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Incentives for technology transfer institutes

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Abstract in English

We study the incentives that motivate technology transfer institutes to deliver social value added for the public funds invested. Four institutes were selected for case studies: TNO and DLO of the Netherlands, the German Fraunhofer Society, and the Finnish VTT. Public funding is legitimised by underinvestment in absorptive capacity and coordination problems in matching demand and supply of knowledge. Currently, the amount of public funding is not conditional upon pre-specified and measurable performance indicators. This indicates a risk of ineffectivity and inefficiency. We present an indicator - constrained contract research turnover – that seems to be a good measure for the social value added technology transfer institutes are expected to deliver. The constraint refers to the following condition: ineligible is contract research turnover that builds on a knowledge base that, according to an independent expert committee, is (or could have been) created and maintained by private technology transfer firms. We discuss a policy option that makes public funding contingent on this indicator. We compare this policy option with an alternative that attaches incentives to a throughput measure of performance, respectively that applies implicit rather than explicit incentives to enhance effectivity and efficiency.

Key words: technology transfer, science-industry interaction, incentives, public policy

Abstract in Dutch

Dit rapport onderzoekt hoe intermediaire kennisinstellingen te prikkelen hun overheids-financiering effectief om te zetten in maatschappelijke meerwaarde. Vier van zulke instellingen zijn onderwerp van case studie: TNO, DLO, Fraunhofer (Duitsland) en VTT (Finland). Overheidsfinanciering is legitiem: private partijen hebben onvoldoende prikkels om te investeren in kennisabsorptie en om coördinatieproblemen tussen kennisvraag en kennisaanbod op te lossen. Momenteel is de overheidsfinanciering niet afhankelijk van een duidelijk gespecificeerde prestatie-indicator. Dit kan ineffectiviteit en inefficiëntie in de hand werken. We stellen een indicator voor – relevante omzet uit contractonderzoek – die een goede maat lijkt voor de maatschappelijke meerwaarde die van een intermediaire kennisinstelling verwacht wordt. Het woord ‘relevant’ verwijst naar de volgende voorwaarde: tot de prestatie-indicator behoort alleen de omzet uit contractonderzoek dat voortbouwt op een kennisvoorraad die – volgens een onafhankelijke visitatiecommissie – niet door private kennisintermediairs is of zou zijn opgebouwd. We presenteren een beleidsoptie die de overheidsfinanciering afhankelijk maakt van deze indicator. We vergelijken deze beleidsoptie met aansturing op een throughput indicator, en met aansturing via impliciete prikkels waaronder het reputatiemechanisme.

Steekwoorden: intermediaire kennisinstellingen, wisselwerking, innovatie, prikkels, beleid

Een uitgebreide Nederlandse samenvatting is beschikbaar via www.cpb.nl.

Contents

Executive summary

We study the effectiveness of technology transfer institutes in building bridges between science and society. In this way, these institutes aim to foster the utilisation of scientific knowledge and to articulate knowledge demand of private and public parties alike. More precisely, we ask how effectively these institutes allocate their public funds. This is a question about incentives, since technology transfer institutes respond to incentives like any other organisation. We therefore analyse whether the incentives that technology transfer institutes face are congruent with the role of the organisations. Hence, we search for a measure of technology transfer output that strongly correlates with social value added, and we discuss the pros and cons of attaching strong and explicit incentives to such a measure. In this work, we thus focus on the governance of a given technology transfer institute and we do not pick up questions such as: should governments put up the public tasks of a technology transfer institutes for tender, or: should governments pass on the public tasks of technology transfer institutes to universities?

We bring forward two market failures legitimising government funding for technology transfer institutes. The first market failure is the underinvestment in absorptive capacity. A firm needs to do basic research to absorb existing scientific knowledge and to transfer such knowledge into applicable knowledge. Since the returns to basic research are difficult to appropriate, a firm has weak incentives to invest in technology transfer relative to what is optimal from a societal perspective. The second market failure is the coordination problem. Markets may invest too little in technology transfer because of large coordination costs to reap the economies of scale and scope in technology transfer.

