1771 1829	**1st Industrial Revolution**
1733	Flying shuttle (textiles)
1769	Steam Engine
1771	1st Spinning factory
1875	Cans
1829 1875	**2nd Industrial Revolution (steam and railways)**
1829	Steam locomotive
1821	Steamships
1839	Vulcanized Rubber (1843)
1838	Telegraph
1846	Anesthesia
1849	Concrete
1855	Bessemer converter
1875	Steel
1856	Synthetic dye
1860	Asphalt
1860	Plastic
1860	Pasteurization
1865	Rotary printing press
1866	Dynamite
1867	Aluminum
1875 1908	**Age of steel, electricity and heavy engineering**
1860	Internal combustion engine (1885)
1876	Telephone
1881	Immunizations
1882	Electric power plant
1882	Light bulb (Edison)
1895	Rayon
1897	X-Rays
1901	Radio
1903	Aeroplane
1908 1971	**Age of mass production, oil and automobile**
1908	1st Ford's factory
1911	Division of labour (Taylorism)
1913	Cracked gasoline
1928	Antibiotics
1935	Television
1947	Microwaves
1948	Transistor
1949	Computer
1951	Tetra brick (1963)
1953	DNA (1972)
1955	Optical fiber (1970)
1958	Microchip (1968)
1958	Internet
1959	Bases nano technology
1971 2009	**Age of information and telecommunications**
1971	Micro-processor
1973	Industrial robot
1976	PC computer
1981	Space Shuttle
1985	Microsoft Windows
1988	1st stem cell transplantation
1991	Carbon nanotubes
1992	3D Printer
1993	GPS
2004	Graphene

INSTITUTO DE ANÁLISIS INDUSTRIAL Y FINANCIERO

UNIVERSITY COMPLUTENSE OF MADRID

Joost Heijs

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THE INERTIA OF THE SYSTEMIC FAILURES: THE CASE OF SPAIN

JOOST HEIJS,

Instituto de Ánalisis Industrial y Financiero
Universidad Complutense Madrid

ABSTRACT

This paper enter more deeply, into the study and analysis of problems leading to the malfunctioning of the Spanish innovation system (SIS) presenting strengths and weaknesses of this system within the theoretical framework of innovation system approach and more specifically the concept of systemic "failures". Such failures act as a barrier that inhibits creation of virtuous circles that facilitate that the private investments R&D and impedes that the innovations and the public funds for policies in those areas obtain the best possible results. Solving the systemic failures should assure that public investments in R&D are converted in innovations relevant or useful for the productive system. Many of these failures were identified some decades ago but, in our opinion, neither Spanish politicians in charge nor the involved stakeholders take serious or strict measures to tackle the cases of inefficiency that have been detected.

KEY WORDS

Systemic failures, Spanish innovation system, inefficiency, Spain, optimum, SWAT analysis.

RESUMEN

Este articulo propone un estudio y un análisis profunda de los problemas que llevan al malfuncionamiento del sistema de innovación español, presentando puntos de fuerzas y debilidades del sistema bajo la guía teórica del enfoque del sistema de innovación y más especificadamente del concepto de fallos sistémicos. Estos fallos actúan como una barrera que imposibilita la creación de círculos virtuosos que facilitan la inversión privada in I+D e impide que las innovaciones y las financiaciones públicas en estas áreas obtengan los mejores resultados posibles. Solucionar los fallos sistémicos aseguraría que las inversiones públicas in I+D se conviertan en innovaciones relevantes o útiles para el sistema productivo. La mayoría de estos fallos han sido detectados ya hace varias décadas, pero según nuestra opinión, ni la clase política española en cargo, ni los agentes económicos involucrados toman serias medidas para solucionar las ineficiencias averiguadas.

PALABRAS CLAVE

Fallos sistémicos, Sistema de innovación español, ineficiencia, España, optimo, DAFO análisis.

THE INERTIA OF THE SYSTEMIC FAILURES: THE CASE OF SPAIN

1.- Introduction

In 1528 the Chancellor of Salamanca and Valladolid University sent the following entreaty to the Emperor Carlos V: ***"Your Majesty is earnestly entreated to make the chairs in Salamanca and Valladolid not permanent but temporary…if they are for life many inconveniences and much harm ensues… and they do not take good care to study or enable their students to profit…whereas if they are temporary this is of great advantage"***[1]**.** This is merely one example of the systemic failures in the Spanish innovation system and as can be observed, it is not a new topic, in fact, many of the problems dealt with here have already been well entrenched for decades and not seriously tackled by the politicians and the stakeholders. Often such implementation implies a struggle with the research institutions and their members or the workers union which the politicians like to avoid. The present crisis and the corresponding cuts and shortages of funding have given rise to a debate concerning efficient expenditure. In this way these problems become an ever more important issue. These financial problems could justify form a political point of view the measures to solve several problems. Nonetheless, despite financial cuts in the public budgets, little progress has been made towards solving them.

There exist failures in the Spanish system of production and innovation that hamper technological development, and the absorbing of new technologies and learning, thus leading to a low level of efficiency in the Spanish innovation system, a fact recognized by several authors (Sebastian/Ramos, 2010, Heijs, 2010; ERA- watch 2009/2010; Hernández/Pérez, 2010). This article studies the problems that cause malfunctioning of the Spanish innovation system (SIS) is highlighting the strengths and weaknesses of the SIS from an innovation systems approach emphasizing the systemic failures or "defects". Such failures are an important obstacle or threshold that impedes the optimum use of the available resources and act as a barrier that impede that creation of virtuous circles that facilitate that the private investments R&D and innovations and the public funds for policies in those areas obtain the best possible results. Solving the systemic failures should assure that they are being transformed into excellence and avoiding that the results of public investments in R&D are converted in innovations relevant or useful for the productive system. In fact, the main consequence of the long standing failures is the perpetuation and enlargement of some of the existing inefficiencies. Several of them do exist already for decades and others, as we have just mentioned, have been present since 1528.

2. Systemic and market failures: a theoretical approach[2]

The concept of systemic failures or problems is based on the theory of innovation systems which, in turn has its roots in the evolutionary theory and the interactive innovation model. In fact, it is a question of the malfunctioning of the R&D process itself and the interaction between agents of the national or regional innovation system (NRIS). The interactive theory put its attention on the problems of articulation of the different agents with reference to their management capability, ability to spot technological opportunities or threats and their ability to

1 Taken from the minutes of the Cortes de Castilla y León and transcribed as reflected in the minutes.

2 This article, due to limitations of space, only records small description of the systemic and market failures. For more information we recommend the work of Woolthuis et al (2005); Smith (2000; Smits/Kuhlmann (2004); Autio et al (2008).

obtain access to and integrate external information with internal knowledge (Vence, 2007; Metcalfe, 2003). A system is made up of a set of elements and their interrelationships. An (innovation) system would be a constellation, which is social, dynamic and interdependent and possesses a wide range of R&D and innovation activities (generation, reproduction, application, feedback and learning). Firms´ technological development depends not just on individual actors and factors but also the interaction and synergy of different (f)actors in the system. The firm itself forms part of an environment which can be defined as an interdependent system. The system is an open, heterogeneous one (diversity) and learning and technological transfer-which is often in the form of unintended externalities- have no frontiers. Cumulative causality, and virtuous or vicious circles, are characteristics of a region´s economic development and are of particular relevance in the case of R&D and innovation activities which are very highly complex and have a very important component of individual and collective learning.

The evolutionist theory recognizes market failures (see below) but considers them more as obstacles which are inherent to the very same process of innovation and technological change which hinder the correct working of mechanisms in the classic market when seeking its natural equilibrium. As indicated by Lundvall, “When it is a question of knowledge, market failures are the rule rather than the exception“. (1992, p. 18). The evolutionist theory recognizes, in addition to market defects, systemic faults. It is not so much the divergence between private profit and social benefit but, rather, the malfunctioning of the innovation system itself, which hampers the development of certain types of scientific innovation and knowledge. Systemic failures are based on lack of capacities found in the individual NRIS agents and/or in combination with the less than optimal functioning of the interaction between them. As a result, they show the inadequate, inefficient behaviour of the innovation system. In fact, these failures are mismatches between elements of NRIS and may exist even when R&D investment would be optimal and no market failure existed. Moreover, systemic failures justify R&D and innovation policies. We will analyses below from a theoretical viewpoint the different types of systemic failures based on the following taxonomy[3].

- **Failures of individual and collective capacity (SF1a) (SF1b)**
- **Formal and informal institutional failures (SF2a) and (SF2b)**
- **Interaction, coordination and network failures (SF3)**
- **Infrastructural failures with respect to Science and Technology (C&T) (SF4)**
- **Failures of relevance and suitability or appropriateness (SF5).**
- **Contextual failures (SF6).**

Capacity failures (SF1) (Smith, 1999; Breschi/Malerba, 1997) are the limitations of the technological and commercial capabilities of individual agents or actors (Individual capacity failure, F1a) or collectively as a sector, technological area or region (Collective capacity failure, F1b). They refer to inability on the part of possible innovators (business managers or scientists) to develop new innovations or absorb and/or integrate external technologies. This expresses itself in insufficient capacity for learning and absorbing. Collective capacity failure (collective failure to learn; Breschi/Malerba, 1997) at regional or national level is expressed on the basis of a deficient structural change towards medium-high technology sectors. In the case of both types (individual and collective) a specific form of failure can be discerned, under the name of ***Transformation failure*** (Smith, 2000). This case concerns the technological capacities of individual agents (firms, scientists, universities, etc.) in sectors or the NRIS in adapting to profound technological changes. When carrying out these changes it may be that the old or obsolete technological paradigm prevails due to lack of the technological capacities required

3 Based particularly on the works of Woolthuis (2005) and Smith (1999).

for the change and due to the predominance of "old" interests expressed through the opposition of some powerful agents who are still providing old technologies.

Such problem of adaptation or transformation problem is also known as a **lock in problem or path dependency**. In other words the recent situation has a strong dependence upon the historical paths and/or decisions taken in the past (Edquist et al, 1998) deriving from socio-technological inertia. This inertia is generated because in firms and technical schools certain technologies and routines have been learnt and festered within the organisation; moreover, the top people in power are specialists in the corresponding technique. Once technologies alter, they cannot easily change (path dependency) and have a certain amount of power to put the brake on any technological change that might affect their status and power. The lock in problem is related to this concept. In this case not only is there the question of opposition to change but the situation is produced by firms and other agents being blind to the new trends influencing their activities (Carlsson & Jacobsson, 1997).

Institutional failures (SF2) refer to the way in which the legal and informal innovation system is organized. A distinction is made here between the formal, hard institutional failures (SF2a) such as laws, and formal, compulsory norms and regulations (Smith, 1999; Edquist et al, 1998; Johnson and Gregerson, (1994) versus soft, informal institutional defects (SF2b), such as social and cultural customs (Johnson and Gregerson, 1994, Carlsson/Jacobson, 1997; Smith, 1999). That is to say, inadequate characteristics of informal or tacit institutions exist, such as cultural, social and political values, which would be the informal institutional defects. As a result of these defects, which sometimes are very deeply embedded, it is difficult to reshape the NRIS institutions to make them work more efficiently and effectively (Carlsson and Jacobson, 1997).This is particularly due to the fact that formal and informal failures (hard and soft) are often complementary. For example, "hard" institutional failures could be lack of recognition and mechanisms to guarantee excellence, based among other factors, on inadequate mechanisms for selecting researchers, lack of leadership and planning, lack of selection of priorities or insufficient productivity incentives. On the other hand, soft failures are included within the culture of protection and positive discrimination in favour of collaborators, regardless of their merits. This means a perverse culture in which agents do not hesitate to take advantage of formal institutional defects.

