Autor(es): **Hoost Heijs**

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Resumen:

El documento presta especial atención a los condicionamientos del sistema de innovación como conductor del éxito de la implementación de tales políticas. Al final de este documento se comenta la posibilidad de transferir el modelo alemán a economías más débiles como España o las de Europa del Este. Una de las conclusiones principales es que países como España, Portugal o del Este de Europa deben iniciar el establecimiento de condiciones previas lo que implica la necesidad de determinar políticas a largo plazo y profundos cambios en los sistemas de innovación existentes. Otro argumento, es que estos países deben centrar sus políticas en las necesidades y posibilidades presentes de su industria y que debe construirse en sus fronteras tecnológicas actuales.

REGIONAL TECHNOLOGY POLICY AND INNOVATION SYSTEMS:

A COMPARATIVE STUDY OF GERMANY AND SPAIN.

JOOST HEIJS.

Facultad de Ciencias Económicas y empresariales

Instituto de Análisis Industrial y Financiero

Universidad Complutende de Madrid

1. Introduction

In recent decades, policies promoting technological development and innovation have become an integral part of public policy, and have accounted for an increasing percentage of public budgets. This attention has been based on the assumption that new, higher technologies are an important factor determining the competitive positions of the three leading global regions: East Asia, North America and Western Europe. The gap between Europe and the other two regions, including Europe's enormous delays in product development and its comparative disadvantages in key technological areas such as micro-processors, telecommunications and data processing, was an important factor in the decisions of European central governments to intensify their technology policies in the 1980s. During that period, technology policy was aimed at promoting R&D at large firms competing on international high-tech markets. Since the mid-1980s, technology policies have been focused more on technology transfer for the dissemination of new productive technologies and on eliminating bottlenecks of innovation, especially for small and medium-sized enterprises (SMEs). As a result, technology policy has been approaching ever closer to the level of everyday enterprises, and the role of regional technology policy has been gaining in importance.

Because of the rapid incorporation of Central and Eastern European countries into the global economy, these countries will increasingly encounter the need to strengthen their technology policies at national and sub-national levels. In the long run, this is the only way for them to become and remain competitive based on factors other than low wages. In this study we will attempt to draw on the experience of Western European countries in the area of technology policy, which may yield useful lessons for countries in transition. We will begin in Section 2 with a discussion of technology policy as part of an integrated regional development policy. This will be followed by an examination of the characteristics and instruments of technology policy in Section 3. Section 4 presents a comparison of the German and the Spanish models of technology policy. Germany offers a model of successfully integrated policy with useful lessons for countries in need of further technological development. We will also argue that Spain, due to both its history and the current characteristics of its industry, offers valuable insights for countries in transition seeking to formulate a technology policy to further their economic and industrial development. We will then conclude in Section 5 with an outline of a well-designed framework for regional development policy based on a modern national and regional system of innovation.

2. Technology policy and regional development

Several factors have had asymmetric effects on the economic development of regions throughout the industrialised world in recent decades, causing significant problems especially for regions with concentrations of traditional industries such as textiles, mining and heavy industry. These factors include technological change, decreasing rates of economic growth, overcapacity in the western economies, and the process of globalisation. The affected industries often turn out to have a weaker industrial structure and a less developed capacity for innovation and modernisation. As a consequence, they have been more vulnerable to economic crises and less successful in meeting new demand for differentiated high-quality products and flexible production methods.

With the advancement of the processes mentioned above, the orientation of regional policy also started to change. Traditional policies based on inward investment and technical infrastructure rapidly became obsolete, while it became clear that innovation and the upgrading and modernisation of the endogenous regional economic factors deserved more emphasis. Regional technology policy began to be recognised as an indispensable instrument for the support of local industry.

Central-level technology policy is usually focused on the strengths of a country's industrial system, generally following the interests of a country's core regions. Often it does not take into account regional particularities, and frequently it is based primarily on the needs of large firms or on large R&D projects oriented towards basic research in key technologies. This makes it necessary for weaker regions, likely to be dominated by low-tech or middle-high-tech enterprises, to develop complementary policies focused on technology transfer, as such a focus is more important in such regions than the generation of R&D. Technology transfer is most often promoted as part of an integrated regional development strategy, falling under the competency of regional and local administrations.

The need for regional technology policy in lagging regions is underlined by the fact that such regions normally have an over-representation of small and medium-sized enterprises (SMEs), which due to their size are subject to disadvantages restricting their innovative potential. For example, individual SMEs cannot follow all technological developments, are too small for their own economically viable R&D, and lack the scale necessary to effectively operate expensive capital equipment. An additional problem for these firms is a lack of technological capabilities and insufficient technology management. Many of them are not capable of analysing their own technological situation or of designing an innovation-oriented

strategy. These disadvantages can be mitigated to a large extent through the adequate supply of innovation services, typically through locally based institutions. Such a supply-based policy works particularly well for firms that are already oriented toward innovation. For firms which lack innovation capabilities or which do not have an innovation culture, an even more intensive approach is appropriate, including face-to-face technology consultancies. This creates a further need for local or regional support with low entry barriers and direct linkages to technology transfer centres and research and education institutions.

Pyke, Becattini and Sengenberger argue that support to innovation in SMEs is not only important in modern industries but in traditional industries as well. Most Western European countries lost interest in supporting traditional industrial sectors based on SMEs, often located in peripheral regions. However, success stories of SMEs in traditional sectors such as textiles, clothing and leather have changed the prevailing opinion that these sectors should migrate to other, low-wage countries. Rather, such industries and regions may do very well if supported by a technology policy aimed at upgrading production methods, strengthening competitive advantages, and exploring the endogenous potential in existing traditional industries. As national policies often ignore these opportunities, regional and local actors have had to take up these tasks.

