HIGHLIGHTING TECHNOLOGY TRANSFERING STRATEGIES TO BE ADOPTED BY COLOMBIAN UNIVERSITIES: COMPARISON ANALYSIS WITH GERMANY

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RESUMEN

Colombia is becoming an important regional reference in Science, Technology and Innovation (STI) due to its constant growth investment, a new internal structure of STI governance and an increasing effort from Universities and private sectors to bet even more on knowledge-based businesses. However, the lack of governance of the main Institutions involved in STI management, the unclear shape of the network created between these institutions, the lack of labor division, among other factors, make the National Innovation System (NIS) weak to maintain growth in the long term, in order to push economy forward.

The analysis of Germany’s technology transferring model and its surrounding NIS, gives into account some of the missing linkages and activities in Colombia: Incentives for technology transferring processes, technology transferring capabilities, technology absorbing capabilities, compatibility, intermediaries, division of labor to cite only a few.

This research will highlight the main strategies used in Germany’s Technology Transferring model, which can be articulated by Colombian’s Universities to improve the dynamic of the whole NIS, relying on the fact that an economy that ensures a higher level of well-being, base growth and social development in science, technology and innovation.

Germans have already tested the majority of the technology transferring channels, and have begun to intensify in the successful ones. Just like others OCDE countries, the combination of channels like entrepreneurship, incubators, strong Intellectual property services, and joint technology initiatives, specialization within clusters or special sectors that can be included in any Colombian university’s transferring strategy.
INTRODUCTION

Colombia is becoming an important regional reference in Science, Technology and Innovation due to its constant growth investment in STI as shown in Table 1 (Lucio, et al., 2013), a new internal structure of STI governance (Congreso de Colombia, 2009) and an increasing effort from Universities and private sector to bet even more on knowledge based businesses (OCyT, 2012). However, the lack of governance of the main Institutions involved in STI management, the unclear shape of the network created between this institutions and lack of labor division, the unmanaged resources coming from royalties from minery and also the lack of knowledge and experience in technology transferring processes, make the National Innovation System (NIS) weak to maintain growth in the long term, in order to push economy forward.

Table 1 STA expenditure as a percentage of GPD for some selected countries, 2002-2011

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<tbody>
<tr>
<td>Argentina</td>
<td>0.46%</td>
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<td>Brasil</td>
<td>1.26%</td>
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<tr>
<td>Canadá</td>
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<td>Chile</td>
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<tr>
<td>Colombia</td>
<td>0.41%</td>
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<td>Costa Rica</td>
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<tr>
<td>Cuba</td>
<td>0.94%</td>
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<tr>
<td>Ecuador</td>
<td>0.18%</td>
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<td>0.20%</td>
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<td>España</td>
<td>1.05%</td>
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<tr>
<td>Estados Unidos</td>
<td>2.63%</td>
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<td>2.71%</td>
<td>2.85%</td>
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<tr>
<td>México</td>
<td>n.d.</td>
<td>0.75%</td>
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<td>n.d.</td>
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<tr>
<td>Panamá</td>
<td>0.74%</td>
<td>0.90%</td>
<td>0.70%</td>
<td>0.68%</td>
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<td>0.50%</td>
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<td>0.47%</td>
<td>n.d.</td>
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<tr>
<td>Portugal</td>
<td>0.71%</td>
<td>0.74%</td>
<td>0.78%</td>
<td>0.99%</td>
<td>1.17%</td>
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<tr>
<td>Trinidad y Tobago</td>
<td>0.23%</td>
<td>0.21%</td>
<td>0.19%</td>
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<td>Uruguay</td>
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<tr>
<td>Venezuela</td>
<td>0.31%</td>
<td>0.25%</td>
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<td>1.78%</td>
<td>2.69%</td>
<td>2.54%</td>
<td>2.36%</td>
<td>n.d.</td>
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<tr>
<td>América Latina y el Caribe</td>
<td>0.69%</td>
<td>0.67%</td>
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<td>0.81%</td>
<td>0.84%</td>
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<td>1.11%</td>
<td>1.11%</td>
<td>1.00%</td>
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</table>

Source: Lucio, Jorge. (2013). Indicadores de Ciencia y Tecnología Colombia. Bogota, Colombia: Observatorio de Ciencia y Tecnología
The goal proposed by the National Planning Department of promoting competitiveness through innovation in Colombian’s Vision 2019 (DNP, 2006) must be achieved articulating R&D efforts with industrial sectors, meaning that the usage of diverse technology transfer channels should be used and the following compliances met: “(a) there is staff trained to absorb, adapt and innovate, (b) technology transfer is liable when existing local firms have the capacity to imitate, adapt and generate technology and (c) ownership public policy measures are established” (DNP, 2006).

Even though the number of patents radicated from Universities has increased (Colcienicas, 2013), and some research groups had adventured through technology transferring processes with new products, industrial secrets or spin-off’s, there are still some missing links in the connection between STI and Economy. “Effective technology transfer, especially for small producers, faces serious deficiencies…”, “…in quality and efficiency of adoption, derived from an institutional model in which the results of research and development are not widely appropriated by producers” (IICA - Instituto Interamericano de Cooperación para la Agricultura, 2010).

