – are those with more patents in the last period.

# 5 SECTORS

This section wants analyze the patenting activity in different sectors.

First, we look at their absolute technological performance by focusing at their patent world shares in different fields and for 2 different periods of time (1990-1994 and 2000-2004). Then, we look at the international technological specialisation (ITS) - defined as the international technological performance of a country in a specific technology relative to its overall international technological performance.

In the first case, the technological strength of a country is approximated by the share of that country s patents to total world patents and similarly, the technological strength of a country in a specific sector can be measured by the share of that country's patents to total world patents in that sector.

For what concerns the ITS many authors have adopted the so-called Revealed Technological Comparative Advantage index (RTA) in order to measure the ITS in a technological field. RTA is the traditional Balassa indicator of revealed comparative advantage applied to innovation analysis (Balassa 1965). It measures the share of patents granted to (or applied for by) firms and other organisations in country c in technology j on total world patent in technology j, divided by the share of total patents granted to (or applied for by) firms and other organisations in country c to total world patents.

$$RTA_{c,j} = \frac{\dfrac{P_{c,j}}{\sum_c P_{c,j}}}{\dfrac{\sum_j P_{c,j}}{\sum_j P_{c,j} \sum_c P_{c,j}}}$$

where $p_{c,j}$ denotes the total amount of patent applications in technological class j by country c. This index has a weighted average equal to 1 and a skewed distribution, taking values between zero and infinity. A modified and symmetric version of this index has nicer properties in order to perform statistical analyses:

$$RTAN_{c,j} = \frac{RTA_{c,j} - 1}{RTA_{c,j} + 1}.$$

RTAN is a monotonic transformation of RTA that is better suited to the statistical analysis of ITS because it is symmetric and reduces the value of extreme observations; it has

values that belong to the [–1,1] set. RTAN>0 (RTAN<0) means that country c is relatively specialised (de-specialised) in class j.

## 5.1 World patent shares

Figure 1 shows the world patent shares for the emerging economies in the seven sectors and in the two sub-periods (1990-1994 and 2000-2004).

China and India display a considerably higher percentage growth of their world shares between the two sub-periods, in particular in high opportunity sectors like Electrical Engineering and Electronics and Pharmaceuticals and Biotechnology.

However, even if China and India show the highest shares in most of technological classes, to some extent in some sectors other countries play an important role. For example in Instruments also Russian Federation play a significant role; in Mechanical and Transports Russian Federation and Brazil follow the China, while South Africa has the highest share in Consumer Goods and Civil Engineering after China.

## 5.2 International technological specialisation

Figure 2 show the ITS as measured by equation (5.2). In the period 90-95 the selected emerging countries are specialised in Chemicals and Materials, and to some extent in Pharmaceuticals and Biotechnology and in Industrial Processes. At the same time they were heavily de-specialised in Electrical Engineering and Electronics and Instruments.

It is noteworthy that, if we consider all the emerging countries together, it seems they deepen their specialisation pattern over the ten years considered. Apart from the Electrical sector for China and the Pharmaceutical sector for Brazil, the RTAN grows in the sectors where in the first period it is positive and declines in the sectors where in the first period it is negative (as we show in the next section).

China and India are also becoming more specialized in Chemicals and Materials. However, they are massively counteracting the initial de-specialization in Instruments and in Electrical engineering and Electronics.

## 5.3 Stability of Specialization Patterns

This section analyses the dynamics of technological specialization patterns in Latin America. Specialization is defined as a process that occurs within a country across sectors.

To assess the stability of the technological specialization we refer to a simple regression analysis of the following equation:

$$RTAN_{c,j}^{t2} = \alpha_j + \beta RTAN_{c,j}^{t1} + \varepsilon_{c,j}$$

where t1 and t2 refer to the first and second sub-periods (85-89 and 95-99 respectively). If $\beta = 1$ there is no structural change between t1 and t2. If $\beta > 1$ countries are becoming more specialized (de-specialized) in sectors where they are already specialised (de-specialized). Finally if $0 < \beta < 1$ we observe that specialization levels of each sector tend to converge to the mean value. If $\beta = 0$ patterns of specialization are randomly distributed.