Another factor limiting the innovation potential and technological capabilities of peripheral regions is the absence of large multinational enterprises with their own research laboratories. Not only is the technological potential of such enterprises important, but also their influence on the policy-making system. Due to their size, personal contacts, lobbying capabilities and importance as employers, large firms have a profound impact on education, government policy-making and public research activities. They can therefore often mobilise public funds for their own interests and those of the regions where they are located, causing a relative disadvantage for the development of the innovation system in other regions.

A final but very important argument in favour of technology policy in weaker regions or countries is that improvement in the technological level of production is the only way to create sustainable competitive advantage based on long-term innovation and growth in productivity. Competitiveness can also be sustained in the short run by decreasing costs through lower wages. However, if competitors also follow this strategy the benefits will fade, resulting in a downward-spiralling cycle of destructive competition based on the ongoing deterioration of wages. For Central and Eastern European countries, this means that if they want to improve living standards in the long run, they should gradually move away from competition based on low wages and upgrade their technological and innovative capabilities. Initially this may well be achieved through inward investment and technology imports, but this should be progressively complemented by the development of an

endogenous innovation system.

3. Technological change and technology policy.

Technology policy attempts to assist structural change in the economy, with the ultimate objective of strengthening economic growth and creating or reinforcing competitive advantage for a country, region or sector through technological change. Technology policy in most developed countries until the early 1980s was based on the *linear model*. This model views R&D as an isolated activity performed in research centres without the direct influence of market considerations. Innovation is considered a linear, sequential process occurring in isolated stages, beginning with basic research and extending through to the introduction of an innovation-based product onto the market. Under this model, technology transfer – the dissemination of new technology – is supposed to take place automatically and without significant costs or delay through the mechanism of the "invisible hand": technology is seen as information easy to transfer and copy. The linear model virtually neglects factors such as the influence of institutions, strategic and competitive behaviour of other firms or countries, or factors related to demand and education. Policies based on the linear model are aimed at the generation of innovation, for example through the establishment of research centres and support for basic research on key new technologies.

An alternative model which has been gaining ground in recent years and fuelling radical changes in the design of technology policies is the *interactive model,* based on the notion of continuous interaction between different actors and elements throughout the innovation process – from basic research to industrial development, commercialisation, and introduction onto the market. While the linear model highlights only the activities of a firm's R&D department, the interactive model stresses the firm's technological capabilities and entrepreneurial attitude, and sees innovation management as an integrated, strategic corporate activity in which the entire firm is involved. A firm's technological capability consists of its know-how with a tacit, accumulative dimension. Technology transfer is viewed as expensive and difficult, while understanding new technologies is seen as time-consuming. The interactive model considers innovation to be a dynamic process occurring in stages, with continuous feedback at each stage – moreover, the entire process is viewed as taking place within a changing environment. The model implies that support for basic research and the generation of new technologies is not enough, and that more political attention should be given to technology transfer and the improvement of innovation capabilities within enterprises. The design and implementation of technology policy is seen as a process of learning-by-doing within a changing context, demanding continuous

adaptation to circumstances and competitive pressures.

Technology policy as a form of public intervention can play an important role in regional development. However, its potential is restricted by a host of other factors within the innovation system. Regional and national innovation systems can be divided only in theory, because they are in reality complementary and interdependent. A national innovation system places constraints on regional systems, but regional systems are a very important part of the overall innovation system, especially in federal states such as Germany.

A broad range of policy instruments may be used to complement each other in an integrated technology policy. There are traditional policy instruments such as institutional support, education and technological infrastructure, and financial support. *Institutional support* for R&D and the provision of *education and technological infrastructure* are traditional activities of the state. Traditionally, support is provided for basic and applied research to establishments of higher education and other public, semi-public or private R&D institutions. Other aspects of this type of support include a broad range of activities to support R&D in enterprises, aimed mainly at assisting technology transfer through information or advisory services, fostering cooperation and networking, as well as the establishment of technology and innovation centres. *Financial support* may be aimed at fostering R&D on the enterprise level, and can be divided into two main types. First, financial incentives can be offered to firms in the form of tax incentives, subsidies, or special low-interest loans. Second, cooperative and networking efforts may be aimed at creating synergy through the interaction of various actors within the national and regional systems of innovation.

Apart from these traditional methods, there are other types of instruments to support technological development, differing in type from those mentioned above. These may also be labelled technology policy instruments in the broad sense, and include public demand, legalisation and regulation, training and education, the establishment of public enterprises, and corporate measures. *Public demand* is derived from government expenditure in normal activities such as public services, infrastructure, defence and national security, or the solution of public problems (eg through environmental measures). A clear policy of public procurement can thus be used to provoke innovation. This is not yet general practice, although long-term technology-stimulating procurement strategies which diminish the uncertainty of future markets could well complement more traditional public policies.

Legislation and regulation (eg through intellectual or industrial property law) are important in protecting the results of innovation, giving firms an incentive to increase their R&D performance because they can be assured that they can temporarily enjoy sole benefit from their innovations, without competitors having access to them. However, such legislation should not hamper the spread of innovation within the economy. Important types of regulation in this regard include technical norms and safety regulations, protection of patents and trademarks, competition policy, environmental protection legislation, etc. *Training and education* are important for both the innovative environment and the capacity of the economy to absorb and adopt new technologies rapidly. A key element is the integration between the educational system, research centres and the private sector.