What incentives do technology transfer institutes actually face? A comparison of four technology transfer institutes (Dutch TNO and DLO, the German Fraunhofer Society, and the Finnish VTT) reveals major similarities in the incentive structure. All receive substantial government funding for which they do not have to compete explicitly. For none of the institutes the amount of these funds is conditional upon pre-specified, measurable and verifiable performance indicators. Part of the government funding supports research programmes for which the government is a relatively well-informed principal. From time to time, all institutes are subject to some form of ad-hoc government-commissioned evaluation, but criteria are not specified in advance and findings do not necessarily have implications for government funding. All boards of management hire external committees to evaluate the research units of the institute, but again implications are unclear. A major share of turnover of all institutes comes from contract research for public and private clients who are likely to trigger off relatively strong incentives to deliver value for client's money. The boards of management all reward units for success in attracting contract research assignments through the allocation of government funds and through merit pay.

Still, the four institutes differ to some extent. First, there are notable differences in sources of turnover and thus in the impact of the incentives attached to these sources. Second, the institutes differ in the incentives the boards of management associate with the distribution of government funds over the research units. Third, the institutes differ in price setting policies: value-based pricing versus cost-based pricing.

Does this incentive structure guarantee effectivity and efficiency? Not necessarily. The absence of explicit incentives attached to government funding indicates a risk of ineffectivity and inefficiency. The risk is mitigated, however, by the internal incentive scheme on behalf of the board of management, by the reputation mechanism (persistent underperformance will ultimately become public and punished), and by intrinsic motivation and (post) career concerns of management and employees.

Explicit incentives contribute to effectivity and efficiency if performance can be measured sufficiently well. Current internal performance assessments suggest two indicators that jointly constitute a reasonable indicator of effectiveness and efficiency of the use of government funding to foster technology transfer:

- An independent expert opinion about the additionality of the technology portfolios relative to the market (and to universities);
- Contract research turnover as a measure of utilisation of those technology portfolios.

This analysis establishes two policy options:

- **Policy option 1**: Make government funding contingent on constrained contract research turnover. The constraint refers to the following condition: ineligible for a reward is contract research turnover that builds on a technology portfolio that, according to an independent expert committee commissioned by the government, is (or could have been) created and maintained by private technology transfer firms.
- **Policy option 2**: Make government funding contingent on the quality of the technology portfolio. Quality is to be measured by an independent expert committee commissioned by the government. Quality could have many dimensions, and may include the two dimensions that constitute Policy option 1 (contract research turnover and experts' opinion on additionality).

The default policy option turns up if neither constrained contract research turnover, nor the quality of the technology portfolios brings a good measure of effectiveness:

- **Policy option 3**: Continue the current situation. The government settles for implicit incentives and relies on the reputation mechanism and on intrinsic motivation and on the resulting performance of the internal incentive schemes.

  The critical policy dilemma is to weigh the benefits of increasing incentives for effectivity and efficiency against the costs of misdirected incentives. Current internal performance assessment practice suggests, however, that serious opportunities for external measurement of effectiveness and efficiency of technology institutes do exist. To be precise, constrained contract research turnover seems to be a good indicator of the social value added technology transfer institutes are expected to deliver, and it is a measurable indicator. Consequently, we argue that policy options that make government funding of technology transfer institutes contingent on such measures (in particular Policy option 1) deserve careful consideration in the policy debate.

Preface

The technology transfer institute is a major policy instrument aimed to foster the interaction between the sciences on the one hand, and industry and society on the other. These institutes promote the utilisation of scientific know-what and know-how, and they articulate demands for scientific knowledge. In this way, technology transfer institutes are meant to contribute to welfare.

This paper studies the effectiveness of technology transfer institutions. More precisely, the paper studies the incentive scheme that governs the way these institutes allocate the public funds they receive to accomplish their mission. And it discusses policy options that attach more explicit incentives to a measure of effectiveness of technology transfer institutes, i.e. an output indicator that strongly correlates with social value added. In this way, the paper aims to contribute to the policy discussion how to enhance the utilisation of scientific knowledge and how to increase the focus of the scientific research agenda on the knowledge demand of society.

