The impact of science, technology and industrial policies on economic performance in Portugal after accession to the EU: a contribution to its explanation

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An exploratory assessment of the impact of Science, Technology and Industrial Policies on the economic fabric of Portugal is made. The main policy developments and mechanisms since accession to EU and the evolution of the economic and S&T system during that same period are briefly described. Several indicators of economic development, including productivity levels, composition of exports, among others, are used to assess the changes that occurred during the period.
It is argued that the trajectory followed since accession to the EU of the Portuguese economy is, on the one hand, closely related to the strategic options and the investment priorities of the large national programmes co-financed by the EU that have been in place since 1989, and on the other hand, related with the production strategy and endogenous capabilities of the economic agents. Namely, there seems to be a close relation between the industrial modernization priorities of the programmes and the relative performance of the low technology sectors. A relation between the programmes on advanced training of human resources and the performance of the high technology sectors is also suggested.

1. Introduction

Contributions to the explanation of economic development after Solow's (1956) model have tried to take account of the residual by incorporating technology and its impact on economic convergence. Imitation, diffusion and production of technology seem to be at the core of the process (Posner, 1961). Mechanisms to explain that process have been proposed (Abramovitz, 1986; Romer, 1994) and they seem to converge on the importance of several enabling factors such as education, a certain level of R&D resources, and other institutional factors which greatly influence the rate of convergence. Recognising the systemic nature of the innovation process (Lundvall, 1988) efforts have been made to understand the importance of certain fundamental structures and the role of crucial actors that are paramount to the complex process of convergence (Teubal, 1996). In this paper we analyse government policies launched in Portugal after its accession to the EU in 1986 that were aimed at creating those fundamental structures and we make an exploratory analysis of some aspects of the process and its contribution to economic development.

2. A brief description of science and technology policy in Portugal since accession to the EU

One important feature of the Portuguese S&T system, which has had enduring consequences in terms of innovation performance, is the evolving separation between science policies and technology policies that has gradually but persistently occurred since the birth of S&T policies in Portugal.

Table 1. Science policy programmes in Portugal

Programme	Measure	Funding (million Euros) current prices
CIENCIA (1990-1993)	1. Development of R&D infrastructures in priority domains: Information technologies and telecommunications, production and energy, new materials, health, agriculture, biotechnology and fine chemistry, marine science.	124.25 (46.7% of total)
	2. Advanced training and innovation in priority domains: Advanced training, support of innovation in firms, creation of an Innovation Agency	66.5 (25% of total)
	3. Global support of the scientific and technological system: R&D infrastructures in the exact sciences, engineering sciences, earth and environmental sciences, economy and management sciences, for common use, for popularising R&D, for general training in science and technology.	66.5 (25% of total)
PRAXIS XXI (1994-1999)	1. Reinforcement of infrastructures: R&D laboratories, common use R&D infrastructures, Science and Technology Parks	105 (22.8% of total)
	2. Development of the base of the S&T system: Structural programmes, stimuli to the internationalisation of the S&T system	67.4 (14.6% of total)
	3. Mobilisation of the S&T capacity for innovation and regional development: Programmes for regional development and innovation stimuli.	82.25 (18.1% of total)
	4. Advanced training of human resources.	183.75 (40.1% of total)

Source: SECT (1990) and Gabinete do Gestor do PRAXIS XXI (1996).

Almost since the outset of explicit S&T policies in Portugal there was confrontation between two main currents: one that privileged an integrated perspective in terms of science and technology policies and another that favoured an institutional specialization and separation of science polices, one the one hand, and technology and industrial policies, on the other hand (Caraça, 1999).

Table 2. Industrial and technology policy programmes in Portugal

Programmes	Measure	Funding (million euros) current prices
PEDIP (1989-1992)	1. Basic and Technological infrastructures: Basic infrastructures (energy, roads, railways, ports) and technological infrastructures	462 (32,5% of total)
	2. Vocational Training	162 (11,4% of total)
	3. Incentives for productive investment: Incentives to industry. Restructure and modernisation of industrial sectors (woollens, foundry, information technologies, electronics, equipment goods industry)	582.75 (41.1% of total)
	4. Financial engineering: Capitalisation of enterprises.Risk capital enterprises	37.6 (2.7% of total)
	5. Productivity missions: Demonstration projects. Support for Entrepreneurs. Protection of intellectual property and inventions.	112 (7.9% of total)
	6. Industrial Quality and design: Development of standards, metrology and approval and certification methods.Incentives to improve quality and design.	54.25 (3.8% of total)
PEDIP II (1994-1999)	1. Support and Consolidation of Technological infrastructures	330.75 (13.9%)
	2. Complementary mechanisms of financial engineering: Risk capital societies. Financial support.	91.8 (3.9% of total)
	3. Consolidation and reinforcement of enterprises strategies: Audits. Technology acquisition and development. Innovation and internationalisation. Support of dynamic factors of competitiveness. Strategic contract-based programmes.Certification, standards. Industrial property	1381.63 (58.2% of total)
	4. Productivity, quality and internationalisation promotion: Quality and design. Inter-firm co-operation.Internationalisation. Innovation and technology transfer. Environment. Productivity and demonstration projects. Energy efficiency	185.5 (7.8% of total)
	5. Human resources promotion Vocational training	336.87 (14.2% of total)

