Technology Transfer and Innovative SMEs:
Where is the Public Process more Effective – EU or US?

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Abstract

Public policy in the EU and US is concerned with the competitiveness of business firms and their benefits to their economies. Much emphasis is being put on technological innovation as the dynamic process to achieve these beneficial outcomes. The process itself is perceived as a linear model beginning with basic science and culminating in the commercialization of resulting technologies by entrepreneurial firms. Two points are generally conceded in studies of this topic: 1) the science stock driving the process is mostly the product of publicly funded research (Nelson, 2004, *Research Policy*, 33(3), 455-471); and 2) evidence (Walsh & Kirchoff, 2002, *Journal of Enterprising Culture*, 10(2), 133-149) suggests that smaller firms are more effective commercializers and develop more "major" innovations than do larger firms. Their success, however, often depends on technology transfer.

This paper focuses on a small part of a large and complicated process. At the program level, involving SMEs in technology transfer, several conclusions can be drawn. The European (EU) emphasis on defined platforms and themes seems to provide a more efficient network of focused technology transfer. In the US universities (and attached hospitals) have relied on their own technology transfer offices to market licenses and to encourage spin-offs, a less efficient system.

INTRODUCTION

Public policy in the EU and US is much concerned with the competitiveness of business firms and resulting benefits to their economies. Much emphasis is being put on technological innovation as the dynamic process to achieve these outcomes. The process itself is perceived as a linear model beginning with basic science, moving through applied science to defined technologies, and culminating in the commercialization of those technologies by entrepreneurial firms. Two points are generally conceded in the studies on this topic: 1) the science stock driving the process is mostly the product of publicly funded research (Nelson, 2004, *Research Policy*, 33(3), 455-471); and 2) evidence (Walsh & Kirchoff, 2002, *Journal of Enterprising Culture*, 10(2) 133-149) suggests that smaller firms are more effective commercializers and develop more "major" innovations than do larger firms. Their success in this complex and highly risky process, however, often depends on successful and affordable technology transfer.

The purpose of this paper will be: 1) to outline common technology transfer practices of universities and public research organizations and SMEs in the EU and US; 2) to critically examine the effectiveness of those practices; and 3) to propose a revised model that could increase the SMEs' ability to innovate through technology transfer from public sector institutions.

TECHNOLOGY TRANSFER PRACTICES (EU and US)

Some form of technology transfer generally occurs in most organizations among and between departments in the organization. This paper is interested in the transfer from the public sector to small and medium sized enterprises. Most such transfers mechanisms rely on formal programs. In view of the rapidly growing, highly fragmented literature on the subject, this author focuses necessarily on a small slice of the pie. From the macrocosmic view, the conceptual issues involved are complicated. Technology transfer is defined in many different ways, depending on the discipline of the research, and also on its purpose. One issue is how to define technology itself: how to distinguish between the set of processes and products, and the knowledge of their use and application. Without the knowledge base the physical entity cannot be put to use. Another issue, perhaps more easily defined, has to do with the movement of know-how, technical knowledge, or technology from one organization's competency and capability set to another's. In this paper we will inspect the processes by which ideas, proofs-of-concept, and prototypes move from research related to production-related phases of development (Bozeman, 2000, *Research Policy*, 29. 627-655).

Select Practices in the EU

The European Commission on Enterprises has developed a technology transfer network, known as the ETTN, as an outcome of initiatives begun in 1998. This virtual technology park (http://ettn.jrc.i) is testing the ability of information and communication technologies (ICTs) to overcome the difficulties of transferring technologies to SMEs. The network involves 15 SME platforms in Portugal, Spain, Italy, Germany, Denmark, Sweden, Belgium, Northern Ireland, the Netherlands, and Scotland. Each of the platforms makes use of a technology broker, an expert in technology transfer for SMEs. They focus on SME needs and competiveness by helping them identify ICT technology solutions to their problems, either working through the regional platform or through the entire network. The solutions can involve efforts from business planning to research collaboration and licensing.

