10

The Matrix INT (Instruments and Needs of Technology) and the Evaluation of Innovation Policies

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Introduction

Innovation – both technological and organizational – is a fundamental ingredient of economic growth, and it has a crucial role in enhancing the positive potentials of the process of international integration. However, the perspective of the 'knowledge society' raises risks of exclusion, which may reduce the benefits of international integration and lead to further divergence and segmentation between economically strong regions and countries and less developed countries and regions. This chapter focuses on the case of small and medium size firms (SME) and on the medium and low-technology industrial sectors representing the crucial specialization in the industrialization process of less developed countries. Innovation affects the capabilities of SME to survive and to grow in the actual process of liberalization and openness to the international markets. In particular, innovation in SME has to be broadly defined as extending beyond research and development activities and also beyond the adoption of new technologies, in order to include more incremental developments, such as the adaptation of product and services to meet the changing needs of customers and markets and the adoption of new organizational methods both internally and in the relations with other firms in a sectoral or regional framework.

The methodology described in this chapter aims to evaluate the gap between the characteristics of the demand and the supply of technology transfer (TT) services to SME in a wide international framework, comprising both developed countries and less developed countries. It considers the factors determining innovation according to three

complementary perspectives: types of industry/technology, types of firm and types of region. It emphasizes that the problems and opportunities of innovation with specific reference to SME are different in various individual countries and that that determines a different structure of the demand of innovation policies. It also classifies a wide set of instruments in innovation policy according to three policy-making models: government, market and multilevel governance. Finally, it illustrates a new model defined as Matrix INT (Instruments and Needs of Technologies), which allows the measuring in a rigorous and quantitative way of the complementarities and the trade-offs between various policy instruments in innovation policies. This model reveals the joint effects of the policy instruments on specific factors and needs of the innovation process and the relevance of these specific needs in a typology of industry/technology, firm and region.

Problems and needs of firms in the innovation process

The design of the innovation policy and the identification and creation of specific policy instruments requires that each specific policy case study to be considered (i.e. individual firm, sector, cluster, national or regional economy) is analyzed according to three dimensions (see Figure 10.1):

- the typology of industries/technologies
- the typology of firms
- the typology of regions

as that allows some of the major problems and needs in the field of innovation policy to be identified.

First of all, the evolution of the technological bases in the various fields of production affects the need of modern policy instruments in innovation policies. That underlines the importance of analyzing the process of technology convergence and the increasing interdisciplinary integration of modern technologies and also the parallel process of increasing specialization and diversification of the various industries.

Building upon Pavitt's taxonomy of innovating firms, Archibugi and Orsenigo (2002) propose to group industries in five large categories (Pavitt 1984; Marsili 2001). Individual firms are included in each category according to the sources of innovations (Pavitt 1984; Winter 1984; van Hippel 1988; OECD 1992; Archibugi *et al.* 1999; Breschi, Malerba and Orsenigo 2000) and the technological trajectory they

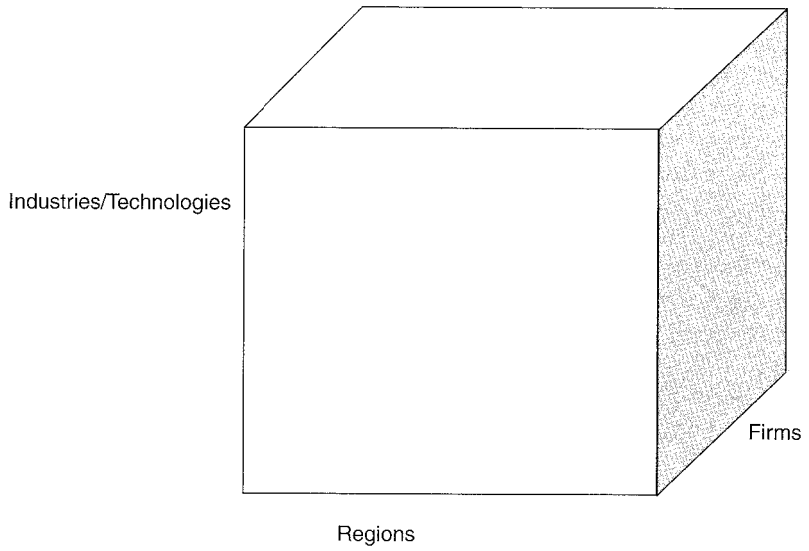


Figure 10.1 The combination of three dimensions in the design of innovation policies

follow rather than according to the characteristics of the prevailing product, as in the usual statistical classifications.

The *science-based* regime characterizes innovative activities, where the universal nature of scientific knowledge technologies generates a continuous stream of new products. They are characterized by high technological entry barriers, which originate in the high specificity of knowledge applications across production processes, and in high cumulativeness of innovation. Innovative activities are principally devoted to product innovation and benefit from the direct contribution of scientific advances in academic research.

The *fundamental-processes* regime characterizes activities where technological entry barriers are high and especially related to scale advantages in innovation and strong persistence of innovation. Innovation is mainly process innovation and, although affiliated firms and users represent the main external source of knowledge, it benefits from the quite important and direct contribution of scientific advances in academic research.

The *complex (knowledge) system* regime presents a knowledge base that combines mechanical, electrical/electronic and transportation technologies. The distinctive feature of this regime is the high degree

of differentiation of technological competencies developed by firms, especially in upstream production technologies, and of external sources of knowledge, including an important, although indirect, contribution of academic research.

The *product-engineering* regime includes the bulk of capital goods firms. This regime is distinguished by the high diversity of technological trajectories explored by firms. Innovation is in products and benefits from external contributions of knowledge, mainly from users.

The *traditional industries* regime includes a variety of production activities, which mainly benefits from upstream sources of capital-embodied knowledge, as the knowledge base is characterized by the acquisition of technological expertise from specialized suppliers. However; these activities are also characterized by strong innovative capabilities in product design and vertical and horizontal differentiation, often have a direct contact and knowledge of large national and international markets and are quick to introduce product incremental innovations and customization.