Source: Gabinete do Gestor do PEDIP (1993) and (1999)

This institutional and policy confrontation led, in practical terms, to a growing, and perhaps effective, separation between science policy and technology and industrial policy and the locus of decision making relative to each component became also divided between the Ministry of Science and Technology (Science Policy) and the Ministry of Economy (Technology Policies).

The large national programmes launched after accession to the EU and co financed by the EU reflect this divide. The CIENCIA programme (1990-1993) and the PRAXIS XXI programme (1994-1999) were essentially instruments of science policy (Table 1). The PEDIP programme (1989-1992) and the PEDIP II programme (1994-1999) were instruments of technology policy (Table 2). Both PEDIP programmes were also and essentially mechanisms of industrial policy.

In the following sections we will try to highlight what we believe are the most important relations between the policies pursued since Portugal's accession to the European Union and the evolution of the socio-economic structure of the country. Considerable structural change has occurred since accession, particularly evident in the considerable reduction in the percentage of total employment in the primary sector and the considerable increase in the percentage of total employment in the tertiary sector. We will not address this topic. Our emphasis will be on the industrial structure (which has remained almost unchanged in terms of percentage of total employment) and on the research sub-system.

3. Instruments of science policy: the CIENCIA and PRAXIS XXI programmes

The main priority of the CIENCIA programme was investment on physical infrastructure while the priority of PRAXIS XXI was on the promotion of research projects. While 75% of total funds of the CIENCIA programme were devoted to physical infrastructures, the PRAXIS XXI programme devoted only about 25% of total funding to physical infrastructures.

Both invested heavily in advanced training. The two programmes together awarded more than 9000 individual scholarships (OCT, 1999), of which approximately 45% were doctoral grants and approximately 39% were master's scholarships. Approximately half of the doctoral scholarships were conducted abroad (mainly in the European Union and United States). The annual growth rate of Portuguese doctorates is about 10%. The annual number of successful doctorates grew from 100 (in 1980) to 694 (in 1998). It is estimated that the stock of doctorates in 1999 is about 8000 (MCT, 1999).

The question now is what has been the economic impact of these programmes. There are no updated comprehensive studies of the possible impacts of these huge investments in human resources, but the perception is that most of the graduates were absorbed either by the universities or by the new scientific and technological infrastructures created by the very same programmes. The universities and the higher education institutes were probably the main recipients. The university system itself suffered major changes and growth rates since and before accession to the EU due to a general enlargement of the educational component of the system. The universities grabbed the opportunity to augment and upgrade their human resources base, as they were the institutions in Portugal more capable and fit to take advantage of the opportunity provided by the programmes, and because advanced training was a requisite for career development.

The opportunity for advanced training rolled in parallel with the opportunity to fund research projects. Both CIENCIA and PRAXIS XXI heavily financed research projects. The universities were also the main beneficiaries of this type of financial support, in conjunction with the state research laboratories and the newly created scientific technological infrastructures. Research projects specifically aimed at innovation, involving in general the promotion of consortia between enterprises and research institutes have been relatively few compared with the overall resources devoted to project funding.

Thus, the impact in terms of the economic structure of the country has not been a direct one, but rather an indirect one, trough the intermediation of the university and research system. The main impact is the increase in the number of first-degree graduates from the universities and their integration in the production structure. This mode of knowledge transfer allowed the progressive modernization of the production processes and management routines of the firms (specially SMEs) and increased their absorptive capacity (Cohen and Levinthal, 1990). This is important because the level from which the knowledge base of the firms was being upgraded was considerably low.