The European Commission has also developed another innovation accelerator titled the Community Research and Development Information Service, or CORDIS. Under its umbrella, CORDIS offers many programs (http://cordis.europa.eu). The cooperative research plan administered by the Sixth Framework Programme (2002-2006), or FP6, encourages applications by those SMEs (meeting the employee, turnover, and asset restrictions) with research and innovation needs. After thorough evaluation of the innovation proposal, the applicants can be teamed with R&D providers - research institutes - for a minimum of one year and a maximum of two. The funding ranges from .5million Euros to 2million. The research has to qualify in one of the seven thematic areas, including life sciences and biotechnology, nanotechnologies, food sciences, and information and communication technologies. If the funded research is successful within the timeframe, the SME retains the intellectual property rights.

FP6 also coordinates the Pilot Action for Excellence on Innovation Start-ups program, or PAXIS. Entrepreneurs with technology innovative ideas can apply to PAXIS for spin-off support, incubator services, financing alternatives, and entrepreneurial training. This program can also provide technology transfer assistance. Five geographic clusters across the EU, each dedicated to a family of technology, provide the organization for the program.

Select Practices in the US

In the US, between 1980 and 2000, Congress passed eight major policy initiatives dealing with technology transfer. With the passage of the Bayh-Dole Act in 1980 universities, not-for-profit corporations, and small businesses were allowed to patent and commercialize their federally funded inventions. In addition, the Act allowed federal agencies to grant exclusive licenses for their technology in order to provide more incentives to business. One key expectation was that universities were expected to give licensing preference to small businesses. To expect this behavior to take place at an accelerated rate, however, requires considerable public research funding. The largest share of this funding for US universities comes through the Department of Defense (DOD), the Department of Energy (DOE), the National Institutes of Health (NIH), and the Department of Agriculture (USDA). Although universities are generally credited with performing a much higher proportion of basic research activities than industry, it is also true that there is a significant amount of applied research, particularly in the engineering disciplines (Graff, Heiman, & Zilberman, 2002, California Management Review 45(1) 88-115). Government policies and sponsored research funding (by government agencies), however, don't mean that academic technology transfer is not an arduous task. The research activity has to lead first to invention disclosures – the first step in creation of intellectual capital; then to claiming property rights to the disclosure – often patenting; and finally to licensing or options to license or purchase. This process is usually managed by an office of technology transfer.

The Federal Technology Transfer Act of 1986 opened a new era for US government operated research laboratories in much the same manner as Bayh-Dole did for universities. Besides responsibility for mission-related research (often related to national security and energy matters), the Act charged the laboratory system with new activities that, hopefully, would lead to transfer and commercialization of technologies developed on site. The main instruments used to carry out this policy are cooperative research and development agreements (CRADAs), intellectual property licenses (IPLs), and work for others (WFOs). CRADAs allowed federal labs to enter into technology transfer agreements with private firms through a type of joint venture. Both parties may contribute resources, but the business firm that contributes funding receives an option or a license to any intellectual capital that results. WFOs differ from CRADAs in that the laboratory performs all the work and all costs are recovered from the sponsor. The federal labs negotiate IPLs on much the same terms as universities, other research organizations, and private firms. The opportunities these programs present for SMEs depend on their ability to formulate rigorous plans for development and commercialization of the lab-based or joint venture technologies. The programs incorporate preferences for US industry and for smaller businesses, but the labs, like any business partner, favor those firms that have prepared an operational plan to succeed (Gross & Allen, 2003, *Technology Transfer for Entrepreneurs: a Guide to Commercializing Federal Laboratory Innovations*).

A preliminary classification that offers a comparison between the EU and US technology transfer practices between the public sector and SMEs must include the following:

Areas of innovation (themes in EU v. less focus in US)

Geographical networks (platforms in EU v. institutions in US)

Program emphasis (ict, incubation/start-up, licensing v. joint dev. & licensing)

TECHNOLOGY TRANSFER PERFORMANCE

Data in the EU and the US that measures SMEs' participation in the programs described above, or that provides quantitative information on transfers of technology and use of rights from the public sector to small and medium sized firms is very sparse. (This is compounded by the notion that the "end game" in this policy pursuit is increased economic development through innovative SMEs.) More aggregate data is available, and sometimes it allows for a glimpse of the microcosmic level activity. Given that fact, the accompanying tables will be a starting point for this discussion. In addition, I will present some aggregate US data in percentage form and some regional data from a smaller state in the US which has many SME equivalents.

