Annex 6

Jakob Vestergaard, Innovation and University Interaction with Industry in Colombia – Policies, expereriences and future challenges, Study Commissioned by the World Bank, Nov. 2006

INNOVATION AND
UNIVERSITY INTERACTION WITH INDUSTRY
IN COLOMBIA

- Policies, experiences and future challenges

Study commissioned by the World Bank[1]

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[1] The views expressed in this paper are entirely those of the author and do not necessarily represent the views of the World Bank, its Executive Directors or the countries they represent..

Foreword

First of all, thanks to the interviewees for taking time to participate in this study. The interviewees were:

Universities:
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Alvaro Turriago, Camilo Diaz, Diego Zuluaga, Fanny Almario, Felipe García Vallejo, Fernando García, Gabriel Zamudio, Galo Tovar Narváez, Iván Montenegro, Javier Medina, Julio Vaca, and Maria del Rosario Guerra de Mesa.

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Last but not least, I should like to thank Roberto Pizarro who, in addition to being an excellent translator, was an important source of information and insight on Colombia.

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ACRONYMS & ABBREVIATIONS

CST	Council for Science and Technology (UK)
DfES	Department of Education and Skills (UK)
HEI	Higher Education Institutions
IDB	The Inter-American Development Bank
IOs	Intermediary organisations
ITD	Innovation and technology development
NIS	National innovation system
OCyT	Colombian Observatory of Science and Technology
OST	Office of Science and Technology
RICYT	Red de Indicadores de Ciencia y Tecnología
SET	Science, engineering and technology
SMEs	Small and medium size enterprises
STPC	Science and Technology Policy Council (Finland)
S&T	Science and technology
TEKES	The National Technology Agency (Finland)
TNCs	Transnational companies
WB	The World Bank
WDI	World Development Indicators

INTRODUCTION

BACKROUND, RESEARCH QUESTIONS AND METHODOLOGY

1 INTRODUCTION: BACKGROUND, RESEARCH QUESTIONS AND METHODOLOGY

1.1 Background

This study proceeds from the World Bank's assessment that Colombian innovation system could significantly contribute to the development of a knowledge-based economy, but its potential has not been fully realized. In the last decade, Columbia has made considerable efforts to improve its science base, yet investment in science has not translated into a high level of innovation in the private sector. The problem lies partly in weak interaction between research institutions and private firms. Weak industry-science linkages reduce economic benefits from public investments into science and technology and hamper the development of knowledge-based firms that are competitive in the global economy. The present study undertakes an analysis of the institutional framework for university interaction with industry within the context of the overall innovation system. The overarching objective of the study is to make policy recommendations that may assist the Colombian government in promoting science and technology driven economic development.

1.2 Research questions and methodology

The study seeks to arrive at the formulation of policy recommendations by addressing the following set of research questions:

a) What are the framework conditions for innovation and what is the nature of the institutional set-up of the innovation system in Colombia?
b) Which institutions, rules, programs and policies have been introduced to stimulate (i) university interaction with industry and (ii) innovation?
c) How does the Colombian innovation system compare in terms of institutional set-up with other Latin American countries and the developed countries?
d) Building upon this comparison, which institutional reforms could improve the performance of the Colombian innovation system?

In addressing the stated research questions, the report draws upon the conceptual framework developed in a recent benchmarking study of European science and technology policies (EC 2001). The key concept in the methodology developed by the EC was that of 'framework conditions', for university interaction with industry. This conceptual framework may be seen as an operationalisation of the concept of a National Innovation System (NIS). The concept of a NIS is a contested one, and a number of different definitions exist.[2] For the purpose of this study, a National Innovation System will be seen as comprised of a set of *organizations* and a set of *institutions* (Alcorta & Peres 1998) "which interact in the production, diffusion and use of new, and economically useful knowledge" (Lundvall 1992). The *institutions* are "rules and laws, established practices and common habits and routines that govern the behaviour of organisations" and *organisations* are "actors with predetermined roles within the innovation process, including basic and applied research; knowledge dissemination; invention; product and process research, design, experimentation and development; and, new product commercialisation" (Alcorta & Peres 1998: 859-860). In the framework adopted in this study, each of the two components of the NIS conceptualisation is further decomposed in two. Institutions are divided in on the one hand the legislative and cultural foundation for innovation in the country and, on the other hand, the promotional policies and programmes introduced to actively stimulate innovation processes.

[2] For a discussion of competing definitions of the NIS concept, see Niosi 2002.

Organizations are divided in, on the one hand, the agencies charged with the task of either funding or making policies for innovation activities (the institutional setting) and, on the other hand, the organisations engaged *operationally* in activities promoting industry-science interaction (intermediary structures).

Table 1 Four components of National Innovation Systems

Institutions		Organizations	
Legislation and culture	Promotion programmes	Institutional setting and funding system	Intermediary structures

On the basis of this policy-oriented conceptualisation of a National Innovation System, the research design consists in combining the following five elements:

- Collection and systematisation of national data on the Colombian innovation system
- Validation of these national data by interviewing national experts (academic as well as governmental)
- Interviews with top representatives at key universities on strategies and initiatives for interacting with local industry
- Interviews with national experts (academic as well as governmental) on what they see as the most enabling national framework conditions, as well as what they see as the main barriers to university interaction with industry and business innovation
- Interview with policy experts on future challenges and possible policy strategies in the promotion of (i) university interaction with industry and (ii) innovation

The present report is based, in other words, on a combination of desk research and interviews with key experts at the national policy level, and at the university level.[3] The interviews were *policy-focused*, in the sense that particular emphasis was given to the enabling and restraining roles of policy with respect to innovation and university interaction with industry. Further, interviews were *change-oriented*, in the sense that all interviewees were asked to identify possible future reforms that they believed would further stimulate university interaction with industry.

Finally, the methodology adopted is *comparative*. This is manifested in two ways. First, for each of four components of the National Innovation System defined above, the study compares findings for Colombia with findings in previous studies of Finland and UK, in which the same methodology was applied.[4] Second, the report benchmarks the Colombian experience not only against the National Innovation Systems in Finland and UK, but against overall trends in economic growth and S&T investments in a wider range of countries, including Brazil, Chile, Finland, Malaysia, Japan, Spain and UK.

The methodology is reflected in the structuring of the report: Each of the defined NIS components has a separate chapter describing findings in Finland, UK and Colombia, and ending with a comparative discussion identifying potential lessons for future S&T policy-making in Colombia.

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[3] Given the time and resource constraints of the study it was not possible to interview all relevant actors groups. For a full list of interviewees; see the preface. Among the relevant actors groups that were not interviewed were the following: Technology Development Centres, Centres of Excellence, universities in other regions than Bogotá, private sector companies, ASCUN, Department of National Planning, CONPES, etc.

[4] Readers interested in more detail on the Finland and UK cases, can refer to Vestergaard 2003a and 2003b

Thus, the remainder of the report consists of the following chapters: a brief, overall comparison of economic growth and S&T investments in eight countries (Chapter 2), a history of science and technology policies in Finland, the UK and Colombia (Chapter 3); a description and discussion of legislation and culture pertaining to the NIS in Finland, the UK and Colombia (Chapter 4), a description and discussion of the institutional setting and funding system of the NIS in Finland, the UK and Colombia (Chapter 5), a description and discussion of the promotion programmes in Finland, the UK and Colombia (Chapter 6), a description and discussion of the intermediary structures of the NIS in Finland, the UK and Colombia (Chapter 7). Each of the chapters 3 to 7 ends with a section on potential policy lessons for Colombia. These sections are gathered in Chapter 8 (in a slightly shortened version), and thus the busy reader may start here, and then refer back to individual chapters of special interest.

CHAPTER 2

BENCHMARKING ECONOMIC GROWTH AND S&T INVESTMENTS

2 BENCHMARKING ECONOMIC GROWTH AND S&T INVESTMENTS

In 1991, Colombia embarked upon an economic policy trajectory of liberalization, privatization and structural reform – *Apertura* – and growth expectations were high. The expectations, however, were not met. Today, 14 years later, the reality is that the Colombian growth over the period is among the lowest in Latin America (World Bank 2005), and considerably behind developing economies such as Chile and Malaysia which, in 1991, were on par with Colombia in terms of GDP per capita (see table 2 below).

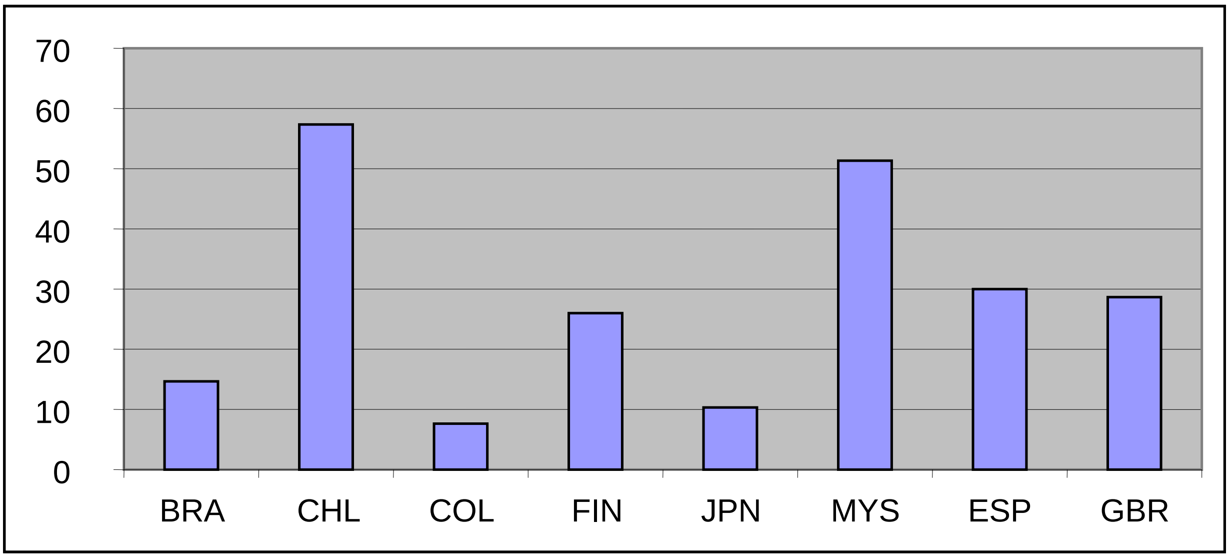
Table 2 GDP per capita (PPP, constant 2000 USD)

	1991	1993	1995	1997	1999	2001	2003
BRA	6,425	6,517	6,930	7,189	7,086	7,423	7,360
CHL	6,167	7,029	7,993	8,912	8,819	9,378	9,706
COL	5,889	6,021	6,341	6,473	5,979	6,113	6,331
FIN	20,688	19,845	20,706	22,329	24,008	25,172	26,092
JPN	23,929	24,053	24,630	25,676	25,299	25,932	26,420
MYS	5,937	6,742	7,683	8,692	8,305	8,708	8,986
ESP	16,282	16,146	16,934	17,919	19,298	20,490	21,152
GBR	19,945	20,256	21,601	22,703	24,008	24,968	25,645

Source: WDI Online

As it appears, GDP per capita in Colombia is less than 25 pct of what it is in countries such as Finland, Japan and the UK. Moreover, it is the lowest of this selection of countries, including Chile and Malaysia. This was the case also in 1991, but at that time differences in GDP per capita between Chile, Colombia and Malaysia were very small, ranging from approx. 5.900 USD to 6.200 USD. By 2003, however, Colombia had fallen significantly behind. Differences in growth performances come out very clear when the overall growth over the period from 1991 to 2003 is depicted graphically:

Figure 1 Growth in GDP (%) from 1991 to 2003



Source: WDI Online

Note: MYS stands for Malaysia.

The modest growth performance of Colombia through the 1990s is all the more worrying given that in the 1980s, Colombia were among the best performing economies in Latin America (World Bank 2005, UN 1999: 22). In fact, among the selection of Latin American countries presented below (table 3), only Colombia and Chile had positive GDP growth in the 1980s.

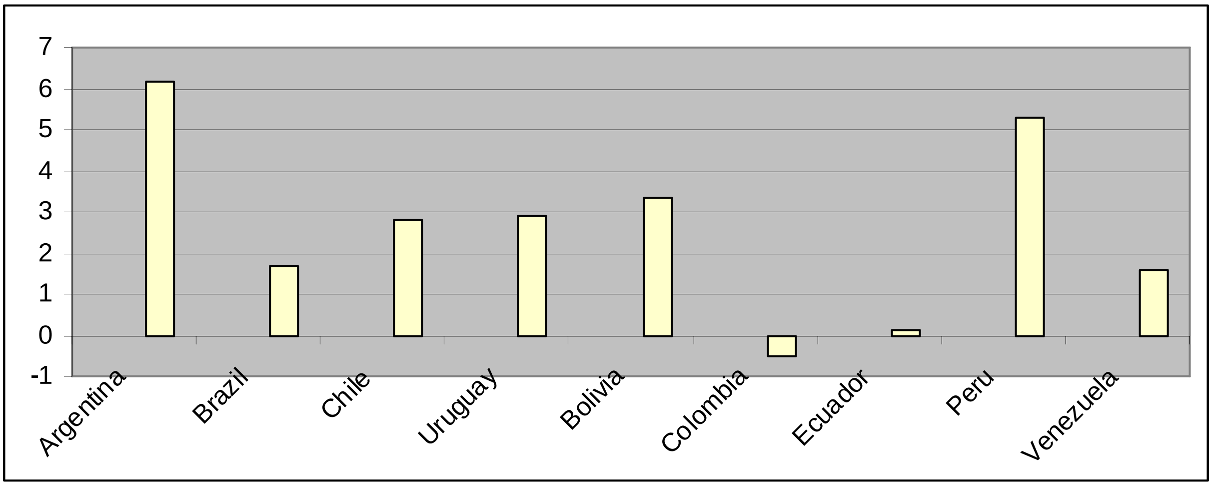
Table 3 Average annual GDP growth rates (pct)

Country	1981-1990	1991-2000
Argentina	-2.99	3.18
Brazil	-0.42	1.27
Chile	2.08	4.89
Uruguay	-0.66	2.24
Bolivia	-1.95	1.4
Colombia	1.26	0.74
Ecuador	-0.47	-0.35
Peru	-2.99	2.28
Venezuela	-1.75	-0.15

Source: World Bank 2005

When these data on the average annual GDP growth rates in the 1980s and 1990s are combined to measure the increase in these rates from the first period to the second, the Colombian growth trajectory stands out even more clearly:

Figure 2 Increase in average annual GDP growth, from 1980s to 1990s

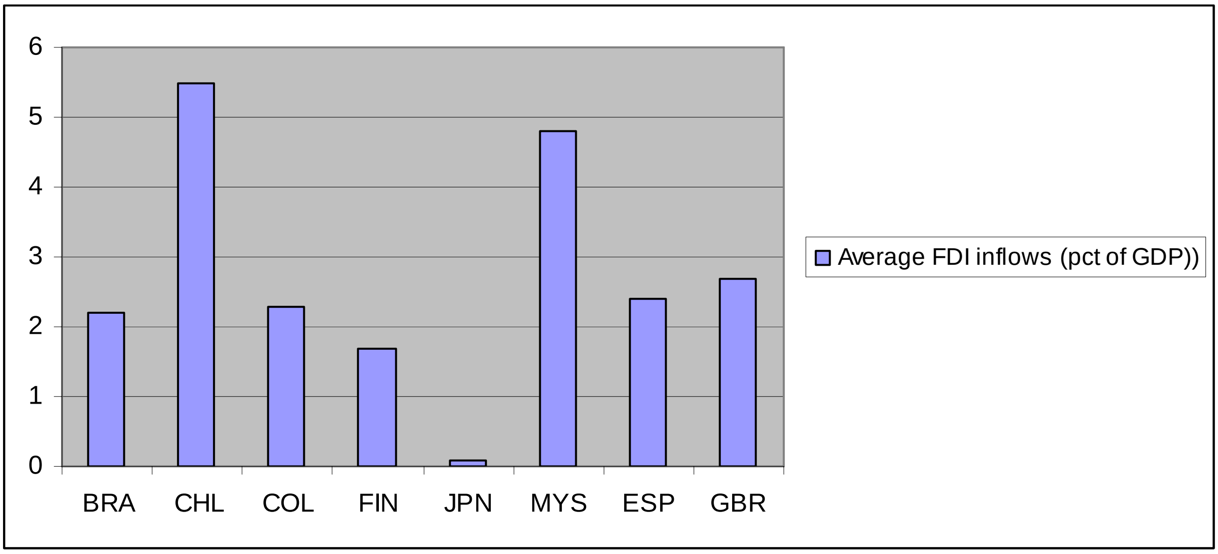


Source: World Bank 2005

As it appears, Colombia is the only country among this selection of South American countries that experienced a decline in average growth in the 1990s relative to the 1980s.

Through out the 1990s, Colombia has been committed to stimulating inflows of foreign capital and technology (UN 1999: 19) – and levels of foreign direct investments have in fact been reasonable, comparable to the levels of economies such as Finland, Spain and Brazil:

Figure 3 Foreign direct investments (average net inflows, % of GDP), 1991-2003



Source: WDI Online

In other words, the comparatively low GDP growth in Colombia in the 1990s cannot be blamed on a low level of inflow of foreign direct investment. Foreign direct investments can vary substantially with regard to the contribution they make to knowledge-intensive production, technology transfer and linkages to local industry. One interviewee argued that FDI in fact have reduced R&D in Colombia, because TNCs "send the R&D abroad, to the headquarters" (Zamudio 2005). Colombian policy-making is currently considering initiatives to commit foreign investors to making a contribution to local technology development (see more on this in section 6.3)

Throughout the 1990s, Colombia has been dedicated to policies aimed at macroeconomic stability through fiscal discipline, and as a consequence has been one of the few Latin American countries that have kept its foreign debts at manageable levels, and thus has not defaulted its payments or applied to renegotiate foreign debt (UN 1999: 18). With regard to economic policies, Colombia has, in other words, more than any other Latin American country, 'followed the prescriptions'. This surely makes the modest growth performance all the more disappointing for the Colombians.

When it comes to investments in science and technology, the Colombian performance in the period from 1991 to 2002 is quite modest:

Table 4 R&D expenditure (in pct. of GDP) [5]

	1996	1997	1998	1999	2000	2001	2002
BRA	0.77	..	..	0.87	1.04	..	..
CHL	0.58	0.54	0.54	0.51	0.53	0.54	..
COL	0.30	0.27	0.21	0.20	0.18	0.17	0.10
FIN	2.54	2.71	2.88	3.23	3.40	3.41	3.46
JPN	2.78	2.84	2.95	2.96	2.99	3.07	3.12
MYS	0.22	..	0.40	..	0.49	..	0.69
ESP	0.83	0.82	0.89	0.88	0.94	0.95	1.03
GBR	1.88	1.81	1.80	1.87	1.84	1.86	1.88

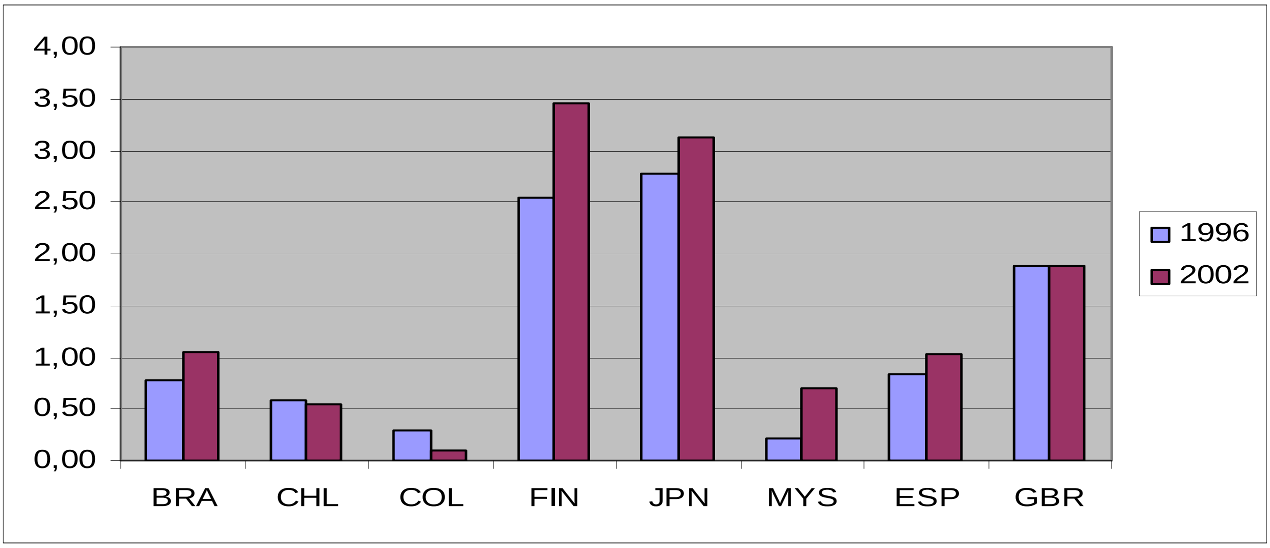
Source: WDI Online

The level of R&D expenditure in pct of GDP in 2001 was less than one third of Chilean R&D expenditure, and in 2002 seventh-fold less than R&D expenditure in Malaysia. This is all the more aggravating given the fact that in 1996, Colombian R&D expenditure in pct of GDP was considerably closer to the level of Chilean R&D expenditure and higher than it was in Malaysia at that time.

Thus, Colombia suffers from a double calamity: not only is Colombia's investment in R&D at an extremely low level (0.1 pct of GDP in 2002), it has been declining more or less continuously throughout the 1990's, a troubling trend in Colombian policy-making. This overall deteriorating trend comes out very clear when illustrated graphically, in terms of the percentage growth in R&D expenditures from 1991 to 2002:

[5] Expenditures for research and development are defined in the WDI database as "current and capital expenditures (both public and private) on creative, systematic activity that increases the stock of knowledge. Included are fundamental and applied research and experimental development work leading to new devices, products, or processes" (WDI 2005).

Figure 4 R&D expenditures, 1996 vs 2002 (% of GDP) [6]



Source: WDI Online

Aggregate investments in science and technology – i.e., public and private R&D expenditures *plus* other S&T investments – follow the same deteriorating pattern in Colombia (see section 3.2). More specifically, aggregate investments in science and technology declined from 0.63 pct in 1996 to 0.22 pct in 2002 (RICYT 2005). Fortunately, this substantial decrease in S&T investments in Colombia, from 1996 to 2002, was not paralleled by a proportionate decline in researchers per million people. As the table below indicates, the decline here is modest, from 83 to 81 researchers per million people. However, again Colombia is rating low comparatively: Chile has more than five times as many researchers per million people; Malaysia and Brazil have approximately four times as many.

[6] Last year data is 2002, except for Chile (2001) and Brazil (2000).

Table 5 Researchers per million people

	1996	*2002*
Brazil	-	323.94 [7]
Chile	395.03	418.58 [8]
Colombia	83.42	80.92
Finland	5,152.37 [9]	7,430.73
Japan	4,909.03	5,084.92
Malaysia	89.64	294.47
Spain	1,312.48	2,036.27
United Kingdom	-	2,690.66 [10]

Source: WDI Online

Whereas Chile started its PhD programmes in the 1970, Colombia got its first PhD programme as late as 1994. The director of the Colombian Observatory of Science and Technology, José Luis Villaveces, recently described this as “Colombia’s biggest mistake”, which led to “a kind of paralysis in the research done in universities” (cited in Fog 2004). This late beginning in the production of doctorates comes out very clear in comparative data on the production of doctorates, cf the table below.

Table 6 The production of doctorates

	1996	*2002*
Brazil	2,949	5,335
Chile	55	83
Colombia	-	28
Spain	5,827	6,276
United States	31,894	31,819

Source: RICYT

There are many other factors than S&T expenditures that influence the growth performance of a country. There is, however, every reason to believe that S&T expenditure is one of the key factors. A recent study by the World Bank observed that “roughly half a cross-country differences in per capita income and growth are driven by differences in total factor productivity, generally associated with technological progress” (World Bank 2004a: 1). The World Bank study further observed that Colombia’s weak performance in innovation “is partly due to a lacklustre performance in innovation investments”, and that “low rates of investment are not due to low returns”, since

[7] Figure is for 2000 (n.a. for later years)
[8] Figure is for 2001 (n.a. for 2002)
[9] Figure is for 1997 (n.a. for 1996).
[10] Figure is for 1998 (n.a. for later years)

estimations suggest that economic returns to R&D in a country like Colombia is as high as 80 pct (World Bank 2004a: 4). On this background, the study concluded that "Colombia should be investing between 4 and 10 times more in R&D than it did in the 1990s" (World Bank 2004a: 4). It is worth noting, in this regard, that S&T expenditures, unlike many other factors, is a factor that public policy-making can exert a great deal of direct influence upon.

The overall picture that emerges from these data on economic growth and S&T investment is that Colombia has underinvested into knowledge-driven economic development. Thus, despite being a rich country both in terms of natural resources and human capital,[11] its economic growth and development has been below its potential since the early 1990s – and well below the performance of economies that Colombia would otherwise be expected to compare with, such as Chile and Malaysia.

At this point, an important additional comment must be made. Colombia has, since the mid-1960s, been engaged in war with leftist guerrillas. Besides tremendous human suffering – in terms of lost lives and a high level of general insecurity – this has had severe negative impacts on the Colombian economy. It is beyond the scope of the present report to discuss this in any detail, however.[12] For our purposes here, it suffice to stress that the war with guerrilla and paramilitary groups in Colombia has been a serious strain on the public budget for long periods of time, including the 1990s which saw a considerable strengthening of these groups "on the back of increased involvement in drug-trafficking, kidnapping and extortion" (EIU 2004: 5).

Despite the modest growth performance over the past 15 years and despite the deteriorating trend R&D expenditures since the mid-1990s, there is room for optimism on behalf of Colombia with regard to the prospects of economic growth in the future. As will be apparent in subsequent chapters, Colombia has a well-developed national innovation system. This has the potential of becoming the foundation of new era of substantial economic growth and development in Colombia. The remaining chapters will strive to show how.

[11] It is beyond the scope of the present report to analyze and describe the sectors in which the Colombian economy has a strong innovation and economic growth potential. Let me refer briefly, however, to a recent World Bank study, which identifies the following sectors of "innovative comparative advantage": "ordnance, chemical products, food & kindred products, petroleum and engines" (World Bank 2004a: 6)

[12] I refer readers to a recent report by the World Bank (2004b), Colombia – Essays on conflicts, peace and developments.