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F.J.H. Don
Director

1 Introduction

Basic research often yields practical ideas. However, in many cases the practical relevance of new knowledge is not immediately obvious, at least not to people outside science, and further applied research needs to be done. To prevent that existing knowledge remains unused, public policy measures aim to help firms and public organisations in transforming basic research into applied ideas. The other way around, practical problems may call for basic research. Yet, knowledge demand is often diffused and many problem owners are unable to find and mix the necessary scientific expertise. In order to prevent such demand from not being served, public policy aims to help firms and (semi-)public organisations to articulate their knowledge needs.

Technology transfer institutes are one such public policy instrument. These institutes employ substantial research activities to bridge the gap between science and society. This paper studies the Dutch TNO and DLO, the German Fraunhofer Society, and the Finnish VTT as examples of technology transfer institutes.

The study is initiated because of the so called "European paradox". This paradox supposes that the quality of European science is high, but the usage of that knowledge is limited compared to the US (Pavitt, 2000). This seems to be particularly the case in the Netherlands. For example, whilst the number of scientific publications per capita is relatively high in the Netherlands, the number of patents is lagging behind that in the US. However, the measures of this knowledge gap between science and industry are only imperfect, and the evidence is inconclusive (see for an extensive discussion CPB, 2002, chapter 4). Yet, it gives reasons to study the transfer of technology.

The aim of this paper is to study the effectivity of technology transfer institutions. More precisely, we ask how effective these institutes spend their public funding to bridge the knowledge gap. This is a question about incentives, since technology transfer institutes respond to incentives just like any other individual or organisation. We therefore analyse whether the incentives that technology transfer institutes face are in congruence with the role of the organisations. Hence, following the so called principal-agent framework,[1] we ask what measure of technology transfer output strongly correlates with social value added, and we discuss the pros and cons of attaching strong incentives to such a measure.

Our main findings are the following. In some respects technology transfer institutes are likely to get the right incentives. Especially in doing contract research for the market, satisfying knowledge demand of firms and (semi-)public organisations, we do not find major reasons to worry about wrong incentives. However, we also find that the government provides only

[1] See, e.g., Laffont and Tirole (1993) and Koning et al (2004).

implicit incentives on basic government funding. Although there are potentially plausible reasons for this lack of incentives, we suggest benefits of attaching stronger and more explicit incentives to government funding. This stimulates an effective and efficient use of subsidies and it rewards an institute for being successful.

We present two policy options that provide explicit incentives to government funding for technology transfer institutes. In the first one, we propose that the government makes basic funding contingent on realised contract research turnover, with a restriction that prevents the institute from getting rewarded for being active in domains where private parties will do the job. In the second one, we propose a similar incentive scheme, but based on the quality of the knowledge stock (a throughput variable) instead of restricted contract research market turnover (an output variable). We describe the pros and cons of each of these two proposals, and of the third policy option to continue the incentive structure as it is now. We argue that the first policy option merits particular attention, since constrained contract research turnover is strongly correlated with the value added society expects from technology transfer institutes. Furthermore, current practice shows that this indicator is measurable indeed.

The remainder of the study is organised as follows. In section 2, we discuss the role and rational of technology transfer institutes, and the role of the government respectively. An impression of four such organisations is given in section 3. We then analyse their incentive structure and present policy options in section 4. Section 5 concludes.

A related case study of TNO, a major Dutch technology transfer institute, previously appeared as Chapter 6 in Koning et al (2004).

A broader perspective on policy options for technology transfer institutes

This paper concentrates on the policy question: what is a good incentive structure for a technology transfer institute? The paper thus takes the existence of a unique technology transfer institute as given. A broader analysis would have dropped this restriction, and would have addressed question such as:

Should governments put up the public tasks of a technology transfer institutes for (international) tender?

Should governments pass on the public tasks of technology transfer institutes to universities?

These questions are beyond the scope of this paper.

2 The role of technology transfer institutes

In this section the labels 'firm' and 'industry' are meant to include all profit and non-profit entities that inhabit the demand side of the market for knowledge. They thus include ministries in search for a solution of an environmental problem, municipalities looking for a measurement system for airplane noise pollution, and agricultural trade organisations in demand of better ways to grow tomatoes.

2.1 Closing the knowledge gap

The supply of knowledge by universities does not seem to perfectly match the demand by firms and vice versa. Some existing knowledge remains unused; other knowledge is desired but not provided for. This is the so called "European paradox." Underutilisation and underprovision of knowledge hampers economic growth.