EIS and OECD data

Table 1 presents a selection of indicators from the 2005 European Innovation Scoreboard (EIS) for a representative sample of EU states. The TrendChart attempts to identify metrics that that are relevant to specific types of EU innovation policies, including intellectual property rights, commercialization of public research, and innovation collaboration (Arundel & Hollanders, 2005, *Policy, Indicators and Targets: Measuring the Impacts of Innovation Policies, European TrendChart on Innovation)*. Of note is the public funding of R&D. The EU goal is one percent with business funding at two percent for a combined innovation funding of three percent of GDP. Without a time series to measure changes, many of these variables must be related to policy targets. It is interesting to note the percentages of SMEs innovating in-house with the percentage co-operating with others. But it would be helpful to know which of these groups were more successful in commercialization of innovations. In the category of Supplementary indicators the focus on information and computer technologies is readily apparent from the European patent applications of France, the United Kingdom, and the Netherlands.

Table 1 European Trend Chart on Innovation Source: European Commission, European Trend Chart on Innovation

EIS 2005 indicators	**Belgium**	**Denmark**	**France**	**Italy**	**Latvia**	**Netherlands**	**United Kingdom**
New S&E graduates (per 1000 population aged 20-29)	11.0	12.5	22.2	7.4	8.6	7.3	21.0
Public R&D expenditures (% GDP)	0.56	0.80	0.81	0.60	0.25	0.75	0.68
Enterprises receiving public funding for innovation	11.50	3.20	10.30	14.80	2.00	14.70	3.80
University R&D expenditures financed by businesses (share financed by business)	12.7	2.7	2.9	3.8	23.9	6.8	5.6
SME's innovating in-house	38.3	25.9	29.2	28.8	14.9	18.0	22.4
Innovative SMEs co-operating with others	9.60	16.60	9.30	2.70	6.20	8.00	7.20
SME's using non-technological change	49.0	26.0	23.0	49.0	35.7	38.0	0.0
EPO patents per million population	148.1	214.8	147.2	74.7	6.0	278.9	128.7
USPTO patents per million population	70.4	83.8	68.1	30.3	0.3	86.6	64.5
Triad patents per million population	35.1	47.6	36.1	13.5	1.1	53.8	30.0
EXIS indicators							
Percent firms that applied for one or more patents	8.0	6.5	14.0	5.9	0.0	6.5	6.1
Supplementary indicators							
Number of EPO ICT patent applications (2000)	275	221	2185	682	0	1590	2134
Royalties and license fees as a % of GDP	-0.73	0	0.82	0	0	-0.63	1.38
Government/higher education researchers per 1000 employees (2002)	0	0.6	0.5	0.31	0	0	0

Tables 2 through 7 present comparative investments in research and development, over a time series, across a sample of EU states, the EU-15, the EU-25, and the US. These tables are important because they indicate the upstream investment that might impact technology transfer programs targeting SMEs downstream (Dosi, Llerena, & Labani, 2005, *Evaluating and Comparing the Innovation Performance of* *the United States and the European Union, TrendChart* Policy Workshop 2005). Depicted in Table 2 is the Government Financed General Expenditure in R&D (as a percentage of GDP). Even if Finland, France, and Sweden's percentages exceed the US average, the aggregate picture for the EU -15 and EU-25 is less than the US. Table 3 shows that the US government spends considerably more in R&D carried out by firms (business enterprise R&D – BERD) than the EU aggregates. In comparison, the publicly supported forms of R&D expenditures, such as higher education and other government programs, are very similar in the US and the EU aggregates.

Table 2 Government Financed GERD as a Percentage of GDP
Source: OECD (2004a).

Country	**1998**	**1999**	**2000**	**2001**
Finland	.87	.94	.89	.87
France	.81	.80	.84	.82
Spain	.35	.36	.36	.38
Sweden	…	.89	…	.90
United Kingdom	.55	.55	.53	.53
EU-15	**.65**	**.65**	**.65**	**.66**
EU-25	**.63**	**.63**	**.63**	**.63**
United States	**.79**	**.76**	**.71**	**.76**

Table 3 Decomposing 2001 Government funded R&D: BERD and non BERD Note: Gross expenditures are expressed in million 2000 dollars – constant price and PPP.
Source: Calculations on OECD (2004a). Source: OECD (2004a).