An important type of shortcoming are the **interaction failures (coordination and networks) (SF3)** (Carlsson and Jacobson, 1997; Autio et al, 2008). This failure is concerned with interactions between agents and bodies. As an example we have the lack of suitable mechanisms for ensuring interaction. This in turn hinders the optimum use of complementary knowledge and the creation of synergies (Carlsson/Jacobson, 1997; Breschi/Malerba, 1997). A "network" failure occurs when the activity of different agents is very badly coordinated, among other reasons, because of the lack of interaction and/or inadequate interaction. Due to the relevance of technology diffusion, the spill-over effects (externalities) and the increasing interdisciplinarity the concept of interaction between RNIS agents has to be promoted to ensure the achievement of long-term aims in term of competitiveness and growth (Salmenkaita and Salo, 2001). Networks based on reciprocal interaction and mutual confidence does not spring up in a spontaneous fashion, indeed it requires a deliberate effort and specific policies to create links between agents. Enabling such connections requires creating social capital (Nahapiet and Ghoshal, 1998; Salmenkaita and Salo, 2001). Correcting these failures involves improving interaction in order to generate, in this manner, synergies brought about by complementarities and mutual or collective learning. These learning processes are inherent for the concept of innovation systems. What this means is that the interaction and/or the networks are a basic component in mutual and collective learning. Creating associations and communities of agents and cluster policies may help to solve this problem. However, they can only be successful if such networks are open and seek to act in the forefront rather than becoming conservative associations for the protection of existing rights and interests. In this latter hypothetical case we would talk of a combination of interaction (SF3) and transformation (SF1b) defects or failures.

Another type of system deficiency are the **Infrastructure failures with regard to the S&T** (SF4, Smith, 1999; Edquist et al, 1998) In this case we refer to problems related to the availability, suitability and optimal use of the scientific and technological (S&T) infrastructure (physical S&T equipment and installations). These installations have an important role in technology transfer and in converting scientific results into innovations for the market. Thus it is important to adjust them to the needs of the productive system[4]. The need and relevance of a good publicly promoted Science and Technology infrastructure derives, as will be indicated later, from market failures and finds its justification in the necessity to create a critical mass, thus generating externalities for the productive system as a whole. Because of the advantages of scale and indivisibles, large amounts of investment are required, thus preventing S&T institutions being created by individual firms. This, therefore, is a problem for public investment to solve. ***Infrastructure failures*** refer not only to the absence but also the malfunctioning of the S&T infrastructure, which means an inadequate physical infrastructure due, among other reasons, to the lack of excellence and efficiency. What is more, the infrastructure must offer installations and equipment which fits in within the needs of the scientific and/or the productive system. In this way, we should avoid infrastructures which are obsolete or not adapted to market needs. In other words, there could be a relevance failure (SF5) also known as the "effect of the cathedral in the desert".

The next type of system defects are the **failures in relevance and suitability often due to mismatching (SF5)** Innovative activity must be able to be applied and useful to the productive system or for helping to solve social problems (such as illness, protection of the environment, etc). When R&D activities and their results are not suitable or are useless for the social and economic system as a whole, we talk of a failure of relevance or suitability or, in other words, a mismatching fault. One example would be a curriculum (study plan) of high educational institutions which is not designed to meet the needs of the labour market. The last –sixth- type of systemic failure refers to **contextual failures (SF6)** which identify those aspects of context or environment (not directly related to the innovation system) which cannot be easily acted upon but ones which indirectly affect the productive structure (SFor example the presence of small and medium sized firms (SMEs) vs the lack multinationals with their headquarter effect on R&D), the macroeconomic framework, per capita GDP, etc.

Many of the systemic and market failures interact among themselves. The distinction between the different systemic failures is purely for analytical purposes, since in practice there is a certain overlap or interdependence among them. As we have just mentioned, the relevance and mismatch failure (SF5) could be the result of the existence of inadequate infrastructures (SF4- infrastructure defects). Moreover, part of this lack of relevance could be due to the fact that the infrastructures not interact in an adequate way with other agents (SF3). In the analysis of systemic weaknesses and failures in Spain examples will be given of this overlapping in the form of specific cases.

In addition to systemic defects, other problems –**the market failures-** will be identified and analysed. These stress the problem of incentives and resources. The existence of market failures stems from the neoclassical theory and refers to those situations in which perfect market requirements are not met, and this is an obstacle, according to this theory, to the optimal allocation of resources (investments). In the case of R&D and innovation these failures are more the rule than the exception, and they are very important since, in general, they lead to insufficient investment in R&D and innovation. Such activity is an indivisible good which

4 This aspect also refer to the failure of suitability and mismatching of such infrastructural facilities.

needs costly initial investment (Critical mass and advantages of scale), it normally has a low appropriation level, and there also exists a field of imperfect information often in combination with a high level of economic and commercial risk, thus involving high uncertainty. The first of the market failures, known as **advantages of scale and indivisibility** (MF1a), is a particular problem in the case of R&D and innovation. Because of the high costs of entry in the innovation market and the lengthy duration of a large number of R&D projects there is the need for a **minimum critical mass** (MF1b). Such indivisibility based on the high cost of initiating R&D processes, would mean that only a few large firms could begin such activities and thus corner the market. At the same time, regions or countries which do not have large (multinational) companies and headquarters and, subsequently whose productive system consists basically of SMEs will not have these facilities. The second market failure is based on the concepts **of public goods and externalities and the problem of appropriability (MF2),** which spring from the same global idea. Knowledge, in many cases, is a good which can be easily copied **(public good)** and its use and marketing, as a consequence of imitation, plagiarizing or pirating, is not limited to those economic agents who create and use it **(appropriability problem).** This generates overflow problems **(externalities)** in those agents who took advantage of technological progress without contributing to its costs. The evolutionary theory does not deny the existence of innovation in form of public good based on codified information easy to copy. However, this theory also argues that they coexist with large amount of tacit knowledge difficult to master which cannot be codified and therefore is not a public good.

The third type of market failure is **imperfect information and uncertainty (MF3).** Asymmetric information is an obstacle to the neoclassical coordinating mechanism of the perfect market. The innovation process is developed within a dynamic framework with a high level of uncertainty due to the fact that information is distributed in an asymmetric manner, so that development and decision-making are based on expectations with a speculative component. There is information shortage and, consequently uncertainty with regard to; (1) technological and commercial future success (being able to apply the technology successfully and make it relevant for the market; (2) final prices and/or costs and (3) the real potential of future virtual markets. This market, in turn, depends to a great extent on the final price and possible threats from future substitute technologies. This last aspect is almost totally unknown (due to secrecy regarding competitors´ innovative activities). Furthermore, the speedup of technological advances in the last 20-30 years has shortened the period in which the inventor can benefit from his/her invention.

In the following pages the weaknesses and strengths of the Spanish innovation system (SIS) are analysed with reference to the above-mentioned system and market defects. Four global aspects of the innovation system are studied, the general context, the business and R&D and innovation system, the public R&D and innovation system (public research bodies and universities) and R&D and innovation policies (instruments for promoting R&D+i).

3.- Failures in the Spanish innovation system

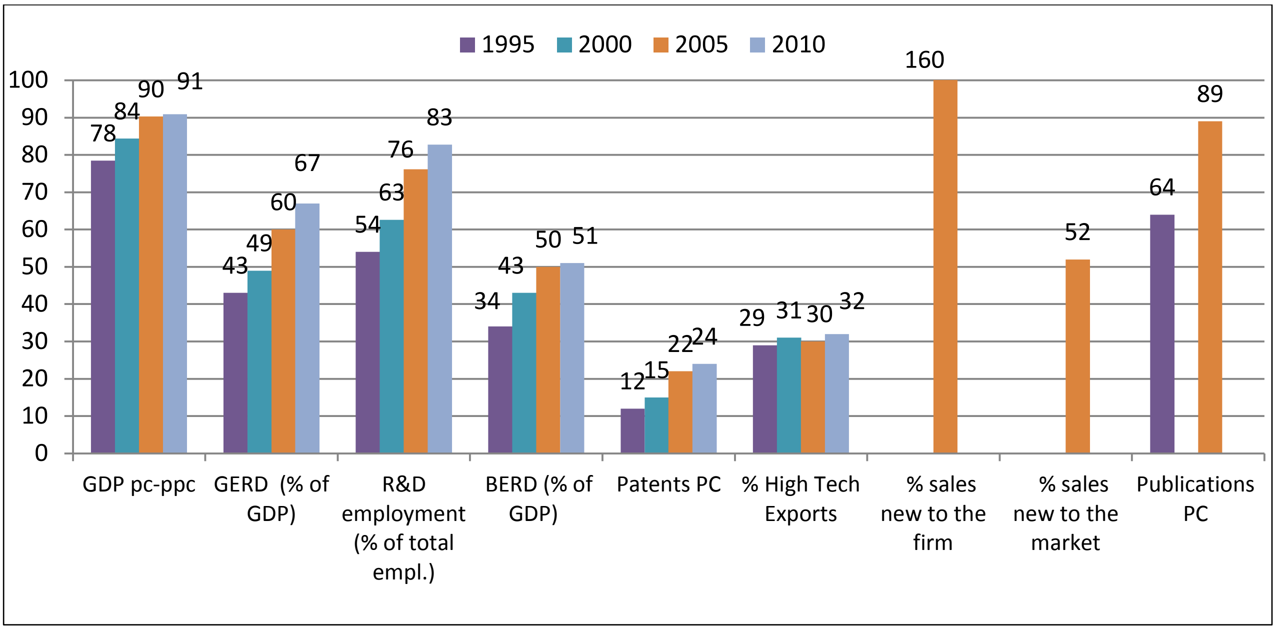
3.1.- General economic environment

Nowadays there is no doubt, by the Spanish policy makers, business man and workers association, that Spain´s emergence from the crisis and recovery of its competitiveness has to be based on technological change. The need for the Spanish economy to make technological progress has been substantially accentuated by changes in its macroeconomic framework. In recent decades Spain has shown substantial convergence with the most advanced countries in

Europe in terms of per capita GDP. Prior to the 2008 crisis, this indicator stood at around 91% of the average for the European Union[5] 15 while in terms of R&D and innovation Spain is at 55-60% of this average (See graph 1).This means that, apparently, economic convergence has been easier to achieve than technological convergence. The latter is pending and makes it difficult to emerge from the crisis. This technological backwardness is the outcome of the Spanish growth model of the last 10-15 years, based upon sectors with a low technological level and "bricks and mortar", whereas the production system as a whole has not gone for a model based on the knowledge economy, which can be considered a transition failure (SF1b).

Graph 1. Spain´s technological backwardness compared to the European Union[6]

Values as percentage of European average (UE= 100)



Source: Own elaboration based on EUROSTAT. (2010 data are the latest available post-2007; PPC=purchasing power parity).

Spain, in the first ten years of this century, showed a higher growth rate than the European average thanks to low interest rates, fiscal policies, European funds and the arrival of immigrants. By 2006, the governor of the Bank of Spain (Banco de España BE. Miguel Ángel Fernández Ordóñez[7], indicated that the Spanish economy´s Achilles heel was low growth of productivity, ever-increasing family indebtedness, the accumulation of inflation differentials, the sky-high external debt and lack of international competitiveness. This is just one of the possible confirmations that prior to the crisis there was already a panorama which did not bode well for the future. The high level of complacency in the boom years of the Spanish economy, despite its strong growth rate, was covering the problem of poor competitiveness and impeded the taking of the necessary measures to tackle a change in that model, which in 2006 already showed clear signs of exhaustion (Fernández Ordóñez 2006). Competitiveness can only be improved by applying slow, long-term plans, plans such as improving human capital or investment in R&D+i. While it is true that the financial and human resources devoted to R&D

5 The 15 most advanced EU countries before the expansion to Eastern Europe that we used as the reference point for Spain. Per capita GDP is reflected in terms of purchasing power parity.

