Fraunhofer Institut Systemtechnik und Innovationsforschung

The Science and Technology Base of the Provincia Autonoma di Trento: Capacities, Trends and Opportunities

TECHNICAL REPORT

Dr. Kerstin Cuhls
Dipl.-Psych. Arlette Jappe
PD Dr. Knut Koschatzky
Prof. Dr. Stefan Kuhlmann
Dr. Vivien Lo
Prof. Dr. Emmanuel Muller
Thomas Stahlecker, MA

Fraunhofer-Institut für Systemtechnik
und Innovationsforschung,
Breslauer Strasse 48, 76139 Karlsruhe
Tel.: +49-721/6809-181, -184
Fax: +49-721/6809-176

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1.1 Introduction: Key issues of the project

In January 2003, the Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI), Karlsruhe, was commissioned by the Provincia Autonoma di Trento to carry out a regional foresight and competence study titled: "The Science and Technology Base of the Provincia Autonoma di Trento: Capacities, Trends and Opportunities".[1] Its main objective was to support the Province in developing regional strategies for its research and innovation system. The term foresight implies a long-term and systematic view into future (technological) development sources. The foresight exercise was based on an in-depth assessment of the current state of the provincial innovation system including the identification of major actors and subsystems as well as the structural couplings within and between these subsystems. Key issues of the project centred on:

- The present scientific-technological position and specialisation of the Province compared to the Italian average in the light of patent and bibliometric statistics (chapter 2.1of this report).
- Knowledge exchange, co-ordination and synergies within and between the actor groups in the research and innovation system (chapter 2.2).
- Funding and long-term perspectives of research promotion in the Provincia Autonoma di Trento (chapter 2.3).
- Entrepreneurial culture, absorptive capacity and dynamics of the business sector in the Province (chapter 2.4).
- International "Good Practice" examples which could give impulse and stimulus for an adaption and restructuring of the provincial research and innovation system (chapter 3).
- Mid- and long-term scenarios regarding the regional technological development (chapter 4.1).
- Shaping factors and measures to integrate the actors in regional, non-regional and international production and innovation chains and improve the knowledge base and the absorptive technological capacity of the regional innovation system (chapter 4.2).

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[1] The project team of Fraunhofer ISI wishes to thank all those in the Provincia Autonoma di Trento who contributed to this study and especially the team of the University and Scientific Research Department without their friendly and co-operative assistance this study could not have realised in the way as it is now presented.

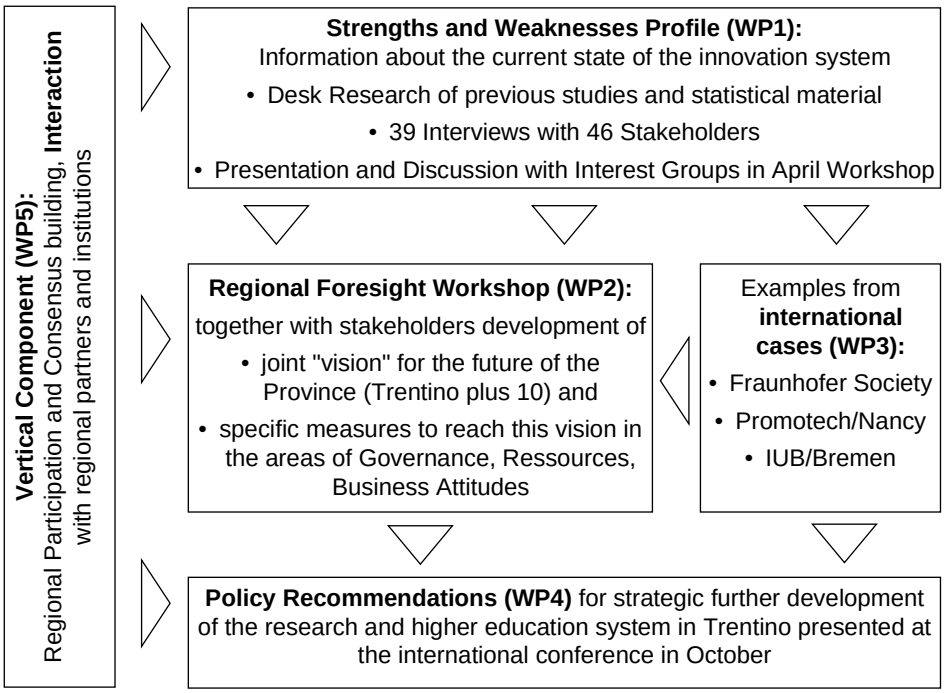
In order to clarify and develop these issues, the Fraunhofer ISI has worked with a range of different *methodological tools* which were chosen and adapted to suit the specific characteristics and requirements of the Provincia Autonoma di Trento. The set of tools consisted of:

- indicator-based assessment of regional technology/innovation potential (bibliometric and patent analysis),
- guided individual and group interviews,
- workshops,
- discussion tables with decision-makers and representatives of different actor groups,
- foresight module with workshop.

1.2 Project Concept and Methodology

The project was structured in five main components or working packages, four horizontal components and one vertical component (cf. Figure 1). As the early integration of the different interest and target groups is an important success factor in elaborating a sustainable regional innovation strategy, particular attention was given to including representatives from the research institutes, university, industry and business association and provincial policy makers into the discussion from the first steps of the process until the conclusion of the project. This integration was understood as the vertical component of the study, covering all work packages.

Figure 1: Project steps and working packages



The integrative aspect was realised, firstly, in the formation of the Working Group (steering committee) and the Task Force which supported, discussed and gave input to the Fraunhofer ISI project throughout the whole process. Secondly, the different steps and results of the project were discussed with these two committees as well as a larger number of actors from the different interest groups at two discussion tables (February, June 2003), two workshops (April, July 2003) and the final international conference "Building the future in an enlarged and more integrated Europe. The Trentino Foresight Exercise as a contribution to the European Research Area" (8th Provincial R&D Institutional Conference of the Autonomous Province of Trento, October 2003).

As working packages 1 and 2 consisted of a project-specific designed approach with the implementation of a number of different methodological instruments, they are presented in some detail in sections 1.2.1 and 1.2.2. With regard to policy recommendations, it is also necessary to shed some light on recent developments in regional innovation theory and their implications for regional science and innovation policy. This aspect will shortly be discussed in section 1.2.3.

1.2.1 Strengths and Weaknesses Analysis

The strengths and weaknesses profile of the research and innovation system of the Provincia Autonoma di Trento developed in the Fraunhofer ISI project was based on quantitative and qualitative data drawn from a broad range of available sources:

- Statistical data and indicators, particularly analysis of regional indicators of the European Innovation Scoreboard 2002 (DG Enterprise, Trend Chart on Innovation) as well as bibliometrical and patent indicators;
- information and programmes assorted by the Provincia Autonoma di Trento, e.g., the provincial scientific report 2001 and the provincial development programme;[2]
- previous studies on the economic system of the Province, e.g., Camagni/ Zaninotto (Eds.) (2002), Mariotti (Ed.) (2003), OECD (2002);[3]
- qualitative, structured, personal interviews with 46 experts representing the most important institutions of the Trentino research and innovation system including all concerned stakeholders and interest groups (cf. Table 1).[4]

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2 Andreaus, M./Eulisse, E./Zanetti, M. (Eds.) (2002): *La Ricerca Scientifica in Trentino. Rapporto Annuale 2001.* Trento: Provincia Autonoma di Trento; PAT (2002) *Programma di sviluppo provinciale per la XII Legislatura*. Trento: Provincia Autonoma di Trento.

3 Camagni, R./Zaninotto, E. (Eds.) (2002): Competitività del sistema produttivo. Quaderni della programmazione competitività 1. Trento: Università degli studi di Trento/Provincia Autonoma di Trento; Mariotti, S. (Ed.) (2003): Innovazione e nuove tecnologie: Analisi e politiche. Quaderni della programmazione competitività 2. Trento: Università degli studi di Trento/Provincia Autonoma di Trento; OECD (2002): Trentino: Basic data. Local Reviews on Entrepreneurship. OECD – LEED Programme.

4 In total, 39 interview appointments were held. The difference between number of interviews and number of interviewed persons stems from a small number of group interviews. The interviews were conducted in March and April 2003, lasting between 45 and 90 minutes.

Table 1: Composition of interviewees

Type of institution	No. of interviewees	Type of institution	No. of interviewees
Provincial Research Institutes	12	Provincia Autonoma di Trento and Communes Trento and Rovereto	5
Research Institutes with shared provincial and national/ international funding	7	Other funding institution	2
National Research Institutes	2	Economic Development Agency	2
Private Research Institutes	1	Industry- and Business associations	5
University	4	Enterprises	6
		Total	46

The interviews were structured according to a number of first theses which were developed on the basis of the aforementioned analysis of available quantitative data and studies as well as the underlying model of the regional innovation system.[5] The qualitative approach complementing the quantitative methodology was chosen in order to gain a deeper understanding of the provincial context, embeddedness and implicit and unwritten codes ruling the local research and innovation system. A regional innovation system is not only determined by the available (knowledge) resources, the governance and institutional setting, the interaction and networks within the system and with actors 'outside', but also by the attitudes, perceptions and understanding of the participating actors. Therefore, it is essential to comprehend the specific culture and 'workings' of such a system, which can generally only be achieved through intensive personal interviews. The self-understanding and -perception of the relevant actors – including for example their attitudes to risk, inherent degree of trust or communicative patterns – as well as the shared frame of reference are pivotal framework conditions which shape and determine a regional innovation system.

This correlation is of particular importance considering the size of the Province and the limited number of actors, which bears on the one hand the problem of lack of "critical mass", yet on the other hand also greater chances of being able to group

5 See for example: Cooke, P./Uranga, M. G./Extebarria, G. (1998): Regional systems of innovation: an evolutionary perspective. *Environment and Planning A*, 30, 1563-1584; Cooke, P. (2002): Regional Innovation Systems: General Findings and Some New Evidence from Biotechnology Clusters. *Journal of Technology Transfer*, 27, 133-145; Braczyk, H.-J./Cooke, P./Heidenreich, M. (Eds.) (1998): *Regional Innovation Systems*. London: UCL Press; Koschatzky, K. (2001): *Räumliche Aspekte im Innovationsprozess. Ein Beitrag zur neuen Wirtschaftsgeographie aus Sicht der regionalen Innovationsforschung.* Münster: Lit-Verlag: 173-184. Kuhlmann, S. (2002): Governance and Intelligence in Research and Innovation Systems. Utrecht: Faculteit Riumtelijke Wetenschappen, Universiteit Utrecht.

forces in order to follow a joint competitive strategy. On this account, the Fraunhofer ISI project was conceived with a strong interactive and co-operative orientation mirroring the long-standing tradition of mutuality in the Province. The foresight approach – which is based on the idea of mobilising *joint* actions – was specifically chosen in order to, firstly, take up and draw on this tradition of mutuality, thus working with existing structural elements and providing continuity in spite of the suggested changes and restructuring, and, secondly, to address changes on different levels of decision making and action at the same time, in order to stir a system which has been caught up in itself for a long time. Following this approach, the results of the extensive expert interviews were presented at a first workshop in April and discussed and balanced with participants. The emerging strengths and weaknesses profile of the Autonomous Province Trentino lay the foundation for the foresight process launched in the July workshop "Trentino plus 10".

1.2.2 Regional Foresight and Vision Building

Foresight is a systematic attempt to look into the longer-term future and draw conclusions for today.[6] It is by now well established as a useful instrument in bringing awareness of long-term challenges and opportunities into more immediate decision-making. The current definition from the EU describes foresight as: "a systematic, participatory, future intelligence gathering and medium-to-long-term vision-building process aimed at present-day decisions and mobilising joint actions. The term 'foresight' therefore represents the processes focusing on the interaction between science, technology and society".[7] Foresight is thus not a single methodology but different methods can be and are mixed to fulfil the purpose. There is a whole range of formal and informal methods to perform the task of looking into the future such as surveys, Delphi studies or different workshop types. The central point of foresight activities is to bring together actors from different sectors, thematic and societal backgrounds so that different ideas are introduced and assessed from different points of view. In foresight exercises, expectations of diverse actors about possible development paths are purposefully brought together, to formulate strategic views about the future. Participatory methods are used to include the main regional actors and generate new ideas and innovative solutions. Stakeholder involvement is critical in order to ensure consent with the action plans developed in the course of foresight exercises.

In the development and management of future-oriented innovation systems in Europe, foresight activities are given an important role nowadays. As research and

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6 Martin, B. (1995): Technology Foresight 6: A review of resent overseas programmes. A foresight article. London: HMSO.

7 Strengthening the dimension of foresight in the European Research Area, www.cordis.lu/rtd2002/foresight/home.html.

innovation policies have to be based on (implicit or explicit) visions of the future, foresight is increasingly seen as a valuable instrument for guiding decision-making, especially with regard to building the European Research Area.[8] With the Lisbon goal, the European Union has set itself the task of improving its response to the challenges and opportunities presented by globalisation and the knowledge-driven economy. Regionalisation of governance and socio-economic networking can be regarded as key factor in the development of the European economic system in a globalising world. This implies an urgent demand for regionally tailored development strategies as a means to address strategic questions in a locally restricted but socially comprehensive manner. Foresight activities can provide robust orientations for regional decision makers in detecting and identifying opportunities for further development, and pointing out networks of actors necessary to take advantage of these opportunities as well as identifying barriers and risks that need to be addressed in advance. The advantage of the regional level is that a wide constituency of societal stakeholders can be involved and new inter-group networks can be generated. Thus, regional foresight can help create and develop social capital, participative policy-making approaches and institutional learning.[9]

There are different objectives of foresight which range from priority-setting in science and technology to vision-building and networking. The purpose of the Trentino exercise was twofold: firstly, the aim was to provide inputs into strategy and policy planning, and secondly, to mobilise collective strategic actions. The preparation and specific design of the foresight workshop "Trentino plus 10" was based on the strengths and weaknesses analysis of the first phase of the project. The major aim of conducting the Trentino foresight exercise was to develop a joint "vision" for the future and work out specific measures to make the region one of the leading regions internationally. The participants were invited to bring in their specific knowledge of the situation of the region so that a vision could be outlined that most of the stakeholders can support. The participants of the workshop represented a mix of sectors and thematic backgrounds. During the foresight exercise they were given the opportunity to discuss the future of Trentino on a broad level, overcoming limited actor circles and thereby stimulating interaction, exchange and networking between the different interest groups and spheres.

One of the outcomes of the foresight process was the decision to go on with strategic discussions in the region bringing together the different actors of the innovation

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8 For further information see for example the homepage of the foresight unit of DG RTD: www.cordis.lu/foresight.

9 Renn, O./Thomas, M. (2002): *The Potential of Regional Foresight*. Final Report of the STRATA-ETN Expert Group "Mobilising the regional foresight potential for an enlarged European Union – an essential contribution to strengthen the strategic basis of the European Research Area (ERA)." Luxembourg: European Communities; Renn, O. (2003): Editorial, *Regional Foresight Association 1st Newsletter*. Institut für Sozialwissenschaften, Universität Stuttgart, Germany.

system. Hitherto, such a forum for jointly discussing future developments has been lacking. Yet, as Trentino is entering a new phase of its development, it has become clear that such a forum is needed. In this new phase, new competencies and capabilities are needed like the ability for visionary thinking and looking beyond one's own daily limited perspective, and the competency to realise these visions in the co-operation of the different spheres and interest groups. The foresight workshop had been conceptualised to support and promote such capabilities and should be regarded as the start of a new way of long-term strategic planning in the Province.

1.2.3 Regional Innovation Systems and the Scope of Political Action

Although regional economics has been dealing with the distribution of economic activity in space for several decades, it was the models of Lucas, Romer, Krugman and many other economists which, by introducing external effects and allowing the regional accumulation of knowledge, re-discovered spatial aspects in economic theory.[10] Specifically, the work of Krugman about geography and trade laid the foundation of a revival of economic geography.[11] This "new economic geography" is not only fuelled by models of the new growth theory and the new trade theory, but by many other theoretical concepts dealing with the regional distribution of technological development and innovative activity. Among the most popular are Porter's reflections about the factors influencing the competitive advantage of nations, the different contributions to the cluster concept and the concept of regional innovation systems.[12] These concepts and theories are at least partly influenced by findings from innovation economics, according to which innovation is not a linear, but an evolutionary, cumulative and feedback process, which can only be realised in the co-operation and in the economic and social interaction of different actors, and as a result produces technological, organisational and social innovations.[13]

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10 see for example Lucas, R. E. (1988): On the Mechanics of Economic Development, *Journal of Monetary Economics*, 22, 3-42; Romer, P.M. (1986): Increasing Returns and Long-Run Growth, *Journal of Political Economy*, 94, 1002-1037; Romer, P.M. (1990): Endogenous Technological Change, *Journal of Political Economy*, 98, S71-S102. Grossman, G.M./Helpman, E. (1990): Comparative Advantage and Long-Run Growth, *The American Economic Review*, 80, 796-815; Krugman, P. (1979): A Model of Innovation, Technology, Transfer, and the World Distribution of Income, *Journal of Political Economy*, 87, 253-266. Krugman, P. (1991): *Geography and Trade*. Leuven: Leuven University Press.