CHAPTER 3

HISTORY OF SCIENCE AND TECHNOLOGY POLICIES

3 HISTORY OF SCIENCE AND TECHNOLOGY POLICIES

3.1 FINLAND

Concerted political effort over the past two decades has made Finland a much cited success-story of strategic science and technology policy. A key comparative strength of the Finnish national system of innovation is the high degree of cooperation among universities, companies and research institutes. As late as in the 1970s universities were not *permitted* to cooperate with industry (Romanainen 1999). The transformation that took place during the 1980s and the 1990s was to a high degree the outcome of a determined and well-coordinated science and technology policy.

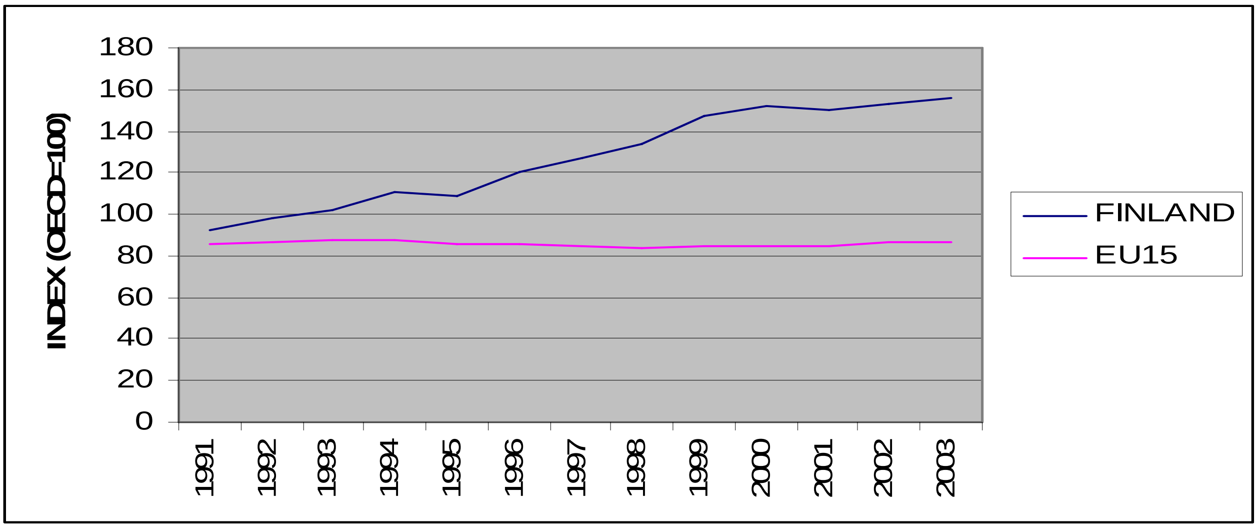
The 1980s saw a shift of emphasis from science to technology in overall Finnish policy-making. The establishment in 1983 of the National Technology Agency (TEKES) was one notable expression of this shift. The focus of TEKES was on technology development in key sectors of the economy. The key sectors of the Finnish economy by the early 1980s were the forestry and metals industries. Industrial and economic policies very much focused on the interests and needs of these export-oriented industries. There was, however, a tendency to consider only larger companies as an issue for national policy, leaving the concerns and interests of small and medium size enterprises to be dealt with by regional authorities. This changed radically during the 1980s. Policy began recognising the importance of linkages within and between sectors, and in TEKES technology programmes the development of such linkages and networks became a key objective. From these technology programmes grew by the early 1990s what has been termed ’the cluster approach’ (Romanainen 1999, Rouvinen & Ylä-Anttila 1999). In 1993, the National Industrial Strategy stressed the paramount importance of clusters as the fundamental basis of national competitiveness. Previously, industrial policy was focused on very specific industries. Now the new policy emphasised the importance of facilitating the economic growth of a range of clusters, rather than targeting a few industries. This was in part an expression of a general shift in policy that took place during the late 1980s from intervention to facilitation.

This shift was closely related to the establishment in 1987 of the Science and Technology Policy Council (STP Council). The STP Council replaced the Science Council, which had been operating since 1963. Not only did the STP Council mark a strong political emphasis on integrating science and technology policies, that had previously been formulated separately and with little coordination. It marked also the beginning of an era in Finnish policy-making where science and technology policy became a *strategic core* in the formulation of a whole range of other policies, including educational policy, economic policy, fiscal policy, industrial policy, regional policy and technology policy. The concept of a ‘national innovation system’ soon became the organising and unifying concept of this new coordination of policies.

The fact that there was a general political consensus on the strategic importance of science and technology policy for the international competitiveness and economic performance of the country was crucial for the way in which the political system responded to the severe economic crisis that hit the country in the early 1990s. In the late 1980s, Finland saw a major economic boom resulting from the liberalisation of financial markets. This boom soon turned into severe banking crisis, however. In combination with the collapse of the socialist markets, this produced a severe economic crisis. Though the public sector budget was in crisis, the commitment to progressive science and technology policy remained high. In the near absence of a private venture capital market, public money was invested to provide this (Romanainen 1999). Furthermore, instead of adjusting target levels for public and private investments in R&D downwards, according to the overall economic trend, the STP council adjusted target levels upwards, aiming to reach a R&D share of GDP at 2.45 pct. by 1995 and 2.7 pct. in 2000.

This policy was fully aligned with industrial policy. The 1993 National Industrial Strategy stressed that in the face of the economic recession industrial policy should focus not on reallocating current resources, but on influencing the "quantity and quality of resources emerging in the future" through *investments* in the national system of innovation (cited in STPC 1993). As a result of this emphasis on the strategic importance of strengthening the national system of innovation by investing in research, the government policy of balancing the public budget by cutting expenditures was not applied to public funding of research. The graph below benchmarks Finnish gross domestic expenditure on R&D against the average of all OECD countries and the average of EU countries. As evidenced by the data, EU investments in R&D as pct of GDP are well below the OECD average throughout the period – more specifically ranging from 84 to 87 pct of the OECD average. Finland, by contrast, rises far above the OECD average in the course of the 1990s, culminating in 2003 with R&D investments in pct of GDP exceeding the OECD average with 56 pct.

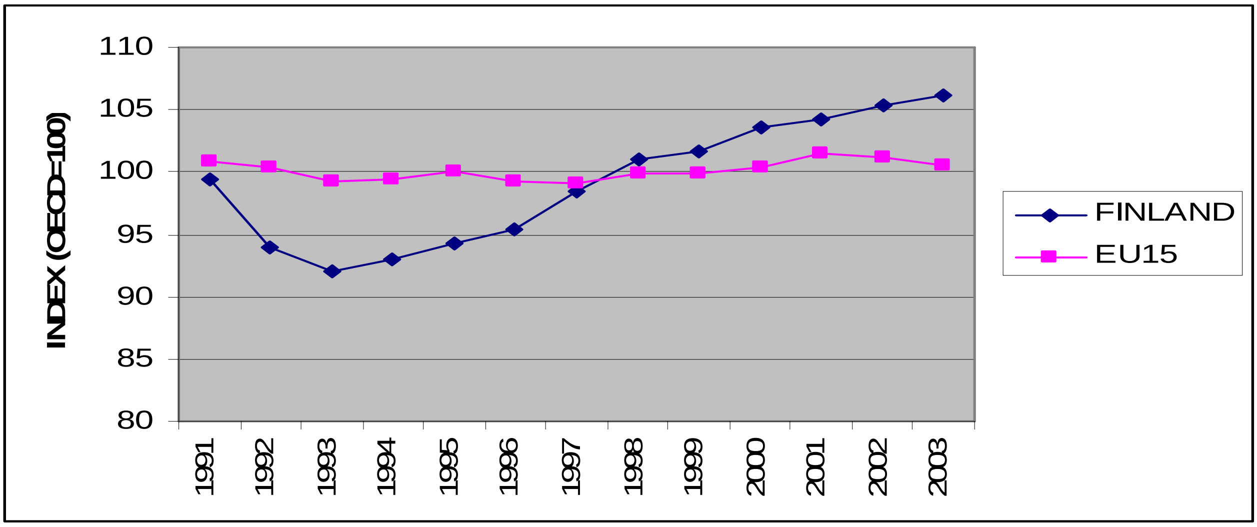
Figure 5 Gross domestic expenditure on R&D as pct of GDP (OECD=100)



Source: OECD

By the late 1990s, the Finnish economy had more than fully recovered from the crisis. In fact, a remarkably high economic growth had been achieved. The graph below benchmarks Finnish GDP per capital against the OECD average and against EU countries. The EU average here is on par with the OECD average, more specifically ranging from 99 to 102 pct of OECD average GDP per capita. After the economic recession in the early 1990s, where Finnish GDP per capita drops to 92 pct of the OECD average, Finland resumes a remarkable economic growth rising well above the OECD average, ending with a GDP per capita 6 pct higher than the OECD average.

Figure 6 Gross domestic product per capita (OECD=100)



Note: GDP per capita; indices using the price levels and PPPs of 2000.
Source: OECD

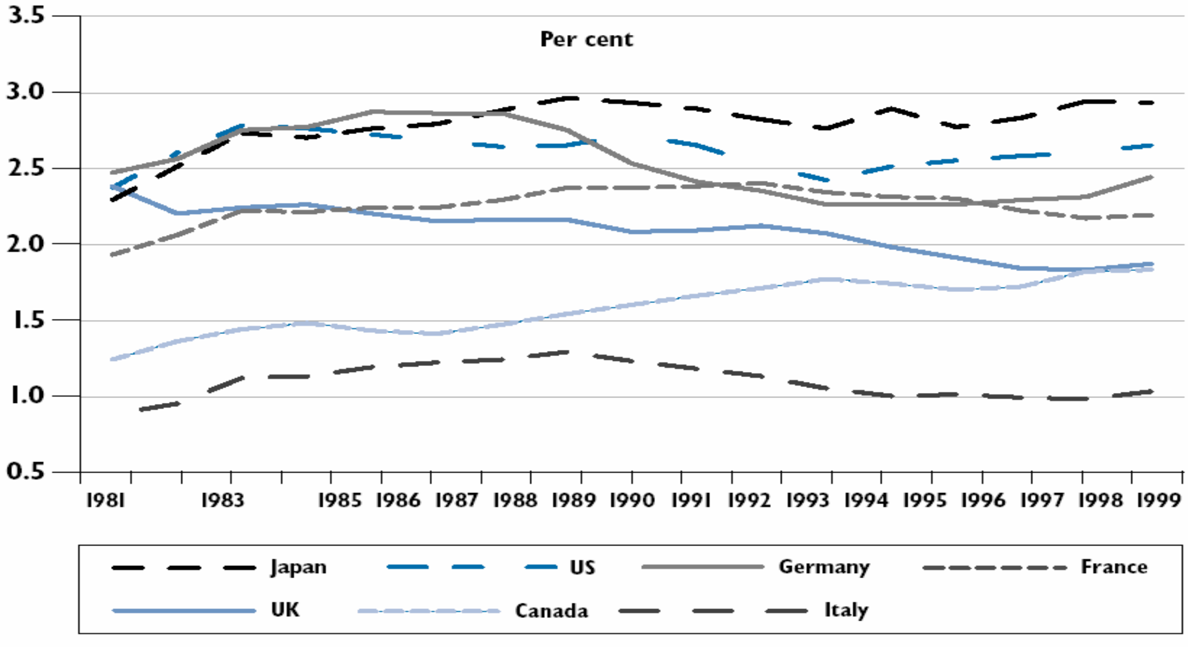
3.2 UNITED KINGDOM

The 1990s was a turbulent period for UK science and technology policies. The science budget was a responsibility of the Department of Education and Science (DES) up until 1992. The Department of Education and Science provided core funding for research in Higher Education Institutions and hosted the Secretariat of the Advisory Board for Research Councils which allocated funds for the autonomous, non-departmental Research Councils. It was UK policy at the time, that co-ordination of matters relating to science across government departments did not require a Minister of Science, but could be handled by the Prime Minister, as part of her general responsibility for trans-departmental issues. This meant that the DES had a very central position in the formulation of UK science policies. During the course of the 1990s, this strong position was somewhat weakened, however. In 1992, the new Prime Minister (John Major), announced the formation of the Office for Science and Technology (OST) in the Cabinet Office. Further, he appointed the first Cabinet level Minister for Science since the 1960s. OST was created by combining the Cabinet Office Science & Technology Secretariat with the Science Branch of the Department for Education and Science. Thus, key areas and responsibilities relating to science and technology policy were taken out of the Department of Education and Science, and made the jurisdiction of the Prime Minister in the Cabinet Office. Only three years later, however, the OST was moved out of the Cabinet Office and into the Department of Trade and Industry (DTI). The new Science Minister thus assumed the position of a junior minister within DTI. Though science had thereby lost its dedicated Cabinet Minister, the argument in favour of this change was that it would bring science closer to industry.

Policies throughout the 1990s focused on the stimulation of the relationship between the science base and industry. Despite the stated priority given to science, all public sources of income other than the Research Council budgets declined continuously, however, under the Conservative Government from 1979-1997. In 1986, a pressure group of several thousand scientists concerned with the deteriorating infrastructure in universities and other public sector research institutions was launched, under the name, *Save British Science*. Yet it was not until 1998, one year after the election of the Labour Government, that public funds were provided to alleviate this problem of deteriorating infrastructure.

In its first year in Office, the Labour Government undertook a Comprehensive Spending Review of all public expenditure, and as a result of this, science emerged as a major priority for increased public funding. This change of government policy has contributed crucially to bringing to an end a 20-year long period of more or less steady decline in R&D spending as a percentage of GDP, from 2.4 pct in 1981 to 1,8 pct in 1998 (DTI 2002). Though ending this decline was an important achievement, the UK still faces the challenge of redressing the balance. By the early 1980s, the United Kingdom was fully on par with the world’s most R&D intensive economies. At the turn of the century, UK had lost this lead position:

Figure 7 R&D expenditure as a share of GDP in G7 countries



The relationship between science and economic performance has been a key concern in the formulation of UK science and technology policies for more than a century (Georghiou 2001). Yet, UK performance in science-based industrial innovation at the end of the century doesn't match the high standing of the nation's scientific record. There is, in other words, a persistent problem in transferring an internationally excellent scientific performance into high levels of industrial innovation and science-based economic growth. One observer identified four "persistent reasons for the erosion of the UK's industrial standing": the short-term outlook of capital markets; under-resourcing of education and training; weakness in co-ordination; and the loss of a strong technological culture in which engineers are accorded high status (Georghiou 2001: 254). To these four factors, a fifth factor may be added: the disincentives for innovative research and third mission that funding based on the Research Assessment Exercise (RAE) seems to produce inadvertently (more on this in section 5.2).

By the end of 1998, the Labour Government published its Competitiveness White Paper, *Our Competitive Future: Building the Knowledge Driven Economy*, followed in March 1999 by an implementation plan. A key element of the new Labour Government policy was the provision of a new stream of funding, specifically seeking to promote industry-science relations in general, and commercialisation of research results in particular. This new stream of funding was made available through new public promotion programmes – more on these in section 7.2. By providing what is now termed 'a permanent stream of funding' for a wide range of third mission activities, the UK took a lead in Europe in this area of science and technology policy. Critical observers argue, however, that as long as UK policy-makers do not address the fundamental weakness of its national innovation system, the impact of such promotion programmes will be severely impeded, producing modest changes at best.

3.3 COLOMBIA

Over the past three decades, science and technology policies in Colombia have undergone a number of dramatic shifts. Together these make up the following five phases in the history of Colombian science and technology policy (Tovar 2005, UN 1999):

- Import substitution (1959-74)
- Centralized technology development (1975-1989)
- Pulling back (1990-1994)
- NIS approach (1995-2002)
- New start? (2002-)

Import substitution (1959-1974)

In the import substitution period, the main objectives of science and technology policy were to control technology transfer and foreign direct investments, and to strengthen the science and technology infrastructure based on a supply approach. The State was the predominant actor, and national funding was dedicated to science in national research centres and laboratories. In this period, there was generally very little industry-science interaction.

Centralized technology development (1975-1989)

By the mid-1970s, science and technology policies began to be coordinated with overall National Development Plans. This was the expression of an increased emphasis on trying to integrate academic research into national development plans and efforts to meet the country's basic needs. Thus, in this period, science and technology policy shifted towards central planning of national technological development.

Pulling back (1990-1994)

In 1990, the general strategy of science and technology policy shifted again. At this point, Colombia embarked on its strategy of *Apertura económica*. Faced with this new policy of liberalization and privatization, a redefinition of science and technology policy became necessary. The foundation of a new institutional structure for science and technology policies was laid in the Science and Technology Law of 1990. The strategy was a dual one of exposing the economy to full foreign competition and developing a National System of Science and Technology, in the form of National and Regional Programmes of Technological Research and Development. The agenda of privatization affected the area directly, most notably by the privatization of *Centro Technológico Multisectorial* (IIT). This centralized, national centre for industrial technology research was replaced by a network of Sectorial Technology Development Centres, all of which were private legal entities (see more on this in section 6.3). The idea underlying these and similar initiatives in this period was that the state should pull away from funding research. In the case of IIT, three competent research groups (food technology, coal research, and mechanical research) were dismantled, and only half of one of them (food technology) is active in industrial R&D today. Thus, in terms of Colombian technological capabilities, key observers describe these privatizations of public industrial research and development structures as "a failure" (Chaparro 2005).[13] In line with this observation, recent science and technology studies have argued that the privatisation of state-owned enterprises during the 90s "involved the destruction of human capital and domestic

[13] When the Ministry of Agriculture later wanted to privatize CORPOICA, these plans met resistance from the World Bank and the Inter-American Development Bank (Chaparro 2005).

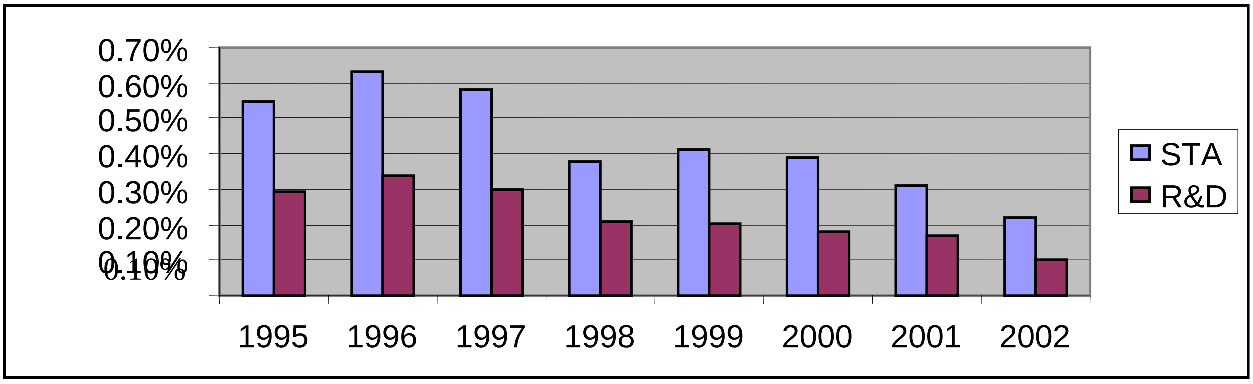
technological capabilities" (Cimoli & Katz 200: 16, Velho 2005: 103). Another study coined the term 'foreignisation' to describe the trend in Latin America that the privatization of public companies have almost always been done "through foreign companies", which are reluctant to resort to local knowledge and technology (Arocena & Sutz 2001: 1225). This in turn have been characterised as resulting in an unfortunate 'disconnecting' of local R&D from potential users (Velho 2005: 106).

NIS approach (1995-2002)

In the beginning of the 1990s, the emphasis in science and technology policies was still very much on science, with little focus on innovation and university interaction with industry (Tovar 2005). The first systematic attempt to address this problem occurred in 1995, with the introduction of the National System of Innovation as the guiding concept in science and technology policy-making. A long-term perspective of science and technology policy was adopted, with the formulation of *Plan Estrategico 2010* emphasising *innovation* relative to science in itself. There were two key dimensions of the effort to build a National System of Innovation: (a) the introduction of three new types of intermediary organisations with the mission of promoting industry-science linkages (see section 6.3), and (b) a new set of funding instruments (see section 7.3).

In 1996, there was a shift of government, with Mr. Pastrana taking office. The Pastrana government was in office until 2002, and these six years seem to constitute a backlash in terms of investment in science and technology. As it appears from the graph below, funding for Science and Technology as a percentage of GDP declined continuously and significantly throughout this period, with 2002-levels at just one third of 1996 levels.

Figure 8 Colombian S&T expenditure (% of GDP) 1995-2002



Needless to say, with expenditures on S&T declining, the systematic effort launched in 1995, to build a National Innovation System, was an effort somewhat 'against odds'. The period from 1996 to 2002 encapsulates both the best and the worst of the history of Colombian science and technology policy: The NIS approach was adopted and today Colombia has one the institutionally best developed innovation systems in Latin America (Holm-Nielsen et al 2002: 7). At the same time, however, the NIS has been under-funded and as a result Colombia has fallen behind comparable economies, such as Chile and Malaysia for instance, in terms of innovation and knowledge-driven economic growth.

New start?

In May 2002, Mr. Uribe took office, and central government support for the agenda of science and technology development and investments in the further improvement of the Colombian innovation system has increased. It is too early, however, to evaluate and characterise this new period. Colombia no doubt has a high potential for science and technology driven economic growth. But it remains to be seen whether the investment level and policies necessary for Colombia to catch-up in terms of innovation and knowledge-driven economic growth will in fact be implemented and sustained.

3.4 CONCLUSION: POTENTIAL LESSONS FOR COLOMBIA

When Colombian economic growth began declining following liberalisation in the early 1990s – just as it had in Finland at that time – the exact opposite policy as that of Finland was adopted. Instead of increasing public funds for science and technology, opting to invest and develop their way out of the crisis, Colombia's commitment to and funding of R&D declined. The Finnish case more than anything shows that determined investment in science and technology can spur high economic growth. By the late 1990s, the UK too had recognized the necessity of public investments in the innovation system, and put an end to a deteriorating trend in R&D expenditures.

In the contemporary age of global knowledge economy, funding of science and technology is of paramount importance in pursuing economic growth and development. In fact, without substantial S&T funding, other S&T efforts are likely to have little if not negligible impact. Thus, when Colombia developed a national innovation system in the 1990s in accordance with a number of key trends in the most developed countries, these good developments did not have the desired effects. The focus of science and technology policy shifted from science to innovation, from intervention to institutional facilitation, and from targeting large companies to targeting SMEs and cluster development – but actual, overall innovation and economic growth performance did not improve. As one interviewee remarked, it matters little how good the seed is, if it is not watered (Posada 2005).

The positive aspect of the recent history of science and technology policies in Colombia in the 1990s, is that – given the efforts to create a good institutional structure – considerable economic growth can indeed be achieved in the near future, if substantial funds for S&T are supplied and utilised in a strategic manner. This is what the Finnish case shows us.

CHAPTER 4

LEGISLATION AND CULTURE

4 LEGISLATION AND CULTURE

Country sections in this chapter are divided in two. First, a section on the legal framework, followed by a section on key cultural aspects pertaining to innovation and university interaction with industry.

4.1 FINLAND

4.1.1 Legislation

Legal framework for universities

The legal framework in which universities operate is defined primarily by the Constitution of Finland, which states the freedom of sciences. The Higher Education Development Act states provisions on the objectives of the higher education system, appropriations and their allocation, whereas the Universities Act ensures the autonomy of universities, prescribing their operations and objectives only in very general terms.

Experts mention legislation with regard to extra earnings for public science researchers and regulation on equity investment by public science institutions in enterprises as the two most important barriers to industry-science interaction (EC 2001: 102). The regulation concerning investment by public science institutions state that "a government organisation receiving funding (even partly) directly from the state budget, may not invest in the private sector without the specific consent of the Parliament" (EC 2001: 101). Only by such specific parliamentary consent are equity investments in, for instance joint research labs, possible. Such investments are rare, and instead several universities have set up foundations, through which they are able to make equity investments.

With regard to the other barrier mentioned by experts, legislation with regard to extra earnings for public science researchers, the Act on Civil Servants limits the right of a civil servant to hold secondary occupations, by which is understood any waged work or task. In practice, sporadic occupational tasks are not subject to limitations, while for instance being member of board of a company is indeed considered a secondary occupation, and thus requires that the researcher apply for a permission to hold this position. In granting permission or not, the researcher's employer must reflect on whether the researcher will be more challenged in his office or in any way be bothered in the appropriate execution of his tasks, whether the secondary occupation will compromise the confidence in his impartiality, and finally whether the secondary occupation as a competing activity may potentially damage the employer. If the researcher, on these conditions, is given permission to hold a secondary occupation, there are no restrictions as to the amount of remuneration.

In addition to the two above-mentioned barriers, it must be stressed that actors share the view that legislation has, and does indeed still 'lag behind'. Industry-science relations have intensified enormously during the past decade, but there have been few legal guidelines for these interactions. Particularly on the university side of the relation, actors call for clearer legal ground rules for their interactions with business.[14]

An attempt to develop such guidelines was recently made under the auspices of the Ministry of Education (Mäkipää 2003). A working group with participants from the Ministry and

[14] With regard to fees for contract research, this is regulated by 'The Act of the Principles of State Fees', the basic principle being that contract research must "be provided on market conditions" (EC 2001: 101).

representatives from commercialisation units at key universities developed a set of guidelines. More specifically, ten such guidelines were developed.

1. Universities should promote research-based entrepreneurship, that is (i) compatible with university's mission and objectives, (ii) compatible with strategy and main activities, (iii) not in conflict with main purposes.
2. University's funds should not be used for the development of new business activities.
3. University's liabilities and guarantees should be clearly defined in contractual agreements.
4. Attention should be paid to possible interest of conflicts between researcher and entrepreneur.
5. Attention should be paid to possible disqualification due to conflict of interest of a researcher/entrepreneur in specific research topics/projects.
6. Entrepreneurship activities should not compete with the teaching and research as the prime activities of universities.
7. The procedures of permission for secondary occupation/ perquisite position should be followed.
8. Confidentiality aspects in contract research needs more attention.
9. University employees or students as participants in entrepreneurship activities should not receive any monopoly rights.
10. University name and logo should not be used in entrepreneurship activities by private researchers/entrepreneurs.

Source: Mäkipää 2003 (emphasis added).