6 We present the level of Spain in comparison to the most advanced countries in the European Union (EU-15 or EURO Zone). Regarding the R&D results only data for the EU-27 is available. Therefore the technological distance compared to EU-15 will be higher than what is reflected in the graph.

7 In his appearance before the Senate Budgetary Commission in November 23, 2006.

have shown a substantial increase and that, in the period 2006-2010, the government has opted clearly for innovation, the results are clearly not enough.

The need for the Spanish economy to make technological progress has been strongly reinforced by some changes in its macroeconomic framework. Spain has lost its historical comparative advantage based on low wages[8] (SF6), and can use no longer the exchange rate of its Peseta[9] (SF2a/F2b) as an instrument for recovering -artificially– its competitiveness. This new reality would have to be regarded as a challenge or opportunity forcing businessmen and politicians to face the lack of competitiveness on the basis of technological change. This means that the Spanish production sector should create activities with high added value and seek real productivity increases, instead of making excessive use of artificial instruments such as tweaking the exchange rate and low wages (Heijs, 2010). Another macroeconomic change is that Spain has achieved a relatively high intensity of capital per worker (capitalization rate).When such a level is reached, the productivity gains from extra capital investment by worker -in the long term- tend to be very low or almost zero[10]. Consequently, from that moment onwards, capital accumulation in itself is not anymore an engine for long-term economic growth and productivity can only be increased through technological progress. All of this means that in Spain there is only a minor need for an increase of the capital investment by worker but, rather, Spain need capital or machinery with a higher technology level providing higher efficiency and productivity levels. In this way, the same capitalization rate by worker achieves higher productivity. Another way of increasing productivity would be to produce goods with higher added value (greater technological level).

To sum up, technological progress is the only way to guarantee an increasing standard of living in the long term but this is precisely the area where Spain is making slow progress. The weakness of the Spanish Innovation System (SIS) lies in a transformation failure (SF1b) in its production system towards a knowledge based growth and technological progress. Spain has not managed (or only partly managed) to transform its production system towards a modern one on the basis of technological advances and an innovation culture (SF1-F2b) [11]. On the one hand, there is no doubt that Spain´s technological level has shown vast improvement in recent decades. Buesa (2003/2012) stresses the creation of a home-grown innovation system which was practically unknown in the seventies. In the period 1980-2008 expenditure on R&D multiplied sevenfold and its level with respect to GDP has risen from 0.43% to 1.35% in 2008. However, Spain is still not showing real steps (or reflect only some marginal changes) in changing the production system to one which is based on technological change. In fact, Spain´s R&D intensity (R&D expenditures by GDP) has not exceeded 66% of the UE-15 average and its business R&D intensity is 51% of this average (see the graph). Even the weight of the high technology sectors in GDP has fallen from 33% in 2000 to 26% in 2009 (Buesa, 2012). The economic crisis has worsened the situation. There have been cuts in private and public R&D and in recent years some 3,500 innovative firms stopped doing R&D or disappeared. In the case of results of the R&D activities the backwardness is even more marked. In the case of hi-

8 According to EUROSTAT 2010 data average Spanish wage costs were 2800€ per month whereas in Eastern European countries this cost was between 400€ in Romania and 1,400€ in Czech Republic.

9 The use of the exchange rate is an indirect way of lowering wages (purchasing power) of imported goods. Cuts in wages are politically unacceptable while a drop in the exchange rate is acceptable by social agents.

10 The law of diminishing marginal returns states that in all productive processes, adding more of one factor of production, "*ceteris paribus*", will at some point yield lower per-unit returns. In other words, the higher the capital intensity by worker, the lower the productivity gains due to new capital investments that increases this capital intensity. This means that the extra production increase due to introducing more capital per person is increasingly less. On a certain point only the technological progress can assure extra productivity gains maintaining constant the capital intensity by worker.

11 The lack of an innovative culture may simultaneously reflect two systemic defects. It may be the result of a cultural attitude (SF2b) or the inability to recognize or be able to put technological change into practice (SF1).

tech patents and exports Spain is placed respectively at 15% and 32% of the European average. While it is true that results in science are nearer to the European average this placing has not led to technological convergence at firm level where the results from public R&D are applied to innovations launched on the market.

Another aspect of the macroeconomic environment is the deindustrialisation process of the Spanish economy[12]. In fact, an important challenge for Spain is the need for re-industrialization. The European Commission argues that "a new industry policy needs to be launched with the long term objective of considerably increasing the weight of industry in the Spanish economy". As argued by several reports[13] and interviewed opinion leaders the current deindustrialization is affecting negatively R&D and the potential for success of the new R&D&I policies. In fact such deindustrialization diminishes the possible modernization of other sectors and the corresponding positive synergies and consequently they have more business innovation expenditure. Due to the progressive deindustrialization of Spain, the main actors of the science and technology system have experienced a reduction of their potential domestic market for knowledge based activities or goods. Zabala (2013) argues that "the industry is the driving force of innovation. Even very good policies will not have success if there is no industry to absorb them", and the Report of PwC underpin that the industry is the sector with the highest creation of added value by labour unit and the main sector for exports. On the other side also the service sector depends partially on the industrial sector. Like mentioned by Zabala (2013), nowadays all large industrial enterprises offer some high added value services and all service sector enterprises are partially based on complex capacities of industrial origin. So both sectors are complementary and their coexistence should create positive synergies. The industrial policy should be complementary with the promotion of R&D and innovation. An integrated approach is required in which both reinforce each other mutually based on the support of emerging sectors complementary to the support of the traditional sectors for its upgrading and modernisation. It has to be pointed out that often new emerging technologies increase the efficiency of the activities of the more traditional sectors.

A last aspect the economic context is the bank system. Spanish banks are based on attempts to obtain short-term profits (such as the bricks and mortar economy), and cannot be viewed as industrial banks pursuing long-term industrial development, as is the case, for example, in Germany (SF1/SF6)[14]. Moreover their experience on the evaluation of R&D or innovation projects is low which impede often the achievement of credits by innovative firms.

3.2.-The innovative culture of the Spanish production/business sector

In the last 15 years before the crisis the Spanish production system has extended the critical mass of the innovation system in a very important way. The number of innovative firms has increased from some 1800 firms in 1995 to more than 15.000 in 2008. However since the beginning of the crisis this number decreases to 11.500 in 2010[15].

Table 1.- Evolution of the R&D and innovation activities in Spain

[12] In the most advanced European countries, industry has a higher weight in their economies (in Spain 13.3% of its gross value added compared to 15.3% for the EU-27 in 2012),

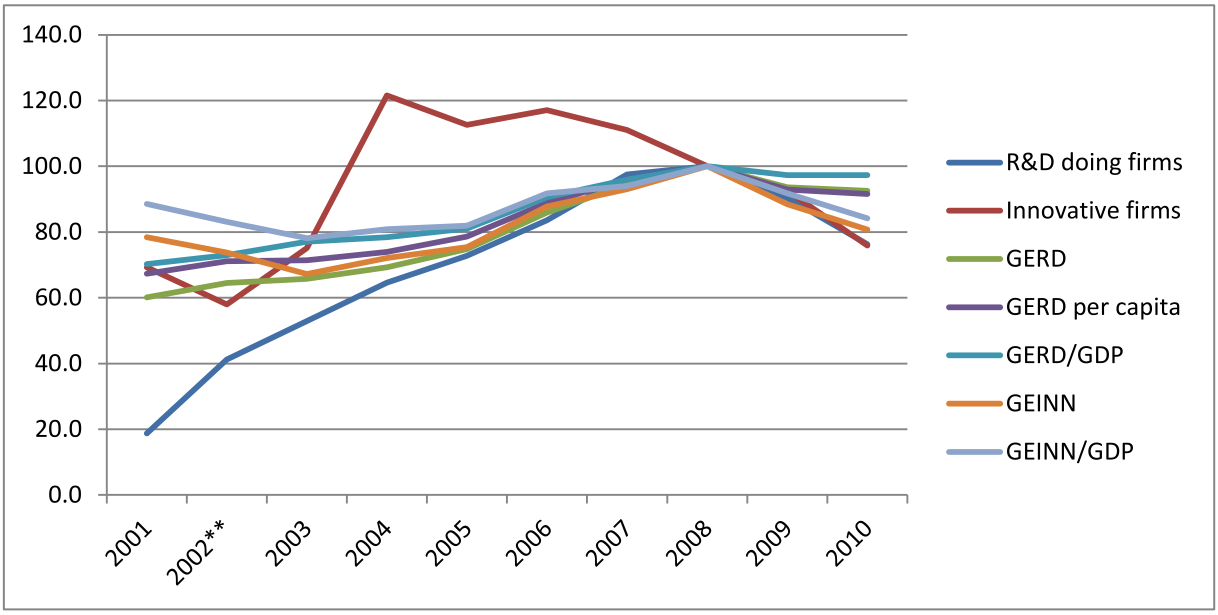
[13] Some related reports PWC, 2012; European Commission Staff Working document on Assessment of the 2013 national reform programme and stability programme for SPAIN (EC, 2013); OPTI 2010; Fundación EVERIS, 2010; the Reflections of the Spanish Industry of the "Consejo General de Colegio Oficiales de Ingenieros Industriales": http://www.ingenierosindustriales.es/Docs/Reflexiones_sobre_la_Industria_Espanola.pdf

[14] REQUIRES A REFERENCE AND WHTA HAPPENS WITH RISK CAPITAL

[15] The number of firms considered innovative went up from 24,500 to 49,500 between 2002 and 2006 (25% of all Spanish firms). However, since that year the number reduced continuously till 32,000 in 2010 (18.6% of all firms).

	Number of R&D doing firms	Number of Innovative firms	GERD	GERD per capita	GERD by GDP	GEINN	GEINN by GDP
2001	2,814	29,228	4,855	119	0.52	15,611	1.62
2008	15,049	42,206	8,073	177	0,74	19.919	1.83
2010	11.481	32.041	7,469	162	0.72	16,091	1.54

Tendency in index numbers (2008 = 100)



Own elaboration: data from www.INE.es The Gross Expenditures on R&D (GERD); and Innovation (GEINN), expressed in millions of euros on constant prices for 2008.

In similar fashion R&D and innovation expenditure has registered an important increase in this period and only did reduce slightly in the last 3 years.

Despite these clear increase of the R&D expenditures, and as has already been indicated, the Spanish growth model was not based on a knowledge economy but on "bricks and mortar" and other not very productive sectors. In the last two decades wage increases in Spain have given rise to a relocation of production units in traditional sectors to low-wage countries, a trend which has grown in this period of economic crisis. This by itself would not be a problem had new firms been created in the medium-high tech sector, but this has hardly been the case. This lack of change can be considered as a transformation failure (SF1b). Innovation and technological change can be considered the only way of overcoming the present crisis. With the present weight in the industrial structure possessed by the traditional low-tech sectors Spain is not competitive with low-wage countries like China, India or Eastern countries and those which form part of the European Union (Poland, Romania, etc.)[16].Consequently, a hypothetical fall in wages does not solve the problem of changing Spain into a more competitive country. Probably it helps on the short term, although in the long run Spain has to innovate to improve its competitiveness and to be able to emerge from the present economic crisis. In the next pages we analyse some of the basic problems affecting the production sector with regard to R&D and

16 Remember footnote 13

innovation are: the lack of critical mass (MF1); the informal institutional failure (SF2b) of the absence of a culture of innovation with a determined opting for technological change and limited technological capacity along with limited absorption and/or learning capabilities which can be considered as a capability or transformation failure (SF1b).