11 Krugman, P. (1998): What's new about the new economic geography?, *Oxford Review of Economic Policy*, 14, 7-17.

12 Porter, M.E. (1990): *The Competitive Advantage of Nations and Their Firms.* London: Macmillan; Porter, M.E. (1998): Clusters and the new economics of competition, *Harvard Business Review*, November-December 1998, 77-90; Braczyk, H.-J./Cooke, P./Heidenreich, M./Krauss, G. (Eds.) (1998): *Regional Innovation Systems. The Role of Governance in a* Globalized *World*. London: UCL Press.

13 Koschatzky, K. (2001): *Räumliche Aspekte im Innovationsprozess. Ein Beitrag zur neuen Wirtschaftsgeographie aus Sicht der regionalen Innovationsforschung.* Münster: Lit-Verlag: 62.

According to the concept of regional innovation systems, s*uccess factors of regional innovation promotion* are related to

- an innovation-oriented local or regional institutional system with flexible policy networks, a regional capital market and a governance system with appropriate financial authority;
- a rich, in learning, knowledge transfer and qualification aligned institutional structure;
- intensive local and regional networking, enhanced by national and international co-operative linkages between regional actors, which facilitate mutual knowledge exchange and enable collective learning processes;
- a creative and entrepreneurial-oriented human capital which contributes to a continuous renewal of the regional enterprise stock.

The emphasis on open, flexible and competitive networks as a key element for structural change and the utilisation of so far underdeveloped knowledge potentials, the possibility to support network building processes by public policy intervention and the importance of spatial proximity at least in early phases of technological development and innovation processes made the "region" an interesting political action field. It is assumed that within a limited spatial entity with a limited number of actors, public funds for initiating and supporting network building can be allocated much more precisely and perhaps also more efficiently than in measures without a regional focus. Especially in regions with a high autonomy in fiscal policy and in public spending good chances are given for a successful promotion of economic and innovative potentials.

As can be seen from the different theoretical concepts and underlying empirical studies, the following three aspects are the basic ingredients of a regional innovation strategy:[14]

(1) Activation and targeted promotion of the regional innovation resources to *strengthen the collective learning capability and to develop and apply new technologies and services*: for this it is first necessary to ensure and develop the competence in formulating, implementing and administering policy measures in political institutions. In further steps, the needs and deficits of regional

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14 based on Koschatzky, K./Gundrum, U. (1997): Innovation Networks for Small Enterprises. In: Koschatzky, K. (Ed.): *Technology-Based Firms in the Innovation Process. Management, Financing and Regional Networks.* Physica-Verlag: Heidelberg, 212; see also Koschatzky, K. (2002): Innovationsorientierte Regionalentwicklungsstrategien: Konzepte zur regionalen Technik- und Innovationsförderung. Karlsruhe: Fraunhofer ISI (Working Papers Firms and Regions No. R2/2002); Zenker, A. (2001): Innovation, Interaction and Regional Development: Structural Characteristics of Regional Innovation Strategies. In: Koschatzky, K./Kulicke, M./Zenker, A. (Eds.): *Innovation Networks, Concepts and Challenges in the European Perspective.* Heidelberg: Physica.

innovation actors must be ascertained, the offer to and the demand for available resources be identified and the activation of relevant resources be organised. The main task in this context is the creation of framework conditions for regional structural change and for regional growth.

(2) Co-ordination and coupling of these resources in regional innovation networks in order *to generate regional system innovations* and to integrate all process steps from research and development to production and marketing by combining all relevant actors from industry, science, politics and society: for this it is necessary to identify individual actors, possible promoters and the existing informal and formal networks, to mediate the establishment of networks and to provide financial support as well as to accompany the development of the networks in the course of time.

(3) Integration of these regional networks in national and international knowledge and technology networks by creating active interfaces and promotion of supra-regional Cupertino to *ensure and increase regional competitiveness*. Regional openness for new, problem-solving approaches even if they lie outside existing routines is necessary, as well as the willingness to participate as a region in regional competition (benchmarking).

Policy measures, however, be they oriented towards innovation and technology promotion or regional development, *are only able to establish new, fundamental development paths in exceptional cases*. This can be attributed among others to the fact that the development of new techno-economic paradigms[15] is beyond the reach of political action. Mostly through historical coincidence exactly those ingredients which form the basis of new technologies can be found in a region. *Technology policy can strengthen such processes*, but their setting up is rather the exception than the rule. Positive impacts on regional growth and regional structural change are to be expected if it succeeds to arrive at a more efficient utilisation of public promotional funds (which so far is not always the case). In this way, development processes in a region could be initiated in a more targeted manner, which strengthen the innovation and technology competence of enterprises, broaden the regional knowledge base and give impetus for continual learning process. As a result, the chances could be improved to create regional competence centres or clusters which would contribute to growth of the regional economy and to a reinforcement of the regional technological and economic competitiveness.

Usually, there are three starting points for strategy development and implementation:

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15 cf. Freeman, C./Perez, C. (1988): Structural crises of adjustment:. Business cycles and investment behaviour. In: Dosi, G./Freeman, C./Nelson, R./Silverberg, G./Soete, L. (Eds.): *Technical Change and Economic Theory*. London: Pinter Publishers, 45-47.

- the socio-economic and scientific-technological subjects and objectives of regional development, competence building and sustainable trajectories
- the shaping and improvement of the relevant systems (i.e. education and research, industry, policy, demand), their systemic integration and their institutional and organisational settings
- the governance of innovation promotion, learning and qualification, i.e. programmes, measures, regulations, their implementation and evaluation, and the ability for continuous adjustments and improvements.

These different aspects cannot be regarded and treated in isolation, but are by themselves a comprehensive system. The complexity of socio-economic systems and their scientific-technological paradigms results from the fact that the different elements work together by amplification or weakening and can thus have foreseen and unforeseen impacts on the different elements of the whole system. This makes planning and strategy building an experiment ("experimental policy") which demands continuous observation, evaluation and adjustment.

In the investigation of the Trentino scientific, economic and political system, these aspects were made the basis of the empirical analysis and further thoughts on policy conclusions.

1.3 Structure of the report

The further report is structured as follows: In the next chapter, the results of the strengths and weaknesses profile (WP1) are presented. Section 2.1 contains the results of the analysis of regional indicators of the European Innovation Scoreboard and sections 2.2 to 2.4 the picture gathered from the qualitative, structured interviews. Chapter 3 follows with the international "Good Practice" examples (WP3). The sectoral and technological priorities developed for and during the Trentino foresight exercise are depicted in section 4.1 (WP2). The subsequent section 4.2 outlines the suggested context-specific measures for the strategic further development of the Trentino research and innovation system based on the project results (WP4). Chapter 5 concludes the report with an outlook and further necessary steps.

This technical report documents the different working steps carried out so far. With regard to the documentation of the Fraunhofer ISI project, which was finished in October 2003, it is a final report. With regard to the process the project was able to initiate, it should be conceived as an initial report documenting the starting phase of a longer process. In this respect this report cannot be exhaustive.

2 Strengths and Weaknesses Profile of Trentino

2.1 Quantitative Basis of the Innovation Score Board and the Fraunhofer ISI Bibliometrical and Patent Analysis

Within the European Innovation Scoreboard - a data and indicator track record of DG Enterprise and a part activity of the Trend Chart on Innovation - regional comparative data has been collected and analysed for the first time in 2002.[16] Due to the limited availability of innovation data at the sub-national level and due to the need of comparability between the countries and regions of the European Union, it is not possible to analyse the Provincia Autonoma di Trento by herself. Data are only available for the region Trentino-Alto Adige. Although there might be an levelling effect when data of the two provinces forming the region are put together, the presented figures will at least provide some indications for the innovative performance of the Province.

The selected indicators (cf. Table 2) cover of human resources, employment in high-technology sectors, and the creation of new knowledge through R&D and patents. Additionally, GDP per capita is used for measuring the economic potential of the regions.

Table 2: Regional indicators of European Innovation Scoreboard 2002

No.	Short definition	Year*
1.2	Population with tertiary education (% of 25 - 64 years age class)	2001
1.3	Participation in life-long learning (% of 25 - 64 years age class)	2001
1.4	Employment in medium- and high-tech manufacturing (% of total workforce)	2000
1.5	Employment in high-tech services (% of total workforce)	2000
2.1	Public R&D expenditures (GERD - BERD) (% of GDP)	1999
2.2	Business expenditures on R&D (BERD) (% of GDP)	1999
2.3.1	EPO high-tech patent applications (per million population)	2000

* Most recent year for a minimum of five countries

For all regions, two aggregate indicators reflecting the innovative potential are used:

- The *regional national summary index (RNSII)* is calculated as the average of the indicator values indexed to the country mean. A RNSII > 1.0 indicates that the region is performing above the country's average, a RNSII < 1.0 below the

16 European Commission (2002): 2002 *European Innovation Scoreboard: Technical Paper No. 3: EU Regions*. Brussels: European Commission, Enterprise Directorate-General.

country's average. Due to the indexation on the country mean, RNSIIs should not be compared across countries.

- The *revealed regional summary innovation index (RRSII)* is calculated as the average of the RNSII and the regional European summary innovation index (REUSII). The REUSII is calculated as the average of the indicator values indexed to the EU mean. The RRSII takes into account both the region's relative performance within the EU and the region's relative performance within the country. It is designed to pinpoint "local leaders", i.e. regions performing well in a country, although the country might be lagging behind the European average.

According to the RNSII, the leading innovation regions are shown in Table 3. As can be seen there, the three leading Italian regions are Lombardia (RNSII of 1.44), Piemonte (1.35) and Lazio (1.35). Of the 20 Italian NUTS-2 regions, Trentino-Alto Adige reaches the 13th position (together with Marche) with a RNSII of 0.68.

Table 3: Leading innovation regions within countries

Country	**No. of regions**	**% regions above country mean**	**Leading regions** (RNSII in brackets)		
Austria	9	22	Vienna (1.45)	Carinthia (1.29)	--
Belgium	3	67	Vlaams Gewest (1.11)	Reg. Bruxelles (1.09)	--
Germany	16	25	Berlin (1.35)	Bavaria (1.34)	Baden-Wuerttemberg (1.34)
Spain	18	28	Comunidad de Madrid (2.01)	Cataluna (1.34)	C.F. de Navarra (1.30)
Greece	13	15	Attiki (1.39)	Kriti (1.04)	--
France	22	14	Île-de-France (1.60)	Midi-Pyrénées (1.31)	Rhône-Alpes (1.12)
Finland	6	33	Uusimaa (1.30)	Pohjois-Suomi (1.07)	--
Italy	**20**	**20**	**Lombardia (1.44)**	**Piemonte (1.35)**	**Lazio (1.35)**
Ireland	2	50	Southern&Eastern (1.12)	--	--
Netherlands	12	33	Noord-Brabant (1.59)	Utrecht (1.06)	Limburg (1.02)
Portugal	7	29	Lisboa e V.d.T (1.39)	Centro (1.01)	--
Sweden	8	25	Stockholm (1.46)	Oestra Mellansverige (1.00)	--
UK	12	25	Eastern (1.48)	South East (1.35)	South West (1.21)

Source: European Commission (2002)

Regarding the *innovative activities in Trentino-Alto Adige*, Table 4 displays the seven indicators explained in Table 2, together with the GDP per capita and the two aggregate indicators for the region and the Italian average. Trentino-Alto Adige excels the Italian average in the share of participation in life-long learning (8.33 % of 25 - 64 years age class compared to 5.06 % in Italy) and in the GDP per capita (22,698 € compared to 16,870 € for Italy in total). Within Italy, Trentino-AA reaches the first position in the share of the population engaged in lifelong learning, followed by Friuli-Venezia Giulia with a participation rate of 7.01 %. The openness for lifelong learning seems to be a strength of the region.

Table 4: Innovation indicators for Trentino-Alto Adige and Italy

Indicator*	Trentino-AA	Italy
Tertiary education (%)	9.23	10.03
Lifelong learning (%)	8.33	5.06
M/HT employm. manuf. (%)	3.09	7.62
HT employm. services (%)	2.32	2.92
Public R&D (%)	0.22	0.47
Business R&D (%)	0.18	0.54
HT patent application	1.10	4.90
GDP per capita ('000 €)	22698	16870
RNSII	0.68	
RRSII	56	

* See table 2 for more details

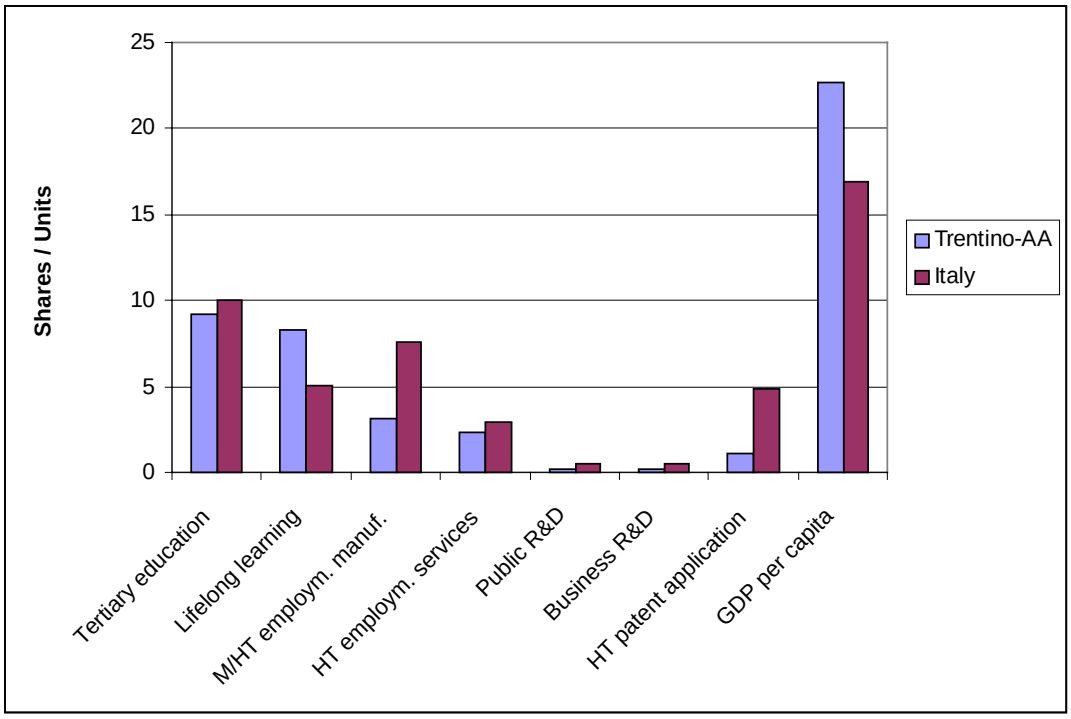
Source: European Commission (2002)

Compared with the Italian average (cf. Figure 2), the region lacks behind with regard to the other indicators. The share of the population with tertiary education is slightly smaller than the Italian mean (9.23 % of 25 - 64 years age class, compared to 10.03 % for Italy). Here, the regions takes the 12th position together with Abruzzo among the 20 Italian regions. A much stronger weakness regards the employment in medium- and high-tech manufacturing. Only 3.09 % of the total workforce is employed in medium- and high-tech enterprises, while in the Italian average 7.6 % are. This has certainly something to do with the industrial base of the region and the still dominating traditional sectors, i.e. agriculture, handicrafts and tourism. With this share, Trentino-AA ranks 17th in Italy, just ahead of Sicilia (2.3 %), Sardegna (2.26 %), and Calabria (1.21 %).

A better performance can be found with regard to the employment in high-tech services. Here, the region is fairly close to the Italian average (2.32 % of total workforce and 2.92 % respectively). The pronounced service orientation of the regional economy is reflected in this figure. As a matter of fact, Trentino-AA reaches the 13th position among the 20 Italian regions. Public and business R&D does so far

not play the role it should play in a modern, competitive regional economy. The region is far below the Italian average (low shares of public and business R&D expenditures, low high-tech patenting activity). These performance figures should give the stimulus for an increase in public and private R&D activities, since R&D is an important cornerstone for new and improved products and processes, for the generation of new knowledge and thus, in a knowledge economy or learning region, for income and wealth. Nevertheless, income can also be generated by other economic activities than R&D and innovation. Although in general there is a positive correlation between innovation and R&D on the one hand and per capita income on the other, the region's gross domestic product per capita of 22,698 € provides a good example for the importance of other income sources as well. As a consequence, there is no must for an increase in public and private R&D investments so far. But on the other hand, this would open up additional income and employment opportunities and could broaden the economic, scientific and social base of the region, especially with regard to highly qualified labour.

Figure 2: Innovation indicators for Trentino-Alto Adige and Italy



Source: own calculations according to European Commission (2002)

Complementing this rough first insight into the Trentino innovation system, Fraunhofer ISI performed two database searches for compiling a profile of the patenting and publication activity in the Province. Patents are used as a so-called throughput-indicator which provides indications for the creative and inventive ability of organisations (firms, research institutes), regions and nations. Since not all inventions are

patentable and for not all inventions a patent is applied, this indicator also sheds some light on a certain aspect of the innovation process. Publications can be used as an indicator for scientific output. But as with patents, also this indicator has some limitations. Most databases have a certain bias related to the covered journals. There is either an overemphasis on journals published in English, which discriminates disciplines or countries with a high rate of publications in the own language, or on certain disciplines. For example, the most used Science Citation Index overrepresents medical journals and does not cover all journals which are not published in English. Nevertheless, for international or interregional comparison it still represents the best data source.

