Systems of innovation and competence building across diversity:

Learning from the Portuguese path in the European context

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Abstract: Innovation, a broad social and economic activity within the emerging learning societies, transcends any specific technology, even if revolutionary, and is tied to attitudes and behaviours oriented towards the exploitation of change by adding value. We analyse the on-going Portuguese path towards an innovative society. We start by characterizing innovation in Portugal within the European context. To better understand this case study, we introduce the analysis of innovation over time and across space, inspired by the techno-economic paradigms approach. This leads us to conceptualise "learning" and the process of knowledge accumulation, as a framework to understand the new demands for being innovative. We conclude by suggesting elements for innovation policies for Portugal, arguing for the need to promote *systems of innovation and competence building* based on learning and knowledge networks.

Key words: systems of innovation, learning society, competence building, techno-economic paradigms.

1. **Introduction: Framing Innovation Practices and Theory Building**

The understanding of innovation adopted in this chapter encompasses the way in which firms and entrepreneurs create value by exploiting change. Change can be associated with technological advances, but also with modifications of the regulatory framework of industry, shifts in consumers tastes, changes in demographic makeover, or even major alterations of global geopolitics. Further, in the current socio-economic context, innovation increasingly means the ability to cope with uncertainty in diversified environments, which are particularly influenced by social and institutional factors (see, for example, Conceição, Heitor and Lundvall, 2003; Smith, 2002). To choose such an ambitious definition of innovation presents important challenges. First, it calls for an analysis of many economic, social and institutional issues. Our effort cannot attempt to deal with these issues comprehensively. We will rather attempt, throughout the chapter, to discuss important trends that are likely to influence innovative performance in the presence of diversity, looking at the specific environment in which Portuguese firms conduct their business, and, consequently, determine the conditions and opportunities for innovation in the European context. The choice of such an ambitious definition of innovation limits equally the extent to which clear-cut solutions and recommendations to enhance the innovative performance of a country or region can be provided. Our hope is that by raising and discussing some selected questions and concerns we contribute to a better awareness of possible weaknesses and potential strengths of the Portuguese system of innovation within a diversified European environment.

It should be noted that innovation is a shared goal of countries within the European Union and even beyond, including other European countries, namely those that are candidates to becoming members of the EU in the coming years. We argue that this unified goal requires policies that are designed in an integrated and systemic way, but that are implemented with diversified actions. "Policy integration" should occur across a "portfolio dimension", since innovation policies require coordination across several areas: science and education policies; social and health policies; environmental and industrial policies; employment and market regulation policies. However, the implementation of policies designed in an integrated way need, in a multi-country and multi-cultural context, to consider differences across countries, regions and cultures, thus requiring action diversification. In fact, balancing action diversification with policy integration involves significant problems that extend into the very systemic nature of the relationships between country governments and the role and mission of multi-national political institutions, apart from specific regional and local contexts.

Many contributions in recent years have confirmed the perception that the success of developing systems of innovation, either at national or regional levels, depend on the creation, dissemination and accumulation of knowledge, which per si are fundamental factors for the promotion of economic growth (Swan et al., this volume; Conceição, Heitor and Lundvall, 2003). However, the scarcity of empirical data on intangible economic factors makes it extremely difficult to demonstrate the growing importance of knowledge. Economic growth has traditionally been explained as being the result of increases in the labour and capital factors, with technological change contributing as an exogenous – that is, "outside" of the realm of economic modelling- factor (Solow, 1997, for a recent review). However, the challenge posed by the endogenous growth theories to this traditional approach (see, for example, the review in Aghion and Howitt, 1997, for a review) have led to a need to rethink how these three factors influence the process of economic development. This rethinking has been taking place, in part, by bringing together other perspectives on the process of the relationship between technological change and economic growth, such as the evolutionary theory (Nelson and Winter, 1982) and the perspective of techno-economic paradigms (see discussion below).

Our inspiration to frame the process of knowledge accumulation comes from the contribution of Lundvall and Johnson (1994), who introduced the simple, but powerful idea of *learning*. Lundvall and Johnson (1994) suggest that a "learning economy", rather than a "knowledge economy", describes better the way in which knowledge contributes to economic development, promoting innovation. The fundamental difference between the two terms is associated with the fact that the former considers a dynamic perspective. According to Lundvall and Johnson (1994), some types of knowledge do indeed become more important, but there is also knowledge that becomes *less* important. There is both knowledge creation *and* knowledge destruction. By forcing us to look at the process, rather than at the mere accumulation of knowledge, Lundvall and Johnson (1994) add a dimension that makes the discussion more complex and more uncertain, but also more interesting and intellectually fertile.

Following the concept of the learning economy, which is further demonstrated in the volumes edited by Archibugi and Lundvall (2001) and Conceição, Heitor and Lundvall (2003), innovation is the key process that characterizes a knowledge economy understood from a dynamic perspective. Lundvall and Johnson's (1994) learning economy is about new knowledge replacing old knowledge. This dynamics is very close to Schumpeter's concept of "creative destruction", which is a standard description of the innovation process. Innovation is associated with creativity, with the generation of new ideas, but also with initiative and risk-taking. Innovation entails bringing new ideas to fruition in the marketplace, satisfying demands or creating new needs, in a process that improves overall welfare.

Beyond innovation, we also consider in this chapter the need to look at competence, as the foundation from which innovation emerges, and which allows many innovations to be enjoyed. In other words, competence contributes both to the "generation" of innovations (on the supply side of the knowledge economy) and to the "utilization" of innovations (on the consumptions side of the knowledge economy). Competence is also fuelled by innovation itself. Competence is associated with skills and capacities, both individual and collective ones. When we consider competence, we focus on "higher order of skills" (Carneiro, 2003). These generic skills include higher levels of education, but also capacities that are more generic, such as creativity, risk-taking, and initiative.

This chapter is organized in seven sections. Following this introduction, we consider innovation in Portugal within the European context. To better understand this case study, we introduce, in section 3, the analysis of innovation over time and across space, looking at the techno-economic paradigms approach. This leads us to conceptualise, in section 4, "learning" as a framework to understand the new demands for being innovative. Then, in section 5, we briefly discuss the fundamentals of the economics of knowledge in order to attempt to deepen our understanding of learning towards innovation. In section 6 we build on the conceptual framework of the previous sections to frame innovation policy, namely in the Portuguese context within a diversified European environment. Section 7 provides a brief summary and conclusion.

2. Characteristics of Innovation in Portugal

The measurement of innovative performance of an entire country—in a way comparable across the diverse realities of many countries—is a demanding challenge, which has been addressed in Europe by a joint effort of the OECD and the Eurostat through the development of innovation surveys according to a set of criteria that values cross-country comparability of results (see Conceição and Ávila, 2001). Portugal has been an integral part of this effort. This European effort is designated by Community Innovation Surveys (CIS), and its framework of enquire has been adopted both in official and autonomous research surveys in many countries, from Eastern European countries to Latin America (Inzelt, in this volume, describe the Hungarian experience, for example).

By giving more importance to cross country comparability, the CIS looses somewhat of its potential ability to probe into the dynamics of innovation within each country, since it only asks broad and generic questions, which can be accepted to have similar meanings in different economies. However, it provides a reliable way to compare national innovative performance across countries. Figure 1 shows the overall innovative performance of countries in Europe measured by the shares of firms that have introduced innovations over a two-year period (with reference to the period 1995-1997, as quantified through the CIS-2 exercise). The horizontal axis indicates innovative performance in manufacturing, and the vertical axis—in services. The results show a general close relationship between innovation in services and in manufacturing, since countries are located across a 45-degree diagonal. In general, innovation rates are lower in services than in manufacturing.

[Insert Figure 1 here]

Portugal appears towards the bottom of performance, being the least innovative country in manufacturing. However, in services Portugal innovates more than Belgium, Finland and Norway. Slightly more than a quarter of Portuguese manufacturing firms are innovative, while almost 30% of service firms are innovative. Here again we can see an indication of the duality: unlike other countries, services in Portugal – which have grown as a share of the economy at rates higher than the EU average – are more innovative than manufacturing firms, which are still largely dominated by traditional sectors of the Portuguese economy (such as the textile sector, for example).

Knowledge of the process of innovation in Portugal, and of the way in which it contrasts with the innovation process in Europe can be gathered from other aspects of CIS. Thus, Figure 2 shows that Portuguese firms rely much more on resources external to the firm (as, for example**,** information sources for innovation process) than European firms (on average).

[Insert Figure 2 here]

Figure 3, on the other hand, shows that issues related to high costs and difficulties in funding are much more prominent in Portugal than on average in Europe.

[Insert Figure 3 here]

Even though there is a large consensus across Europe that the lack of qualified personnel is the most important factor hampering innovation (Figure 4), still this factor pales behind high innovation costs and lack of financing as a deterrent of innovation in Portugal.

[Insert Figure 4 here]

However, it is important to look at the diversity that exists within Portugal. We concentrate on manufacturing only. Even within manufacturing, though, there are substantial differences across sectors (Figure 5). The machinery, electrical and optical equipment sector exhibits almost 50% of innovative firms (the rate of innovation in this sector is comparable to the average rate in countries such as Italy and Norway).

[Insert Figure 5 here]

Innovation in Portugal seems to be associated with a number of characteristics of the firms in a way that conforms both with theory, and to results in other countries. A descriptive analysis of the results of CIS show that size classes of large firms have a higher share of innovative firms than size classes composed of small firms. A descriptive analysis also shows that firms that are part of a group of companies show higher rates of innovation. Combining these two variables in a multivariate model, with the dependent variable being dichotomous (1 if the firm has innovated, 0 otherwise) shows, without any other conditioning variables) that large firms and firms that are part of a group do have higher probability to innovate (that is, actually introducing an innovation) than small firms and firms that are not part of a group of firms (first column in Table 1).

However, as we saw above, there is large diversity of innovative performance across manufacturing sectors. Still, when industry dummies are added to the model (second column in Table 1) none shows up as significant. This can be interpreted by saying that the sector effects are not strong determinants of innovation (when the size of the firm and whether the firm is part of the group are included).

However, when we considers only two groups of firms – those that are high or medium high technology, on the one hand, and those that are low or medium low technology, on the other – the results show that firms in the high/medium-high technology group do indeed exhibit a much higher probability of innovating that the average firm (note that the coefficient associated with the dummy for the low/medium-low technology firms is not significant).

[insert Table 1 here]

The results indicate the existence of duality, as explained in further detail by Conceição and Heitor (forthcoming). Note how large and statistically significant the coefficient associated with high/medium-high technology is, even after controlling for the size of the firm and the fact that it may belong to a group. Thus, more sophisticated firms in markets with higher demands seem to have a substantially higher probability of innovating than other firms. This is not tied, one should stress, to a mere "sector effect" (the sector dummies were not significant), it is really a characteristic of a large group of sectors that have in common belonging to the high/medium-high technology category. The duality here is clearly substantiated.

Naturally, other factors, beyond size and belonging to a group, influence innovation and Conceição and Heitor (forthcoming) report also on the effect of the firm level of productivity and the importance of exports. Both of these variables are known to have important effects on innovation and the results tell exactly the same story: when the differentiation is made according to the technological intensity, the duality comes up again, not as strong as before (part of the variation is now picked-up by productivity), but it is still present.

Of course, the models above have merely descriptive value; we do not make any claims in terms of causality, much less explanation. They are understood as showing the correlations among the variables included. It is known, for example, that several of the variables are simultaneously determined (namely innovation and productivity; on this see Conceição and Veloso, 2002). Thus, the point we make is that, even controlling for a number of characteristics that influence innovation, there is a clear duality in terms of probability of innovating when considers technology intensity as a criteria for differentiating firms. This duality appears to be a clear characteristic of the Portuguese society, which in turn must be understood within a diversified European context.

The question which does arises is related with the ability of Portugal to cope with the accelerated rate of technological change we leave with, in a way that will allow fostering innovation. This is a complex and evolving question, which requires a better understanding of the process of technological change, as described below.

3. Looking at Innovation Over Time and Across Space: The Techno-Economic Paradigms Approach

The interaction between the emergence of new technologies and the larger economic and social patterns of behavior can be understood, following Schumpeter (1934), as a process of *creative destruction*. At a first approximation, this statement is obvious: new technologies disrupt and often replace older ones. At a higher level of analysis, the implications of new technologies are broader. The impact is often felt not only as a replacement of older for new technologies, but brings with it opportunities for new firms and difficulties for existing firms, the obsolescence of some occupations and shifts in the structure of employment, changes in the terms of trade between regions and countries. On the other hand, it is clear that not all advances in technology are disruptive to the point of creating substantial changes in economic and social conditions. In fact, most technological advances and innovations make their impact felt in a relatively smooth way, when analyzed from a macro perspective.

One way to conceptualize the interaction between technological change and shifts in economic conditions, together with the process of sometimes-disruptive innovations, but most often-smooth adoption and diffusion of new technologies, is the idea of techno-economic paradigms. The discussion that follows is based on Freeman, Clark and Soete (1982), Freeman and Perez (1986), and Dosi (1988). A techno-economic paradigm embodies a relatively stable cluster of core technologies, around which innovation and economic activity take place. The core technologies have a strong impact in the economy and society, being defined as core given their potential for generalization and penetration across a wide number of products and processes, across all sectors of economic, and often human, activity.

Within a paradigm, the core technologies are virtually unchanged over time, but this does not mean that there is not economic and technological progress. On the contrary, these core technologies provide a positive heuristic that defines the knowledge and incentives for innovation and economic activity to occur. At the same time, this progress in inherently limited by the conditions set by the interaction of the core technologies with the dominant modes of economic activity, from the organization of firms, to the distribution of employment. Therefore, progress exists within a certain techno-economic paradigm, but occurs within a framework defined by a set of core technologies and modes of organizing economic activity.