Country	**Government Financed BERD**	**on GDP%**	**Government Financed nonBERD**	**on GDP%**
EU-15	9,369	.10	53,352	.56
EU-25	9,868	.09	55,073	.52
US	18,849	.19	57,533	.57

Another important metric has to do with the percentage of higher education R&D (HERD) financed by industry. This can indicate the importance of university-business interaction. Table 4 reveals that Europe clearly has some leading states in this activity. And as a result, the EU leads the US in the percentage and the trend over the time period presented.

Table 4 Shares of Higher education Expenditure on R&D (HERD) financed by industry. Source: EIS and OECD (2004a).

Country	**1998**	**1999**	**2000**	**2001**
Belgium	11.1	10.5	11.8	12.7
France	3.4	3.4	2.7	3.1
Germany	10.5	11.3	11.6	12.2
Spain	7.0	7.7	6.9	8.7
United Kingdom	7.3	7.3	7.1	6.2
EU-15	**6.4**	**6.5**	**6.6**	**6.8**
EU-25	**6.4**	**6.5**	**6.5**	**6.7**
United States	**6.1**	**6.1**	**6.0**	**5.5**

Where is the higher education R&D invested? In Table 5 it is apparent that the sample EU states, Germany, Spain, and Sweden, devote more of that funding to engineering, social sciences, and the humanities than does the US, with its focus on funding health and biomedical sciences. Using data from national budgets, Table 6 reveals that the US appropriates a much higher percentage of its budget to defense related R&D than does the EU. This fact also suggests that the earmarks for small business programs, such as the SBIR and the STTR (government grants allowing SMEs to develop technologies and products), are greatly increased. Whether or not the EU's appropriation for economic development benefits SMEs as much is not measured.

Table 5 Shares of HERD by country and S&E field: 1998 or 1999. Note: NS&E natural science and engineering. Source: OECD, Science and Technology Statistics database, 2003.

Country	**NS&E**	**Natural science**	**Engineering**	**Medical science**	**Agricultural science**	**Social science & Humanities**
Germany	78,4	29,2	20,3	24,7	4,2	20,6
Spain	77,9	39,4	18,7	14,2	5,6	22,1
Sweden	76,3	21,0	21,9	27,4	6,1	17,6
US	93,7	41,8	15,5	29,1	7,4	6,3

Table 6 Distinct components of GBOARD (%).Note: Numbers refer to 2004 for the US and to 2001 for EU-15 and EU-25. Source: OECD (2004a).

Defense Budget R&D	**Civil Budget R&D**

		Econ. Development	Health & Environ.	Space Program
EU-15	15.2	17	14	5
EU-25	14.9	17	13	5
US	55.1	5	26	8

Another view of the investment in higher education is to examine overall human capital formation rates in the EU and the US. Table 7 shows the percentages of university educated, new science and engineering graduates, and total researchers in the populations of the EU and US. The EU states in this sample - particularly France and Sweden – exceed the US in new S&E graduates. Europe, however, does not compare as favorably with the US in terms of the metrics measuring the higher educated (tertiary) and researchers.

Table 7 Population with Tertiary Education (% of 25-64 years age class),
New Science & Engineering graduates (per 1000 population aged 20-29),
And Total Researchers (per Thousands of Total Employment). Note: US indicator for tertiary education in 2003 refers to 2002. Italian number for S&E graduates in 2003 refers to 2002, EU-25 to 2000. UK number of researchers refers to 1998. Source: EIS 2005 indicators and OECD (2004a).