In the case of Trentino, a specialisation profile was calculated for 28 technology fields (European patent applications; database: PATDPA) and 27 science fields (publications covered by the Science Citation Index). This profile compares the Trentino share in each field with the Italian share in the same field and puts these shares in a + 100 to – 100 scale. A 0 would indicate that both shares are similar (no specialisation). The higher the positive/negative difference between the two shares, the more positive/negative is the specialisation. The formula is as follows:

$$\text{Index} = 100 * \tanh \ln [(P_{kj} / \sum P_{kj}) / (\sum_{k} P_{kj} / \sum_{kj} P_{kj})]$$

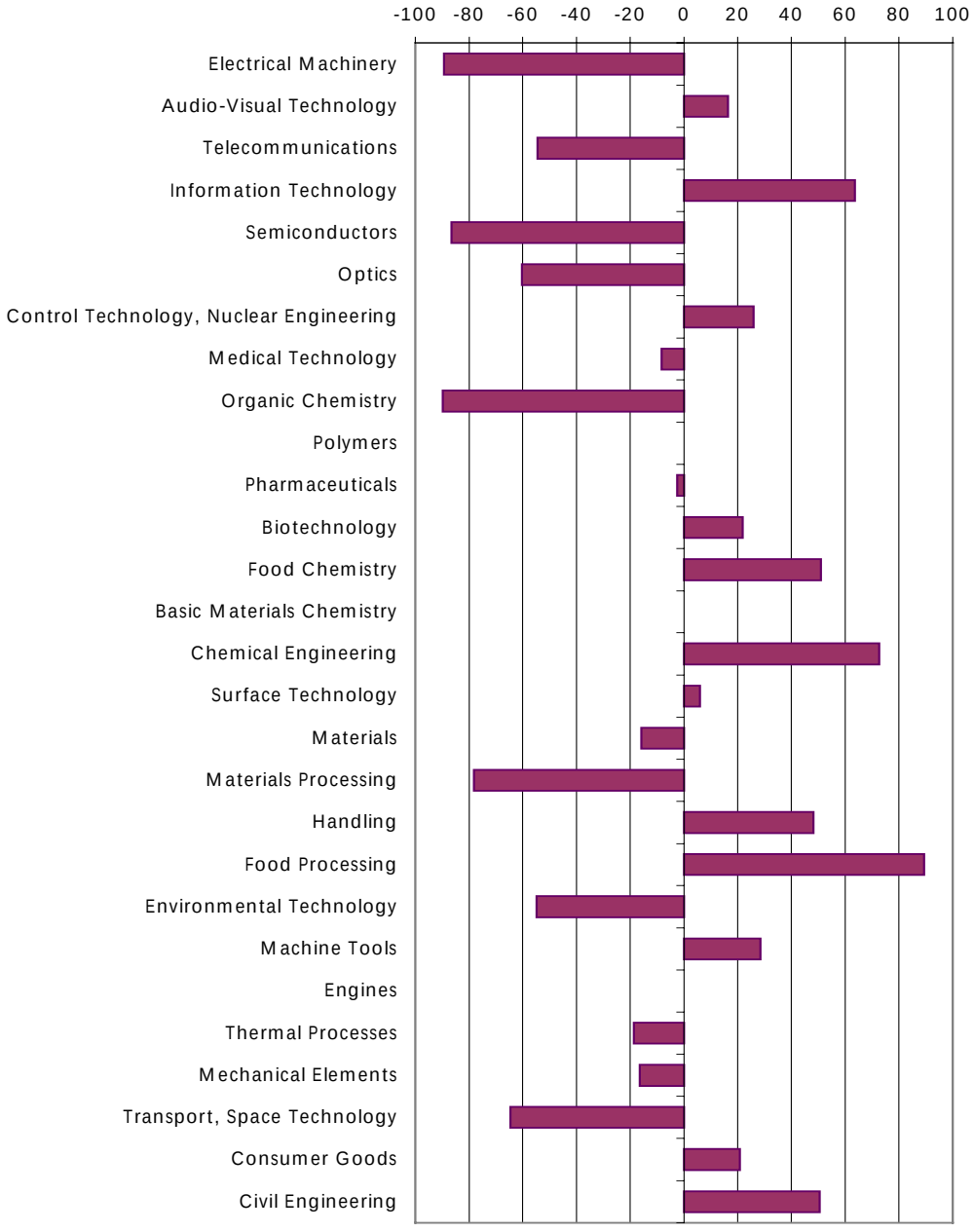
P_{kj} is the number of patents / publications in region k (Trentino) in Italian total in technology field / scientific field j.

For the period 1990-2000 on average 18.6 patents per year had their origin in Trentino (inventors address). Compared with an Italian annual average of 2,755 patent applications, the Province reached a share of 0.7 % in all Italian patent applications. This corresponds to Trentino's share in total Italian population. The technological specialisation profile reveals strengths in information technology, in food chemistry and chemical engineering, in handling, food processing and civil engineering. A clear positive specialisation (above + 20) is also obvious in control technology and nuclear engineering, in biotechnology, machine tools and consumer goods (cf. Figure 3). These are the technology fields where Trentino (although on a relative basis) excels the Italian average.

In the same period 1990-2000 on average 266 publications per year with authors from Trentino were recorded in the Science Citation Index. The scientific strength of the Province is documented by a share of nearly 1 % in all Italian publications (on average 27,382 per year). According to the specialisation profile, computer science, materials science, industrial and mechanical engineering, civil engineering, physics, mathematics as well as optics, instruments, nuclear science and polymer science are the pronounced scientific strengths of the Province (cf. Figure 4). On the other hand, telecommunications, organic chemistry, pharmacy, biotechnology, chemical engineering, thermic processes, medicine and biology are fields in which

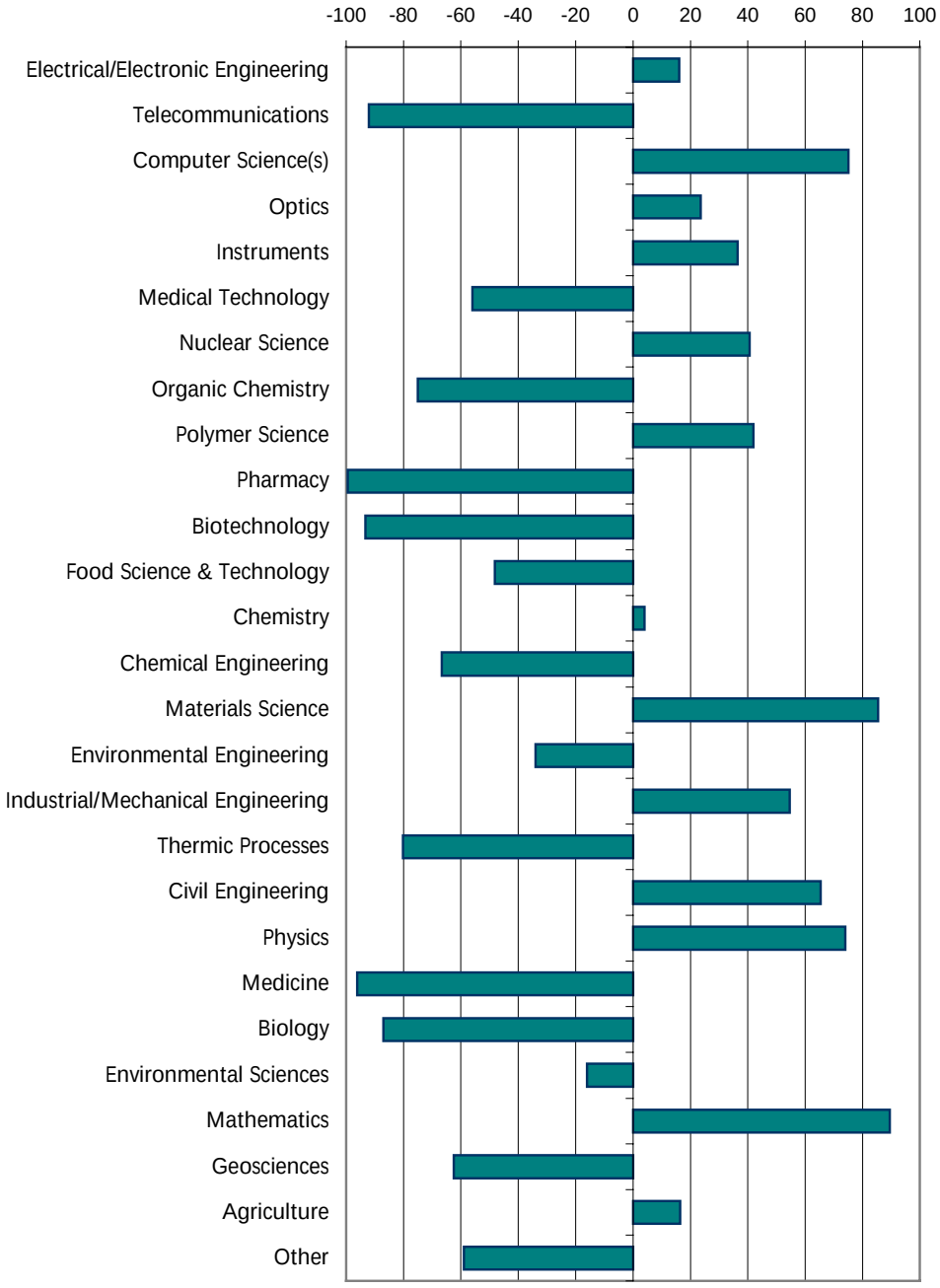
the publication output is much below the Italian average. Even in food science and technology, which affects an important sector in Trentino's economy, the scientific output measured in publications is weak.

Figure 3: Technological specialisation of PAT measured by patent applications 1990-2000



Source: European patent applications searched in PATDPA; own database search

Figure 4: Scientific specialisation of PAT measured by publications 1990-2000



Source: Scientific publications searched in Science Citation Index; own database search

Comparing both profiles, it can be concluded that computer science matches well with information technology and civil engineering on the science side with civil engineering on the technology side. On the other hand, there seem to be fields with a strength either on the science or on the technology (industrial application) side,

e.g., optics (positive science specialisation, but negative in patents) or biotechnology (strongly negative in scientific output, but positive in patents).

It should be stressed that with these indicators and analyses it is not possible to paint a comprehensive and profound picture of the Trentinian innovation system. Nevertheless, both the European Innovation Scoreboard and the patent and publication analysis together with innovation statistics compiled and published by PAT (e.g., the reports on scientific research in Trentino) can serve as a basis for the development of further conceptions about future potentials in the Province. With this background, extensive expert interviews were conducted in order to assess the connective and functional quality of the provincial innovation system. In the following three sections, the results of these expert interviews are presented, focussing on three crucial areas for the advancement of the Trentino research and innovation system: networking, funding and entrepreneurial spirit.

2.2 Networking and structural coupling in the provincial research and innovation system

In spite – or better because – of growing internationalisation and globalisation processes, there is an increasing awareness about the economic benefits of sectoral clustering and networking within regions. Especially with regard to the aspects of innovativeness and learning processes, the need for networking between different institutions and actors is recognised strongly nowadays. This is because the acts of learning and innovating are recognised as essentially *social* processes, that are not happening in a social vacuum but in close interaction with other entities. Thus the social economic system, the environment in which a firm or research institute is embedded is extremely important because it supports the capability to learn, to acquire new knowledge and to transform this new knowledge into innovations.

A range of different advantages are attributed to embeddedness in regional networks of which the most important ones are the lowering of transaction costs and enhancement of innovativeness:

- Productivity is enhanced by lower transaction costs, i.e. costs for searching, interacting, communicating, which are generally lower in spatial and cultural proximity.
- Innovation is dependent on interactive knowledge exchange between a variety of knowledge actors, especially because of the proximity necessary for tacit knowledge exchange. Particularly for high-tech firms, collaboration with research institutes or other firms is essential for the development of their technology.

A significant role in this aspect is attributed to tacit knowledge – that is knowledge that is difficult to put in writing or formulas and is based mainly on experience. This type of knowledge is very difficult to transmit over distance because it requires personal contact and knowledge of the framework conditions. It is nowadays generally agreed that embeddedness in social context can immensely further the transmission of tacit knowledge. Embeddedness is here defined in terms of the extent to which a social community operates in terms of shared norms of co-operation, trustful interaction and untraded interdependencies.[17]

Embeddedness of the research institutes, university and local business community

The networking within the research community can be characterised as follows:

- Partly strong links through personnel overlap / new institutional co-operations.
- System shows co-operative and competitive elements.
- Integration through networking could overcome problem of critical mass.

This description also mirrors the networking between the research institutes and the university. A number of newly institutionalised initiatives integrating personnel from different organisations strengthen existing linkages. Yet at the same time, the interaction is also determined by competition for funding and highly qualified manpower. Different incentive and career systems disallow a stronger intermingling and exchange of human capital which could strengthen the networks and knowledge exchange within the subsystem of knowledge generation and diffusion to which both the research institutes and university belong.

With regards to networking within the local business community, networks have the advantage of allowing a flexible division of labour in the production process and also of permitting the benefits of external economies of scale. In other words: in regional networks small firms can act *as if* they were larger, because they co-operate with other small firms. This can even take the form of virtual organisations. In front of customers, networks can be an advantage to get assignments for which they would be too small otherwise. Redundancies within these networks enhance the robustness of the regional system against market volatility and can boost competitiveness. Networking in the Trentino business sector is characterised by:

- Few co-operations because of sectoral fragmentation (also often neither customers, subcontractors nor competitors in the Province).
- Relations dominated by competition (no tradition of co-operating).
- Due to small size co-operations could offer great advantages (external economies of scale).

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17 Cooke, P. (2002): Biotechnology clusters as regional, sectoral innovation systems. *International Regional Science Review*, 25, No. 1, 8-37.

A crucial point for the functioning of an innovation system is the transfer *between* these two subsystems, between the education and research system where knowledge is generated and diffused and the industrial system where knowledge is applied and exploited in marketable products and services. In a setting like the Province of Trento, where there is a rich innovation infrastructure, with research institutes and university, firms have considerable opportunities to access or test knowledge, whether internally or externally generated to the region. A second strength is the strong interaction that is showing in local traditional industries (which are mostly low-tech) and with spin-offs of research institutes (high-tech). Yet, overall, the networking between research and business community shows great opportunities for improvement. There is a situation where on the one hand, there is an abundance of knowledge produced by public institutions in a broad variety of technology fields, and on the other hand, firms invest less than the national average in innovative activities. This almost automatically leads to the question of how the knowledge produced by the public institutions can be so transformed and accessed that it benefits the private sector. One of the problems in this regard is that neither research institutes nor firms see much potential for a knowledge or technology transfer.

The information gathered from the interviews is depicted in the left half of Figure 5. Within the innovation system, four subsystems or spheres can be differentiated: the provincial government PAT, the research institutes, the university and the business community. While the PAT seems to have intense and good interaction with the other three spheres, networks between the other spheres are not so well developed. As was pointed out earlier, university and research institutes have a whole range of shared activities and personnel, yet also between these spheres, exploitation of synergies could be strengthened. While currently there are many initiatives underway to expand the co-operation and the interaction between the three spheres, it is still too early to say whether they are successful. Needless to point out that it is very difficult to bring three systems closer together which have so far in the larger part developed with great independence.

In extension of the so-called Triple Helix,[18] an innovation system can be modelled, where all four spheres – state, university, research and industry – are closely overlapping. In this type of system, there is no clear division of spheres or division of labour anymore. Agents are acting and enacting processes in different spheres at the same time. This system is closely held together by networks which combine actors from all four spheres and organisations that belong to different spheres at the same time. These networks and organisations act as interface agencies which bring together the requirements and needs from the different spheres so that the systems can adapt to each other and grow interactively.

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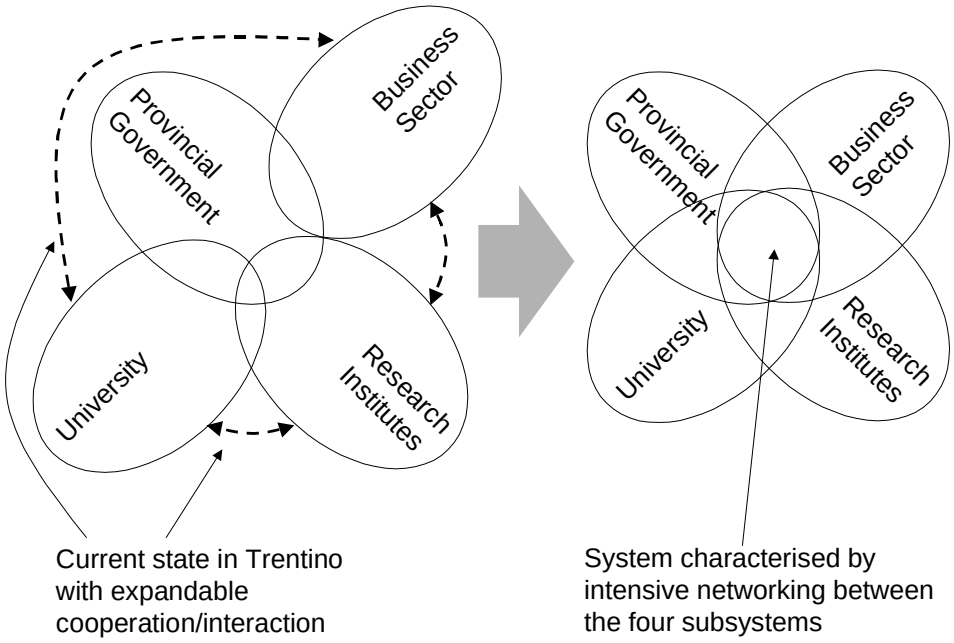
18 Etzkowitz, H./Leydesdorff, L. (2000): The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy*, 29, 109-123.