Table 10.1 schematically reports the most important needs of SME in terms of technology transfer, when the process of knowledge creation and of innovation adoption is analysed according to the typology of industries/technologies. These needs differ between the types of industries/technologies, and the list within Table 10.1 demonstrates factors which determine these differences (Archibugi *et al.* 1999; Archibugi and Orsenigo 2002).

Secondly, the process of technological innovation is related to the development of a learning process and to the accumulation of knowledge within the individual firms. The issue of the organizational structures and dynamics within the firms then needs to be addressed, in order to design policies that aim to enhance the internal production of know-how, the competencies of the human resources and the creative and entrepreneurship capabilities. According to Orsenigo and Decastri (2002), SME may be classified in four major types:

- *'Schumpeterian' firms*, i.e. companies which are born on the basis of an innovation and try subsequently to develop it.
- *'Marshallian' firms*, i.e. SME that are active in a specific geographical area (clusters, districts, productive and innovation systems, etc.). They are typically extremely specialized in some stage of the value chain and/or in a product niche. They entertain close – often socially shaped – linkages with the other firms in the area and they learn largely via informal processes, acquisition of capital goods, exposition and

Table 10.1 Typologies of industries and factors influencing their needs on learning

Typology of industries/technologies
1. Science based
2. Fundamental processes
3. Complex knowledge system
4. Product-engineering
5. Traditional industries

Factors influencing needs by typology of industries/technologies
1. Promote codified knowledge, through support to basic research, higher education and university–industry cooperation and also international transfers and cooperation.
2. Promote tacit knowledge and enhance internal skills and competencies through specialized professional training and lifelong learning and tight client–supplier collaborations.
3. Promote combinatory/complex knowledge through interdisciplinary research, exploration of new technological potentials and new combinations of different technologies.
4. Promote prescriptive knowledge and applied research through 'normative' or 'demand pull' approaches in industrial application, exploitation of existing technological advances and the development of 'transfer sciences'.
5. Promote innovation networks and access to complementary technologies and capabilities through cooperation with other firms of different sizes, sectors and countries and partnership between private and public institutions.
6. Promote the imitation of innovation in other countries and firms.
7. Promote the appropriability of technological discoveries.
8. Promote the protection of 'infant industries'.
9. Promote international openness and competition.

solution of immediate, specific problems, and interactions with other companies. Their technological strength derives essentially from the processes of knowledge sharing and by the dense knowledge flows that take place in the geographical area where they are located. In many cases, such knowledge flows are largely informal.

- *'Smithian' firms*, i.e. firms based on processes of division of labour and specialized in the supply of intermediate products and components to other (often larger) companies, often on the basis of organized sub-contracting relations and hierarchies. Their participation in the network of sub-contracting relations is a fundamental source of technical knowledge and skills.
- *'Marginal' firms*, characterized by low technological skills and little effort explicitly devoted to learning.

The main problems that these types of firms face in their innovation and learning activities and therefore the scope for potential policy action may be indicated as in Table 10.2. Again, criteria are given to distinguish the needs of firms according to their innovation and learning capabilities and strategies (Guilford 1959; Galbraith 1982; Geroski *et al.* 1997; Nonaka and Konno 1998; Perrin 2000; Orsenigo and Decastri 2002).

Thirdly, the innovative potential of firms depends not only on internal capabilities, but also on their relations with other firms and their embeddedness in a local environment. Thus, innovation and

Table 10.2 Typology of firms and factors influencing their needs on learning.

Typology of firms
1. Schumpeterian firm
2. Marshallian firm
3. Smithian firm
4. Marginal firm

Needs by typology of firms
1. Promote accessibility to a variety of technological sources and to foreign markets, through interaction with external actors, cooperation schemes, intermediaries, infrastructures, logistics, information systems.
2. Promote receptivity or openness, through improved human capital, well-designed learning processes, the development of tacit knowledge and the development of proactive rather than reactive strategies toward technological change.
3. Promote common identity, the sharing of common values, creation of teams, alignment with company's strategic objectives and consensus on a joint clear strategy.
4. Promote internal creativity both by individuals and by interactive groups of people, through greater autonomy, empowerment, internal mobility and intensive interaction between different capabilities and through the development of a strong internal technological base and the persistence of innovative activities.
5. Promote internal entrepreneurship capabilities, through the development of internal organizational capital, launch of new projects, adoption of new management methods, new production processes, re-engineering projects, spin-offs of innovative start-ups and access to innovative finance.
6. Promote local embeddedness in the external environment or 'relational capital', through stronger relationships with suppliers, and improved relations with other firms and the suppliers of modern equipment.
7. Promote the access to skilled labour and attract or retain qualified workers.
8. Promote market orientation and shareholder value, through customer satisfaction, strong relations with clients and the explicit management of the intellectual assets, internal core competencies, brands and patents.

development policies should have different characteristics according to the type of regions considered.

Regions can be classified according to different perspectives (Cappellin 2002b), such as their development and technology level (i.e. *developed regions, intermediate regions and economic lagging regions*), the level of urbanization and the structure of their urban system (i.e. *metropolitan regions, intermediate regions and rural regions*), the diversification of their sectoral composition (i.e. *high-tech clusters, diversified industrial regions, specialized industrial districts, rural areas*), the dynamism of their industrial sectors and the bounds to a past structure (i.e. *dynamic industrial regions, old industrial and re-conversion regions, transition economies*), or the geographical position (i.e. *metropolitan regions, border regions, internal small rural areas, large peripheral areas*).

According to the approach of territorial networks (Cappellin 1998 and 2003b), it is possible to identify a limited set of factors (see Table 10.3) which have a key role in the process of innovation and development within various regions. It should be emphasized that these factors assume a different importance and priority in regional policies according to the specific characteristics of each region (Porter 1998; Steiner 1998; Maillat and Kebir 1999; Cappellin 1998 and 2003a).

The various needs identified in relation to the three dimensions indicated above can be quantified according to a tentative scale from 1 (not important) to 5 (very important). Thus, each of the industries/technologies, firm types and region types indicated above has a different profile, which may be represented as in Figure 10.2 on page 176.