As it appears, university funds are not allowed to be used for new business activities and entrepreneurship activities should not compete with teaching and research as the prime activities of universities. Universities are encouraged to promote research-based entrepreneurship, but are also made clear that any substantial allocation of funds and/or resources in terms of working hours is illegal. This construal of a fundamental opposition and conflict of interest between the traditional missions of universities (research and education), and the new third mission (promoting the utilisation of new knowledge and contributing to the economy) is problematic. Framed in this manner, university entrepreneurship seems to be alienated from the outset, rather than being taken up as truly a new *mission* for universities.

Intellectual property rights

In Finland, the foundation of IP law is the Act on Employer's right to an invention made by an Employee (EC 2001: 100). This Act states that the IP of inventions made by employees are transferred to the employer. The Act covers all private sector organizations and most civil servants. More specifically, researchers in public research organisations such as VTT (see section 5.1) are covered by the Act whereas researchers in universities are not. With regard to university researchers, the basic rule is that the researcher owns the invention. In practice, the ownership and use of IP in Higher Education Institutions and in Public Sector Research Organisations varies with the principles of the agent providing the funding and with the policy of the university or research institution in question. The Academy of Finland has the principle of not claiming rights for inventions, thus leaving IP with the performing researchers. The National Technology Agency (TEKES) has as its overarching principle to leave IP as the property of the organisation which has benefited from the funding. In practice this means, that university researchers are often required to transfer their rights to the university before a funding contract with TEKES can be signed.

4.1.2 Culture

The overall cultural attitude toward university interaction with business in Finland is heavily influenced by the general notion that it is of paramount importance that public science contributes to industrial innovation. This attitude is seen to be the result, more than anything, of a coherent science, education and technology policy during the 1980s and 1990s (EC 2001: 99). Further, observers emphasise the ‘sense of urgency’ that the economic recession in Finland in the early 1990s brought about – a progressive science and technology policy was widely recognised by the public to be absolutely crucial for recovering for the prospects of recovering from recession (Seppälä 2002; Tuurkonen 2002).

Despite the generally favourable cultural attitude in the Finnish society toward university interaction with industry, universities themselves are divided on the issue, with some researchers being quite sceptical, if not hostile, towards the political pressures to increase interaction with business (see more on this in section 6.1.3). Finland has a strong tradition of autonomy in research and education, and some researchers feel that independent, basic research is endangered by the political agenda of increased interaction with industry. At the same time, however, observers stress that the Finnish often portray themselves as the engineers of Scandinavia, compared to the Swedes, who are considered to be Scandinavia’s businessmen. These two aspects of Finnish culture – the culture of ‘engineership’ and that of autonomous science – put the country in a strenuous situation of ambiguity. As witnessed by the guidelines described above, university entrepreneurship is on one hand encouraged, and on the other hand illegalised. The achievements of Finland in the area of industry-science relations over the past two decades are even more remarkable in view of this ambiguity.

This ambiguity is perhaps the underlying cause of a key weakness in the Finnish innovation system. Though Finland is generally renowned for integration S&T policy in all other key policy-making, there is one exception to this. When it comes to science and technology policy on one side, and higher education policy on the other side, there is very little policy integration (see section 5.1.1).

4.2 UNITED KINGDOM

4.2.1 Legislation

Legal framework of universities

Institutions in the UK higher education sector share the characteristics of being: (i) legally independent corporate institutions, (ii) bodies having charitable status, and (iii) accountable through a governing body which carries ultimate responsibility for all aspects of the institution. Charitable status confers a number of benefits, including exemption from capital gains tax, income tax and corporation tax on income other than trading income arising outside the course of the carrying on of the primary purpose of the institution.[15] Charities are required (i) to apply the assets and income of the institution only for the defined charitable purposes, (ii) to act only within their legal powers, (iii) to take particular care in organising trading activities which may not be regarded as charitable, and (iv) to manage and protect the property of the institution (Committee of University Chairmen 2003).

The legal status of charities gives UK universities an advantage over most other European universities with regard to university entrepreneurship and commercialisation of research. Being charities, universities are encouraged to generate funding from trading activities with business, community and public agents, whether in the form of sales of products, consultancy or other. Whereas in many other countries such trading activities are regarded as more or less problematic, and certainly requires the setting up a separate companies at arms-length of regular university operation, in the UK the establishment of such separate companies is required only when some particular trading activity is not in line with the charitable purpose, i.e research and education. A charity may indeed generate a surplus, and retain it, as long as it uses this surplus in accordance with its charitable status, which in this case implies spending it on research and education. Thus, in the UK the legal framework encourages and accommodates trading activities as an integral part of regular university operation, whereas in many other countries trading activities are seen as potentially damaging to the university mission, and thus legally severely restricted and indeed impeded.

Intellectual property rights

Up until 1985, the National Research and Development Corporation (NRDC) had a monopoly in the exploitation of publicly funded research in the UK Higher Education sector. The Conservative government brought this monopoly to an end, and launched instead a policy of decentralised ownership of intellectual property. The notion was that only if universities themselves could take ownership of intellectual property, would proper incentives for commercialisation prevail. Thus, by the mid-1980s, many universities started setting up technology licensing offices, specialised in intellectual property management. These were set up within, or parallel to, existing industrial liaison offices.

In UK, the question of how to organise efforts to commercialise research results have thus over the course of the past 20 years increasingly been left to the universities themselves to decide upon. This includes the question of incentive schemes. The distribution of royalties to staff is thus carried out though different arrangements at different universities. Taking the University of Newcastle as an

[15] All higher education institutions are normally exempt from VAT on the supply of education and research. They may however be liable for VAT on trading activities

example: The university is the owner of a patent, and revenues are shared between the university and the inventor(s). After subtracting legal costs, the first £ 5,000 of IP income goes to the inventor(s), the next £ 200,000 of IP income is split - 50 % goes to the inventor(s), 25 % to the department(s) of the inventor(s), and 25 % to the university. In the case of IP exploitation via a university-owned start-up company, the inventor(s) can take equity in the company, the inventor(s) involvement being subject to the university's company directorship policy.

As observed in the EC benchmarking report, no specific employment regulations which may impede ISR activities exist in UK universities. There were, however, for long a crucial difference between researchers employed in universities, and researchers employed in certain Public Sector Research Establishments (PRSE). In some PSREs scientists were bound by the civil service management code and thus had no incentive schemes for commercialising research results until the government revised the code in 2000. Until the reform of the code in 2000, the presence of incentives for researchers in PRSEs to commercialise IP was dependent upon whether the scientist worked for a government department or for a non-departmental public body (i.e., research council institutes). Those scientists who were employed in research council institutes were subject to incentive schemes, whereas those who were employed by government departments were bound by the civil service management code which forbade the use of incentives. After the reform of the code in 2000, all researchers employed in the public sector are subject to incentive schemes for commercialisation. The table below gives two examples of such incentive schemes in UK public sector research.

Table 7 Incentive schemes in UK research council institutes, 2000

Biotechnology and Biological Sciences Research Council		*Medical Research Council*	
Income from IPR	Proportion of receipts paid to inventor(s)	Income from IPR	Proportion of receipts paid to inventor(s)
First £ 1,000 (gross)	100 %	£ 500 to 1,400	100 %
£ 1,000 to 50,000 (gross)	20 %	£ 1,400 to 80,000	33.3 %
£ 5,000 to 500,000 (net)	10 %	£ 80,000 to 600,000	25 %
£ 500,000 to 1 million (net)	5 %	£ 600,000 to 1.5 million	20 %
Over £ 1 million (net)	2.5 %	£ 1.5 million to 15 million	15 %
		Over £ 15 million	10 %

Source: EC 2001

4.2.2 Culture

In the recent EC benchmarking study on industry-science relations, a favourable cultural attitude to industry-science relations was noted as one of UK's key comparative advantages (EC 2001). This favourable cultural attitude is no doubt closely related to the legal framework for universities as described above.

In many countries, universities are not allowed to generate and accumulate funds from third parties that would enable them to gradually increase their professionalism in interacting with industry. When a 'third mission' activity is taken up in, for instance, a Danish university, economic costs in a narrow sense may be covered. But when such 'third mission' activities are undertaken, the complexity of the university's operations increases significantly – ultimately at the cost either of the standard of education and research activities, or at the cost of the individual researchers involved. This means that whatever institutional interaction the university has with industry, it has it *in spite* of the legal regulation of universities. It is paradoxical that on one hand there is a strong political wish for universities to increase their interaction with industry, and yet in many countries, universities are not allowed to generate funds to finance their investment in this interaction.

In UK, the norms with regard to costing have for long been the exact opposite of that of many countries such as Finland and Denmark. Whereas in Denmark universities are only allowed to cover their costs when they do paid services for public or private partners, in UK universities are required to charge a full commercial price. The rationality behind the UK model is that by charging a market-price there is no under-bidding based on public funding. If the market chooses the publicly provided product it is then not because of underbidding based on public subsidies, but because the public producer brings a type of knowledge to the market, that the market does not itself generate. Thus, the public product, in this perspective, corrects a market failure. Consequently, universities selling their products in the market-place are not seen as introducing market distortions, but as bringing to market products and activities that are beneficial to society, correcting the failure of the market to produce these products and activities on a private basis. This, then, is in line with the fundamental mission of universities: to produce '*public goods*', i.e., goods that are not supplied (sufficiently) by markets, such as scientific knowledge and science-based education. Thus, whereas in many countries there is considerable ambivalence in allowing universities to operate on the market, in the United Kingdom this ambivalence has been sidestepped by means of the following two principles:

- Universities should indeed bring public goods to market, the more the better
- When bringing public goods to the market, universities should always charge a full commercial price.

For universities to transform to be at one and the same time (i) entrepreneurial, i.e. engaging in interaction and trading activity with business and community, and (ii) based on scientific knowledge production – an organisation and regulation of universities that supersedes the traditional private-public distinction is a promising strategy indeed. Such an organisation and regulation of universities is a key advantage of British science and technology policy. In UK, universities are neither public, nor private, in conventional terms. They are private in the sense that they engage in trading activity, but non-private in the sense that the surpluses they generate can never be paid to anyone as profits, but must always be spent on further research and education. They are non-public in the sense that they are private charities, but public in the sense that the overall aim of their activities is to serve public ends; namely research and education.

One expression of the positive attitude to industry-science relations in UK, is that a very large share of UK universities consider technology transfer to industry to be a major mission. As a consequence, it is a much more common practice in UK than in most other countries to operate industrial liaison offices and commercialisation units at universities (see section 6.2).

4.3 COLOMBIA

4.3.1 Legislation

The legal framework for the Colombian innovation system has been developed in two steps. First, in 1990, the Congress of the Republic approved the Science and Technology Law (Ley 29), and in the following year a number of decrees followed up on the new law (particularly decrees 393, 585, and 591). In and through these legal changes, a National System of Science and Technology was conceived and institutionalized. Guidelines for promoting the development of science and technology in Colombia were provided, particularly in the form of measures such as tax exemptions and deductions.[16] Second, from 1994 onwards, a new phase began, in which the emphasis was on building a National *Innovation* System by adopting "modern approaches to innovation" (UN 1999: 117). The changes in this period related more to promotion programmes and to intermediate structures, than to basic legislative changes – and will thus be further described in sections 6.3 and 7.3. In the following, I briefly describe (i) the legal framework of universities in Colombia and (ii) recent developments in the area of intellectual property rights.

Legal framework for universities

There are four types of tertiary institutions in Colombia. These are classified in the law on tertiary institutions (Ley 30, article 16) according to their respective missions (World Bank 2003: 6):

Table 8 Tertiary Education Institutions in Colombia

Institution type	*Mission*
Universities	Teaching and research at graduate and undergraduate levels
University institutions	Teaching academic disciplines of high specialization
Technological institutions	Short-term, academic education in technological fields
Technical training institutions	Short-term vocational education, training and skills upgrading

Source: World Bank 2003

In terms of ownership by legal status of institutions, Colombia's tertiary education system is characterised by a large share of privately-owned institutions, ranging from 62 pct of universities being private to 85 pct private technical training institutions (World Bank 2003: 7).

The regulatory framework is described as a mixture of two types of governance, one emphasizing direct government control and the other emphasising a combination of autonomy and accountability. The trend is in the direction of the latter type of governance (Holm-Nielsen et al 2005, World Bank 2003). The Constitution recognizes the importance of the freedoms of teaching, learning and research and guarantees tertiary institutions substantial autonomy – ranging from the autonomy to define the institution's purposes and goals, to the autonomy to design and implement appropriate research projects.

A recent World Bank study of tertiary education in Colombia stressed a number of governance problems, concluding that Colombia does not yet have a "well-articulated governance system" (World Bank 2003: 8). The report particularly stressed the problem posed by the existence of

[16] Tax schemes were twice modified through legislative changes, in 1997 (Ley 383) and 2000 (Ley 633).

regulatory bodies with overlapping functions, which was seen to result both in a lack of clarity in roles and responsibilities, and in tension among the involved government organizations. Further, the report noted that a great obstacle to effective management in the sector is “the lack of a clear and transparent vision for tertiary education” (World Bank 2003: 11). In addition to these two main problems, I should like to add a third.

According to numerous interviewees, the tertiary education sector is biased towards teaching activities with little focus on research and third mission activities. The vast majority of university professors do mainly teaching and little research. In a country with a relatively low number of university professors and PhDs (Thorn et al 2005), this problem is all the more aggravating for the innovation and R&D agenda. As a key cause of this problem of prioritizing teaching over research, several interviewees mentioned the fact that teaching is what gets university researchers their salary, and often the effort to generate a reasonable salary involves so much teaching, that little time is left for research.

Intellectual property rights

The two key agencies in Colombia dealing with IPR and copyright issues is the *Superintendencia de Industria y Comercio* – a National Bureau under the Ministry of Industry, Commerce and Tourism – and the National Directorate for Copyrights and Connected Rights (*Direccion Nacional de Derechos de Autor y Derechos Conexos*), under the Ministry of Interior and Justice.

The most recent important development was a joint decision with Bolivia, Ecuador, Peru and Venezulea (the Andean Community) to harmonize intellectual property law. This new harmonized intellectual property law, under Decision 486 of the Cartagena Agreement, took effect on December 1, 2000. The agreement harmonizes IP law through the adoption of the GATT-TRIPS agreement on intellectual property rights.[17]

Observers recently noted that Colombia did not provide “adequate and effective IP protection” (Agatipova 2002: 13), and it was stressed that Colombia since 1991 had been on the special Watch List of the United States Trade Representative (USTR), reviewing the adequacy and effectiveness of IP protection globally. By complying with the GATT-TRIPs Agreement, the expectation is that Intellectual Property protection will improve considerably in Colombia. More specifically, the expectation is that it will help Colombia move from a ‘non-robust IP system’ to what is termed a ‘trade-facilitating system’ (World Bank 2002: 14-15). As of today, Colombia remains on the USTR Watch List, however.

> Despite Colombia’s progress in certain areas toward strengthening its IPR regime, Colombia still needs to make further improvements and therefore will remain on the Watch List for 2005 (USTR 2005).

Copyright piracy (music, business software, etc.) and lack of successful prosecutions for IPR infringement are mentioned as key problems (USTR 2005).

4.3.2 Culture

Two cultural issues with a great bearing on innovation activities and university interaction with industry must be highlighted. First, the Colombian NIS is negatively affected by what interviewees

[17] More info about this may be found at www.comunidadandina.org.

repeatedly described as a fundamental problem of lacking trust between universities and private companies as a key barrier to industry-science collaborative R&D.[18]
University attitudes to the private sector suffers from the prejudice that CEOs are only interested in personal benefit and not in the public good, and from a lacking recognition of the link between private entrepreneurship and national economic growth. In private companies, universities are perceived as far too academic to be useful for any practical/commercial purposes, and as being 'against' the private sector. This latter aspect is partly explained by the fact that the attitude of many CEOs is tainted by their own experience with universities, which usually dates back to the 60s and 70s, when universities were involved in 'left-wing' activism (Chaparro 2005).

This problem of mutual mistrust obviously is not conducive for industry-science collaboration in innovation technology development projects. The theme of lacking trust has one further dimension, however, which aggravates it further. There seems to be a widespread if not collective lack of trust in the ability and potential of Colombians to develop science and technology that can compete internationally (Posada 2005). A key manifestation of this is the notion that economic development should be achieved by importing foreign technologies, rather than by endeavouring to spur economic growth by local technology development. The above depiction of these trust-problems is of course a rough generalisation. Moreover, it is important to stress that things are moving in the right direction, even if still only somewhat slowly.

The second cultural issues that should be stressed here is equally important, and equally detrimental to innovation and university interaction with industry. The concept of 'investment' in S&T and absorptive capacity is not generally well understood in Colombia. This expresses itself both in private sector behaviour and in public policy-making.

In percentage of total R&D, private R&D is doing well. In fact, Colombia has the highest share of private R&D of the four chosen Latin American countries in the table below.

Table 9 The composition of R&D

	Pct of R&D financed by enterprises	Total R&D (as pct of GDP)	Private R&D (as pct of GDP)	Public R&D (as pct of GDP)
Colombia	46.9	0.17	0.08	0.09
Chile	24.9	0.57	0.14	0.43
Mexico	29.8	0.39	0.12	0.27
Uruguay	46.7	0.22	0.10	0.12

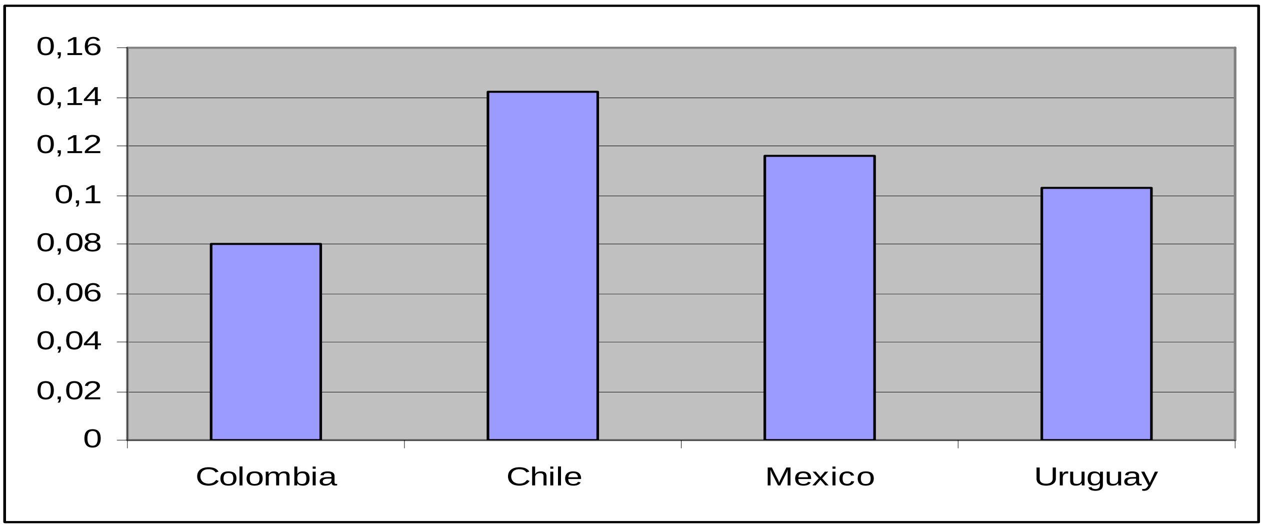
Note: Data on share of R&D financed by enterprises.

Source: RICYT

As revealed by the data in table 9 on the composition of R&D as a percentage of GDP, this is due not to a high level of private R&D, but to a comparatively low level of public R&D. In fact, R&D investments by private sector companies are quite low in Colombia.[19]

[18] A certain degree of mistrust among the university sector and the productive sector is a problem known in many countries. It seems, however, to be particularly pronounced in Colombia.
[19] The current director of Colciencias expressed the view that official data on private R&D in Colombia is likely to be underestimating action private sector R&D, because Colombian accounting practices often registers knowledge only as an expenditure, not as an asset (Rosario 2005).

Figure 9 Private R&D as a pct of GDP in 2001 [20]



Note: Data on share of R&D financed by enterprises.
Source: RICYT

In line with the low level of private sector R&D, less than 1 pct of the total loan-giving of the big Colombian industrial bank is loan-giving for innovation (Vaca 2005). Often, when university researchers, committed to the agenda of cooperative research and development with industry, approach CEOs, they have to pull a huge fight just to get the CEO's to agree on a 12-month time frame for a collaborative R&D project. The general attitude among Colombian CEOs is that if it doesn't show results and pay off in two or three months, they will not participate (Pardo 2005).

What is at stake here is that spending on R&D is framed in terms of exchange rather than in terms of investment. This is, needless to say, a substantive impediment to innovation and technology development.

[20] Data for Uruguay is for 2002, not 2001 (n.a.)

4.4 CONCLUSION: POTENTIAL LESSONS FOR COLOMBIA

In a study from 2002, Colombia's performance with regard to 'rule-of-law' was compared with that of other Latin American countries (Kaufman et al 2002). The rule-of-law index used in the study was constructed by aggregating 42 indicators, ranging from the prevalence of crime to enforceability of public and private contracts. In a comparison of the fourteen participating Latin American countries, only Cuba was rated lower than Colombia (Hansen et al 2002: 12). Needless to say, this environment is not conducive of trust in the economy, nor for the promotion of a business culture more oriented towards making longer-term investments.

There is no clear consensus as to the importance of IP protection for innovation and economic development in LDC's. The controversies in this area include the issue of whether a relatively weak IP regime, such as that of Korea, may in fact be stimulate innovation by allowing for "inventing around" existing patents (World Bank 2002: 15). It is beyond the scope of the present report to engage in this discussion. In this context it suffice to say that in a country where mistrust and the lacking understanding of the concept and necessity of investment are key cultural barriers (see below), recent efforts to improve IP protection are highly commendable as will be indeed any efforts in the future to further strengthen Colombia's standing with regard to 'rule of law' in general.

A recent World Bank study argued that Colombia's innovation performance suffers "the lack of collaboration between the private sector and research organisations such as universities" (World Bank 2004a: 5). From this perspective, improving relations between the university and business sectors is of paramount importance. Three cultural barriers to such collaboration exist, however. Developing and implementing a broad strategy for increasing *trust*, *self-confidence* and *understanding* in the Colombian innovation system could potentially have a substantial impact on Colombia's innovation and economic growth performance. *Trust* across the university and business sectors of the economy; national *self-confidence* in the S&T potential of the Colombian economy and its people (Chaparro 2005, Rosario 2005), and *understanding* of the concept and necessity of S&T investment.

Informing private sector CEO's and other high-level managers of the growth potential of R&D is likely to be have a particularly strong impact, given that the reluctance of private sector managers to invest in S&T and to interact with university researchers, is a key constraining factor in the Colombian NIS (Almario 2005, Naranjo 2005). Indeed, educational programmes for professionals from both the business and the university sector, teaching them how to benefit from each other, could be a promising way of promoting collaboration and innovation across these two sectors (Forero 2005). Another core element of such a strategy should be increased funding schemes for collaborative research. There are few mechanisms more effective than this in stimulating trust and development of more positive attitudes across the university and business sectors. The issue of different types of funding streams, and which to increase or decrease, I shall return to in section 5.4.

Two important absences in the legal framework of the Colombian innovation system must be stressed at this point. Both of them pertain to the problem of prioritizing teaching over research and third mission activities. First, the absence of a national guideline for recruitment and promotion at universities, emphasising engagement in R&D activities with the productive sector.[21] Second, a permanent, separate stream of funding for university engagement in R&D activities with the

[21] The absence of such guidelines seems to be a general problem in Latin America that in addition to hampering engagement in R&D activities with the productive sector, is seen to cause other severe problems: "Complete absence of wage recruitment, promotion and training policies has provoked low morale among researchers and many have expressed a desire to leave the institutions" (Velho 2005: 103).

productive sector. Previously, the reasoning of COLCIENCIAS on this issue was that the time university professors expend in collaborative R&D projects was the investment that universities should rightly make, paralleling the investments made by COLCIENCIAS and the involved R&D enterprise, respectively. There is increasing recognition, however, that this line of reasoning is a key barrier to stimulating collaborative research, simply because in most universities there are no funds free to be invested in this manner (García 2005). To this issue we shall return in section 7.4.

Before closing this section, I should like to refer briefly to a recent experience of local technology development in shrimp farming, based on collaborative research. For many years, shrimp farms in the northern region of Colombia had showed no interest in doing cooperative research with university researchers in the field. However, when shrimp firms in 1995 were hit by disease, a cooperative research agreement was made and a project funded by COLCIENCIAS launched (CENIACUA). Not only did the project manage to cure the disease and in that sense rescue this industry in one of the more remote regions of Colombia. Through the cooperative research, knowledge and technologies were developed that made CENIACUA an internationally recognised key source of knowledge in shrimp disease combating, with foreign delegations visiting regularly (Botero 2005, Turriago 2005. The CENIACUA case serves to illustrate that when cultural barriers – such as lacking trust between university and industry sectors and lacking confidence in the country's capacity for technology development – are overcome, Colombia's high potential for internationally competitive innovation and technology development comes through very clearly.

CHAPTER 5

INSTITUTIONAL SETTING

5 INSTITUTIONAL SETTING

Country sections in this chapter consist of four subsections. First, a section is devoted to briefly describing the main governmental agencies, including a description of the key policy-making agency. A second section explains the overall structure and logic of the funding system, and finally a third section takes up a topic of particular pertinence to a characterisation of the institutional setting and funding system of the country in question.

5.1 FINLAND

5.1.1 Main agencies

The main public funders of R&D in Finland are the National Technology Agency (TEKES) and the Academy of Finland, which are under the auspices of the Ministry of Trade and Industry and the Ministry of Education, respectively. Needless to say, these are not the only government agencies involved in public funding of R&D. In what follows TEKES, VTT, the Academy of Finland, and the Finnish National Fund for Research and Development (Sitra) will be described briefly.

The National Technology Agency (TEKES)

In Finland, funding has been used strategically as a change agent. This strategy has had two components: introducing new conditions and procedures for competitive funding, and increasing the overall level of funding. In this process, The National Technology Agency (TEKES) has played a particularly central role. Since its foundation in 1983, TEKES has grown to be the principal promoter of R&D in Finland. TEKES provides funding both to research projects at universities, to long-term R&D projects in companies, and to business R&D projects aiming at developing new products, production methods or services. In 2003, total R&D funding from TEKES amounted to 387 million euros, spread over 2,261 co-financed projects. The fact that TEKES stresses co-financing of the projects and programmes it engages in is a very central aspect of its approach to R&D funding. Through its extensive funding of R&D in universities and companies, TEKES has taken a central role in strengthening the technological competencies and economic productivity of the Finnish economy. TEKES will be further described in and through some of the public promotion programmes it is in charge of (see section 7.1).