Thus, within a paradigm, innovation occurs as the core technologies become more and more pervasive and influence ever-wider realms of production and distribution. When a major technological advance occurs, disrupting the existing core technologies and modes of economic operation, then a new techno-economic paradigm emerges. The displacement of the core technologies of the old paradigm creates a new wave of invention and innovation and is no longer tied to the previous paradigm core technologies. The emergence of a new core technology requires, and creates the opportunity for, an entire new set of small and incremental innovations that permit the widespread usage of the new core technologies. Thus, when a shift in techno-economic paradigm occurs, we have not only a "substitution effect", but also an expansion of the creative frontier that allows the emergence of new technologies and enables, in the end, a shift to yet another techno-economic paradigm.

Additionally, beyond the technological and purely economic factors, the social and institutional frameworks that fit a certain techno-economic paradigm may not be adequate for a new one. Indeed, the process of emergence of a new techno-economic paradigm results from the interaction of the technological, economic, institutional and social spheres. Having just a new technology coming in may not have any effect if a set of changes in the other dimensions does not accompany the technological novelty. A certain set of institutions and social features may provide enough contexts for innovation within a certain paradigm; in other words, it is not necessarily needed to create institutions and social rules at the same pace that technological innovation progresses. But when there is a shift in techno-economic paradigm, a new institutional framework may be needed.

A number of authors, working together and independently, developed the theory of techno-economic paradigms beginning with Schumpeter, who argued that the expectations of profits would drive the "entrepreneur" to innovate (see, again, Freeman, Clark and Soete (1982), Freeman and Perez (1986), Dosi (1988)). The entrepreneur's drive towards innovation is motivated by the temporary monopolistic position from which the innovator would benefit. Schumpeter (1934) regarded this position as temporary because the advantages from this privileged position would eventually "perish in the vortex of the competition which streams after them", since other firms would copy the innovator. Schumpeter (1934) called this process *creative destruction*. Therefore, for Schumpeter, innovation appears at the forefront of economic progress, driving prosperity. In a later version of these same fundamental ideas, Schumpeter refined this earlier simplistic version of an entrepreneur in a perfect market composed by a multitude of competing firms that destroy any persistent market advantage. In his final work Schumpeter (1942) acknowledged that some large corporations could sustain a market advantage by an institutionalization of the effort to innovate through the establishment of large R&D facilities.

The reinterpretation of Schumpeter's fundamental ideas of innovation as a process of disequilibrium in the broader context of techno-economic paradigm is due primarily to Christopher Freeman and his co-authors. Often called a "neo-Schumpeterian" approach, this perspective is articulated, as mentioned, in Freeman, Clark and Soete (1982), Freeman and Perez (1986), Dosi (1988) and, more recently, in McKnight et al. (2000), to cite a few representative examples. Freeman and his co-authors generalized the concept of Schumpeterian innovation to the national level, making an analogy between innovation at the firm level and a change in a techno-economic paradigm at the country level (Freeman, 1988; Freeman and Soete, 1997).

This macroeconomic definition of innovation corresponds to what is, at the firm level, a radical innovation. Under this extreme there are milder types of innovation, like incremental innovations, that correspond, at the micro level, to improvements in existing products and processes. Freeman (1988) builds a similar hierarchy for his macro analysis of innovation, leading to a conceptual framework that has some similarity to the evolutionary perspective of Nelson and Winter (1982).

It is important to stress two important dimensions of the techno-economic paradigm theory: *time* and *space*. Time is, indeed, crucial, as we saw, since the process of technological change and its economic and social impact is seen as a progress, more stable within a certain techno-economic paradigm, and very different across techno-economic paradigms, which differ over time. Space is equally important, since it is not clear that a certain techno-economic paradigm will not affect all the regions of the world similarly. Certainly there will be different rates of adoption of new core technologies when there is a paradigm shift, or even, within a paradigm, different ways in which specific innovations and modes of economic organization develop in different countries and different regions. Some countries may originate or lead the development of a new techno-economic paradigm, and others may lag behind, or even stay closer to older than the new techno-economic paradigm.

An important idea joining the time and space dimensions of the techno-economic paradigm theory is that of technological trajectories within national innovation systems. The idea of trajectories in national innovation systems (developed, with a comparative analysis across countries, in Nelson, 1991, for example) speaks to the fact that each country follows its own developmental path, within the general framework of the existing techno-economic paradigm, but also – and this is crucially important – influenced by the past history and specific conditions of the local context.

This brings to the discussion the asymmetries in country performance, which, according to our interpretation advanced in earlier papers, can be seen as being dependent on what we could call with generality knowledge accumulation through "learning" processes. Conceptually, the foundations for the relationship between learning and economic growth are well established in the recent literature (Bruton, 1998), and stem from a combination of the pure neoclassical perspective of growth with the Schumpeterian view. Learning is reflected in improved skills in people and in the generation, diffusion, and usage of new ideas. Likewise, organizational learning reflects social processes driven by collective cultures and appropriate management attitudes. The ability to continuously generate skills and ideas (which is to say, to accumulate knowledge through learning) is the ultimate driver of an economy long-run prospects (World Bank, 1997).

The fact that countries have different levels of income is clearly self-evident. Therefore, it is equally obvious that each country has followed its own trajectory, within the context of an existing techno-economic paradigm and the specific innovation system of the nation. We look here at some evidence on the translation of different paths in the economic performance of countries. But we begin with an interpretation of the major techno-economic paradigms, illustrated in Table 2.

[Insert Table 2 here]

The table shows five important techno-economic paradigms. While the paradigms presented result from one interpretation, they serve now to illustrate with some empirical evidence the features of techno-economic paradigms presented before. Let us consider, for example, the first techno-economic paradigm. This corresponds to the emergence of the Industrial Revolution, as mechanization was increasingly incorporated in manufacturing, especially in some industries such as textiles. However, the technologies well diffused and used within this paradigm presented some important limitations for the increase of the scale and output of the productive activity. Most firms remained small and local. Process control was poor and hand operated machines did not allow for output of reliable quality. Naturally, advances in steam engine technologies and machinery were already taking place, but it took a long time until they were ready for fruition. When these important technologies matured to the level that made their economic utilization possible, they became the core technologies of the second techno-economic paradigm. The new techno-economic paradigm based on steam engine and on machinery ameliorated some of the previous limitations, and created in itself the germ for new types of economic organization, as the table details.

If we cross the techno-economic paradigms with geography, then we start joining together the ideas of technological trajectory and national innovation system. The two first techno-economic paradigms were led by Britain. In this context, the US and Germany, for example, were “latecomers”. Still, they became leaders in the third techno-economic paradigm, with Japan also leading in the fourth and the US arguably retaining the lead alone in the fifth, although we will be looking at this claim in more detail below.

Still, the manifestations of the current differences in the paths followed by different countries are dramatic. Even taking a set of relatively homogeneous countries, such as the OECD, shows great disparities in income per capita and productivity. Productivity, in a way, is probably the best indicator of the extent to which a nation is taking full advantage of the conditions provided by the existing techno-economic paradigm. A recent study by Ark and McGuckin (1999) tackles international comparisons of productivity and income in a particularly careful way, especially in finding comparable measures across countries. They also link labor productivity with output per capita following a common decomposition procedure. While the relationship between these two variables may seem obvious, in fact there are many subtleties involved. For example, a country that is very productive but where workers engage in productive activities fewer hours than a less productive country can result in an output per capita that is higher in the second country. Table 3 shows the results presented in this work. Column (1) indicates labor productivity and column (8) provides the level of GDP per capita.

[Insert Table 3 here]

Portugal and Turkey have the lowest hourly labor productivity rate of the OECD. Portuguese hourly productivity is about half of the OECD average. Productivity in Greece is 19 points above Portugal's and Spain's productivity is 28 points above the Portuguese hourly labor productivity. Still, when one looks at column (8), Greece's GDP per capita is actually lower than Portugal's by two points and Spain's GDP is only 11 points above Portugal's.

The decomposition of the table shows the variety of effects involved. Column (2) shows the impact of the number of hours worked. The summation of columns (1) and (2) produces the GDP per person employed. We see that Spanish and Japanese workers work longer hours than in most of the other countries. Per worker productivity in Spain, measured as GDP per worker, raises almost to the OECD level. Portuguese workers also work long hours, adding 2 points to the per hour productivity measures. In Italy, France, The Netherlands, Norway and the United Kingdom less hours of work reduce per employee productivity. Standards of living are determined not only by the number of hours worked and the productivity of each hour of work, but also by the "number of mouths to feed". The effect of the labor force participation connects per worker productivity and GDP per person. It is the effect of the labor force participation, for example, that brings down the income per capita of the productive and hard working Spanish workers: the combined effect of unemployment and the low level of labor force in the working age population take 26 points to the per worker productivity. The same happens in Greece, where 12 points are taken to the per worker GDP. In Portugal, both the effects of hours worked and labor force participation are small and positive. It is, therefore, clear that the real challenge to increase the level of GDP per capita in Portugal is not so much a reduction of unemployment or, more generally, an increase in labor force participation (as in Spain, for example), but that it is really the increase in the fundamental hourly labor productivity. To understand impact of these differences on innovative performance and, consequently, to derive innovation policies, it is important to look at the new demands for being innovative, to which we turn in the next section.

4. The Learning Society: A Framework to Understand the New Demands for Being Innovative

Recent models of long-term economic growth have been able to explain the increase in per capita income in developed countries (see Johnson, 2000, for a summary perspective, and Landes, 1988, for a broader treatment) with extremely parsimonious models based exclusively on the growth of knowledge. The factors behind the increase of knowledge are equally simple: the increase in population and the emergence of specialization in the production of knowledge. Kremer (1993) uses a model exclusively based on population growth, where more people means that there are more individuals capable of making a significant discovery and that the larger the population the larger the benefits from those discoveries. In other words, technological improvements make population growth possible which, in turn, creates more possibilities for new discoveries. A slightly more complex model by Hall and Jones (1999) includes also the effect of the specialization of growing proportion of the population in activities associated exclusively with the creation and transmission of knowledge. This entails the need to include *institutions* and *policies* – a combination that the authors call *social infrastructure* – which, according to this model, explain difference across countries in their level of knowledge generation and income per capita.

The gradual transition towards knowledge-based economies has intensified in the last part of the 20th century. According to the OECD (1999) more than 50% of the OECD countries' GDP is associated with knowledge-based industries[1]. Lundvall (2000) asserts

[1] Even if the definition of knowledge-based industries is rather generous, including a large part of services and the high and medium-high technology manufacturing.

that the intensity of the acceleration of knowledge creation and diffusion requires a more dynamic characterization. In Lundvall's opinion, we should speak about the emergence of a *learning society*.

In summary, while much attention has been devoted to specific technologies, namely to digital technologies in recent years, the association between information technologies and augments in productivity remains ambiguous. Still, it is undeniable that the spread of the computer and the Internet is changing in profound ways the way people and firms behave and interact, with important consequences for policy and strategy. A more fundamental change at the start of the new millennium is the increasing importance of knowledge for economic prosperity. This feature of current developed countries corresponds to the continuing of a trend of acceleration of the importance of the creation and diffusion of knowledge throughout the century. Beyond digital technologies, other technological breakthroughs, in many areas from the life sciences to the many fields of engineering, are likely to be seen in the future (see Coates, this volume).

In this context it is important to look both at the *level* of the measures that indicate the extent to which a country is engaged in the knowledge economy and to the *growth* in recent years. Figure 6 provides a first illustration, with the horizontal axis representing the intensity of knowledge-based industries in the mid 1990s and the vertical axis the growth rate of these industries in the previous decade.

[Insert Figure 6 here]

Most countries are clustered at the bottom of the figure, with growth rates between 2% and 4% a year. The horizontal distribution of the countries shows Germany, the US, Japan and other leading developed countries to the right, with Spain and Greece to the left. In this context, Portugal and Korea stand out. The intensity of the knowledge-based industries in these countries is relatively low, especially for Portugal, which has the lowest level of knowledge-based industries. However, the growth rates for Portugal and Korea are remarkably higher, with the knowledge based industries in Portugal growing close to 7% a year, and Korean knowledge based industries at more than 12% a year. The rate of growth of knowledge-based industries in comparable periods was of 3.1% for the European Union and of 3.5% for the entire OECD.

The difference between the growth rates of Portugal and Korea is not as extraordinary as it may seem. In fact, the business sector as whole rose in Korea at 9.1% a year, while in Portugal the growth rate of the entire business sector was 4.6%. Consequently, the difference between knowledge-industries growth rate and the entire business sector growth was of 2.3% for Portugal (or 50% of the business sector growth rate) while in Korea the difference was 3.4% (a higher difference, but only 37% of the entire business growth rate). The case of Portugal and Korea are relevant because they are illustrative of latecomer industrialization and may represent indications of the process through which these latecomer countries become engaged in the new techno economic paradigm.

Turning our attention only to information and communication technologies (ICT), Figure 7 presents essentially the same framework of the previous figure, but now with the intensity of ICT expenditure in 1997 on the horizontal axis and the growth rate of this intensity from 1992 to 1997. Again, most countries are clustered in the bottom of the figure, with growth rates below 4%. The levels, as indicated by the horizontal distribution of countries, confirm the perception that the US is a leading country. The expenditures on ICT as a percentage of GDP in the US are about 2% above the European average. Individual countries, such as Sweden, outperform the US, but most countries lag behind.

But, as with knowledge-based industries, the growth rate in expenditures provides a different picture. In fact, Portugal is the leading OECD country in the growth rate of ICT expenditure from 1992 to 1997, with a growth rate of more than 10%. Most of this growth rate can be accounted for by increases in expenditures in telecommunications (about 9%). Expenditures in IT services and software are particularly low, below 1%. Only Turkey, Greece and Poland have shares of expenditure on IT software and services below the Portuguese value. The growth in this category has been equally dismal, below 2% a year.