Figure 5: Interaction between the four spheres in the regional innovation system



Openness of the system, national and international integration

While close regional networks show a lot of advantages, too much can be just as harmful as too little. The case of regional networks that are too much closed to extra-regional linkages is called "lock-in". A lock-in occurs when there is so little interaction with the world outside a region that new developments, new knowledge and innovations are not noticed because actors are too much concentrated on what goes on within the region. In these cases, changes in the outside environment can lead to the decline of a whole region, like in the famous case of the Ruhr-region in Germany.[19] A second aspect for linkages with outside the region is of course the honing of international competitiveness, which can only occur when there is an awareness of what is happening on the market or in the technology fields and what the changing demand structures are.

There exists a whole range of different contacts between actors from the Province and actors outside the Province and Italy. Yet, due to their diversity, these are difficult to quantify. Especially the research institutes and university show many cooperations and initiatives where they interact with foreign research institutes, domestic and foreign universities and even to some extent with domestic and foreign

19 Grabher, G. (1992) La Debolezza Dei Legami Forti. Il Ruolo Ambivalente Della Cooperazione Inter-Aziendale, *Piccola Impresa*, No. 2, 3-25.

business customers. A prominent example is the co-operation with the universities of Bolzano and Innsbruck in the so-called BIT-School concept.

In contrast, the business sphere shows strong differences between the sectors. While the traditional specialisation sectors of Trentino – and the larger part of other firms – entertain only a limited number of contacts outside the Province, the knowledge- and research-intensive spin-offs show a strong propensity for interaction with organisations outside the Province. Usually, they are in intensive contact with their customers, as their products have a high client-specificity. In the majority of cases, these customers are located outside of the Province and even in other countries. Other important sources of information like suppliers and competitors are also rarely found in Trentino. This has two effects: (1) Information exchange is not as intensive as in spatial proximity which allows daily interaction, (2) new, external knowledge is being inducted into the Province which in interconnection with local research institutes can stimulate dynamic learning processes in the regional innovation system. Co-operation with extra-regional research institutes are predominantly based on international contacts, as the high specificity of the needed research performance is considerately narrowing down the number of interesting co-operation partners. In this connection, there were several indications that exchange barriers exist in form of lack of interaction possibilities and an overly strong local embeddedness of the foreign research institutes.

Co-operation and competition, incentives and barriers

A basic difficulty for the development of a learning region with a division of labour between knowledge generating, diffusing and applicating spheres, is the so far low propensity for exploiting the potential for synergies and co-operation. Barriers for knowledge exchange were found particularly in the areas of:

- language and communication barriers;
- incongruity of time horizon;
- difference of research focus (publication versus product).

Differences in languages are the most conspicuous expression of underlying differences in research and work cultures. This includes differences in the approach, goal understanding, expectations, frame of reference, incentives and unspoken codes of behaviour. Thus, incongruity of time horizon and differences in research goal can also be subsumed under this point. Different goals of knowledge utilisation have a direct impact on the approach to knowledge production. These "cultural" differences negatively affect joint work flows and therefore also the experience exchange, which is the essential way of technology transfer in co-operations.

From the perspective of the business sector, the quality of the research institutes and the fit of research fields is rated good to excellent. Yet, the research is perceived as

being too attached from the market and there are difficulties in expressing and formulating the need for R&D. While the first point is a general problem of co-operation between research institutes and industry, the second is probably amplified by the local economic structure which is dominated by small, low-tech firms and even large enterprises with little innovative activity. Further barriers to co-operation is the limited knowledge about interesting technologies in the research institutes due to a low degree of (in)formal interaction and difficulties in formulating a long-term perspective as management capacity is the most important and scarcest resource in the firms. Recent changes in funding and positioning of research institutes have also diluted the clear division of labour between academia and industry and research institutes are increasingly perceived as competition for local research funds. An interesting finding was that the enterprises pointed to good relations with individual researchers while the interaction with management proves to be difficult. Thus, personal, informal contacts can pave the way for formal co-operations, yet barriers are observed on a structural level.

From the perspective of the research institutes, the business sector bears potential for the realisation of synergies and division of labour – e.g., back-end for research – and also of accessing new ideas and financial resources. Barriers in co-operation stem from the lack of large sized industry or clusters of small industries and the low technology content of the majority of local firms. Due to these two characteristics, only limited possibilities in research co-operation are perceived on the side of the research institutes. Furthermore, the expectations of firms – e.g., for a "simple" product upgrade – often do not match the profile and competencies of the research institutions, depending on how strongly they are oriented towards the economic structure of the Province.

Many of the barriers and restraints mentioned are due to general co-operation problems between the research and the business sphere amplified by characteristics typical for the Trentino situation. The gap between the knowledge generating and the knowledge applicating subsystems is ideally bridged on two levels – the institutional and the personal – simultaneously. On an institutional level, it has become clear that financial promotion is not sufficient to reinforce private R&D investment, other resources, especially management capacity and competency, are also lacking. On a personal level, the significance of embedding and linking persons already holding many contacts has been stressed. Although the creation of networks is inherently difficult as they are by nature tendentially decentralised organisations, their support and promotion is an essential step if the rich knowledge infrastructure of the Trentino research is to be opened further for the local business sector and realised into innovations and commercial products.

2.3 Financing and sustainability in PAT's research funding system

Financing is one of the key elements of innovation systems because it bridges the gap between the emergence of new knowledge and innovations and their way to the market. The so called funding gap is regularly named as barrier to innovation by a large number of innovative companies, especially by smaller companies who have difficulties in funding research and development out of their own capital. For most regions, it is not possible to exert much influence in the financial sphere as they depend on fixed budgets allocated in block form.[20] Since most regional administrations do not have remotely enough capital, funding for basic and applied research is generally the key limitation on regional initiatives for advanced technology.[21]

The Provincia Autonoma di Trento is in the exceptional position where it is able to govern this significant element to a much wider extent than most other regions. With its budgetary competence and capability the regional government may decisively assist the capacity of the regional industry to mobilise its innovative capability. Because the capability to vary the scale and scope of budgets available can be crucial to supporting innovation – especially among SMEs – such regions have a strong potential for regional systems of innovation. Its autonomous spending and taxation authority is therefore one of the essential strengths of the Province of Trento. This is also recognised by the community. Awareness of the significance of the provincial financial strength for the regional innovation system has been one the dominant topics in the interviews. The crucial point for the growth and long term sustainability of this system is however the question of the strategy with which to deploy this financial strength. This includes decisions about the range and combination of financial instruments to apply, actors to involve and goals and priorities to set.

PAT's third channel of financing

The main goal of the Provincia Autonoma di Trento with regard to the innovation system is clear: promotion and development of research and higher education in Trentino. Thus a large portion of funds is poured into the provincial research institutes and the university. The results of the Fraunhofer ISI project indicate that this priority setting is carried by a surprisingly broad consensus among the different interest groups. The main advantages that are associated with this strong public funding are that it allows:

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20 Cooke, P./Uranga, M. G./Extebarria, G. (1998): Regional systems of innovation: an evolutionary perspective. *Environment and Planning A*, 30, 1563-1584.

21 Cooke, P. (2002): Regional Innovation Systems: General Findings and Some New Evidence from Biotechnology Clusters. *Journal of Technology Transfer*, 27, 133-145.

- start-up financing for the localisation of new technology and knowledge fields and innovative activities in the Province;
- a sheltered area for building up national and international competitiveness and thus the potential for internationalisation activities in order to help the system to take off;
- the development of a system integrating institutions and actors from a diversity of disciplines and thus overcome the teething troubles of interdisciplinary research approaches;
- a longer term stability for planning and research strategies, as governments do not react as volatile as the private sector, but are able to pursue longer term priorities;
- the attraction of highly qualified human capital and thus the infusion of new knowledge and ideas into the provincial system either through monetary incentives or the creation of an attractive research environment;
- the building up of own human resources by creating innovative training courses of high quality in specialised technology fields.

Yet, this large number of advantages has to be carefully weighed against the drawbacks that strong public funding of a regional innovation system can entail. Among the most critical points mentioned in the interviews were the domination of the local economy by the public sector. But also concern was voiced that in spite of its generous financial provision, the Province's resources are limited when compared to national funds with which technology districts are set up in other regions (e.g. biotech districts in Germany). If no clear priorities for a chosen set of technology specialisations are decided on, the biggest advantage of the Province trickles away with low effectivity. This problem is aggravated by short-termism of programmes and repeated changes of priorities. Further, it was stressed that in order not only to build up knowledge and human capital in the province, but also to keep it and thus establish a sustainable and growing knowledge input into the innovation system, the financial strategy has to be accompanied by a strategy for the embedding of human capital. Especially the absorptive capacity of the local industry for these human resources but also the lack of longer-term perspectives in the research arena were mentioned as strong disincentives to stay in the province. And lastly, the risk of becoming self referential, or in other words, the danger of (relatively) low international competitiveness due to intense provincial funding. The aim of promoting internationalisation is always in danger of turning into just the opposite.

There is great concern that public funding – which is considered as one of the greatest strengths of the Province – might also be the source of amplifying weaknesses of the regional innovation system. Again, it all depends on the *strategy* with which the finances are deployed.

Incentive system and project based funding

The Provincia Autonoma di Trento finances research and development in public institutions, like research institutes and the university, and in private enterprises. The problems encountered in financing R&D are fundamentally different between these groups and thus they require different incentive systems. While for public institutions the decisive point is the introduction of more market into the system, the challenge in the private sector is the support of R&D activity expansion and thus funding the public benefits of private efforts.

In the public sphere, the key question for the funding of research institutes and for research in the university is the balance between long-term stability of funds and incentives for competitiveness. Interview partners stressed the necessity of ample, long-term investments in basic research for future progress. Yet, the introduction of the project-based funding of PAT is overall regarded as a positive development. As major advantages were considered:

- improvement of competitiveness in national comparison;
- source for additional funding with great opportunities especially for young scientists;
- separation of wheat from the chaff as only a limited number of projects are funded;
- attraction of larger European projects with the funding;
- possibility for basic research projects which are generally put on low priority when institutional funding does not cover finance plan.

On the other hand, a number of limitations also have to be considered:

- competition is restricted, as due to the size of the Province there is only a certain amount of competitors per discipline;
- as it is relatively easy to attain funding through this channel, it reduces engagements for other funds with more competition, like the European funds, and thus leads to inertia;
- too strong dependence on changing political constellations and budget restrictions of the Province.

Institutional funding is undoubtedly indispensable for basic research, the maintenance of international excellence and the attraction of third-party funds, for example from the European Union. Yet, the allocation of institutional funding in block form has to be questioned. The differentiation between institutional funding, project based funding and third party funds can set significant incentives for competitiveness. There is a whole range of possibilities to introduce performance linked elements into the funding system. Examples of possible financing models include the

linking of the amount of institutional funding to the amount of acquired third party funds or other performance indicators like publications, patents, spin-offs etc. In this way stability can be combined with performance incentives and thus bring more market into the institutional finance system.

Sustainability and institutional stability

Unless the Provincia Autonoma di Trento is setting its goal on creating a purely academic research cluster, the sustainability of the innovation system rests in a large part also on the private business sector and its capacity to absorb the knowledge and innovations produced in the public research institutions. Only if the private sector is research and innovation oriented it can profit from the activities of the public institutions, as otherwise the knowledge gap becomes too difficult to bridge. Thus, it is not surprising that in the interviews one of the main weaknesses mentioned for the innovation system of the province were the low expenditures for R&D of private enterprises in Trentino. Although this a general Italian problem, the Province lags behind even in national standards.

Generally, the most frequently indicated barriers constraining innovation in the private sector are financial – lack of funds for innovation, too high risk of innovation projects, too expensive technology. The smallest SMEs and highly innovative firms are especially confronted with financial constraints.[22] As far as can be judged from the interviews, private research projects are mainly financed by internal funding supplemented by customer and public funding. From an enterprise perspective the advantages of new public funding channels are seen as follows:

- high success rate for attainment of funding;
- more money can be put into pre-competitive research;
- co-operation with external research institutions has become easier.

Although the new public funding channels were generally applauded, additionality effects are as yet scarce and there were also disappointments:

- application procedure takes up too many resources in relation to project size, evaluation process too long;
- does not cover the lack of capacity for application, management and administration of research projects; promotion of innovation project management skills and support services targeting these deficiencies are missing;
- lack of understanding for the requirements of long-term research strategies remains unchanged;
- little impact on R&D activities of business community so far.

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22 Kaufmann, A./Tödtling, F. (2002): How effective is innovation support for SMEs? An analysis of the region of Upper Austria. *Technovation*, 22, No. 3, 147-159.

While basic scientific research is financed by public research funds, the exploitation and commercialisation of scientific findings is depending on market oriented channels. Although bank loans are a major source of finance in the Province, it appears that access to loans for R&D is restricted due to the risk aversity of financial intermediaries. There is a funding gap in the market provision of high risk oriented capital. Access to venture capital in the Province is almost negligible. This is a manifest disadvantage for the regional innovation system, as venture capitalists not only supply money like other financial intermediaries but also management and marketing experience, something that a large amount of start-up firms lack. They can also realise synergies between firms in which they invest and thus promote the emergence of supply chain clusters.[23]

In the interviews it was indicated that not only supply but also demand for venture capital is underdeveloped in the Province. Entrepreneurs see few advantages for private financial sources and have a habit of depending on the Provincia Autonoma di Trento for funding. Yet, especially for new growth technologies and the assessment of their market potential, venture capitalists can play a decisive role. Financial capital is one of the major factors that speed up the rate of change and thereby accelerate learning. There are several ways in which a local government can bridge this lack of market actors, for example through guarantees or through an innovation-growth fund that provides risk capital is managed similar to a venture capital fund. The priority here lies on capital for the commercialisation of innovations.

PAT's role in the European Research Area

In considering the linkages between the Province and Europe, regional actors seem to be quite well integrated. Although several institutions have only in recent years begun to strengthen their engagement in international competition, the success rate, for example, in application for funds with the European Union is impressive in many instances. The only drawback mentioned in this context was that while the number of projects was more than satisfactory, the volume was not. Again there were indications of discongruities between financial strategy and human capital strategy, project leaders seem to be reluctant to apply for additional manpower as there is not enough absorption capacity for these highly qualified researchers, once the projects are finished. The overall assessment of interview partners is that the Provincia Autonoma di Trento has excellent preconditions for being able to position itself in the European Research Area - despite its small size. Its autonomy status and the liberty for setting priorities of promoting specific technologies and sectors are both assets that might outweigh many other drawbacks like its peripheral location and lack of industry. The targeted vision can be summarised in the words of one

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23 Cooke, P./Davies, C./Wilson, R. (2002): Innovation Advantages of Cities: From Knowledge to Equity in Five Basic Steps. *European Planning Studies*, 10, No. 2, 233-250.

interview partner: "the wealthy Trentino technology district will be solidly placed in the second-tier group in Europe".

As mentioned at the beginning, the crucial point is the strategy for deploying the provincial funds in order to be able to reap their benefits. The strategic orientation does not only include the question of which technologies to promote but also what type of innovation system to target. For the sustainability of the high quality of life in Trentino three strategies were suggested in the interviews:

(1) Trying to retain the autonomy status by showing that it leads to excellence in research capacity.

(2) Focusing on research as "industry" which becomes the main part of the export basis of the Province.

(3) Expansion and strengthening of industrial base in targeted key sectors, bridging the existing gap between research and market, filling in the private sector element of a regional innovation system.

Although these strategies do not exclude but can complement each other, they presuppose different attitudes, frames of mind and understanding of the future path of the Province. The first strategy is based on further dependence on public funding. The second strategy is aiming on a middle path, combining a strong public sector with a more competition and market oriented approach. The decisive aspect for the second strategy is the creation and strengthening of ties to firms respectively financial sources in general outside the Province. The third strategy targets a future independence of means from Rome. The crucial point here is the building up of entrepreneur spirit, a subject discussed in the next section. Generally, it has become clear that for bundling and orienting the different activities and actors of the budding regional innovation system, a strategic focus is essential. The direction, where the province wants to go in the future has to be clear for all forces that are taking part.

2.4 "Culture" of Entrepreneurship and challenges to the local business community

Within the process of economic development and restructuring – whether on national or regional level – new technology oriented and knowledge intensive firms are considered to play a major role. These firms support the structural change, have growth- and employment potential and a better level of exchange with other countries. Studies carried out by Birch (1979, 1987)[24] for example showed, that between

24 Birch, D.L. (1979): *The Job Creation Process*. Cambridge; Birch, D.L. (1987): *Job Creation in America*. New York.

1969 and 1976 two thirds of all new jobs in the U.S. were created by firms with less than 20 employees or new firms. In regional innovation and production systems, new firms are important for the modernisation and regeneration of innovation networks and existing mature firms as they can serve as suppliers of new technologies and knowledge. Against this functional background as well as within the context of high unemployment rates in quite a lot of EU-countries and regions, the 1990s were characterised by political efforts – on national, international and regional levels – to create better framework conditions for entrepreneurial activities. Policy initiatives focus, for example, on the exploitation of commercial ideas out of universities and non-university institutions, on the access to venture capital, on PR-campaigns for a better awareness of entrepreneurial opportunities within the society and on the creation of "start-up-clusters" on the regional level. Although each region has to find its own way of economic adjustment, the increase of international competition, privatisation efforts and decreasing tax incomes are factors which affect the framework conditions and political possibilities for all regions in Europe.