As some of the first dispositions are met to begin the operation of a knowledge based economy in Colombia, there is still a long way before we can manage to follow the top OCDE countries. Never the less, looking at history and evaluating successes and mistakes from these countries, one can realize some of the strategies that can be developed to move one step towards finding out what is missing from the general technology transfer model in Colombia.

On the other side, with a clear governance and structure and after overcoming a fusion between the east and west science and technology systems, Germany has prevail as the most important technology developer in the world (Meyer-Krahmer, 1992). Strong research institutes, off-bound-from-universities research (außeruniversitäre Forschung AUF) and the Hochschule and University systems generate the perfect climate for efficient use of resources and outcomes to an economic field. Different governmental programs aimed to involve even more industry and the research and innovation system have given German industry conscience to invest and relate naturally with academy and other knowledge generators, adding more value and becoming global leaders in their sector. This is translated into the increase of innovation active companies and incoming large international companies to found R&D centers in Germany (BMBF, 2012).
This document will go through both Colombian and German’s National Innovation Systems’ technology transferring strategies, compare or analyze some of them and suggest as conclusion some possible ways to improve knowledge and technology transfer in Colombian Universities.

RATIONALE
This document will highlight the main strategies used in Germany’s Technology Transfering model that can be articulated by Colombian’s Universities to improve the dynamic of the whole NIS, relying on the fact that an economy that ensures a higher level of well-being, base growth and social development in science, technology and innovation (DNP, 2006).

The benefits for Universities with the improvement of a better technology transferring system, as stated by Michael Wacholder: “…one of the main incentives, but not the only one, is the economical, which is linked to the marketing of University knowledge in the market, and also becomes an important source of additional income different from conventional”. In addition to economic benefits, this will increase quality in education, due to the close relationship with industry; the knowledge expertise and best practices to encompass the praxis and lexis of higher knowledge, among others. Finally, we can say that the transfer encourages the fundamental mission of the university, which is based on providing socio-economic development (Ramírez, 2013).

Above all the reasons for boarding this issue, is the need to fill the gap between research products and market ready products in Colombia, as the mainstream for Technology Transferring Offices (TTO’s), venture capital investors, NIS institutions, R&D personnel, innovation facilitators and people that are already playing in Colombia’s National Innovation System and want to improve economy through knowledge and technology transferring processes.

Some of the reasons for setting Germany as the reference point are:
- R&D intensity\(^1\) reached approximately 2.7 % in 2008, the highest level since Germany was reunited.
- The German Association of Chambers of Industry and Commerce (DIHK) published in 2009, showed that about 30 % of companies surveyed attributed their innovations to an improved research and innovation policy. (BMBF, 2010)
- Germany was until 2008 the largest exporting country in the world, followed by USA and China.

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\(^1\) Percentage of GDP spent on research and development
Germany, Japan and the USA are leading countries in terms of high tech trade are, being Germany the largest also in regard to R&D intensive goods.

“German strengths on cutting edge areas (goods and commodities with necessary investments in R&D of 7% and more), can only be found in electronic medical instruments, automotive sector, machinery, as well as chemistry (pigments or special chemistry), positively contribute to German export portfolio” (Fraunhofer Institute et al, August 2008).

As seen in Figure 1, German’s behavior and strategies to maintain leadership in the market of high-tech trade are by far the best within the close competence of the other two big players in the sector of innovative products and goods. This trend will continue with the new innovation policies adopted by the High-Tech Strategy given the fact that it has had a high mobilization effect (BMBF, 2010), promoting more privat investment in excellence sectors as more money is invested by the government.

*Figure 1 Share of worldwide trade of high-tech (in percent)*

TECHNOLOGY TRANSFER

Definition

The concept given by UNCTAD for Technology Transfer refers to as “Transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service excluding those transactions merely involving sales or the lease of goods” (as cited in Dornberger, 2014), being this definition the one adopted for understanding the importance of the transfer as a way for achieving innovation and as a vehicle that brings the ideas and knowledge closer to a clearer market approach.

Some of the different channels used to achieve technology transferring processes are listed in Table 2, in which the transfer mode refers to the kind of relationship between the provider and the receiver of the technology and also related to the level of economic scope of the transferring (micro, meso, macro, meta).

Table 2 Channels of international technology transfer

<table>
<thead>
<tr>
<th>Transfer Form</th>
<th>Transfer mode</th>
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<tbody>
<tr>
<td></td>
<td>Market</td>
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<tr>
<td>Foreign direct investment (FDI)</td>
<td></td>
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<tr>
<td>Joint ventures</td>
<td>X</td>
</tr>
<tr>
<td>Strategic alliance</td>
<td>X</td>
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<tr>
<td>Subcontracting</td>
<td>X</td>
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<tr>
<td>Licensing</td>
<td>X</td>
</tr>
<tr>
<td>Trade with capital goods</td>
<td>X</td>
</tr>
<tr>
<td>Mobility of people (Brain drain, brain gain)</td>
<td>X</td>
</tr>
<tr>
<td>Technical cooperation (TC)</td>
<td></td>
</tr>
<tr>
<td>Spin-off’s / Start up’s</td>
<td></td>
</tr>
<tr>
<td>Trade secret</td>
<td>X</td>
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</tbody>
</table>

Is usual (and necessary) to link technological and service innovation together, as being prerequisites for applications in a wide variety of sectors. “The effectiveness of key technological developments is critically dependent on their successful transfer to commercial application and on their production being harmless to human health and the environment” (BMBF, 2010).