Demand and assimilation of doctorates or masters by the production structure has been low. This is related to its relatively low human resource competence base and its related strategy based more on production and not so much on product differentiation or innovation. The apparently insufficient integration and institutional divide between science policy and technology and industrial policy may also have contributed to this lack of foresight. One of the expectations behind the massive investment in advanced training, asides from the main intention to upgrade scientifically the whole science and technological infrastructure of the country (explicitly formulated in terms of science policy), was also the linear perspective and expectation that some, if not a considerable part, of those human resources would be absorbed by the production structure contributing to foster industrial R&R activities. That has not happened, in spite of fiscal incentives to R&D and support for the integration of doctorates in firms and technological centres (MCT, 1999b), and in spite of the fact that the capacity of the public research system to absorb doctorates and masters seems to have reached a saturation level.

The overall impact of the science policies pursued until now was the considerable upgrade of the research system including universities, state laboratories and institutes and some private non-profit laboratories, and a considerable increase in the production of scientific output. The scientific output is encouraged by an evaluation system that rewards scientific excellence. The number of doctorates increased at an approximate annual rate of 8,5% from 1984 to 2000 (OCT, 2002) and the number of ISI publications increased at an approximate annual rate of 12% from 1984 to 2000

(OCT, 2001a). Total FTE personnel devoted to R&D increased at an approximate annual rate of 5,5% from 1984 to 1999 (OCT, 2001b).

Researchers from the university or the research laboratories have been relatively successful in terms of applying to projects under the European RTD Programmes (Caraça, 1991; Caraça, 1993). Some of the perceived effects of the programmes are related the reduction of the isolation of the scientific system, to the setting of new standards, to the improvement of scientific skills and helping to reduce the brain drain, among others.

In terms of direct impacts of the CIENCIA and PRAXIS XXI programmes on the production structure we believe that they are much more modest. Some of the major impacts are related to the creation of new firms associated with diffusion of Electronics and Information Technologies (EIT), and to some academic spin-offs in the field of biotechnology (Laranja, 1998). Growth of the science based industrial sectors has been modest, if not close to zero (Table 4). The components of the CIENCIA or PRAXIS XXI programmes that dealt directly with support of innovation in enterprises were modest relative to the total budget of the programme (approximately 6% of total budget in CIENCIA and 10% in PRAXIS XXI; a considerable proportion of these funds were applied in the creation of an Innovation Agency; funding of research projects in consortia involved only about 1,7% of CIENCIA and PRAXIS XXI total budgets). The results of similar measures, such as the SME Community Initiative, a programme that run from 1997 to 1999 aimed at supporting firm’s competitive dynamic factors are, according to Bateira (2001) not very satisfactory. The strategy followed by the overall majority of firms is still centred around production processes modernization, trough the acquisition or adaptation of established processes or products showing little appetence for investments that are directed towards product innovation and differentiation.

4. Instruments of technology and industrial policy: the programmes PEDIP and PEDIP II

That leads us directly to the impact of the two PEDIP programmes that run from 1989 to 1999, which were explicit instruments of industrial and technology policy, whereby the component “industrial policy” takes a prominent role. The main priority of both programmes was the modernization of the industrial structure of the country, which was achieved mainly through incentives to acquisition and diffusion of embodied technology (measure 3 of both PEDIP and PEDIP II reflects the priority of the programme; see Table 1 and 2). The second priority relates to the implementation, consolidation and support of physical technological infrastructures, namely metrological laboratories, sectoral technological centres, institutes for diffusion of new technologies, centres for technological transfer, technological poles, (measure 1 in both PEDIP and PEDIP II). Measures related to the support of innovation projects or research and development in industry represent a small proportion of the overall budget (approximately 5% of total PEDIP II budget). The bulk of investment in PEDIP (measure 3) represents incentives to modernization of the production structure, and the second largest value represents incentives to technological infrastructures. A similar situation is visible in PEDIP II (measure 3).

The priorities implicit in the Framework Programmes must be confronted with the strategy followed by the recipients (the firms) and their associated capacities. An element of strategy is directly linked to educational level. An indicator of the capacities of the firms can be found in education statistics. The level of educational attainment of the labour force is in general extremely low (Table 3). The numbers show that there is a serious imbalance in terms of education policy, science policy and technology policy. The considerable efforts done in terms of enhancing the human resources base of the country are excessively concentrated in the upper end of the educational spectrum, leaving the middle and lower end in a rather fragile situation. The situation is particularly serious as it concerns secondary education, which is the weakest link of the chain, and eventually one of the most important in terms of systemic efficiency of the innovation process.