VTT

The Technical Research Centre of Finland (VTT) employs more than 2,850 R&D personnel and has a turnover of more than 200 million Euros. VTT develops technologies in order to improve both the competitiveness of companies and the basic infrastructure of society, and to foster the creation of new businesses. VTT has eight Research Institutes – Electronics, Information Technology, Automation, Chemical Technology, Biotechnology and Food Research, Energy, Manufacturing Technology, and Building Technology – as well as an information service and a technology studies group.

Academy of Finland

The Academy of Finland constitutes the Finnish research council system. The Academy states that its overall function is “to enhance the quality and prestige of basic research in Finland by providing funding allocated on a competitive basis, by carrying out systematic evaluation and by influencing science policy” (Academy of Finland 2003). The Academy further states that its funding of a wide range of basic research is intended to “provide a solid foundation for innovative applied research” (Academy of Finland 2003). The Academy of Finland’s operation covers all scientific disciplines. The Academy operates within the administrative sector of the Ministry of Education and is funded through the state budget. In 2002, over 13 per cent of all government research funding was channelled through the Academy. The objectives for the Academy’s operation and the resources made available to the Academy are decided on an annual basis in talks between the Academy of Finland and the Ministry of Education.

SITRA

Sitra, the Finnish National Fund for Research and Development, is an independent public foundation under the supervision of the Finnish Parliament. Sitra seeks to identify and help further developing Finnish enterprises that are internationally competitive and profitable. To such companies Sitra offers funding and services that will advance their progress. The focus of Sitra’s corporate funding is directed towards enterprises that are at the start-up stage. Sitra’s corporate funding activities include PreSeed funding, and Network Development Funding. Sitra’s *PreSeed service package* has been created to accelerate the emergence of new technology-based business, to improve capital management and to introduce companies to the providers of further funding. The PreSeed service has two arms: LIKSA and INTRO. LIKSA is a joint funding service operated by Sitra and TEKES that can be used to obtain knowledge and services related to the commercialisation of technology. The aim is to evolve a good business plan more swiftly than hitherto using continuous assessment. The INTRO service takes care of the efficient presentation of start-up enterprises so that they can find both institutional and private investors who will be prepared to provide simple straightforward funding in the future. A new form of funding for Sitra is the *Network Development and Finance* scheme. In this scheme new types and concepts of business are set up in collaboration with small and medium-sized enterprises. The aim is to combine traditional know-how with new technology. Sitra encourages SMEs to network by investing in the development of such networks. Sitra will invest mainly in existing networks and their flagship companies but may also invest in new networks. In addition to providing funding, Sitra also cooperates closely with TEKES and other key actors in the Finnish NIS.

The Science and Technology Policy Council

The main actor in designing science and technology policy is the Science and Technology Policy Council. The Science and Technology Policy Council of Finland was established in March 1987, to assist the Council of State and its Ministries in questions relating to science and technology. The Science and Technology Policy Council is chaired by the Prime Minister. Other members include the Minister of Education and Science, the Minister of Trade and Industry, the Minister of Finance, and up to four other ministers. In addition to them, the council consists of ten other members well versed in science and technology. These must include representatives of the Academy of Finland, TEKES, universities and industry, as well as employers’ and employees’ organisations. The Council has an executive committee and a science policy subcommittee and a technology policy subcommittee with preparatory tasks. These are chaired by the Minister of Education and Science and by the Minister of Trade and Industry, respectively. The Council's Secretariat consists of two full-time chief planning officers. The Council has been assigned a number of key tasks, most importantly:

- To direct S&T policy and make it compatible with other national policies
- To prepare plans on the overall development of scientific research and education
- To issue statements on the allocation of public science and technology funds

- To handle the legislative matters pertaining to the promotion of research and technology development
- To follow up and assess policies, programmes and measures adopted

The Council discusses main policy challenges in its triennial policy reviews, and makes general suggestions concerning all actors. This usually includes suggestion on how resources for public funding of R&D should be allocated. The actual implementation of these suggestions is left to the ministries and agencies. Individual research or technology programmes are not decided by the Council, nor by the ministries, but at the level of the implementing agencies. The representation in the STP council of all key stakeholders makes its statements and proposals on science and technology policy a strong basis for subsequent policy-making.

A key component of the Finnish approach has thus been a high degree of integration of policy-making across a number of key policy areas, including science, innovation, industrial, and economic policies. It is important to stress that this is one of the strongest comparative advantages of Finnish science and technology policy. There is, however, in this coordinated policy-making, a missing link: namely higher education policy. This was noted in a report evaluating the role of universities in the Finnish national innovation system:

> It has to be noted… that [overall] developments in the realm of higher education policy did not have any (visible) links to science and technology policy. For historical reasons, links between these two policy realms have been weak, even though the target institution of the policies has been the same (Nieminen & Kaukonen 2001: 33).

Due to the lack of integration of higher education policy and science and technology policy, Finland remains in the ambiguous situation of simultaneously promoting and severely complicating university entrepreneurship and commercialisation of research (see section 4.1.2). The case study in section 6.1.3 illustrates how this hampers the benefits that the Finnish economy reaps from its science base. The integration of higher education policy and science and technology policy in a manner that yields clearer and less ambiguous guidelines for university entrepreneurship and commercialisation is thus a key challenge for future policy-making in Finland.

5.1.2 The funding system

During the 1990s, the Finnish government has reformed its mode of regulation with regard to the university system. Generally, the policy of the Ministry of Education through the 1990s was to increase the administrative autonomy of universities, and to replace budgetary and regulatory control with ‘management by results’, through evaluation and consultation procedures. These new principles of higher education governance were part of a general movement in the direction of ‘new public management’ in the Finnish public sector. These developments were reflected also in a significant change in the overall patterns of public research funding.

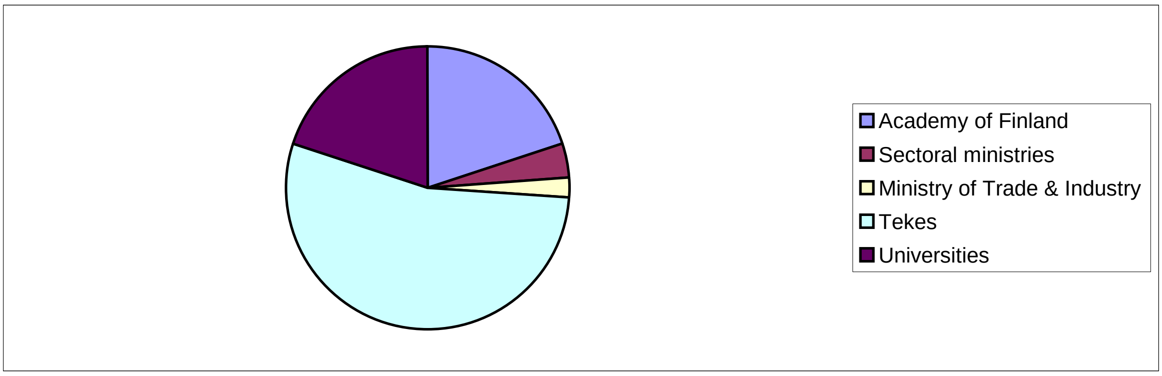
> Public funding was increasingly channelled through competitive funding mechanisms and the criteria for funding from extra-budgetary sources increasingly presupposed cooperation (cooperation within the university system, international cooperation, university industry cooperation) as a condition for funding (Nieminen & Kaukonen 2001: 32)

The increased emphasis on competition and cooperation was the two most significant changes during the 1990s. It must be stressed that the shift in the distribution of government research funding was substantial. In the period from 1990 to 1996 alone, the balance shifted dramatically. In 1990, 58 pct. of government funding was given directly to research-performing organizations (universities and research institutes), and only 42 pct. was distributed through funding organizations

(TEKES, Academy of Finland, etc.). In 1996, funding distributed through funding organizations had increased to 52 pct. of total government research funding, and the share of direct budget funding to the research-performing organizations correspondingly decreased to 48 pct (Nieminen & Kaukonen: 33). By means of this shift, the relative balance between budget funding and competitive funding changed significantly in favour of competitive funding. From the perspective of the universities, this has meant a radical change in the composition of its research funding. The share of budget funding decreased from 67 pct. in 1991 to 53 pct. in 1998, with a corresponding rise in the share of competitive and other external funding from 33 pct. to 47 pct. (Nieminen & Kaukonen 2001: 38).

In the section on the history of science and technology policy in Finland (3.1), the commitment by Finnish policy-makers to the strategic importance of science and technology policy in the difficult economic situation of the early 1990s was emphasised. Though the Finnish economy recovered from the economic crisis by the mid-1990s this commitment was not abandoned. On the contrary, in 1996, the government of Finland decided to allocate 3.35 billion FIM in proceeds from state property sales, to further increase the level of public funding for research and development. The purpose of this additional appropriation, disbursed between 1997 and 1999, was to intensify the operation of the national innovation system for the benefit of the economy. The STP council drew up a plan for the appropriation whereby the bulk of the funds were to be allocated to research and development, notably increasing the resources allocated to TEKES and the Academy of Finland by means of competitive tenders.

Figure 10 The additional appropriation for research



Source: Prihti et al 2000.

The vast majority of the funds were allocated on the basis of competitive bidding, for which cooperation in and among industry and science actors was a key criterion.

The original target in the additional appropriation programme was to raise the national investment in R&D to 2.9 percent of GDP by 1999. This goal was reached and surpassed in 1998. In 1999, an appropriation increment of FIM 1.5 billion was introduced on a permanent basis.

The policy throughout the 1990s of promoting university interaction with industry through continuously increasing the amount of funding available for different modes of collaborative research and development through competitive bidding, has been a core element in Finnish science and technology policy. The commitment to this strategy was recently affirmed in the triennial policy review by the Science and Technology Policy Council (STPC 2003: 37).

5.1.3 Special topic: evaluation

Many observers point to *evaluation* as a key element in Finnish science and technology policies. In its 1990 policy review, the Finnish STP council declared “increased evaluation in all parts of the research system and in different sectors of science and technology policy” to be a key objective (STPC 1990: 62). The Finnish policy on evaluation as a core element of its science and technology policy was outlined in a separate statement by the STP council in 1991. Here, the STP council stressed the need to “extend evaluation to the whole national system of innovation”. Three years later, the STP council noted that few of its objectives had “come true as fully as the recommendation for increased evaluation” (STPC 1993: 28).

The role intended for evaluation was to continuously inform “objective-setting and selection within the innovation system” and further develop “the knowledge-base which supports decision-making on the improvement of the system” (STPC 1993: 28). Thus, in the Finnish approach, evaluation is an integral element in the ongoing effort to identify and further strengthen the comparative advantages of Finnish economy through R&D, rather than merely an instrument of public control of the correct use of public funds. This applied for the recently completed evaluation of biotechnological research; *Biotechnology in Finland – Impact of Public Research Funding and Strategies for the Future* (December 2002). This evaluation, funded by the Academy of Finland, evaluated “the current status of the Finnish biotechnology innovation system”, and proposed “improvements as appropriate”, all in order to “serve as a basis for drafting the next national biotechnology development programme” (Academy of Finland 2002). The evaluation combined an external assessment by an international expert group with an internal self-assessment exercise, and on the basis hereof formulated recommendations directed to the academic sector, the funding organisations and to industry. The fact that evaluations are used in this strategic and policy-developing manner is but one expression of the practice in Finland of formulating science and technology policy on the basis of a comprehensive system of continuous policy research and assessment.

Another notable example hereof is the launching by TEKES of a technology programme aimed specifically at informing the development of advanced technology policy; namely *ProACT – the research programme for advanced technology policy*. Jari Romanainen, then director of TEKES, motivated the practice of basing the formulation of science and technology policies on science and technology policy research in the following manner:

> Policy design and implementation must be innovative and able to experiment with different approaches and tools in order to meet the challenges of the changing innovation environment. This is possible only if the theoretical framework and methodologies continue to evolve and are able to provide a better understanding of the complex interactions and linkages within the innovation environment. Understanding how the system works is the key to successful policy design and implementation. (Romanainen 1999).

Examples testifying to the fact that research and evaluation in the field of science and technology policy are in fact taken seriously, and do in fact strongly influence policy-making are numerous. One classic example is the study on industrial clusters by the Research Institute for the Finnish Economy which preceded and heavily influenced the National Industrial Strategy 1993, and later generations of cluster programmes. A more recent example is the evaluation of Biotechnology in Finland. The biotech evaluation report stressed the need to “modernise University organisational structures… so as to achieve more flexibility” (Academy of Finland 2002: 76), and this was a key focus area of the recent policy statement by the Science and Technology Policy Council (STPC 2003).

An important element of the Finnish approach to the formulation and implementation of science and technology policy is the division of labour between the STP council, the Ministries and the funding and implementing agencies, such as TEKES and the Academy of Finland. That policy-making in this field is extremely well-coordinated, does not imply that everybody are involved in everything. On the contrary, a substantial degree of autonomy with regard to policy implementation has been delegated to the funding agencies.

> Individual research or technology programmes are not decided by the Council, nor by the ministries, but at the level of the implementing agencies. This makes it possible for the system to react relatively quickly to new industrial and societal challenges as they are identified (Romanainen 1999).

TEKES employs staff with research experience and significant understanding of those technological fields that they are involved in evaluating and further developing. This enables TEKES to provide high-quality mediation between public science researchers, industry partners, and other players in the innovation system. Basing science and technology policy on policy research and evaluation, and basing policy implementation on high-quality scientific mediation appear to be important elements of the Finnish model.

5.2 UNITED KINGDOM

5.2.1 Main agencies

The main public funders of R&D in UK are the Higher Education Councils and the Research Councils, which are under the auspices of the Department of Trade and Industry (DTI) and the Department for Education and Skills (DfES), respectively. Needless to say, these are not the only government agencies involved in public funding of R&D and S&T policy-making in the UK. In what follows the Research Councils, the Higher Education Councils, the Office for Science and Technology (OST) and the Council for Science and Technology Policy will be described briefly.

Higher Education Funding Councils

There are separate Higher Education Funding Councils for Wales, for Scotland, for Northern Ireland, and for England. The name of the latter is the Higher Education Fund for England (HEFCE). These Higher Education Funding Councils belong to the Department for Education and Skills (DfES), and they provide what is termed 'block funding' for universities. This block funding primarily covers expenditures on infrastructure and the proportion of salaries to academic staff allocated to research. This funding is intended to enable research departments to cover costs relating to: (i) building research capabilities (ii) training new researchers, (iii) making credible proposals for research project funding, and (iv) pursuing a certain amount of blue-skies research (DTI 2002). The amount of funding given to individual universities and departments is determined by a formula largely determined by the ratings awarded in the Research Assessment Exercise (Georghiou 2001: 256). Therefore, this block funding is also termed Quality Related funding (QR).

Research Councils

A second stream of public funding is provided by the Research Councils, funded by the Office of Science and Technology (OST), situated within the Department of Trade and Industry. The funding provided by the Research Councils is project funding based on open competition and peer review. At present, there are seven such Research Councils (RCs) in the UK: the Medical Research Council, The Biotechnology and Biological Sciences Research Council, the Natural Environment Research Council, the Engineering and Physical Sciences Research Council, the Particle Physics and Astronomy Research Council, the Economic and Social Research Council, and the Council for the Central Laboratory of the Research Councils (DTI 2002).

Office for Science and Technology

The Office for Science and Technology (OST) is located with the Department of Trade and Industry. The Secretary of State (SoS) for Trade and Industry has overall responsibility for the Government's science policy and support for S&T in his cross-Departmental role as the Cabinet Minister for Science and Technology. The SoS aims to "strengthen the UK's S&T capabilities" and to "maximise the contribution to sustainable growth and quality of life in the UK" (OST 2005). The SoS is supported in this role by the Department of Trade and Industry's Minister for Science and the Office of Science and Technology (OST). OST is responsible for developing and coordinating Government policy on science and technology both nationally and internationally. OST is also responsible for the allocation of the Science Budget into research via the Research Councils. The overall mission of the Office of Science and Technology is to support "excellent science, engineering and technology and their uses to benefit society and the economy" (OST 2005). In pursuing this mission, the OST has defined a set of immediate objectives, notably (i) to sustain and improve the science and engineering base, (ii) to improve the performance of government departments using science and technology, (ii) to improve the flow of people and ideas between the science and engineering base and users, (iii) to improve engagement between science and the rest of society, and (iv) to ensure sound advice is given to Ministers across Government on science issues (OST 2005).

The Council for Science and Technology

The Council for Science and Technology (CST) is the UK government's top-level advisory body on science and technology policy issues. CST's remit is to advise the Prime Minister on strategic issues that cut across the responsibilities of individual government departments. CST gives advice on the strategic policies and framework for:

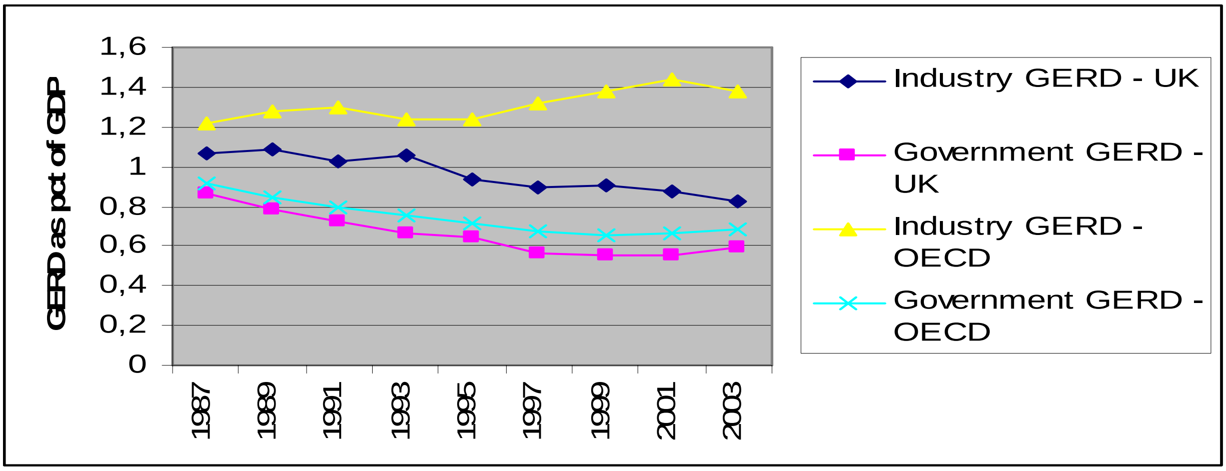
- sustaining and developing science, engineering and technology (SET) in the UK, and promoting international co-operation in SET
- fostering the practice and perception of science, engineering and technology as an integral part of the culture of the UK
- promoting excellence in SET education
- making more effective use of research and scientific advice in the development and delivery of policy and public services across Government
- promoting SET-based innovation in business and the public services to promote the sustainable development of the UK economy

In developing its advice CST endeavours to take into account the cultural, economic, environmental, ethical and social context of developments in SET, and works on issues of strategic importance, taking a medium to longer term approach. The CST is an Advisory Body, and is independent from central government. Thus, though government can ask CST to consider particular issues, CST is under no obligation to agree to these requests if it believes that other work would be of greater value. The Council delivers its advice to government by various routes including: publishing reports; through confidential written advice; and through discussions with ministers, officials and special advisers. For instance, the CST recently (March 2005) published a report that encouraged government to do more to engage the public in the development of science and technology based policies, or risk jeopardising the economic and social gains expected from the investment in science and innovation. The members of the Council are senior experts drawn from across the field of science, engineering and technology. They are appointed by the Prime Minister in line with public appointments guidelines. Further, the CST draws on additional expertise by inviting non-members to join subgroups that are taking forward specific pieces of work.

5.2.2 Funding system

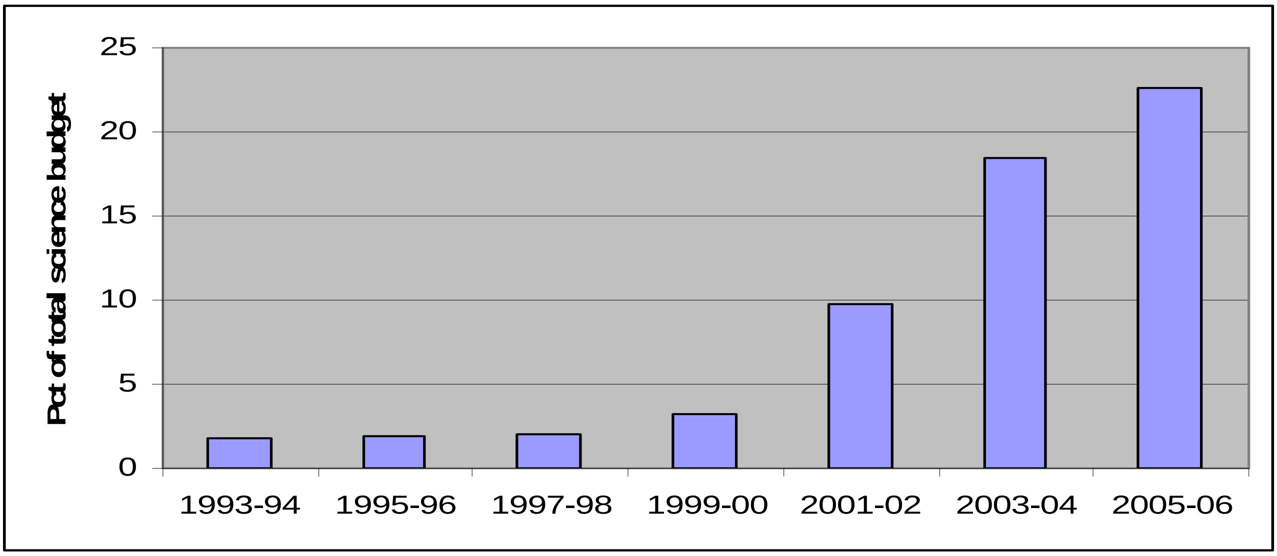
The institutional setting for universities in the UK may be said to be characterised by a high degree of organisational independence (EC 2001: 244), for two reasons primarily. First, there are no specific working contract regulations for university researchers and secondly, no basic funding for universities are provided by central government. Funding for basic research and teaching is provided by the Funding Councils only in accordance with the results of the RAE. For an extended period of time the public streams of funding were declining, and universities were forced to find other sources of funding. As a result, today funding from third parties accounts for more than 40 pct of total research funding. Public as well as private R&D spending in the UK remains, however, at a relatively low level compared to other OECD-countries.

Figure 11 R&D as a pct of GDP by financing sector – UK vs OECD



The UK government provides two streams of funding, known as 'the dual support system' (DTI 2002: 29), with one stream of funds provided by the Higher Education Funding councils, and the other provided by the Research Councils. Over the course of the 1990s, the latter type of funding for university research has grown significantly in importance relative to block funding from the Higher Education Funding councils. More specifically, the funding distributed from the OST through the Research Councils has grown from a level below 2 pct throughout most of the 1990s, to a 18 pct in budget year 2003-2004, with a further increase to a level of 23 pct budgeted for the year 2005/2006.

Figure 12 Research council funding as a share of the total science budget



Source: DTI 2005

As mentioned above, the funding by the Higher Education Funding councils is based on the Research Assessment Exercise and the effect of the RAE-based allocation of block funding is that resources are concentrated heavily in highly-rated departments. A further critique of this funding model is that the RAE does not reward university interaction with industry, and UK policy-makers are increasingly recognising the disincentives thereby created for individual researchers to engage in such interaction. Recent policies have tried to counter-balance the disincentives for third mission activities by providing separate funds particularly for the promotion of such interactions; for instance the *Higher Education Reach Out to Business and the Community* (HEROBAC) program. In and through such programmes, the objective of promoting industry-science relations have become the central organising principle for new science and technology funding initiatives in the UK (OECD 2002: 109).

Paying lip service to the ideal of a knowledge economy, many governments speak of a need to increase university interactions with business, but few of them realise that for such increased interactions to be of any significance in terms of scale and quality, considerable professionalisation is required. In UK there is wide recognition of this, and a separate stream of funding has been provided to enable universities to undertake the necessary institutional restructuring and professionalisation of its third mission activities. In 2003, commitments were made to significantly increase the level of this permanent stream significantly in the following years. More specifically, an increase of third stream funding of more than 80 pct over a three year period was budgeted.

5.2.3 Special topic: regionalization

In April 1999, UK government created a number of Regional Development Agencies (RDAs), following the Regional Development Agency Act of 1998. The OECD benchmarking report described this as giving "new impetus to regional innovation policy, making each regional development agency responsible for furthering economic development [and] the promotion of business efficiency, investment and competitiveness in its area" (OECD 2002: 141). There are, however, serious reservations with regard to the actual impact of this legislation. The Regional Development Agencies are formally the responsibility of the Department of Environment, Transport and the Regions. The policies of this Ministry remain, however, distinctly non-regional in their making as well as in their objectives (Charles & Benneworth 2002). When it comes to innovation policy as well as science and technology policy more generally, the focus of UK policy is exclusively and explicitly national. This leaves the RDAs in a difficult situation:

> Each of the new English RDAs has the responsibility to write innovation strategies for their regions building on the work undertaken in the drafting of their regional economic strategies. The weakness of … these new regional arrangements was that although they were repeatedly informed of the importance of developing clusters, their mandate did not extend much beyond mapping activities and facilitating business clubs. All the RDAs faced the difficulty of trying to write a strategy for a knowledge-based economy knowing that the most critical decisions affecting them are taken without consideration for … regional needs (Charles & Benneworth 2002: 75).

It is a major challenge for future UK policies to develop a coherent third mission policy that cut across all relevant policy areas. It is a barrier to the advancement of third mission activities in the UK, that science funding is allocated and science policies formulated with little emphasis on the ultimate objective of third mission activity: the regional economy. In the most recent formulation of third mission policy, the importance of contributing to regional economy is the single most emphasised objective. The section on third mission policy in the 2003 White Paper on Higher Education thus opens with the following statement:

> Much has been done through specific schemes and the Higher Education Innovation Fund to improve [business] links. As a result, they are already excellent in some places, but good links are neither extensive nor consistent enough. To improve, institutions should increasingly be

> embedded in regional economies, and closely linked with the emerging agendas of Regional Development Agencies (DfES 2003: 36).