Scope
This work evaluates the market and network transferring modes used in Germany and compares them to the ones used in Colombia, analyzing only the micro and meso level of technology transferring processes (Dornberger, 2014), looked from the technology push and market pull also (Schumpeter, 1956). International technology transfer (Foster, 2012) and other hierarchical ways of knowledge and technology diffusion like FDI and mobility of people are not contemplated in this paper.

Highlighting the Process
The generation of new knowledge and its commercialization are first steps of innovation. A technology transferring process can only be achieved if knowledge is put to commercial use both quickly and efficiently, meaning this that the linkage between a knowledge generator and industrial or commercial institutions should be provided. Universities usually lack commercialization mission, instead they create relationships with other actors inside the NIS.

Promoting knowledge transfer is often done via a dual, but rather linear, model of commercialization, characterized by supply-push forces (Schumpeter & Backhaus, 1934) where universities and PRIs transfer research results via the sale, transfer or licensing of intellectual property, to existing firms or to new ventures (spin-offs). The second model is a market-pull based on contract research or collaborative research and development (R&D) whereby “universities and PRIs are solicited by industrial actors to find solutions to production and innovation problems” (OECD, 2012).

The interaction between this two models and its integration into the NIS generates collaboration either upstream into the research side (also called “open science”) or downstream on the commercialization side (also called “open innovation”). The latter one creates other kind of actors or intermediaries within the system that broker commercialization activities, mostly intellectual property (IP) services (OECD, 2012).
Innovation policies are to integrate and create playable fields for this relationship to develop naturally in a business environment, where the knowledge generators, the receivers and the intermediaries work together with the goal of promoting innovation. Rules, funding and special orientation should be provided and governed. For this reason, Germany’s Federal and Colombian’s democratic Governments are doing efforts to continue improving the links between science and industry (BMBF, 2010) bringing tools in the forms of programs that have been, well tested through a very rich technology transferring history for Germany, but that lack coordination and consistency for Colombia (OCDE, 2013).

The direct outputs of a well-developed NIS with healthy technology transferring processes are the international or trans-national trade activities, especially export and furthermore, high-tech goods and commodities exports. High-tech markets are- as a matter of fact- more internationalized than low tech markets, given the fact that the performance of a high-tech good can be compared with similar or substitute products worldwide. “Indicators for the output of innovation systems is exports and imports of goods and commodities in general, as these are indications for the success of input (R&D expenditure) or throughput (scientific publications or patent applications) of innovation systems” (Fraunhofer Institute et al, August 2008).

Main Ideas for the Analysis

Guided by the following questions, this document will analyze the complexity of both models and try to highlight the main strategies used in Germany’s Technology Transferring model and compare these findings with the ones applied by Colombian’s Universities:

- Why is Germany so effective in technology transferring processes?
- What strategies are missing in Colombia in comparison with Germany to improve dynamics in the NIS?
- How can Colombian Universities improve the knowledge and technology transfer between university’s research and industry?

THE COLOMBIAN INNOVATION SYSTEM

As shown in Figure 2, Colombian Innovation System was created around the year 2000, with the leadership of Colciencias, institution that managed the Science and Technology System. This managing
The governmental institution is guided by the National council of Science and Technology, who is in charge of missionary orientation for the whole system, and giving the power to implement different programmes. This programmes focus on different areas and have different financial sourcing, actually coming in great amount from national science, technology and innovation budget and also from the 10% coming from royalties gained by minery exploitation in Colombia.

Figure 2. Colombian Science Technology and innovation system


The broad programs manage different projects submitted by public and private research institutions under calls and give assessment and funding. These programs are: Basic Sciences, Social and Human Sciences, Industrial Technological Development and Quality, Agricultural Science and Technology, Environment and Habitat, Scientific studies of education, Science and Health Technology, Science and Technology of the Sea, Biotechnology, Electronics Telecommunications Computer, Mining and Energy.
Other important actors that have been growing inside the system are for example:

- **Innpulsa Colombia**: Institution that fosters high-impact entrepreneurship (dynamic entrepreneurship) with direct national funds. Offers different programs for SME and research institutions.
- **Tecnova**: Created by private and public capital as a special service provider: Intellectual property management, technology scouting (surveillance), competitive intelligence. Its characteristics have introduced this institution to turn into a technological broker given the complexities of patent negotiation.
- **Ruta-n**: Public local institution belonging to a medium sized city in Colombia (Medellin), developed to attract FDI and foster innovation trough high-tech services and also public local government funds.

National Department of Planning and Colciencias are the leading agencies of the National System for Science, Technology and Innovation (NIS). The World Bank (WB) and the Inter-American Development Bank (IDB) have provided a loan of USD 50 million for strengthening Colombia’s STI governance structure (OECD, 2012).

**Technology transfer in Colombian history**

There is no author or institution inside Colombia that can quote a technology transferring model. All universities are actually working around their own models, via knowledge transferring from other countries or regions or through empirical processes. One example of the first is the Westfälischen Wilhelms- Universität, who is actually leading, teamed up with other 5 latin America Universities the project: “d-PoLiTaTE Desarrollo de Programa para Líderes en Transferencia Tecnológica/Entwicklung eines Programms für Führungskräfte im Forschungstransfer” and that is being coordinated by the Innovation Office of Münster Univerisität (Arbeitsstelle Forschungstransfer AFO), Germany. Other models like Spain and Brasil are being studied and adapted.