The estimation of the above equation using Ordinary Least Squares shows that the estimated $\beta$ is 0.78. This might suggest a pattern of slow $\beta$−de-specialization. Moreover the F test (F= 5.79; p-value=0.02) suggests that the estimated parameter $\beta$ is statistically different from one. Hence this evidence therefore shows structural changes in emerging countries in the period considered.

# 6 CONCLUSIONS

This report analyses empirically the nature of patenting activity in a selected number of large emerging economies countries using two databases: the USPTO and the EPO patent database. It shows that international patenting is growing but it's not a pervasive and diffused activity across all the countries. If China and India experienced a growth rate in patenting activity almost always above the 200% in the 3 periods considered (1990-1994, 1995-1999, 2000-2004), on the other side South Africa - which was the country with more patent applications in the first period at the USPTO, is the country with the lowest growth rate.

This report analyses also the technological position of emerging countries in the world. It shows that the emerging shares of world patents are extremely low, even though it is increasing in almost all sectors. We also underlined the sectoral heterogeneity in the patenting activity: in the period 90-95 the selected emerging countries are specialised in Chemicals and Materials and to some extent in Pharmaceuticals and Biotechnology and in Industrial Processes. At the same time they were heavily de-specialised in Electrical Engineering and Electronics and Instruments.

In the 2000-2004, apart from Electronics and Instruments, where all countries seems performing better, Brazil seems performing better in Pharmaceutical and Chemicals and Industrial Process; China in Consumer Goods; India in Chemicals; Mexico in Industrial Processes, Mechanical and Consumer Goods; South Africa in Chemicals, Pharmaceutical and Industrial Processes.

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**Table 1. Patent applications at the EPO and USPTO, by inventors' country (growth rate with respect the previous period**

| | EPO Patent Applications | USPTO Patent Applications |
|---|---|---|
| | Brazil | |
| 1990-1994 | 250 | 408 |
| 1995-1999 | 517 | 737 |
| 2000-2004 | 902 | 1200 |
| total | 1669 | 2345 |
| | China | |
| 1990-1994 | 218 | 432 |
| 1995-1999 | 712 | 1233 |
| 2000-2004 | 4125 | 7762 |
| total | 5055 | 9427 |
| | India | |
| 1990-1994 | 165 | 248 |
| 1995-1999 | 535 | 1117 |
| 2000-2004 | 2315 | 4899 |
| total | 3015 | 6264 |
| | Mexico | |
| 1990-1994 | 95 | 268 |
| 1995-1999 | 229 | 543 |
| 2000-2004 | 335 | 802 |
| total | 659 | 1613 |
| | Russian Federation | |
| 1990-1994 | 627 | 537 |
| 1995-1999 | 1143 | 1712 |
| 2000-2004 | 1417 | 1973 |
| total | 3187 | 4222 |
| | South Africa | |
| 1990-1994 | 452 | 635 |
| 1995-1999 | 658 | 788 |
| 2000-2004 | 769 | 931 |
| total | 1879 | 2354 |

**Table 2. Patent at national offices, by inventors' country. Source: Wipo**

| | Brazil | China | India | Mexico | Russian Federation |
|---|---|---|---|---|---|
| 1992 | 6,474 | 14,409 | 3,424 | 7,695 | 51,344 |
| 1993 | 6,650 | 19,618 | 3,720 | 8,212 | 32,477 |
| 1994 | 6,497 | 19,067 | 4,800 | 9,944 | 25,745 |
| 1995 | 7,448 | 18,699 | 6,566 | 5,234 | 24,444 |
| 1996 | 8,057 | 22,742 | 8,562 | 6,754 | 25,994 |
| 1997 | 16,235 | 24,774 | 10,155 | 3,962 | 23,229 |
| 1998 | 16,037 | 47,396 | 8,954 | 3,705 | 24,753 |
| 1999 | 17,509 | 50,044 | 4,826 | 12,110 | 27,844 |
| 2000 | 17,376 | 51,906 | 8,503 | 13,061 | 32,337 |
| 2001 | 17,204 | 63,450 | 10,592 | 13,565 | 34,090 |
| 2002 | 16,022 | 80,232 | 11,465 | 13,062 | 33,308 |
| 2003 | 17,704 | 105,317 | 12,613 | 12,207 | 34,870 |
| 2004 | 19,272 | 130,384 | 17,466 | 13,198 | 30,190 |
| 2005 | 20,005 | 173,327 | 24,505 | 14,435 | 32,253 |
| 2006 | 24,074 | 210,501 | 28,940 | 15,505 | 37,691 |