Complementarities between doing basic research and doing applied research seem to be an important cause: the one cannot do without the other (Aghion and Howitt, 1998). Yet, universities and firms are independent organisations. Universities focus on doing basic research for the benefit of all; firms have more interests in directly applicable knowledge that bring healthy returns in the market. The complementarities are therefore unlikely to be fully exploited.

Industry and university need each other for at least two reasons. First, university needs to know industries' needs to address demands for knowledge. It is not true that universities should always and only fulfil industries' needs, because this may shift their attention away from long term basic research to more short term research. Still, it is fruitful if part of the basic research goes into the direction of knowledge creation that ultimately has some industrial use. Second, industry needs absorptive capacity, e.g. the capacity to read and understand scientific papers, to transform basic research into applied research. This absorptive capacity is typically tied to those who do scientific research themselves (see Cohen and Levinthal, 1989).

How can we bridge the gap between science and industry? One may stimulate universities to engage in more intense direct interaction with firms. This is indeed part of the policy of some countries, for example the US (see Hall et al., 2001), and it is at the heart of policy discussions in countries such as the Netherlands (see, e.g. SER, 2003). However, some observers fear that such an intensive interaction would undermine academic freedom and openness and that it would shift university away from its primary mission of doing basic long term research. Furthermore, differences in culture and language would hamper the effectivity of direct interaction.

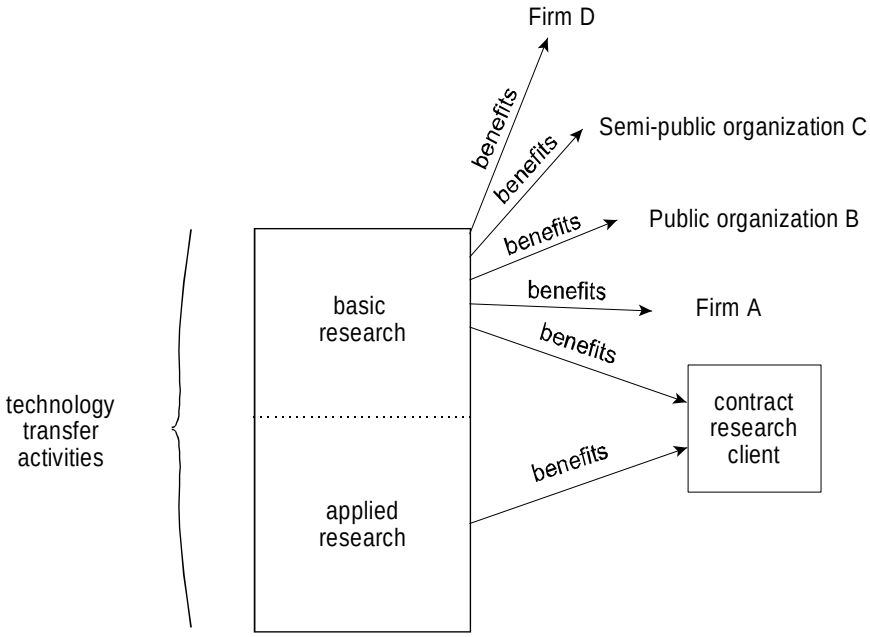
Another possibility is the technology transfer institute intermediating between science and industry. It provides the absorptive capacity to translate basic science into knowledge applicable by industry and it articulates industry's unmet knowledge demand. Set aside from academia, the previously discussed negative aspects of direct interaction between science and industry are not a concern. Yet, at least three other potential problems spring to one's mind. First, a technology transfer institute does not necessarily help to match industry's demand with the universities' supply of knowledge. It does not directly determine the universities' research agendas. Nor does it directly exploit the inspiration that applied research can offer to basic research (Schmoch, 1999). Secondly, a technology transfer institute needs a lot of information to perform. For example, it needs to know what knowledge is relevant for industry. We may expect some loss of information by setting up an intermediate institution relative to direct interaction between universities and industry. Finally, any intermediary necessarily duplicates some efforts: technology transfer researchers have to learn what researchers at the universities already knew,

2.2 Market failures in the process of technology transfer

Why would private incentives to engage in technology transfer activities fall short of the socially optimal incentives? We identify two potential reasons for (partial, but substantial) failure of the market for technology transfer.