Public enterprises can be used to establish new industrial sectors of strategic importance such as in energy, defence or chemicals. This practice was frequently used in Southern European countries in the first half of this century, and in the former communist countries until recently (while in the former West Germany, for example, these initiatives were taken by private firms). Today these public enterprises are gradually being privatised in most countries, and this policy instrument is losing its potential. In technologically advanced countries such as Germany, Japan or the United States, governments often finance *corporate measures* (eg foresight studies or technology impact assessments) to ensure the availability of knowledge and long-term vision and orientation. They support such studies to become aware of the risks and potential of new technological trends and to determine future challenges to the country’s production structure.

As mentioned above, these instruments must be used in a complementary fashion, as part of an integrated technology policy. Both the mix of policy instruments and their division among the various administrative levels should be complementary. At the national level, the legal framework should support innovation and ensure that the national innovation system remains internationally competitive, while technology transfer and the development and strengthening of regional technology management capabilities should be the task of regional and local governments.

4. Technology policy in Germany and Spain: a comparison.

This section will present a comparative analysis of technology policy in Germany and Spain, the primary goal of which is to examine why German technology policy has been so much more successful than that in Spain, and to recognise the constraints on the successful implementation of technology policy instruments. Such a comparison provides valuable lessons for technology policy formulation in Central and Eastern European countries. Spain shows significant similarities to these countries, which may not be obvious at first glance. Especially important is Spain's industrial development under the Franco dictatorship, which contained an emphasis on foreign investment but was dominated by state-owned enterprises, high influence of the public administration on the most important decision of the private sector, high political involvement in the decisions about the development of new industrial fields/sectors and a high level of protection of the domestic market. In addition, Spain's central political structure allowed little room for local or regional initiatives. Although democratic rule is now firmly established in Spain, and its membership in the European Union has improved its situation considerably, the legacy of the past can still be felt and is difficult to overcome – much as in Central and Eastern Europe. The inefficient state-run industrial sector could not be simply modernised overnight or replaced with modern enterprises and management methods. There remains a mentality of expecting orders from "above", rather than seizing the initiative to improve the immediate situation on a local basis (although this situation continues to change and improve). And Spain remains plagued by extremely high unemployment – 20.9% in the second quarter of 1997. Thus in many ways we may say many elements of Spain's "transition" are still to be completed, and one of the elements that stands out most clearly in this regard is the area of technology policy and development of its innovation system.

Before we begin the comparison of these two national innovation systems and later discuss issues relating to the transferability of foreign models, we should point out the limited role of public policy within the economic process. For example, the German region Baden-Württemberg is often praised for its successful initiatives in technology policy; but although public policy has fulfilled an important facilitating role, it has been largely subsidiary. The locomotive of industrial development in core regions such as Baden-Württemberg are private-sector enterprises, with public policy of secondary importance. Also, the impact of technology policy depends on the interaction of the policy instruments with their environment, and any determination of policy lessons or "best practices" must take contextual differences into account. It is only possible to learn from foreign experiences if the foreign systems are properly understood. Strategies based on naive copying should be avoided, and institutional learning across national borders stimulated. While it is quite possible to extract certain lessons for proper policy from a comparison of technology policy in these countries, these policies must be interpreted within the context of their national innovation systems.

4.1 Technology policy, competition and demand for innovation

One of the main characteristics of the German model of technology policy is its strong market orientation and the leading principle of subsidiarity in the government's research and technology policy. The government plays a reserved role, and market-based initiatives are the key elements in technological development. The role of policy is to help create and strengthen the environmental conditions in which enterprise R&D activities can flourish, without unduly hampering or delaying the innovation and investment efforts of industry. Direct government involvement in industrial research and development is only allowed when firms or industries cannot innovate quickly enough, or in the context of joint research projects with considerable general economic importance and external effects. But, based on the principle of subsidiarity, any such projects are only co-financed, not wholly subsidised by the state, and results must be published. The subsidiarity principle is applied in order to ensure the rationalisation of technology policies. The number of so-called free riders abusing support schemes diminishes if they must also be involved financially in the R&D projects, or if they have to pay fees to public consulting offices. This helps ensure that the risk of investing in R&D is not faced by the state alone.

However, technology policies based on the principle of subsidiarity and with a market orientation are only feasible when there is sufficient demand for technology and innovation services, and when there is already an innovative culture among private entrepreneurs. In Germany, such broad demand for innovative products is present, and is based on several interdependent and reinforcing elements of the industrial sector. The first is the presence of headquarters of multinational firms with R&D laboratories, such as Siemens, Thyssen, Daimler-Benz, and so on. A second element, directly related to large companies such as these, is the existence of a network of specialised, innovation-oriented SMEs. The presence of these firms (the so-called "headquarters effect") implies a large market for innovative goods. Spain has only a few large multinationals, and most industrial firms depend on foreign technologies. The percentage of innovative firms in Spain is therefore much lower than in Germany, and this lowers the receptivity of technology policy measures among Spanish firms.

Another element directly related to large multinational companies is the market in which those firms are competing. While Spanish firms until recently competed mainly with each other on the domestic market, German firms have already been competing on the world

market for quite a long time. This means that German firms have had to stay on the leading edge of technological possibilities, while Spanish firms have been able to maintain a lower technological level. This problem is reinforced by the fact that Spain not only lacks demand for innovative products, but it is also struggling with the poor image of its technologies. The few large firms that do actually demand innovative technologies purchase them mainly from abroad, rather than trusting technologies "made in Spain" .