The first problem would be, despite the increased expenditure and number of firms carrying out R&D, the lack of the necessary critical mass (MF1b) to generate advantages of scale and a process of specialization. This problem is particularly reflected in the significant weight of small and medium-sized firms and low-tech and/or traditional sectors (ERA-WATCH, 2009/2012, EC, 2011[a]) along with the almost complete absence of large Spanish firms and/or multinationals. The dominance of SMEs combined with the lack of a sufficient number of large Spanish firms and multinationals is a problem because it are the large firms which determine the existing critical mass[17] and who would be required to play a main role and drive the creation of R&D clusters and lead the networks in certain sectors. This would generate synergies, economies of scale and scope and specialisation processes with their corresponding systemic advantages. That means the absence of them gives rise to another systemic defect; since it complicates the creation of networks and interaction (SF3). There also exists a genuine risk of Spanish multinationals being sold off to foreign firms with the possible transfer of their R&D activities to central headquarters abroad[18]. Moreover, Spain has a small hi-tech sector and marginal growth in the most promising emerging sectors (SF1).

Another basic problem is the lack of a culture of innovation (SF2b – COTEC, 2011)[19] directly interrelated to the lack of technological capacities (SF1). Both failures impinge on each other and it is not possible to discover which came first and/or which one is the cause and which the consequence. While there is still an existing low-innovation culture capacities will not be created, but the lack of capacities prevents the generation of an innovative culture. The situation seems to be in certain way a vicious circle in which the changes are going very slow.

Moreover the lack of an innovative culture prevents or impedes the creation of a critical mass (MF1b). Spain has a low percentage of innovative firms compared to countries such as Germany or the European Union[20] Furthermore, Spain has lost over 25% of its R&D doing companies and over 35% of its innovative firms between 2006/7 and 2011. The absence of an innovative culture is also reflected in a survey by COTEC Foundation (COTEC, 2011), which indicates how one of the main problems or obstacles to business innovation is the lack of culture in the financial system to fund innovation (SF2b-80%)[21] and the insufficient potential of internal demand as an engine of innovation (MFI1b-83%)[22]. This low demand for "innovations" may be caused by the lack of a technological culture among consumers and/or businessmen (SF2b) but may also be interpreted as a lack of critical mass (MF1b) since the

17 Multinational firms are responsible for nearly two thirds of R&D expenditure on a world scale.

18 A large part of R&D activities by multinationals takes place in the country of origin because of advantages of scale and the need for critical mass. Furthermore, such centralization of R&D also should ensure the maintenance of a higher level of secrecy in particular where the R&D is regarded as strategic.

19 The COTEC is a foundation –presided by the Spanish King and promoted by the large Spanish firms- that promote the innovation in the production sector. It annual report on STI is one of the main sources for information on this topic

20 According to the latest data presented by Eurostat (2008) 44% of firms in Spain are regarded as innovative (including firms with innovative activities in the broadest sense (innovation of products, processes, organization or "marketing"). In Germany the figure is 80%, in Eastern European countries it is between 24-34% and the average throughout the Soviet Union is 52%.

21 In brackets the percentage of firms who consider it as a very important problem in terms of the number who replied to the COTEC or CIS surveys.

22 The 2010 Innovation Survey also reflects this problem. 28% of innovative firms consider shortage of demand (SF1-F3c) as a reason for not innovating and 29% of innovative firms consider demand as the main obstacle to innovation..

existing demand is too small to generate new innovative activities. Like mentioned already by Adam Smith (1776) the level of specialisation is limited by the size of the market and this is also the case for innovation systems. Likewise, the COTEC survey reflects in the last years a negative trends with regard to innovative culture (48%, F2b) and preoccupation with the lack of business dynamism concerning innovation threats (53%, F1-F2b).

The third problem –also confirmed by the COTEC foundation-, is that the structure of Spanish production as a whole is lacking in technological capacities (SF1; COTEC, 2011). In fact firms look on innovation as an option for solving short term problems rather than a strategic option for the long-term future (SF1). The lack of innovative capacity is also reflected in another structural and historical weakness of innovative firms: the low level of patenting (COTEC, 2011A)[23]. The COTEC survey also reveals a lack of collaboration in innovation matters among firms. (78%), due possibly to a problem of capacities (SF1a) reflected in inability to cooperate or interact (SF3) (COTEC, 2011).

3.3.-Public R&D system: Public Research Bodies (OPIs) and universities

In the last two decades important growth in R&D in the public sector alongside a very important increase in expenditure has been observed (see ERA-watch 2010/2012, Buesa, 2003/2012) with annual 25% growth rates in 2005-2009. But in spite of the enormous economic effort, the public R&D sector has not modernized its way of working nor has it become more efficient. In fact public research bodies who have received the greatest part of extra public aid have seen their number of publications per researcher fall (See Buesa, 2012). Though it is true that in Spain there are exceptionally talented scientists, the Spanish public research system in general is not noted for its quality and productivity and a large number of "systemic " failures festered for decades and are the main reason for the lack of significant improvement.

3.3.1.- Lack of an excellence-based culture and meritocracy

An initial group of interdependent systemic faults in the Spanish scientific system is based on the lack of an excellence-based culture and meritocracy (SF2a/F2b). There are many direct signs of the lack of a culture of excellence and productivity. For example, 25% of university teachers have not had their research activities officially accredited (they have no six-year research bonus), and only 50% have the maximum number recognition of six-year research bonuses possible. Moreover, Spanish universities are notable for their absence in the international rankings for university quality, where they are placed a long way below the leaders. The top Spanish universities appear at places lower than 150 or 200. (The exceptions are business schools ranking where Spain is well placed). Another example reflecting the total lack of interest in introducing a meritocracy-based culture is the evaluation of doctoral theses where in 99% of cases a Cum Laude is unanimously awarded. This fact exists in combination with lack of interest on the part of universities and OPIs to put and culture based on excellence [24] into practice. This lack of attention is shown by the high level of endogamy and corporatism[25] (SF2b). Here the failures of formal institutions (SF2a) and informal ones (SF2b)

23 Regarding patents, Spain is at 32% of the European average (CE, 2010b)

24 In this work there are various significant proofs of this lack of interest. For example, the data shows that in selection of research and educational staff endogamy prevails over meritocracy. Universities and OPIs did not used their autonomy to regularize the selection and hiring process through their statutes. Another example of this lack of interest is the universities neglect of their obligation to assess teaching activity for the recognition of periods of teaching (five-year bonuses). In fact in the vast majority of the universities everybody get that bonus without any evaluation. Other examples are the fact that there is no requirement to have a minimum level of English to enter university and doctoral thesis receives a Cum Laude as a general rule.

25 This is a concept in which the very same members of an organization (in this case the Spanish university) defend their own interests and members above the general interest of the society.

are complementary and lead to a large number of scientists having no qualms about taking advantage of a permissive formal regulation which favours their own interests.

Even if public institutions were willing to implement such a culture of excellence, there are some institutional obstacles blocking such strategy. First off, all the rigid systems of incentives (wages-F2a) mean that neither productivity nor excellence receives its reward, and this acts against the recruitment of the most talented. Theoretically or formally there exist certain mechanisms for rewarding productivity, which should act as an incentive to excellence. But these are not very selective, and are in some cases awarded in automatic fashion and merely offer a marginal wage rise. The whole set of productivity bonuses could increase somebody´s wage by a maximum of 15% but this theoretical maximum is based more on seniority than productivity (SF2a) and is received only after thirty years (becoming the recognition of all six "five-year" teaching periods and all five "six-year" research periods)[26]. It must be stated that most of the productivity payments are not based on one´s most recent activities but rather on productivity throughout one´s whole working life, so it loses any incentive effect. Moreover, the five-year teaching periods require an official evaluation of teaching quality, though in fact they go through on the nod in the case of most university teachers (SF2a)[27], without any real application of evaluation of the quality of the teaching taking place. What is more, even these people on special assignments or who for any reason do not teach receive these five-year period bonuses. So in fact, it is a seniority bonus. To obtain a bonus payment after a six-year period of research in most scientific areas[28] a certain level of productivity is required, even though they are based on easily achievable levels (SF2a). Likewise, a researcher who reaches this minimum receives a similar reward to those with higher productivity levels in the same period and this "productivity" bonus is consolidated for the whole of one´s working life, thus, once again, introducing a seniority element[29]. Referring to the "entreaty" by the Chancellor of the University of Salamanca and Valladolid the problem would not be the existence of lifetime tenured posts, but the lack of productivity incentives, or in the event of there being such incentives, the low or non-existent level of requirements or discrimination. To which in our case must be added the careless way in which those in charge in universities apply them correctly.

Additional to the absence of formal regulation (SF2a) to reward productivity, excellence, and social and economic relevance of public R&D, there exists also a corporatist culture (SF2b)

26 Bonus payments for five- year teaching periods formally reward teachers who have taught their classes well and bonuses for six-year research periods give rise to a wage bonus for those researchers who can accredit their research quality.durante muchos años se ausentan de forma injustificada en más del 50% de sus clases sin que se haya abierto un expediente al respecto.

27 Regarding five-year bonuses for teaching, which formally reward quality in teaching, there is no system for assessing such quality and they are granted automatically, except for those who are subject to disciplinary proceedings. But, in practice such proceedings are only initiated in exceptional cases such as racism or clearly sexist behavior. What is more, there are cases of teachers who for many years were absent without just cause for more than 50% of their classes without any disciplinary action being taken.

28 Criteria for the awards depend upon each scientific area and there are an important number of areas where six-year research bonuses are given almost automatically. Where there is greater strictness would appear to be in the area of economics, politics and engineering (55-65%) while in other fields such as Biological Sciences 90% obtain this recognition (SFernández Esquinas et al 2006). These percentages are not directly comparable since in the most demanding areas the people who do not think they are going to make it exclude themselves whereas in the most permissive areas everybody requests the award. This means that in fact the differences would be much greater.

29 For example, a researcher who has obtained two six-year bonuses at the beginning of his/her career (based for instance on 6 quality articles) but has done no research during the last 12 years obtains a greater productivity bonus than a young researcher who in five years has published 20 articles. The latter does not obtain the bonus because he needs another year to complete the six-year period and, moreover, after the sixth year despite having achieved in 6 years a clearly higher productivity level than the former in 24, his/her bonus will amount to half that of the other researcher.

which has given rise to a high level of endogamy in contrast to a meritocracy-based culture. In Spain in 95% of the competitive examinations for a university and OPI post the in-house candidate is chosen whereas in the USA, United Kingdom and France these percentages are 7%, 17% and 50%, respectively (Haug, 2009). Moreover, a recent study (Sanz/Castro 2011) shows that this endogamy goes against meritocracy since it applies negative discrimination against the most productive and mobile. This study analyses the determining factors impinging upon whether one wins a place with tenure as a public servant doing public research in universities and OPIs and reveals-against all common sense- that the number of publications and international mobility (periods of time abroad, etc.) have a negative effect on achieving a permanent post. That is, they reduce the chances of gaining a place. As these researchers state: "It is clear that teachers who are endogamic and do not move are at a relative advantage for obtaining an early tenured post compared to the non-endogamic and immobile ones (p.54)".

It is true that for the last decade some minimum requirements for obtaining a post as a researcher (based on accreditation) were introduced, but universities –with the support of the labour unions – allow contracting commissions to be set up ad hoc in order to assure the win of internal candidate. The evaluation of candidates is based upon ad hoc hiring criteria with a large discretionary power to match the criteria to the strong points of the curriculum of the internal candidate, thus making it difficult for any outsider to gain access (SF2a/F2b). Accreditation has to a great extent hindered[30] the entry of people with very low qualifications, though at the same time universities only announce new posts (SF2b) when an internal candidate has been accredited and all the members of the examining board who judge the candidates are personally appointed by the department itself (SF2a), which makes it almost impossible for external candidates to achieve entry[31].