The first reason deals with the idea of absorptive capacity. As outlined earlier, those who want to transform basic research into applied ideas need to be able to understand basic research. But in order to understand and absorb basic research, one has to perform basic research oneself. Doing basic research, however, is generally not to the benefit of an individual firm. The payoffs of basic research are difficult to appropriate and unsure. Basic research often provides answers to questions not posed, and therefore offers small value to the firm itself (see also Stephan, 1996). Hence, firms are willing to pay for applied research, but not for basic research. Since applied research goes hand in hand with basic research, firms underinvest in research. Figure 2.1 illustrates this market failure.

Figure 2.1 The returns to technology transfer activities are not fully appropriable



The second reason is a coordination problem. Firms may desire to perform, or have access to, applied research. Some firms will be large enough to hire a researcher for that purpose. Other firms are too small to hire a full time researcher. In principle, several small firms may bundle funds to hire a researcher. However, the more firms are needed to hire a researcher, the more difficult it will be to coordinate such process. More generally, the larger the coordination cost of reaping the economies of scale and scope in technology transfer, the more unlikely that the market will provide for the socially desired level of technology transfer.

We have thus identified two potential market failures: the need for absorptive capacity and the coordination problem. Both lead to underinvestment in technology transfer and, hence, to underinvestment in innovation, and both legitimise public policy.

2.3 Technology transfer institutes address technology transfer market failure

One public policy instrument to cure for technology transfer market failure is public funding for technology transfer institutes. Tax payers' money supports technology transfer activities that are socially beneficial, but privately unprofitable. Some countries, including the Netherlands, have favoured intermediary institutes relative to direct incentives to university-industry interaction, another technology transfer policy instrument. These countries have established public technology transfer institutes, partly funded by tax payers, partly funded by contact research clients.

Public policy may lack effectivity, and technology transfer policy may be prone to government failure just like any other policy instrument. Reasons include a lack of information at the central level where (not) to spend public funds or an impossibility to attach the right incentives to the funding.

This paper assesses the effectivity of (the incentive structure governing) technology transfer institutes and it presents policy option to enhance this effectivity. Before this assessment in section 4, the next section offers a description of four technology transfer institutes.

3 Four technology transfer institutes in brief

This section describes the structure and organisation, the sources of funding, and the incentive structure of four technology transfer institutes: TNO (the Netherlands), DLO (the Netherlands), Fraunhofer (Germany) and VTT (Finland). With respect to incentives, we classify these as strong and explicit versus soft and implicit. Strong and explicit incentives are defined as clearly stated rules which specify in advance how budgets depend upon performance. Otherwise we speak of soft or implicit incentives.

3.1 TNO[2]

Structure and organisation

The Dutch organisation for applied natural sciences TNO is a relatively large technology transfer organisation. Its mission is formulated as "*to apply scientific knowledge with the aim of strengthening the innovative power of industry and government*". It employs over 4,500 workers and its current annual turnover exceeds 460 million euro. In 2001, it accounted for about 4.5 percent of total R&D spending in the Netherlands (NOWT, 2003).

TNO is organised into research institutes, business centres, knowledge centres, and ventures. The business centres are collaborations between institutes that focus on similar technologies or markets. Knowledge centres are collaborations between institutes and universities. A supervisory board supervise the management board. A representative from the Ministry of Education, Culture, and Science (OCW) is member of the supervisory board. The defence activities are supervised by a council for defence research. The government appoints the boards of management and supervision.

TNO is not for profit. In principle, prices are set according to costs.