It is clear that through other technology transferring channels Colombia has had access to newly developed technology coming from developed countries, and that Universities have been working with companies and government for years. However, awareness on Intellectual Property rights and knowledge asymmetry between technology givers and receivers have burdened during years some of the development possibilities in the science and technology sector.
One of the most advanced universities in technology transferring services is the Universidad de Antioquia, who began in 2002 the “University, Enterprise, State” meetings, gathering the three elements from the triple helix in search for more interactivity in the system (Robledo Velásquez, 2002). Its experience has already given accounts of some licensing processes and spin-off creations as pioneer and leader in technology transferring in Colombia.

As stated by Montenegro (2011), Colombia is reaching the second stage of the following scale:

- Connection with global flows of knowledge
- Scope or convergence (catch up)
- Strengthening the capacity of innovation and technological leadership

More than 10 years have passed since the National Innovation System has been adopted and many indicators have increased, for example number of patents radicated, start-ups companies founded, high-tech entrepreneurship and the increase in R&D investment. However, OCDE (2013) recently published the results of the “Studies in the Innovation policies: Colombia” with some important facts to be issued around the whole system. Some of the findings where:

- Low levels of productivity and innovation business and a long "tail" of weak companies.
- A growing dependence on commodities or raw minerals and slow diversification into new economic activities.
- High levels of inequality of income and opportunity, particularly in regard to access to higher education.
- The small scale of formally organized innovation system and its concentration in an "island" of academic and research institutions.
- Limitations of human capital and resources in research organizations resulting in a low (though growing) research results of varying quality.
- Deficiencies in training and technical technological learning and production companies.
- A great social need for innovation, which is not sufficiently articulated in terms of demand or supply related to innovation.
- A combination of STI policies unbalanced, biased towards the promotion of a narrow range of modes of innovation of little relevance to most businesses and social innovation.
- A limited policy coordination between ministries and regions.

Even though this not so cheering findings, OCDE confirms in the same report that the potential of Colombia in becoming regional science, technology and innovation leader are potentially high.
GERMAN INNOVATION SYSTEM

As shown in Figure 3, the German innovation system links strongly the federal and regional governments with different financial sources and with a strong set of public research institutions that share the responsibilities and have a clear labor division within the system as described in this same chapter.

**Figure 3 Organizational chart of institutions in the field of research and innovation**

Research Organizations by Institutional Funding:

- Federal and Industry
  - BMBF: Federal Ministry of Economics and Technology
  - BMWi: Federal Ministry of Education and Research
  - DFG: German Research Foundation
  - Fraunhofer Society
  - GSI: German Synchrotron Light Source
  - Helmholtz Association
  - UNESCO: United Nations Educational, Scientific and Cultural Organization
  - WSI: Leibniz Association
  - HEIs: Higher Education Institutions

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  - BMBF: Federal Ministry of Economics and Technology
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Innovation Governance

The Federal Government through the Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Economics and Technology (BMWi) in conjunction with the 16 Länder (Federal States) governments are the main state actors in the whole German NIS, directing both public and private R&D activities towards specialized fields of technology, particularly the so-called thematic R&D programmes and providing institutional funding for the public research organizations (Rammer, 2011).
The 16 Länder’s main priority in research and innovation policy is to fund universities, some industry linkages and innovation programs in the higher education sector and others offered both by Federal ministries and State governments, e.g. R&D grants programs: financing of technology start-ups, venture capital programs and loans for innovation projects. Enterprises use both Federal and State research and innovation programs almost in the same proportion (Rammer, 2011).

Informal co-operation at parliamentary level and joint commissions make possible coordination between the policies set by both the Federal and the State governments. “The Bundesrat, the second chamber of the parliament, consists of representatives of the State governments and has to endorse many laws passed by the first chamber, the Bundestag”. (Rammer, 2011)

**Stakeholder Involvement**

Most important stakeholders in German innovation policy are:

- The Federal Association of German Industry (BDI)
- The German Chamber of Trade and Commerce (DIHK)
- The Federation of German Unions (DBG)
- Science and technology organizations (Fraunhofer Society, Helmholtz Association, Leibniz Association, Max Planck Society, German Research Foundation, Science Council, Conference of University Presidents).
- In 2008, the Parliament (Bundestag) set in force a new independent advisory committee, the Expert Commission on Research and Innovation, which reports to the Federal Government (Rammer, 2011)
- Projektträger. These are program administering agencies responsible for certain fields of technology and/or government programs and typically having a research background from one of the large public research centers organized in the Helmholtz Association. Generally, Federal Ministries delegate the administrative and bureaucratic tasks to this organizations.
- University Aninstitutes. These actor represent the TTO’s in the American sense, because they serve as direct intermediaries between industrial customers and Universities. These are legally independent private firms, giving them much more flexibility and effectiveness in cooperation. They are also known as group of institutes. “It can be assumed that their significance will grow
further with the increasing externationalization of R&D from industry” (Fraunhofer Institute et al, August 2008).