3.3.2.- Lack of efficiency and deficient suitability of the R&D results for the production sector or society as a whole

A second set of interdependent systemic failures which complicate or hamper the creation of quality universities with an efficient use of the sources for R&D relevant for the production sector or the society as a whole is the: fragmentation of research groups, the separation between science and innovation, the lack of leadership and absence of strategic planning –in almost all its terms- geared to general, relevant objectives or ones which would be of relevance and use to the society as a whole (SF1-Lack of leadership defect). The lack of such a strategy hinders (SF1) the maximization of results (efficacy) of R&D and teaching in relation to national needs and objectives (SF5): the costs minimizing (efficiency –F1)[32] and (MF1) the creation of a critical mass based on related specialisation and diversification due to the dispersion and fragmentation of R&D activities. Some of the elements or consequences of these systemic failures are: academic orientation towards fields a long way away from the production system (SF5) and the low level of usefulness and relevance of their results (SF5; in combination with the absence of mechanisms for the control of quality and excellence (SF2a), and the defence of

30 To a large extent because there are 18 bodies in Spain charged with evaluating and/or awarding accreditations. The national body in general (depending on each scientific area) has an acceptable level of requirements. Moreover, each Autonomous Community has its own organization for accreditations (valid only in its own region). Besides the costs and inefficiency of these regional bodies the result is that in many of them the requirements are much less strict.

31 Because endogamy is present many potential outside candidates refuse to apply for the post. But if they were to apply and the internal candidate´s curriculum was clearly inferior it might happen (and frequently does) that the meeting had not produced a candidate and a later meeting would be summoned. This would enable the hiring of the internal candidate to go through at a later date.

32 The lack of efficiency is observed, among other cases, in the comparative costs of university degrees. For example, according to a report from the Audit Office, training for a graduate in Social and Judicial Sciences costs 7,000€ in the University of Seville, 10,600€ in the University of Jaén and costs reach 33,000€ in the University of Lérida.

corporate interests by the Scientific Community and its members (SF2b). The failure of relevance and mismatching (SF5) is facilitated by the way decisions are made (SF2a) and the process by which researchers are evaluated (see below). Decisions on study plans and the existence of grades are made in a decentralised, unilateral manner by each faculty based on its own interests (SF1a; F5; F2b). Among other reasons due to the marginal role of social agents in the future of the university (SF2a-F3).

Another aspect defining the lack of seriousness in Spanish universities is their low efficiency level (SF1a). Hernández and Pérez (2011) indicate three main reasons for this inefficiency. Firstly, the growing numbers of new universities and/or local campuses created by regional governments, despite insufficient demand from potential students (SF1-F2). A second cause is the fact that future stable employment of young researchers, university teachers or researchers in public bodies depends almost exclusively upon the possibilities of their own system, and this generates a strategy of internal growth. To justify such growth, new studies and degrees (including courses for experts or masters) were created, once more, without the necessary student demand. Both trends have created important cases of inefficiency and have exponentially increased the cost per student[33]. An estimate from Hernández/Pérez (2010) reveals that in more than 15% of degree courses there are fewer than 20 students a year and in 42% fewer than 50. What is more, between 1998 and 2011 (see table 2) the number of students fell by more than 12% while the number of teachers rose almost 27% and the figure for administrative staff showed a 52% rise. At the same time, most teachers did not give the legally established number of classes, so the increase in university staff does not correspond to real needs. And on the other hand most of the administrative processes were automatized and/or digitalized so the increase of the administrative level is also not justified. Once more, this unbalanced evolution implies an extra per unit cost and thus a very significant inefficiency. Even in the crisis years (2008 and 2011) and despite important financial problems, the number of university teachers rose by 17%. The third explanation for the low efficiency stems, as has already been explained, is caused by the low level of productivity and the lack of excellence of research activities (SF1a). As has already been mentioned, 25% of Spanish researchers have not passed (or requested) official recognition of the quality of their research activities (Hernández/Pérez, 2011) despite the fact that the discriminatory level required to obtain such official recognition is very low (Heijs, 2010).

Table 2.- University figures of Spain

	1998-1999	2010-2011	Growth 1998-2011	Growth during the crisis 2008-2011
Students	1.580.158	1.387.459	-12,19	16,71
Teachers or researchers (PDI)	85.921	108.790	26,62	16,60
Administrative personnel (PAS)	36.505	55.475	51,97	-1,08
Students/PDI	18,39	12,75	-30,65	0,10
Students /PAS	43,29	25,01	-42,22	17,98

Source: Own elaboration, data of the Spanish National Office for Statistics

Another aspect explaining inefficiency is the fragmentation of the public research system. At the present time the research model is based upon total autonomy and freedom for researchers. The researchers themselves take decisions and self-regulate the quantity and the orientation of their R&D orientation. A certain number[34] of university teachers exist that only accomplish

[33] See also the previous footnote (26).
[34] This is probably a minority although not exceptional.

with their lectures (around 8 hours a week during 30 weeks a year) and do not do any other academic activity. This autonomy has given rise to a research model which is broken up into fragments in the shape of small research groups (SF1- lack of critical mass). This absolute freedom in their own research activities has naturally harmed or complicated –even for the universities themselves- the development of a strategic plan (SF1) which would integrate the different partial aims of all those involved, both internally and externally[35]. Moreover, according to Fernández de Lucio (2010)) - present incentives reward such fragmentation because of the system of incentives for the researchers (SF2a). The reason for this is that, in order to promote staff or obtain funding in universities it is necessary to have been a “main researcher. This leads to a breakup of the system in smaller and smaller groups due to the incentives which could be considered a formal institutional failure (SF2a).

As one of the principal virtues of the pubIic R&D system one could point to the fact that Spain has a high level in publications, albeit accompanied by a rather low impact factor (ERA watch, 2010; Hernández/ Pérez, 2010). This fact could also indicate the orientation of public researchers towards purely scientific work divorced from the needs of the production system (SF5), something which is caused among others in part by the evaluation system of the academic researchers. The yardstick applied in evaluating quality of research is based upon the number of publications and their quality, whereas applied R&D and technology transfer scarcely count as merits or have been marginalised in these yardsticks (SF2a/F3/F5).

In fact interaction between the production sector and the scientific system is very low and in some areas almost non-existent (SF3). For the individual researchers and scientific organisations exist almost no incentives for cooperation or interaction with the economic and social context (SF2). Moreover external stakeholders (like firms that take in the students) have only a marginal role (SF3) in the decision making process concerning teaching, the curricula or study plans and/or the orientation of R&D and innovation in universities or public research bodies. This systemic failure has a negative effect on the correct matching of curricula students that completed recently their study with future demand from the labour market (SF5/F3) and on the usefulness of R&D findings (SF5). Most of the curricula university grades are designed on the basis of the interests and the real power of the teaching staff and are in almost no way influenced by other possible actors outside the university. Nor has any serious study been carried out on future needs of the labour market. This situation has led to a mismatching between the abilities and knowledge of recently graduated students and the demand for human capital. This level of mismatching (SF2-F5) is considered by firms as a very important problem (59%) or important (31%) (COTEC, 2011). This mismatch is also confirmed in doctorate courses. In general those in charge of human resources in firms speak of the low value added level of the doctor´s degree for firms. Sometimes they even consider it as a negative merit which makes it more difficult to get a job in the business sector[36]. In fact only 15% of Spanish academic doctors work in the business sector, whereas in countries such as Germany, Austria or the United States this percentage is around 35%. On the other side, publication of scientific results conflicts with the interest of firms in keeping industrial secrets to gain maximum profit from R&D investments and be able to appropriate the benefits (MF2).

35 An example of how difficult it is to apply a strategic plan is that of the criteria for distributing subjects among members of a department or a faculty. In general these criteria do not take into account quality or merit. According to general regulations the first to be chosen are those who occupy the highest places in the hierarchy (professors, tenured lecturers …) and within each category by order of seniority. When attempting to apply a strategic plan by creating a quality doctorate it may occur-and often does-that the most senior teachers demand their rights. This often affects the quality of the course.

36 Opinion of senior experts in Randstad and Adecco Human Resources (El Periódico., La Expansión, 28-10-2006).

The principle of academic freedom is protected by the constitution and has awarded universities a high level of independence and self-government (SF2a). As we have just claimed in this section, this fact has led to a culture in which researchers defend their own demands (corporatism) above the needs and interests of society (SF2b). These circumstances have given rise to a situation in which universities or public research centres are characterized as closed, not very transparent communities rather than dynamic, open, meritocracy -based organizations. Academic freedom coexists with a very limited level of economic autonomy since almost all the income comes from the State general budget and the Autonomous Communities upon which the institutions depend. Nevertheless, this economic dependence has never been used to force universities to professionalize their organization and working practices or to account for them. The Law of Science, Technology and Innovation (April 2011) has not provided much help to solve the lack of excellence and the existence of endogamy (F2a). It should not be forgotten that scientists and academics have an important role as managers of R&D and innovation policy and education[37]. Regulation maintains wide discretionary scope which enables excellence criteria to be deceitful applied because does not avoid abuse of this area by the scientific world (SF2a/F2b).

Another example of lack of interest (SF2b) on the part of politicians and universities in creating an atmosphere of meritocracy and excellence is the regulation of students´ obligations and rights. The fact is that the decree regarding these aspects of sanctions dates from 1954 and has been declared unconstitutional on several occasions[38]. Furthermore, some critical voices have been raised over the last 20 years or more in favour of new regulations, something which has never happened[39]. This suggests that there is a great deal of legal uncertainty when it comes to punishing a student for copying during exams, as well as plagiarism in the cases of doctoral theses[40].

Regional governments could correct a large number of systemic failures by using economic dependence and applying general excellence criteria in the allocation of funds[41]. Moreover, part of these funds could be reserved for those universities which meet certain requisites of professionalization and transparency in their management and selection of researchers. Where none of them meet this standard, the funds should be returned to the State Treasury for use in other similar areas, for example, joint R&D projects between firms and universities.

The problems mentioned in this section do not mean that the whole public system is made up of people with scant motivation and low quality. In fact, Spain has large numbers of high grade, dynamic researchers. The problem is that this segment does not participate, or only partially does so, in running universities. This is either due to their working almost exclusively on research and/or educational tasks or because they are not interested or do not have time to devote to bureaucratic matters. What is more, “democratic” self-management makes it difficult for people who are demanding in terms of efficiency and meritocracy-and who stand for election to get enough votes. As indicated by Paloma Sánchez regarding the democratic culture

37 They quite often form part of a political elite which regulates laws and norms in public science such as ministers, secretaries of state etc. Furthermore, they preside over or form part of control and assessment bodies.

38 Decree September, 1954, in accordance with which the regulation of academic discipline is approved. Regarding the legalisation of fraud by plagiarism see Cavanillas (2008). Ciberplagiarism in university regulations. http://www.uoc.edu/digithum/10/dt/esp/cavanillas.pdf.