Country	**Tertiary Education**			**S&E Graduates**			**Researchers**		
	1999	*2001*	*2003*	*1999*	*2001*	*2003*	*1999*	*2001*	*2002*
France	20.9	22.6	23.1	19.0	20.2	22.2	6.8	7.2	7.5
Germany	23.0	23.5	24.3	8.6	8.0	8.4	6.7	6.8	6.9
Italy	9.5	10.0	10.8	5.5	6.1	7.4	2.9	2.8	…
Spain	21.1	23.6	25.2	9.6	11.3	12.6	4.0	5.0	5.1
Sweden	28.5	25.5	27.2	9.7	12.4	13.9	9.6	10.6	…
UK	27.5	28.7	30.6	15.6	19.5	21.0	5.5	…	…
EU-15	**20.5**	**21.5**	**22.5**	**10.2**	**11.9**	**…**	**5.6**	**5.9**	**…**
EU-25	**19.4**	**20.1**	**21.2**	**9.4**	**11.0**	**…**	**5.3**	**5.6**	**5.8**
US	**35.8**	**37.3**	**38.1**	**9.3**	**9.9**	**10.9**	**8.6**	**…**	**…**

What about evidence of technological output? Patent-based indicators, or legal ownership of intellectual capital, are widely used despite well-known problems of varying industry/sector relevance of patents, skewed value distributions, and changes in patent laws. Table 8 discloses that, using patents as a proxy of innovation output, the US has attained a position of leadership over the EU. Note the lead in biotechnology and telecommunications patents registered in Europe, Japan, and the United States. It would, however, be helpful to know the percentage held by universities and public research institutes as well as by large and small firms. The larger share held by the former would likely indicate a healthy pool for possible technology transfer to SMEs.

Table 8 *Shares in "triadic" patent families.* Note: "Triadic" patent families are inventions filed with the European Patent Office (EPO), the Japanese Patent Office (JPO), and the US Patent and Trademark Office (USPTO). Source: OECD on-line database.

	1990	**1992**	**1994**	**1996**	**1998**	**2000**
Total Shares						
Eu-25	.27	.28	.29	.29	.30	.23
US	.39	.40	.40	.38	.36	.38
Aerospace						
Eu-25	.17	.18	.21	.21	.23	.20
US	.40	.43	.44	.41	.39	.39
Mechanical Engineering						
Eu-25	.41	.39	.39	.40	.41	.30
US	.30	.34	.27	.23	.23	.26
Chemistry						
Eu-25	.33	.36	.36	.34	.34	.28
US	.42	.40	.39	.41	.40	.45
Materials						
Eu-25	.29	.33	.31	.31	.32	.21
US	.37	.35	.34	.33	.33	.38
Biotechnology						
Eu-25	.29	.30	.29	.26	.26	.19
US	.50	.47	.50	.53	.55	.62
ICT sector						
Eu-25	.17	.18	.21	.21	.23	.20
US	.40	.43	.44	.41	.39	.39
Telecommunications						
Eu-25	.22	.26	.28	.27	.30	.21
US	.42	.46	.45	.43	.39	.47
Consumer Electronics						
Eu-25	.10	.11	.11	.14	.15	.22
US	.30	.34	.41	.35	.35	.26
Computers, office machinery						
Eu-25	.11	.13	.16	.15	.18	.17
US	.45	.46	.46	.43	.42	.39

Before turning to performance indicators gathered nationally, regionally, or institutionally in the US, how does the data discussed in the Tables 1 - 8 relate to the topic of this paper? There are many useful macroscopic metrics of input: government- financed and business-financed higher education R&D; shares of R&D investment by country and science and engineering field; and stocks of, and rates of creation of, human capital disposed towards innovative activity. And there exist innovation outputs like shares in "triadic" patent families. But it is difficult to find more specific information on SMEs involved in technology transfer agreements with public sector institutions, whether as spin-offs, or by licensing and other activities.

AUTM and Idaho institutional data

What performance indicators are available for our subject in the United States? The Association of University Technology Managers (AUTM) annually surveys the offices of technology transfer (OTT) where they exist in universities, hospitals, government laboratories, and not-for-profit research institutes in the US. (Canadian institutions undergo a separate survey.) The highlights of the data collected from respondents to the 2004 Licensing Survey follow:

*16,871 invention disclosures received by US respondents;
*USPTO issued more than 3,800 patents to universities;
*567 products based on public research were introduced;
*More than 300 biotech drug products and vaccines were in trials;
*462 startup firms were formed;
(Since 1980 universities have spun out 4,543 new firms)
*4,783 new licenses and options executed;
*More than 65% of licenses and options went to SMEs
(with <500 employees).