Historically, Spain shows significant similarities to the countries of Central and Eastern Europe which are the subject of this volume. Spanish industrialisation was characterised by the relatively low importance of the private sector. Under the Franco dictatorship, Spain was centralised and internationally isolated. The Spanish model of development adopted in the 1960s was based on the investment of foreign capital. However, just like most Spanish firms of that time, the foreign firms competed almost exclusively on the domestic market, where competitive pressures were relatively low. International competitors and competitive pressure to stimulate innovation and new technologies were absent until the late 1980s. Foreign firms helped modernise the Spanish industrial structure at that time with their massive technology imports. Inward investment remained a workable policy option until the beginning of the 1990s. Due primarily to relatively low wages, foreign investment grew rapidly in those years. But the modernisation which arrived on the back of inward investment was not accompanied by the development of a national scientific-technological system, because foreign firms usually established only production facilities, leaving their R&D activities elsewhere. Today, with salaries in Spain and other Southern European countries increasing, multinational firms are focusing their investments in countries with low wages and higher potential growth rates in consumption, for example in Central and Eastern Europe. This may offer interesting opportunities for technological development and innovation in these countries, if they are able to combine inward investment with clear long-term technology policies aimed at building their national innovation potential.

The Spanish private sector, having traditionally competed only on the domestic market, does not consider innovation and technological change to be an important element of its competitive strategy. While German firms are innovation-oriented and easily pick up R&D support, many Spanish firms are not capable of identifying their own technological capabilities or problems, and they still have to be convinced of the importance of innovation. The high capability of German enterprises to make use of technology policy depends in part on the orientation of German entrepreneurs toward innovation, and also on an industrial structure which makes it possible to apply the principle of subsidiarity. In Spain, this is much more difficult. The use of subsidiarity as a basic principle is not always feasible, especially in countries where the innovative activity of enterprises and their willingness or capacity to co-finance innovation are low. This does not mean, however, that the government has to provide huge public resources to support innovation with no effective controls or obligations. Rather, financial support for R&D in enterprises should be complemented by other policy measures. SMEs lacking technology management capabilities can be supported with

management consultancy, combined with low interest credits (which may possibly be converted into subsidies in the case the supported projects fail). Another policy instrument to support research by SMEs could be the use of public demand, as described earlier.

4.2 Regional and national initiatives of technology policy

Innovation has long been seen in Germany as a basic element of international competitive strategy, as reflected by the strong involvement of the German government, including the Federal Ministry of Research and Technology. The German system of technology policy has a long history, and consists of complementary top-down and bottom-up measures. Both regional and central governments show deep interest and political involvement in innovation, and have obtained a great deal of experience in formulating technology policy since the turn of the last century. At the end of the 19th century, Germany began a dynamic phase in its industrialisation in which the regions played an important role. The creation of Technical *Hochschule* (polytechnics or technical colleges) in different cities can been viewed as an early variant of regional technology policy. Especially in the regions Baden and Württemberg, both government and enterprises did a great deal early on for the promotion of technology through the education of the labour force, including sending trainees abroad.

Under the pressure of rapid technological progress in other countries in the 1960s, the German federal government initiated activities to close the technological gap with Japan and the United States. The technology policies of the time – mainly initiated by the central government – were based on an linear concept of innovation, supporting basic research and large firms. Although regional governments had real responsibilities in research, education and industrial development, technology policy instruments which are today viewed as typical regional measures (such as incubator centres, science parks or technology transfer centres) were almost non-existent.

At the end of the 1970s, regional public administrations began intensifying their technology policies parallel to the central level, and SMEs became a clear target group. In this period,

the German *Länder* developed their current structure of technology policy aimed at regional interests, partially built upon existing regional potential, but also including the support of technology transfer as an important element. In the past, technology transfer as such was rarely a specific focus of federal policies, which rather concentrated on technology generation. The evolution of the German model in reaction to changing economic circumstances led to an activist attitude on all administrative levels, and to the creation of a differentiated structure of complementary technology policy instruments. As a result, the German innovation system evolved from a linear-model based, one-way process into a more integrated and interactive system.

The Spanish innovation system is characterised by low political involvement and the fragmentation of its decision-making system, much like that in Central and Eastern Europe. Technological progress was never a clear objective of Spanish industrial policy, and technology policy was a marginal activity until the end of the 1980s. After Franco's death in 1976, Spain was rather involved in democratic transition, economic crisis and reindustrialisation. Only at the end of the 1980s did Spain begin implementation of a national innovation plan, and even then it was without clear priorities or objectives.

As a result of its centralised political structure and the low involvement of the central government in innovation, Spain has had little experience with regional technology policy, another close parallel to the situation in Central and Eastern Europe. Although the central government had begun in the mid-1960s with so-called Regional Development Plans, based on detailed planning initiated and implemented by the central government, technology policy was almost non-existent in these plans. More recently a decentralisation process has been taking place, but most regions have been rather passive. Only a few core regions of the Spanish economy (such as the Basque Country, Catalonia, Madrid and Valencia) have been developing their own policies in the field of innovation for a longer time now. Other (peripheral) regions are now becoming more aware of their role within the new Spanish political framework, and most began in 1997 to analyse their innovation systems in order to develop their own regional innovation policies. This effort, which is being carried out with the financial support of the European Union, may mark the beginning of a process which will overcome the lack of regional initiatives, passive entrepreneurial attitudes, and previous political experience on the regional level. Technology policy and public intervention cannot solve all the economic problems of less developed regions, but they can support initiatives and have a positive influence on local enterprises unaware of the importance of technology and innovation.

4.3 Technology policy instruments in Germany and Spain

Germany has a diversified, specialised support system for strengthening its R&D infrastructure and the technology transfer system. A broad range of R&D institutes specialise in various R&D activities and focus on different geographical areas, including centres for basic research, special institutes for applied research, centres for direct problem-solving, and consultancy services. The *Länder* governments – particularly in Baden-Württemberg – implement a broad range of regional technology policy measures focused on technology transfer, including incubator centres, technology parks, technology consulting centres and technology transfer centres. In this way regional governments complement the R&D infrastructure provided by the federal government.