[Insert Figure 7 here]

Going back to the conceptualization of the knowledge-based or learning economy that we presented above, it can be said that, fundamentally, the performance in this knowledge-rich competitive environments in terms of innovative performance depend on the **quality of human resources** (their skills, competencies, education level, learning capability) and on the activities and incentives that are oriented towards the generation and diffusion of knowledge. But beyond human capital, which corresponds to the **aggregation** of an individual capacity for knowledge accumulation, developing a collective capacity for learning – as suggested by Wright (1999) in the context of the US – is as, if not more important, than individual learning. Instead of individual or even aggregated human capital, a further important concept for learning seems to be *social capital*, as analysed by Conceição et al. (2000), among others.

The importance of social capital, while still controversial, is increasingly being seen as an important determinant of economic performance and, especially, of innovation and creativity. Temple (2000) discusses the impact of education and social capital together as determinants of growth. Temple (2000) argues that there is a growing number of works suggesting that social capital is at least as important as education as a driver of economic growth.

Education is used often as a proxy for human capital. For social capital, the equivalent indicator is the level of "trust". Figure 8 shows the results of a survey conducted in the early 1990s on each country's citizens' perception of the internal level of trust. Respondents in each country were asked if their countrymen could be trusted, and the percentage that replied yes is reported in the chart.

[Insert Figure 8 here]

The next question is, then, to find out what are the determinants of social capital. Glaeser (2000) suggests that education is strongly associated with social capital, which indicates that an important component of policies aimed at increasing social capital necessarily needs to go hand in hand with policies aimed at increasing the educational level. The reason is not only the fact that there is an association between human and social capital, but also the fact that being in school provides a context for social interaction and learning that has important spillover effects in strengthening social relationships and networks. Alesina and Ferrara (2000) confirm the important role of education as a determinant of social capital, but show also that beyond individual characteristics, the characteristics of the community are equally important. These characteristics include dimensions associated with the way people compare themselves with each other, such as income inequality.

One other important dimension of the learning society includes the activities expressly oriented towards the generation and diffusion of knowledge. It is, as with education, risky to reduce a complex set of activities to a single educator, but the national effort on research and development provides an indication of the commitment, at the country level, to activities explicitly oriented towards the generation of new knowledge. These activities tend to occur in institutions, such as universities and research labs, or within institutional settings, such as the R&D unit within a firm, that provide incentives that foster the specialization on exploration and discovery, as well as exchange of knowledge (Conceição and Heitor, 1999).

Figure 9 shows both the scale and the intensity of national expenditures on R&D for several OECD countries, with the horizontal axis, representing the scale of the expenditure, having a logarithmic scale. The relationship between scale and intensity shows decreasing returns: as the scale of the investment grows, the increase in intensity also grows but at a decreasing (in fact, logarithmic) rate. The results also suggest that there are **three different** “paths” in which this relationship is expressed.

In the lower left-hand corner of the figure we identify a line that includes the Southern European countries. The thick line in represents a simple fitting of the position of most countries. Nordic countries have a path of their own, with a much higher responsive intensity to increases in scale. For Ireland the scale of R&D expenditure is almost the same as for Portugal, but the intensity for Ireland is comparatively much higher. The large intensity of R&D expenditures in Ireland is largely due to the fact that the R&D that is performed in the business sector, which in 1997 accounted for almost ¾ of the total R&D expenditure in Ireland. Ireland showed the largest increase in business R&D expenditure of all OECD countries in the 1990s, at an annual growth rate of close to 20%. However, most of this growth is being driven by foreign affiliates doing business in Ireland. The share of foreign affiliates in manufacturing R&D in Ireland in 1995 was close to 70%. This large share indicates a very low capacity of domestic firms to innovate. Ireland is, in this regard, an exception, since for most OECD countries domestic firms take the largest share of R&D performed in the business sector.

[Insert Figure 9 here]

R&D efforts are understood as an input; an important outcome of R&D expenditures is scientific papers. Scientific articles are, in themselves, important to diffuse and deepen innovation. Figure 10 shows the same countries as Figure 9, and the horizontal axis is also the same: the logarithmic absolute expenditure by country. In Figure 10 the vertical axis is also presented in logarithmic scale. As when we analyzed scale and intensity of R&D, we fit a straight line, which fits well with the data[2]. Given that both axes are in logarithmic form, scientific production follows a power law, a feature known to be associated with scientific publications.

[Insert Figure 10 here]

R&D expenditure is an important indication of the commitment and resources a country devotes to knowledge production and diffusion, but the growing importance of knowledge extends beyond those activities traditionally associated with creativity and learning. Innovative performance, in particular, depends on conditions that foster technology-based entrepreneurship. Mechanisms such as venture capital and high growth start-up stock markets (like the NASDAQ) are ways to mobilize private capital for investment in knowledge economies (Soete, 2000). Gompers and Lerner (1999) show that venture-capital backed start-ups appear to have a disproportionate positive impact on innovation.

However, following Antonelli and Calderini (1999), “the internal bottom-up learning process based upon the improvement of design and technological processes plays a major role in feeding the continual introduction of technological and organizational innovations”. In this respect, the authors conclude that technological

[2] The R-squared is 0.95.

knowledge is embedded in the specific circumstances in which the firm operates, and its generation is the result of a joint process of production, learning and communication, of which R&D activities are only a part (Conceição and Ávila, 2001; Evangelista, Sandven, Sirilli and Smith, 1998). In more general terms, the analysis of the innovative performance of countries in the learning society calls for the need to consider all the processes of learning (both "formal" and "informal", in the nomenclature of Conceição and Heitor, 1999) and to better understanding the economics of knowledge.

5. Deepening our Understanding of Learning towards Innovation: Building on the Economics of Knowledge

The paragraphs above show that, from a systemic perspective of innovation, *learning* is understood, broadly, as *knowledge accumulation*. There are different levels of "learning entities", from individuals, to organizations, to whole economies. A first important step in our discussion is the clarification of our conceptual understanding of terms such as "knowledge" and "learning", often loosely used with dramatically different meanings. The recent paper by Johnson et al (2002), following the work of Cowan et al (2000), provides further evidence for the need to clarify these concepts. This conceptual clarification of our understanding of learning as knowledge accumulation is the objective of this section.

We find it useful, as developed in more detail in Conceição and Heitor (1999), to follow Nelson and Romer's (1996) differentiation between ideas and skills, or software and wetware, to use these authors' nomenclature. The conceptual difference between *software* and *wetware* lies in the level of codification. While ideas correspond to knowledge that can be articulated in words, symbols, or other means of expression, skills cannot be formalized, but always remain in tacit form (see Nonaka et al., this volume). Under this taxonomy, knowledge may be divided into two worlds (Johnson et al, 2002): the world of codified ideas (software) and the world of non-codified skills (*wetware*).

The difference in the level of codification has implications in terms of the "economic properties" of the two types of knowledge that we consider. The most important implication is associated with the differences in the rivalry associated with the consumption of each type of knowledge. Since the knowledge underlying *software* is codified, it is easily articulated and reproduced by simple, inexpensive means. Consequently, rivalry in the consumption of software is low. By contrast, the transmission of skills (*wetware*) is complex, expensive, and slow. Skills result from a combination of factors, ranging from their largely innate quality, through individual experience, to formal training. Thus, rivalry is comparatively higher in the consumption of wetware.

The differences in rivalry between *software* and *wetware* have important implications for knowledge production. Dasgupta and David (1994) suggest that there are basically two alternatives for the production of software. The first consists of **intervention by the state** in the production of ideas, by means of direct production, or by subsidizing production, such as funding of university R&D. The second alternative consists of granting property rights for the creation of ideas, that is by defining regulations for **intellectual property** specific instruments that include patents, registered trade marks and copyright (see Conceição and Heitor, 2001, and Conceição, Heitor and

Oliveira, 1998, for a more comprehensive analysis). Therefore, the production of ideas requires more complex institutional mechanisms than those provided by the market. As for skills, the market provides a large proportion of the incentives needed for their production, at least when these are analyzed in isolation, although with important limitations (see, again, Conceição and Heitor, 2001).

We bring our own understanding to the process of knowledge accumulation when the interaction between software and wetware is explored. The idea of **interaction** between ideas (software) and skills (wetware) is what, in our understanding, defines learning. Analysis of the interaction between ideas and skills leads us to explore the learning processes associated with the generation of each type of knowledge in a more integrated and dynamic way, beyond the mere accumulation of ideas and skills, each in isolation. Our view is yet another perspective on the ongoing debate between the complex and multifaceted interaction between different types of knowledge. Recent manifestations of this debate include Johnson et al (2002), in which they contest the implicit assumption of Cowan et al. (2000) that codification always represents progress.

Indeed, according to Freeman and Soete (1997), ideas and skills are no more than two sides of the same coin, two essential aspects of the accumulation of knowledge. New ideas spur the development of the skills required to use those new ideas. The bridge from the production of ideas to the usage of ideas is established by producing new skills. Increased use of an idea, which requires its diffusion, will lead to a constellation of other ideas, aimed at improving and extending the initial idea, which will lead to the need for further skills and so on, in a self-reinforcing cycle that leads to the accumulation of knowledge. The accumulation of knowledge results from the production, usage, and diffusion of both software and wetware, in an interactive learning process that leads to knowledge accumulation, as initially proposed by Conceição and Heitor (1999).

5.1 Learning Processes and the Accumulation of Knowledge: The Interaction between Software and Wetware

According to Solow (1997), the formalisation of the process of economic development in the new growth theories follows the conceptual structure originally proposed by Arrow (1962). It is worth looking briefly at Arrow's analysis, as it contains the kernel of the reasoning behind the idea of economic development as a learning process. Instead of following the orthodox thinking of his time, which attributed to technological change the component of growth that could not be explained by the accumulation of labour and capital factors, Arrow argued that experience in the use of capital led to an increase in the knowledge used in production. In plainer terms, Arrow drew up a relatively simple model in which workers in a company learn by using the means of production, thereby increasing the company's productivity.

In this way learning, that is the accumulation of knowledge, appears as the driving force behind the increases in efficiency, which lead to economic growth. It is interesting to note that Arrow chose an informal way of learning, learning by doing, as the basis for his reasoning. It should also be noted that in this model knowledge is accumulated only in the form of skills. The contribution of the new economic growth theories has been precisely to extend this reasoning to other types of learning, as well as to the accumulation of ideas, starting from when Romer (1986) showed the wider implications of Arrow's arguments.

Thus, Lucas (1988) also analysed the accumulation of knowledge in the form of skills, but this time putting forward education as a formal learning process. In turn, Romer (1990) and Grossman and Helpman (1991) constructed models in which the accumulation of ideas results from effort put into research, another formal learning process. In this context, Table 4 summarises how these contributions fit into a framework of possibilities which relates the accumulation of knowledge to the different kinds of learning that can lead to this accumulation. The construction of this table was also inspired by Foray and Lundvall's analysis (1996), in which they placed particular emphasis on the formation of networks of personal and professional contacts, which result from processes of social interaction, the fourth process in Table 4.

This table also illustrates three other points. First is the analysis that remains to be made in respect of the empty boxes. Secondly, examination of the dates of the contributions reveals that the emphasis at the beginning of the 1990s was on the study of the accumulation of ideas through R&D, a tendency that has become stronger in recent work (see Romer, 1993, 1994).

[Insert Table 4 here]

There are at least two reasons for this. On one hand, the study of informal learning processes is more complex and less amenable to empirical testing. We are accordingly left with the study of the accumulation of ideas through R&D, since the role of education has already been extensively researched since the theories of human capital appeared in the 1960s. On the other hand, the really striking aspect of the times in which we live is the increasing codification of knowledge, and the potential of the "digital economy" and the "information society" (Romer, 1996, Foray and Lundvall, 1996).

It is important to note that the potential of the "digital economy" is strongly reflected in the existence of increasing returns, which leads to phenomena such as the apparently unstoppable growth of companies that trade in ideas, such as Microsoft. Indeed, the economic value of an idea is associated with its market potential (Romer, 1996). As has been seen, it can be extremely expensive to produce ideas, but they are cheap to distribute. The first disk containing the Windows operating system cost Microsoft several million dollars (the entire cost of development), but all the rest cost less than a dollar each. Since there is a vast market and costs, after initial development, are low, the only limit to Microsoft's growth is the size of the market itself. Arthur (1994) points out that the fact of increasing returns, besides being linked to the non-rivalry of ideas, is reinforced by the phenomenon, originally explored by David (1986), known as "lock-in". In the case of Microsoft, "lock-in" took place when the Windows operating system became established as the virtual industry standard. As can be seen, there is much to explore concerning the impact on growth of the accumulation of ideas, but our concern at the moment is to examine the boxes in Table 4 that remain empty, particularly the interaction between ideas and skills.

It is thus time to begin moving into territory that is still being explored, which requires reference to contributions from other groups of economists concentrating on the study of economic growth. Before pursuing this theme, we should note the difficulties that have beset the new economic growth theories. The main criticism is linked to their lack of empirical evidence, despite the intellectual validity of their arguments (Pack, 1994). Mankiw (1995), in a relatively recent assessment, even suggested a return to Solow's traditional formulation. However, according to Soete (1996), empirical difficulties should lead not to a reduction in efforts to pursue the new concepts further, but rather to a recognition that new indicators and quantitative methods must be found that are more appropriate for the knowledge-based economy.

One crucial aspect of the accumulation of knowledge is the interaction between ideas and skills, which gives rise to the learning processes in Table 4. Indeed, according to Soete (1996), ideas and skills are no more than two sides of the same coin, two essential aspects of the accumulation of knowledge. Herbert Simon, quoted by Varian (1995), puts the argument as follows:

> "What information [in the sense of ideas, according to our terminology] consumes is rather obvious: it consumes the attention of its recipients. Hence, a wealth of information [that is, of ideas] creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it".