Table 9 reveals incomplete information from two universities and a government laboratory located in a smaller western state in the US. The University of Idaho (UofI) and the Idaho National Lab (INL), as you can see, have much more experience in research and transfer activities than Boise State University. Missing from the patent count for INL are the entries for the years 2000 – 2003. The patent counts are 34 for 2005 and 31 for 2004. Drilling down from the licenses granted data reported by UofI and INL reveals that 70% have been executed by spin-offs or SMEs. These institutions, joined by Boise State University, will need to keep a healthy patent count in the future so they can achieve transfer through licenses and spin-offs to SMEs.

Table 9 Idaho Research and Technology Transfer. Note: * is approximation based on charts from INL Technology transfer 2005 Annual Report Source: Reports to AUTM

	Year	Research expenditures total ($M)	Sponsored research awards G&C ($M)	Invention disclosures (#)	Patent application (#)	Patents issueD (#)	Licenses granted (#)	Royalties ($K)
Boise State University	2000			1				
	2001			0				
	2002			3		1- issued		
	2003			4		1- provisional		
	2004			1		1- iss., 1- prov.		
	2005			3	2	1- prov., 2- pending		
	Total			**12**	**2**	**2- iss., 3- prov., 2- pend.**		
University of Idaho	2000	42.0	45.5	21	11	3	3	73.8
	2001	48.9	62.8	19	8	6	1	198.0
	2002	57.5	62.5	30	13	3	7	245.6
	2003	67.0	76.7	34	14	3	2	95.8
	2004	75.6	80.7	50	17	5	21	307.9
	2005	73.6	75.6	28	20	2	15	425.2
	Total	**364.6**	**403.8**	**182**	**83**	**22**	**49**	**1,346.3**
Idaho National Laboratory			CRADA Funds *	*			*	*
	2000		7.2	82			10	260.0
	2001		3.5	129			11	324.0
	2002		.7	104			9	584.0
	2003		3.8	77			5	129.6
	2004		6.7	148		31	7	500.0
	2005		3.5	110		34	16	790.0
	Total		**25.4**	**650**			**58**	**2,587.6**

Obviously, what is missing from this information is data that tracks the licenses and spin-offs over time. Unfortunately, at this point, no verifiable data exists about the successful commercialization of those innovations.

CONCLUSION AND SUGGESTIONS FOR REVISED POLICIES

This paper has focused on a small part of a large and complicated process. The literature on technology transfer, including recent studies questioning its market impact and economic criteria, is multidisciplinary and vast. Predicting and measuring the commercial results from R&D has evaded quantification for the most part. (This may explain why the private sector relies so heavily on the public sector to lead the way; and why universities and government laboratories are considered the appropriate environments for basic science.)

Some conclusions, however, can be drawn. Accelerating technology transfer requires increasing public funding in the EU, and maintaining or increasing that funding in the US. Building the stock of science-based technologies is expensive. How the funding is directed is of major concern. Both the EU and the US through political design or through researchers' interests appear to target the R&D investment (this was true in the US before September 11, 2001). Sometimes government policies are a direct impediment. To wit, the recent restrictions on stem cell research in the US. Obviously, suggestions at this level are beyond this brief paper's capability and competence.

It is at the program level involving SMEs in technology transfer that several recommendations can be made. The first is designed to bring the best aspects of the EU programs described above together with aspects of the less structured US practices. The European emphasis on platforms and themes seems to provide the basis for a more efficient network of focused technology transfer. In the US the universities (and hospitals attached to universities) rely on technology transfer officers to market licenses or to encourage spin-offs. This seems like less efficient marketing. (In contrast, the federal labs in the US have created some relationships and some collaborative programs like the CRADAs which offer the promise of more efficient networks.) So, it appears that the US could use more formal networks in the university-SME relationship. On the other hand, patenting information suggest that universities in the EU could benefit from adopting some of the research intensity of the US universities.

Finally, whatever program changes are made that would enhance the SMEs ability to use technology transfer in order to gain competitive advantage, more precise measurement of those activities and their results needs to be achieved. Otherwise, the effectiveness of policies and programs will always be in doubt.