Enterprise-level technology support in Germany is also based on a division of responsibilities between administrative levels. The national government is involved in large R&D projects relating to broad societal problems or items of national importance, the upgrading of innovation in the new eastern *Länder*, and the promotion of cooperation and networking. Both the national administration and some *Länder* have special programmes in individual fields (eg CAD/CAM, robotics and CIM, information technology, or biotechnology) to disseminate key technologies in the economy, particularly to SMEs. There are also measures to create technology capacities in new sectors, such as technology-based business start-ups in which both national and regional administrations are involved.

The country's recent reunification is having strong effects on the German innovative system in the 1990s. Special initiatives of the centre have aimed at the construction of an efficient, market-oriented R&D structure in the new *Länder*. These initiatives have absorbed large amounts of public funds; in 1992 alone, some DEM 610 million were allocated for restructuring and strengthening industrial research and development capacities in the eastern part of the country. Some measures for SMEs used in the former West Germany in the 1980s are now being implemented in the new *Länder*, including financial support for the hiring of highly-qualified R&D personnel. Some new policy measures have also been developed, such as support for up to 40% of the costs of R&D in case of cooperation between partners from new and old *Länder*, in order to foster reunification. Initial evaluations of these policy programmes show that they are contributing significantly to the emergence and further development of innovative SMEs.

The establishment of basic and applied research infrastructure in eastern Germany seems to have been less successful. Efforts in this regard include, among other activities, the privatisation of R&D departments of the former "Kombinate" (state companies), and the reconversion of research institutes of the former Academy of Sciences into so-called Forschungs-GmbHs (Research Ltds.), which have absorbed large part of the total amount of available funding (some DEM 415 million). Existing institutions have been restructured following the western German example, and new research and technology transfer agencies are being set up. Although there are still no real evaluations of these initiatives, the fact that some of the new created market based research institutes (Forschungs-GmbHs) are threatened with closure due the lack of demand for their services raises questions about this top-down approach. This is an important lesson, and must be considered when analysing the transferability of the western German model to less developed innovation systems such as those in Spain or in Central and Eastern Europe.

As mentioned above, Spain had a late start in the development of its technology policy, and its innovation system is still rather poor. In the 1960s, Spain introduced some rather marginal initiatives to foster new technologies, such as the creation of research associations and a National Fund for the Development of Scientific Research, providing loans for R&D projects which could be converted into subsidies in case commercial success was not achieved. However, these instruments failed due to a lack of funding and because they did not incorporate a clear definition of priorities or a control procedure regarding the results of the projects. More sophisticated technology policy programmes began to be implemented by several public institutions at the end of the 1980s, consisting largely of financial support for R&D projects. Examples are the low-interest credits of the Centre for Technological Development in Industry (CDTI); the National Plan of Research with its available financial support for cooperation between firms and research centres; scholarships for researchers; and subsidies from the Ministry of Industry for industrial designs and other programmes. However, the policy framework is still fragmented, involving many different ministries and public institutions but without clear coordination or distribution of responsibilities. The linear orientation of the Spanish national and regional innovation system is clearly reflected in: the separation between research and industrial applications based on the isolation of different actors of the innovation process, policies are more oriented towards the production of science than of technology, research is performed predominantly in public centres and is oriented to the production of science and technology with little attention to diffusion within the economy and there is more orientation towards "high"-tech rather than mature industries.

4.4 Higher education, science, and their integration with industry

A very important characteristic of the German national and regional innovation system is the

integration of science, higher education institutes (HEIs) and industry. Universities, polytechnics and other HEIs fall under the political responsibility of the *Länder* governments. This makes that their research institutes are focused on the problems and needs of the region. The federal government has its own institutes for basic R&D aimed at general problems and needs of the German economy.

Although the most important contribution of the HEIs to technological development is traditionally the preparation of human capital, they also have a clear role in technology transfer. The linkages between universities or polytechnics and the industries of their region are based on a few simple but important mechanisms. First, there is the widespread practice of student internships in enterprises, often in the context of preparation of a master's thesis. This simple fact implies that professors and HEIs must be aware of the latest technological developments in the relevant industries, and continuously update their educational programmes to advise their students during the internship period. Another simple but effective mechanism of interaction between industry and education is embodied in the qualification requirements of professors at HEIs – each professor must have at least five years experience with a certain level of responsibility in industry or a comparable field, and due to that fact are be able to "speak the language" of the private sector.

An interesting example of integration between industry and HEIs is found in Baden-Württemberg, in the so-called Steinbeis model for technology transfer. The Steinbeis Foundation is a strictly non-profit organisation for technology transfer, with over two hundred centres located in polytechnics and universities. The Steinbeis Technology Transfer Centres are focused on small, practical technological problems of SMEs, primarily from their own region, which are often neglected in national and regional R&D support schemes. The Steinbeis Foundation does not have its own R&D infrastructure, but makes use of existing government-owned facilities at HEIs; most Steinbeis technology consultants also work at polytechnics. In this way, high overhead costs are avoided, making the technology transfer agencies of the Steinbeis Foundation relatively competitive. Since the managers of the centres are also professors at the HEIs, they have thus had at least five years industrial experience or similar contact with business. In addition, they are allowed to perform an amount of contract research for industry in order to supplement their income.