Policy-making approaches and instruments of innovation policies

The analysis of the role and characteristics of the individual intermediaries in technology transfer policies should be defined in a wider framework of various instruments of innovation policy. In particular, the design and implementation of innovation policy must tackle the problem of the architecture of the institutional framework and solve those policy issues which occur in the relationships between the centre and the periphery, the public and the private sector, the firms, the workers and the various external stakeholders, the world of production and that of financial intermediaries, the public technology transfer centres and the private consulting companies, and last but not least, the integration of an economic and technological perspective with a social and institutional perspective. In this regard, the debate in Europe

Table 10.3 Typology of regions and factors influencing their needs on learning

Typology of regions
1. High-tech clusters
2. Metropolitan regions in developed countries
3. Diversified and dynamic industrial regions
4. Specialized industrial clusters
5. Intermediate regions
6. Old industrial and re-conversion regions
7. Transition economies
8. Economic lagging regions
9. Metropolitan areas in economic lagging regions/countries
10. Border regions
11. Internal small rural areas
12. Large peripheral areas
Factors influencing needs by typology of regions
1. Promote external openness, accessibility, exports and external investments.
2. Promote territorial quality, territorial planning and infrastructure.
3. Promote institutional thickness, decentralization, self-organization, social capital and multilevel governance.
4. Promote local identity and consensus on a common development strategy.
5. Promote SME birth rate and entrepreneurship capabilities.
6. Promote sectoral diversification and spin-offs of new firms.
7. Promote the access to credit and diversification of financial intermediaries.
8. Promote the vertical/horizontal integration, subcontracting networks and firms specialization.
9. Promote interactive learning processes, diversity, creativity and knowledge networks.
10. Promote skilled human capital, receptivity and labour mobility between firms.
11. Promote productivity growth, adoption of innovation and R&D investment.
12. Promote employment growth and a lower unemployment rate.

on industrial and innovation policies allows us to identify various alternative approaches in public policy-making:

- the centralist model of sectoral planning ('government')
- the free market model
- the public–private partnership model of 'multi-level governance'.

Both the recent evolution of technologies and the process of increasing international integration of national economies seem to underline

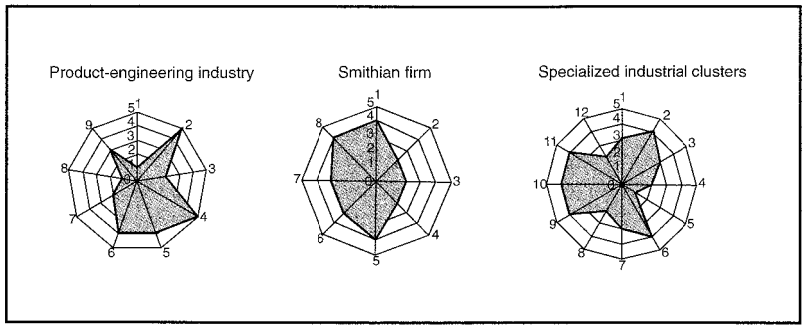


Figure 10.2 The profile of individual industries/technologies, firms and regions

the usefulness of the model of 'multilevel governance'. In fact, most programmes designed and implemented at the European level have focused on stimulating the process of institutional building and aimed at the creation of 'national or regional systems of innovation' by promoting the creation of inter-firm networks in innovation. Especially in the economic lagging regions, various EU programmes have been designed to promote an evolution from a traditional hierarchical model ('government' model) to models where public–private partnerships have assumed a crucial role.

The 'multilevel governance' model allows a flexible combination of bottom-up initiatives and top-down coordination and financing. Thus, it is possible to distinguish within it two different types, which can be indicated as 'governance model 1: public–private strategic partnership' and 'governance model 2: local networking and cooperation'. In the first type, a crucial role is assigned to national public authorities in promoting and steering the innovation networks made by different firms and actors. On the other hand, the latter type is characterized by a stronger autonomy of the different economic and social stakeholders. It may represent the case of a 'complex adaptive system' characterized by a high capability of self-organization and by national authorities providing incentives for local and international networking (Holland 2002).

In Figure 10.3, these four models of policy-making are described according to their respective position within two major dimensions: 'hierarchy vs. autonomy' and 'isolation vs. integration'. The first dimension measures the power of the central authorities vs. the freedom of the various firms and individuals. The second dimension measures the level of explicit economic interdependence, the sharing

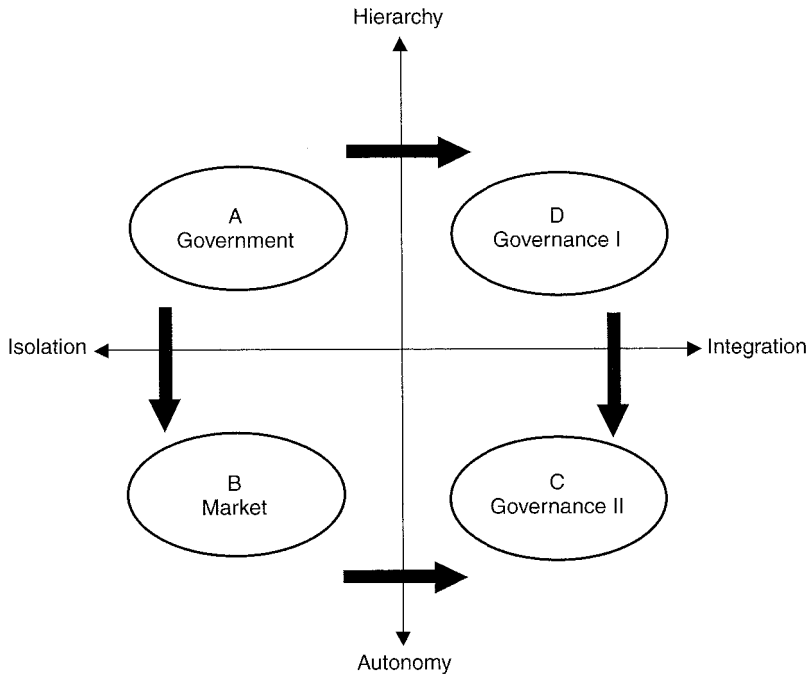


Figure 10.3 Four decision-making models

of common values and the sense of belonging vs. the absolute isolation of each individual confronted with the law designed and enforced by the state or confronted with the overall market price and conditions as in a perfect competitive market. When these two dimensions are considered, recent evolution in technology and industrial organization seems to indicate both the need to increase the autonomy of the various firms and actors and the need for a greater integration of the individual actors, due to their increasing interdependence, the increasing complexity of the factors determining the innovation processes and the need to integrate complementary technologies.