In other words, many good ideas are useless if the skills needed to use them do not exist. Studies by Pavitt (1987), Nelson (1996), and Rosenberg (1990) follow the same line of thinking. Nelson (1997) describes various circumstances, in which individuals, companies, universities, and other institutions have made use of their skills in order to increase their accumulation of knowledge, acquiring further skills as well as ideas. The main implication of this argument is that the interdependence between ideas and skills casts doubt on the idea that the market supplies the necessary incentives for the production of skills, as was concluded in sub-section 3.2, where these were analysed in isolation. It seems, therefore, that there is greater scope in the knowledge-based economy for institutional arrangements and public policies that go beyond the logic of the market (World Bank, 1998).

Although to a great extent skills result from the innate characteristics of an individual or from the history of an institution or a country, they also depend on the learning processes (education, research, experience, social interaction) in which these entities are involved (North, 1990). Without skills, ideas may be irrelevant, and without ideas, there is no need for new and better skills. Analysis of the interaction between ideas and skills understandably brings us to explore learning processes in a more integrated and dynamic way, beyond the mere individual accumulation of ideas and skills set out in Table 4. To illustrate the close and complex interdependence between ideas and skills, Figure 11 shows the interactions between these two kinds of knowledge.

At this point we should stress that our analysis would be enriched by drawing from the large output of scholarship that originated from the cognitive sciences and from the education sciences on learning. However, this project lays outside the aim of this paper, since we do not intend to contribute to a theory of learning. Our purpose is rather to propose a simplified framework to model the dependency between software and hardware, suggesting that it is through this interaction that new knowledge is generated, that is, learning occurs.

[Insert Figure 11 here]

From Figure 11 it can be seen that while skills appear as a cluster of small ovals, reflecting the individual nature of the skills of people and of institutions, ideas appear as a single oval. This represents the indivisibility of ideas (David, 1994), meaning that, once created, an idea remains at least potentially accessible everywhere, and there is no need to rediscover it — hence the common expression "There's no need to re-invent the wheel".

Figure 11 shows several learning processes that have been analysed in various places in the literature. Again we should stress that we have been selective in the way we chose the types of learning processes that are depicted in the figure. Our objective is not to be exhaustive, but rather to emphasise the learning mechanisms that are more directly related to the functions of the university, as will become clear in the next section.

Thus, there are two main cycles:

cycle 1 - codification of knowledge (Foray and Lundvall, 1996), the result of progress in information technology, telecommunications and the scientific and technological base; that is, the great number of existing ideas that are the starting point or "feedstock" for new ideas to be constructed using existing skills;

cycle 2 - interpretation of codified knowledge (OECD, 1997), using existing skills as a starting point or instrument to decode the ideas which are being studied or used, leading to improved skills.

Cycle 1 covers learning processes that result in the codification of knowledge, which is the generation of new ideas. Specific examples include R&D and artistic creation. In both cases, ideas are generated as a result of a process of exploration, in science or in search of a form of expression. This type of learning is convergent, meaning that on the basis of different and unique skills, ideas are generated that have the potential for common use.

Cycle 2, on the other hand, relates to learning by assimilation of knowledge, which results from activities such as education, experience, and social interaction. Through interpretation of these ideas, different skills emerge. Imagine a mathematics class: all the students are using the same book, they attend the same classes, they do the same exercises. However, the ways in which they assimilate and interpret these are different, meaning that the learning process is divergent. Schon (1987) and others expand on the inner workings of this type of learning, but we keep our discussion at a more superficial level.

The main conclusion of this section, as shown in Figure 11, is that the accumulation of knowledge, which is the basis for economic growth, is the result of a series of complex processes, in which there is considerable interdependence between the accumulation of ideas and of skills. It is necessary to examine the role of the principal institutions of contemporary society and to attempt to determine how they fit into these processes. Conceição and Heitor (1999) show how this conceptual understanding can be used to analyze broad historical interactions between knowledge and development (such as in the evolution of China and Europe, Landes, 1998) as well as the adoption and diffusion of specific technological innovations (such as standards of videotape recorders). The model also acknowledges the indivisibility of ideas, as proposed by David (1994) (once created, an idea remains at least potentially accessible everywhere, and there is no need to rediscover it).

This conceptual understanding of the learning processes is critical to draw implications in terms of the complex relations associated with the building-up of innovation systems (Christensen, 2002). In this chapter we develop, next, the importance of stimulating innovation (generation of ideas) and the parallel importance of developing competencies, within an overall framework looking at inclusiveness.

6. Fostering Systems of Innovation and Competence Building: The challenges of Inclusiveness

The analysis presented above considers a context in which the wealth and well being of individuals, organizations and nations is increasingly based on the creation, dissemination, and use of knowledge in a way to foster innovation. This fact is reflected in the trend in developed economies towards an increasing investment in advanced technology, research and development, education, and culture. As a consequence, concepts such as learning ability, creativity and sustainable flexibility gain greater importance as guiding principles for the conduct of individuals, institutions, nations and regions. Against this background, and emphasizing concepts such as the non-rivalry of information and the externalities associated with education and research and development, this section builds on the notion of localized technological change and the need to develop an agenda to promote the inclusive development. This is particularly appropriated to understanding the dynamics of innovation in much of Portuguese industry, which is heavily characterized by the so-called "traditional sectors".

Following Antonelli and Calderini (1999), “the internal bottom-up learning process based upon the improvement of design and technological processes plays a major role in feeding the continual introduction of technological and organizational innovations”. In this respect, the authors conclude that technological knowledge is embedded in the specific circumstances in which the firm operate, and its generation is the result of a joint process of production, learning and communication, of which R&D activities are only a part. In these terms, current evolutionary economics has shown the importance of path dependence of economic processes, in that it is at the core of selection mechanisms between competitive firms and technologies (Metcalfe, 1997). Competition is therefore the result of the rate of change of market share, apart from being dependent on differences in the rates of growth of individual firms. The result is a fully endogenous process, which, in the presence of increasing returns, gives rise to a strong interdependence between specialization and diversification. The direct implication for innovation policies in Portugal is the important, but limited role of demand at the firm level in assessing the amount of incentives for firms to introduce technological innovations. In more general terms, the analysis call for the need to feeding all the processes of learning, implementing technological cooperation among firms and between firms and research institutions, and on the process of on-job-training of the workforce. Technological centers specifically designed to sustain localized processes of technological change might play an important role in this context. However, it is important to clearly emphasize the important role of the science and technology system, S&T, in fostering innovation, as well as the related implications for public policy.

In these terms, although there is an emerging set of literature on technological innovation and industrial economics looking at the distinctive features and institutional characteristics of European regions (e.g. Wolfe and Gertler, 1999; Gambardella and Malerba, 1999), there have been few attempts to build analytical frameworks to improve understanding and to allow the development of well-sustained technology policies for less favored zones and late industrialized European regions, such as those of Portugal. In fact, the neoclassical approaches in industrial economics have emphasized the analysis of the microeconomic behavior of firms and built theories specialized in the American and Anglo-Saxon systems and related market dynamics. On the other hand, evolutionary economics have attempted to improve our understanding of learning processes and the role of institutions in economic development, but have not specialized on the specific historical context of European regions, namely those characterized by late industrialization (e.g. Cooke and Morgan, 1998). Building on the evolutionary approaches and system theory, the concept of "national system of innovation" (e.g., Lundvall, 1992; Nelson, 1993; Edquist, 1997) has led to numerous studies of individual European countries, but there is still a long way to go in order to assess the specificity of transition economies and late industrialized regions and countries, including Portugal.

The various aspects above include heterogeneous approaches to innovation, but consider "change" at the center of the analysis. This has been considered throughout the entire chapter, but taking into account that firms´ competencies are characterized by stability and inertia and, therefore, lock-ins and competence traps are expected to occur, in that successful firms may be driven by their success in existing technologies to disregard new alternatives. Other important aspect to take into consideration is that the phenomena of increasing returns and path-dependence affect the nature of the innovation processes and the dynamics of industries in Portugal, and Europe.

Among the various aspects raised above, it should also be noted that the sectoral specificity in the organization of innovative activities, on one hand, and the specific characteristics of local systems of innovation, on the other hand, are expected to play a significant role in shaping the organization of innovative activity in Portugal. The prevalence of one effect over another dependes on history and competitiveness of firms and their degree of internationalization.

6.1. The Importance of Stimulating Innovation

The section above made explicit the way in which we understand learning as knowledge accumulation, which is a result of a complex set of learning processes where there is considerable interdependence between the accumulation of ideas and of skills. We now turn for the analysis of innovation as the concept that best fits with the idea of the knowledge economy understood from a dynamic perspective.

It is by now well understood that the early conceptualisations of innovation as a linear process were clearly insufficient to describe the complexity and contingency of the innovative effort of people, firms and countries (Nelson, 1993; Dosi, 1988; Kline and Rosenberg, 1986). Still, what is surprising is the extent to which the linear perspective still informs much of today's public perceptions about innovation, as well as policy design and implementation. The reliance on simple and direct indicators such as expenditure of R&D by the private sector, and the obsession in some circles associated with improving these types of indicators, reflects the dominance of the linear perspective.

We do not question the importance of these and other indicators, but it should have also become clear by now that they provide an incomplete description of the innovation process and are tied to the linear perspective (see, for the continuation of the linear perspective, Guellec and Pottelsberghe, 2000). Romer (1990, 1993) recognizes the importance of what he calls *appreciative theories* of growth and innovation in helping more formal approaches to better describe the richness of the innovation process, but somehow the link has been hard to accomplish.

The link between the complexity of the innovation process and the special economic characteristics of knowledge, and of conceptualisations of the learning process such as the one advanced in section 5, could be a bridge. In fact, Romer (1990) and Nelson and Romer (1996) construct a theory of endogenous growth drawing on the non-rival nature of ideas. Dasgupta and David (1994) advance new ideas about the economics of science building also on the same principles associated with the special characteristics of knowledge. Thus, the conceptual understanding of learning advanced in section 5 of this chapter could serve more than just being an interesting modelling tool, allowing the development of new conceptual approaches. It could also become a useful guide for policy, especially in light of the still predominant domination of the linear model. In a series of papers, Conceição and Heitor (2001) have explored the implications of the conceptual model presented in section 5 to advance policies associated with innovation (that is, the generation of ideas, or software). We turn, next, to the other side of our conceptual model of learning: the importance of wetware.

6.2. The Relevance of Competence Building

Competence is the foundation on which innovation is generated and diffused. Competence is associated with individual skills, but also with collective capacities. It is also on competence that a learning society can be constructed and sustained in order to foster innovation. Some suggest that technological change is (or has become) skill-biased (Autor, Katz and Krueger, 1997). Empirical work supporting the skill-biased technological change conjecture includes studies such as Krueger (1993). Thus, for some, the connection between innovation and competences is primarily understood as being related with this hypothesis.

However, the skill-biased technological change hypothesis is far from being uncontroversial, as the discussion that follows shows. From a conceptual point of view, critics note that the treatment of technological change rarely goes beyond asserting that new technologies, and especially computers, are responsible for a steady increase in the demand for skills (Galbraith, 1998). Technology is conceptualized as in the linear models of innovation. Criticisms based on empirical analysis include DiNardo and Pischke (1997) and the realization that there is a mismatch in the timing of the increase in inequality and the spread in the diffusion of computers, and the fact that the increased adoption of information technology has not noticeably contributed to increased productivity (see Galbraith, 1998, for a comprehensive review). Alternatives to the skill-biased technological change include the perspective advanced by Bresnahan (1999), who proposes an organizational complementarity between information technologies and telecommunications (ICTs) and highly skilled workers.

But the relationship between competences and innovation is not only seen through the skill biased technological change perspective. And competence building also entails much more than formal skills. For example, Dore (1976) differentiates “education” from “schooling”, which refers to “mere qualification-earning”, leading to an “educational inflation” spiral. Several other authors (e.g., Bourdieu and Passeron, 1970; Boudon, 1973; Jencks, 1972; Bowles and Gintis, 1976) are similarly skeptical about a direct relationship between increases in the level of education and economic performance. The differences between the economists of human capital and these other authors, who come primarily from sociology, remain until today. In fact, some of the critiques have important parallels with economic perspectives, such as Boudieu and Passeron’s (1970) theory of the social filter, whereby schools work as filters to preserve and maintain social and educational differences, and the “inheritance of inequality” perspective of Meade (1964).

However, if one is ready to accept the existence of a labor market where wages reward, at least partially, productivity and skill, Katz and Murphy (1992) provide strong evidence that supply and demand go a long way in explaining the patterns in the evolution of inequality. Most of the recent studies on inequality focus on a single-country longitudinal analysis of the evolution of the dispersion of income. Examples of the same methodology applied to other single country studies include Schmitt (1995) for the UK, and Edin and Holmlund (1995) for Sweden.

This discussion clearly highlights the link between competence (skills, education), and innovation (technological change) towards inclusive learning. The connection between education, skills and competence, on the one hand, and the learning society, on the other, must consider the manifold interconnections between competence and the learning society and links them with the broader context of the anxieties and concerns, hopes and expectations that we live with today.

An important issue is to know what it takes to be part of the learning society. We may not know exactly what the learning society is, but we do know that there are requirements to be part of it. We need, in particular, to build competence, of which skills are a part. However, for some cases, the need for new skills is not associated with technological change, but with an organizational change, and the new skills provided are not particularly intensive in specialized knowledge. It is important to stress this point because the discussion can easily be drawn into the skill-biased technological change discussion. Naturally, technological change does indeed play a role in increasing the demand for “a higher order of skills”, but there are other elements of change driving this demand. What is hardly questionable is that those that do not possess the skills nor the ability or possibility to acquire them become excluded.