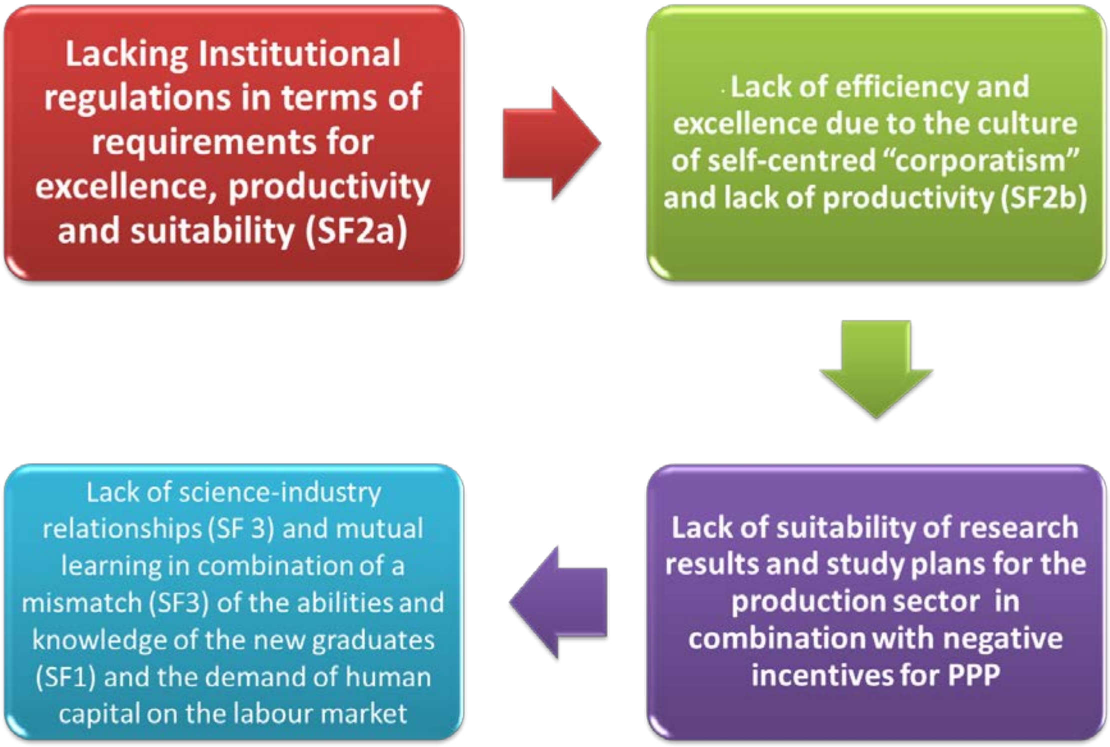
39 In the Royal Decree 1791/2010-in accordance with which the University Students´ Statute is approved-the development of a law regarding this will be developed in no more than a year´s time even if such a law has not been presented.

40 For example in the Universdad Complutense a disciplinary proceeding for plagiarism was opened (in 2010). Finally, at least officially –the end result was to dismiss it with the argument that it was simply an initial draft.

41 The Comunidad de Madrid makes a partial application of such criteria for research funds, although its effect is reduced because some universities (e.g. the Universidad Complutense) do not apply these criteria for internal distribution of these funds (among faculties and departments).

of universities (2008): “It is a weak model unable to manage the university with criteria and in a rational manner”. In fact, events of recent decades have shown that the democratic model offers every possibility to pressure groups to maintain their existing privileges with no need to account for them to society in general.

Graphic 1 An example of the sequence of system failures in the public science system



3.4.- R&D and innovation policies

Probably the area in which there has been most modernization in the Spanish innovative system is concerned with R&D and innovation policies. In the last decade a broad group of complementary instruments has been developed focused on challenging the problems of the Spanish Innovation System (SIS) (OECD, 2006; COSCE, 2005, ERAWATCH 2012) in combination with increase –before the crisis- of over 100% of the budgets. These evident improvements coexist with failures in the operational mechanisms the policies which prevent the achievement of its basic, inherent aims namely: enable Spanish firms to compete successfully in international markets. Regarding three main policy failures (SF1/SF2) can be mentioned. The first one is the “coffee for all” culture in opposite of a clear priority setting in terms of the most relevant and promising areas related to the strengths and challenges of the Spanish production and innovation system (SF1b). Secondly, the Spanish Science and Technology Policies (STIP) is still based on the linear approach biased to science and marginalising the innovation policies. And finally, the lack or deficient development of some instruments, especially in the policy mix on the innovation side. Some other important obstacles the success of the STIP stem from misuse by beneficiaries and agents (SF2b) and/or the lack of capacity of the agents of the innovation system (SF1) to adequately pick up the measures.

3.4.1. Lack of priority setting and leadership

The STI policies require long term policy objectives in combination with the concentration of actions and resources (budgets) on few priorities, concentrating resources on a limited set of research and innovation priorities in line with the existing local and national capabilities framed in an international dimension. However, in the last decades the different Spanish governments opted -and still opt- deliberately for a horizontal approach of almost all its STI policies. In fact, the recently approved strategic policy documents (The Spanish State Strategy –STS- 2013-2020 and State Plan –SP) for STI 2013-2016 –SP-STI) are not based on an updated and in depth analysis of the Strength Weaknesses, Opportunities and Threats (SWOT – analysis) of the Spanish innovation system and production sector in order to match the existing opportunities and challenges for R&D and innovation with the potential and capabilities production sector. The lack of an in depth SWOT analysis is an important shortcoming because the STS-STI is a long term future strategy that requires a suitable and tailor-made SWOT analysis. Moreover, the current economic crisis implies very fast changes in the innovative context -still difficult to trace in the statistics- that require alternative and creative solutions, not acting in continuity with the past. Concluding, the lack of priorities[42] and leadership can be considered as an important systemic failure in terms of a lack of policy making capabilities (SF1a) and institutional failures (SF2) and led in the past an indiscriminate inefficient growth of the Government Budget Appropriation for R&D (GBAORD).

An important problem which reduces clearly the potential positive effect of the STI policies is the political option to satisfy the interests of the highest number of agents ("*coffee for all*" distribution) in combination with the use of these policies - in a partial and/or informal way- as an instrument of cohesion policy. During the last decade a large number of experts and policymakers expressed the suspicion that the distribution of the budgets of the national R&D plan (that formally is excellence based) has a strong territorial bias and is often based on political arguments instead of reasons efficiency, relevance or excellence. In fact, we found a negative correlation coefficient (-0.4) between the regional support intensity of the National Plan for STI policies[43] and the regional R&D intensity –for the period 2000-2008-. This reveal that the innovative regions or the regions with the highest innovative potential obtain relatively less support than the regions which can be considered peripheral in terms of innovation and subsequently confirmed the so called "coffee for all" or cohesion hypothesis. These facts confirm the lack of priority setting and leadership and implies dispersion of investments and budgets which makes it difficult to achieve critical mass and leads, therefore, to a serious fall in the efficacy and efficiency of the policies. Some specific policy instruments were created to overcome this problem however only handle a part of it and do not overcome the causes.

One of the causes for such "coffee for everybody" approach is the intention to create consensus based priorities and objectives approved by all stakeholders. *However, the need of consensus for the new policy documents generated an undesired agreement on minimums, based on abstract and obvious priorities[44] avoiding or impeding the establishment of a best optimum in terms of specific (operational) objectives and very specific strategic priorities[45]*. The same consensus is pursued by the distribution for he funds distributing it between a maximum number of stakeholders (the coffee for everybody approach".

[42] For an in depth analyses of the priorities of the Spanish STI policies see ERAWATCH 2012.

[43] The correlation by each the different type of instruments of the National Plan show that this negative sign is generated mainly by the support or promotion of Human Resources ((-0,29) and S&T infrastructures (-0,54). While the support for R&D projects shows no significant correlation coefficient. This lack of correlation means reveals a distribution at random where some high tech and low tech regions get relatively high budgets and other high tech and low tech regions get relatively low budget. Concluding, also for this type of instrument (the R&D projects) the "coffee for all" Hypothesis seems to exist and implies that the formal excellence criteria are not applied.

[44] Neither the State Strategy or Plan have precise objectives or measures but abstract ones: "the impulse the R&D&I in enterprises" or "the training of human capital" , etc…

[45] The State Strategy includes only a few specific priorities (Societal Challenges) reproducing exactly those established on European level, barely reflecting their adjustment to the national needs and opportunities (SF2a).

Furthermore, the efficiency and impact from the policy instruments is directly related to excellence and, even more important, the relevance of the R&D financed by public funds. In the last decade mechanisms have been incorporated into R&D and innovation policy instruments to ensure the latter but it turns out that they do not work very well and-often- are avoidable. Moreover greater incentive is given to excellence as reflected in publications while relevance has a marginal role in the scales and criteria in use for allotting public aid to R&D. While relevance has a marginal role in the scales and criteria in use for allotting public aid to R&D. In fact the way that the public administration fosters excellence is not totally clear. On one side extra incentive is given to excellence as reflected in publications and to the reputation on international. While no clear relationship exists to link the level of Excellency to the relevancy. Taken into account the innovative level of the Spanish production sector the relevance cannot directly be related to excellence in terms of working on broadening the technological frontier, however the use of existing technologies is needed. An example could be the Technology Centres in the Basque Country that working more and more for international clients and that diminish their contribution to the regional production sector (confirm in an interview with FEDIT and Mikel Navarro)

3.4.2. The linear science biased model of the Spanish STI policies

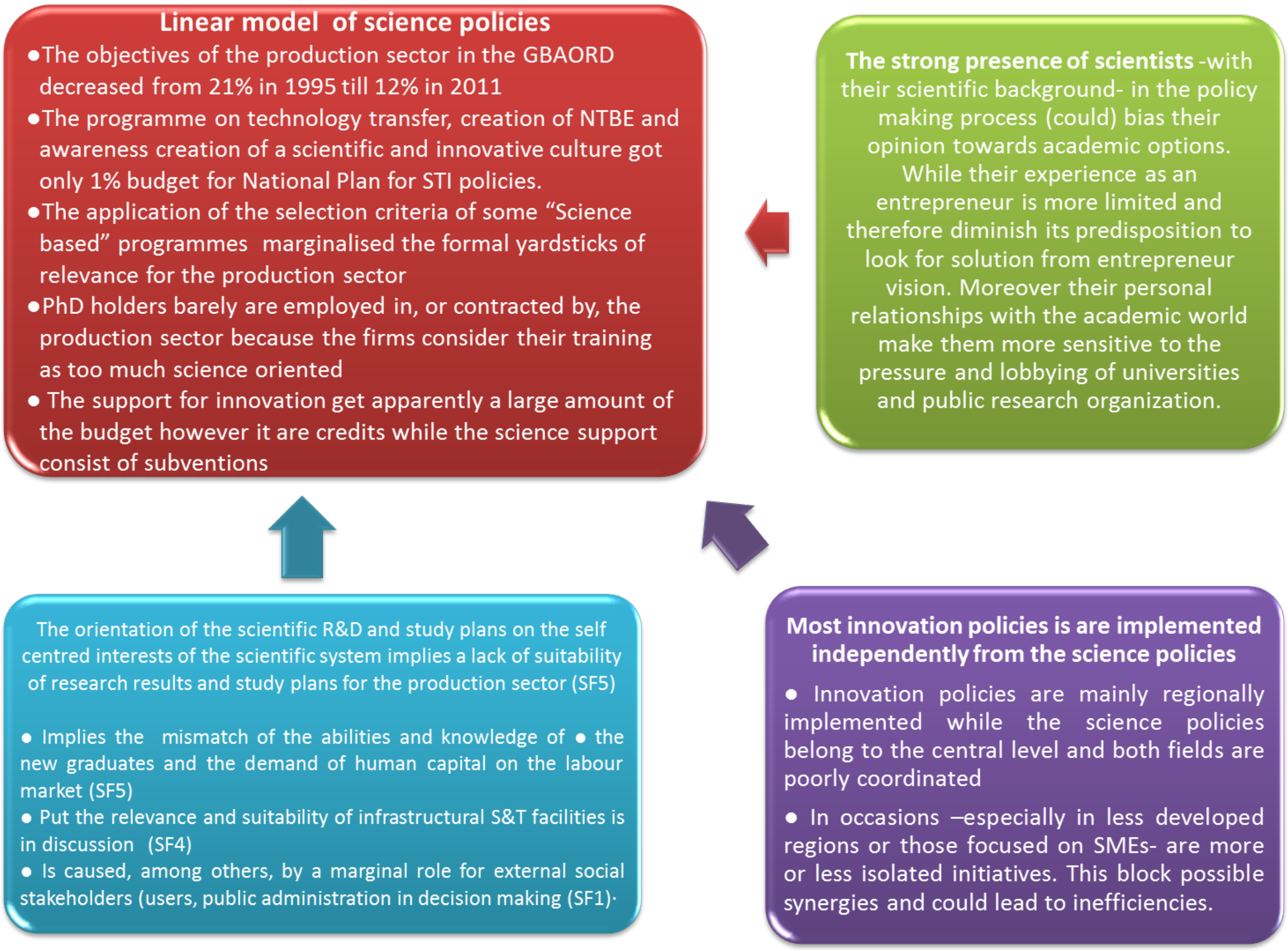
Despite of the improvement and reorientation of the policy mix towards more support for innovation and public private cooperation the Spanish STI policies are still strongly focused on R&D in detriment of support for innovation on STI policies. And specific policies backing innovation, steering excellence and promoting knowledge intensive entrepreneurship are still insufficiently developed. In other words a second basic system failure is that the **Spanish R&D&I policy is still based on the “linear model”**[46]. The characteristics of such linear model and the possible causes are reflected Graphic 2. In fact a large part of Spanish public R&D expenditure is devoted to basic R&D (23%) and applied (42%), whereas technological development receives only 35%. In China, United States or Korea the percentage devoted to technological development is much higher (respectively, 58%, 48% and 45%). In the case of public R&D expenditure by universities and OPIs, only 14% is spent on technological development and basic and applied research get 43%. [47] Several opinion leaders[48] argued that **the scientific bias is caused by the strong presence of scientists and academics in the policy making process** in combination with the lobby power of large universities and public research organizations.