Thus, in Table 10.4, the different instruments adopted in innovation policies are grouped according to the above-indicated four policy-making approaches for facilitating an international comparison. The first class of instruments ('government' model) considers the case when the national government intervenes directly in order to promote 'national champions' or to protect 'strategic industries'. A crucial role

Table 10.4 Policy-making approaches and instruments of innovation policies

(A) 'Government' model strategic partnership

1. Public-owned industries
2. Subsidies to strategic private industries
3. National agencies of sectoral industrial plans
4. Public funding of R&D
5. Regional offices of national agencies or departments
6. Public demand and fiscal incentives
7. Large public R&D institutions
8. Science parks
9. TT service centres (fully publicly financed)

(B) 'Market' model

1. Privatization of public industries
2. Market deregulation
3. Liberalization and MNE attraction
4. IPR regulation and national patent offices
5. Private professional services
6. Private technology brokers
7. Private venture capital
8. Private research companies
9. Technological education centres
10. Public information and benchmarking centres

(C) 'Governance' model 1: public–private

1. Strategic planning contracts with large firms
2. Territorial pacts with local actors
3. Regional technological parks and centres
4. TT centres and programmes (partially nationally publicly financed)
5. University–industry liaison offices
6. Professional continuous education centres
7. National programmes for R&D and innovation networks
8. National networks of TT service centres
9. National financial trusts for financing innovative firms
10. International networks of TT centres

(D) 'Governance' model 2: local networking and cooperation

1. Cooperative research projects between SME (CRAFT)
2. Autonomous (non-governmental) research institutions or foundations
3. Business Innovation Centres (BIC) and Innovation Relay Centres (IRC)
4. TT centres of industry associations and chambers of commerce
5. Local incubators of innovative firms
6. Regional/local development agencies
7. Local stakeholders coordination tables
8. Regional Innovation System (RIS)
9. Territorial knowledge management (TKM)
10. Regional innovative start-up funds

in this case is played by national ministries and agencies created by the national government, although these latter may be regionally decentralized. Thus, also the cases of large science parks and research institutions and of technology transfer (TT) centres totally publicly financed are considered in this class. These types of innovation policies instruments seem to be the most diffused at the international level and they can still play an important role in many less developed and also developed regions and countries. A second and opposite class of instruments ('market' model) considers the case when the crucial role to promote innovation is left to market forces. Certainly, general measures in industrial policy, such as privatization, liberalization and market competition regulation, as well as specific regulations of intellectual property rights (IPR), may have an indirect but powerful impact on innovation performance of regional and national economies. According to this approach, private TT intermediaries, such as professional services, technology brokers, venture capitalists (VC) and specialized new research start-ups play a crucial role. However, even within this model public authorities are still important, especially in facilitating the circulation of information and in enhancing a higher level of formal education of the labour force.

The third class ('governance' model 2) encompasses those policy instruments which are based on the concept of public–private partnership, when the leader role is played by public authorities. This is the case of national planning contracts with large private or public firms or of territorial pacts for employment bringing together many local actors. Specific instruments, such as university–industry liaison offices, TT co-financed by private industries, technology parks focusing on specific sectors and clusters, will lead to a tight integration between public and private institutions. Moreover, the concept of cooperation is the key element in programmes aiming to create networks at the national and international level between the various actors and intermediaries active in a regional or national innovation system.

Finally, the fourth class ('governance' model 1) encompasses those policy instruments which are often supported by public resources but have been created by a bottom-up initiative of private actors, groups and citizens. A crucial role in this case is played by the cooperation between firms and especially between SME, by the incubators of new firms and by independent foundations or research institutions. Local stakeholders are grouped together around an industry association or chamber of commerce. 'Business Innovation Centres' and 'Regional

Development Agencies' can be very helpful instruments in promoting local cooperation. Within this approach some innovative instruments, such as 'Regional Innovation Systems (RIS)', which have been widely experienced in European countries, also have to be classified. Another, similar methodology is 'Territorial Knowledge Management (TKM)', which aims to facilitate the relationship between local firms within territorial networks (Cappellin 2003a). SME barriers to financial markets will be overcome with the help of start-up funds (seed capital and VC) by regional organizations.

The various instruments in innovation policies have different capabilities for responding to the problems and needs indicated in Tables 10.1, 10.2 and 10.3. Thus, policy-makers have to identify those policy instruments which may be more effective, and improve the internal organization of public institutions by comparing the policy instruments locally available with international benchmarks. Table 10.5 indicates the relative importance of four specific policy instruments according to the various policy needs which have been earlier considered in an industry/technology, firm type and region type perspective. Thus, a score has been assigned to each combination of instrument and innovation need. This scoring system highlights the different qualities of instruments required within the four policy-making models to satisfy the needs of SME.

Table 10.5 Problems and factors influencing needs of innovation policies

Needs by industries/technologies	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
A Large public R&D institutions	3	0	3	1	2	2	2	1	0
B Private venture capital	0	0	0	2	2	1	2	0	2
C TT centres and programmes	0	0	0	1	0	0	1	1	0
D RIS – regional innovation system	1	2	1	2	2	2	2	2	1

Needs by firm type	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
A Large public R&D institutions	3	1	1	2	1	0	2	0
B Private venture capital	1	1	0	3	1	0	1	2
C TT centres and programmes	1	1	2	0	0	1	1	0
D RIS – regional innovation system	3	2	3	2	1	3	2	2

Needs by region type	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
A Large public R&D institutions	2	1	1	2	0	1	1	0	3	1	3	1
B Private venture capital	3	0	1	1	2	2	3	0	1	0	2	0
C TT centres and programmes	2	2	2	2	3	3	1	3	2	2	2	1
D RIS – regional innovation system	2	1	2	3	1	2	1	1	3	1	2	1

Note: The numbers of the columns correspond to the number of factors influencing needs in Tables 10.1, 10.2 and 10.3.