6.3 The need for a dynamic national science base

Pavitt (1998) noted that innovation studies confirm Tocqueville´s idea that technological change would require the development of publicly funded basic research and associated training. In this context, analysis has shown that the main practical benefits of academic-based research are not “easily transmissible information”, but it involves the transmission of tacit and non-codifiable knowledge, with tendency for geographically localized benefits (e.g. Katz, 1994). Furthermore, following Hicks (1995), countries and firms benefit academically and economically from basic research performed elsewhere only if they belong to the international professional networks that exchange knowledge. This requires high quality foreign research training and a strong presence in basic research, mainly because academic research is certainly not a "free good", although it has some attributes of a "public good". In this context, Pavitt, among others (e.g. Narin et al.,1997; Mowery and Rosenberg, 1998), conclude that "public expenditure on academic research is a necessary investment in a modern country's capacity for technical change".

It is also clear that one must consider the nature and extent of the influence of national patterns of technological change on the national science base. The analysis suggests the co-evolution of scientific performance with national technology and economy (Pavitt, 1996).

Casual observations have however shown that patterns of scientific strength and weakness, are strongly influenced by the nature of the societal and technological problems to be solved. In any case, current understanding of the complexities of the knowledge bases that underlie future technological knowledge base is very limited.

If any conclusion can be taken with direct application to Portugal, is that allocation to resources between broad fields of science should remain incremental, and that inadequacies in the rate of technological change should not be claimed to academic research. However, important questions remain to be solved, mainly in terms of the way academic governance influence the performance of basic research activities, and the linkages between basic and applied disciplines. Also, the way the demands for knowledge influence research policies remain to be examined.

It is clear today that one important dimension of the knowledge economy includes the activities expressly oriented towards the generation and diffusion of knowledge. It is, as with education, risky to reduce a complex set of activities to a single educator, but the national effort on research and development provides an indication of the commitment, at the country level, to activities explicitly oriented towards the generation of new knowledge. These activities tend to occur in institutions, such as universities and research labs, or within institutional settings, such as the R&D unit within a firm, that provide incentives that foster the specialization on exploration and discovery, as well as exchange of knowledge. If it is unquestionable today the critical role of the national S&T systems, it is also clear that they do not represent by themselves a true measure of innovation, namely in socio-economic terms. This has led us to broaden our analysis and to attempt to relate current practices for the evaluation of S&T with innovation measurements and other social measures.

6.4. A Policy Exercise: Promoting Innovation in Portugal

Recent work within the framework of the OECD International Futures Program suggests two broad policy-related conclusions which apply not only to OECD countries in general, but to a large extent also to the case of Portuguese regions. The first is that if one is to build on the opportunities offered by the considerable progress that has been made in key technological sectors, if one is to reap to the full the economic benefits of rapidly integrating markets and the emerging knowledge society; and if solutions are to be found to tackling the challenges that the management of such a rapidly changing world raises, then what is needed are innovative, creative societies. The second is that in achieving that higher degree of innovativeness and creativity, policy will matter. The way ahead does not necessarily mean less government, not less policy but - certainly in some key areas - different policy.

The reservation "in some key areas" is important. Just because we are headed into a rapidly changing world in the coming decades does not mean that we have to throw out all policies and make a completely fresh start. Indeed, some policies that have proved their worth in the past may well continue to do so in the future. However, it is clear that in other policy areas at least incremental adjustments are called for, and in yet others some radical new thinking is required. This provides, in fact, a simple but convenient framework for looking at the role of general policies in the future and their implications for innovation: -- 1) policy continuity 2) policy reform 3) policy breakthroughs.

In this context, we present below four main groups of strategies to be considered for Portugal, which, per si, reinforce the need to develop innovation policies:

- *Human capital for Innovation*: Substantial investments in human capital, and mainly at the basic and secondary levels, will continue to be a main target to promote and nurture innovation if the skill and qualification requirements of future jobs are to be met. This will require imaginative new ways of organizing education and validating people's knowledge. Regarding the Higher Education System, our work suggests two important ideas. First, we propose that the institutional integrity of the university needs to be preserved. Universities are a special type of learning organization specialized in producing and diffusing knowledge in unique ways. Second, we argue that, important as universities are, they are not enough to guarantee prosperity, and there is a need to promote a diversity of organizational arrangements, even at the higher education level. Indeed, this organizational diversity could be a major contributor to ensure the institutional integrity of the university. In addition, it is concluded that the allocation of resources between broad fields of science should remain incremental, in a way that the aim of policy should be to create a broad and productive science base.

- *Institutional Renewal for Innovation*: The evidence from OECD suggests the value of structural and regulatory reforms in supporting the development of innovative and creative societies and economic growth. Among dominant factors, we envisage the role of market liberalization, and market opening, including the privatization of critical infrastructures. The process is to be implemented together a comprehensive program of organizational renewal, namely at the State level, and in a way to promote the establishment of cooperative agreements towards the establishment of social capital. Fiscal incentives for network organizations and a new Regulatory framework for employment protection and market regulation should be attempted.

- *Networking and Corporate strategies for Innovation*: a framework for devising and implementing strategies in business environments typical of transitional economies, such as those in the Portugal, is to be considered taking into account clustering effects. The low level of "thrust" typical of the Portuguese society is a major barrier, that is to be overcome along the enterprise chain value and making use o aggressive "product development strategies", together with specific factors as: Time to market; Market and Technology; Product and Process Innovation; Increasing returns markets; Managing environmental complexity; Managing organizational change; Devising knowledge strategies.

- *Alternative forms of financing Innovation*: different funding forms to be used in Portugal, including offset and countertrade tools, are conceived in order to promote and develop different approaches to innovation within national companies. Traditional means in financial innovation tends to be "outdated" on the "new" economy context. Although national security is not a priority, activities such coast inspection, citizen protection and rescue, and humanitarian programs, are some examples of the existing need for the country and, at the same time, to consider the use of offsets to foster economic development. Beyond offsets in processes for buying military equipment, countertrade should be considered as well for purchase of civil goods and critical infrastructures, such as the new Lisbon international airport. The research carried out aims to launch guidelines the benefits for the Portuguese economy of the innovative use of tools as offset and countertrade to increment new forms of cooperation between existing firms and new technology based firms creating multi-polar, interdisciplinary and market driven networks.

7. Summary and Conclusions

This chapter addresses complementary aspects of relevance towards improved understanding of innovation in an emerging learning society. It focus on Portugal within a European scene, considering a context increasingly characterized by uncertainty and diversified environments, which are particularly influenced by social and institutional factors. Under this scope, our understanding of innovation encompasses the way in which firms and entrepreneurs create value by exploiting change. This leads us to question the traditional way of viewing the role that contemporary institutions play in the process of economic development and to argue for the need to promote *systems of innovation and competence building* based on learning and knowledge networks.

We describe a conceptual understanding of the relationship between *learning* and *knowledge accumulation*, leading to *innovation*. Our analysis led us to suggest that while the role of institutions needs to be re-examined, the variety of demands and the continuously changing social and economic environment is calling for **diversified systems** able to cope with the need to produce policies that nurture and enhance innovation in the emergent learning society.

In addition to the various arguments used in this chapter derived from emerging concepts associated with the economics of knowledge, a growing body of literature illustrates the importance of demand conditions to allow for technological diffusion in the network society. It is through the diffusion process that technological innovations are translated into wide economic impact, as more and more people and firms consume and use the new products or processes. And if we accept that this increasingly generalized usage of technological innovations fuels, not only increases in well being, but also the conditions to generate further innovations, one cannot escape the importance of demand conditions for economic and technological prosperity in the emerging learning society.

In fact, historians of economic evolution have shown that demand conditions were crucial in the process of early industrialization in the US. For example, Rosenberg (1994) describes the demand conditions that were conducive to the earliest stages of industrialization in the 19th century. In fact, in Rosenberg's (1994) argument, they were crucial to create a new industrial system out of an agricultural society. An important component of the demand conditions was a relatively high level of income per capita and, equally crucial, a relatively egalitarian distribution of the marginal income available beyond the one needed for subsistence. Inspired by this analysis of the interaction between inequality and technology, we believe the concept of *system of innovation and competence building* discussed in this chapter should be further analysed to improve understanding whether, with the current wave of technological innovations, there is also a relationship between levels of inequality and the rates of diffusion of technology. The argument we are advancing here is that social cohesion, beyond the issues associated with ethical judgement and justice, may also be of importance to the learning society.

Innovation should then be understood as a **broad** social and economic activity within the framework of the learning society. It should transcend any specific technology, even a revolutionary one, and should be tied to attitudes and behaviors oriented towards the exploitation of change by adding value. Recent work within the framework of the OECD International Futures Program suggests two broad policy-related conclusions. The first is that if one is to build on the opportunities offered by the considerable progress that has been made in key technological sectors, if one is to reap to the full the economic benefits of rapidly integrating markets and the emerging knowledge society; and if solutions are to be found to tackling the challenges that the management of such a rapidly changing world raises, then what is needed are **innovative**, creative societies. The second is that in achieving that higher degree of innovativeness and creativity, policy will matter. The way ahead does not necessarily mean less government, not less policy but – certainly in some key areas – **different** policy.

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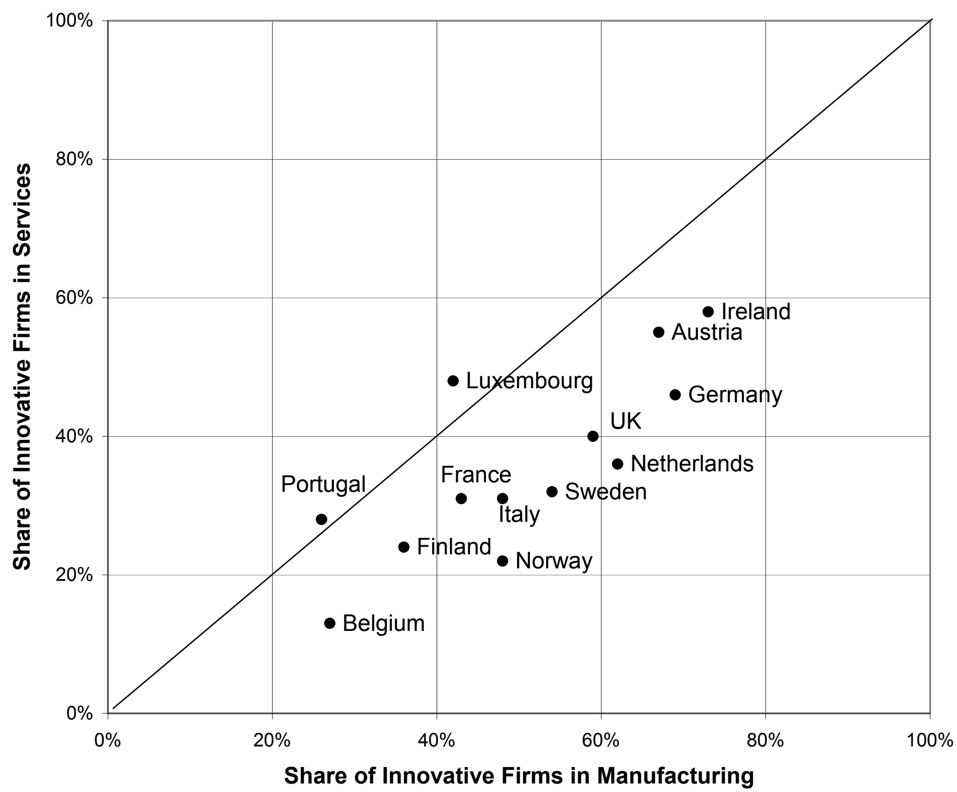

Figure 1- Innovative Performance of EU Countries for the period 1995-1997.

Source: Conceição and Ávila (2001).

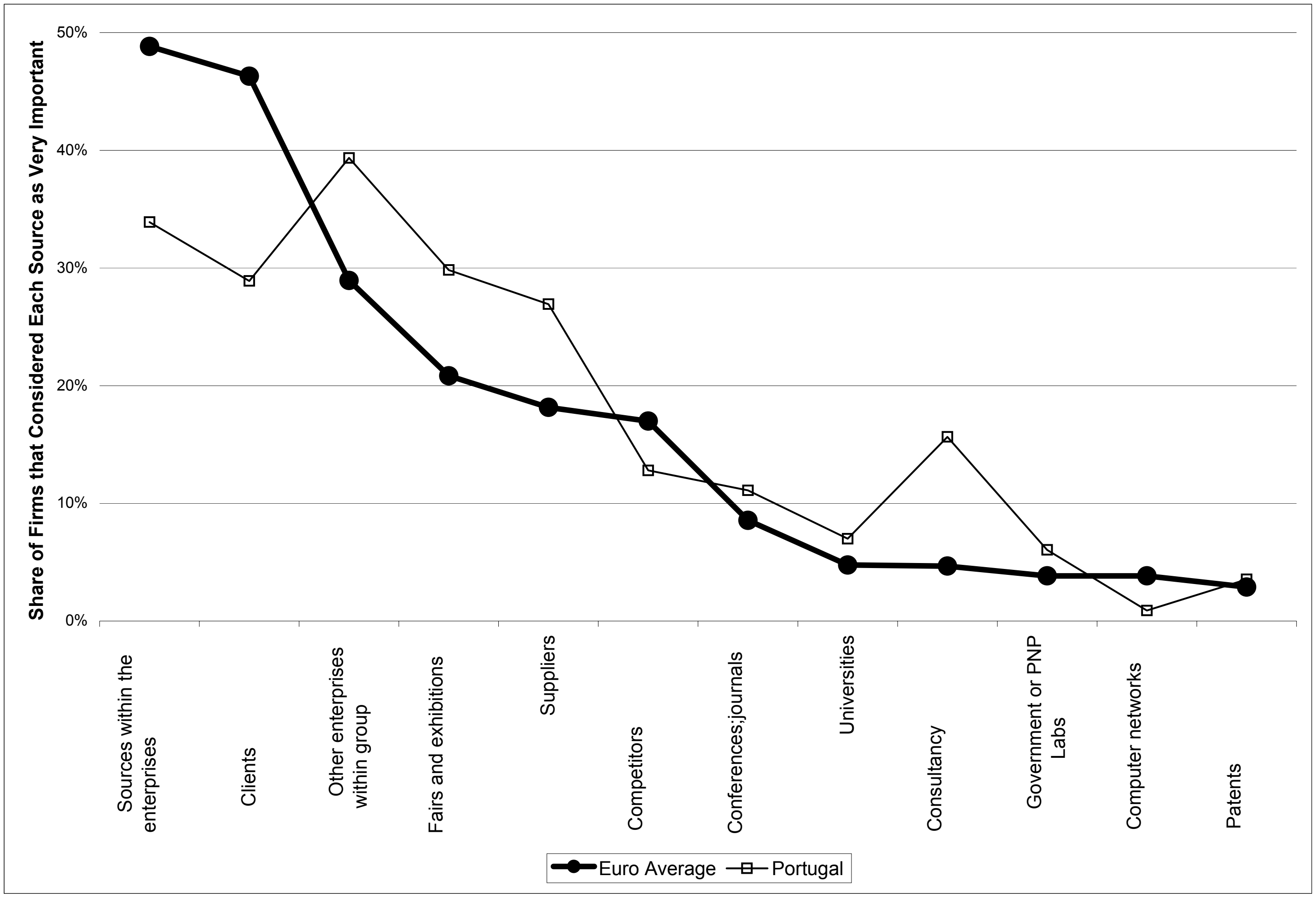
Share of Firms that Considered Each Source as Very Important
50%
40%
30%
20%
10%
0%
Sources within the enterprises
Clients
Other enterprises within group
Fairs and exhibitions
Suppliers
Competitors
Conferences;journals
Universities
Consultancy
Government or PNP Labs
Computer networks
Patents
Euro Average
Portugal