Table 3. Educational attainment of the labour force (1999): distribution of the labour force 25 to 64 years of age, by highest level of education attained.

	Pre-primary and primary education	Lower secondary education	Upper secondary education	Tertiary education and advanced research programme	All levels of education
Portugal	**64**	**13**	**12**	**11**	**100**
Spain	32	25	17	27	100
France	14	18	43	24	100
United States	3	7	51	39	100
OECD mean	**13**	**18**	**42**	**24**	**100**

Source: OECD (2001) Education at a Glance.

The educational level of the workforce and the programme priorities merge and compromise. In general, the technical and managerial capacities of the firms, as a whole, are not enough to go beyond the imitation and acquisition strategies followed by the majority of the firms. Funds offered by the programmes for more aggressive innovative activities (R&D activities) are in excess supply (Gabinete do Gestor do PEDIP, 1999). Technological centres and other infrastructures created by the programmes face problems of demand, do not perform the tasks they were supposed to perform, and are confronted with serious financial situations (Godinho, 1997).

Evidence of the strategy followed by the majority of firms is given by the results of several large innovation surveys of Portuguese industry. A survey made in 1987-1988 (GEP/MIE, 1992) involving 1026 firms of the industrial sector indicated that the most important factor that has favoured/launched the innovation process in the firm was the acquisition of equipment. R&D activities were one of the least important factors that favoured/launched innovation processes in the firm. As was said above, technology and industrial policy mechanisms implemented after accession just enhanced and favoured this perspective.

A new survey conducted ten years later in 1997-1998 (Barata, 1999), which tried to follow the same format as the previous survey in order to enable comparability of results, showed again that the most important factor that favoured/launched the innovation process in the firm was the acquisition of equipment. R&D activities were on the middle of the list of factors, in terms of its importance as a factor that favoured/launched innovation in the firm. Results from the second Community Innovation Survey also show that only 7% of Portuguese firms in the manufacturing sector are novel innovators (novel innovators are defined as firms that commercialised products that are new not only to the firm but also new to the market) compared with a mean of approximately 21% for the European Economic Area (source: Eurostat).

These results support the argument that the strategic behaviour of the majority of the firms in the manufacturing sector did not change significantly since accession to the EU.

5. The perceived impacts of science and technology policy programmes on the economic structure

What were the impacts on the economic structure of the country? According to the described situation we can suggest several hypothetic predictions:

- Looking at the overall investment programme, no significant structural changes in the industrial sector are expected. Investment directed towards the industrial sector was tailored to the capabilities of the sector, it was conceived so that the sector could take advantage of the immediate financial opportunities and it was not designed to induce structural change. There were segments of the programmes (PEDIP and PEDIP II) that explicitly addressed sectoral intervention (electronic sector, equipment goods sector, and to a lesser degree textile sector) aimed at structural change. However, the resources devoted to those measures were relatively modest, taking into consideration the backwardness of the target sectors.
- Although no structural change is to be expected, catching-up within sectors is expected, in terms of productivity growth and quality, as a direct consequence of investment in physical capital. The major impacts are to be expected in those sectors that rely heavily on production processes and are more dependent on innovation made in other sectors, i.e. in supplier dominated sectors (Pavitt, 1984).
- In spite of the significant investment and priority given to the research sector, namely the public research sector, no major structural change is expected, namely in terms of the relative increase or readjustment of the high tech sectors. The reason lies on the fact that no special attention was given to industrial R&D or innovation, and the emphasis on science policy would lead to expect that diffusion of R&D results to the economy would not occur significantly.
- We can expect impacts in the medium-low and medium-high sectors in terms of increased relative proportion of value added and/exports. Increases in productivity may not be exceptional but the most determined and consistent innovation activities will probably have occurred in these sectors. The decade long cumulative investment in the mature scientific and technological areas related to these sectors (in education, research and industry), the boom these investments have received with the programmes and the expansion of the high education sector are one set of explanatory factors. In addition, their dependence on development activities and not so much in science-based activities interacts easily with the prevailing strategic framework and greatly facilitates the application of knowledge in commercial activities.

Table 4. Selected indicators of the Portuguese manufacturing sector.