A practical expression of this emphasis on regional development is that the White Paper announces the decision to engage RDAs more closely in the distribution of HEIF funding, giving them a formal role herein from the year 2004/2005 (DfES 2003: 38). Other policies as well as other – much larger – streams of funding seem, however, to work in the direction of continued concentration of UK public R&D in South East England, largely due to the system of basing block funding on the Research Assessment Exercise (RAE). In the recent OECD report benchmarking industry-science relations in UK, France, US and Japan, emphasis was given to the negative impact of the RAE on university interaction with industry:

> In the United Kingdom, framework conditions are increasingly favourable to the collaboration of industry and science... However, within the universities, the importance of publication within the Research Assessment Exercise carries a risk that academic work embodying public good characteristics will continue to be undervalued… Specific policies for the promotion of ISRs may not be sufficient to counter opposing forces. The Research Assessment Exercise… has frequently been identified as a barrier to ISR, even if it fulfils a valuable function in terms of its main objectives (OECD 2002: 152-153).

UK faces the challenge of revising its system of allocating core funding to the universities; its so-called 'block funding system'. Two main policy options exist. Either the connection between core funding and the RAE could be loosened, or the criteria of the RAE itself could be reformed. In June 2002, the Higher Education Council for England announced that it would conduct a review of the RAE, in partnership with other UK higher education funding bodies:

> The review will investigate different approaches to the definition and assessment of research quality, drawing on the lessons both of the recent RAE and of other models of research assessment, and will advise on the future of research assessment…There are concerns that the RAE does not give proper weight to applied research and favours basic research, which results in conventional research outputs, such as articles in peer reviewed journals… The review will need to consider, among other things, to what extent existing steps have been successful and what should be put in place to tackle these issues in future (DTI 2002: 30).

5.3 COLOMBIA

5.3.1 Main agencies

The key agencies involved in the direction and coordination of the Colombian innovation system are the following: the National Council of Science and Technology, COLCIENCIAS, the Councils of the National Programs of Science and Technology, the Regional Commissions of Science and Technology, the Colombian Observatory of Science and Technology, and SENA (COLCIENCIAS 2005, RICYT 2005). Each of these will be described briefly below.

CNCyT – National Council of Science and Technology

National Council of Science and Technology (CNCyT) is the permanent governmental body for the direction and coordination of the system of science and technology. CNCyT acts as the main advisor to the government on all science and technology matters. The Council is chaired by the President of the Republic and is further comprised of the head of the National Department of Planning (DNP)[22], the ministers of Economic Development, Agriculture and Education, the rector of the National University, a rector of a private university, a member of the scientific community, a member of the private sector, a representative of the Regional Commissions of Science and Technology and the director of COLCIENCIAS. The main functions of the Council are the following (Ricyt 2005):

- to propose strategies to incorporate science and technology in plans for social and economic development
- to stimulate the innovative capacity of the productive sector
- to prepare government bills and decrees for the development of science and technology
- to create new regional and national programs of science and to set criteria for the
- assignment of resources
- to approve and to arrange all the necessary measures for the implementation, monitoring and evaluation of science and technology policies and programmes

Councils of National Science and Technology Programmes

There are 11 National Science and Technology Programmes in Colombia. Each of these has a national council which is responsible for approving research, promotion and funding policies within this sector, and for guiding and approving the allocation of funds between the various projects. Further, the Councils are responsible monitoring and evaluating. At present, there are National S&T Programmes in following sectors: Agriculture, Basic Sciences, Biotechnology, Electronics, Telecommunications and Data processing, Environment, Education, Health, Human and Social Sciences, Industrial Development, Marine, Mining & Energy.

[22] The National Department of Planning (DNP) is the technical secretariat of CONPES, the highest level of policy-making in Colombia (UN 1999: 119).

The Regional Commissions of Science and Technology

The Regional Commissions of Science and Technology are responsible for the coordination and direction of National Innovation System at the regional level. These Regional Commissions were created in 1994, in seven regions in Colombia (Amazon, East Central, Atlantic Coast, Capital District, North Occident, Orinoquia, and Pacific). Among the main functions of the regional commissions are the following:

- Proposing and organizing regional programmes for science and technology
- Monitoring and evaluating programs of science and technology in the region
- Raising funds from public and private sources for regional science and technology activities

The Colombian Observatory of Science and Technology – OcyT

The Colombian Observatory of Science and Technology (OcyT) is a research centre that studies science and technology activities in Colombia. It produces indicators for the area of science, technology and innovation, carries out bibliometric studies, collaborates with COLCIENCIAS in the constitution of databases and national indices and participates in linking Colombia with international systems of scientific information. In these ways, the Observatory assists the different institutional actors of the national innovation system in carrying out analyses, making decisions, devising strategies, and evaluating research and development policies and performance.

SENA

The National Training Service Centre, created in 1957 as a result of the joint initiative of organised workers, entrepreneurs, Catholic Church and the ILO. It is a national public entity with legal status, under the authority of the Ministry of Labour and Social Security.

A large part of SENA's incomes are derived from a requirement to all Colombian employers of paying 2 pct of the salary of their employees to a fund administered by SENA (Tovar 2005). SENA invests in the social and technical development of Colombian workers. It offers and executes vocational training for the integration of people in productive activities that contribute to the economic, social and technical development of the country. Besides the integral vocational training imparted in its Training Centres, it offers the following services:

- Information, orientation and training for the job
- Support to entreprise development
- Technological services to the productive sector
- Support to innovative projects, technological development and competitiveness.

The training that the institution offers leads to operational and instrumental mastery of a given occupation, to the appropriation of the technological knowledge that the occupation requires and the capability to adapt to changes.

In 1996, a law (Ley 344) was passed requiring that 20 pct of the income generated by SENA was to be spent on innovation activities, whereas previously the entire income had been spent on 'traditional' training activities. This was an important change for the Colombian innovation agenda, even more so given that SENA's funds are considerable (see below).

SENA´s policy towards innovation, competitiveness and productive technological development endeavours to meet the needs of to the productive sector, by offering the execution of joint projects, research and academic development as well as supply of technical, human and financial resources.

SENA's role in the Colombian NIS is intriguing. It needs further investigation whether SENA's involvement in innovation is efficient, or whether the funds it disposes over for innovation activities would be more efficiently utilised if allocated instead to the prime innovation agency, COLCIENCIAS.

COLCIENCIAS – Instituto Colombiano para el Desarollo de la Ciencia y la Tecnologia
The Colombian Institute for the Development of Science and Technology (COLCIENCIAS), originally established in 1968, is the central governmental agency for the promotion and development of science and technology. Its overall objective is to promote technological and scientific advancement, to incorporate science and technology into programs for the social and economic development of the country, and to formulate medium- and long term plans for science and technology development in Colombia. A key concern for COLCIENCIAS is to establish mechanisms that promote interaction between universities and the private sector, with a view to stimulating the innovative capacity of the productive sector and to strengthen scientific investigation and technological development more generally, In brief, COLCIENCIAS is charged with the task of continuously improving the Colombian system of innovation.

COLCIENCIAS' finances a wide range of projects and programmes, ranging from strategic programmes for the regionalisation of science and technology, over programmes to improve the mobility of researchers, to the financing of innovation. Some of the key schemes and programmes operated and/or funded by COLCIENCIAS will be described in section 7.3. COLCIENCIAS is the largest source of public funding for science and technology in Colombia. In 1998, the funding dispersed by COLCIENCIAS amounted to 46,640 million pesos, or just about one third of central government funding that year.[23]

5.3.2 Funding system

Investments in R&D in Colombia have been decomposed in the five categories by the Department for National Planning (CONPES): (i) Central government investments, (ii) spending by SENA of special funds for innovation (cf ley 344), (iii) private sector investments in S&T, (iv) donations for innovation through tax incentive schemes, and (v) other investments. As it appears from the table below, the Colombian NIS have experienced some rather dramatic shifts in the overall composition of science and technology investments.

Table 10 Decomposition of Colombian investments in Science and Technology

	1996	*1998*	*2000*
Central government	302,409	132,800	80,563
SENA (ley 344)	-	15,000	79,800
Private sector	394,771	356,197	269,706
Donations (ley 383)	17,272	33,863	82,253
Other	16,305	55,225	50,416
Total	730,757	593,085	562,738

Note: Million 1998-pesos.

Source: CONPES 2003

[23] Calculation based on information from COLCIENCIAS on budget in 1998, and data from CONPES, cf. table 10 above. More specifically: (43,640 * 100)/132,800=32.86 pct.

The following figure gives an overview of how COLCIENCIAS, the main public S&T funding agency, invests its funds in different types of S&T projects and activities. As it appears from the table below, more than 40 pct of COLCIENCIAS funds are dispersed in and through two types of funding: *Financición a la investigación en Ciencia y Tecnologia* (CyT) and *Financiación de innovación*.

Table 11 COLCIENCIAS – Main lines of funding (in pct)

Research funding *(Financiación a la investigación en CyT)*	24
Innovation funding *(Financiación a la innovación)*	17
Proyecto inteligente	8
Institutional support	10
Scientific community consolidation *(Consolidación comunidad cientifica)*	19
Information systems	3
Communication and popularization of science	6
Regionalization	2
Internalization of science	1
Administration of the S&T system *(Administración del SNCyT)*	6
Other	4
	100

Note: Data for 2003

Source: OCyT 2004.

All innovation and research projects financed by COLCIENCIAS are co-financed projects, and there has been a successful attempt to decrease COLCIENCIAS' share of the financing of projects. More specifically, COLCIENCIAS' share in the financing of research projects have decreased from 48 pct in 1995 to 36 pct in 2003 (OCyT 2004: 145). Most projects financed by COLCIENCIAS take place in Higher Education Institutions, but a substantial number of private research centres and enterprises run projects funded by COLCIENCIAS too. Out of a total of 371 institutions receiving project funding in 2003, 246 were HEI institutions, 75 were private research centres, 37 private enterprises and 13 were public institutions (OCyT 2004: 146). In 1995, the total number of projects funded by COLCIENCIAS was 184 – i.e half the number of projects financed in 2003. In the same period, COLCIENCIAS' budget decreased significantly, however. Total funding declined from 47½ million USD in 1995 to 14½ million USD in 2003 (COLCIENCIAS 2005). With total funding being reduced to less than a third of the 1995-level, and the number of projects funded doubling in the same period, the average allocation per funded project has declined substantially.

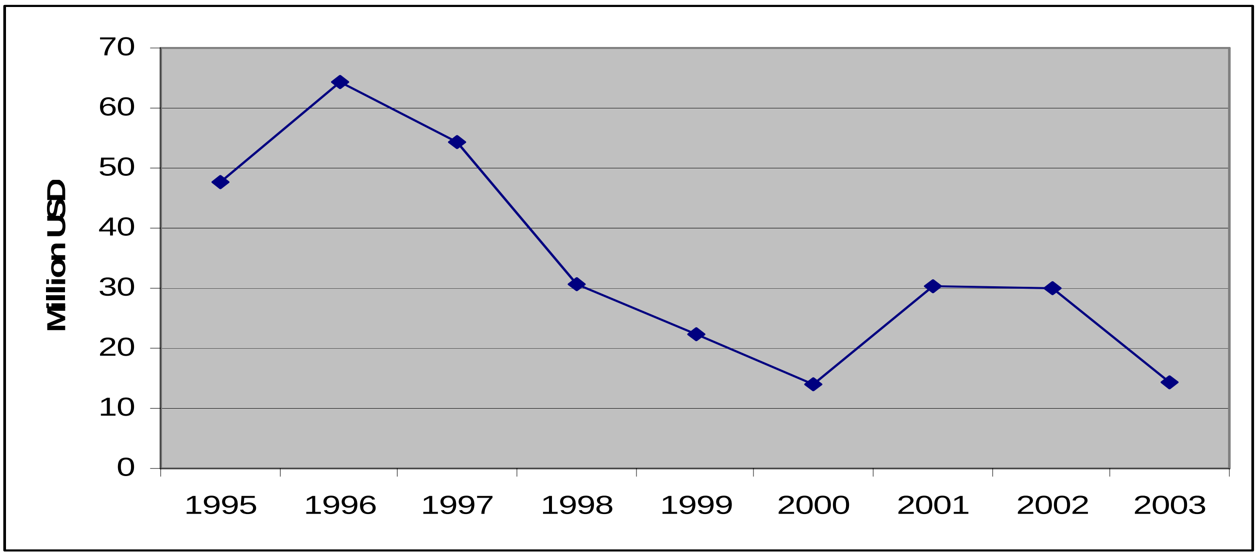
An important development in the funding of higher education institutions in Colombia was the introduction of performance-based funding. The first law introducing this type of funding was passed in 1993. Initially, this new type of funding was tied to increases in GDP, and in its first years of existence the Colombian economy experienced a severe economic recession, with declining GDP. In a recent reformulation of the law (Thorn et al 2005), performance-based funding was tied to total funding for Higher Education Institutions, rather than to GDP increases. According to this new funding system, the goal is to allocate 12 pct of total HEI funding on the basis of a set of performance indicators. More specifically, 75 indicators have been identified. Indicators for research include (i) articles published in national and international magazines; (ii) number of research reports; (iii) number of text books published; (iv) research groups recognized by COLCIENCIAS; and (v) research projects approved by the institution. It should be mentioned briefly, that the model of performance-funding adopted in Colombia (Holm-Nielsen et al 2005: 10-11), includes no third mission criteria. Because the model gives a budget increase of 2 pct to the best performing universities, which is taken from the worst performing universities, the performance-funding model has been subject to considerable critique from university rectors.[24]

The issue of performance-based funding will be discussed in more detail in section 6.4, as it relates to the more general problematic of the reliance on incentives in S&T initiatives.

5.3.3 Special topic: instability of funding

Interviewees all pointed to stabilization of S&T funding in Colombia as a major challenge for future policy-making. The following graph of the total budget of COLCIENCIAS, from 1995 to 2003 well illustrates this problem.

Figure 13 COLCIENCIAS' budget 1995-2003



Note: Million USD (current PPP)
Source: COLCIENCIAS 2005

Instable public funds for science and technology is a severe problem. A recent OECD study examined the impact of public R&D expenditure on business R&D (OECD 2000). The study concluded that whether in the form of direct funding or in the form of tax incentives, public funding of R&D performed by firms have a positive effect on business financed R&D. More specifically,

[24] For a more detailed discussion of these issues, see Thorn et al 2005.

one dollar in direct funding to firms, resulted in 1.70 private R&D on average. Moreover, the study concluded that both for direct funding and tax incentives stability of funding was crucial: "firms do not invest in additional R&D if they are uncertain of the durability of the government support" (OECD 2000:3). The study was based on data from 17 OECD countries in the period 1980-2000. There is reason to believe that this negative influence of instability on the impact of public R&D expenditure on private R&D is no smaller in a non-OECD economy. Even more so, perhaps, in Colombia, where mistrust and the short financial time-horizons of the private sector remain key problems.

In addition to undermining the positive impact that public R&D expenditures might have on the level of private R&D activity, instable public S&T funding further aggravates the problem of mistrust in the Colombian economy. A brief example may be illustrative of this. At Universidad de Sabana, outside Bogotá, a project was undertaken to assist local enterprises.[25] The project was financed by SENA. In accordance with contracts signed between the parties, Unisabana has carried projects for which they have so far only received 40 pct of the promised funding from SENA, because funding was suddenly discontinued. This has left Unisabana with a credit balance for already completed projects of 350.000 USD. If projects already approved and contracted but not yet completed are included in the calculation, Unisabana has a credit balance with SENA of approximately 1 million USD. This has put Unisabana in a situation of financial distress – and in a position where further efforts to contribute to regional economic development through consulting local firms is extremely difficult if not impossible (Velásquez 2005). Needless to say, it will not take many such examples of projects suddenly discontinued and universities left in financial chaos, before any hope of building relations of trust with local firms will be undermined for years to come.

[25] The programme in question is *Programma Nacional de Mejoramiento Continuo* (SENA). The following is based on Unisabana 2005.

5.4 CONCLUSION: POTENTIAL LESSONS FOR COLOMBIA

Compared to most Latin American countries, the Colombian innovation system is institutionally very well developed (Holm-Nielsen et al 2002: 7). This does not imply, however, that opportunities for further improvements do not exist. Four main lessons with regard to institutional setting and funding system emerge.

First, a key problem in the Colombian innovation system is that Colombia has not made science and technology policy a strategic core in overall industrial, economic and social policy-making. Science, technology and innovation policy remain low on the policy agenda in Colombia – both in terms of awareness and in terms of central government organisation. Reorganising and repositioning the Council for Science and Technology at a higher level of central government and increasing funds for its executing agency, COLCIENCIAS, could potentially be an important step in strengthening the Colombian innovation system. In both respects, Finland may serve as a role model. In line with this, it should be considered whether the formation of an organization such as Sitra, specialized in identifying and assisting companies with a potential for innovation and technology development might be a fruitful initiative. At present, COLCIENCIAS has an indeed very broad mission, and a division of labour such as in the Finnish model between TEKES and Sitra could well prove to be productive for the Colombian NIS.

Second, a general lesson of Finnish and UK experiences is that considerable funding of collaborative research and other forms of university interaction with industry is required to promote innovation effectively. In this regard, the UK system has both a weakness and a strength. The weakness consists in the heavy reliance of its funding system on the Research Assessment Exercise which is over-focused on publications in high-ranking scientific journals. The strength consists in the permanent stream of funding for third mission that is provided. The opposite pattern applies for Finland. Here the key strength is that its funding system strongly emphasizes funding of collaborative university-industry R&D projects, whereas funding for third mission of universities are modest, and thus remain a key barrier to university involvement in innovation and commercialisation activities. The way forward for Colombia, in this area, is to take the best of the two models. More specifically, to increase the share of public funding that requires collaborative R&D as Finland has done, and supply considerable funds for third mission, as UK has done.

Third, from UK experience it is important to learn that building regional innovation systems requires a lot more than merely creating regional development agencies, or regional TDCs. At present, the vast majority of research projects financed by COLCIENCIAS are highly concentrated around the three or four largest cities of the country, in the central part of the country (OCyT 2004: 156). This is unfortunate, for building regional innovation systems is what creates a strong national innovation system. To do so requires the formulation of regional economic development strategies, backed by public funding, and it requires engaging universities and the productive sector in the formulation and implementation of these.[26] This is an extremely important area for third mission funding. More specifically, public funding could be made available in two streams. First, public funding should be supplied for the identification of technology development and export potentials

[26] The emphasis on creating regional innovation systems does not imply, however, that regions shouldn't consult each other, and coordinate and cooperate. Recent experience from Chile showed that two neighbouring regions with similar characteristics and technology development potentials had developed S&T strategies without consulting each other. It is important that policy-making stimulates and facilitates coordination and cooperation among the regions. This, in turn, requires that S&T policy-making is high on the overall policy agenda in Colombia – which brings us back to the first potential lesson stated in this section.

in each of the region, undertaken collaboratively by universities and private sector partners in the region. Second, a stream of public funding could be made available for the development of *strategies* at each university, on how each university may contribute to such regional technology development and export efforts.

Fourth, from Finnish experience, the lesson is taught that an important part of the institutional setting for an efficient NIS is procedures for continuous assessment and evaluation. Colombia has not been performing well in this area. One interviewee observed that since an evaluation of Colombian science and technology policies was carried out by the UN in 1999, no overall evaluations have been made. Another interviewee made the remark that there is a sense in which Colombian science and technology policy is “always a seed, never a fruit”. The evaluation culture could be considerably strengthened in Colombian policy-making. Return-to-public-investment evaluations are crucial, not only for the process of revising and developing policies and programmes, but also as a means of generating data that can help convince politicians and private sector managers of the benefits of science and technology investments. Responsibility for ensuring that evaluations are made should be clearly defined and backed by the necessary public resources. It is worth a serious consideration, whether the creation of an independent evaluation unit might be an efficient way of strengthening this aspect of the Colombian NIS.

CHAPTER 6

PROMOTION PROGRAMMES

6 PROMOTION PROGRAMMES

Whereas chapter 5 included sections on the overall funding systems of the three countries, this chapter describes in more detail some of the promotion programmes through which non-core funding is dispersed. This is all the more important given that observers in all three countries emphasized the importance of such programmes for stimulating positive changes in favour of innovation and university interaction with industry.

6.1 FINLAND

In the following the main public promotion programmes in Finland will be described. Particular emphasis will be given to Technology Programmes and Cluster Programmes.

6.1.1 Key public promotion programmes

Technology Programmes

Approximately half of TEKES' funding takes the form of *Technology Programmes*. Thus, in 2001 TEKES provided 185 million euros to financing technology programmes, out of its 385 million total funding that year. These are devised to promote R&D in specific sectors of technology or industry, and to pass on research results to business in an efficient way. These programmes have proved to be a very effective instrument in promoting cooperation and networking among companies and the research sector. Technology programmes are planned in cooperation by companies, research institutes, and TEKES. The planning takes place in workgroups and open preparatory seminars. The final decision of launching a programme is made by the board of TEKES. Each technology programme will then have a steering group, a co-ordinator and a responsible person at TEKES. The duration of the programmes ranges from three to five years; their volumes range from EUR 6 million to several hundred million euros. TEKES usually finances about half of the costs of programmes. The second half comes from participating companies. Projects funded under each technology program are selected competitively.

It is important to understand that TEKES funding is not *either* for companies *or* for universities. Thus in 2001, companies were involved in virtually all TEKES-funded university research projects, in and through their participation in project implementation, monitoring and utilisation of results. Similarly, in 6 out of 10 TEKES-funded business projects, companies ordered research services from universities, academic institutions or research institutions. This cooperation and networking is built into TEKES operations from the initial formulation of a technology programme. TEKES technology programmes are seen as a tool with which to make strategic choices and steer research and development. In the words of TEKES, the technology programmes seek to "strengthen the key technologies and expertise from the perspective of Finland's future and provide a foundation for related business operations" (TEKES annual report 2001). These strategic choices and overall technology priorities are worked out in cooperation with industrial cooperations and unions, companies, universities, and actors in the public administration, under the leadership of TEKES. In fact, this procedure of identifying the needs of industry and society, and design technology programmes to meet those needs, may be said to be the essence of TEKES activities. The currently ongoing technology programmes are listed in Appendix A.

The Cluster Programmes

The overall goal of the Cluster Programmes was to "generate new innovations, businesses and employment", by transferring and accumulating knowledge in and across chosen fields, and by improving co-operation between authorities, public funding sources, legislators, and the private sector (EC 2001). The original initiative to the cluster programme came from the STP council. The Council noted in 1996, that successful efforts to increase collaboration in and among different actors in the industrial sectors of telecommunications and wellbeing, should be extended to other sectors. The Council further noted that this would be best done by means of an inter-ministerial programme, which would then seek to increase not just collaboration within the targeted sectors, but also collaboration among public authorities in different policy sectors.

Thus, when the Cluster Programme came into being, a handful of different ministries was involved: the Ministry of Trade and Industry; the Ministry of Education and Science; the Ministry of Agriculture; the Ministry of Transport and Communications; the Ministry of Social and Health; the Ministry of Labour; and the Ministry of Environment.

> The novelty was to gather all the stakeholders – not only universities, research institutes, and companies, but also sectoral government research laboratories and the most relevant users – together to plan and execute joint projects aimed at increasing the competitiveness of the whole cluster (Romanainen 1999).

The Cluster Programmes started in 1997-98 and were designed to run for 3-4 year periods. They consisted of eight programmes: *the Wood Wisdom* cluster (forestry), *the Well-being cluster*, *the Food Cluster*, *the KETJU cluster* (Logistics), *the TETRA cluster* (Transportation), *the NetMate cluster* (the use of information networks in SME business), *the Workplace Development cluster* and *the Environmental Cluster*. Each programme was organised under a sectoral ministry, and each programme had its own publicly assigned and funded co-ordination. Moreover, there were several steering groups in each cluster, typically involving enterprises, public authorities, funding institutions and public science institutions. More than 300 projects have been funded, bringing together about 300 enterprises and as many organisations from the public sphere. The total finance of all 6 cluster programmes was 102 million euros in the first 4 year period. For an overview of the clusters, the number of participating enterprises and the composition of funding; see Appendix B.

The Centre of Expertise Programme

The Centre of Expertise Programme (CoE) was created in accordance with the Regional Development Act,[27] and started in 1994. The overall objective of the Centre of Expertise Programme is to identify regional strengths and create economic growth by increasing the number of competitive products, services, enterprises and jobs based on the highest standard of expertise. Centre of Expertise Programmes are realised through cooperation between industry, local government, technology centres, universities, polytechnics, research institutes and other branches of public administration. Responsibility for leading the operations lies with the local technology centre company. A main purpose of the CoE programmes is to bring leading experts in research, education and private enterprises in a region or network into close interaction. The Centre of Expertise network provides enterprises with knowledge and know-how derived from national and, where necessary, also international contacts and resources. The Centres of Expertise lean on the following services provided by technology centres: project management; business development and marketing; technology transfer; enterprise incubation; patenting, licensing and financing; co-ordination of extensive research, development and training projects; and development of operating environments and models.

[27] More specifically, Regional Development Act No. 1135, 1993.

Initial implementation of the programme over the period 1994 to 1998 was based on eleven Centres of Expertise. Based on the outstanding results of this work, the Council of State extended the programme by nominating new fields of expertise and new Centres of Expertise to implement the second national programme over the years 1999-2006. Fourteen regional CoEs and two nationally networked Centres of Expertise was appointed for this purpose. In this second phase, fields of expertise has been broadened from the traditional high-tech sectors to include new media, cultural business, recreational experience industry, design, quality and environmental expertise.

Programme work in the regions is co-ordinated by a National Committee for the Centre of Expertise Programme with members representing the ministries involved, the business community, the research community and experts in municipal and regional administration. One of the main principles applied in implementing the Centre of Expertise Programme is *competitive tendering*. The main criteria for selecting CoEs have been (i) concentration of expertise of an internationally high standard, (ii) impact for the proposed programme measures, and (iii) efficient organisation. The Centres of Expertise also compete annually for government basic funding, which serves as seed-stage finance, and is matched by a contribution from the region.

Technology clinics

A technology clinic is a service to help a company test new methods and new know-how quickly and flexibly.[28] Technology clinics are thus intended to facilitate and speed up the transfer of technologies from technology providers to technology users. The main goal of the initiative is to promote the adaptation of specified technologies for problem-solving in Small and Medium Scale Enterprises (SMEs) in order to introduce new technological possibilities and to raise their awareness of external R&D resources. The client of a technology clinic is a SME in need of know how and technology, and the typical assignment for the clinic is a problem that the client cannot solve alone, but which is too small to justify launching a R&D project. Thus, the typical cost is less than 20,000 euros. The core idea is to provide lines of communication between SMEs with specific technological problems, and the leading research experts in the country. An additional outcome of the technology clinics is that SMEs that use their services gain experience in cooperating with universities and research institutions. Moreover, through this interaction with a technology clinic, the external network of the company is expanded with key researchers working in fields relating to the products of the company, and with the employees of the technology clinic, which provides companies with a person-to-person relation to the public R&D funding and services system.