- Patent exploitation firms. As a result from the Federal Government’s SIGNO programme, this firms assess inventions in terms of their market potential, patentability and provide advice and funding for the property right application (EFI, 2012). The Hochschulverbund or higher education network founded this offices to work as independent and external service providers, and have been specializing their portfolio depending on the thematic of the higher institution they are in charge of. These guarantees that there is no direct competition between each patent exploitation firm (EFI, 2012).

**Policy Analysis, Evaluation and Monitoring**

Priority setting in German innovation policy uses a mix of instruments initiated by Foresight activities particularly relevant for identifying upcoming fields of technology and run by each Federal Ministry with at least one separate unit responsible for strategy and priority setting (Rammer, 2011). SME’s and the Mittlestand companies are the main focus of German policy, giving also emphasis to regional development due to unbalances left after the reunification. Cluster support and university industry collaborations are the main strategies pursued in the past and the present. Key factors in the system are the distribution of responsibilities as well as the increased importance of innovation funding activities on the federal level (Fraunhofer Institute et al, August 2008).

The Bureau for Technology Assessment works directly for the German Parliament as a review unit for technology and innovation policy. On-going programs are monitored by ‘Projekträger’, but many programs are also subject to on-going evaluations. “Ex-post evaluations are carried out for most large Federal programs” (Rammer, 2011). Effectiveness of innovation policy has been published for programs like: Research Bonus2, IGF3, ZIM4, EXIST5, High-tech Start-up Fund6 and SIGNO7. Other programs and initiatives are currently in the process of evaluation, e.g. SME Innovative, Top Clusters, ERP Start-up Fund, ERP Innovation Program and Validation of Innovative Potentials. Evidence-based adjustment over programs and re-designed along identified challenges and needs for public intervention. “Recommendations of evaluations constantly focus on adjusting smaller programs details while being in favors of continuing the program as such” (Rammer, 2011).
Newly developed measures and programs are funding directly on knowledge and technology transfer from science to industry and an orientation to applications and commercialization of research results. Some of these measures include:

- Innovation-friendly regulations
- Pre-conditions for financing high tech start-ups
- Support for (small and medium-sized) enterprises in research projects

Now, policy is beginning to sharpen only a few amount of cutting-edge and cross-sectional technology fields particularly in those fields of research and technology that are critical for meeting the global challenges as well as supporting only innovative SME’s, in favor of certain topics and regions (Fraunhofer Institute et al, August 2008).

Since 2008 special programs are being designed with the goal of commercializing research results (Rammer, 2011):

- Validation of Innovation Potentials: attempts to fill a specific gap in the transfer of scientific knowledge into commercial application by offering grants to researchers at public research organizations (incl. universities) to further investigate the commercialization prospects of their research findings.
- Research Campus: provides funding for long-term oriented cooperation between universities, public research organizations and private companies.
- Top Cluster: program funds regional networks
- Innovation Alliances: initiative provides public funding for large-scale, long-term projects that are critical for developing break-through technologies.
- Innovation Union flagship initiative: has defined a number of priority areas, in particular the commercialization of research (getting ideas to the market), social innovation, public sector innovation, design and creativity, and services innovation.

**Funding**

Funding alternatives come from strong public and private sources. Each one has their own programmes and the system itself has been refining the tasks and objectives of funding for each one, articulated also with the policy and directly to the needs of improvement of more vulnerable niches like SME’s and regions. Some of the financing alternatives are:
• Deutsche Forschungsgemeinshaft (General Research Foundation, DFG), which is the most important in Germany and it is active in the whole range of disciplines – from engineering to arts and humanities. This includes programs like EXIST for start-ups and special innovations services and ZIM directed to R&D and innovation in SME’s.
• Industrial joint research funds of the German Federation of Industrial Cooperative Research Associations (AiF/IGF) whose sources are private capitals and with special programs.
• Federal funds through the Bundesministeriums für Bildung und Forschung-BMBF FHprofUndn, the Research Bonus (Forschungsprämie), the Top Cluster Competitions (Spitzenclusterwettbewerb), the innovationsinitiative Unternehmen Region
• Other programs financed by the the Bundesministeriums für Wirtschaft und Energie BMWi program Network Management East (NEMO), the program InnoNet, promotional line “Forschungskooperative” (Fraunhofer Institute et al, August 2008).
• KfW Bankengruppe as the Reconstruction Loan Corporation, is also an important funding actor in the system, with programs like ERP-Startfonds designed for companies in the field of research and innovation that are no older than ten years at the time the application is submitted.
• Public-Private funds include the High-Tech Gründerfonds (HTGF), that provides technology-oriented business start-ups with grants of up to EUR500.000 in the first founding round
• Federal Government’s “High-Tech Strategy for Germany” and co-financed by the European Social fund (ESF) have founded the EXIST programs, one of the major bets in University-Based Business Start-Ups. (EFI, 2012)

Research institutions access public and private sources, and also private firms fund their research activities with public sources as well. This share can range from 40% in the case of Fraunhofer Society up to 100% in the case of some Universities or Max Planck Institutes. Universities, primarily financed by the länder are prioritized for public funds. Especially in the recent past, many universities increased their activities to get project funding, which increases their share of this kind of financial inflow (Fraunhofer Institute et al, August 2008).