The situation in the Provincia Autonoma di Trento is no exception. In creating international competitiveness and becoming stronger integrated into the international division of labour, particular PAT's business community is facing major challenges. With the aim to create values and generate income, existing firms as well as start-up-companies will be crucial for the production and innovation system. Creating a better entrepreneurial "atmosphere" – which includes the ability of people to take financial and social risks – is a task which touches the whole society and cannot be "implemented" in a short period of time. Therefore, a systematic long-term policy approach has to be developed in order to guarantee that PAT will be among the leading European regions in the years to come.

Today, the manufacturing sector of PAT can be characterised as fragmented with no dominant specialisation patterns and cluster structures. Many small firms, multiple activities, no large companies and a weak presence of firms in foreign markets are further structural characteristics. Firms carrying out own R&D (e.g., technology oriented firms and knowledge intensive business services) are rather the exception than the rule. Although no figures are available, it can be assumed, that the amount of technology oriented firms among the total firm population as well as among new firms is rather low. The industrial base has little technology background; traditional or mature branches dominate and as such, regional recipients for new technologies are missing. The combination of a fragmented firm structure, little or limited rejuvenation activities of the production sector in the shape of new firms, a strong regional focus of business activities and a traditional behaviour in general appear to be the major weaknesses of PAT's innovation and production system. Speaking of technology and innovation oriented modernisation, a mismatch between the output of the local research system and the demand or necessities of the economic sector can be noticed. In particular, there is a lack of stable and systematic bridges with universities and other research institutes. This aspect corresponds with the above

mentioned low R&D performance of PAT's manufacturing sector and the low "absorptive capacity" for new technological know-how and knowledge.

Concerning the segmented structures and an underdevelopment of the horizontal and vertical division of labour within the manufacturing sector, the following quotation of one of the local experts being interviewed describes the situation in PAT:

"The Provincia Autonoma di Trento has no industrial district structures. The system is too diffuse to call it industrial district. There is a lack in co-operation culture - no interest in complementarities of competencies. Linkages between firms occur mainly in the low-tech branches. The interaction of the very few similar new firms is rather informal and perceived as competitive rather than collaborative. I don't believe that the province is going in this direction. The districts in Veneto or Emiglia Romagna for example are based very much on the same business areas and skills (e.g. leather, shoes etc.). I don't see this kind of specialisation pattern and regional skills here."

These structural weaknesses must be confronted with the strengths of PAT's business sector to gain a complete picture. Although there is little awareness of economic problems that may lay ahead and perspectives of private companies, a good economic performance of the majority of firms can be noticed. Between 1995 and 2001, the number of industrial firms and employees grew considerably. Looking at the sectoral structure and the number of firms, it becomes evident that PAT's production system is characterised by a relatively stable and static firms population. The above mentioned segmented or diversified firm structure can be an advantage in case of sectoral crisis ("risk diversification"). It also has to be mentioned, that quite a few successful high-technology spin-off companies have entered the market and seem to be in a position where they can serve as "role models" for other scientists of local research institutes or other potential entrepreneurs. Last but not least, in recent years the Provincia Autonoma di Trento has built up institutional structures to support spin-off or start-up companies within its territory. Experiences in supporting start-ups, establishing and operating technology transfer systems and being aware of the importance of creating an "entrepreneurial atmosphere" are significant pre-conditions for further activities and initiatives.

Entrepreneurial climate – critical aspects for PAT

Table 5 shows the entrepreneurial density in PAT compared to other neighbouring regions. Due to a lack of comparable figures from other European regions, the evidence of these figures is limited as the differences between PAT and the other regions are too small to make a precise analysis. However, it can be emphasised that the entrepreneurial density in PAT matches the most important neighbouring regions. A certain aversion towards taking entrepreneurial risk can be observed which seems to be not only limited to the Trentino Province.

Table 5: Entrepreneurial density in PAT compared to other regions[25]

	PAT	NE regions	Bolzano	Friuli-Venezia
1992	7.4	8.2	7.8	7.4
1999	10.4	10.9	11.8	9.7

Source: Movinprese

Against the background of some basic structural characteristics as well as the strengths and weaknesses described above, three major questions have to be discussed:

- Is the lack of industry or private business in PAT one of the biggest challenges in the years to come? Should there be a bigger support of entrepreneurial activities in PAT?
- How can a systematic policy approach look like and in which way can public support measures be implemented efficiently?
- In general: should more attend be paid to the economic sector and its modernisation and regeneration?

Starting points for support

Entrepreneurial behaviour is traditionally not very pronounced in Trentino - a "culture of entrepreneurship" in research, teaching and administration at higher education institutions and research institutes does not exist or is rather weak. In addition, the limited local market is not able to support entrepreneurial initiatives. Nevertheless, recent activities show starting points for public support in PAT which cover entrepreneurial education aspects as well as structural changes in general, for example:

- courses at the faculty of economics with prominent persons from large firms as speakers;
- university project with small groups of students simulating the creation of business concepts and firm projects;
- agreement between the university and the Associazione degli Industriali to strengthen the connection with the local business sector (e.g., courses in mechatronic);

25 Entrepreneurial density is the number of firms by total population. For a comparison of the figures, it has to be taken into account that in 1996 an additional registering of agricultural firms took place.

- university support in the shape of administrative handling of royalties and the creation of a foundation to finance and manage spin-offs.

With these activities, the actors in the Provincia Autonoma di Trento have started to improve the framework conditions and initiate first steps to create a "Culture of Entrepreneurship" with a change in mentality and behaviour. As with the creation of networks and structural coupling (section 2.2), this task should not be underestimated as changes in culture and mentality are extremely difficult to actuate, especially if there are no perceptible pressures from outside or within the system. Nevertheless, without a stronger and more dynamic business sector, it will scarcely be possible for the province to transform and use the knowledge and human resources developed in the research sector into welfare for its population as a whole and to become the international player it is aiming to be.

2.5 Outlook for further steps in the development of Trentino's science and technology base

As a result of the strengths and weaknesses analysis, the Trentinian science and innovation system could be characterised by the following positive attributes: close informal networks, institutional 'thickness' and embeddedness, rich innovation infrastructure, good funding system (R&D budget 2002: 97,69 million Euro[26]), a sheltered area for building up national and international competitiveness, and a relatively stable and static firms population (sectors and numbers of firms). Major weaknesses concern the weakly developed co-operations between science and industry and within the business sector, the strong public sector and the high propensity for subsidies with so far little strategic priority setting, the little developed entrepreneurial culture and small industrial base, the fragmented and segmented firm structure, and the low R&D and high-tech intensity in the regional industry. From these strengths and weaknesses it can be concluded that Trentino faces *four major challenges*:

- the need for a better integration of the science and business system,
- an improvement of entrepreneurial attitudes and linkages within the business system,
- adjustments and the need for priority settings in the research funding system and the research infrastructure, and
- the development of the technology base with regard to already existing strengths and the exploitation of competitive advantages with regard to other regions.

26 Without university.

These challenges were the starting point for a further discussion of future prospects in the foresight workshop. As a general conclusion it could be argued that certain economic/technological areas in Trentino have the potential to form the basis for building sustainable, internationally competitive advantages and that an obvious need exists for a more focused strategy regarding the further development of the research and higher education system. The resulting derivation of technological and economic specialisation clusters will be presented in more detail in chapter 4. As an input for further discussion, especially regarding the funding of research institutes, the contribution of business incubators to regional economic development and the expansion of the education and research infrastructure, the next chapter presents a selection of issues for orientation in the formulation of policy recommendations. These examples were presented during the foresight workshop.

3 Examples from international cases

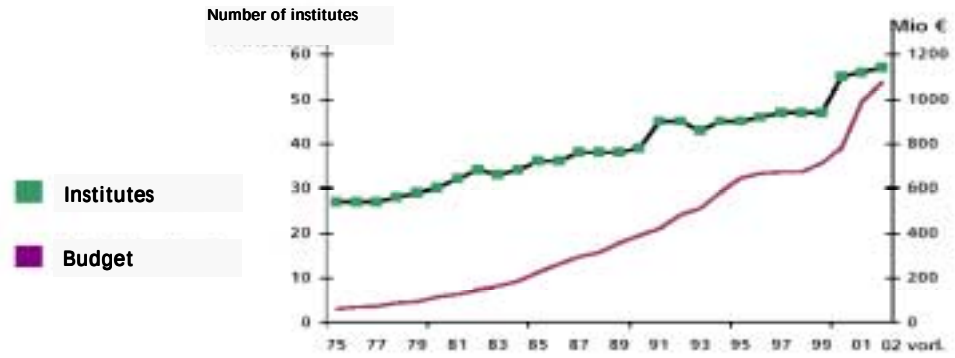
3.1 Financing and organising applied research in Germany – the model of Fraunhofer Society

The Fraunhofer Society was founded in 1949 in Munich as a non-profit organisation. It is the leading organisation for institutes of applied research in Germany and Europe. At present, there are about 80 research establishments of 57 institutes at 40 locations throughout Germany (cf. Figure 6). The staff size is about 13,000, the majority of whom are qualified scientists and engineers. Fraunhofer's annual research volume is over 1 billion Euro. Contract research is financed by a share of 37 % basic funding, 33 % contract financing (industry) and 30 % public financing acquired in competition (Germany, EU, other countries). Besides continuous growth until the late 1980s, two major aspects have influenced the development of Fraunhofer Society: the German unification with the integration of research groups and institutes located in East Germany (beginning of the 1990s), and the integration of the "Gesellschaft für Mathematische Datenverarbeitung" (GMD, a former national research centre) at the end of the 1990s (cf. Figure 7).

Figure 6: Locations of Fraunhofer institutes in Germany

Fraunhofer's major research areas are information and communication technologies with over 3,000 employees, microelectronics (2,500 employees), materials and components (2,300 employees), production technologies and organisation (2,100 employees). Other research activities are related to surface technology and photonics (approx. 1,000 employees) and life sciences (approx. 600 employees). 2,000 employees are engaged in various other research fields and in service and administration (headquarters of Fraunhofer in Munich).

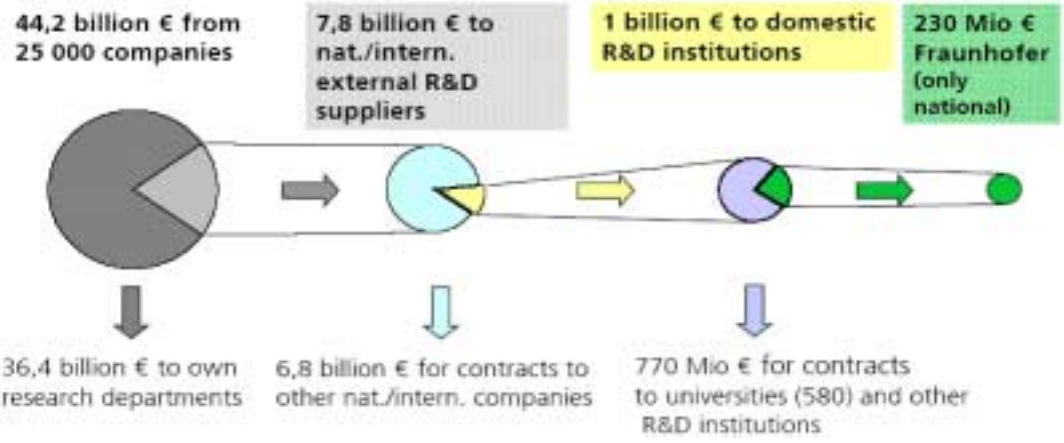
Figure 7: Development of Fraunhofer Society



Source: Fraunhofer Society

Within the German innovation system, the Fraunhofer society is not the largest research organisation, but plays an important role in bridging basic research with the need of industry for applied research results. Nevertheless, the majority of research and development (R&D) is carried out in industry itself (cf. Figure 8). Of the 1 billion Euro which industry pays for R&D work carried out by German R&D institutes (universities and non-university research), Fraunhofer obtains a share of about 230 million Euro.

Figure 8: Market for industrial research and development in Germany

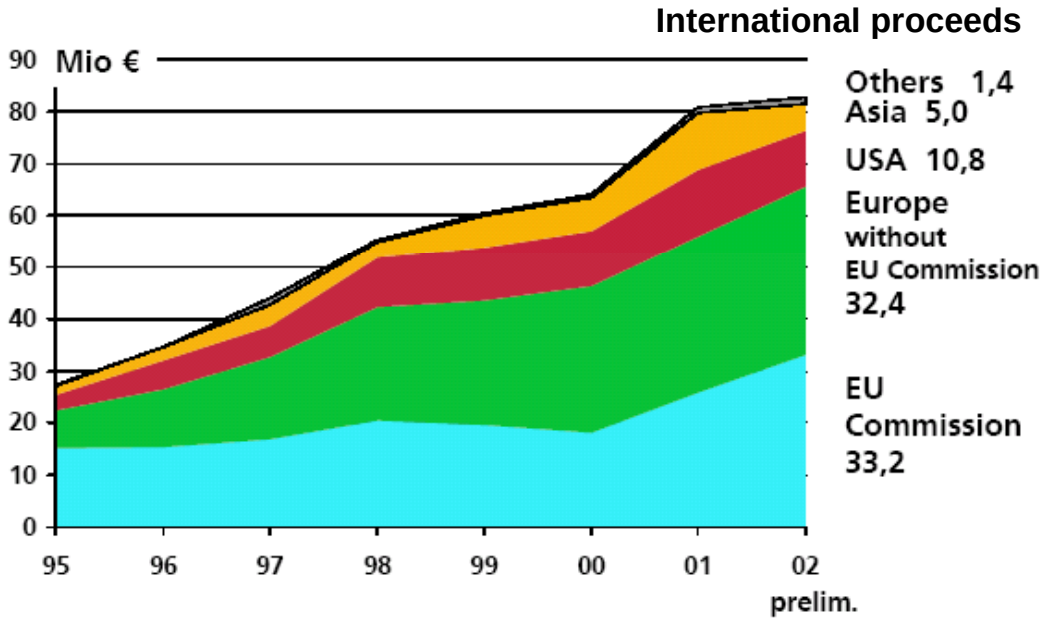


Source: Fraunhofer Society

As mentioned above, the Fraunhofer society is financed by a mix of different sources. 37 % of the whole budget consists of basic funding, approximately 33 % is contract financing (industry) and 30 % comes from public bodies via project funding and other financial contributions. As many other large research organisations, the Fraunhofer society is not only oriented towards the national customers, but acquires around 83 million Euro (that is 15 % of its contract research budget) on in-

ternational markets (cf. Figure 9). A sharp increase in international proceeds can be observed since the mid 1990s.

Figure 9: International orientation of Fraunhofer Society



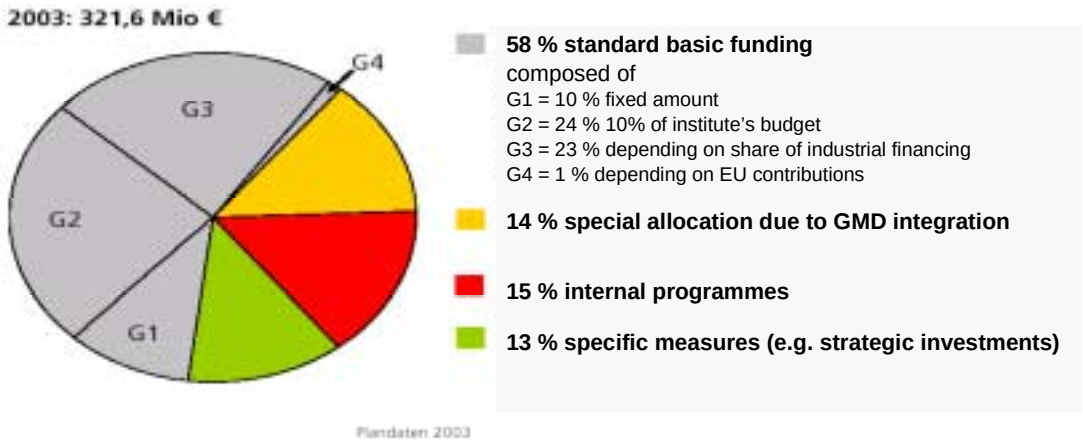
Source: Fraunhofer Society

With regard to basic funding, 90 % is allocated by the federal government and 10 % by those federal states which host Fraunhofer institutes. The basic funding is not fixed, but success-based according to certain criteria like contract volume, share of contracts from industry, etc. It is annually negotiated between the board of directors of Fraunhofer society and the sponsors from the ministries (Fraunhofer commission). The basic funding is obtained by the Fraunhofer as a whole, i.e., the board of directors. The distribution among the different institutes lies within the autonomy of the society. No external control is executed, but there is an in-build mechanism of success-based self control according to which institutes receive less money when they are unsuccessful on the research market. Although Fraunhofer is an independent non-profit organisation, public principles in administration and in payment schemes have to be followed.