Source: WIPO Statistics Database, December 2009. Note: Counts are based on the patent filing date. Resident filing refers to an application filed at an Office of or acting for the State in which the first-named applicant in the application concerned has residence. Data for South Africa are incomplete and are not reported.

**Table 3. Percentages of patents with at least a foreign co-inventor**

| | Brazil | China | India | Mexico | Russian Federation | South Africa |
|---|---|---|---|---|---|---|
| 1990 | 8 | 13 | 34 | 22 | 9 | 16 |
| 1991 | 10 | 14 | 46 | 5 | 30 | 9 |
| 1992 | 12 | 16 | 33 | 7 | 30 | 5 |
| 1993 | 14 | 19 | 33 | 14 | 31 | 10 |
| 1994 | 16 | 23 | 25 | 23 | 37 | 7 |
| 1995 | 16 | 24 | 19 | 31 | 44 | 19 |
| 1996 | 11 | 20 | 25 | 24 | 44 | 19 |
| 1997 | 18 | 28 | 22 | 21 | 45 | 10 |
| 1998 | 13 | 31 | 30 | 19 | 43 | 13 |
| 1999 | 16 | 25 | 28 | 27 | 41 | 9 |
| 2000 | 14 | 22 | 18 | 25 | 46 | 19 |
| 2001 | 18 | 22 | 22 | 21 | 53 | 10 |
| 2002 | 25 | 25 | 20 | 23 | 47 | 17 |
| 2003 | 16 | 27 | 22 | 41 | 47 | 8 |
| 2004 | 23 | 35 | 26 | 29 | 55 | 18 |

**Table 4. Top Domestic Applicants at the USPTO**

| | *1990-1994* | | *2000-2004* |
|---|---|---|---|
| **Brazil** | | | |
| PETROLEO BRASILEIRO S.A. - PETROBRAS | *58* | PETROLEO BRASILEIRO S.A. - PETROBRAS | *49* |
| EMPRESA BRASILEIRA DE COMPRESSORES S.A. -EMBRACO | *15* | EMPRESA BRASILEIRA DE COMPRESSORES S.A. -EMBRACO | *25* |
| METAL LEVE S/A INDUSTRIA E COMERCIO | *14* | MULTIBRAS S.A. ELETRODOMESTICOS | *24* |
| **China** | | | |
| CHINA PETRO-CHEMICAL | *22* | HUAWEI TECHNOLOGIES | *251* |
| INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE | *11* | HONG FU JIN PRECISION INDUSTRY (SHENZHEN) | *135* |
| TIANJIN UNIVERSITY | *6* | TSINGHUA UNIVERSITY | *120* |
| **India** | | | |
| COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH | *38* | COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH | *758* |
| RANBAXY LABORATORIES | *6* | STMICROELECTRONICS INDIA | *119* |
| ZANDU PHARMACEUTICAL WORKS | *3* | RANBAXY LABORATORIES | *55* |
| **Mexico** | | | |
| HYLSA | *8* | DOMENGE, ALBERTO G. | *7* |
| CENTRO DE INVESTIGACION Y DE ESTUDIOS AVANZADOS DEL I.P.N. | *7* | INDUSTRIAS JOHN DEERE | *5* |
| INDUSTRIAS JOHN DEERE | *5* | INNOVAMEDICA | *5* |
| **South Africa** | | | |
| CSIR | *17* | SASOL TECHNOLOGY (PROPRIETARY) | *36* |
| TANK, KLAUS | *13* | CSIR | *16* |
| TECHNOLOGY FINANCE CORPORATION (PROPRIETARY) | *13* | UNIVERSITY OF CAPE TOWN | *9* |

Domestic applicants are companies that reported a national address in the patent application.