The Steinbeis model is based on the market principle, a characteristic feature of all elements of German technology policy. State subsidies to the foundation are limited, and are only available for the purchase of equipment during the initial phase of establishing a Steinbeis Centre. No funding is available for the on-going operations or administration of the centres; 95% of their income is derived from industrial projects. Each centre is its own administrative unit, and must generate its own income, and so over time certain centres are

closed down and others are opened according to changes in demand on the technology markets. The only free support provided by the centres consists of an initial five hours of consulting supplied gratis to each firm and paid for by the regional government. In this way, the firm does not have to pay before having an opportunity to see if the centre really can help with the problem at hand. After the first five hours firms are charged, ensuring that the centres provide services of genuine use to local enterprises. The Steinbeis model is an important tool for improving the integration between HEIs and the regional productive sector, especially for small and medium-sized firms.

In Spain the universities were until 1996 the exclusive domain of the central government, and their research was not always focused on the problems of regional or even national economic problems and needs. This isolation was reinforced by the lack of linkages with industry and the autonomy of the professors and universities. Perhaps the most important ingredient lacking from the Spanish innovation system and the implementation of technology policy is integration and cooperation between research institutes, the education system and industry. In the majority of Spanish HEIs, (including technical universities and polytechnics) students are not obliged to participate in internships at enterprises. As a result, many graduating engineers have never seen a firm from inside. Professors often enter the education sector directly after their studies, and only few have experience in the industrial sector. As a result, a significant portion of Spanish professors spend their whole lives in education, without any direct contact with firms, without knowing how to "speak the language" of enterprises, and with lacking awareness of enterprise needs. Integration should oblige the universities and polytechnics to continuously renew their educational programmes, and remain on the same technological level as firms.

Public research centres and higher education institutes in Spain are strongly science-oriented. Efficiency could be improved if the polytechnics were more integrated into regional economy and industry. An important change in this regard was the decentralisation of the political responsibilities of the universities in 1996. This may facilitate – in the long run – an improved focus of research institutes and universities on regional needs and opportunities.

Spain, along with most Central and East European countries, still has to begin integrating the various sub-systems of innovation. In this process, the examples from the German innovation system may provide interesting lessons. Not all linkages existing in Germany can easily be introduced in other countries, however. For example, the great difference in salaries between industry and education in Spain and most countries of Central and Eastern Europe makes it impossible to require five years of industrial experience for professors. It is imperative, however, that they search for creative solutions for the closer integration of government, education and industry. Student internships in industry could be a first step

toward facilitating the future implementation of a new innovation model. Some elements of the Steinbeis system are also worthy of consideration, such as allowing professors to earn extra income by working on industrial projects.

5. REGIONAL DEVELOPMENT, TECHNOLOGY POLICY AND THE TRANSFERABILITY OF THE GERMAN MODEL.

In this study, we have tried to point out the importance of technology policy for sustainable long-term regional development. Competition based on modernisation of the industrial structure promises a brighter future than competition based on low wages alone, with its accompanying downward spiral of incomes as firms seek to match their competitors' low costs. However, the technological gap is large, both for Spain and for the countries of Central and Eastern Europe. These countries must give more attention to development based on sustainable competitive advantage in industry, growth in productivity, and improvement in the quality of human resources. They should focus on closing the technological gap with the rest of Europe by developing comprehensive technology policies which integrate economic, industrial and regional programmes while coordinating activities on various administrative levels.

The logic of national and regional innovation systems implies that its not only the sum total of the constituent elements or actors which determines the strength of such systems – there also exists an added value arising from the interactions and interdependencies within the system. This means the impact of a particular policy instrument depends in large part on the constraints or preconditions of the innovation system itself. Such constraints and preconditions include, for example: the political involvement of government administrations, the level of coordination and cooperation within the policy-making system, accumulation of experience by regional and national governments in formulating technology policy, the innovative orientation of firms and of the industrial structure as a whole, demand for innovative products, and the level of integration between research, education and industry. This last item is of particular importance.

Due to differences in existing national and regional conditions, the simple copying of policies successful in western German *Länder* is not sufficient for countries with less developed

innovation systems. Technology policies in these countries should be aimed at establishing their own national and regional innovation systems, including long-term measures for improving systemic conditions and lowering constraints on more effective policies. This does not mean that they cannot use certain interesting elements of the German system – some items, such as support for the hiring of R&D personnel or elements of the Steinbeis model, may be quite useful. However, their implementation must take into account local conditions and constraints in existing innovation systems, while simultaneously attempting to improve them.

Although Germany strongly supports basic R&D and the development of high technologies for the maintenance of its competitive advantage at the international level, the countries of Central and Eastern Europe, like Spain, should rather focus on technology transfer. The tasks facing these types of economy are fundamentally different – while Germany must intensify the existing innovative activities of its firms, technologically lagging countries need to develop the means to assist firms in initiating R&D activities and spread awareness of innovation as a source of increased competitiveness.

The starting point for the design of a comprehensive regional technology policy built on a region's innovative capabilities should be an analysis of the Strengths, Weaknesses, Opportunities and Threats (or SWOT-analysis) of the regional innovation system. A SWOT-analysis should determine which technologies are of regional importance (according to industry structure, technological competence, and regional technological demand), as well as how to improve access to those technologies. Political responsibilities should also be clearly distributed, strengthening cooperation and coordination between administrative levels and making technology policy instruments complementary. Regional policy makers should determine how they can improve the use of national and international programmes by enterprises in their regions, and where necessary complement the policy framework with regional initiatives designed to create a favourable environment for the release of the region's innovative potential.