The distribution of allocation to the institutes is organised according to the following model (cf. Figure 10): 58 % of the budget consists of standard basic funding which is composed of a fixed amount of 10 %. 24 % are allocated according to 10 % of the institute's budget (success criteria), 23 % depend on the share of industrial financing (success criteria) and 1 % on the amount of EU contributions. The remaining 42 % come from different sources. 14 % are a special allocation due to the integration of the GMD, 15 % is money from Fraunhofer internal programmes

(another internal distribution mechanism) and 13 % are paid for specific measures. Since not all institutes are affected by the GMD integration and not all are able to participate at the internal programmes, in reality these shares often differ between the institutes. While the average basic funding for all Fraunhofer institutes is 28.1 % of the total budget, it was only 22.5 % for Fraunhofer ISI in the period 1998-2001. This implies that a higher share had to be financed by external proceeds.

Figure 10: Distribution of basic funding to the institutes (model)



Source: Fraunhofer Society

All Fraunhofer institutes are legally dependent bodies. Nevertheless, they are free in organising their internal organisation (e.g., with regard to the number of departments, the definition of cost centres and the distribution of basic funding to the different units). As a matter of fact, a large variety of organisations models exist. The majority of institutes is organised within seven alliances: microelectronics, production, information and communication, materials and components, life sciences, surface technology and photonics, and defence research and technology. Only a few institutes do not belong to one of these alliances. There are institute alliances which consist of institutes with similar competences acting jointly in the R&D markets. These alliances develop joint strategies and play a role in allocating financial resources. Besides, there are theme-centred alliances consisting of departments of different institutes which co-operate in developing and marketing specific strengths/tools (e.g., simulation tools).

For all the institutes, the Fraunhofer headquarters in Munich act as service centre. For this service, the institutes have to pay an annual contribution (dynamic allocation) taking into account the amount of service work carried out by the institutes themselves (e.g., accounting of business trips). In Fraunhofer ISI, 6 % of the total budget has to be allocated to central services.

Since the cost structures of the institutes differ according to the infrastructure (e.g., clean rooms, laboratories) and the composition of the staff (scientists, technicians, secretaries), the overhead costs and thus the prices the institutes charge for a working hour vary. Full cost calculation is applied in all institutes. Within the status of a non-profit organisation, institutes can make losses, but only for a few years. When the financial situation does not improve, the institute will be re-organised or closed (as has happened with some institutes in the past). Positive proceeds, which are mainly the result of an overload of work, can be carried forward to the next year and remain in the institute's budget.

Due to a fixed limit of personnel capacities, Fraunhofer institutes have a somewhat restricted flexibility in reacting rapidly to market changes. In this respect, those institutes have an advantage which are closely associated with an university institute. In this interaction, a free flow of people (students, scientists) can be realised. There is a general pattern that working contracts are temporally limited, at least at the beginning of an appointment. On average for the whole Fraunhofer society, only 20 % to 40 % of the employees hold a permanent position. Nevertheless, deviations from this general pattern exist. In the Fraunhofer ISI, about 70 % of the staff have a permanent contract. This is due to the fact that the "flow heater principle", according to which a position at the Fraunhofer should serve as spring board for a position in industry, cannot be applied since Fraunhofer ISI mainly serves the public market.

With its organisational and financial structure, the Fraunhofer society is one of the most successful research organisations in Germany. This was acknowledged by a commission on the systematic evaluation of the Fraunhofer-Gesellschaft, which was carried out during 1998. For the first time, the model of Fraunhofer financing and its effect within the innovation system, were subjected to critical appraisal by an external panel of international experts. The Fraunhofer was assigned to play an important role in the further adjustment of the German national innovation system. As a matter of fact, some of its organisational and financial models seem worthwhile for a more detailed review on their suitability for the Trentinian research organisations.

3.2 Materialising and strengthening creativity – the role of business incubators – the case of Promotech in Nancy

The aim of the following section is to propose some reflections related to the potential role of business incubators in local development and to give impulses and conceptions to the Autonomous Province of Trento for a more concerted promotion of business start-ups. In section 2.4, the importance of supporting entrepreneurial spirit and start-ups in the Province has been argued in some detail. Business incubators are an instrument that can further this goal considerably as recent studies have

shown. Yet, incubators exist in a broad range of different forms and not all are successful. In recent years, a lot of attention on the level of the European Union has therefore been paid to compare different designs and identify "Good Practices".[27] A "Good practice" presented in this section is the example of Promotech in the Technopôle of Nancy. In order to emphasise the advantages and potential strengths of business incubators, the following questions will be discussed:

- Why are business incubators promoted in different regions and countries?
- What are the factors explaining the success of some incubators? (taking the concrete example of an incubator: PROMOTECH)
- What are the critical issues for the future?

Starting with a generic definition of business incubation, it can be admitted according to the NBIA[28] that: "a business incubator is an economic development tool designed to accelerate the growth and success of entrepreneurial companies through an array of business support resources and services". Even if there is no single formula for business incubators, in general, they are defined as physical facilities that provide new firms with the supportive network necessary to increase their probability of survival during the crucial early years when they are most vulnerable.

Why are business incubators promoted in different regions and countries ?

In general, an incubator may be guided by missions of local job creation, promotion of economic self-sufficiency among a specific population, diversification of the local economy, transfer of technology from universities or corporations, or the development of specific industries. Nevertheless, and even considering the diversity of business incubators across various countries and regions,[29] it is possible to identify three main – and partly overlapping – types of objectives which are principally pursued by policy makers promoting business incubators.

A first type of policy goals leading to business incubators' creation and development lies in the willingness of supporting entrepreneurship and local job creation. The underlying rationale is that micro, small and medium enterprise development will be an engine of endogenous development at local level and thus of growth and economic welfare. A second crucial motivation in terms of economic development concerns the diversification and strengthening of the local fabric. This concerns particularly lagging-behind or restructuring regions. Even in regions which are not

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27 See for example the following studies: CSES (2002) Benchmarking of Business Incubators. Final Report for the European Commission, Enterprise Directorate General by Centre for Strategy & Evaluation Services (CSES). Brussels & Sevenoaks; META Group (2003) Incubation Schemes Survey, SCONE Thematic Network funded by the European Commission, www.sconetwork.net.

28 National Business Incubation Association (NBIA), see: http://www.nbia.org/.

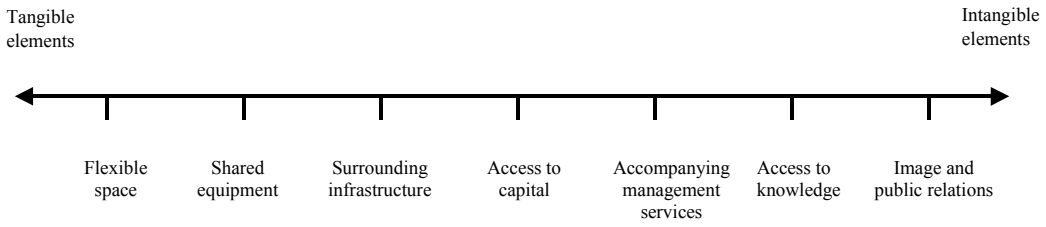
29 Cf. for instance OECD (1999): *Business Incubation - International Case Studies*. Paris: OECD.

confronted with dramatic ruptures, business incubators can favour a certain tendency towards sector diversification through enterprises creation. As a consequence, the whole regional economy may become more resistant to exogenous disturbances.

Finally, and depending on their "content" – i.e., the type of tenant firms and the nature of relations between business incubator and its environment – business incubators may foster knowledge transfer at local level. This type of goal is probably the most ambitious and the most difficult to reach. It corresponds to a situation in which business incubators play an active role in the reinforcement of academia-enterprise relationships. As such, in supporting, for instance, specifically new and growing high-tech businesses in an area, incubators can promote the development of a culture of entrepreneurship and innovation at universities and research centres. This may in turn affect positively local economic development in providing employment opportunities, diversifying the local economy and enhancing the quality of life for all residents. This is exactly the aim that business incubators in the Province should target.

Reversing the issue and adopting the point of view of tenant firms, the usefulness of incubators may certainly strongly vary depending of individual situations. Nevertheless, it may be argue that a wide range of services can be offered within an incubator, including for instance management assistance, access to financing, business or technical support services, and shared office services such as access to equipment, flexible and affordable leases, and expandable space. This spectrum is illustrated in Figure 11, which displays key elements that tenant firms are benefiting from.

Figure 11: Key elements (in the view point of tenant companies)



The case of PROMOTECH

PROMOTECH[30] was created in 1980 as a spin-off from a research centre of the National Polytechnical institute in Lorraine and as such is one of the oldest business incubator in France and even in Europe. It has been officially labelled as BIC by the European Commission (DG XVI) in 1985. PROMOTECH is located in Nancy, and since 1988 on the site of the Nancy science park: *la technopôle de Nancy-Brabois*. Since 2001, the activity of PROMOTECH has been extended to further sites in the Nancy area, and constitutes a not to be neglected element of the local urban and economic development strategy. Nowadays, PROMOTECH – employing a 12 persons team – is hosting simultaneously 30 to 35 firms (corresponding approximately to more than 100 jobs on average). Concerning physical facilities, 2,500 m^2 are available for tenant firms, the occupancy rate is varying between 80 and 90 % (implying a quasi-saturation).

Besides "pure" accompaniment of newly created firms (which takes the form of sheltering, supporting services, monitoring, networking, etc.), the PROMOTECH team is pursuing following activities:

- the promotion of entrepreneurship in universities, research organisations & private firms;
- the support of firms' creation (personalised coaching, training, business plan conception);
- the accompaniment – as a consultant – of local economic promotion (within the Nancy area as well as on behalf of further European regions).

In trying to detect, explain and characterise the key success factors of the PROMOTECH experience, different aspects have to be considered. First of all, the comprehensive services offered to tenant firms are unique (at least in north-eastern part of France) and are reinforced in terms of image and infrastructure by the location on the *technopôle de Nancy-Brabois*. Second, an evolution and constant adaptation of the working profile and tasks of the PROMOTECH team over the years can be perceived. This is notably due to an attitude shift of the local universities and research organisations which put a much higher priority on technology transfer issues nowadays compared to twenty years ago. Finally, the continuous support of the elected representatives over the decades as well as a proactive and vanguard attitude are decisive elements of success in the PROMOTECH case.

30 For further information see: http://www.promotech.fr/.

In combining these findings with lessons gained from other research projects at the Fraunhofer ISI,[31] it is possible to outline some general principles characterising effective business incubation:

- the definition of clear missions guiding business indicators;
- the establishment of tenant selection and maximal duration policies;
- the quality and scope of the services proposed ("good mix");
- the performance of evaluations of the business incubator (on an independent and regular basis);
- a philosophy of mid and long term financial sustainability.

Critical issues

Considering the possible contribution of business incubators to the future development of Trentino, three critical issues should be stressed. The first issue deals with the quality and intensity of networking phenomena generated or at least favoured by local business incubators. As such, it is important to conceive business incubators as intermediary organisations evolving in a local context, i.e., depending on the regional innovation system and at the same time contributing to it. The second issue concerns the relation between incubation and knowledge. In fact, business incubators could be interpreted as "knowledge catching and knowledge generating" institutions since the creation of new firms is nothing else than the materialisation of business ideas and as such an expression of (socio-economic) creativity. Finally, business incubators are expected to play the role of a "window to capital" for tenant firms at the different stages of their development (e.g., in favouring the mobilisation of private equity).

These overlapping issues are addressed in the concept of "networked incubators" as, for example, explored by Hansen et al. (2000).[32] In this concept it is assumed that such incubator tenants are able to combine the advantages of two different worlds: the scale and scope of established companies and the entrepreneurial capacities of start-ups which benefit from venture capitalists investments. Table 6 shows the advantages of start-ups in incubators as compared to established companies and start-ups attended by venture capitalists.

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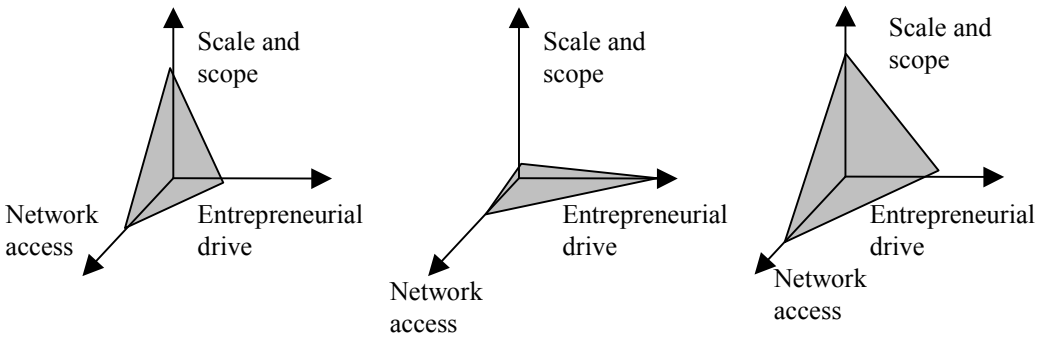
31 The TRANSACT project for the TRANSfer of existing and successfully proven supporting schemes for technology-based start-up ACTions in Newly Associated Countries (supported by the European Commission). For further information see www.ibh-hohenheim.de/projekte/TRANSACT/.

32 Hansen, M./Chesbrough, H. W./Nohria, N./Sull, D. N. (2000): Networked Incubators: Hothouses of the New Economy, *Harvard Business Review*, September-October, 74-83.

Table 6: The advantages of networked incubators

	Established companies	Venture capitalists (VC) supported new-founded firms	Tenants located in networked incubators
Scale and Scope • leveraging size and reach in order to lower costs by pooling resources and spreading them across units	**High** Historically the key advantage of large global companies.	**Low** VC-backed start-ups are left alone to obtain services and buy supplies.	**Medium** Common services and pooling of resources ensure some benefits, especially time savings.
Entrepreneurial Drive • stimulating individuals to pursue risky and disruptive innovations	**Low** Bureaucracy hinders new ventures; entrepreneurs are not rewarded.	**High** Entrepreneurs are free to pursue ventures and own large equity stakes.	**High** Entrepreneurs are free of bureaucracy and own equity in ventures.
Network Access • forging partnerships, obtaining advice, and recruiting people	**Medium** Many established companies have some, but not extensive, contacts with Internet companies	**Low** A VC partner may have an excellent personal network, but it doesn't go beyond the individual partner.	**High** Organised and active networking among portfolio companies and strategic partners.



Adapted from: Hansen et al. (2000, p. 80)

In favouring the multiplication of firms, the diversification of the local fabric, and especially in supporting the creation of high-tech companies, business incubators may offer a vector of regional development and of economic evolution. Considering the current situation in Trentino, one of the most pressing problems is the discrepancy between the academic knowledge generated and the level of its diffusion in regional activities. Consequently, to reinforce and to focus the role of local business incubators may be a way to strengthen and to materialise creativity in the Autonomous Province of Trento.

3.3 Diversity and competition in institutions of higher education – the case of the International University Bremen

The International University Bremen (IUB; Figure 12) was chosen as an example of international "Good Practice" because it represents a bold effort of the state of Bremen to

- improve and diversify university education in Bremen;
- attract excellent students and researchers from abroad;
- capitalise on perceived short-comings of German university system;
- increase competition and to push for university reform.

Figure 12: IUB Campus Centre

With regard to the increased efforts needed in Trentino to attract and embed highly qualified human resources – be it students, teachers or researchers – the example of the IUB can give some ideas how the introduction of a new element in the existing education system can stimulate the dynamic of the whole. In the past couple of decades, Bremen's port and shipbuilding employment has been dramatically reduced, and the city seeks to develop a strong profile in science and technology in order to revitalise its economy. The founding of IUB is part of its regional innovation strategy. Since the IUB has been founded fairly recently, it is presented here as an ongoing experiment, not as a model success story. Still, in spite of its novelty, the IUB has already managed to reach a certain level of excellence. In an evaluation of the Stifterverband für die Deutsche Wissenschaft (assocation of benefactors for the German sciences) of Germany's 18 private higher education institutions in 2001, the IUB was one of three universitys rated best (1.5), as it provides a quality of education and research well above the average.

The principal similarities to the Trentino Region lie in the comparatively high degree of regional autonomy of Bremen as well as in the regional development goals. Both regions seek to attract large numbers of (foreign) students and researchers and to prevent brain-drain, aiming at

- a push towards international excellence in research and education;
- modernising university education through flexible introduction of new fields of study and new degree programmes;
- closer science-industry relations;
- attraction of additional external research funds.

The system of higher education in Bremen

Apart from the newly founded IUB, the Hansestadt Bremen offers a broad range of Higher Education Institutions such as the University of Bremen, the Hochschule Bremen and the Hochschule für Künste. The *University of Bremen* opened in 1971, during a period of rapid expansion of university education. Initially its orientation leaned towards social sciences and pedagogical education, but since the 1980s there are continuing efforts to strengthen natural sciences and technical subjects. In 2002/03 the university has 19,500 students and 1,427 fulltime research and teaching staff. Not surprising, the university is an important partner in knowledge transfer to regional SMEs.