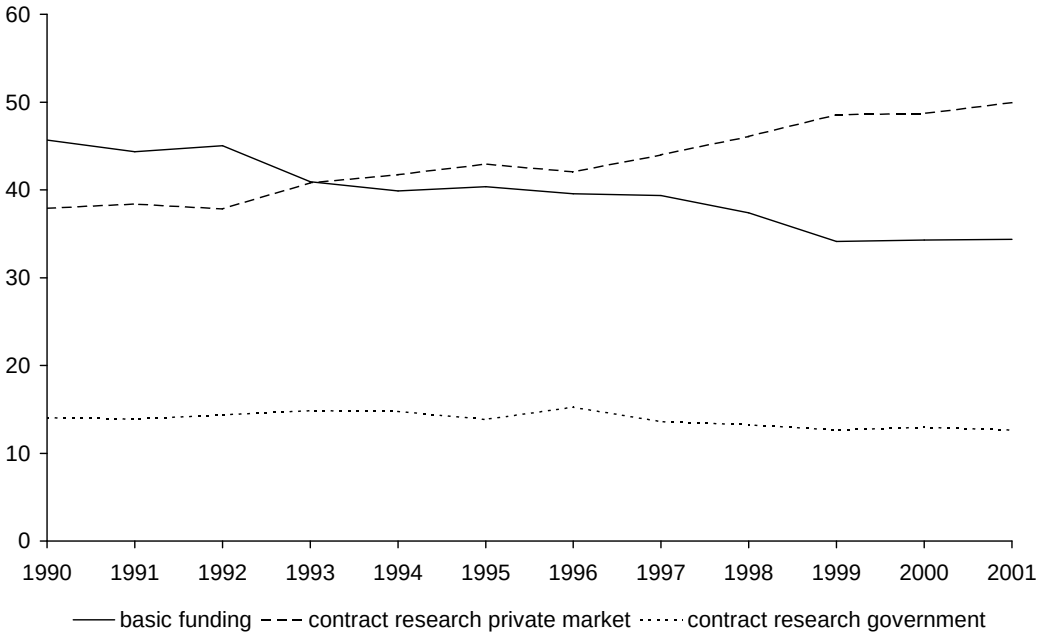
Financing of research

In 2001, the total turnover of TNO equalled about 467 million euro (excluding ventures). This turnover stems from three main sources. First, direct government funding for investments in strategic research amounts to 35 percent of total turnover. About 15%-point is available for basic research, and about 20%-point is devoted to research programmes framed to support the policy priorities of several Ministries. Secondly, contract research in the domestic public sector makes up 13 percent of turnover. Thirdly, contract research in the private sector accounts for another 50 percent. The remainder of the turnover stems from international public sector contracts, such as EU framework programs.

[2] Chapter 6 of Koning et al (2004) provides a closer look at TNO.

Each of the three main sources of funds has grown over time in absolute terms. However, basic government funding has decreased in relative terms, whereas turnover from private contracts has increased. Turnover from public sector contracts has been stable at around 15 percent (see graph).

Figure 3.1 Composition of turnover of TNO



Incentives

From the three main sources of turnover, the softest incentives come along with the government funding. The exact amount of funding is not associated with any explicit quantitative target. A lot of discretion in determining the level of funding is left to the government. In practice, the board of TNO formulates a multi-year strategic plan and the Ministry of OCW decides upon the level of government funding for that plan. Reputation is the strongest incentive in this respect. Stronger, but still implicit incentives come along with the programme funding, since here relatively well-informed Ministries debate the research agenda with TNO. Some Ministries exert stronger incentives than other. An exception to the rule of implicit incentives is the co-financing program by the Ministry of Economic Affairs. This part of the funding requires that firms contribute on average 40 percent of the research costs. Missing this target has consequences for the co-financing budget in subsequent years. These strong and explicit incentives concern the 15 percent that the co-financing program takes out of total government funding.

More powerful incentives come from contract research clients, including the government in its role of customer. Evidently, TNO has incentives to fulfil the needs of its research clients

otherwise demand will contract. However, since TNO – being rather unique in the field - lacks strong competition from other research organisations, these incentives are not overly strong. Accounting rules ensure that no monopoly profits are made, but inefficiencies may creep in because higher costs can relatively easily be passed on through higher prices.[3]

Within the TNO organisation, the board of management provides strong incentives to the TNO institutes to perform well in terms of market turnover and in terms of strategic research proposals. First, the larger the institute's share in total market turnover of TNO, the larger its share in TNO's basic funding. Second, the more promising a research proposal, the more likely the board will award the proposal with a share in TNO's basic funding. No explicit incentives come along with the findings of the external committees that assess TNO's knowledge stocks on behalf of the board; the strength of the implicit incentives because of these assessments is unclear.