[46] Zabala 2013; Rodriguez Pose, 2013; Heijs, 2012; ERA-watch 2012/2013; Buesa, 2012; EC 2012/2013

[47] In the case of the European Union the situation is even more unbalanced since 35% is spent on basic research, 45% on applied research and 19%on technical development. (Data from Europe, China and the USA taken from Arnold 2012 and the data for Spain come from the ……

[48] Like Emilio Muñoz who was in charge of the first National STI Plan of Spain (see http://www.revistacts.net/index.php?option=com_content&view=article&id=331: el-debate-el-complicado-camino-de-las-politicas-cientificas&catid=19:debates&itemid=37

Graphic 2 The linear model of the Spanish STRI policies and its causes[49]



Although suspicious exist that the mentioned corporatist behavior is also carried out by a large number of scientists in charge of the STI policies (SF2b) we do not argue that they always deliberately determine the policies against the interest of the production sector. However their scientific background could bias their opinion (SF1a) giving more value to academic options to deal with the problems.

While their experience as an entrepreneur is more limited and therefore diminish its predisposition to look for solution from the more practical view of the entrepreneurs (SF2b). Moreover their personal relationships with the academic world make them more sensitive to the pressure and lobbying of universities and public research organization. In general scientists have very often joined bodies with power of decision not just in questions of scientific policy, but also in innovation policies. Moreover in the opinion of several experts often the measures that solve the mentioned system failures are designed on such a way that they are avoidable and lack a compulsory accomplishment mechanism.[50]

Another cause of the lineal model is the separation between science and innovation. Some of the aspects of the public R&D system that reflect this separation –the lack of incentives and

[49] **A broader description of each of those aspects can be found in ERAWATCH 2012;**
[50] For example a positive change was the introduction of an system of "accreditation" for the contracting of new scientist or lecturers. However on the same time the power of the departments in the evaluation commission increased strongly which maintain the high level of the earlier mentioned endogamy.

interest for PPP, the mismatch between study plans and research results versus the needs of the production sector, and the marginal role of external stakeholders in the decision making process for study plans and scientific research- , were already discussed in the former section. Another cause is the so called "academic autonomy guaranteed in the Spanish constitution. This freedom impinges directly on the purely scientific orientation of public R&D and therefore sustains the linear model of R&D and innovation policy. Academic freedom in research is sometimes used as a scientific pretext for divorcing the Spanish scientific model from economic progress. This argument would justify the fact that universities and other scientific organizations are considered to be independent bodies which are not required to account for their activities to the public administration assuring benefits for the production sector or the society as a whole.

Regarding this question**,** few changes have been observed. Until some 10 years ago, the relevance for the production system in the criteria for awarding funds for R&D projects did not exist while nowadays it does have certain relevance. But those criteria are easy to get round it. For example the reviewers of the proposals presented for the "call for project" are almost exclusively coming from the academic sector, the selection criteria are acidic oriented and leave a high level of freedom for interpretation (discretionality).

3.4.3. The lack of certain specific instruments

Complementary to the lack of certain types of instruments it can be stated that **a substantial part of the innovation policies** is implemented on regional or local level and in occasions –especially the policies in in less developed regions and those policies focused on SMEs- **are more or less isolated initiatives**. This fact blocks possible synergies and could lead to inefficiencies. We can highlight two interdependent problems. On one side, the lack of a coherent integral approach of some specific innovation policy areas in combination with the low accessibility of most instruments for small enterprises. A large part of the innovation policies –especially those focused on SMEs- is implemented on regional or local level with a lower involvement of the national government. As stated by some of the interviewed experts especially in the (less) developed regions they consist of a set of more or less isolated initiatives and some regions even did not develop the whole set of required policies. A representative of the SMEs stated even that it was an error to promote R&D policies mainly on national level and transfer a substantial part of the innovation policies towards a regional level. This creates confusion and breaks the required relationship between both aspects. Such fragmented approach is especially problematic because the critical mass of each of them is below the required optimum and therefore efforts should be summed up instead of divided. As stated by an expert, the current situation implies dispersion of resources, objectives and strategies that do not favor the establishment a critical mass required to be competitive. Taking into account the scarce number of enterprises that are capable to increase the added value by innovation the situation is even worse.

Essentially the SMEs of all regions have the same or similar problems and the same occurs with the regional research and innovation systems. A decentralized design of those policies implies divided, dispersed and unconnected measures and causes fragmentation and consequently, lack of competitiveness. Accordingly the State Government should recover part of the initiatives on innovation policies and those focused on SMEs. In the Spanish institutional and political context such a national framework for "regional" policies is not always easy to implement. However the Central Government could create a modular framework for certain policy domains that regions could use or incorporate in their own policy mix obtaining additional funds. In this context we suggest to focus on the upstream component of the value chain (R&D), analysing how to rally the conversion of knowledge and scientific results into solutions for current/ future unmatched needs. Like the creation of specific instruments to facilitate exploitation of research results; or to boost innovation in traditional sectors. Some diverse isolated policy instruments exist on these topics but an integrated overall approach seems not to exist.

Concluding, we appreciate a low level of the development of novel instruments on the above mentioned subjects which underpins again the science oriented character of the R&D and innovation policies.

Another problem, as in most countries, is **the low accessibility of the instruments for small enterprises**. In the last years 26% of the Spanish firms stopped their R&D efforts and 35% ended their innovative activities. The large majority were SMEs. Most "R&D and innovation based" instruments are only accessible for large and medium sized firms, able to set-up formal R&D&I projects suitable for support. Some instruments for smaller SMEs exist on regional level –most of them co-financed with EU funds- however they have in general also a more traditional "project-based" approach.

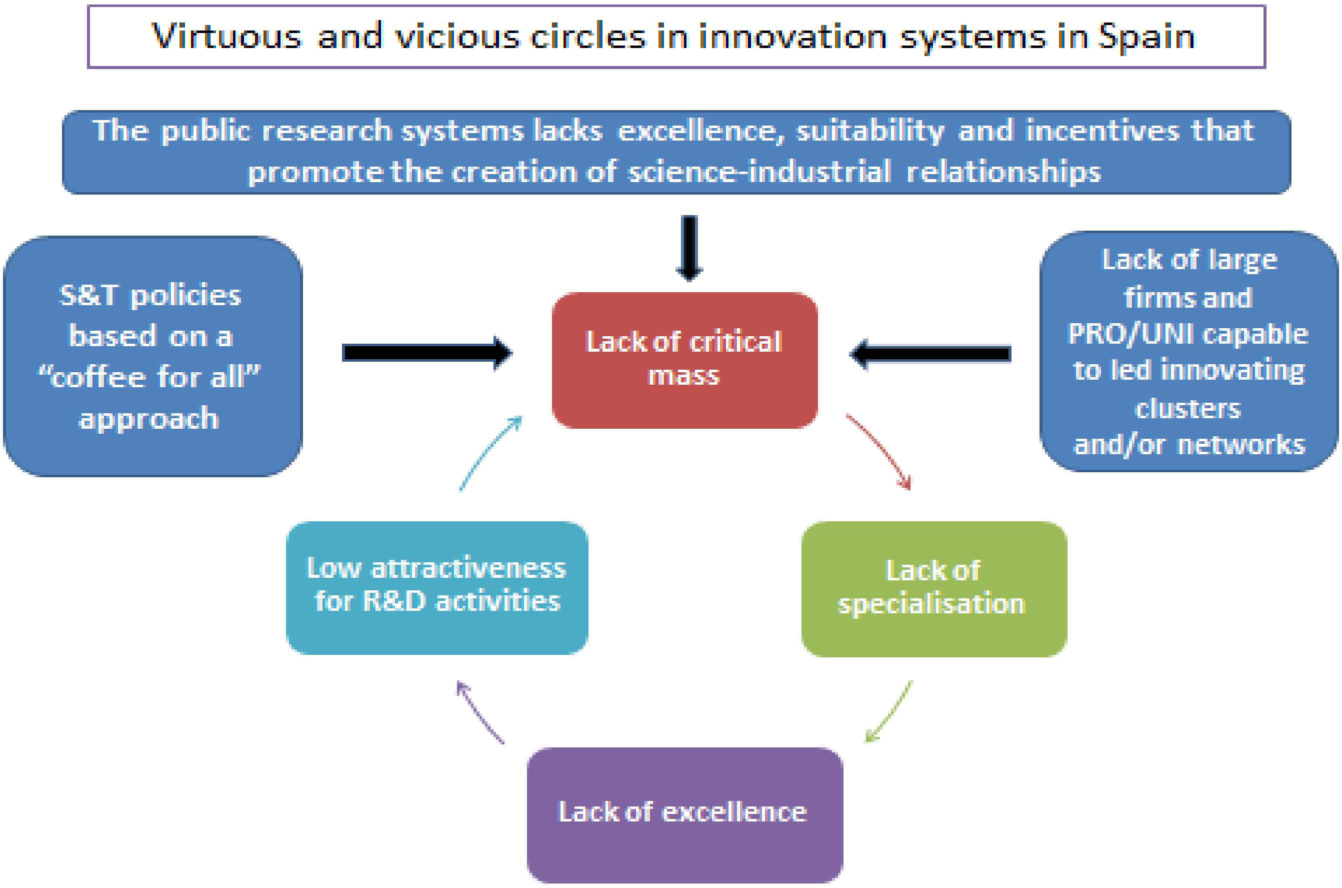
As we have mentioned, the impact of policies also depends upon the use and/or abuse of the agents receiving the financial support. There are certain aspects, many of them mentioned in previous sections, which cause a substantial drop in the potential efficiency of R&D+i policy. The first of these is the utilitarian attitude and inefficient working of certain agents in the scientific system whose work is divorced from the interests of the production system and society as a whole. Present day R&D policy is unable to overcome by itself the market failures and/or the system. That is, increased R&D effort and greater configuration of policies-mentioned as strongpoints of the SIS-must be accompanied by structural changes which should ensure that the public R&D system works properly and is able to alleviate the backwardness in Spanish technology. Modernizing the system would be a prerequisite for being able to guarantee a suitable, optimum impact for R&D and innovation policies. For example, implementing policies to create clusters or promote cooperation between firms and the scientific sector could be impaired due to the lack of excellence, relevance and interest in scientific results generated by the public R&D system. This problem of relevance hampers the creation of a dynamic innovative system in which agents are mutually and positively influenced by each other in generating synergies and virtuous circles which could bring about a positive spiral of R&D expenditure, innovatory culture, technical capacity and collaboration and, thus, a higher level of international competition.