Figure 2- Sources of Information for Innovation

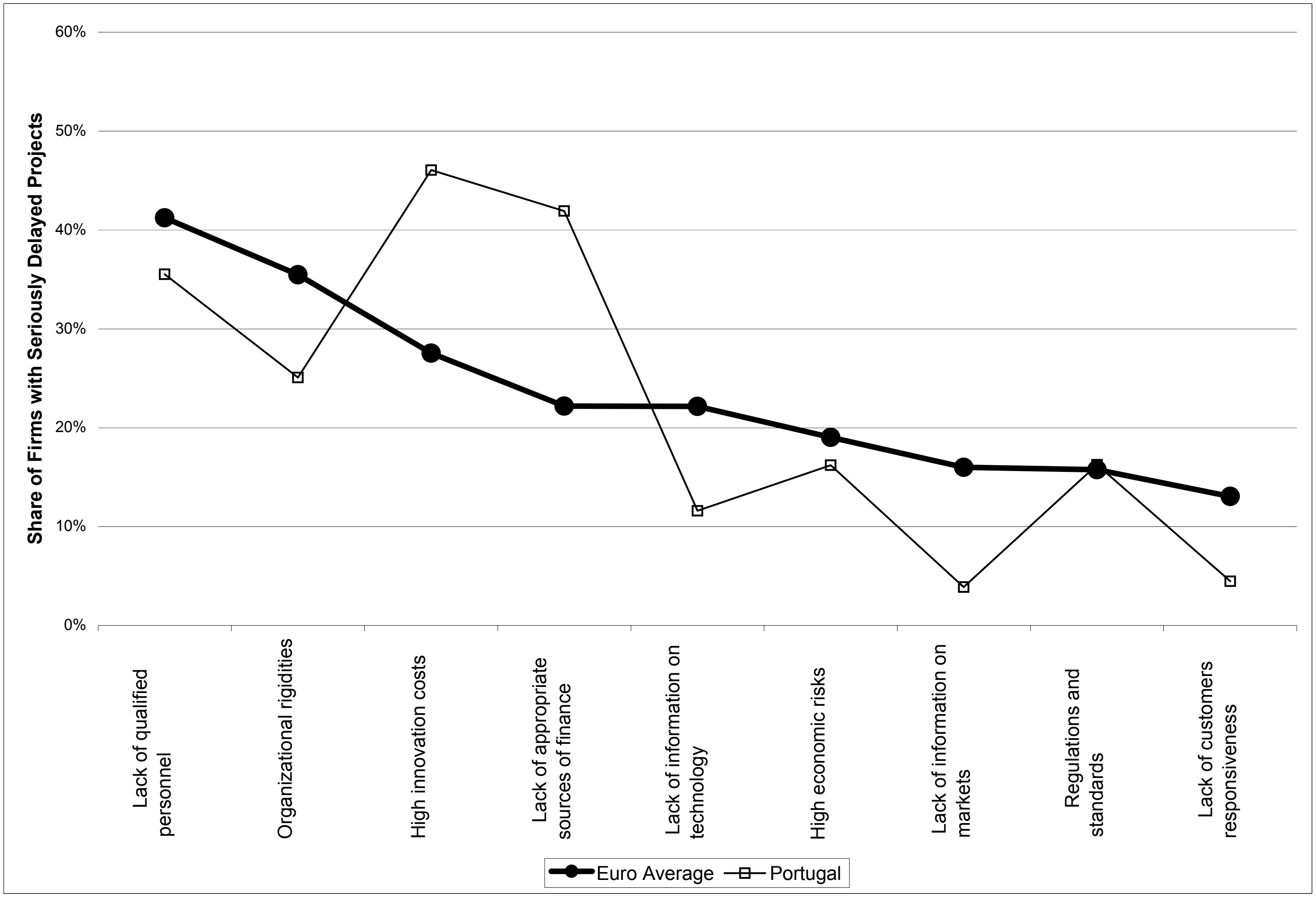

Figure 3- Factors Hampering Innovation

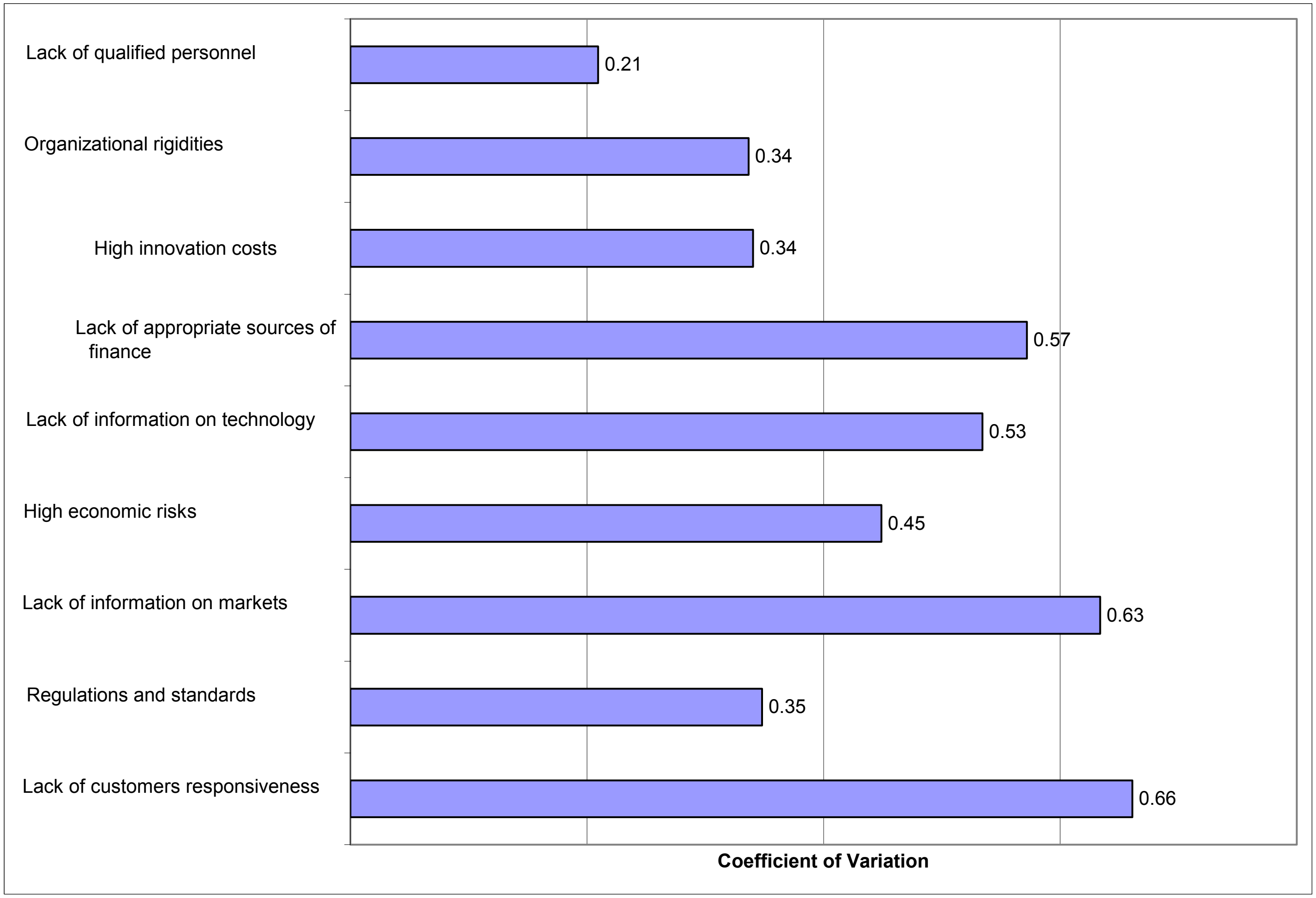

Figure 4- Degree of Consensus Across Europe on the Hampering Factors

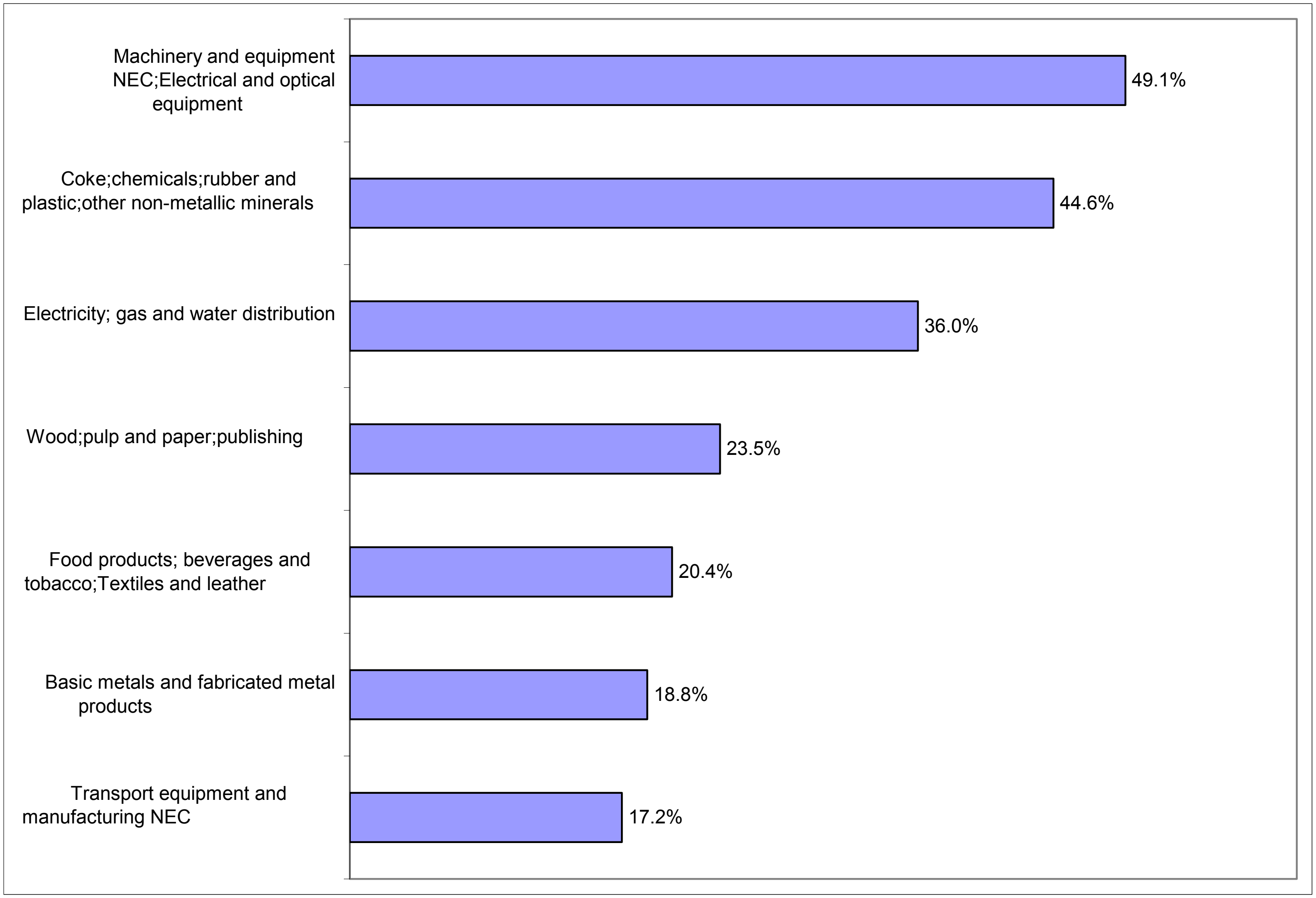

Figure 5- Innovation Rates (% of Innovative Firms) in the Portuguese Manufacturing Sector