There are 6 different generic types of TCs: *technology-based clinics* that focus on a specific technology; *theme-based* clinics that aim towards promoting awareness and technology development in relation to a particular theme or problem; *cutting-edge clinics* that aim at keeping Finnish SMEs at the forefront of technological development in particular areas of technology; *catching-up clinics* that aim to help Finnish SMEs catch up with international standards in selected areas of technology; *methodology clinics* that aim to disseminate good management practices and methodologies in the SME sector; and *demonstration clinics* that aim to offer demonstration services to a selected group of customers in a particular sector. Four stakeholders are involved in each technology clinic: A customer SME; TEKES; a clinic co-ordinator; and the technological service provider. The latter is usually a public science institution, but can also in some instances be a private company with particularly relevant R&D expertise in the field. The role of TEKES is primarily that of providing funds – up to 60 pct of the costs can be covered by TEKES, and the remaining part must be covered by the SME. SMEs do not apply to TEKES for financing, but

[28] The following description of technology clinics are based on EC 2001 and Komulainen 2002a, 2002b.

directly to the TC coordinator who have been authorized by contract to accept and fund assignments on behalf of TEKES. In 2002, there were 16 TCs in operation, covering areas such as Intelligent Materials; Wood Fuel; Technology Strategy Clinic for Building and Construction Industries, to name a few. The Technology Clinic initiative was initiated in 1992, and by 2001 TEKES funding for TCs was at approximately 1 million euros.

6.1.2 Overview of public promotion programmes

There are, of course, other promotion programmes than the ones described above. The following list provides an overview of the major public promotion programmes in Finland.

Table 12 Main Public Promotion Programmes in Finland

Name of Programme	*Content*
Technology Programmes	Funding for joint large research projects in 60 technology fields
Technology Clinics	Funding for technology consulting to SMEs, developing a market for external technology assistance
Centres of Excellence	Leading public research to top international level in selected fields of research in order to strengthen the knowledge base
Cluster Programmes	Funding co-operative projects and networks of innovation actors in sectoral fields (research- producer-supplier-user chains)
Researcher Mobility Programmes	Subsidies or tax relief to researchers moving abroad or coming from abroad
Centres of Expertise	Building up regional networks in certain fields of technology involving enterprises, universities, municipalities and intermediaries
TULI & Spinno	Promotion of start-ups from science by providing a supportive infrastructure which actively looks for spin-off ideas
Increasing Education in the Information Industry	Strengthening education relating to information industries
Licensing Science's Patents by Industry	Providing supportive infrastructure (consulting, negotiation, information) to inventors in public science for licensing IPR

Sources: EC 2001 and TEKES 2005.

6.2 UNITED KINGDOM

In UK, policy initiatives and promotion programmes are widely seen to be more influential than legal regulations. This was emphasised most recently in the OECD benchmarking report on ISR issues (OECD 2002: 130).[29] In the following the main public promotion programmes in UK will be described. Particular emphasis will be given to the Foresight programme, the Science Enterprise Challenge, and Higher Education Reach-Out to Business and Community (HEROBAC).[30]

6.2.1 Key public promotion programmes

The Foresight Programme

Only one year after its foundation in 1992, the Office for Science and Technology launched a White Paper on Science, Engineering and Technology (OST 1993). A key instrument of this White Paper was the Technology Foresight Programme. This programme was designed to serve three objectives: (i) informing priorities for public spending on science and technology; (ii) bringing together the science base and industry in new networks; and (iii) promoting a 'foresight culture' The Foresight Programme is managed by the Office of Science and Technology (OST). At the core of the Programme are 16 panels with varying degrees of academic representation in their membership, along with representatives from industry and government. The first phase of the Programme culminated in the publication of sectoral reports by each panel. These reports aimed to identify the likely social, economic and market trends in each sector over the next 10 to 20 years, and the developments in science, engineering, technology and infrastructure required to address these future needs. The most recent phase of the Foresight Programme has concentrated on stimulating wider and deeper engagement of business, beyond the R&D function, towards marketing, finance and business planning. A key follow-up measure was a dedicated scheme, the Foresight Challenge competition, allowing consortia of business and the science base to apply for matching funds for projects addressing Foresight priorities. Foresight activities are regarded as being one of the most effective government mechanisms in the promotion of industry-science relations.

Teaching Company Scheme (TCS) /Knowledge Partnership Program

The Teaching Company Scheme founded in 1975 – today known as the Knowledge Partnership Program – is regarded as one of the greatest successes of UK industry-science links. The TCS was initiated by the DTI and aims to develop active partnerships between Higher Education Institutions and industry in the field of education. The scheme sets up partnerships between firms and Higher Education Institutions through the formation of Teaching Company programmes. Firms take on graduates, known as TCS associates, to work full time on specific projects jointly supervised by the Higher Education Institutions and the company. Projects are closely linked to the interests of the firm and aim at achieving a substantial and comprehensive change in the firm, for example in management and production techniques. Partnerships are exclusively between Higher Education Institutions and firms within the region as the associates must travel regularly between the two organisations. The scheme has five formal objectives, namely to: (i) raise the level of industrial

[29] One must bear in mind, however, that the absence of a barrier to university entrepreneurship may not be felt and noticed by observers, who are accustomed to its absence. But from a comparative policy perspective such 'absent barriers' are extremely important.

[30] The following descriptions of UK promotion programmes are extracted from EC 2001, OECD 2002 and Georghiou 2002.

performance by effective use of academic resources, (ii) improve manufacturing and industrial methods by the effective use of advanced technology, (iii) train able graduates for careers in industry, (iv) develop and retrain existing company and academic staff, and (v) provide academic staff with broad and direct experience of industry, to benefit research and enhance the relevance of teaching.

A typical programme lasts for two years. The graduates have a science and engineering background and are recruited jointly by the partners. The associates spend 90% of their time working in the company on specific projects and are paid at industrial rates. The remaining 10% of their time is spent within the HEI undergoing training. Until 1981, the TCS was financed totally out of public funds, but since then firms have provided up to one-third of the cost of new programmes and at least 50% of the cost of renewed programmes. The programmes range in size from one associate over two years to 14 associates in a three-year programme which is then renewed. A review in 1996 found that 70 % of associates are offered employment in participating companies at the completion of a TCS programme. There has been a growing involvement of TCS with smaller companies and in 2000 nearly all the schemes in operation (91 pct.) were with SMEs. Well over 2,000 TCS partnerships have been created since it was first established. The cost of government grants to the scheme was around GBP 23 million in the financial year 1999-2000.

HEROBAC & HEIF

The Higher Education Reach-Out to Business and the Community scheme aims towards developing the capability of Higher Education Institutions (HEIs) to respond to the needs of business, by enabling HEIs to put into practice organisational and structural arrangements to achieve their strategic aims in this area. The HEROBAC Fund is intended to initiate a permanent third stream of funding – complementing existing grants for teaching and research from the Higher Education Funding Council for England's (HEFCE) – to reward and encourage HEIs to enhance their interaction with business. The HEROBAC scheme recently came to an end and while there are a number of operational projects, all major future third mission funding through government will be channelled through the Higher Education Innovation Fund (HEIF), which was announced by the government's White Paper on Science and Technology in 2000. HEIF thus marks an attempt to consolidate and simplify what might be seen as a confusing array of third-mission support initiatives (Hill 2002). The HEIF scheme has as its core the belief that all HEIs should be engaged with business in different ways. The fund is intended to enable them to develop links across the full range of their academic endeavours. HEIF receives funding from across government, from the Department of Trade and Industry, from the Higher Education Funding Council for England, and from the Department for Education and Skills. The broad funding base indicates a high level of support and commitment for third mission activities across government.

6.2.2 Overview of public promotion programmes

The above three promotion programmes are widely recognised as being highly effective in promoting industry-science relations. There are, of course, other important public promotion programmes than these. The Science Entreprise Challenge, which provides funds for establishment of ‘enterprise centres’ at universities, and the University Challenge Fund, which provides capital investment for the very early stages of commercialisation, are two important programmes, both introduced in 1999. The main public promotion programmes are summarised in table 4.4 below.

Table 13 Major Public Promotion Programmes in UK

Programme	*Content*
Foresight Programme	Building up of networks and consortia, strategic vision of technology development
LINK	Funding for collaborative research projects which shall act as demonstration projects
Faraday Partnerships	Establishing intermediary infrastructure for technology transfer in certain fields of technology
University Challenge Fund	Support to universities or consortia of universities to set up local "seed" funds supporting early stage commercialisation
Teaching Company Scheme (TCS)	Subsidies to enterprises for employing highly qualified graduates on specific projects
Science Enterprise Challenge	Establishing "centres of enterprise" at up to 8 universities, encouraging the incorporation of entrepreneurial training into science and engineering curricula
Higher Education Reach-Out to Business and the Community (HEROBAC)	Funding for the establishment of centres of expertise in HEIs, ISR-oriented training for HEI staff, "one stop shops" for business partners.
Joint Research Equipment Initiative (JREI)	Funding of equipment in areas of high quality research
Collaborative Awards in Science & Engineering (CASE)	Grants to students for carrying out doctoral research addressing industrial problems and jointly supervised by HEIs and firms
University for Industry (UfI)	Support to HEIs for activities in the education of adults, especially concerning new technologies

Source: EC 2001

6.3 COLOMBIA

In this section Colombian promotion programmes will be described. First, in the section on key public promotion programmes (6.3.1), a set of initiatives and projects relating to (i) financial support for innovation and technology development in firms, and (ii) funding of research will be described in some detail. Second, in section 6.3.2, a wider selection of Colombian public promotion programmes are described briefly, including the Centre of Excellence programme and the Technology Foresight programme.

6.3.1 Key public promotion programmes

The underlying rationale of selecting the above mentioned two types of programmes and projects is that, besides being important programmes in the efforts to stimulate innovation and university interaction with industry, these programmes and projects yield important insights to key aspects of Colombian approach to promotion programmes: (i) the use of financial incentive schemes to promote innovation and technology development, and (ii) the use of additional research funding as a lever for strengthening the science base in Colombia.

Financial support for innovation and technology development in firms
COLCIENCIAS operates a number of schemes to support innovation and technology development (ITD) in private firms. More specifically, five different types of 'services to firms' can be distinguished (Montenegro 2005, Vaca 2005).

Table 14 Incentive schemes for private firms

Scheme	*Incentive*
Schemes for co-financing of innovation projects	Matching grants: 30-70 pct (depending on firm size)
Credit schemes ('soft loan')	Up to 50 pct of innovation/technology development budget
Financing of collaborative research projects with research institutions	Up to 70 pct
Cofinancing of patenting	Registration costs subsidised
Special credit scheme for SME's	Loan upfront, 20-60 pct to be paid back (depending on success of the project)

The funds given through co-financing schemes depends on the size of the firm undertaking the ITD project. Small and medium size firms get 70 pct of their investment covered by COLCIENCIAS, whereas a large company gets 30 pct of its investment co-financed by COLCIENCIAS. Grants given to SMEs through this co-financing scheme, amount to up to 120,000 USD for one SME or 480,000 USD for a set of SMEs in the same sector.

The special credit scheme for SMEs is a new scheme launched in 2005; *Riezgo Tecnología Compartido*. Credit is given upfront and payback is made dependent on an evaluation of the ITD project. If the evaluation is good, the SME only has to pay 20 pct of the credit back. If the evaluation is bad, the pay back rate is 40-60 pct. This obviously gives a strong financial incentive to do perform well in the ITD project. The incentive structure of the scheme may, however, frighten

SMEs that are risk adverse and reluctant – which many Colombian SMEs are. In this context, incentive schemes that signal that SMEs can only incur modest financial losses may be commendable. One option might be to have a uniform payback requirement of 20 or 30 pct, and instead make the evaluation of the ITD project a question of whether a grant, or additional credit, can be given.

With regard to schemes for collaborative research, in which private firms at present can get up to 70 pct of their investment covered by a public grant, one interviewee suggested that private firms should not be requested to make any financial contribution to the research at all. Instead, the strategy should be ensure the participation of private firms by offering collaborative research fully covered by public funds, and then prove that it is in fact better to develop technology than to import technology and expertise from abroad. The interviewee suggested that public funding agencies could see this type of funding as a form of '*trust incubation*' (Botero 2005). Another suggestion made by interviewees with regard to funding of collaborative research was to give full public funding for the first half of the duration of the project, and then require full private funding the latter half of the project, with an option to discontinue the project if the private firm was not satisfied with the project (Pardo 2005).

In addition to these credit and grant schemes, a fiscal incentive has been launched to further increase the private firm incentives for engaging in ITD projects, in the form of a tax deduction scheme. More specifically, a tax deduction of up to 1.2 times the value of the investment is given to firms undertaking ITD projects – with a maximum deduction, however, of 20 pct of company turnover. Strengthening this tax incentive by moving the 'max 20 pct of turnover'-rule might well be an interesting policy option to further stimulate the interest of especially SMEs in ITD projects (Tovar 2005).

Applications by firms for the schemes operated by COLCIENCIAS are in many cases evaluated by peer review, undertaken on behalf of COLCIENCIAS by national and international consultants (Vaca 2005). Three dimensions organize these evaluations: relevance, quality and contribution to technology. Whether an ITD project has a university-interaction-with-industry component is not a key criteria. If an ITD project has quality and relevance, and contributes to technology development, supplying funding is considered fully justified, regardless of the university-industry component. This appears reasonable in the current situation where engaging a private firm in an ITD project is itself a success. One might consider, however, whether extra incentives for interacting with universities could be given. One option might be to offer the CEOs of all private firms undertaking ITD projects in cooperation with a university, a course in Innovation and Technology Development Management, financed by COLCIENCIAS. This would, in addition to providing incentives for collaboration with universities, address the need to educate Colombian CEOs, cf the discussion in section 4.4.

This introduces a theme that I shall return to in section 6.4 below, namely the heavy reliance on credit and grant schemes in COLCIENCIAS's approach to promoting innovation and technology development in the private sector. I shall argue, that a focus on providing education and expertise is crucial. For example, COLCIENCIAS subsidizes the costs of patent registration for private firms – but it does not supply expertise and advice to firms about the process of registering a patent. This needs to be addressed in future policy-making.

Strengthening Colombian science and technology development

A wide range of initiatives have been undertaken, particularly in the past decade, to strengthen the Colombian science base. These efforts are crucial to innovation and technology development in Colombia for, as one interviewee noted, there can be no technology transfer and science-driven economic growth without a strong science base (Forero 2005). In the following, a number of these initiatives shall be mentioned briefly, followed by a discussion of progress made so far and challenges for future policy-making in this area.

As mentioned previously, Colombia launched its first PhD programmes in 1994. This was a very important development, as the absence of PhD research in the universities and the lack of a strong research culture in Colombian higher education institutions has been too sides of the same coin. Up until just 4-5 years ago, it was not a requirement for university researchers to have a PhD degree or the equivalent (Rosario 2005). The year after, in 1995, the Centre of Excellence programme was launched. COLCIENCIAS received 150 applications from research institutions around the country. Three criteria were adopted in the evaluation of proposals: (i) contribution to their respective field of science, (ii) capacity to train researchers, and (iii) ability to apply knowledge toward solving tangible problems (Agapitova et al 2002). Four of the applicants were selected and classified as excellent: Centro Internaciónal de Física (CIF); Centro Internaciónal de Entrenamiento e Investigaciónes Medicas; Corporación para Investigadores Biolgicas; and Fundacion para la Educación Superiór y el Desarollo. In 1996, about 150 USD were allocated to these four Centres of Excellence, and they continue to receive public funding. At present, two new Centres of Excellence are under way; one in complex processes, and one in energy capacity (García Vallejo 2005). Another very important stream of funding must be mentioned here, namely COLCIENCIAS' scheme for supporting the formation, consolidation and multiplication of research groups in Colombia.

Since 1995, COLCIENCIAS has been supplying public funding for R&D projects within the framework of 11 national science and technology programmes. The 11 S&T programmes, and the number of projects funded, are listed in the table below.

Table 15 National science and technology programmes in Colombia

	1995	2003	1995-2003
Ciencia y Tecnología de la Salud	30	59	435
Ciencias Sociales y Humanas	38	31	291
Ciencias Básicas	26	49	278
Desarollo Tecnológica	16	67	261
Estudios Científicos de la Educación	14	31	218
Electrónica Telecomunicaciónes e Informática	7	42	174
Ciencia y Tecnología Agropecuarias	14	30	144
Biotecnología	17	16	139
Ciencias del Medio Ambiente y Hábitat	4	14	129
Investigaciónes en Energía y Minería	8	21	123
Cienciay Tecnología del Mar	10	11	83
	184	371	2,275

Source: OcyT 2004: 149.

The recipients of public funding for these projects are research groups or research centres, public or private. COLCIENCIAS never fully covers the cost of these projects – the recipients have to generate part of the funding themselves. Currently, COLCIENCIAS is proposing a reform that will launch six science and technology areas instead of the previous 11 science and technology programmes. The six proposed areas are (COLCIENCIAS 2005c: 22):

- Fundamental research in natural sciences, social sciences, and humanities
- Energy and materials science
- Life sciences
- Environmental science
- Education, culture and institutions
- Management of knowledge, its social applications, and its link to technology

The rationale underlying this proposal is the attempt to promote interdisciplinarity, integration across research areas and shift the emphasis from research to innovation (García Vallejo 2005).

The programmes and policies launched to strengthen the Colombian science have been successful. The number of research groups has increased from 216 to 3,000 in the course of the 1990s (Tovar 2005). The number of articles published in journals registered in the Science Citation Index have increased from a level of 391 in 1996 to 715 in 2003 (OCyT 2004: 76-77). The success in strengthening the science base has not yet, however, manifested itself adequately in terms of technology development and economic growth. The above mentioned proposal to reform the national science and technology programmes may be seen as a reaction to this problem, seeking to emphasize more strongly the innovation and technology development aspect of research. Another attempt to move things in this direction, is taking the form of a proposal of a new law from COLCIENCIAS; *Ley de Ciencia*, *Tecnologia y Innovación*, which proposes to (i) stabilize S&T

funding, and (ii) developing new funding mechanisms – with the overall objective of making NIS a model for policy-making and coordination. A final new type of initiative which warrants mentioning here is a scheme to commit foreign capital invested in Colombia to contributing to local technology development through ‘common interest’ agreements (Zamudio 2005). The scheme seeks to commit TNCs to subcontract Colombian companies and train Colombian engineers in exchange for tax deductions (Zamudio 2005, Vaca 2005). A recent example of this was the agreement with GM Motors on the fabrication of the OPTRA car, in which GM motors committed to use local suppliers for an amount of at least 600,000 USD.

6.3.2 Overview of public promotion programmes

The above depicted are not the only promotion programmes in play in the Colombia innovation system. The table below lists the main public promotion programmes in Colombia..

Table 16 Major Public Promotion Programmes in Colombia

Programme	*Content*
Science and Technology Programmes *(Programas de Ciencia y Tecnologia)*	Provision of funding for high-quality research projects. The principal objective of these funds have been to stimulate the emergence and consolidation of research groups in the main HEIs and research institutions and increase the quality of research in Colombia in and through these research groups
Formation of researchers *(Formación de Investigadores)*	Increasing human capital in science and technology, notably by supporting the consolidation and multiplication of research groups and by promoting and funding the recruitment of young researchers
The Centre of Excellence programme *(Centros de Investigación de Excelencia)*	Funding for research institutions that are excellent in relation to three criteria: (i) contribution to its scientific field, (ii) capacity to train investigators, and (iii) ability to apply the acquired knowledge toward solving tangible problems
Knowledge Economy Vision *(Programa Nacional de Transformación Productiva)*	Identification of sectors with knowledge-economy-potential. These sectors are identified through studies undertaken by universities. All studies investigate the relation between a set of five themes, and the objective of transforming the productive sector. The five themes: Conflict; public expenses; productivity; social transformation; and simulations/scenarios.
Science Networks *(Red Caldas)*	Promotion of science networks, linking Colombian researchers working abroad with the national scientific community – including networks organized according to research themes of strategic importance to Colombian economic development
Capacity Building in Information Technologies *(Proyecto Inteligente)*	Promoting capacity building in the area of information technologies, to strengthen this sector of the economy, by facilitating access to education. Credits given are partly condoned, subject to requirements such as the attainment of training certification or creation of a firm
S&T Waves *(Programa Ondas)*	Targets children and young people, with the objective of promoting an S&T culture from basic school and onwards. The programme seeks to stimulate the development of a seedbed for S&T thinking and knowledge of the role of S&T in economic development

Sources: COLCIENCIAS 2005b, Agapitova et al 2002, Medina 2005.

6.4 CONCLUSION: POTENTIAL LESSONS FOR COLOMBIA

A core element of Colombian efforts promotion programmes has been that of providing incentives for innovation. Providing incentives to innovate is of course, in itself, a good policy. Such policies will, however, only be effective to the extent that lack of incentives is a key constraining factor. I should argue that there is a mismatch between the strong emphasis put on providing incentives for innovation and what I see as a relatively modest importance of such incentives among a range of key constraining factors for innovation. Phrased in other terms, the policy advice implicit in this goes as follows: further strengthen incentives to innovate (tax incentives, credit schemes etc), but shift the emphasis of science and technology policies to promotion programmes that deals with the fundamental problems of the Colombian NIS: (i) lack of trust between universities and the private sector, (ii) poor understanding of the concept of innovation, and (iii) lack of resources in universities for research in general and for cooperative R&D with private companies in particular. With respect to all of these three fundamental problems, the university may potentially be the key change agent in the Colombian NIS. This requires, however, that the need for an institutional restructuring of universities is recognised.

The Science and Technology Policy Council (STPC) in Finland recently recognised that enabling universities to take up the third mission of promoting the utilisation of new knowledge in a serious manner, demanded a commitment from policy-making, both in terms of increased funding and in terms of a revision of the legal framework within which universities operate. The recent policy review from the STPC explicitly stated that “the implementation of the national strategy entails that university core funding is increased” (STPC 2003: 20). Moreover, it was recognised first, that changes taking place with regard to the universities’ mission is shaking up the university as its core, and secondly, that this requires, on the part of policy-makers, that universities are correspondingly *shaped up* to its new mission:

> Various research, studies and pilots are being conducted to find out the measures needed to obtain the best results from the inputs made into education and research… One major question is how the *university as an institution* will be able to manage the pressures and growing expectations directed at it with regard to social, cultural and economic development – whether the university has the internal capacity for renewal needed to lighten its work load in the face of constant new challenges (STPC review 2003: 19).

Erkki Ormala, the director of technology policy at Nokia, noted that at present Finnish university regulation is not aligned neither with the development of the Finnish national innovation system as such, nor with the changing role of universities in the wider global economy (Ormala 2003). Ormala argues a strong case for increasing the basic budgets of universities, but he also argues that such increases in funding streams to universities should not be made without prior institutional restructuring of universities. In its concluding section with policy recommendations, the Science and Technology Policy Council clearly indicate its approach to these issues:

> The ongoing transformation of the university mission and funding structure is systemic; it challenges the whole institution to its very core… Universities must have the possibility and capability for organising their economy and administration in a way which will enable their actual operations to develop flexibly (STPC 2003: 38).

Recent trends in funding of universities in Colombia go in the direction of performance-based funding (see section 5.3). The logic of performance-funding is the following: ‘if you perform better, you get more funding for the next term’. Though shifting funding in that direction is definitively a good and needed policy, it should not stand alone. Implicit in making a shift towards performance-based funding the central element in the reform of university funding is the assumption that the single most important constraining factor for improved performance in universities is *incentive* to perform. This is, however, often not the only constraining factor. In Colombia, most universities are financially and institutionally poorly equipped to meet the triple objective of high quality research, teaching and interaction with local industry. This is a also a constraining factor.

Two policy options for providing funds for university restructuring may be distinguished. One option would be to establish a competitive fund for higher education (as has been done in Chile and Argentina) supporting institutional improvement projects. The other option would be to tie investments in university restructuring to performance contracts made with each individual university.

The performance contracts has the further advantage of making it possible to connect such funding with other key objectives and challenges in S&T policy-making. More specifically, performance contracts with incorporated funding for university restructuring should come with the requirement that universities map the needs and potentials of their regional economies and develop strategies for how they will contribute towards developing this potential in cooperation with other actors in the regional innovation system.[31]

In conclusion, it should be stressed that funding for institutional restructuring of universities may potentially be a key element in a strategy seeking to overcome one of the most severe barriers to innovation in Colombia: the lack of trust that the private sector has in universities in general, and in the potential benefits of cooperating with them in particular. Only if universities are given resources and incentives to make such institutional reforms that will enable them to streamline and professionalize their interactions with industry is the scepticism and mistrust of the private sector likely to be overcome.

[31] To launch performance contracting along these lines, the Finnish three-component model – combining core funding, performance funding and funding for specific initiatives in three-year performance agreements with universities – may be of inspiration. See further details on this in Thorn et al 2005b: 15.

CHAPTER 7

INTERMEDIARY STRUCTURES

7 INTERMEDIARY STRUCTURES

Country sections in this chapter consist of two subsections. The first section gives on overall characterisation of the intermediary structures in the country in question. The second section contains a case study on university entrepreneurship and commercialisation of research.

7.1 FINLAND

7.1.1 Overall characterisation of intermediary structures

In addition to Technology clinics Centres of Expertise, described above (section 6.1), the following types of intermediary structures may be identified: Science and technology parks, technology transfer companies, industry liaison offices, and incubators.

Science and technology parks
Finnish science and technology parks offer premises, a technically developed infrastructure and a stimulating and innovative business environment. In addition to industrial companies and research units, different kinds of private, semi-public and public service organisations are located in the science parks. Each centre has its own general technology profile. Science and technology parks play an important co-ordinating or implementing role in various business development and regional development programmes. Shareholders of the parks are both private and public organisations. The Finnish Science Park Association (FISPA) has 10 member centres and 9 associate members, accommodating a total of approximately 1,000 enterprises, research, and education organisations, which employ more than 10,000 people. Within the National Centres of Expertise Programme, science and technology parks are used as locations for the Centres.

Technology transfer companies
There are seven technology transfer companies located in different technology and science parks. The companies are jointly owned by university foundations and other regional organisations. The National Fund for Research and Development (Sitra) is also an important shareholder in each of them. The task of the technology transfer companies is to promote the commercialisation of research results from universities and research institutes. The companies help their customers in evaluating the new research results, the patenting procedures, licence negotiations, and also take care of the development and marketing of patents when needed. The technology transfer companies also act as co-ordinators in important national and international research projects and programmes.