	Employment (2)		Productivity (3)		Revealed Comparative Adavnatage (4)	
Technological Intensity (1)	1985	1994	1985	1994	1978	1996
Low	0.59	0.59	0.3	0.45	3.39	2.29
Medium-low	0.26	0.26	0.26	0.27	0.61	0.72
Medium-high	0.12	0.13	0.47	0.45	0.3	0.72
High	0.03	0.03	0.44	0.54	0.86	0.39
Total	1	1	0.3	0.39		

Source: Godinho, M.M. and Mamede, R.P. (2001). According to these authors, calculations were based on OECD STAN database and OECD (2000) Science, Technology and Industry Outlook. (1) Sectors are grouped together according to the OECD (1998) definition. (2) Employment distribution in manufacturing industry (%). (3) Productivity level in manufacturing industry relative to a reference group with productivity equalling 1. The reference group corresponds to the weighed average of German, French, Italy and United Kingdom manufacturing industries. Productivity is defined as the ratio between Value Added in current dollars and persons engaged. (4) The index Revealed Comparative Advantage is defined as the ratio between: a) exports of a group relative to total exports of the country; and b) exports of the group for the reference region relative to the total exports of that region. The reference group is less than the 15 countries of the European Union.

There were also productivity gains in the high tech technology sectors, probably related to the high value added of activities on the field of ICT, fine chemicals and advanced electronics sector, which partly coincide with the priority disciplinary areas of the CIENCIA and PRAXIS programmes. The high technology sectors are also heavily dependent on science-based activities performed in the research sector (Faulkner, 1994), which, as demonstrated above were highly supported. Note must be made that many companies in this area are foreign multinationals, and so a not despicable amount of R&D and associated productivity gains are not completely indigenous and/or endogenous. This process of catching-up was not matched by improvements in export performance, showing competitive deficiencies in the high tech sectors (products).

Table 5. Selected R&D indicators.

	GERD/GDP (%)		Researchers and engineers (FTE) per thousand labour force		BERD/GERD (%)	
	1984	1999	1984	1999	1984	1999
Portugal	0.35	0.77	1.0	3.1	29.6	22.7
EU or EEC average	1.62 (2)	1.81 (3)	3.39 (1)	5.5	50.5 (2)	64.7
OECD average	1.89 (2)	2.18 (3)	4.82 (1)	6.4	52.4 (2)	69.3

Source: OECD (1989), OECD STAN Database 1978-1997 and OCT (2001b). (1) Reference year 1983. (2) Reference year 1985. (3) Reference year 1998.

Productivity gains are not so obvious in the medium technology sectors, but on the other hand, export performance of these sectors shows an upward strength. This apparent contradiction may be explained by the fact that international competition in this segment is fierce and the productivity level may reflect a low price strategy. The increased international exposure of the medium technology sectors is congruent with the expectation that the more robust innovation activities were to be found here.

The picture of the S&T system portrayed by aggregate indicators (Table 5) is quite dynamic in terms of R&D expenditure and research personnel growth rates but it persists a statistical inertia in terms of the structural indicator related to business R&D, supporting again the idea of systemic deficiencies.

6. Conclusions

Technology and industrial policy and their associated mechanisms implemented in Portugal since accession to EU addressed and favoured the upgraded permanence of an existing industrial structure, which is characterised by the prominence of low or medium-low technology sectors. Impacts on economic development were considerable, but a model of development based on low value added activities or sectors seems to have reached a peak.

Different policy emphasis and mechanisms are necessary to address and favour activities or sectors with higher technology content. The prevailing linear perspective of S&T infrastructure building must give way to a systemic perspective of the process. Special attention should be given to enhance denser relationships and connectivity between the nodes of the system. Priority must be given to education and training, innovation and horizontal policies (Teubal, 1997) and to greater coordination with science and technology policies. There must be an effort to foster a model of development based on activities and sectors with higher technology, knowledge contents and value added.

7. References

Abramovitz, M.A. (1986) Catching up, forging ahead and falling behind, *Journal of Economic History*, **46**, 2, 385-406.

Bateira, J. and Ferreira, L.V. (2001) Questioning cohesion policy in Portugal. A complex systems approach. In CISEP, *IV Conferência sobre a Economia Portuguesa, Livro de Actas*, Lisboa: CISEP.

Barata, J.M. (1999) Inovação na indústria transformadora Portuguesa.Alguns resultados de inquérito recente. In Godinho, M.M. and Caraça, J.M.G. (eds), *O Futuro Tecnológico. Perspectivas para a Inovação em Portugal*, Oeiras: Celta Editora, pp.249-259.

Caraça, J.M.G. (1999) A Prática de Políticas de Ciência e de Tecnologia em Portugal. In Godinho, M.M. and Caraça, J.M.G. (eds), *O Futuro Tecnológico. Perspectivas para a Inovação em Portugal*, Oeiras: Celta Editora, pp.7-18.