**Figure 1. World Patent Share (USPTO data)**

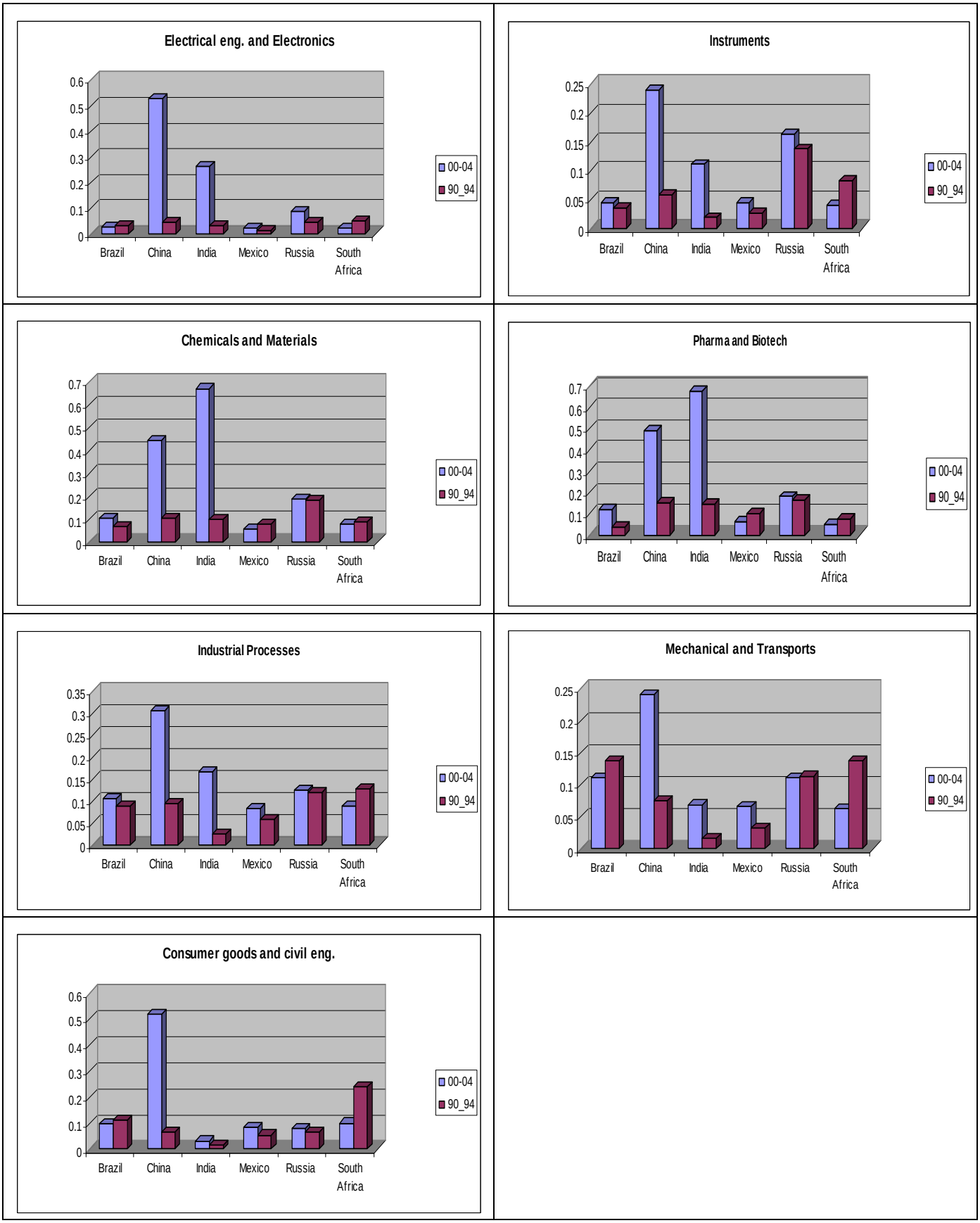