Technology policy can be built on a mobility strategy designed to attract external inputs in the form of new (innovative) firms or research centres, or on a strategy of endogenous development based on existing innovation potential. Koschatzky points out that regions should seek a synthesis between those two strategies. New external inputs in the form of technology transfer can stimulate the regional innovation system and industrial structure as a whole. Lagging regions, including macro regions such as Central and Eastern Europe or Spain, should follow a policy strategy based on their own particular circumstances. These regions must cope with their current economic problems by implementing policies with short-term, direct results – for example by promoting inward investment. But they should combine

these policies with a long-term strategy to build up their own innovation system. Regional technology policy can give special attention to technology transfer from external inputs in order to reinforce and modernise the existing industrial structure. In this way, an endogenous technological potential may be created as a basis for sustainable development in the region.

According to Meyer-Krahmer, there are three key elements to the promotion of regional innovation capabilities:

- Improving regional conditions to favour innovations and technology transfer, particularly through the supply of innovation services and technology infrastructure (eg information and advisory institutions, R&D institutions, supply of capital or venture capital, professional training and other education facilities);
- Offering incentives to existing enterprises that intensify their innovation activities (particularly to small and medium-sized firms); and
- Motivating enterprises to engage in innovation, attracting innovation-oriented firms from outside the region, and stimulating the establishment of new technology-based firms.

As mentioned previously, a fourth element could be added to this list: implementing long-term measures to reduce existing constraints on the national and regional innovation systems. The application of any measures should include direct management support, especially for SMEs in more traditional sectors or regions, in order to help them define their problems and detect possible solutions. This is especially important for countries with a high percentage of firms which are not innovation-oriented and which are less receptive to technology policy measures.

Developing effective technology policy is an important task for the countries of Central and Eastern Europe, just as it remains a significant area of attention for Spain. In their efforts, these countries can draw on some aspects of the German model, adapting certain of its features to their own regional environment. However, the design, implementation and evaluation of these policy instruments is not the main problem, as this can be achieved in a relatively short period. More difficult is improving the environmental conditions for innovation, which is a much more complicated task requiring long-term planning. To again use the example of Spain, we can observe that firms are generally not innovation-oriented, and the country does not fulfil the three most important preconditions for an innovation orientation: (i) the integration of science, education and industry; (ii) political commitment

and a coordinated political framework for innovation; and (iii) Experience and a positive regional attitude towards the creation of technology policy. These characteristics may also be observed in many countries in Central and Eastern Europe. The real problem is the insufficient technological capability of the innovation system as a whole – and within this system, the lack of technological capabilities in the enterprises. Even if technology policy instruments are designed exceptionally well, they will not operate adequately if firms are not able to make use of them.

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2 Questions, suggestion and critics are welcome on my E-mail number joost@ccee.ucm.es

3. There has been clear growth in financial and other support for technology, especially in the highly industrialised economies, although public budgets for R&D now seem to be stabilising. See OECD, *The Impact of National Technology Programmes,* OECD DSTI/SPT 1993 (3), January 1993 and Main science and technology indicators, OECD, Paris, 1995.

4. Until the end of the 1970s, macroeconomic policy in western countries was generally based on continued economic growth and focused on full employment through the control of financial flows and demand management. In this model, regional policies were limited to the development of

regional and technical infrastructure (including airports, highways, railway systems and telecommunications networks), and subsidies promoting inward investment).

5. This also applies to most regions in Central and Eastern Europe, where the technological level of most enterprises is modest and R&D expenditure very limited. These conditions make technology transfer a more appropriate and viable instrument.

6. H.J. Ewers and R.W. Wettmann, "Innovation Oriented Regional Policy". *Regional Studies*, Vol. 14, 1980, 161-179. See also S. Metcalfe, *The Economic Foundation of Technology Policy: Equilibrium and Evolutionary Perspectives,* in P. Stoneman (ED), Handbook of economics of innovation and technological change, Blackwell publishers inc., Cambridge, 1995.

7. B. Dankbaar, "Research and Technology Management in Enterprises: Issues for Community Policy Overall Strategic Review". *Monitor-Sast Project: Commission of the European Communities*. No. 8, 1993.

8. Although locational deficits do have their influence on technological capabilities, there are enterprises in less favoured regions that have found ways to overcome the limitations of their geographical environment by acquiring resources elsewhere. (See Dankbaar, *cit.,* 71). However, such strategies, sometimes useful for an individual firm, do not remedy the underlying problems in the regional industrial structure.

9. F. Pyke, G. Becattini and W. Sengenberger (eds), *Industrial Districts and Inter-Firm Cooperation in Italy.* Geneva: ILO International Institute for Labour Studies, 1992.

10. This occurred while maintaining support for industrial regions with large companies from traditional sectors.

11. Dankbaar, *cit.*, 65.

12. H. Behrend, *Wirkungsanalyse von Technologie und Gründerzentren in Westdeutschland.*

Hannover: Physica-Verlag, 1995. See also Dankbaar, *cit.*; Nauwelears/Reid, *Innovtive regions ? a compatative review of methods ofg evaluating regional innnovation potential,* EuropeanUnion, Sprint-EIMS, 1995.

13. F. Malerba and L. Orsenigo, "Schumpeterian Patterns of Innovation." *Cambridge Journal Of Economics* No. 19, 1995.

14. Ibid.

15. An innovation system can be defined as a "network of institutions in the public and private sector whose activities and interactions initiate, import, modify and diffuse new technologies." (See C. Freeman, *The Economics of Industrial Innovation*, 1982, 1.) Such a system is open and heterogeneous, and its elements either reinforce each other in promoting processes of learning and innovation or block such processes.

16. F. Meyer-Krahmer, *The Determinants of Investment in R&D and the Role of Public Policies: An Evaluation.* Work document Isi-P-91-90, Karlsruhe: Isi-Fraunhofer, 1990.