Another advantage in the whole system is the European funds that are increasing its role for the support of regional EU programs and the integration of the different systems in the network, making possible knowledge and resources exchange due to their geographical integration.
Division of Labor

The 80 institutes of Max Planck Society an also the institutes of the Helmholtz Association can be located on the side of basic science, whereas the Fraunhofer Society is the most important provider of applied science. Members of the Leibniz Association fulfill different task, ranging from long-term basic research to services for other research institutions. This division of labour is the strongest advantage in German innovation system, where a strong and clear division of tasks between research associations and societies and also between public and private actors can be found and where the responsibility and independence in research is autonomous (Dornberger, 2014). The coordination of knowledge and technology transfer, and the funding and support for commercialization is done by the policy, in regard of industri and research institutional needs.

TECHNOLOGY TRANSFER IN GERMAN HISTORY

Since the beginning of the 20th century, Germany has demonstrated its technological superiority through military applications. One of the biggest examples is the first jet reaction engine which was developed by Germany just before the end of the Second World War and its applications for military and afterwards commercial flights. There is a long list of other successful technology transferring processes that can be found in German history, however by means of this work, the liberalization of markets and the globalization effect due to the fall of the communist era as the actual trends of modern trade, create different conditions for trade and economic exchange.

Changes in the educational system like the Bologna EU integration process, followed by the Excellence initiative founded in 2005, encouraged schools to “...promote young academics and provide optimal conditions for doctorate research within a broad, disciplinary field of study. At the same time they are expected to contribute to the respective university’s development of core scientific areas” (EFI, 2012), this being an interesting process for strengthening human factors in the system. However, the Federalism Reform I (Föderalismusreform I) cuted in 2006 the money coming from Universities from the State, leaving only the sources given by the Länder for research funding. This had a beneficial interpretation for the non-university research institutes (EFI, 2012). “Due to these new regulations, framework conditions for advancing research at higher education institutions have deteriorated considerably” (EFI, 2012).
Other measures hindered public researchers’ will to produce innovations, like the abolition of the “university teachers’ privilege”, which removed the right of the public teacher to freely utilize their inventions within a university contract (§ 42 of the Act on Employees Invention (ArbnErfG)), as different from private and non-university research sector did. Since 7 of February 2002, this was removed, meaning that inventors employed in the public higher education sector have to report their job-related inventions to the respective higher education institution (EFI, 2012), which is then entitled to exploit the invention.

In 2006 in the line of NIS articulation strategies, the program “Future concepts” aimed to strengthen universities as “Elite Universities” establishing a long-term strategy for sustainably developing and enhancing top-class research and for promoting young scientists. This is articulated directly with the Clusters of Excellence program and the Excellence initiative, because “…to be eligible for this funding line, a university has to have at least one research school and one Cluster of Excellence” (EFI, 2012).

Patent applications and number of exploitation agreements have reached constant level of around 600 per year (for patent applications) since 2005 (EFI, 2012). The patent exploitation firms increased their revenues up to a total of EUR 4.9 million by 2010. In spite of this increase, patent exploitation agencies do not operate on a cost-covering basis and rely also on on public basic funding.

Some general time-line of different programs has been stablished, improving the old programs with the feedback of industry needs and the research institutions portfolio. Some of the old-improved as well as newly created programs are:

- INNO WATT was created around 2005 and was integrated in 2008 into the ZIM initiative.
- Startotheek. A central information system created to provide up-to-date and comprehensive help in start-up consulting since the beginning of 2006.
- The program EXIST SEED created in may 2007 was replaced by “EXIST Gründerstipendium”, that broaden the scope for start-up projects from non-university research institutions to profit from this support in the pre-founding, preparatory phase. In addition, projects planned to market innovative services e.g., in the education or healthcare sectors would also be promoted.
- EXIST Forshungstransfer (research transfer) was launched in November 2007 with the objective of pursuing industrial commercialization for research results with longer-term marketing potential in a more consistent manner. Researcher groups from universities and research facilities are promoted which further develop technically very demanding product ideas and plan a spin-off on this basis (Fraunhofer Institute et al, August 2008).
From July 2008 some network programs where united in a Central Innovation Program Mittelstand (ZIM). Research projects in individual firms, R&D cooperation between companies and between enterprises and research institutions, as well as R&D networks, in which many enterprises participate are the main coverage of this program.

Tax relief for companies that invest in young technology companies with Venture capital (VC) access is being improved through. The High-Tech Gründerfonds invests in VC, as does the High-tech Startup Fund, ERP Startup Fund and EXIST (OECD, 2012).

Business and science linkages are being strengthened with the Leading Edge Cluster Competition (with a budget of USD 1.5 billion), Excellence Clusters, Research Campus and Research Bonus; the German Centers for Health Research Initiative aims to improve laboratory-to-clinic knowledge transfer.

EUROSTARS, the Strategy for the Internationalization of Science and Research is meant to help German companies enter into partnerships with the world’s most innovative centers, fostering international links (OECD, 2012).

Clusters of Excellence: Consolidate existing research potential at German university locations on networking, cooperation between different university facilities, and also between universities and non-university research institutions and the private sector respectively. This should result in the Sharpening of university profiles and create excellent funding and career structures for young academics (EFI, 2012).

Result of the supervising strategies for NIS policies, some programs deadlines where removed, improved assessment was developed for new programs’ next phases. Other further adjustments where the simplification of conditions regarding stakes in under-takings, collaborative projects and the launch of spin-offs in Germany and abroad. Other laws where modified or simplified in order to promote construction of facilities for the science sector. For public institutions, regulation for procurement of goods and services, like removal of administrative barriers, free choice in terms of procedures for all suppliers and service providers where flexibilized (EFI, 2012).