3.5.- Interaction and mutual causality between the system and market failures

In the above sections we highlighted the different system and market failures in the subsections of the innovation system. In this one we analyse interaction and mutual causality between the system and market failures

In this section some final comments are presented on interdependences between different failures and the different innovation systems (public versus private), as well as on the problems stemming from these interdependences as far as the creation of synergies and virtuous circles are concerned. Moreover we present an analysis of the reasons why a solution for these failures has been hindered.

There are many cases of interdependence among the systemic defects. Apart from two problems which are inherent to market failures and systemic problems, both interfere with and mutually reinforce each other by generating a dynamic or vicious circle where "systemic" failures prevent the generation of the necessary multiplier effects to solve market failures (Critical mass).Interaction between market failures and the system are expressed in the fact that absence of research excellence, lack of strategic planning (linking efforts), fragmentation of the scientific system and the dispersion of aid hinder the achievement of the specialization needed to reach critical mass in key fields and thus achieve a multiplier effect to attract R&D researchers and projects from abroad.



To conclude, if Spain does not succeed in overcoming the "systemic" problems its innovation system will offer little attraction for foreign resources and might even generate flows in the opposite direction leading to Spanish firms subcontracting their R&D and innovation abroad and to the best Spanish researchers taking advantage of the opportunities and salaries on offer abroad (brain drain).

Emerging from this impasse –which has been criticized for decades-requires political will from parties and governors to make use of their powers of regulation in order to introduce unavoidable corrections. The AA.PP should use their allocation of public funds to lead and steer research and teaching in the universities towards strategic targets by creating a competitive approach, not only in the application of instruments (already in existence), but to induce a change in attitude among agents and avoid the concentration of efforts depending only on the will of researchers, universities and public research centres. In other words, a more flexible infrastructure should be created in which the existence of centres and their funding for R&D depend on results and demand for their products[51].

As well as the lack of meritocracy, low salaries and incentives for productivity and the mismatch between the needs of the Spanish economy and the results of public R&D-alongside its low quality level have a negative effect upon the usefulness of the results and on the quality of the human capital trained in the universities. This makes it difficult to transfer technology in

51 A successful funding models is the "Fraunhofer" Technological Institute in Germany (see Heijs/Baumert 2007)

the direction of the production system and means that Spain has a low level of attractiveness both for foreign researchers and for the location of R&D activities.

SYSTEMIC FAILURES OF THE SPANISH INNOVATION SYSTEM

Governance of R&D and innovation

- Lack of legal rules assuring excellence, meritocracy and suitability (SF2a) in combination with corporatism or abuse of the inadequate rules (SF2b) by public R&D organisations
- Linear model of innovation policies biased towards science (SF2a/SF1a)
- Lack of priority setting or "coffee for all" approach of the policies of public and private R&D (SF2) and STI infrastructures (SF4)
- Lack industrial policies and long term priority setting (SF1b)
- Lacking design of partial dispersed support for innovation in SMEs

Public Scientific System

Lack of suitability, excellence and efficiency

- Lack of suitability of research results and study plans for the production sector (SF5)
- Mismatch of the abilities and knowledge of the new graduates and the demand of human capital on the labour market (SF5)
- Negative incentives for PPP (SF2a/SF3)
- Lack of excellence and (SF1)
- The relevance and suitability of infrastructural S&T facilities is in discussion (SF4)
- Marginal role for external social stakeholders (users, public administration in decision making (SF1)

Lack of leadership and meritocracy

- Need leadership/strategic planning (SF1)
- ·Lack of efficiency due to the culture of self-centred "corporatism" (SF2b) and due the lack of real incentives for productivity (SF2a)
- Lack of transparency and meritocracy (existence of endogamy) (SF2)

Interaction

The lack of science-industry relationships (F3) generates a negative impact on the potential creation of a critical mass (MF1) and on the possible mutual learning (SF1/SF3) by the creation of clusters and/or promotion of interaction (SF3)

Private R&D System

Lack of innovative culture (SF1b/SF2a)

- Most Spanish firms still opt for novation for short term problem solving rather than a strategic long-term option for the future.

Limited innovative capabilities (SF1a)

- Low number of large firms or Spanish multinationals that can act as locomotive of the innovation in their sector or technological field (MF1/SF3)
- Production structure based on small and medium sized enterprises with a high presence of low tech traditional sectors (SF6)
- Low level of creation and lack of medium high-tech firms (SF1b/MF1)
- Subsequently an incapacity for the transformation to a knowledge based economy (SF1b)
- Deindustrialisation diminishing the critical mass and demand for R&D services (SF6)

General economic environment

- Loss of historical competitive advantages based on low salaries and the exchange rate (SF6)
- A transformation failure expressed by a growth model not based on knowledge and technological change (SF6)
- Banks system focused on short term benefits instead off industrial long term strategies (SF6)
- Insufficient potential of internal demand as an engine of innovation

There is a debate regarding where the problem of the low level of satisfaction with the relationship between firms and science originates. On the one hand, public research is thought not to respond to the interests and needs of firms, without any assessment as to the extent to which the present model of policy and financing of research may be responsible, and, on the other, it is not clearly recognized that the innovation deficit has its roots in the structural characteristics of the Spanish fabric (Sebastián/Ramos, 2011). There is no doubt that in an (innovation) system both parts (universities and firms) influence the success level of possible collaborations. The lack of capacities in the private sector is an important obstacle. But this fact does not justify the existence of an R&D culture in public centres which is a long way short of excellence and relevance; rather it hinders a positive effect. Moreover, precisely in the public sector, because of a shortage of (large) innovative firms, it should gear its efforts to creating capacities and a greater mass in the private sector. This underlines the relevance of public R&D for the production sector.

I would like, once more, to stress that there is a considerable number of teachers and researchers of an acceptable level who are interested in improving the university. But, as has become obvious, they have not managed to change direction towards a more dynamic, productive university. In reality the public R&D sector is still one of the great weaknesses in the Spanish innovation system which limits the creation of synergies between the public and the private (Ramos, 2008; Heijs, 2010; ERA-WATCH, 2010). Those running universities and Public Research Centres, democratically elected, guard their voters´ interests. Moreover, the unions are also against introducing demanding productivity bonuses and make it easier to help the creation of corporatism. Thus they have become the most conservative social agents in the public R&D system.

The final comment concerns the delay in resolving many of the systemic failures. These, identified decades ago, have never been dealt with. First of all, self-management based on internal democracy and " academic freedom" laid down in the Constitution in combination with the almost complete exclusion of external agents in governing bodies, has given rise to an autonomy applied in favour of the interests of the employees themselves . Universities and public research centres have hardly been obliged to explain their activities and, as has been indicated, the scientists themselves form part of the control and assessment agencies. Thirdly, due to the presence of scientists in regulating institutions, in universities and other public research centres there exists a group of individuals who almost exclusively devote themselves to the pursuit of power within them. This involves interdependence between formulating policies, allocating resources and evaluating the results. All those areas are largely controlled by people from the scientific world, and this means that there will be a conflict of interests which is not properly resolved.

First of all, the Spanish production sector shows several capability failures exemplified by the low capacity to create firms innovative firms (SF1) in both traditional and medium-high tech sectors along with limited capability (SF1) of absorption and/or learning. Those failing capabilities partially caused by the informal institutional failure (the lack an innovative culture, SF2) and by one of the market failures (critical mass FM1).

In relation to the former the main "informal" institutional failure is the low innovative culture of the firms, as confirmed by the surveys of the COTEC and the European innovation Survey. In fact the vast majority of the Spanish firms look on innovation as an option of short term problem solving rather than a strategic option for the long-term future. In other words, there is an absence of a culture of innovation with a determined opting for technological change. In relation to the latter, ***Spain lacks a critical mass required for reaching the minimum size to initiate a virtuous circle of a self- propelling growth of the innovation system; such lack of collective capabilities can be labelled as an transformation failure*** (SF1b). The lack of critical mass impedes the creation the required specialisation to create capabilities as expressed by the low number of innovative firms and intensified by the low number of large firms or Spanish multinationals that can act as locomotive of the innovation in their sector or technological field.

In relation to the systemic failures of the lacking level of Interaction, coordination and network failures (SF3) it is generally argued that Spain lacks sufficient clusters or R&D networks which partially is a consequence of the lack of a critical mass (MF1) especially the lack of large multinational firms impede the typical networks of such a kind of firms with specialised providers in form of SMEs. In general, as was argued section 3.3 the scientific organisations could substitute the role of the large firms as locomotors of the networks. However there bias the public R&D and even the programmes of the master and doctoral studies to non-production activities and subsequently the low level of interaction between the scientific sector and the production system impede such their role as a hub for the promotion of networks. It is not only a problem of critical mass but the lack of collaboration in innovation matters among firms, probably due to a problem of capacities (SF1a) reflected in inability to cooperate or interact (SF3). Moreover with some exception, like the case of the Basque Country the policies to promote networking and clustering are often based on marginal unrelated or not coordinated measures (Heijs, 2013).

4. Conclusions and final comments

In a tight synthesis Spain was-before the crisis- one of the leading countries in the growth of public R&D expenditure (EC, 2011) and has clearly improved the “mix” of R&D and innovation policies but the long-term impact of this effort could be marginal or almost nil if it is not accompanied by measures to ensure structural changes and modernisation of the public R&D system. This system is fragmented and lacks institutional strategies to guarantee synergies and quality. The autonomy of these institutions is not geared to strategies of excellence and specialization to promote technology transfer in support of the production system and the economy as a whole. This moment of profound economic crisis would be the most suitable time to foment the necessary modernisation, but what is certain is that these institutions have made few changes and have worked with complete insensitivity to the country´s social and economic reality. However, there always remains the hope that we may not need to wait another 500 years for the solution to the problems analysed in this paper.

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- Measurement of national and regional innovation systems
- Analysis, design and evaluation of R & D and innovation policies
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Innovations of institutions, trade and organizations		
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New materials	Information and Communications	Products or production systems

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Prehistory - Paleolithic	**BC 600.000 BC 10.000**
Hand axes	BC 250.000
Maintaining fire	BC200.000
Spearheads	BC 200.000
Making fire	BC 60.000
Bow and arrows	BC 30.000
Oil lamps	BC 20.000
Prehistory - Mesolithic	**BC 10.000 BC 5.000**
Rowboat	BC 7.500
Ceramic	BC 7.000
Spinning wheel distaff	BC 7.000
Iron	BC 6.000
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Adobe and brick houses	BC 5.000
Livestock	BC 5.000
Millstone	BC 5.000
Crystal	BC 4.000
Pin (Egypt)	BC 4.000
Cosmetics	BC 3.700
Clove	BC 3.500
Paper / Papyri	BC 3.500
Wheel and axle	BC 3.500
Writing (hieroglyphics)	BC 3.000
Bronze (Mesopotamia)	BC 3.000
Sailboat	BC 3.000
Compass	BC 3.000
Bronze and Iron Old Age	**BC 3.000 AD 300**
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Spinning wheel (China)	1000
Steel (China)	BC1.400
Coins (Libya-Asia)	BC 620
Mill (Greece)	BC 85
Horseshoe (Rome)	AD 100
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