The *Hochschule Bremen* (university of applied sciences) opened in 1982. In recent years it has developed a strong international orientation through its degree programmes, many of which now demand study times abroad. In 2002/03 7,200 students were inscribed. The *Hochschule für Künste* (university of fine arts) offers degrees in arts, digital media, design and music. In 2002/03 it had 732 students.

The project of founding an international private university started in the 1990s with the closing of an old army base. The property – which consisted of numerous brick buildings on an wooded "campus" at 20 km distance from Bremen city – was to be used for the development of research and education. The original idea of Bremen's senator for education, science, and the arts, Bringfriede Kahrs, and the rector (president) of the University of Bremen, Jürgen Timm, was to establish a branch campus of one of the leading US-American universities. Through personal and professional contacts between professors from University of Bremen and Rice University, Houston, the latter was gained as partner institution in 1997. However, as Rice University saw itself unable to establish a branch campus, the new institution was founded as independent private university IUB GmbH with Rice functioning as adviser and model. A partnership alignment was also signed between the IUB and the University of Bremen. The IUB attained start-up funds of 118 mio. Euro and recognition by the state of Bremen in 1999. The institution was accredited by the Wissenschaftsrat (federal science council) in 2001 and in the autumn of the same year received its first students.

Goals and Structure of the IUB

The goals of the institution are expressed in the overarching terms of *excellence, internationalisation, and transdisciplinarity*. The IUB is controlled by an independent board of governors who serve as trustees of its resources and mission. Students and staff are recruited from many countries. An income-blind admission process and a student / professor ratio of 12:1 are measures to enable the development of an excellent university community. There are presently three departments, the school of engineering and science, the school of humanities and social sciences, and the Jacobs Center of Lifelong Learning & Institutional Development. The departments are connected through several common transdisciplinary research themes. Degrees follow the American model encompassing bachelor, master and PhD. All teaching is in English, exchange programmes and international networks are being established, and all students are required to study at foreign universities.

The role envisaged for the IUB is one of a pioneer in the reform of the university system. The principal differences between IUB and German state universities lie in the stronger independency of the private university through replacement of continued institutional funding by private donations and tuition fees. The selection of students is given entirely to the discretion of the university. Opportunities for teacher-to-student contacts are much better through smaller classes. Another important difference relates to the flexibility of recruiting research and teaching personnel through limited contracts aiming at higher mobility and more frequent exchange of professors. Payment of scientific staff is designed to be performance-oriented.

These organisational governance principles are no new inventions and most German Länder now seek to implement some or all of them at state universities. Yet, since the process of university reform must be expected to proceed rather slowly, IUB's strategy is to realise competitive advantage through faster and more thorough implementation. Moreover, the state of Bremen seeks to add momentum to the reform movement in the national university sector through providing a test case and a successful model. The IUB is the first private university in Germany that aims at offering the full breadth of subjects typical of a university. Four years after foundation it is yet too early to evaluate the eventual success of IUB. Yet, the indicators of success show great promises:

- *growth:* goal of 1,200 students and 100 professors in 2005 seems likely to be achieved;
- *staff excellence:* unexpectedly high numbers of qualified applicants for professorships;
- *multinationality:* students from over 40 nations, many from eastern Europe;
- first successes in *fundraising*: major donations for renovation of two college buildings and for two permanent professorships in 2002;

- *research excellence:* first participation in DFG-Sonderforschungsbereich (programme in support of fundamental research) in political science;
- *research excellence:* co-operation with the renowned research centre ocean margins in Bremen.

Indicators of potential risks relate mainly to the dependence on private fund-raising:

- *attractivity of professorships in comparison with state universities*: today salaries are comparable, but a low number of additional staff and very high contractual obligations to attract external research funds may represent strong disincentives;
- *lack of regular institutional funding* may cause low competitiveness for national and EU-research funds, and may lead to strong dependence of research orientations on (short-term) business interests;
- *danger of insufficient fundraising* mainly due to missing national culture of private financial engagement in higher education.

3.4 Motivation for Trentino

As already pointed out at the end of chapter 2, these examples should not be regarded as instruction of "how to do it", but as good practises illustrating how the funding of applied-oriented research institutes could be organised, the development of an incubator could take place or the foundation of a private university be initiated. The examples were selected in order to serve specific purposes. Thus, the Fraunhofer model of institutional funding should not be applied to basic research at universities. Yet, the more the Trentinian non-university research institutes carry out applied research for industrial customers, the more the question could be raised whether their funding system should contain a success-based element, rewarding openness for market-induced research tasks. The Fraunhofer model is very much oriented towards rewarding industrial proceeds, but rewards advances in application-oriented basic research to a much lesser extent. When a certain part of an institute's budget is fuelled by market-based activities, this could serve as stimulus for improving the science-industry bridge and the interlinking between the two systems.

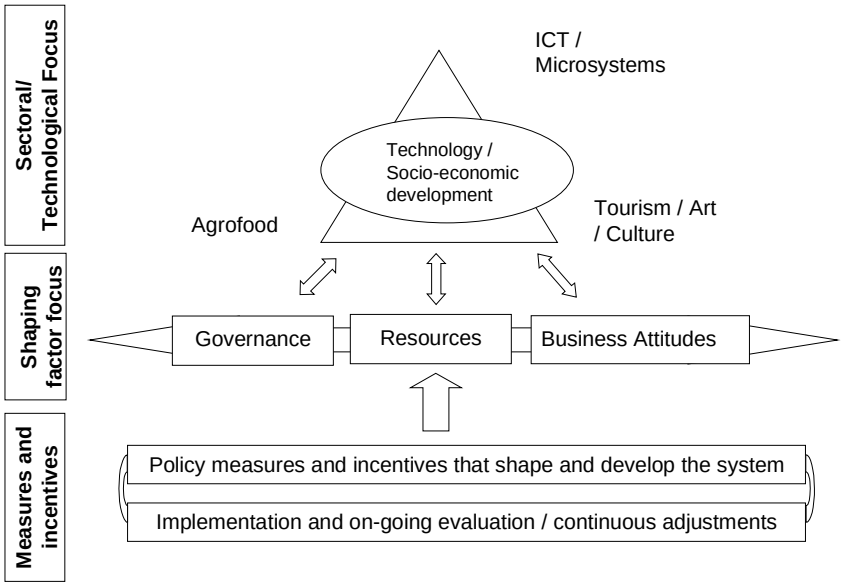
The same aspect of transferability applies to the other examples. The case of Nancy provides some insights into the important role of incubators in regional development, but also into the complexity and the necessary time of developing sustainable organisational structures which can narrow the gap between scientific research and its industrial application. The idea behind presenting this case is not to make it an objective for Trentino to develop an incubator like the one in Nancy. But this model case shows that it might be worthwhile to include this instrument in strategic

thoughts. This applies also for the example of the International University Bremen, which provides a specific solution for a specific regional and national context. Yet, the general lesson that can be drawn from its foundation is how an organisational structure of an educational and research system can be changed and opened for more competition between the different teaching and research institutes. It can thus serve as an example for Trentino of how new research and teaching fields can be opened and how more flexibility in the research infrastructure can be obtained.

4 "Trentino plus 10": The vision of Trentino and its specialisation cluster in ten years

It is by now generally accepted that innovation is not a linear process, but characterised by evolutionary, cumulative and feedback elements. Policy makers who want to promote an innovation system are faced with the problem that there are a multitude of shaping factors and complexity in a regional innovation system which make it difficult to direct and steer. Different stakeholders and actor groups, market trends and technological developments have all to be taken into account. Complexity emerges also from the fact that innovation is based on co-operation and social and economic interaction between a whole variety of different actors and different actor groups. In order to develop adequate regional research and innovation policies, priorities have thus to be set.

Figure 13: Focal dimensions in the Trentino foresight process



For this reason, the foresight process in Trentino was channelled by two focal dimensions, the sectoral and technological priorities developed in the Trentino Competence Triangle (section 4.1), and the decisive shaping factors for bringing about the desired changes. Both, the sectoral and technological priorities as well as the shaping factors determine the measures and incentives which are necessary in order to achieve the desired goal of making Trentino one of the leading Italian and European innovation districts (section 4.2, cf. Figure 13).

4.1 Trentino Competence Triangle – technological and sectoral focus

As traditional locational factors lose more and more importance in favour of factors like knowledge, technology and innovation potential, an intensification of competition affecting both nation states and regions can be observed. The development of an innovation system that can meet the demands of the emerging knowledge-based economy is posing great challenges for regions all over Europe. Within these general framework conditions, the Provincia Autonoma di Trento is in the position to dispose of a well developed science and technology base as well as funds and the resolution to apply these to restructure the present research and innovation system to ensure long-term welfare for its inhabitants in the coming knowledge society. For this purpose, the establishment of a clear structured system of priority setting is an imperative. Only with a well-defined perspective of where resources should be invested, the goal of developing Trentino into one of the leading European innovation districts in ten years in its distinct sectoral specialisation can be reached.

While many regions around the world are investing in establishing competitive clusters in recognised future key technologies like information and communication or biotechnology, only a few broadly positioned territories will be able to become international leaders in these technologies. For smaller regions with a limited scope, the key success factor lies in specialisation. Newly emerging technology fields should therefore be fostered building on existing (sectoral) strengths. Although many lessons can be learned by studying the emergence of successful global centres, due to the intricacies of path dependence, these developments cannot be copied in a simple way. On the contrary, it is the regionally specific and embedded competitive factors that can provide a territory with the decisive edge to attract and hold the human, entrepreneurial and financial capital needed for becoming an international player in specialised technologies.

Of the six technology fields identified as critical for the future development of the Italian industry – aerospace technologies, advanced materials, energetic technologies, information and communication technologies (ICT), biotechnologies, nanotechnologies[33] – three are already anchored in the Province (ICT, microsystems, materials) and a fourth is in the process of being established (biotechnology). In such new growth technologies, there is a fierce competition between territories for attracting players from the business sector and academia in order to become one of the few internationally relevant competence centres. Due to the well-known mechanisms of external/network effects, critical mass and path dependence, it is generally accepted that timing is crucial for trying to establish economic clusters in new technologies. Yet, the evidence of so-called "historical accidents" also shows

33 Technology foresight, technology transfer and local economic development (2003), Fondazione Rosselli/Politecnico di Milano - Centro Politecnico Innovazione, commissioned by MIUR.

that conscious and planned actions and policies have only a limited influence on the eventual developments. Whether the locational "windows of opportunity" for these technologies are still open at present is a question that even in hindsight will be difficult to answer. The uncertainty about future perspectives is therefore greater for emerging technologies than for established economic sectors.[34] It is thus in many respects a political decision to what extent resources and capacities are directed in these growth sectors.

Of the mentioned future key technologies, especially ICT and nanotechnologies can be regarded as cross-sectoral technologies, that will be developed mainly in context with other sectors. In the sixth framework programme of the EU, research in information society technologies is constituting the main funding priority. Next to direct employment effects, these technologies also lead to significant indirect effects with considerable influence on established sectors. It is generally assumed that almost all economic branches will undergo substantial changes due to advances in ICT and nanotechnologies. Nanotechnologies are being heralded as the drivers for the next industrial revolution and expected to offer huge economic potential as the basis for many new kinds of application. The EU is aiming at integrating this research area with knowledge-based multifunctional materials and new productions processes and devices in order to attain improved security and quality of life.[35] As these cross-sectional technologies will affect almost every aspect of economic life, it is of great importance for territories to hold a critical mass of enterprises and private as well as public research capacity. Their cross-sectoral nature makes them indispensable as key future technologies and necessitates at the same a clear containment to specific applications.

Especially given the size of the territory, a broad coverage of the new growth technology fields is not feasible for Trentino as research activities are expected to be high risk, inter- and multi-disciplinary, long term and generic. Priorities should be set with a view to development and application in existing sectoral concentrations in order to achieve synergies with present resources. Based on previous studies and the results of the Fraunhofer ISI project, two sectoral priorities were identified:

- "strengths bound to the territory" which centre on the agrofood sector and include green biotech as well as the environmental sciences and
- "traditional competencies with future prospects" with the mainstay in tourism, art and culture complemented by the building sector, health and humanities.

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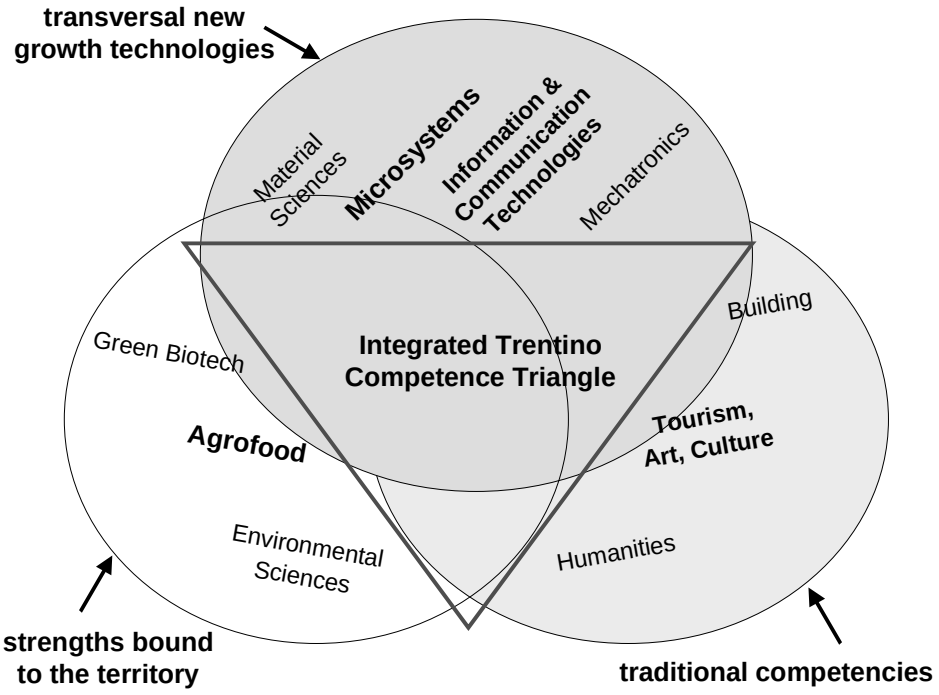
34 Sanchez, N.F./Rehfeld, D. (2003): Potenzialanalyse OWL. Branchen, Kompetenzen, Perspektiven. Gelsenkirchen: Institut Arbeit und Technik.

35 EU (2003): Priority 3: targeting a transformation of industry, *European Industrial Research*, 10-13.

In combination with the mentioned transversal new growth technologies, these sectoral priorities have high potential of constituting a distinct specialisation cluster for the PAT, thus providing Trentino with a unique competitive advantage among the European regions. Of the three emerging technologies already anchored in the province, especially ICT and microsystems show a multitude of possibilities for integration with these sectoral strengths. The following Figure 14 illustrates possible integrated competences specific for Trentino at the interfaces between the two sectoral priorities and the transversal "future" technologies.

Figure 14: Trentino Competence triangle 2014



In developing new technologies at the interfaces of the triangle, the idea of "Trentino as a lab" could be fostered further in the Province. Efforts could thus be directed in establishing provincial players in specialised niche markets – with an international scope – and in promoting and spurring complementary services and production next to scientific research. Promoting, for example, the technology development for intelligent microsensors in food processing, genetic information processing applied to agrofood, microsystems in quality control for environmental protection/food production, domotics in high quality/wellness tourism, multichannel and multisensorial interaction in cultural/touristic experiences or pervasive computing applications for environmental protection/tourism could provide the Provincia Autonoma di Trento with a specific specialisation and competitive advantage

with regard to the scientific-technological profile of neighbouring regions. Yet, the proposed sectoral and technological focus of the Trentino Competence Triangle should not be regarded as fixed. Due to rapidly changing technological developments and market demands, it will have to be updated in regular intervals according to performance and technological and socio-economic change. However, the priority and focus provided by the Competence Triangle are regarded as essential for the future shaping of the Trentino research and innovation system.

The importance of focussing and integrating research is also stressed in the Sixth Framework Programme of the EU. Moves towards multi-disciplinarity and the integration of what were formerly regarded as discrete technologies are perceived as crucial elements in the future mode of knowledge acquisition.[36] Especially in ICT, interdisciplinary research with other fields will be essential in the future. Thus, the Japanese national foresight report of 2001[37] states that information processing is not only an important academic field in itself, but also a key driving force for R&D in other fields, and plays a decisive role of cultivating new social applications. Therefore, interdisciplinary co-operation with the social sciences can contribute to the opening up of new social systems. Not only the stress on integration and interdisciplinarity, but also the priorities proposed in the Fraunhofer ISI-project correspond with the foci of the Sixth Framework Programme. Next to information society and nano technologies, the EU accords a high significance to high-knowledge-content materials which are perceived as a force for innovation in technologies, devices and systems. Health, safety and the environment are regarded as primary areas of positive impact of such multi-sectoral applications. Further EU funding priorities cover food quality and safety as well as sustainable development and ecosystems, topics that are centrally placed in the Trentino Competence Triangle.[38] The importance of the agrofood sector for the future economic system is emphasised in many European foresight projects as for example in those of Spain, Great Britain and Sweden.[39]

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36 EU (2003): Priority 3: targeting a transformation of industry, *European Industrial Research*, 10-13.

37 NISTEP (2001): *The seventh technology foresight. Future technology in Japan toward the year 2030.* NISTEP Report No. 71. National Institute of Science and Technology Policy, Japan.