Another big step regarding creation of start-ups or spin-offs where the reform of the law on limited liability companies (GmbH-gesetz) lowering the necessary minimum capital for founding GmbHs to EUR 10,000. The Federal Government’s increased by USD 1.1 billion for 2010-11 in project funding within the framework of its High-Tech Strategy and the Central Innovation Programme Mittelstand (ZIM) that was
launched as part of the Federal Government’s 2009 stimulus package (Konjunkturpaket II). Its budget was and it was voted the best innovation promotion measure in 2011.

Actual efforts from the Federal Government include the "Concept for Standardization" that, if initiated at an early stage, it can enhance the transfer of research results into marketable products and services and reduce the time it takes for innovations to reach the market. Germany is trying to make better use of the potential of standardization by integrating it more firmly into research funding (BMBF, 2010).

Future trends in Germany’s and European Innovation Systems, are the development of the first Knowledge and Innovation Communities (KIC) of the European Institute of Technology (EIT) (BMBF, 2010) and the development of a European Research Area (ERA), which will provide a strong stimulus for the fields of action of the High-Tech Strategy (LERU, League of European Research Universities, 2010). This has been posted as strategies to achieve the 3% target in R&D intensity, using the vehicle of the 8th Framework Programme (Sommer, 2010). On the other hand, Germany is lacking highly qualified natural scientist and engineers (Fraunhofer Institute et al, August 2008).

GERMANY’S TECHNOLOGY TRANSFER MODEL
As shown by Polt et al (2001) in Figure 4, and comparing this with the actual scenario of the NIS of Germany, the changes in the technology transferring model in Germany are not so different. What Germany has done in the last decade is the refinement of the different communication viases and the sophistication of the tools developed to acquire a knowledge and technology exchange between science and industry. The major challenge that the state is dealing with is the integration of east and west in only one system: “… the research system in the former GDR should be largely remodelled to match that of West Germany” (Meyer-Kramer F., 1991).
Figure 4. Heuristic Knowledge and Technology transfer model.

Comparative Analysis

The analysis of Germany’s technology transferring model and its surrounding NIS, gives into account some of the missing linkages and activities from Colombia: Incentives for technology transferring processes, technology transferring capabilities, technology absorbing capabilities, compatibility, intermediaries, division of labor to cite only a few.

The first clarifying thought that should be stated is that this comparison is done to identify best practices in Germany and which ones can be somehow adopted by Colombian universities to improve technology transferring models, having in mind that economies have different sectorial focuses and trajectories, different comparative advantages, but having in mind the overwhelming advantage of Germany in R&D and innovation indicators.

What makes Germany so effective in technology transfer is that policy and implementation go hand in hand from the governing institution, managing a decentralized organization of the actors by means of an intensified union and coordination between its institutions (Fraunhofer Institute et al, August 2008). This is due to the fact that stakeholders involved in the innovation system share a High-Tech Strategy joint vision and have been able to define and aim goals for a wide range of different fields of innovation, defined priorities, and introduced new instruments. German companies have realized the advantages of the blue ocean (Kim, 2005) in the field of high-tech trade and work hand-in-hand with research facilities. In the case of universities, they are accustomed to ask for external funding from business Enterprise sector (BMBF, 2012).

In this sense, one of the main challenges of Colombia is improving the governance in the system and linking the demand- and supply-side measures, such as R&D and technology programs. In Germany, this challenge is tackled by integrating demand-side policy elements into thematic R&D programs. The main approach is to bring together producers and potential users of new technology in early stages of technology development in order to accelerate the process of commercializing new technologies. This is done by promoting close interaction between the two sides, in this way, “technology producers can learn about the specific user needs and adapt. This interaction gives potential users awareness of new technologies and their innovative potentials” (Rammer, 2011). Another governance issue is related to funding programs which, directed from top-down, impact driven and non-directed, bottom-up science-driven research, must be balanced to guarantee a long-term evolution of the high-tech sector.

Another interesting comparison is the number and functionality of institutions in the NIS and related to the technology transfer processes. In this sense we can say that Colombia has enough public and independent Research Institutions and quality Universities, for supplying important research results, still there is not enough intermediary institutions, especially in the patent commercialization scope, given the fact that normally, Colombian market for research products is very small and start-up/spin-off culture is just beginning to grow. Only some institutions like Teennova or lawyer firms are beginning to assume this technology broker role. Another important market failure is the introduction of technology transferring institutions without any diffusion, commercialization or marketing effort. Clear example is the Seed-Bio-fabric, an important scaling facility founded in 2006 for agricultural purposes, but that has not reached enough demand to maintain sustainability income levels.
SME’s trustiness is still an issue on both countries, given the fact that usually they do not have enough money to cover research expenses and there is no guarantee that other parties can be successfully prevented from utilizing the research results, having in mind the risks of “spill-over effects” that can occur (Fraunhofer Institute et al, August 2008), i.e. other actors or competitors using the same technology being developed through reverse engineering or plagiarism. Thus, investor innovative companies cannot realize the gains of research results under this circumstances.