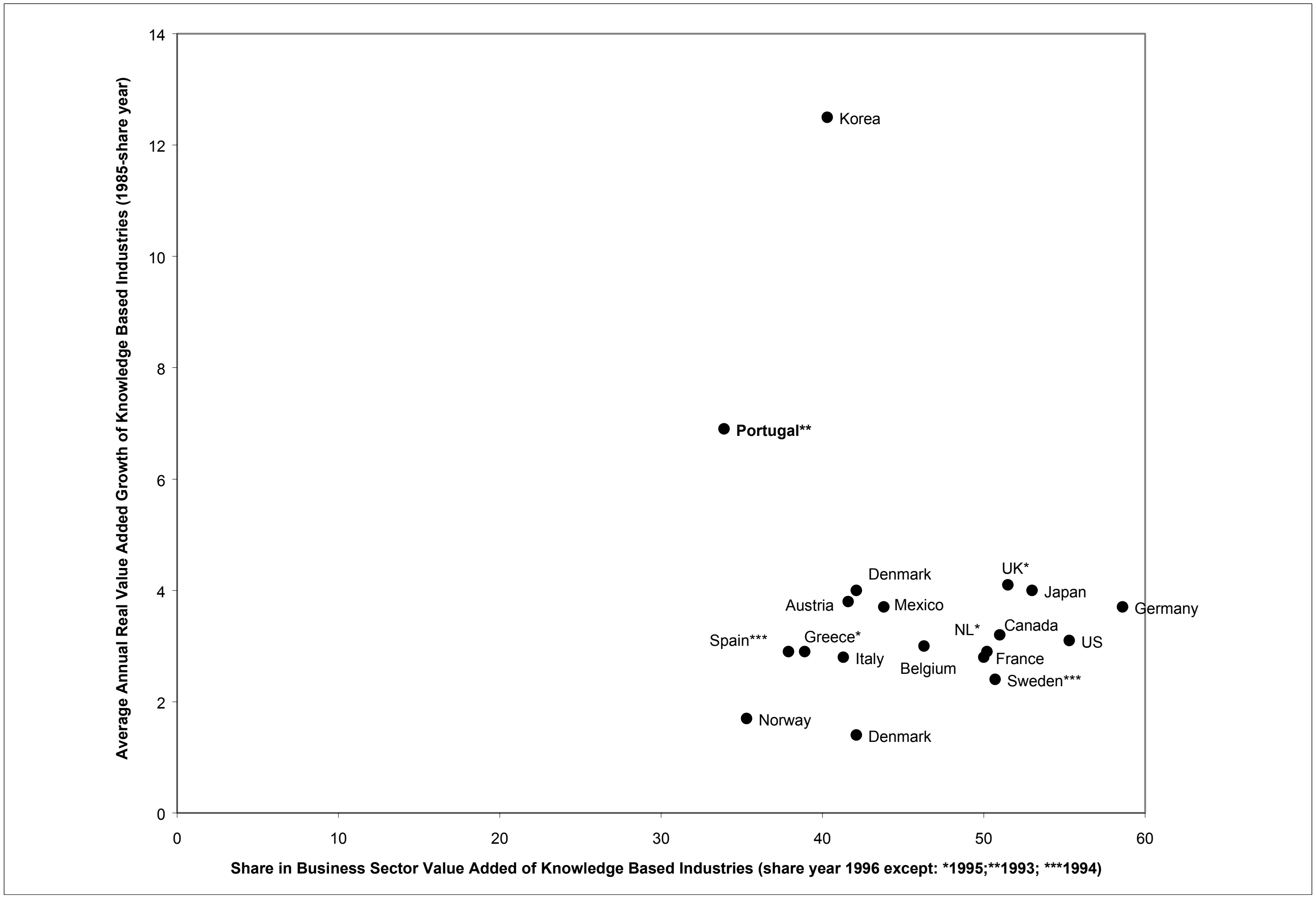

Figure 6- Knowledge Based Industries Intensity and Growth

Source: OECD (2000)

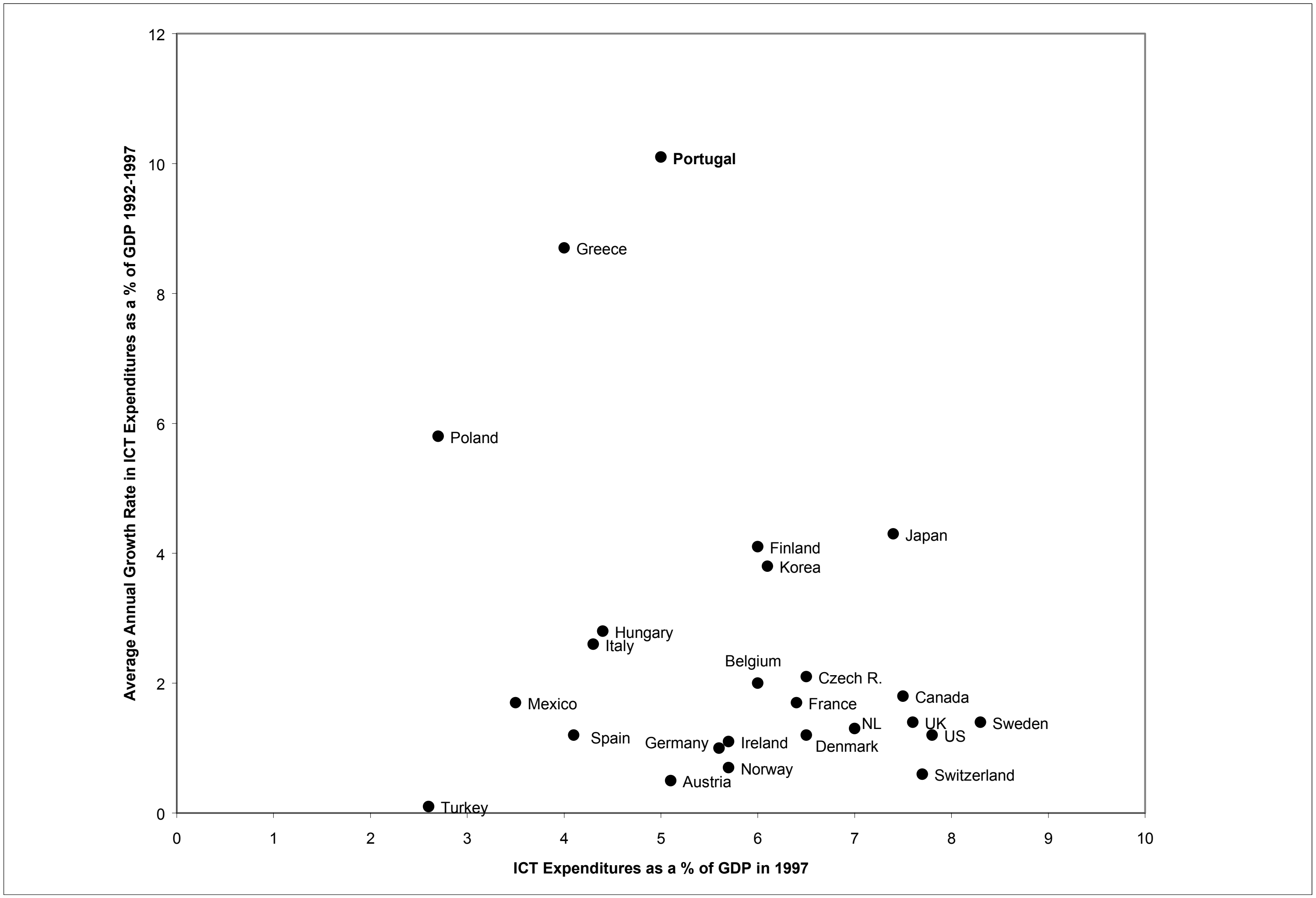

Figure 7- Information and Communication Technology (ICT) Intensity and Growth

Source: OECD (2000)

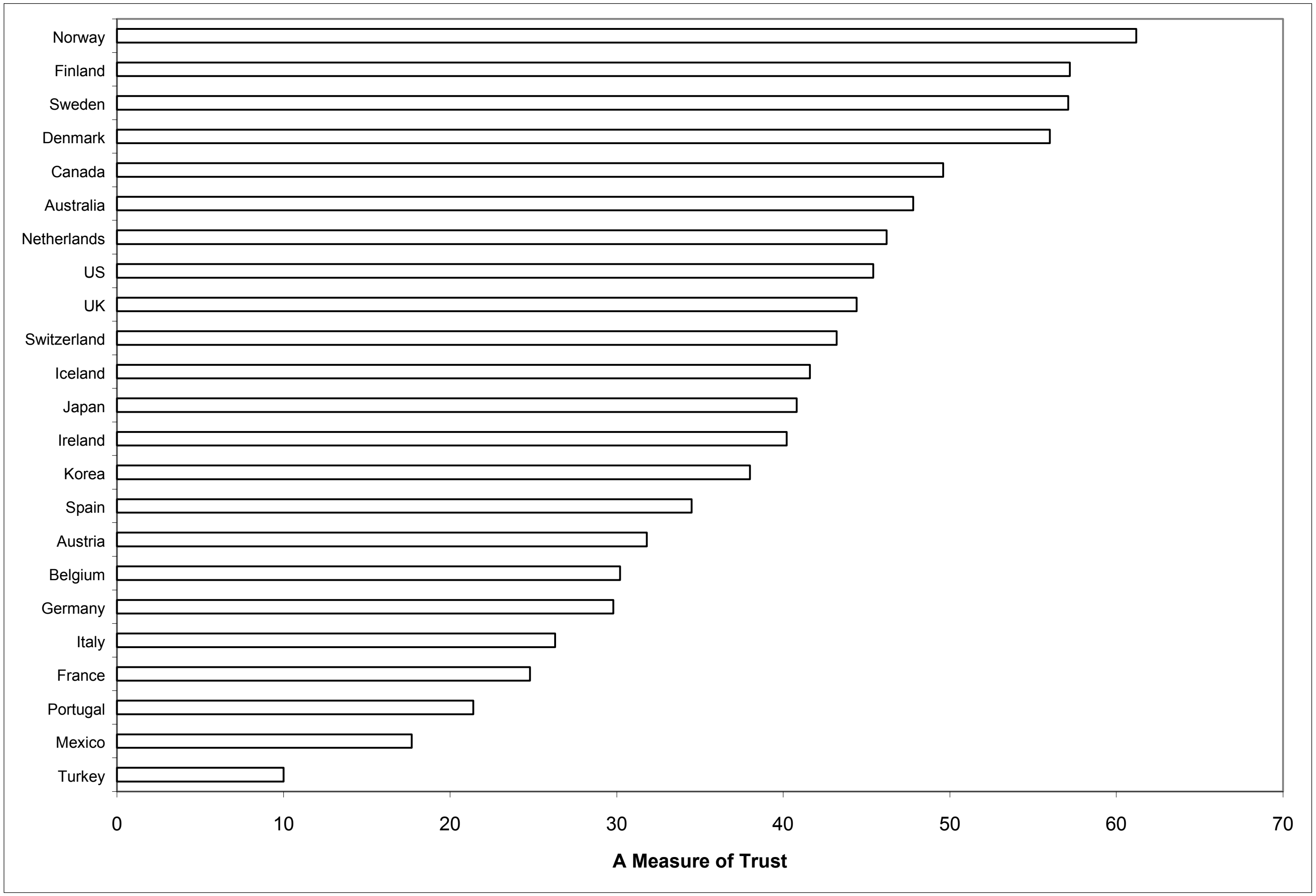

Figure 8- Level of Social Capital Measured by Trust.

Source: World Values Survey. Percentage of people who responded in the affirmative to the question: "Generally speaking, would you say that most people can be trusted?"

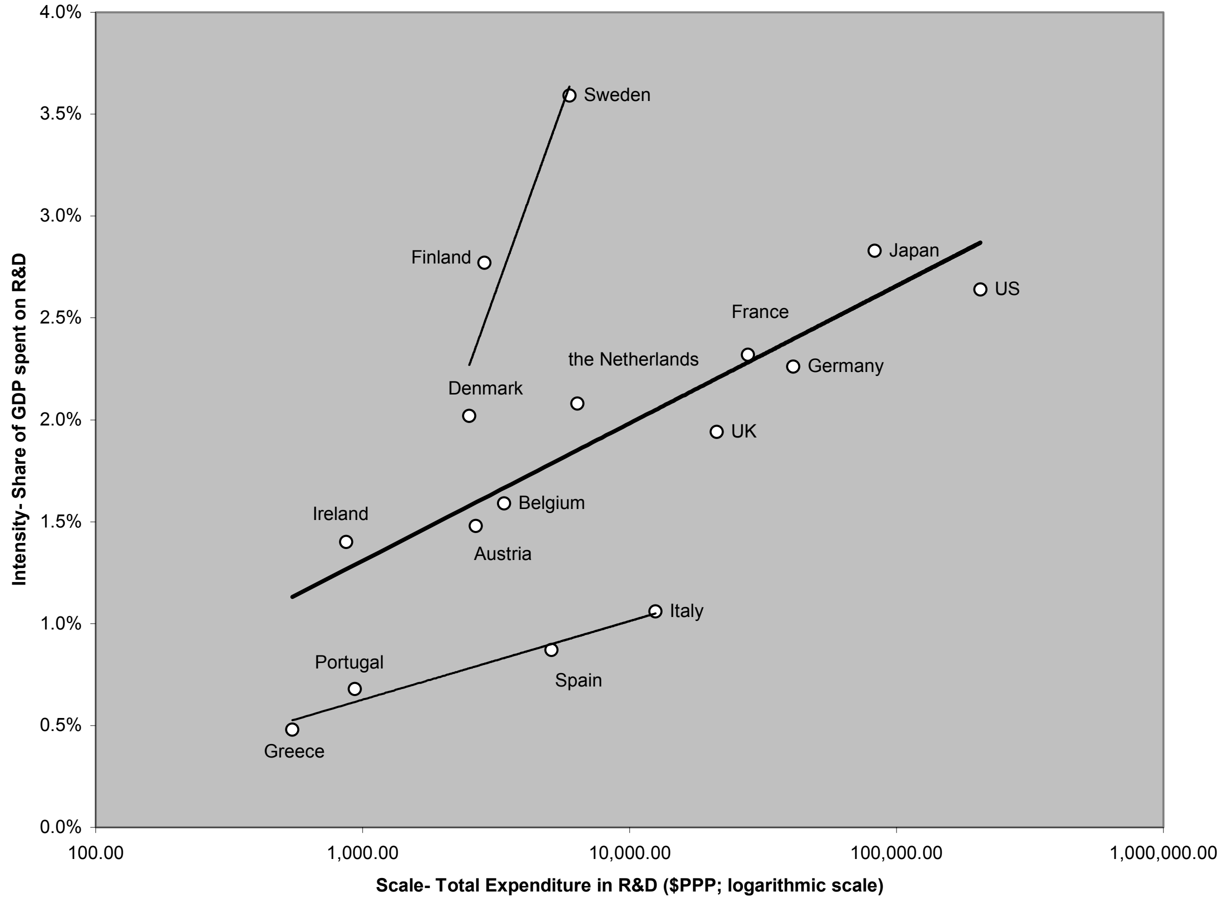

Figure 9- Intensity and Scale of R&D Expenditure in the OECD (1997).