Industrial liaison offices
All universities have industrial liaison offices and some run innovation centres. They attempt to promote research and technology transfer by helping researchers in applying for external research funding, drafting contracts and managing the research projects. Some offices have more personnel and offer wider services. In these cases they are likely to be called research and innovation services units or innovation centres. The services offered cover a huge variety of consulting, information, training and organisation services.

Incubators

At the moment, there are 12 technology incubators located at different technology and science parks in Finland. They co-operate closely together and are usually also close to universities and research institutes. Incubators get their backing from a variety of organisations in the public sector, organisations including large and medium sized companies, business associations and other organisations. Technology incubators offer versatile services to companies that are just starting their activities as well as to companies that want to grow and internationalise. There are nearly 350 enterprises located in the 12 technology incubators, and close to 200 new enterprises started their businesses during the year 2001.

7.1.2 CASE: University of Helsinki – CropCorp

Recently, a study of the process of spinning out a biotech company at the University of Helsinki was carried out (Tuunainen, 2005). All key elements for a successful commercialisation of research results seemed to be present. National science and technology policies were favourable. Public funding for basic and applied research was provided. The central management of the University of Helsinki was keen to promote commercialisation of its research, and had in 1997 formulated a general policy for those purposes. Thus, when Plant Tech was founded in 1998, the University was in the early phases of building institutional support structures for entrepreneurship and commercialization. Yet, the establishment of Plant Tech became an issue of heated conflict.

An internationally renowned academic, Professor Monto, led the spinout company. Professor Monto was a Finn by birth, but had done her PhD and subsequent research in UK and US. In 1990 she was recruited by the Department of Agriculture at the University of Helsinki. In addition to vast research experience, Professor Monto had experience from working for the Food and Agriculture Organization of the United Nations in developing countries. Recruiting Professor Monto was part of an attempt to modernize the Department's research. Professor Monto was the first in Finland to apply modern biotechnology to field-crop plants, and it was believed that she could contribute significantly to the envisaged process of bringing the Department's research profile in plant biotechnology to high international standards. Over a period of eight years, from 1990 to 1998, Professor Monto and a dedicated group of junior researchers had developed a research program with strong commercial potential. By 1998, Professor Monto and her research group were determined to bring their research to market. The research program of Professor Monto and her group initially focused on combating the biological hazards created by viruses in potato production by developing a virus-resistant potato cultivar. Later the research program was expanded to include research on the insect resistance of a number of plants and the development of a production system for foreign proteins in plants (Tuunainen, 2004, p.8).

In the initial phases of its research, the group received its research funding from the Academy of Finland, which gives grants for basic research on a competitive basis. After a couple of years the group's research started yielding commercially promising results. Consequently, from 1997 the group received its funding from TEKES, the national funding agency for industrial and applied research. Though public capital investment for establishing the company was indeed achieved in 1998, Professor Monto never succeeded in realizing this vision. The establishment of the spinout company instead became an issue of heated conflict at the University.

The first conflict concerned the boundary between Professor Monto's official duties as a university researcher, and her work in the spinout company. The Dean of Faculty found that Professor Monto's "use of office hours for the benefit of one's own firm [was] … slightly liberal" (Tuunainen, 2004, p.11). The Department Chair shared this concern, stressing particularly that

Professor Monto to his view was not taking her share of the teaching load of the Department. In autumn 1998, the Department Chair began insisting on accounts from Professor Monto regarding the spinout company and the relative allocation of her working hours. Professor Monto fiercely resisted giving any information about the company. She was confident that she fulfilled her academic duties outstandingly, and felt that the Department Chair's request for information on the company and on her relative allocation of working hours was an expression of "mistrust, overenthusiastic administration, 'bullying' and 'micromanagement', exercised at the expense of the Department's academic performance and applied mission" (Tuunainen, 2004, p.15).

The conflict grew still more aggressive on both sides, eventually culminated when the Department Chair contacted the police regarding a controversy over university research equipment. When Professor Monto left the Department of Agriculture, the conflict had evolved around a range of issues: (i) general information about the spinout company, (ii) allocation of work time between academic duties and company-related activity, (iii) reporting requirements, (iv) partial leave of absence, (iv) undergraduate teaching, (v) relations to the university rector and the wider university administration, (vi) research equipment, and (vii) external communication regarding links between the department and the spinout company. Despite initial, strong institutional encouragement and support, the process of spinning out the company was prone with conflict and eventually the company left the Department, to relocate in the new science park facilities of the university.

When Plant Tech relocated in the science park facility of the University of Helsinki, conflicts arose again. Though the leaders of the host institute in the science park were favourable to entrepreneurship and commercialisation, this was so only on the condition that entrepreneurial activities were "accomplished elsewhere than in the confines of the institute and that it did not affect working hours, or employees' ability to carry out their academic duties" (Tuunainen, 2004: 20). For the purposes of ensuring that a boundary was created between the academic projects of Professor Monto's group and the activities of the spinout company, a collaboration agreement was made. In and through this agreement two boundaries were instituted: a social boundary and a spatial boundary. The regulation that sought to institute a *social* boundary was the insistence that the previous mixed 'researcher-entrepreneur' roles were abandoned, strictly separating those working on academic projects from those working on Plant Tech technology development projects. In addition, the agreement instituted a *spatial* boundary, demanding that the group's premises were clearly divided between those used for academic projects and those used for the commercial projects of Plant Tech.

From the perspective of Professor Monto's group, these boundaries were highly problematic given that its research strategy was to combine basic and applied research, resulting in the actual absence of a clear distinction of what was purely academic and what was purely applied and commercial. The group circumvented the spatial boundary by pulling down the partitions, organising their lab space to fit practical needs rather than follow directions given in the collaboration agreement. When it came to the group's finances, however, the Head of Administration insisted on sustained monitoring to ensure that public grants would not flow from the university to the private company. The conflict continued, in other words. Professor Monto felt that the university "favoured commercialization in the abstract but prevented people from doing it in the concrete" (Tuunainen, 2004, p.11).

Ultimately, the group decided to cease its academic projects and become a fully independent private entity, and Professor Monto herself decided to leave Helsinki altogether, taking up a position in the US. In two successive runs, combining academic research and commercialisation had proved impossible within the confines of the University of Helsinki.

7.2 UNITED KINGDOM

7.2.1 Overall characterisation of intermediary structures

UK universities have a strong tradition in terms of an institutionalised interface with industry. When by the mid-1980s UK universities started creating technology licensing offices, this could be done within already existing industrial liaison offices. At the other end of the spectrum of intermediary structures, further from the universities themselves, the UK has a wide range intermediaries, including Regional Development Agencies and the Association of Independent Research and Technology Organisations (AIRTO). Though UK thus has well-developed intermediary structures, including a high number of Technology Transfer Offices, Science Parks and Incubators, recent trends seem to go in a new direction. Observers increasingly question the establishment of intermediary organisations as a means to promote technology transfer and commercialisation. In the OECD benchmarking report, the concluding section in the chapter on UK said:

> A relatively large infrastructure of intermediary organisations has developed in response to successive initiatives… The issue at stake is whether excessive emphasis on specialised transfer agencies could monopolise knowledge flows and act as a barrier to the creation of positive knowledge culture diffused throughout the industry-science nexus. In other words, is there a risk in consigning ISRs [Industry-Science relations] to peripheral units away from the core? (OECD 2002: 153)

A similar concern has evolved with regard to science parks. Not only have science parks failed to deliver the expected results in terms of new revenue for their owners, but furthermore there are severe doubts as to whether science parks may in fact reduce rather than promote the overall entrepreneurial orientation of universities. In the words of the director of PREST, the science policy research unit at the University of Manchester:

> Probably too much emphasis has been given to the phenomenon of science parks… A newer trend is for on-campus incubators and laboratories… These developments are based on the belief that only the closest proximity is likely to produce the required cross-fertilisation (Georghiou 2001: 276-277).

The new direction being taken now in the UK, is to think of intermediary structures as something that should be located at universities, on-campus. In line with this thinking, university entrepreneurship and commercialisation of research is something that needs to be much more thoroughly integrated in the core of university activities than previous models have allowed for. To exemplify this new type of approach, a brief case from the University of Newcastle will be given in section 6.2.3 below.

Despite the high degree of institutionalization of commercialisation efforts in UK, the UK national system of innovation has been characterised by “unsatisfactory performance in industrial innovation” (Georgiou 2001: 254). Policies have thus tried to strengthen incentives for third mission activities by providing separate funds in and through a set of promotion programmes – more about these in section 7.2.

7.2.2 CASE: University of Newcastle – INEX

Background info

In UK, contrary to continental Europe, it is more common that public researchers are active commercial entrepreneurs also. This mixing of roles is possible, I suggest, because of a very different organisation of science. In UK, universities are organised as charities, i.e. legal entities that are neither public nor private, in traditional terms. In this manner, the 'public researcher vs private entrepreneur' dichotomy is sidestepped – and so is much of the resistance to role mixing. However, though the legal organisation of universities as well as the general political climate seem to be more favourable than in continental Europe, the UK has not had significantly more success in promoting university entrepreneurship and commercialisation of research.

Basing university entrepreneurship and commercialisation of research on entrepreneurial researchers is not a productive strategy – regardless of the legal setup of universities. Entrepreneurial researchers are too scarce a resource to be the key lever for this agenda. According to Ken Snowdon, traditional modes of promoting technology transfer and commercialisation of research fails to recognize a severe problem of scale:

> High-flying academics in our universities are a source of novel and imaginative ideas, however the absolute number of such academics is limited. Convert them all to spin-off company technical directors and watch UK academic research output falter as they concentrate their efforts on bringing just one idea to market (Snowdon 2003).

There are too few researchers to get the agenda of university entrepreneurship going at any significant rate. Moreover, if it is the public researcher that is to take up the challenge of becoming the entrepreneur of new science-based business, a continual erosion of the basis for further stimulation of science-based entrepreneurship at the universities will result: the entrepreneurial researcher will be too busy taking care of his spinout company to undertake new research, participate in teaching and act as an scientific resource for other commercialisation projects.

To put it bluntly, strategies for promoting university entrepreneurship based on the generation of entrepreneurial researchers seem to be 'cutting off the branch they are sitting on'. A model based on entrepreneurial researchers is unlikely to be productive at any significant scale, and further carries the risk of compromising science if/when researchers mismanage their dual role of researcher and entrepreneur. Instead other models for the promotion of university entrepreneurship and commercialisation of research are preferable, cf. the model discussed below.

The University Innovation Centre in Nanotechnology

In its February 2001 'Opportunity for all in a Time of Change'-document, the UK government announced the establishment of the University Innovation Centre for Nanotechnology, the core component of which would be the Institute for Nanoscale Science and Technology (INSAT) and its commercial arm INEX. Both are situated at the University of Newcastle. Nanotechnology underpins innovation in most high-technology sectors, including the biotechnology, defence, communications, electronics and medical sectors. INSAT builds on high-level research in the physical and biological sciences and medicine conducted in the faculties of Medicine, Science, Engineering and Agriculture at the University of Newcastle. In and trough its commercial arm, INEX, the University Innovation Centre for Nanotechnology acts not only as a centre for research and training excellence of international repute, but also as a key cross-sector driver for regional high-technology based cluster development (INEX, 2003). Both INSAT and INEX are based on campus.

The research director of INSAT has developed a model for commercialisation that is quite different from traditional thinking in this field. The model abandons the traditional model of ‘technology transfer’ and the notion that university interaction with industry should take place in intermediary structures, such as science parks located more or less distant from the university itself. Instead, the Newcastle concept argues that industry must be brought into the university. Only then will new industries spin out of the university on any significant scale. In the INEX model the dual objective of (i) efficiently creating spin-off companies and (ii) rapidly developing a more entrepreneurial culture at the university go hand in hand with – and mutually reinforce – one another. As mentioned above, the model takes as its point of departure the recognition of a problem of scale. The total number of researchers that do research with commercial potential is limited, and making these researchers the key agents in efforts to commercialize research is highly problematic in two different ways. First, if they take upon them the role of the entrepreneur, investing their time and energy in bringing one or two of their ideas to market, they will have little or no time left for doing new research. This will, in other words, weaken the science base. Second, even if all these researchers are successful as entrepreneurs, they are so few in numbers that their aggregate impact on economic development will be, at best, modest.

The INEX model proposes to base commercialisation on a combination of the ideas of top-level researchers and the work and effort of the constant flux of students that pass through university research departments. Only a small change is needed to get this model up and running. Snowdon depicts the ‘standard’ state of affairs as follows:

> Academics routinely propose promising lines of enquiry for a never-ending stream of research students and post-docs to pursue. Those young researchers enthusiastically mould those raw ideas into research theses or publications. They submit those theses and publications, while giving little thought (except in the last paragraph of the thesis and moments before submission) to opportunities for commercial exploitation of what they have done. They submit their work (at 5 pm on the last day of term, go out and celebrate), and the next day – they move on. Their work lies gathering dust, a new student arrives, and the cycle is repeated (Snowdon 2003).

If universities are serious about engaging in the commercialisation of its research results this is, Ken Snowdon argues, the obvious place to start. Writing up the research thesis should no longer be the final stage in a PhD program. Furthermore, the business and entrepreneurial skills training that are compulsory components of many UK degree programs need to be much closer linked to actual research project of the participating PhD students. In addition to focusing on the actual research projects, such programmes should embed PhD students within the private sector business support infrastructure as well as introduce them to the commercialisation support structures within the university. In the words of Snowdon:

> These young people – undergraduates, postgraduates and post-docs – represent the largest untapped resource within the UK university system. They are enormously enthusiastic and highly possessive of their research projects. They are the key to the establishment of new high-tech companies and the development of rapidly expanding advanced technology clusters with strong links to the knowledge base (Snowdon 2003).

In seeking to find ways of mobilising what they see as an enormous resource for new business development, INEX focus on stimulating student awareness and on institutionalising commercialisation of research as a career option. One aspect of this is hat today business skills development has been made an essential component of all undergraduate and postgraduate degree programs supported by INEX. At the PhD research level, INEX’s efforts to commercialisation is organised around three ‘pillars’ (Snowdon 2003):

- immediate intellectual property identification
- parallel commercial R&D
- spin-off company environment and support

The first pillar expresses the assertion that early identification of potentially valuable intellectual property (IP) is crucial to commercialisation of research. The traditional *serial* model of technology transfer is seen by INEX as missing the point entirely. A successful technology pullout from the science base requires co-location and direct interaction with commercialisation managers as well as with senior researchers from the outset of the research, Ken Snowdon argues. This is provided for at INEX by means of the second pillar – parallel commercial R&D. INEX parallel R&D programmes form the basis of novel MSc and PhD degree programmes that share the following characteristics (Snowdon 2003):

1. based on commercially valuable IP
2. adopt a systems approach, allowing for larger and multi-disciplinary problems to be tackled in teams
3. put in place potential partners for a future spin-out company from the outset
4. require students to assess IP, time to market and appropriate routes to commercialisation
5. require students to draft business plans

In this model, thus, the research thesis is not the final act – the model is predicated upon the parallel development of a research thesis and a business plan. This should, Ken Snowdon argues, increase the probability that having finished their PhD, students "on the following day students will meet with seed-corn funders to develop further the ideas they have worked on, rather than leave the region". Finally, the third pillar recognises the fact that young entrepreneurs have few assets, and that comprehensive support mechanisms to assist them in spin-out company formation must be put in place if their businesses are to have any chance of survival. Therefore, the INEX model therefore provides the following (Snowdon 2003):

- salary subsidies in the form of an Entrepreneurial Fellowship for up to 18 months
- a full range of business support services, including administrative, financial and legal advice
- accommodation in incubator units entirely integrated within the on-campus university R&D environment.

In terms of ownership, the INEX model gives graduates "a significant equity stake" in the spinout companies formed. Senior researchers involved in the projects as advisors etc, and who may have generated the actual IP, receive only a small equity stake. This is the only reasonable way to organise it, Ken Snowdon contends, for equity stakes should of course reflect relative levels of risk:

> Senior researchers, who would probably not have pursued the commercialisation idea, are 'incentivised' via the opportunity, over time, to acquire equity in a large number of spin-outs, with the added advantage of negligible personal risk. For them it is a win-win situation, and they can continue to do what they do best – generate ideas (Snowdon 2003).

In the INEX model, researchers have a key role in the commercialisation of research. However, having limited financial interests (in the form of modest royalties), it is ensured that the primary role and responsibility of the researcher will be those of academic counselling of student entrepreneurs and ensuring that high scientific standards are being met.

7.3 COLOMBIA

7.3.1 Overall characterisation of intermediary structures

Initiatives have been taken also to launch enterprise incubators (see UN 1999: 68), and some universities have in recent years set up technology transfer units (ASCUN 2004). However, both of these types of intermediary structures are in the early phases of their development. Intermediary structures in Colombia are by far dominated by Technology Development Centres. In the following, the main types of TDCs will be described. First, however, a brief account of the historical background of the present situation is warranted.

Corresponding to the overall shifts in the history of Colombian science and technology policies described in section 3.3, the structures supporting technology development have undergone a number of shifts too. Overall, the movement has been from a centralized model of national technological research centres, over a model of more or less complete privatization, to a model of decentralized, diversified technology development, targeted at specific sectors in the regions. More specifically, the following three periods in the history of Colombian Technology Centres can be identified (COLCIENCIAS 2005):

1957 – 1989: Period dominated by large public (or semipublic) technological research institutes, responsible for serving entire productive sectors (Institute of Technological Investigations; IIT in industry; ICA in agriculture).

1990 – 1994. The process of privatization and of opening of the economy was initiated. IIT was dismantled, whereas in the farming sector, the Colombian Corporation of Agribusiness Research – CORPOICA – was transformed to become a private and public partnership.

1995 – onwards. The National Council of Science and Technology approved the new National Policy for Innovation and Technological Development which launched the National System of Innovation. This introduced a new decentralised and diversified model for the support for technology development in Colombia.

Today, all Technology Development Centres (TDCs) have legal autonomy and are organized as private non-profit organisations, with participation of both public agencies (COLCIENCIAS, local authorities) and private enterprises. Each TDC has a sector-focus, and develops a strategic plan that states its vision and the strategic lines of action it will pursue in response to the demands of the productive sector in the region. The key activities consist in offering technological services to companies and, more generally, in promoting technology transfer in the region. TDCs generally seek achieve their overall objectives through three types of activities: (a) awareness raising, (b) network creation, and (c) project design, management and implementation. All TDCs have masters and PhD students working for them, financed through the Young researchers programme, supported by COLCIENCIAS.

The long-term sustainability of the Centres is based on sales of projects and services, and on low fixed costs. Thus, personnel are usually contracted from project to project, and salaries depend on incomes from sales of services etc.

The main types of Technology Development Centres that exist in Colombia today are the following (UN 1999, COLCIENCIAS 2005):

- Sectoral Technology Development Centres: generation of know-how specialized in key technologies of specific sectors.
- Technology Development Centres in New Technologies: promotion of technological development, quality certification, training and technology transfer in promising new technologies (biotechnology, software development, telecommunications, electronics, etc.)
- Regional Centres of Productivity and Innovation: promoting business development and competitiveness at the regional level, including support to specific clusters in the region, mainly by providing managerial and organizational support services.
- Incubators for Technology Based Enterprises: focus on supporting the creation of new businesses and the generation of employment. These can be independent or belong to a RCPI.

7.3.2 CASE: Centro Internacional de Física (CIF)

Introduction

The International Centre of Physics (CIF) was one of four research institutions selected among 150 applicants in 1995, when the Centre of Excellence programme (see section 6.2) was first launched. CIF is a private, non-profit institution that has as its core objective to promote the development of physics and related sciences both in Colombia and in Latin American countries by implementing basic and applied research programmes, supporting technological development and high-level training activities.[32] On the basis of a co-operation agreement and a commodatum contract entered into with Universidad Nacional, the Centre premises are currently located within the university campus. Besides this, there is no formal affiliation between the Centre and the university. The Centre is run by a Board of Directors and an International Scientific Council advising the Board in scientific affairs. The Centre is a member of COMSATS, a network of Centres of Excellence of the Third World Academy of Sciences.

The Centre consists of seven research groups (described in more detail below), with research spanning from the use of bio-physical methods to develop better medication for tropical disease, over the use of biotechnological studies of plant immunology to develop alternatives to pesticides and genetic therapy, to applied physics studies developing ultrasonic methods for measuring the setting process of cement, with applications both for a large Multi National Corporation (MNC) and for cost-reducing preventive maintenance of bridges in Bogotá.

CIF research projects have not only led to a number commercially promising patents, and to a number of R&D projects with big TNC's, but also to the formation of Colombian enterprises, including a laser precision cutting company (TecLaser), a company producing holographic security seals to protect cheques and securities (HOLOCOL), and a vacuum metallizing company (REXCO). Further, CIF has a strong performance in delivering high quality international research, with publication of both applied and basic research in prestigious international journals. CIF is therefore, more than anything, a powerful example that it is indeed possible to engage in high quality research and contribute at the same time to technology and business development, regionally as well as internationally.

[32] The following is based on Posada 2005a, 2005b.

Courses, services and research students
Since its inception, CIF has held a great deal of courses, meetings, seminars and workshops, both in basic and applied physics, engineering and related sciences. More than 8,000 scientists from over 50 countries have attended them. In addition to updating participants in different areas of science and technology, these events have fostered the establishment of close links between researchers from Latin American and industrialized countries. Often, the creation of new research lines has been the outcome of these efforts.

The Centre offers basic and applied research and advisory services to the productive sector, including training and technical updating programmes, in a vast number of areas including, for instance, industrial biotechnology, optical measurement and control methods, precision cutting and security systems. Finally, the Centre hosts a large number of graduate and doctoral students. 47 young researchers attached to research projects at Centre have pursued Ph.D. studies in physics, life sciences and engineering at prestigious universities abroad. An additional 25 students are currently engaged in research work at graduate and postgraduate level at the CIF premises.

Research
The research at CIF is organized in the following seven research groups: biophysics, biotechnology, bio-development, optics, applied physics, material science, and fundamental aspects of physics. Below three of these research groups will be described briefly – for a brief description of all of the research groups, see Appendix C.

Biotechnology Research Group
During the last seven years, the biotechnology group has been engaged in the search for clean alternatives to the use of pesticides and biocides. Knowledge gained on the biochemistry of plant resistance and susceptibility to diseases, has led to the production of biologically-originated “physiological immunity” inducer substances (elicitors), or systemic resistance in plants against diseases. The efficacy of this pathogenic control system has been tested in the field in potato crops during three successive years with rewarding results. This achievement has resulted in the submission of a national patent for international registration in the near future. Similar techniques are being applied in flowers and other products with encouraging results.

Optics Research Group
One of the best optics laboratories in the Latin American region is available at the CIF. Projects being carried out include the following:

- A project of particular interest to the aeronautical and oil industries, allowing structural flaws detection with regard to non-destructive assay of parts by means of interferometry (ESPI).
- Development of a system for atmospheric pollution studies by means of laser spectroscopy, allowing for the detection of pollutants density and type in a wide area of a city.
- Development of techniques to detect document forgery. One such technique is already in operation at the Forensic Medicine Institute, and another technique has led to a national patent to be shortly submitted for international registration.

Applied Physics Group
This Group carries out applied-type activities in fields related to industrial processes, physics application, industrial automation and electronic instrumentation. Projects carried out so far, include the following:

- Development of equipment to study concrete curing by ultrasound attenuation. With partial financing supplied by COLCIENCIAS and commissioned by Sika Andina SA, this project was successfully implemented last year. It was granted the National Award of Research in

Concretes. There is nothing of its kind at worldwide level, hence, a patent application has already been submitted for registration and a second phase to produce easily marketable equipment is currently under way funded by COLCIENCIAS and Sika.

- Development of a method to study the dynamic behaviour of civil works structures and to define extreme circumstances under which (earthquakes or overloads) the former change their behaviour, thus, signalling to its own deterioration. The equipment is being used in 40 bridges in Bogotá with outstanding results.

7.4 CONCLUSION: POTENTIAL LESSONS FOR COLOMBIA

An important policy lesson to draw from Finnish and UK experiences is that developing a strong NIS is more a matter of concentrating and prioritizing than a matter of proliferating. Commenting on the large infrastructure of intermediary structures that has developed in the UK, a recent OECD report expressed concern that "excessive emphasis on specialised transfer agencies could monopolise knowledge flows and act as a barrier to the creation of a positive knowledge culture diffused throughout the industry-science nexus, and asked, "is there a risk in consigning ISRs [industry-science relations] to peripheral units away from the core?" (OECD 2002: 153). There are three risks at stake here:

- A risk that intermediary organisations (IOs) 'double the trouble'; instead of one, you now have two sets of interaction to develop; between universities and IOs and between IOs and enterprises.
- A risk that intermediary organisations *institutionalize* lacking interaction between universities and industry, rather than promoting and facilitating such interaction.
- A risk that too many IOs creates confusion in the NIS instead of strengthening the collaboration among existing actors

At present there is a total of 47 TDC's in Colombia. The original policy for TDC's was based on the idea that only seed capital was provided, and that TDC's were then to become self-sufficient. After 10 years in operation, this has not happened fully. Interviewees stressed the importance of solving the financial situation of the TDCs, with some amount of permanent budget funding, to guarantee a minimum level of income on the basis of which to undertake their important mission of promoting innovation and university interaction with industry. An impact evaluation of the TDCs is currently being undertaken. Though it is too early to be conclusive, so far the impression of the evaluation team is that there is a critical mass problem. The intermediary structure created with the TDCs could be "too atomized".

Further, an interviewee made the observation that at present universities and TDCs operate more as competitors than as partners. One policy remedy mentioned was to diversify their portfolios, i.e., to ensure that universities and TDCs offer *different* services to business and industry. I argue, however, that a more promising policy option here is to embed TDC's in existing higher education institutions, as non-profit entities that are autonomous but can benefit from proximity and close cooperation with university researchers. In terms of legal set-up and location, the International Centre of Physics (CIF), may serve as a model for such on-campus TDCs. Not only does the CIF case show that an on-campus unit can indeed be very successful in interacting with industry and contributing to innovation and technology development.

Moreover, locating TDCs on-campus offers an excellent opportunity for bringing private sector managers into close interaction with universities and their researchers. The notion that "a successful technology pullout from the science base" requires co-location and direct interaction among university researchers, research students and private sector managers was the core element of the commercialisation model developed at INEX, at the University of Newcastle. Indeed, Colombia could greatly benefit from organising their future efforts in promoting university involvement in innovation and technology development on a model consisting of the following three pillars: [33]

[33] For a more elaborate discussion of this model; see Hansson et al 2005 and Vestergaard 2005d.