The model of Matrix INT

The following model is based on the idea that the choice of the most appropriate policy instruments in innovation policy should take into account the various needs which characterize the different firms, the respective sector and regional environment, and the different capability of the individual policy instruments in responding to these specific needs. The model, Matrix INT (Instruments and Needs of Technology) is characterized by a wide flexibility and is able to consider different types of regions, industries and firms to be combined in multiple solutions. The approach adopted in the Matrix INT model is illustrated in Figure 10.4.

The model starts with the identification of the various problems/needs in the process of innovation. These latter may be classified according to the three dimensions of industries/technologies, of firm organization and of regional characteristics, as indicated in Tables 10.1, 10.2 and 10.3. Then a set of 29 scores describe the problems/needs with respect to the industry/technology specialization, the prevailing firm characteristics and the characteristics of the region of localization. The value attributed to these scores increases with the intensity of the need within a given predefined range (for example 1–5). These scores are indicated in vector B of Equation (1).

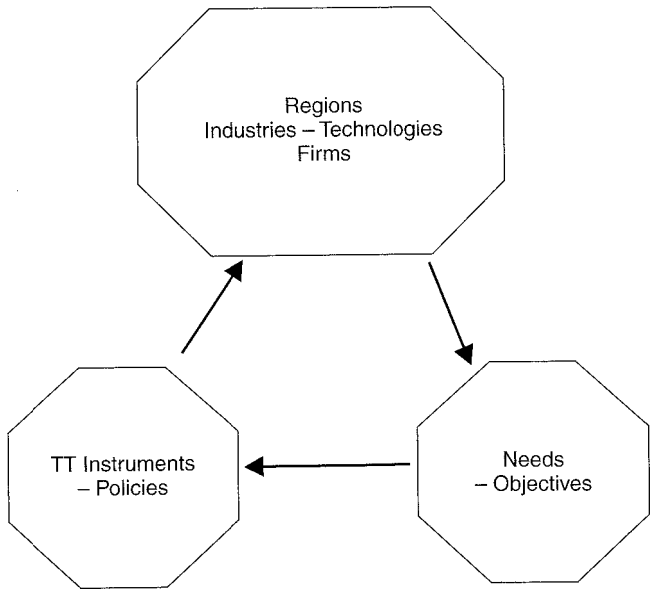
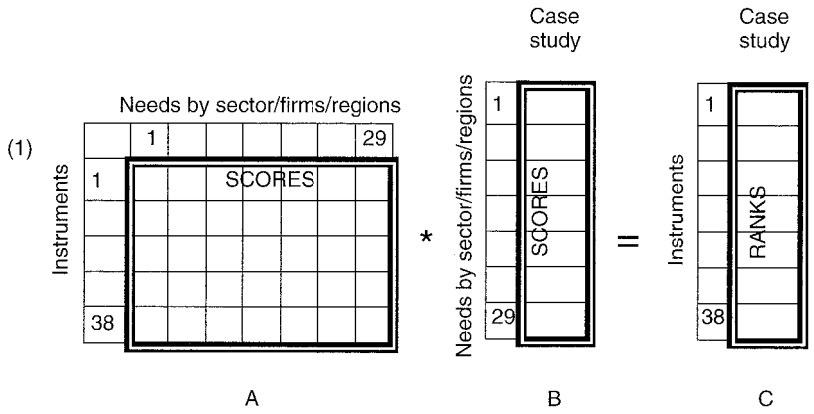


Figure 10.4 The approach of the Matrix INT

Equation (1) The approach of the Matrix INT



As explained above, the various policy instruments in innovation policies which have been listed in Table 10.4 have a different capability or effectiveness in tackling the needs of SME. This is described with a set of scores which have a greater value the more effective the instrument is considered to be on the specific need and have a nil value when no relationship can be identified between instrument and need. Also these scores are evaluated within a given predefined range (for example 0–3). These scores are indicated in the matrix A of Equation (1). The final result of the matrix multiplication gives a vector C, which indicates the ranking of various policy instruments according to their overall effectiveness with specific reference to the case study to be considered.

The approach adopted in the model of Matrix INT is also described in Figure 10.5. In fact, the identification of the industry/technology characteristics, the firm types and the local environment characteristics of a selected case studied (i.e. firm, cluster, sector, region) leads to the identification of specific needs in the innovation process. Then, based on those needs identified it is possible to rank the various policy instruments according to their respective effectiveness.

In order to simplify or guide the assignment of scores to various needs and policy instruments in innovation policy, it may be useful to follow a different procedure and to identify specific benchmarks based on international experience. Research (Cappellin 2002b) has identified various types of industries/technologies, firms and regions, which have been indicated in Tables 10.1, 10.2 and 10.3. Then, specific scores have been assigned to the various needs in each of these different types of

industries/technologies, firms and regions. Moreover, on the basis of the results of a previous large survey conducted by the INSME network on more than 600 TT intermediaries in various countries, it has been possible to assign a score to various innovation policy instruments according to their ability to tackle the specific need to be considered.