38 EU (2003): Priority 3: targeting a transformation of industry, *European Industrial Research*, 10-13.

39 Pino, A./Khayyat, N./Villarán, C./Sánchez, A./Morato, A. (2003*) Agroalimentación. Tendencias tecnológicas a medio y largo plazo*. Madrid: OPTI Observatorio de Prospectiva Tecnológica Industrial; FCCI Foresight Panel (2000) *Preparing for the future. Food Chain and Crops for Industry (FCCI) Panel report*. London: Department of Trade and Industry; Swedish Technology Foresight Project (2000) The Foresighted Society. Stockholm: IVA, NUTEK.

4.2 Shaping factors for the future of Trentino's research and innovation system

In the Trentino foresight exercise of Fraunhofer ISI, in addition to the technological and sectoral specialisation, central shaping factors for the future development of the provincial research and innovation system were identified. These shaping factors were based on the results of the strengths and weaknesses profile of the Province and developed in three strategic areas:

- *Governance:* institutional setting of scientific and industrial system, regulation, administration
- *Resources:* higher education, scientific and business competences, work force, infrastructure
- *Business attitudes:* networking, knowledge transfer, entrepreneurial attitudes, intermediary organisations

The possible impact and priority of shaping factors in these strategic areas was discussed in three working groups with representatives of the different stakeholders and interest groups at the foresight workshop.

In the *Governance working group*, possibilities of a horizontal and systemic innovation policy design oriented towards cross-sectoral and interdisciplinary linkages in the Trentino Competence Triangle were debated. With regard to future priority setting in the policy making of the Province, the discussion made clear that it will be necessary to continuously observe developments in international science, technology and markets – e.g., through strategic intelligence, further foresight exercises, evaluation and monitoring – in order to be able to flexibly adapt to changes and keep up with international competition. Research and innovation policies in the Province will have to be directed clearer to distinctive areas of research specialisation and more targeted efforts have to be directed at integrating the knowledge flow and innovation orientation across the innovation chain.

In the *Resources working group*, the highest priority was given to the system of resource allocation in the research system. An increase in flexibility, clarity and incentive-orientation as well as further promotion of private investment in R&D were perceived as necessary changes in this system. A second important driver of change was developing and retaining highly qualified human capital which touches on the points of Trentino's attractivity for manpower especially excellent international students and the quality of basic education. In this context, the scarcity of management competencies and capacities in the Province were also debated. Particularly in the traditional specialisation sectors, an employment push towards activities with a higher value would open new market opportunities to the Province.

Overall it became clear that it will be necessary to broaden the understanding of valuable resources and their implementation in the Province.

The most important topic in the *Business attitudes working group* was exchange and co-operation, the fundamental structural element of innovation systems. The discussion centred on interfirm and intersectoral networking and value chains, questions of integration into national and international networks and value chains as well as the intensity of knowledge and technology transfer between firms and science sector. A further shaping factor debated one of the weaknesses of the Trentino innovation system, the entrepreneurial attitude and "economic atmosphere" in the Province. In order to transfer and transform the knowledge generated in the research institutions into marketable products and thus into welfare for the Trentino population, it will be necessary to promote a stronger entrepreneurial spirit among a broad share of the population.

4.3 Suggested policy measures for the further development of the provincial science and technology base

On the basis of the results of the foresight workshop as well as the previous working packages, the following research and innovation policies were developed in the Fraunhofer ISI project. These policies are suggested as foundation for further promotion of the research and innovation system in the integration of the science and business system, improvement of entrepreneurial attitudes and linkages within the business system, priority setting in the research funding system and the research infrastructure, and the development of the technology base with regard to already existing strengths and the exploitation of competitive advantages. The policy measures should be used to strengthen the interfaces and interactions between the three different poles of the triangle, strengthen transdisciplinarity in public and industrial research and maintain and strengthen critical mass in the Triangle sectors creating a flexible and knowledge-exchange-intensive "community" for research.

Five objectives can be identified for reaching the desired goal of making Trentino one of the leading Italian and European innovation districts:

Objective 1: Establish an open, high level and flexible *research system* attractive to foreign researchers and students.

Measures:

- Change public funding of the existing non-university research centres towards a more incentive-related funding model. Performance indicators should include:
  networking and joint research projects between research and industry

technology transfer (e.g., number of patents, number of spin-offs)

international research projects

third-party funding (esp. international funding)

- Integrate the differing sub-systems into one joint research system by:

  opening up the different sub-systems for a smooth transfer of people between the different research organisations (university, ITC, IASMA, private and other research institutes), also for allowing changes from academia to industry and back

  establishing common rules of financing and funding for all institutes

- Change the contract and salary system for researchers in order to be able to attract and hold highly qualified researchers (regional, national, international) including:

  a career perspective after an initial 5 to 6 years qualification stage with fixed-term contracts

  flexible salary-increases with performance incentives

Suggestion: Restructure provincial research institutes

While the quality of the research conducted in the provincial institutes is recognised as internationally competitive, the interviews showed that there is a general feeling of lack of strategical planning and usage of possible synergies between the institutes. A second anxiety concerns the attraction and keeping of highly qualified researchers as there seems to be a gap between building highly qualified human capital and providing long-term and at the same time flexible career perspectives.

It is generally agreed that these concerns could be lessened with introducing stronger performance incentives in the funding structure of the institutions. Yet, the question of restructuring the system of provincial research institutes should be addressed on a more fundamental level. Next to the funding structure, key aspects are the internal structure and organisation, role and influence of the provincial government and the legal status of the research institutes. A higher degree of flexibility can be achieved by transforming institutes into foundations, associations or even corporations as, for example, in the model of the Fraunhofer or Max Planck Gesellschaft or the German research centres ("Helmholtz-Gemeinschaft Deutscher Forschungszentren"). Such institutions would have to be provided with explicit structures and bodies for strategic planning and setting of research priorities as well as monitoring systems as the role of the provincial government will be diminished. Organisational and funding structure are not necessarily interdependent although greater flexibility in organisation can be complemented with a funding model with higher autonomy from the government, for example, in a model of 60 percent public to 40 percent third party funding.

Restructuring should not only be focused on the necessities of organisation but also on the necessities of research fields and development. Questions of optimal size, of rate of basic to applied research, of the benefit/necessity of interdisciplinary co-operation and of funding opportunities differ between the research fields. Yet, it should be pointed out that there is not one optimal model for structuring such a research system but different conceivable options depending not only on organisational and disciplinary specificities but also on *political decisions and priority setting*. What the research system should provide is a structure common to all provincial institutions that allows and promotes the exchange not only of information and knowledge but also of researchers between the institutes and at the same time leaves manoeuvring space for adapting to international technological changes and disciplinary specificities.

Objective 2: Make the *research infrastructure* competitive and design it as a role model for other European regions.

Measures:

- Create a more fluid and flexible research infrastructure by:

  funding temporary research and innovation competence centres incorporating regional, national and international researchers in areas of the Trentino competence triangle

  funding small and excellent research and education units in areas not yet covered

- Further the international reputation and at the same time regional integration of the higher education institutions by:

  funding new chairs at the university and recruiting professors with a high reputation

  co-funding chairs and institutes in Triangle-relevant disciplines with the regional economy

  broadening the educational base of the province, in high-tech sectors (e.g., biotech, ICT) and upgrade traditional sectors (e.g., high quality tourism), by establishing respective schools

Suggestion: Broaden the educational base of the province

Although the ranking of the university of Trento is proving the high quality of its education, there are several aspects indicating that in a broader sense the educational basis in Trentino could be supplemented. These aspects include the low propensity of Trentino people for higher education, the lack of entrepreneurial and management skills, low proportion of international students and the lack of certain key disciplines (e.g., biology department as a base for the development of biotech competencies) and sectors (e.g., tourism).

In the education system, the options of the provincial government for exertion of influence and restructuring are limited by national constraints, yet, there remain a number of possible actions. For example, efforts could be made to improve the quality of basic education and increase motivation to learn by introducing new teaching methods and possibly new teachers. Although the university as a national institution is not in the influence sphere of the province, the funding of new chairs could prove a way to add disciplines of regional interest to the university's range. If co-funded with local firms, this would also provide opportunities to increase the exchange between academia and business world. In this way, entrepreneurial knowledge and spirit could be infused into higher education and could be integrated into a broader programme to promote university start-ups.

Additionally, the provincial government could also try to build up own higher education institutions or attract the subsidiary of an international university. This would also increase the number of foreign students and thus of foreign teachers and researchers, raising international exchange and access to external knowledge sources. With such higher education institutions the province would be able to support and advance priorities set in the research and innovation system according to the Trentino competence triangle by a complementary human capital strategy.

Objective 3: Promote *co-operation* and foster *transfer* between research and industry sector

Measures:

- Increase knowledge exchange between firms and university/research centres by:

  creating platforms (e.g., market place for all research centres) and nominating contact persons for a frequent dialogue

  setting up specific technology transfer agencies with a broad portfolio of ideas, with the right competences and for marketing success stories

  sharing human resources between firms and research institutes, i.e., promote changing from academia to industry and vice versa by opening up strict contract and career systems

- Establish a Triangle-innovation oriented business incubator closely linked to the research competence of Trentino
- Support the commercialisation of research results by

  a patenting and licensing support scheme for individuals and SMEs

  providing financial support for research groups which aim at joint patenting

  providing management and financial support for spin-offs

Suggestion: Establish a programme for competence centres

For the expansion of transfer and co-operation between academia and the business sector a programme for supporting competence centres could prove useful. As the results of the interviews have shown, there is a deplorable lack of interaction between these spheres in the province and great need for bringing these actor groups together. More intense and long-term oriented co-operation between academia and industry – as in competence centres – should promote a stronger industrial orientation of academic research, direct it towards excellence and enhance its international reputation. It can also create the critical mass necessary to carry out high-level research. At the same time it may give companies a greater incentive to increase their R&D expenditures (additionality effects), which are traditionally low in Trentino even compared to Italian standards. Through the establishment of competence centres, the province would be able to strengthen research priorities in the regional innovation system according to the Trentino competence triangle.

Competence centres are collaborative research institutions aimed at high-quality, pre-competitive and industrial basic R&D activities that fulfil the needs of the industrial sector and preserve high academic standards. These centres are based on a partnership between university, other research institutions, industry and the government and run only for a limited time. Funding is shared between the government and the private investors, with a set constraint for the amount of public financing. With such centres, competences can be build up in specific research fields and at the same time long-term co-operation supported with a possible positive structural effect on the of the encompassing research and innovation system.

Such a funding programme for competence centres could be guided by the international experiences made with the Austrian K-plus, Swedish NUTEK, Canadian Networks of Centres of Excellence or Australian Cooperative Research Centre Programme where these centres operate successfully.

Objective 4: Improve *innovation competencies* in industry and the entrepreneurial culture in the Province

Measures:

- Increase the entrepreneurial dynamic in the Province by:

  promoting an investment friendly climate with a minimal degree of bureaucracy

  promoting the formation of spin-offs and start-ups by information and financial support

- Support management skills by:

  establishing innovation management training courses for industrial managers, especially for those of small companies

  educating also researchers in innovation management

  teaching entrepreneurship to pupils, students and graduates

- Boost the transfer of research project output in marketable products by:

  involving firms in the definition and development of projects, e.g., creating advisory boards with firms

  generating research projects in co-operation and with (financial) support from industry

Suggestion: Science & Technology Park/Incubator

Science and technology parks have been an important measure in promoting regional firm foundation and the commercialisation of innovations for the past 30 years. Nevertheless, not all of these parks became successful and not all firms in a park ended in a success story. It is not only a question of the size of a park, its management or the kind and quality of the services offered, but of the regional and local milieu the park belongs to. Depending on the objectives a science and technology park should contribute to, different ingredients are necessary preconditions for a successful development path. When a park and its firms should contribute to the promotion and application of new technologies, it is of overwhelming importance that the tenants have close access to excellence research and development work and to human capital in their field of economic activity.

For Trentino it seems to be a development option to establish a science and technology park for newly founded or already existing technology-based firms active in certain technology fields covered by the triangle strategy (e.g. ICT, microsystems, mechatronic), offering them close access to research results produced at the university, IRST and other institutes. Since regular face-to-face contacts and intense ex-

change between researchers in the firms and in the institutes play an important role, geographical proximity to the relevant institutes matters.

An important new function of science and technology parks is incubation. Researchers from the institutes should be supported in the pre-stages of firm foundation by advice, qualification offers and financial assistance. For promoting a culture of entrepreneurship in Trentino, and incubator closely associated to the science and technology park could play an important role.

In Sweden, the UK or the Netherlands (e.g. Groningen Science Park and Incubator) examples of success stories can be found which could provide additional insights into the necessary steps and measures which have to be undertaken for establishing a science and technology park/incubator in Trentino.

Objective 5: *Allocate public funds* efficiently and effectively so that sustainable wealth and income will contribute to a long lasting successful development path

Measures:

- Establish a system of setting research priorities and coherent research planning

  using different levels of priority setting (i.e., thematic priorities and institutional priorities)

  align research priorities with national and European objectives for continuity and matching funds

  clarifying the level of autonomy of the research centres and providing them with funds for own strategic planning

- Make these research priorities and the planning system transparent to all interest groups and use their input by:

  creating open strategic groups with long-term perspective and mixed backgrounds

  introducing and applying strategic intelligence: foresight exercises; continuous monitoring, evaluation and benchmarking of programmes and competence centres

- Improve the system of project funding for firms by:

  speeding up the evaluation process and the feedback from PAT in the existing research funding programmes

  establishing new lines of funding which encourage firms to co-fund research

- Improve the system of project funding for research institutions by:

  awarding co-operation and internationalisation

putting stronger emphasis on the evaluation of output, synergies and critical mass

- Establish an internationally recognised competence centre in strategic intelligence by:

  drawing together provincial and international experts in methods for gaining information for strategic intelligence, e.g., performance measurement, benchmarking initiatives, evaluation studies, foresight exercises, or technology assessment

  further developing these tools in the Trentino research and innovation system and providing different sets of institutions in Trentino with the appropriate information for strategic planning

  supplying the refined tools for other regions (national and international)

Suggestion: Further use of strategic intelligence in priority setting and planning of Trentino's research and innovation system

One of the key demands emerging from the interviews and the foresight workshop was the need for an explicit system of setting research priorities and coherent research planning. In light of the increasing speed of development and change of international markets and technologies as well as the shortening of the validity of knowledge, it is foreseeable that such a system has to be shaped so as to not only adapt flexibly to these changes but also to proactively conceive of and pursue strategies that will sow the seeds for future welfare even in uncertain technological terrains. Knowledge and information are the key factors for the functioning of such a system that will be fitting for the emerging knowledge age.

Building up competences in providing such strategic intelligence for research and innovation policy in a provincial centre would firstly provide Trentino with a specific advantage against other regions and secondly could prove as the means to expand co-operations and networks with other regions. Thus, the province could be further integrated into the European Research Area and become closely tied in international networks of knowledge exchange and production.

5 Outlook and further steps

The fundamental recommendation underlying the suggested policy measures by Fraunhofer ISI is to create a greater flexibility within the institutional fabric of the Province. This concerns the science system, in which the research infrastructure should be subject to further adjustment according to newly introduced general priorities, but also the governance system which needs a re-shaping with regard to a stronger emphasis on priority setting in research and technology funding. It concerns also the higher education system which is so far fairly independent from PAT's influence on its science base and which needs a stronger focus on the scientific backing of the proposed competence triangle. It even concerns the business system, in which entrepreneurship and R&D have to play a greater role in a competitive future Trentino and in which resources should be coupled and synergies be exploited by a tighter networking within the system and also between the science and the business system. Recommendations like competence networks or the temporally limited promotion of interdisciplinary research groups illustrate possible ways of change and re-orientation.

The second important message is that Trentino should further engage in new, future-oriented technologies, both by own development work of the Trentinian research institutes and firms, and by application of external knowledge. Much potential is already available within the Province and should be further utilised as, for example, in the application of pervasive computing for environmental, agricultural, housing, logistics or health issues. However, Trentino should take care not to lose ground in its traditional sectors which not only today but also in the future can significantly contribute to value added and wealth in the Province. Yet, this will only be possible, if Trentino manages to link the traditional strengths with new knowledge and new technologies, thus upgrading them. Future possibilities like the improvement of quality in agrofood or the development of new target groups in tourism, for example, will be determined by the success of incorporating of new scientific ideas, new technical solutions and new organisational concepts in products, processes and services.

Bearing the complexity of a regional economy and a regional science and innovation system in mind, the recommendations made in this report cannot be exhaustive and detailed in every aspect. They should be regarded as framework and as a scientifically based collection of ideas and motivations. Their major function is the initiation of a discussion process in the Province at the end of which a set of approved measures can be formulated and implemented. While such a process cannot be finished in zero time, it should also not be ever lasting. Within the framework described in this project, a first step has been made to open the minds for an acceptance that in a united and expanding Europe new strategies are necessary for preserving Trentino's so far favourable economic conditions. In this respect, the proc-

ess documented in this report is not at its final stage, but just at a promising beginning. Fraunhofer ISI is proud that is has been selected to act as advisor and catalyst in this first phase. When needed, it would also be happy to accompany and contribute to further steps in the shaping and implementation of the "Trentino plus 10" strategy.