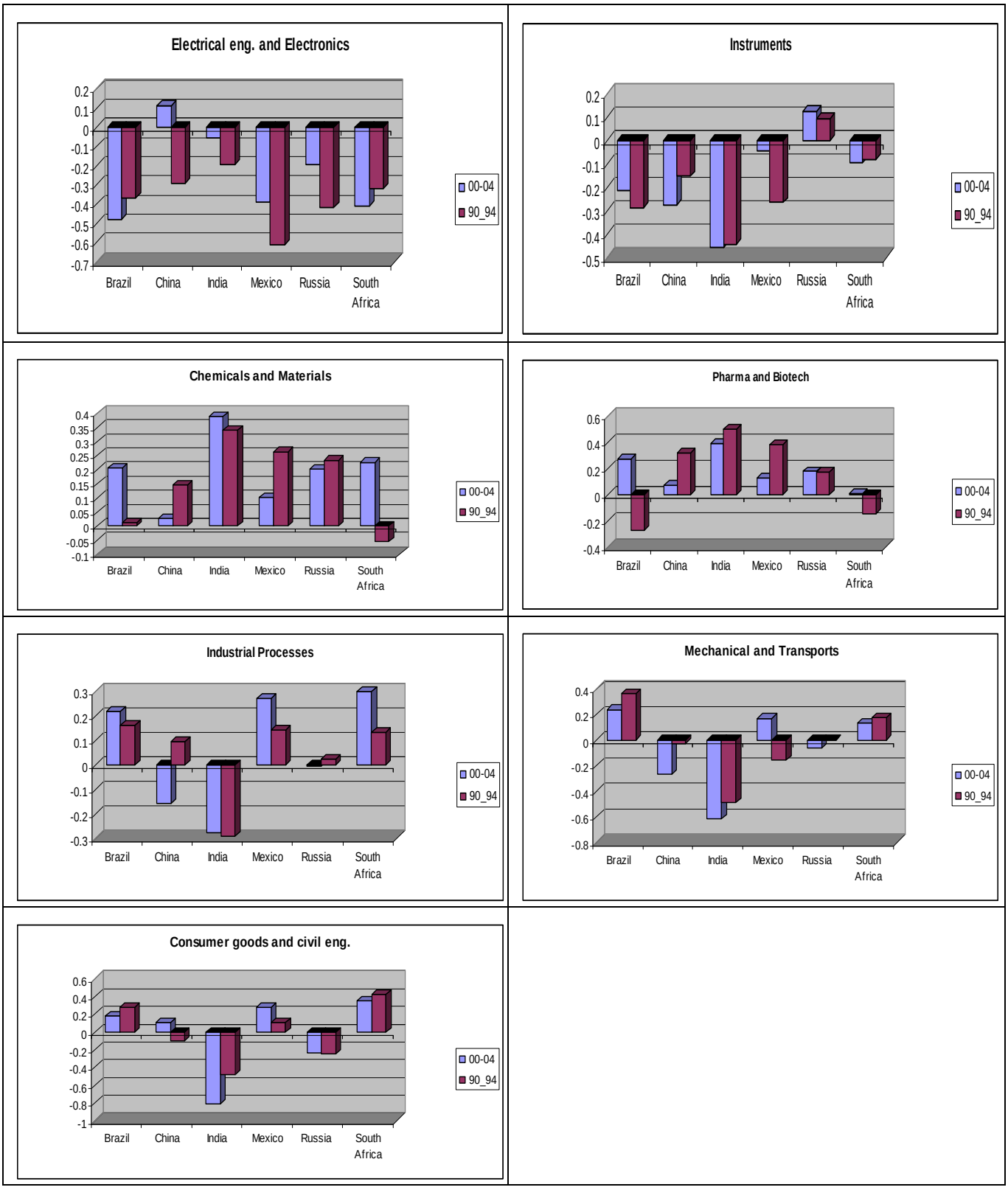
**Figure 2. Revealed Technological Advantages (USPTO data)**