The scores assigned in this research represent the result of the consensus reached within a group of experts with different backgrounds and competencies. However, these scores have to be adapted according to the specific case studies to take into account the specific needs and the relative efficiency of the specific policy instruments to be considered. The model of Matrix INT (Instruments and Needs of Technology) allows us to estimate the relative effectiveness of the various policy instruments by computing a set of scores through the following matrix multiplication, as indicated in equations (2.1), (2.2), (2.3):

(3) **A** (Instruments*Needs) * **B** (Needs* Industries/Technologies–Firms–Regions)
=
C (Instruments*Industries/Technologies–Firms–Regions)

The procedure to compute the scores of the Matrix INT is illustrated with the following analytical expressions. Given the following indexes:

i: index of the need to be considered according to an industry/technology and to a firm and to a regional dimension (*i*: 1, ...8, 9,....17,18,....29),

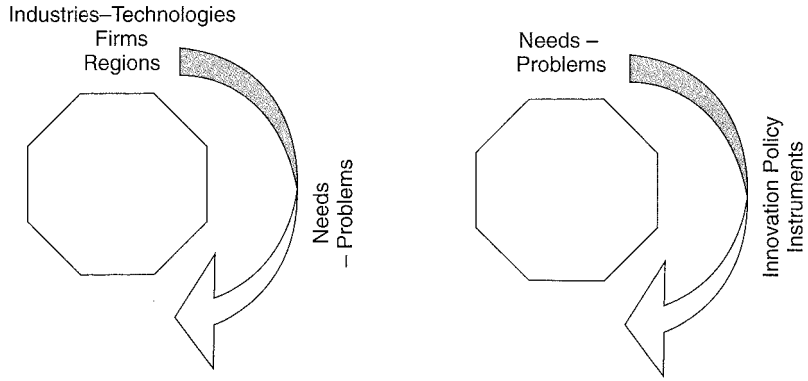
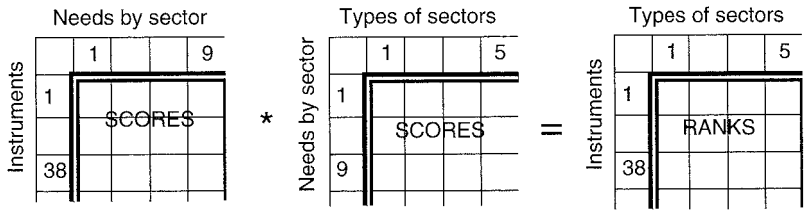
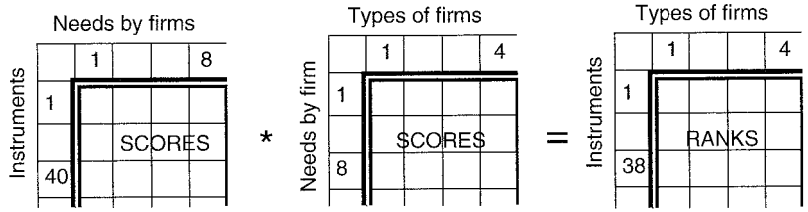


Figure 10.5 From case-study characteristics to innovation policy instruments

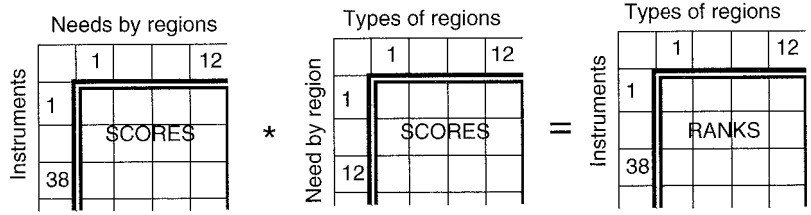
(2.1)



(2.2)



(2.3)



p: index of the policy instrument to be considered according to an industry/technology, a firm and a regional dimension (j: 1,...38),
t: index of various industry/technology types to be considered (t: 1,...5),
f: index of the various firm types to be considered (f: 1,...4),
r: index of the various region type to be considered (r: 1,...12),

we then define:

n_{it}, n_{if}, n_{ir}: scores of the need (i), respectively according to an industry/technology (t), firm (f) and regional (r) dimension,

x_{ip}: score of the policy instrument (p) in response to the need (i).

As indicated above, in the actual calibration of the model, the scores (n) have been defined with a value between 1 (low importance) and 5 (very important), with the constraint that the summation of the scores will be the same for each industry/technology, firm or region type to be considered. That obliges us to identify a well-defined priority between the various needs for a given industry/technology, firm or region type. On the other hand, it assures the possibility of comparing the numerical results obtained for the different types. Similarly, the scores (x) have been defined with a value between 0 and 3, where the value 0 indicates that a given policy instrument does not have any effect on a specific need, while the score assumes the value 3 when the instrument is particularly appropriate to respond to a specific need. The weights (W), to be assigned to a specific policy instrument (p) according to the three dimensions, industry/technologies, firms and regions (respectively indicated as: t, f and r), can be computed as the multiplication of the scores attributed to the individual needs for the specific scores expressing the effectiveness of specific policy instruments, according to the following expressions:

(4.1) $W_{tp} = \sum_i n_{it} x_{ip}$
(4.2) $W_{fp} = \sum_i n_{if} x_{ip}$
(4.3) $W_{rp} = \sum_i n_{ir} x_{ip}$

Then, an overall weight (W_p), referring to a specific policy instrument (p) to be considered, is computed through the following simple expression:

(5) $W_p = aW_{tp} + bW_{fp} + cW_{rp}$

where the parameters (a, b and c) are used to standardize the various scores or to assign a different importance to the industry/technology, firm and regional perspectives. The overall score for a specific instrument is then compared with the scores of other policy instruments. That leads to the identification of a set of 'appropriate' innovation policy instruments which takes into account three different perspectives: an industry/technology, firm and regional perspective. The results obtained depend on the opinions of an interdisciplinary group of experts, an international comparison of regional problems and regional policy instruments in various countries. However, these scores

have to be adapted in other case studies to take into account the characteristics of the specific needs and the relative efficiency of the various intermediaries to be considered.