Scientific publications, academic lectures and collaborative projects are regarded by German researchers as the key transfer channels to the private sector (EFI, 2012) and have been found to be important technology transferring measures (Cohen et al., Foray and Lissoni quoted by OECD 2012). In this sense, Colombia is improving in exponential proportions, however other forms of transfer such as advanced training, advisory services or the launch of spin-offs are barely regarded by research personnel. Research commercialization and knowledge transfer are considerably broader than patenting, that remains somewhat underused due to the fact that some technological research products need long periods of prototyping and testing. However, some of these strategies may fail due to lack of continuity of funding at times of constrained budgets (or political shifts); asymmetric benefits and burdens; lack of participation due to insufficient incentives for researchers, and unclear technology transfer mechanisms.

A major tendency in the model is the professionalization and increasing scale of technology transfer bodies (through the regrouping of smaller ones), the use of Spin-offs and incubators by means of technology maturation. Contract research, and patenting and licensing remain the main instruments, together with mounting attention to open science (OECD, 2012). German, as well as Colombian universities with enough capacity to develop important amount of commercializable research products, sets out a technology transferring office TTO (or An-institutes, as described in the sources). This forms of organization are often maintained in Germany between various universities, with own funds or project funding from federal promotional programs. “Many TTOs have expanded their role and services from managing technology transfer (invention disclosures, filing patents) to a wide range of IP management activities and have increased the quality of technology transfer staff through training and competitive employment policies” (OECD, 2012). Something similar happened to Tecnova, whose mission of joining demand and supply of R&D does not generates enough income to sustain the specialized services in the portfolio, turning attention into other processes like innovation assessment or project structuring.

Venture Capital in Germany is being mobilized from the public sector in programs like the High-Tech Gründerfonds, High-tech Startup Fund, ERP Startup Fund and EXIST. This kind of public investment in
risk capital in Colombia is yet to be tested, because of the law restriction of investing public funds in high risk funds.

Economic crisis has taken its toll in research funding, that is why commercialization efforts are becoming more urgent for public and private institutions. Some trends have developed since the last decade inside the OCDE countries to overcome these impasses:

- As stated by Etzkowitz (2001), research groups inside PRIs and universities have become more entrepreneurial as interrelation between academy and economic sectors increases. Collaborative industry-science linkages ensure the transferring processes and promotes university spin-offs (OECD, 2012).
- Intellectual property collaboration mechanisms like “patent pools” allow for knowledge markets and networks to develop.
- Technology transfer through education and training (disembodied technology transfer) and asset acquisition (embodied technology transfer) encourage technology diffusion and adoption by providing access to knowledge, in terms of innovation skills (Popp quoted by OECD, 2012).

Colombia has managed to survive both crisis (2008 and 2012) with an important terrain gained in resources from minery royalties and other public funding for R&D and innovation, but institutions are competing for resources and research thematic. The novelty of the NIS, created no longer than 10 ago, has not yet given the time to structure a excellence strategy, but it is being integrated to other local and regional initiatives like clusters and international mobility of researchers. According to GEM (2013), Entrepreneurship management in Colombia is well above average and good perspectives of growth are being forecasted in this field (Amorós & Bosma, 2013).
CONCLUSIONS:

Germans have already tested the majority of the technology transferring channels, and have begun to intensify in the successful ones. Just like others OCDE countries, the combination of channels like entrepreneurship, incubators, strong Intellectual property services, joint technology initiatives, specialization within clusters or special sectors can be included in any Colombian university’s transferring strategy.

Micro level strategies like marketing of R&D services can be provided to big and medium sized companies and commercialization of research products through international brokers in joint action with TTO’s in Colombia are plausible scenarios for recent patented developments. The lessons learned by Germany, is that potential adopting companies for recent developed technology are not willing to risk capital for the maturing of technology or the risk of introducing the new product to the market. Instead the start-up/spin-off strategy can be the right choice to introduce new developed products in the market, and use Colombian’s great amount of resources available for entrepreneurship. This will enrich the high-tech sector in Colombia through the creations of specialized SME’s.

Strengthening TTO’s is a good idea, but some changes should be done in the way they actually structure their models: institutional and legal support to entrepreneurial channels for commercializing knowledge, link international technology brokers due to the lack of this firms in Colombia. “Internationally competitive universities and their technology transfer offices are the bedrock of cutting-edge research and are very powerful attractors for the most talented researchers, as well as an important source of innovation at a local and international level” (LERU, League of European Research Universities, 2010).

Meso level strategies can include joining industrial partners for collaborative R&D programs, technology platforms, cluster initiatives and technology diffusion schemes. Promotion of venture and angel capital through a high-tech portfolio

Even though this strategies will work in the actual conditions, some of the biggest restrictions will be the limited access to finance for start-ups and SME innovation projects as obstacles to innovation. One of the strategies to overcome this is to establish confidence through entrepreneurial success and the attraction of private sector investment at the same time. Only then, law can be supportive enough to free public resources in venture capital funds.
Improving the management and commercialization of underused intellectual property rights at universities and public research institutions is also an actual developed task that should be improved, creating a critical mass of qualified expert to serve as multipliers.

Even though these strategies can work from the point of view of the universities, it is necessary that Colciencias, the actual governor of the whole NIS in Colombia, refine the innovation policies and involve other industry governing ministries to initiate more programs involving SME’s and improve technology based business based on in-house research products.

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