Source: OECD (2000)

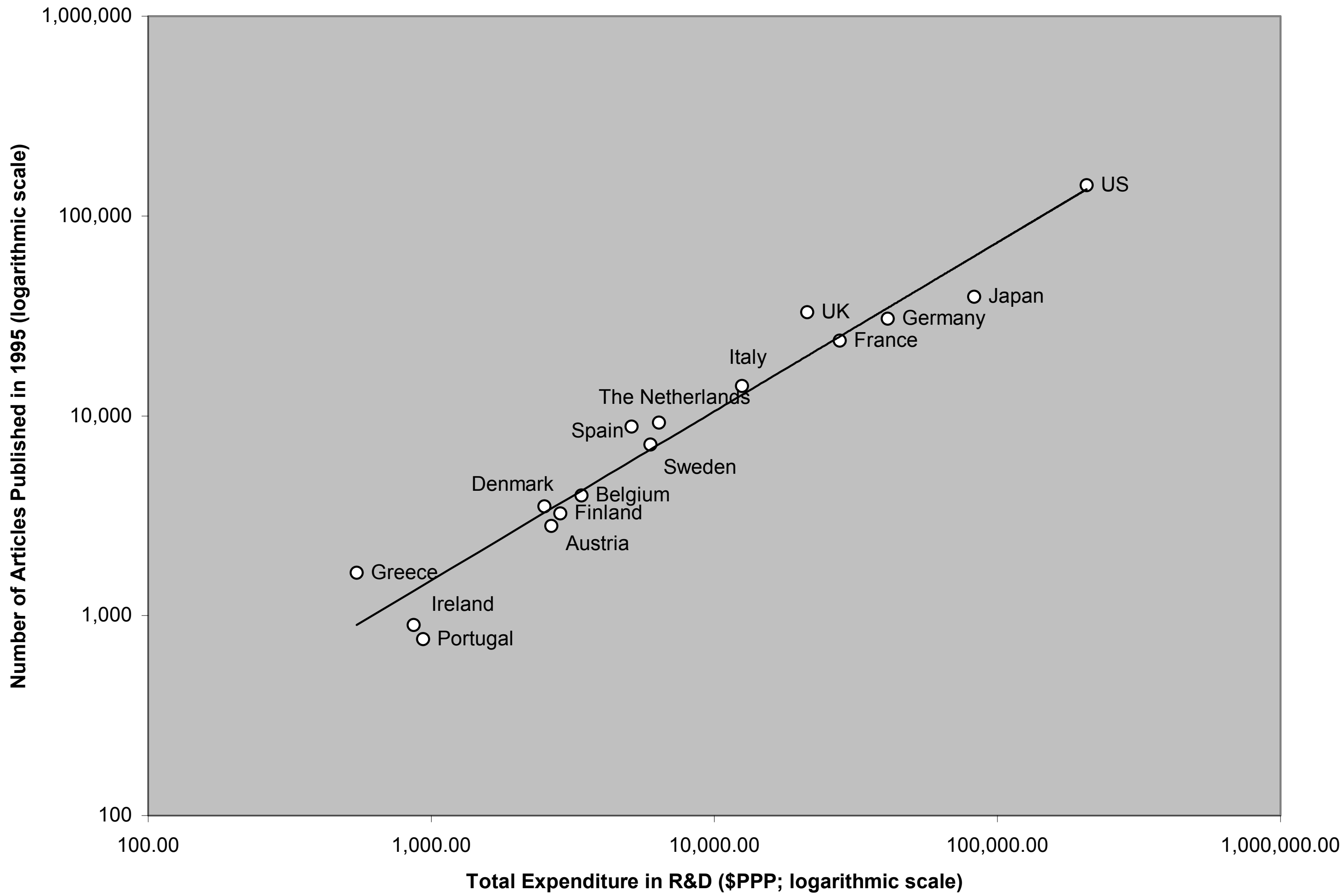

Figure 10- Absolute R&D Expenditures and Scientific Production in the OECD (1997).

Source: OECD (2000)

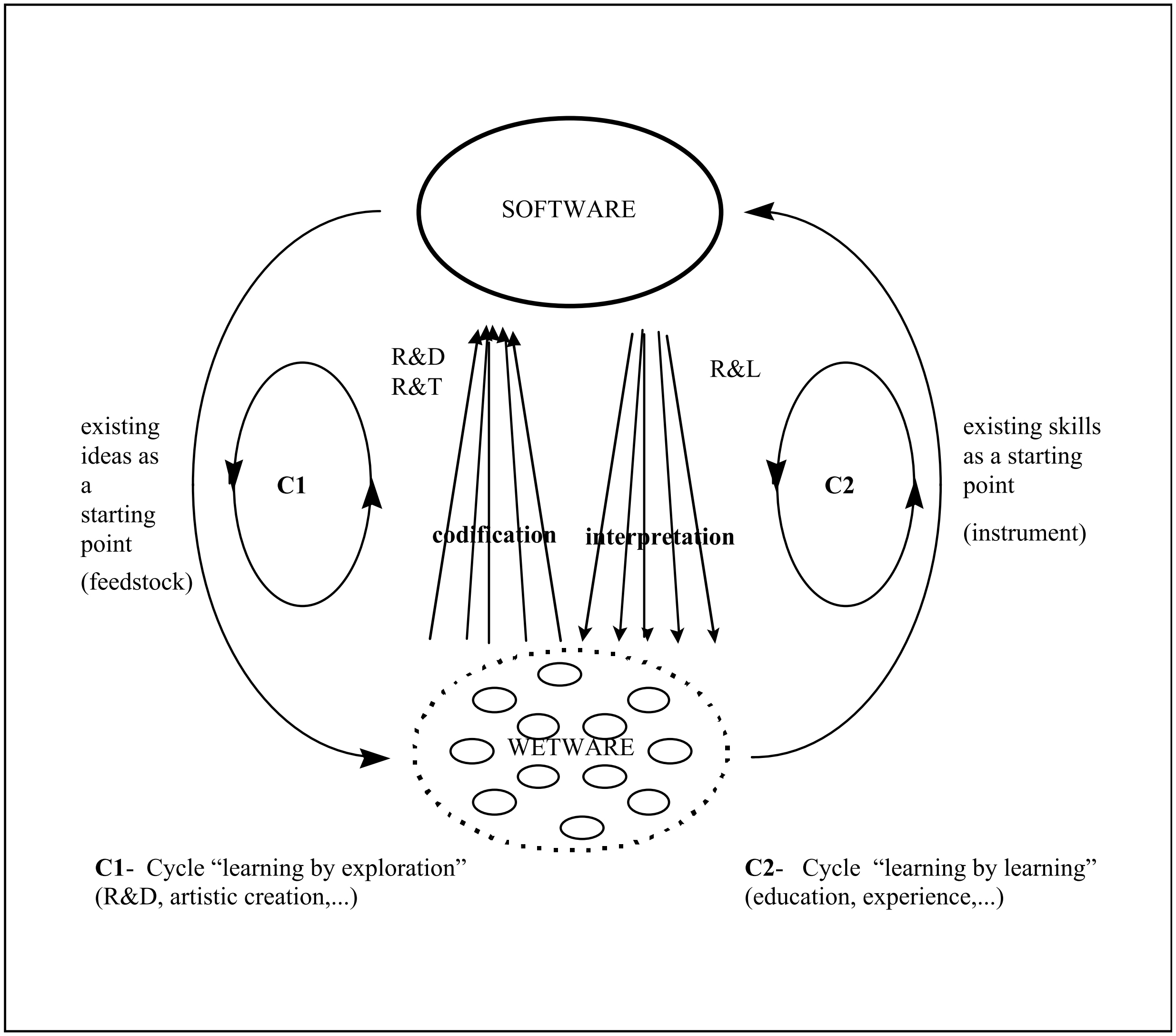

Figure 11 - Diagrammatic representation of the interaction between learning processes and the accumulation of knowledge, identifying the various aspects of university research (notably Research & Development, Research &Training, and Research &Learning, as analysed by Conceição and Heitor, 1999).

Table 1- Regression Results on the Characteristics of Innovative Firms- First Model[3]

	Unconditioned	Industries Dummies	Technological Intensity
	(1)	(2)	(3)
Intercept	-1.576**	-9.104	-1.773**
	(0.2448)	[-0.0001]	[0.2562]
	[0.0000]	[1.0000]	[0.0000]
Firm is part	0.529**	0.318*	0.474**
of Group	(0.1423)	[2.0834]	[0.1435]
	[0.0002]	[0.0372]	[0.0009]
Log of	0.213**	0.262**	0.224**
Number of	(0.0613)	[4.0365]	[0.0625]
Employees	[0.0005]	[0.0001]	[0.0003]
High/		Conditioning	0.757**
Medium High		Industries	[0.138]
Technology		Dummies	[0.0000]
		None is significant	
Medium			0.163
Low			[0.1163]
Technology			[0.1614]
Concordant	84%	87%	85%
Observations	820	820	820

[3] Dependent variable: 1 if the firm has introduced any type of innovation, 0 otherwise. Standard errors in brackets, p-values in square brackets. ** significant at 1% or less. Logistic regression. Results with a normally distributed link function (Probit) were not dramatically different. Manufacturing only.

Table 2- Tentative Sketch of Major Techno-Economic Paradigms

Approximate Period	Description	Key Sectors	Economic Organization
1770s to 1840s	Early Mechanization	Textiles, Canals, Turnpike Roads	Individual entrepreneurs and small firms; local capital and individual wealth
1830s to 1890s	Steam Power and Railway	Steam Engines, Railway, World Shipping	Small firm competition, but emergence of large firms with unprecedented size; limited liability corporations and joint stock ownership
1880s to 1940s	Electrical and Heavy Engineering	Electrical Engineering, Chemical Process Industries, Steel ships, Heavy armaments	Giant firms, cartels, trusts; mergers and acquisitions; state regulation and enforcement of anti-trust; professional management teams
1930s to 1980s	Fordist Mass Production	Automobiles, Aircraft, Consumer Durables, Synthetic Materials	Oligopolistic competition; emergence of multinational corporations; rise of foreign direct investment; vertical integration; technocratic management styles and approaches
1970s to …	Information and Communication	Computers, Software, Telecommunications, Digital Technologies	Networks of large and small firms based increasingly on computer networks; wave of entrepreneurial activity associated with new technologies; strong regional clusters of innovative and entrepreneurial firms

Source: Adapted from Freeman and Soete (1997), Table 3.5.

Table 3- Decomposition of GDP per Hour Worked into Effects of Working Hours, Labor Force Participation and GDP Per Capita, 1997

	GDP **per hour worked** as a % of the OECD Average	Effect of working hours	GDP **per person employed** as a % of the OECD Average	Effect of unemploy-ment	Effect of labor force as a % of the working age population	Effect of working age population as a % of the total population	Total effect of labor force participation	GDP **per person** as a % of the OECD Average
	(1)	(2)	(3)=(1)+(2)	(4)	(5)	(6)	(7)=(4)+(5)+(6)	(8)=(3)+(7)
Australia	**96**	0	**96**	-1	2	0	1	**97**
Austria	**102**	-4	**98**	3	-2	1	2	**100**
Belgium	**128**	-5	**123**	-3	-19	-1	-22	**101**
Canada	**97**	2	**98**	-2	2	2	2	**100**
Denmark	**92**	0	**92**	1	9	1	11	**103**
Finland	**93**	0	**94**	-7	2	0	-5	**88**
France	**123**	-9	**113**	-6	-9	-2	-17	**97**
Germany	**105**	-5	**100**	-3	-4	2	-4	**96**
Greece	**75**	-4	**71**	-2	-11	1	-12	**58**
Ireland	**108**	5	**113**	-4	-12	-3	-18	**95**
Italy	**106**	-11	**96**	-5	-1	2	-5	**91**
Japan	**82**	10	**92**	4	6	4	14	**106**
The Netherlands	**121**	-26	**95**	2	-4	2	0	**96**
New Zealand	**69**	8	**77**	1	3	-1	2	**79**
Norway	**126**	-17	**109**	4	12	-4	12	**122**
Portugal	**56**	2	**58**	0	1	1	2	**60**
Spain	**84**	13	**97**	-14	-13	2	-26	**71**
Sweden	**93**	-3	**89**	-3	6	-4	-1	**88**
Switzerland	**94**	0	**94**	3	12	1	17	**111**
Turkey	**36**	2	**38**	0	-8	-1	-9	**29**
United Kingdom	**100**	-9	**91**	0	3	-2	0	**92**
United States	**120**	-1	**118**	3	9	-2	10	**128**
EU-14	**103**	-5	**98**	-4	-4	0	-8	**90**

Source: Ark and McGuckin (1999); Summations may not add exactly due to rounding errors.

Table 4 - Accumulation of knowledge and learning processes in the new growth theories

		Learning by			
		Formal processes		Informal processes	
		Education	R&D	Experience (by-doing)	Interaction
Accumulation of	Software (Ideas)		Romer (1990) Grossman & Helpman (1991)		
	Wetware (Skills)	Lucas (1988)		Arrow (1962) Romer (1986)	