- University innovation centres and TDCs organised as non-profit organisations (section 4.2)
- On-campus ITD co-operation with private sector partners
- Assigning a key role in collaborative ITD projects to PhD students

The third of these three pillars relate to the role of PhD students in innovation and technology development. There is a general need in the Colombian NIS for increasing the production of doctorates. Again, the model developed at INEX, at the University of Newcastle, could be of valuable inspiration. Public funding of collaborative R&D PhD projects, with a separate commercial component, is a very promising policy option for Colombia. Further, such collaborative PhD projects with a strong commercial component could with great benefit be tied to regional innovation and technology development strategies.

Closing this section, two additional benefits of relocating TDCs to university premises should be mentioned. First, it could be a way of accelerating the development of a structure of technology transfer offices at Colombian universities. Secondly, on-campus TDCs could be charged with the mission of developing and running ITD management courses for private sector managers (cf section 4.4). In such efforts, TDCs could take valuable inspiration from Finnish *methodology and demonstration clinics* (section 6.1), perhaps even developing 'ITD clinics', tailored to the needs and potentials of their respective regions.

CHAPTER 8

POTENTIAL POLICY LESSONS FOR COLOMBIA

8 POTENTIAL POLICY LESSONS FOR COLOMBIA

8.1 History of science and technology policies

When Colombian economic growth began declining following liberalisation in the early 1990s – just as it had in Finland at that time – the exact opposite policy as that of Finland was adopted. Instead of increasing public funds for science and technology, opting to invest and develop their way out of the crisis, Colombia's commitment to and funding of R&D declined. The Finnish case more than anything shows that determined investment in science and technology can spur high economic growth. By the late 1990s, the UK too had recognized the need the necessity of public investments in the innovation system, and put an end to a deteriorating trend in R&D expenditures.

In the contemporary age of global knowledge economy, funding of science and technology is of paramount importance in pursuing economic growth and development. In fact, without substantial S&T funding, other S&T efforts are likely to have little impact. Thus, when Colombia developed a national innovation system in the 1990s in accordance with a number of key trends in the most developed countries, these good developments did not have the desired strong effects. The focus of science and technology policy shifted from science to innovation, from intervention to institutional facilitation, and from targeting large companies to targeting SMEs and cluster development – but actual, overall innovation and economic growth performance did not improve. As one interviewee remarked, it matters little how good the seed is, if it is not watered.

The positive aspect of the recent history of science and technology policies in Colombia in the 1990s, is that – given the efforts to create a good institutional structure – considerable economic growth can indeed be achieved in the future, if substantial funds for S&T are supplied and utilised in a strategic manner. This is what the Finnish case shows us.

8.2 Legislation and culture

A recent World Bank study argued that the main explanation of Colombia's weak innovation performance is "the lack of collaboration between the private sector and research organisations such as universities" (World Bank 2004a: 5). From this perspective, improving relations between the university and business sectors is of paramount importance. Three cultural barriers to such collaboration exist, however. Developing and implementing a broad strategy for increasing *trust*, *self-confidence* and *understanding* in the Colombian innovation system could potentially have a substantial impact on Colombia's innovation and economic growth performance. *Trust* across the university and business sectors of the economy; national *self-confidence* in the S&T potential of the Colombian economy and its people (Chaparro 2005, Rosario 2005), and *understanding* of the concept and necessity of S&T investment.

Making the education of private sector CEO's and other high-level managers a core element of this strategy is likely to have a particularly strong impact, given that the reluctance of private sector managers to invest in S&T and to interact with university researchers, is a key constraining factor in the Colombian NIS (Almario 2005, Naranjo 2005). Indeed, educational programmes for professionals from both the business and the university sector, teaching them how to benefit from each other, could be a promising way of promoting collaboration and innovation across these two sectors (Forero 2005). Another core element of such a strategy should be increased funding schemes for collaborative research. There are few mechanisms more effective than this in stimulating trust and development of more positive attitudes across the university and business sectors.

Another key problem in the Colombian innovation system, which may be said to be of a cultural nature, is the strong prioritization of teaching over research and third mission activities. Two important absences in the legal framework of the Colombian innovation system must be stressed in relation to this. First, the absence of a national guideline for recruitment and promotion at universities, emphasising engagement in R&D activities with the productive sector.[34] Second, a permanent, separate stream of funding for university engagement in R&D activities with the productive sector. Previously, one reasoning on this issue was that the time university professors expend in collaborative R&D projects was the investment that universities should rightly make, paralleling the investments made by COLCIENCIAS and the involved R&D enterprise, respectively. There is increasing recognition, however, that this line of reasoning is insufficient to stimulating collaborative research, simply because in most universities there are no funds free to be invested in this manner.

Before closing this section, I should like to refer briefly to a recent experience of local technology development in shrimp farming, based on collaborative research. For many years, shrimp farms in the northern region of Colombia had showed no interest in doing cooperative research with university researchers in the field. However, when shrimp firms in 1995 were hit by disease, a cooperative research agreement was made and a project funded by COLCIENCIAS launched (CENIACUA). Not only did the project manage to cure the disease and in that sense rescue this industry. Through the cooperative research, knowledge and technologies were developed that made CENIACUA an internationally recognised key source of knowledge in shrimp disease combating, with foreign delegations visiting regularly. The CENIACUA case serves to illustrate that when cultural barriers – such as lacking trust between university and industry sectors and lacking confidence in the country's capacity for technology development – are overcome, Colombia's high potential for internationally competitive innovation and technology development comes through very clearly.

8.3 Institutional setting and funding system

Compared to most Latin American countries, the Colombian innovation system is institutionally very well developed (Holm-Nielsen et al 2002: 7). This does not imply, however, that opportunities for further improvements do not exist. Four main lessons with regard to institutional setting and funding system emerge.

First, a key problem in the Colombian innovation system is that Colombia has not made science and technology policy a strategic core in overall industrial, economic and social policy-making. Science, technology and innovation policy remains low on the policy agenda in Colombia – both in terms of awareness and in terms of central government organisation. Reorganising and repositioning the Council for Science and Technology at a higher level of central government and increasing funds for its executing agency, COLCIENCIAS, could potentially be an important step in strengthening the Colombian innovation system. In both respects, Finland may serve as a role model. In line with this, it should be considered whether the formation of an organization such as Sitra, specialized in identifying and assisting companies with a potential for innovation and technology development might be a fruitful initiative. At present, COLCIENCIAS has an indeed

[34] The absence of such guidelines seems to be a general problem in Latin America that in addition to hampering engagement in R&D activities with the productive sector, is seen to cause other severe problems: "Complete absence of wage recruitment, promotion and training policies has provoked low morale among researchers and many have expressed a desire to leave the institutions" (Velho 2005: 103).

very broad mission, and a division of labour such as in the Finnish model between TEKES, Sitra and Academy of Finland could well prove to be productive for the Colombian NIS.

Second, a general lesson of Finnish and UK experiences is that considerable funding of collaborative research and other forms of university interaction with industry is required to promote innovation effectively. In this regard, the UK system has both a weakness and a strength. The weakness consists in the heavy reliance of its funding system on the Research Assessment Exercise which is over-focused on publications in high-ranking scientific journals. The strength consists in the permanent stream of funding for third mission activities that is provided. The opposite pattern applies for Finland. Here the key strength is that its funding system strongly emphasizes funding of collaborative university-industry R&D projects, whereas funding for third mission of universities are modest, and thus remain a key barrier to university involvement in innovation and commercialisation activities. The way forward for Colombia, in this area, is to take the best of the two models. More specifically, to increase the share of public funding that requires collaborative R&D as Finland has done, and supply funds for third mission, as UK has done.

Third, from UK experience it is important to learn that building regional innovation systems requires a lot more than merely creating regional development agencies, or regional TDCs. At present, the vast majority of research projects financed by COLCIENCIAS are highly concentrated around the three or four largest cities of the country, in the central part of the country (OCyT 2004: 156). This is unfortunate, for building regional innovation systems is what creates a strong national innovation system. To do so requires the formulation of regional economic development strategies, backed by public funding, and it requires engaging universities and the productive sector in the formulation and implementation of these. This is an extremely important area for third mission funding. More specifically, public funding could be made available in two streams. First, public funding could be supplied for the identification of technology development and export potentials in each of the region, undertaken collaboratively by universities and private sector partners in the region. Second, a stream of public funding could be made available for the development of *strategies* at each university, on how each university may contribute to such regional technology development and export efforts.

Fourth, from Finnish experience, the lesson is taught that an important part of the institutional setting for an efficient NIS is procedures for continuous assessment and evaluation. Colombia has not been performing well in this area. One interviewee observed that since an evaluation of Colombian science and technology policies was carried out by the UN in 1999, no overall evaluations have been made. Another interviewee made the remark that there is a sense in which Colombian science and technology policy is “always a seed, never a fruit”. The evaluation culture is lacking in Colombian policy-making. Return-to-public-investment evaluations are crucial, not only for the process of revising and developing policies and programmes, but also as a means of generating data that can help convince politicians and private sector managers of the benefits of science and technology investments. Responsibility for ensuring that evaluations are made could be clearly defined and backed by the necessary public resources. It is worth a serious consideration, whether the creation of an independent evaluation unit might be an efficient way of strengthening this aspect of the Colombian NIS.

8.4 Promotion programmes

A core element of Colombian efforts promotion programmes has been that of providing incentives for innovation. Providing incentives to innovate is of course, in itself, a good policy. Such policies will, however, only be effective to the extent that lack of incentives is a key constraining factor. I should argue that there could be a mismatch between the strong emphasis put on providing incentives for innovation and what I see as a relatively modest importance of such incentives among a range of key constraining factors for innovation. Phrased in other terms, the policy advice implicit in this goes as follows: further strengthen incentives to innovate (tax incentives, credit schemes etc) would be most effective together with promotion programmes that deal with the fundamental problems of the Colombian NIS: (i) lack of trust between universities and the private sector, (ii) poor understanding of the concept of innovation, and (iii) lack of resources in universities for research in general and for cooperative R&D with private companies in particular.

With respect to all of these three fundamental problems, the university may potentially be the key change agent in the Colombian NIS. This could, however, require that the need for an institutional restructuring of universities is recognised. Recent trends in funding of universities in Colombia go in the direction of performance-based funding. The logic of performance-funding is the following: 'if you perform better, you get more funding for the next term'. Though shifting funding in that direction is definitively a good and needed policy, it should not stand alone – because here too the incentive problem is not the only problem. Implicit in making a shift towards performance-based funding is the assumption that the most important constraining factor for improved performance in universities is *incentive* to perform. This is, however, often not the only constraining factor. In Colombia, most universities are financially and institutionally poorly equipped to meet the triple objective of high quality research, teaching and interaction with local industry. This is a serious constraining factor. Before universities can perform, they must be provided with funds to *transform*. Only if basic investments in university restructuring are made, will performance-based funding reach its full impact.

Two policy options for providing funds for university restructuring may be distinguished. One option would be to establish a competitive fund for higher education supporting institutional improvement projects. The other option would be to tie investments in university restructuring to performance contracts made with each individual university. This policy option has the advantage of making it possible to connect such funding with other key objectives and challenges in S&T policy-making. More specifically, performance contracts with incorporated funding for university restructuring could come with the requirement that universities map the needs and potentials of their regional economies and develop strategies for how they will contribute towards developing this potential in cooperation with other actors in the regional innovation system.

Finally, it should be stressed that funding for institutional restructuring of universities may potentially be a key element in a strategy seeking to overcome one of the most severe barriers to innovation in Colombia: the lack of trust that the private sector has in universities in general, and in the potential benefits of cooperating with them in particular. Only if universities are given resources to make such institutional reforms that will enable them to streamline and professionalize their interactions with industry is the scepticism and mistrust of the private sector likely to be overcome.

8.5 Intermediary structures

An important policy lesson to draw from Finnish and UK experiences is that developing a strong NIS is more a matter of concentrating and prioritizing than a matter of proliferating. Commenting on the large infrastructure of intermediary structures that has developed in the UK, a recent OECD report expressed concern that "excessive emphasis on specialised transfer agencies could monopolise knowledge flows and act as a barrier to the creation of a positive knowledge culture diffused throughout the industry-science nexus, and asked, "is there a risk in consigning ISRs [industry-science relations] to peripheral units away from the core?” (OECD 2002: 153). There are three risks at stake here:

- A risk that intermediary organisations (IOs) ‘double the trouble’; instead of one, you now have two sets of interaction to develop; between universities and IOs and between IOs and enterprises.
- A risk that intermediary organisations *institutionalize* lacking interaction between universities and industry, rather than promoting and facilitating such interaction.
- A risk that too many IOs creates confusion in the NIS instead of strengthening the collaboration among existing actors

At present there is a total of 47 TDC’s in Colombia. An impact evaluation of the TDCs is currently being undertaken. Though it is too early to be conclusive, so far the impression of the evaluation team is that there is a critical mass problem. Another interviewee described the intermediary structure created with the TDCs as “too atomized”.

Further, an interviewee made the observation that at present universities and TDCs operate more as competitors than as partners. One policy remedy mentioned was to diversify their portfolios, i.e., to ensure that universities and TDCs offer *different* services to business and industry. I argue, however, that a more promising policy option here is to embed TDC’s in existing higher education institutions, as non-profit entities that are autonomous but can benefit from proximity and close cooperation with university researchers. In terms of legal set-up and location, the International Centre of Physics (CIF), may serve as a model for such on-campus TDCs. Not only does the CIF case show that an on-campus unit can indeed be very successful in interacting with industry and contributing to innovation and technology development.

Moreover, locating TDCs on-campus offers an excellent opportunity for bringing private sector managers into close interaction with universities and their researchers. The notion that “a successful technology pullout from the science base” requires co-location and direct interaction among university researchers, research students and private sector managers was the core element of the commercialisation model developed at INEX, at the University of Newcastle. Indeed, Colombia could greatly benefit from organising their future efforts in promoting university involvement in innovation and technology development on a model consisting of the following three pillars: [35]

- University innovation centres and TDCs organised as non-profit organisations
- On-campus Innovation and technology development (ITD) co-operation with private sector partners
- Assigning a key role in collaborative ITD projects to PhD students

The third of these three pillars relate to the role of PhD students in innovation and technology development. There is a general need in the Colombian NIS for increasing the production of doctorates. Again, the model developed at INEX, at the University of Newcastle, could be of valuable inspiration. Public funding of collaborative R&D PhD projects, with a separate commercial component, is a very promising policy option for Colombia. Further, such collaborative PhD projects with a strong commercial component could with great benefit be tied to regional innovation and technology development strategies.

Closing this section, two additional benefits of relocating TDCs to university premises should be mentioned. First, it could be a way of accelerating the development of a structure of technology transfer offices at Colombian universities. Secondly, on-campus TDCs could be charged with the mission of developing and running ITD management courses for private sector managers. In such

[35] For a more elaborate discussion of this model; see Hansson et al 2005 and Vestergaard 2005d.

efforts, TDCs could take valuable inspiration from Finnish *methodology and demonstration clinics*, perhaps even developing 'ITD clinics', tailored to the needs and potentials of their respective regions.

8.6 Further studies

This report was very much an overview report. Further studies should investigate in more detail the role of Colombian universities in spurring innovation and economic growth. Such studies should draw particularly upon the upcoming national innovation survey, the survey of university interaction with industry conducted by ASCUN (ASCUN 2004), the recent comparative study of university policies for R&D linkages with industry in five Latin American countries (Mullin 2004), and the ongoing impact evaluation of Colombian Technology Development Centres.

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APPENDICES

APPENDIX A Technology programmes in Finland

Ongoing technology programmes [36]

AVALI - Business Opportunities from Space Technology Technology Programme 2002-2005

Clean Surfaces Technology Programme 2002-2006

ClimBus - Business Opportunities in the Mitigation of Climate Change Technology Programme 2004-2008

COMBIO - Commercialisation of Biomaterials Technology Programme 2003-2007

CUBE - The Building Services Technology Programme 2002-2006

DENSY - Distributed Energy Systems Technology Programme 2003-2007

Industrial Design Technology Programme 2002-2005

Drug 2000 - Biomedicine, Drug Development and Pharmaceutical Technology 2001-2006

E-Business Logistics Technology Programme 2002-2005

ELMO - Miniaturizing Electronics Technology Programme 2002-2005

FENIX - Interactive Computing Technology Programme 2003-2007

FINE Particles - Technology, Environment and Health Technology Programme 2002-2005

FinNano - Nanotechnology Programme 2005-2010

FinnWell - Future Healthcare Technology Programme 2004-2009

FUSION - Fusion Technology Programme 2003-2006

Infra - Construction and Services Technology Programme 2001-2005

MASINA - Technology Programme for Mechanical Engineering 2002-2007

MASI - Modeling and Simulation Technology Programme 2005-2009

NeoBio - Novel Biotechnology Technology Programme 2001-2005

NORDITE 2005-2010

Sara - Value Networks in Construction Technology Programme 2003-2007

[36] Data from Tekes 2005.

Streams - Recycling Technologies and Waste Management Technology Programme 2001-2004

Previous technology programmes

Adaptive and Intelligent Systems Applications 1994-1999

Advanced Heavy Machinery 1993-1998

Antares - Space Research Programme 2001-2004

Bionenergy 1993-1998

Building Automation - SamBa 1995-1999

Business Process Re-engineering 1997-2000

Cactus - Water Management in Papermaking 1996-2000

Cell Biology Research Programme * 1998-2001

Climtech - Technology and Climate Change Programme 1999-2002

Code - Modelling Tools for Combustion Process Development 1999-2002

Competitive Reliability 1995-2000

Computational Fluid Dynamics (CFD) Technology Programme 1995-1999

Diagnostics 2000 2000-2003

Digital Media Content Programme 1996-1999

Digital Media in Health Care 1996-1999

Divan - Technology and Development Programme for the Furniture Sector 1999-2002

Electronic Publishing and Printing 1995-1999

Environmental Cluster Research Programme 1997-2002

Environmental Technology in Construction 1994-1999

ETX - Electronics for the Information Society 1997-2001

Exsite - Explorative System-Integrated Technologies 2001-2003

FFusion - Finnish Fusion Energy Research Programme 1993-1998

FFusion 2 - Fusion Energy Research Programme 1999-2002

Fibre - Finnish Biodiversity Research Programme *

Finnish Global Change Research Programme * 1999-2002

Finnsteel Technology Programme 1995-1999

Forest Cluster Research Programme 1998-2001

Frontiers in Metallurgy 1999-2003

Genome Research Programme 1995-2000 *

Globe 2000 - Remote Sensing 1995-2000

GPB - Global Project Business

Healthy Building 1998-2002

Industrial Applications of Multimedia 1996-1999

Innovation in Foods 1997-2000

Innovation in Foods Technology Programme 2001-2004

Intelligent Automation Systems Technology Programme 2001-2004

INWITE - Integrated Technologies for Wireless Telecommunication 1997-1999

iWell - Turning Well-Being Technology into a Success Story 2000-2003

Kenno - Lightweight Panels 1998-2002

Kesto - Materials for Energy Technology 1997-2001

Ketju - Transport Chain Development Programme 1998-2000

Lassi - Light Assembly Industry 1996-1999

Liekki 2 - Combustion and Gasification 1993-1998

Mobile - Energy and Environment in Transportation 1993-1998

Model Factory Concept 1996-2000

Nanotechnology Programme 1997-1999

NAVI - Personal Navigation 2000-2002

Nemo 2 - Advanced Energy Systems and Technologies 1993-1998

NETS - Networks of the Future Technology Programme 2001-2005

New Challenges in Chemical Pulping 1996-2000

On-line Measurements in the Process Industry 1999-2002

Packaging Technology 1994-1999

Pigments - Raw Materials of Paper 1998-2001

Plastic Processing 1998-2001

Potra - Polymers for Building the Future 2000-2003

Presto - Future Products - Added Value with Microtechnologies 1999-2002

ProBuild - Progressing Building Process 1997 - 2001

Process Integration Technology Programme 2000-2004

ProMotor - Engine Technology Programme 1999-2003

Quality in Business Networks 1998-2001

Raket - Energy Use in Buildings 1993-1998

Rapid Product Development 1996-1999

Rasko - Development of Medium and Heavy Assembly 1998-2000

Rembrand - Real Estate Management and Services 1999-2003

Sihti 2 - Energy and Environmental Technology 1993-1998

Smart Machines and Systems 2010 1997-2000

Space 2000 - Space Equipment Technology 1996-2000

SPIN - Software Products - a Launch Pad for Global Success 2000-2003

STAHA - Managing Static Electricity Dynamically 1999-2002

Structural Biology * 2000-2002

Sula 2 - Energy in Steel and Base Metal Production 1993-1998

Sytty - Finnish Research Programme on Environmental Health * 1998-2001

Termo - District Heating and Cooling 1993-1998

Tesla - Information Technology and Electric Power Systems Technology Programme 1998-2002

The Technology and Development Programme for Stone Industry 1999-2002

ThermoNet 1995-1999

TLX - Telecommunications - Creating a Global Village 1997-2001

Tulisija - Wood Combustion Technology Programme 1997-1999

USIX - User-Oriented Information Technology 1999-2002

UTT - Business Concepts for Industries 2000-2004

Value Added Wood Chain 1998-2003

Waste to REF & Energy 1998-2001

Water Services 1997-2001

Vera - Information Networking in the Construction Process 1997-2002

Wood Energy 1999-2003

Wood in Construction 1995-1998

VÄRE - Control of Vibration and Sound 1999-2002

APPENDIX B Cluster programmes in Finland

Name	*Number of projects*	*Number of participating companies*	*Number of participating public units*	*Cluster specific funding*	*Other public funding (million euros)*	*Private funding (million euros)*	*Grand total (million euros)*
Wood wisdom	113	12	49	2,5	17,2	14,7	34,4
Well-being cluster	17	8	22	4,4	4,9	0,0	9,3
Food cluster	12	17	12	2,0	2,4	0,1	4,5
KETJU	30	60	10	2,3	4,1	7,7	14,1
Tetra	48	29	42	1,9	7,5	1,3	10,6
Netmate	10	n.a.	n.a.	1,6	0,4	0,2	2,3
Workplace development	13	86	n.a.	5,0	8,4	0,0	13,5
Environment cluster	60	70	110	4,5	8,0	1,0	13,5
Total	303	282	245	24,2	53,0	25,0	102,2

Source: Vestergaard 2003b

APPENDIX C Research groups at CIF

Biophysics Research Group

During the last ten years, the CIF biophysics laboratory has been engaged in research work in the field of electrophysiology. Equipment available allows measuring currents through ionic channels in cell membranes, either in nerve cells, in animal or plant cells or in microorganism. Further, studies are being pursued in the field of molecular biology pertaining to channels as mentioned. A study of a disease caused by an obligate intracellular parasite that can compromise skin, mucosae and viscera alike, is currently being undertaken. The disease attacks the population living in tropical areas around the world. The research will contribute significantly to knowledge on the parasite and mechanisms for adaptation to its host cell.

Biotechnology Research Group

During the last seven years, the biotechnology group has been engaged in the search for clean alternatives to the use of pesticides and biocides. So far, the most outstanding achievement of this group has been the establishment of a link between laboratory and field biological research. Knowledge gained on the biochemistry of plant resistance and susceptibility to diseases, has led to the production of biologically-originated "physiological immunity" inducer substances (elicitors), or systemic resistance in plants against diseases. The efficacy of this pathogenic control system has been tested in the field in potato crops during three successive years with rewarding results. This achievement has resulted in the submission of a national patent for international registration in the near future. Similar techniques are being applied in flowers and other products with encouraging results.

Biodevelopment Research Group

The Group has been the outcome of the interaction between the Biotechnology Group, the Applied Physics Group and the Technological Development Group. Joint work has allowed for the development of biological technologies for industrial application, including increasing production of plant systemic resistance elicitors, together with the design of specific bioreactors to address metabolic requirements of each microorganism, and design and construction of temporal immersion systems (TIS) for massive propagation of plants for the agricultural industry.

Optics Research Group

One of the best optics laboratories in the Latin American region is available at the CIF. Co-operation efforts between Colciencias, who provided financial assistance, and researchers from the Academy of Sciences of Ukraine, made its installation a reality. Projects being carried out by the Optics Group, include the following:

- A project of of particular interest to the aeronautical and oil industries, allowing structural flaws detection with regard to non-destructive assay of parts by means of interferometry (ESPI).
- LIDAR system for atmospheric pollution studies by means of laser spectroscopy. The system allows for the detection of pollutants density and type in a wide area of a city, covering a distance larger than current stationary posts. A pilot prototype is already available.
- Study of methods to detect document forgery. Two complementary techniques have been so far developed: the analysis of surface profile by means of the fringes projection method. This equipment is already in operation at the Instituto de Medicina Legal (Forensic Medicine Institute), and the study of ink composition in a document through a laser bombing system. The latter system has led to a national patent to be shortly submitted for international registration.

- Human profile reconstruction system by non-destructive optical methods. This system carries a lot of weight as regards aesthetical medicine. This system is currently in the development stage with Maloka support.

Applied Physics Group

This Group carries out applied-type activities in fields related to industrial processes, physics application, industrial automation and electronic instrumentation. Amongst projects carried out so far, the following could be included:

- Development of an equipment to study concrete curing by ultrasound attenuation. With partial financing supplied by Colciencias and commissioned by Sika Andina SA, this project was successfully implemented last year. It was granted the National Award of Research in Concretes. There is nothing of its kind at worldwide level, hence, a patent application has already been submitted for registration and a second phase to produce easily marketable equipment is currently under way funded by Colciencias and Sika.
- Setting up of an automated weather station. While work has been successfully completed, market and price competition with imported equipments is given on equal terms. This device is ready for commercial production.
- Development of a method to study the dynamic behaviour of civil works structures and to define extreme circumstances under which (earthquakes or overloads) the former change their behaviour, thus, signalling to its own deterioration. The equipment is being used in 40 bridges in Bogotá with outstanding results.

Material Science Group

This group is equipped with an Alcatel Vacuum Deposition System for the production of high quality thin films of different materials, using vacuum evaporation, RF and DC sputtering gas mixing equipment and thickness monitor. At present the laboratory is working in the production of ceramic coatings (NTi, NZr) for industrial applications, and the development of thin-film based high Tc superconducting materials suitable for the production of high magnetic films and energy transmission.

Fundamental Aspects of Physics Research Group

Since several years this group has being studying fundamental physical phenomena. At present the work is centred in the reproduction of Michelson Morley experiment which as is well known was the base for special relativity. The experiment is measuring in a systematic way the daily and annual effect of the earth movements on the velocity of light. This experiment is one of the few international efforts being carried out to confirm experimentally the results obtained by these authors.