Caraça, J.M.G. et al (1991) *Evaluation of the effects of the EC Framework Programme for Research and Technological Development on Economic and Social Cohesion in the Community*, Luxembourg: Commission of the European Communities.

Caraça, J.M.G. et al (1993) Study of the impact of Community RTD Programmes on the Portuguese S&T Potential, Lisboa: JNICT.

Cohen, W.M. and Levinthal, D.A. (1990) Absorptive capacity-a new perspective on learning and innovation, *Administrative Science Quarterly*, **35**, 1, 128-152.

Faulkner, W. and Senker, J. (1994) Making sense of diversity: public-private sector research linkage in three technologies, *Research Policy*, **23**, 6, 673-695.

Gabinete do Gestor do PEDIP (1993) *PEDIP. Relatório de Execução. 1988-1992. Vol. I*, Lisboa: Ministério da Indústria e Energia.

Gabinete do Gestor do PEDIP (1999) *PEDIP. Relatório de Execução PEDIP II 1998 Vol. 1*, Lisboa: Gabinete do Gestor do PEDIP.

Gabinete do Gestor do PRAXIS XXI (1996) *Programa: Bases do Conhecimento e da Inovação. Subprograma: Ciência e Tecnologia (PRAXIS XXI)*, Lisboa: Gabinete do Gestor do PRAXIS XXI.

GEP/MIE (1992) *Inovação Indústria Portuguesa. Observatório MIE*, Lisboa: Gabinete de Estudos e Planeamento do Ministério da Indústria.

Godinho, M.M., Selada, C. and Vedovello, C. (1997) Portuguese technological infrastructure : a system in rapid growth but in need of coherence, *International Conference on Technology Policy and Less Developed Research and Developemnt Systems in Europe*, Seville : INTECH.

Godinho, M.M. and Mamede, R.P. (2001) Evolução da produtividade, mudança estrutural e convergência económica nos 'países da coesão' da UE. In CISEP, *IV Conferência sobre a Economia Portuguesa, Livro de Actas*, Lisboa: CISEP.

Laranja, M. and Fontes, M. (1998) Creative adaptation: the role of new technology based firms in Portugal, *Research Policy*, **26**, 9, 1023-1036.

Lundvall, B. -A. (1988) Innovation as an interactive process: from user-producer interaction to the national system of innovation. In Dosi et al. (eds.), *Technical Change and Economic Theory*. London: Pinter.

MCT (1999). *Ministério da Ciência e Tecnologia, 1995-1999*, Ministério da Ciência e Tecnologia.

OCT (1999) *Programmes of Advanced Training of Human Resources in S&T. 1990-1998*, Observatório das Ciências e das Tecnologias.

OCT (2001a) *Produção Científica Portuguesa 1981-2000: séries estatísticas*, Observatório das Ciências e das Tecnologias. (www.oct.mct.pt)

OCT (2001b) *Principais indicadores de Ciência e Tecnologia em Portugal 1982 –1999*, Observatório das Ciências e das Tecnologias. (www.oct.mct.pt)

OCT (2002) *Doutoramentos realizados em Portugal ou realizados no estrangeiro e reconhecidos em Portugal*, Observatório das Ciências e das Tecnologias.

OECD (1989) OECD *Science and Technology Indicators Report Nº3: R&D, production and diffusion of technology*, Paris: Organisation for Economic Cooperation and Development.

OECD (1998) *Science, technology and industry outlook*, Paris: Organisation for Economic Cooperation and Development.

Pavitt, K. (1984) Sectoral patterns of technical change: towards a taxonomy and a theory, *Research Policy*, **30**, 6, 343-373.

Posner, M.V. (1961) International trade and technical change, *Oxford Economic Papers*, **13**, 3, 324-341.

Romer, P. (1994) The origins of endogenous growth, *Journal of Economic Perspectives*, **8**, 1, 3-22.

SECT (1990) *Programa Ciência*, Lisboa: Secretaria de Estado da Ciência e Tecnologia.

Solow, R.M. (1956) A contribution to the theory of economic growth, *Quarterly Journal of Economics*, **70**, 65-94.

Teubal, M., Foray, D., Justman, M. and Zuscovitch, E. (1996) *Technological infrastructure policy: an international perspective*, Dordrecht: Kluwer Academic Publishers.

Teubal, M. (1997) A Catalytic and Evolutionary Approach to Horizontal Technology Policies (HTPs), *Research Policy*, **25**, 8, 1161-1188.