Looking at the contributions of the model of Matrix INT to innovation policies and their evaluation, first of all, it allows taking into account three different perspectives and it represents an operational instrument for reaching a coherent synthesis between the indications derived from different although related approaches in the analysis of the factors of innovation. Second, the Matrix INT allows including a variety of political instruments. Third, the Matrix INT makes it possible to measure in a rigorous and quantitative way the complementarities and the trade-offs between the various policy instruments, when the policy-makers aim to respond to various and interdependent innovation needs. In fact, the same need may be satisfied through various instruments and the same instrument may be adapted to respond to various needs. Thus, the model indicates the interaction between various innovation needs and policy instruments. Fourth, the model of Matrix INT helps the policy-makers to make explicit the priorities (the parameters: n_{it}, n_{if}, n_{ir}) of various needs to be considered as well as the expectation on the effectiveness of various instruments (the parameters x_{ip}). A specific policy instrument can be demonstrated to be superior to other policy instruments only when these parameters assume a specific level. That obliges the policy-makers to analyze the combination of industry, firms and regional typology characterizing a specific policy case study and to choose the instruments according to a comparison of their respective overall impact on a rather wide set of needs.

Fifth, the model Matrix INT can be used to describe the evolution in the set of the most appropriate policy instruments when the specific economy considered evolves from a specific combination of industry/technology, firm type and regional type to a new combination, as indicated in Figure 10.6. According to the results obtained in the INSME study (Cappellin 2002b), the instruments which seem particularly important in the case of the less technologically advanced industries, such as the 'traditional industry', are:

- Territorial knowledge management (TKM)
- Regional technological parks and centres
- National programmes for R&D and innovation networks
- University–industry liaison offices
- Cooperative research projects between SME (CRAFT)
- Public information and benchmarking centres

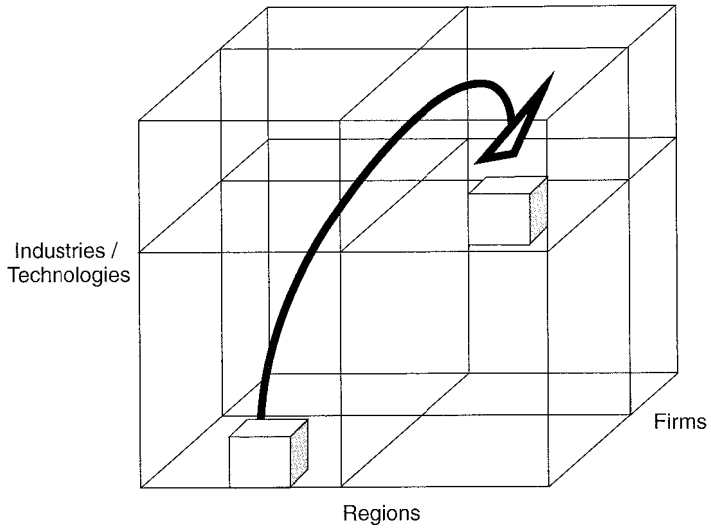


Figure 10.6 Shift to a new profile within the regions–technologies–firms space

- RIS (regional innovation system)
- Science Parks
- Strategic planning contracts with large firms
- Private technology brokers

The policy instruments which are mostly needed by the less technologically advanced firms, such as the 'marginal' firms, are:

- Territorial knowledge management (TKM)
- Local incubators of innovative firms
- Professional continuous education centres
- RIS (regional innovation system)
- Technological education centres
- Regional technological parks and centres
- University–industry liaison offices
- Public information and benchmarking centres
- TT centres of industry associations and chambers of commerce
- Science Parks

Finally, the less technologically advanced regions, such as the 'economic lagging regions', indicate a higher need for the following policy instruments than the more technologically advanced regions:

- TT centres and programmes (partially nationally publicly financed)
- Territorial pacts with local actors
- Regional offices of national agencies or departments
- Professional continuous education centres
- Regional/local development agencies
- Regional innovative start-up funds
- National networks of TT service centres
- Regional technological parks and centres
- TT centres of industry associations and chambers of commerce
- Science Parks

As indicated in equation (5), it is possible to compute an overall score when a specific case study has been defined according to the specific technology/sector, firm and region types, indicated in Tables 10.1, 10.2 and 10.3. As an example, the overall rank of the effectiveness of the various innovation policy instruments has been computed in two extreme cases (Table 10.6):

(a) Case study 1: Science-based industries + Schumpeterian firms + high-tech clusters
(b) Case study 2: Traditional industries + marginal firms + economic lagging regions

Case study 1 is more technologically advanced and underlines the demand for those innovation policy instruments which mainly contribute to the creation of 'codified knowledge', such as:

- Science Parks
- Autonomous non-governmental research institutions or foundations
- Large public R&D institutions
- IPR regulation and national patent offices
- Public funding of R&D
- Private research companies
- International networks of TT centres
- National programmes for R&D and innovation networks
- University–industry liaison offices
- Private technology brokers

In contrast, case study 2 is less technologically advanced and it indicates a higher demand for those policy instruments which mainly

Table 10.6 Matrix INT: comparison of two extreme cases

Policy-making model		*Instruments of innovation policy*	*Case 1: Science based ind. -Schumpeterian firms – High tech clusters*	*Case 2: Traditional industries–Marginal firms – Economic lagging regions*	*Difference of total scores*
A	8.	Science Parks	531.85	397.81	134.04
D	2.	Autonomous non-governmental research institutions	383.93	258.70	125.23
A	7.	Large public R&D institutions	398.13	282.82	115.30
B	4.	IPR regulation and national patent offices	278.09	191.90	86.19
A	4.	Public funding of R&D	354.59	276.99	77.60
B	8.	Private research companies	342.65	265.33	77.32
C	10.	International networks of TT centres	335.54	263.72	71.83
C	7.	National programmes for R&D and innovation networks	423.82	369.37	54.45
C	5.	University–industry liaison offices	501.19	451.00	50.19
B	6.	Private technology brokers	329.17	289.35	39.82
B	9.	Technological education centres	398.72	363.66	35.05
D	9.	Territorial knowledge management (TKM)	532.88	514.19	18.69
A	9.	TT service centres (fully public financed)	233.06	221.93	11.14
C	8.	National networks of TT service centres	270.36	259.37	10.99
B	7.	Private venture capital	287.06	278.64	8.43
D	5.	Local incubators of innovative firms	430.41	425.73	4.67
C	9.	National financial trusts for financing innovative firms	188.46	186.55	1.92
A	1.	Public-owned industries	221.50	226.48	–4.99
C	4.	TT centres and programmes (partially nationally publicly financed)	212.55	219.25	–6.70
C	3.	Regional technological parks and centres	466.60	473.54	–6.94
B	1.	Privatization of public industries	187.99	199.71	–11.72
A	2.	Subsidies to strategic private industries	121.70	140.53	–18.83
A	3.	National agencies of sectoral industrial plans	177.96	197.49	–19.53
B	3.	Liberalization and MNE attraction	331.03	352.41	–21.39
B	2.	Market deregulation	184.86	208.67	–23.81
D	8.	RIS (regional innovation system)	424.57	450.51	–25.94
A	5.	Regional offices of national agencies or departments	150.12	184.43	–34.31
D	7.	Local stakeholders coordination tables	168.81	207.85	–39.04