17. Zegveld, *Technology and change in industrial societies: implications for public policies*, technovation No. 5, 1987, P.225.

18. D. Mowery, "The Practice of Technology Policy", in Stoneman, cit., 1996.

19. P. Cooke and K. Morgan, "The Regional Innovation System in Baden-Württemberg". *International Journal of Technology Management: Special Issue on Technology Growth and HR*, 1994, 394.

20. B.A. Lundvall, "User-Producer Relationships, National System of Innovation and Internationalisation", in *National Systems Of Innovation*, 1992, 5. In Lundvall (ed.) National systems of innovation: towards a theory of innovation and interactive learning, 1992, Pinters Publishers, London

21. BMFT. *Bundesbericht Forschung.* Bundesministerium für Forschung und Technologie, (BMFT), Bonn.

22. Ibid, 20.

23. M. Buesa and J. Molero.*Estructura Industrial de España,* Fondo de cultura económica, Mexici, Mdrid, Buenos Aires *.* 1988

24. Sanchez, P.*La dependencia tecnológica española: Contratos de transferenciua tecnológica entre España y el exterior*, 1984, Minesterio de Economia y Hacienda, Madrid, See also M. Buesa and J. Molero, *cit.*

25. COTEC, *Documento para el Debate sobre el Sistema Español de Innovación.* Madrid: Fundación COTEC para la Innovación Tecnológica, 1997, 27.

26. J. Hucke and H. Wollmann (eds), *Dezentrale Technologiepolitik: Technikförderung durch Bündesländer und Kommunen.* Basel-Boston-Berlin: Birkhäuser Verlag, 1989, 61.

27. (Clement, 1995, P.58).

28. Buesa and Molero, 1988, *cit.*, 195.

29. BMFT, *cit.*, 96

30. This support consists of a subsidy of 50% of the salaries of all personal involved in R&D for a period of 15 months.

31. (WZB 1993, P.40).

32. A network of 21 Technology Transfer Agencies is being established in the five new *Länder*. The principal aim of the centres is to increase the competitiveness of local firms through technology transfer and to improve the innovative climate of the region as whole (Clement, cit. 1995, 58).

33. Buesa and Molero, *cit.*, 195.

34. L. Sanz-Menendez, "Policy Choices, Institutional Constraints and Policy Learning: The Spanish Science and Technology Policy in the Eighties" *International Journal of Technology Management* Vol. 10., No. 4/5/6, 1995, 631.

35. Until the end of 1996, support for cooperation between firms and research centres only available to public-sector firms.

36. Although the number of student internships has increased in the past few years, it is still not a common practice at most universities and technical schools.

37. COTEC, *Documento para el Debate sobre el Sistema Español de Innovación.* Madrid: Fundación COTEC para la Innovación Tecnológica, 1997.

38. Capabilities or regional innovation potential can be defined as all factors determining, contributing to, or impeding the innovative performance of a region, including firms or sectors with low innovative orientation. See K. Koschatzky, U. Gundrum and E. Müller, *Methodology in Design, Construction, and Operation of Regional Technology Frameworks.* Karlsruhe: Fraunhofer-ISI, 1995, 4.

39. Ibid, 59

40. Ibid, 12

41. Such endogenous potential may be especially important if foreign investors begin to relocate their investments.

42. F. Meyer-Krahmer, *cit.*

RESUMEN

Este documento ofrece, tras una breve introducción sobre el cambio tecnológico y sistemas nacionales y regionales de innovación, una descripción de la politica tecnológica en Alemania y España. En comparación con la politica tecnológica española, el modelo alemán resulta un modelo muy elaborado, diversificado y avanzando hacia una red integral de instrumentos de política nacional y regional. Por el contrario el modelo español se caracteriza por ser un modelo poco elaborado con una fragmentación de las responsabilidades políticas y, falta de integración entre la industria, educación y sistema de I +D.

El documento presta especial atención a los condicionamientos del sistema de innovación como conductor del éxito de la implementación de tales políticas. Al final de este documento se comenta la posibilidad de transferir el modelo alemán a economías más débiles como España o las de Europa del Este. Una de las conclusiones principales es que países como España, Portugal o del Este de Europa deben iniciar el establecimiento de condiciones previas lo que implica la necesidad de determinar políticas a largo plazo y profundos cambios en los sistemas de innovación existentes. Otro argumento, es que estos países deben centrar sus políticas en las necesidades y posibilidades presentes de su industria y que debe construirse en sus fronteras tecnológicas actuales.

Palabras claves: Política regional; política tecnológica; transferencia tecnológica; sistema nacional y regional de innovación.

ABSTRACT

After a short introduction on technological change and national and regional innovation systems, this paper presents a description of the German and Spanish models of technology policy. In comparing to the Spanish model the German technology policy is a diversified and well elaborated model moving towards a, more or less integrated framework of national and regional policy instruments. On the other, hand the Spanish model can be characterised by its poor level of integration, its argued that tjhis characteristics is due to marginal political involvement, fragmentation of political responsibilities and a lack of interaction between industry, education and the R&D system.

The paper pays special attention to the preconditions for the development of a more effective model of technology policy. The last part of the paper comments the transferability of the German model to technologically weaker economies like Spain or Eastern European countries. One of the main conclusions of the paper is that countries like Spain, Portugal or the East European ones have to start to fulfil some of the preconditions which implies the need for a long term policy and profound changes in the existing system of innovation. These countries should focus their policy efforts on improving their existing industrial structure in its technological dimensions.

Keywords: National and regional innovation systems; Regional policy; technology policy; technological change, Technology transfer