Table 10.6 Matrix INT: comparison of two extreme cases *continued*

Policy-making model	*Instruments of innovation policy*	*Case 1: Science based ind. -Schumpeterian firms – High tech clusters*	*Case 2: Traditional industries–Marginal firms – Economic lagging regions*	*Difference of total scores*
D	10. Regional innovative start-up funds	276.63	316.49	–39.86
B	5. Private professional services	210.16	251.15	–40.99
A	6. Public demand and fiscal incentives	108.50	151.40	–42.90
D	6. Regional/local development agencies	193.32	243.95	–50.64
C	2. Territorial pacts with local actors	232.10	284.85	–52.75
B	10. Public information and benchmarking centres	365.41	420.01	–54.60
D	3. Business Innovation Centres and Innovation Relay Centres	301.84	363.70	-61.86
C	6. Professional continuous education centres	315.50	387.92	–72.43
D	1. Cooperative research projects between SMEs (CRAFT)	327.19	408.41	–81.22
C	1. Strategic planning contracts with large firms	227.04	328.71	–101.67
D	4. TT centres of industry associations and chambers of commerce	274.71	385.46	–110.75
	Total	11700	11700	0

enhance the development of 'tacit knowledge' and of interactive learning processes between the various SME and local stakeholders, such as:

- TT centres of industry associations and chambers of commerce
- Strategic planning contracts with large firms
- Cooperative research projects between SME (CRAFT)
- Professional continuous education centres
- Business Innovation Centres (BIC) and Innovation Relay Centres (IRC)
- Public information and benchmarking centres
- Territorial pacts with local actors
- Regional/local development agencies
- Public demand and fiscal incentives
- Private professional services

In particular, when the instruments of the four specific policy models described in Table 10.5 are considered, Table 10.6 indicates that they have a different relevance in the two extreme policy case studies. Case study 1, characterized by most technologically advanced industries, firms and regions, emphasizes the role of large public R&D institutions and private venture capital. In contrast, case study 2, characterized by the less technologically advanced industries, firms and regions, emphasizes the role of TT centres, programmes and RIS.

That may be interpreted as indicating that an appropriate combination of the 'government' and 'market' approaches may be more appropriate for the more advanced case study 1, and that the 'governance 1' and 'governance 2' approaches seem to be more appropriate for the less advanced case study 2.

Conclusion

This chapter serves to present a model of a Matrix INT (Instruments and Needs of Technology) characterized by a high flexibility capable of considering different types of regions, industries and firms. It represents a new method of evaluation similar to the multi-criteria analysis usually adopted in the choice of investment projects or in environment evaluation. According to this approach, policy-making processes should be structured into the following phases:

a) the identification of different dimensions of industries, firms and regions to be considered in a specific case study,
b) the identification of prior needs related to specific obstacles to innovation according to these three perspectives,
c) the selection of a complex set of complementary instruments most effective with respect to the identified needs.

The model of Matrix INT indicates complementarities and trade-offs between different instruments in innovation policy, as these latter have a different priority in various industries, firms and regions. On the other hand, each problem may be tackled by different types of innovation instruments and intermediaries, which are characterized by various degrees of effectiveness. Thus, the two major characteristics of the model 'Matrix INT' are:

- the adoption of a 'demand led' rather than a 'supply push' approach. That has led to focusing the analysis on the characteristics and needs

of innovation by various regions, sectors and firms rather than on the survey of potentials and problems of existing TT intermediaries;
- the identification of an intermediate step in the relationship between the analysis of characteristics of specific countries and the design of innovation policy instruments. That has led to focusing on the relationships between the specific needs ('demand') of various industries/technologies, firms and regions and the relative effectiveness of the types of innovation policy instruments ('supply').

The choice of TT intermediaries and innovation policy instruments is often made on the basis of subjective preferences of policy-makers or based on actual interests of already existing TT intermediaries in the region or country considered. That seems a less efficient approach than that indicated by the Matrix INT, which allows a choice of the most appropriate policy instruments by considering three complementary dimensions (types of industry/technology, firm and region), a large set of needs related to these dimensions and finally a diversified set of complementary policy instruments. Moreover, the 'Matrix INT' indicates a methodological framework suitable in an international comparative perspective. It may be useful in empirical studies and operative projects to carry it out jointly within international research and policy networks, aiming to elaborate comparative analysis and to identify specific benchmarks. This methodological framework will help in evaluating the gap between the characteristics of demand and supply of TT services to SME in a wide international selection of countries. It may also be used for the definition and the implementation of pilot projects to be elaborated in the framework of international cooperation. For example the model of 'Matrix INT' could be adopted as:

(a) a methodology for collecting statistical information on innovation factors,
(b) a methodology for defining a coherent set of priorities in policy-making,
(c) a methodology for the ex ante evaluation of the most appropriate policy instruments in innovation policies,
(d) a methodology for comparative analysis of the success or failures of given innovation policy instruments in various countries, or
(e) a methodology for comparative analysis of innovation problems and needs in various countries.

It must be underlined that the model of 'Matrix INT' does not propose a recipe, but a methodology that has to be handled with care and adapted to specific circumstances and problems. It does not indicate a unique best solution for many heterogeneous cases, but rather helps policy-makers to disentangle the various dimensions, variables and parameters to be considered and estimated.

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