3.2 DLO

Structure and organisation

The Netherlands foundation for agricultural research DLO is another large technology transfer institute in the Netherlands. Its mission statement reads: *DLO performs strategic and applied research and transfers and valorises knowledge in the fields of agriculture, food, and the environment*. In 2001, DLO employed 3733 workers[4] and its turnover was 349 million euro. In 1995, it accounted for about 2.6 percent of total R&D spending in the Netherlands (NOWT, 1998).

DLO is the contract research part of Wageningen University and Research Centre. A single board of management heads DLO and Wageningen University and organisational ties also exist at other levels of the organisations. Still, DLO is an independent organisation in terms of the law. DLO is organised into eight research institutes.[5]

The Minister of Agriculture, Nature, and Food Quality (LNV) appoints the board of supervisors. The board of supervisors appoints the board of management.

DLO is not for profit. Hourly rates of researchers are set by the Ministry and differ for contract research commissioned by the Ministry of LNV and other clients. Still, prices are subject to bargaining and may be raised if the client is willing to pay more. Any temporary return is re-invested.

[3] Economist call such inefficiencies 'x-inefficiencies'.
[4] Full time equivalents.
[5] DLO also holds some units that exclusively perform tasks laid down by law.

Financing of research

Turnover in 2001 comes from four sources: direct government funding, contract research for public and private parties, and other. First, direct government funding accounts for 44 percent of total turnover. About 5%-point is meant for strategic expertise development.[6] About 23%-point supports research programmes commissioned by the Ministry of LNV. These programs are increasingly tailored towards the policy priorities of this Ministry and therefore do not necessarily reflect the enabling research needs of contract research clients. 10%-point is devoted to specific tasks laid down on DLO by law.[7] The remaining 6%-point finances occasional research programmes by order of the Ministry of LNV. Secondly, contract research for the public sector makes up about 13 percent of turnover. This includes about 4%-point of turnover from the EU Framework Programme. Thirdly, contract research in the private sector accounts for about 23 percent. The remaining 20% of the turnover stems from turnover from intellectual property rights, consulting, product sales, and other sources.[8] SEO-funds, net income from intellectual property rights[9] and revenues from an R&D-charge included in contract research prices are available for investments in strategic expertise and facilities.

Starting from 2004, the SEO funding will be abolished and the program research funding will be reduced in order to create a 'knowledge base fund' of about 10% of DLO's total turnover.

Incentives

Similar to TNO, from all sources of funding, the weakest incentives come along with the government funding. There is no explicit relationship between government funding and the results of execution of the strategic plan. The research programmes commissioned by the Ministry are relatively open and do not come along with quantitative performance indicators. However, the Ministry is likely to be relatively well-informed about the costs and benefits of the research programs, since the content of its policy making includes DLO's research themes. Moreover, about 5% of the research program funds are acquired in a competitive tender organised by the Ministry.[10]

Relatively strong incentives are associated with the contract research commissioned by public and private parties. Customers are relatively well-informed about which price quality ratio is appropriate, and may switch to alternative suppliers of research in some fields of knowledge, such as universities, TNO, private consultancies, foreign research institutes, and in-house researchers.

[6] In Dutch: strategische expertise ontwikkeling (SEO).

[7] In Dutch: wettelijke en ondersteunende taken (WOT).

[8] In 2001 this category was relatively large compared to other years because of an outbreak of mad cow disease (BSE).

[9] Net income from intellectual property right is close to zero, since IPR managing costs more or less match benefits.

[10] In 2002, DLO won the lion's share in a tender of 4.5 mln euro research funds. This equals about 5% of the research program funds of DLO. DLO did not win in the 2003 tender that was reduced to 0.5 mln euro.

Within the DLO organisation, institutes compete for about 20% of the SEO funds that is not distributed according to the institute's share in the LNV research programs, and business units compete for the share of the R&D surcharge funds that is not distributed in proportion to turnover. An internal knowledge base fund, to be created from 2004 onwards, will be fully allocated through a tender procedure. These internal competitions for strategic funding will give incentives to provide scientifically sound research proposals with a good prospect of utilisation. The task of the board of management is to select the research proposals that fit DLO's strategy best. The management's decision needs final approval of the Ministry.

The board of management commissions audit committees to evaluate the DLO institutes with respect to self-formulated 'terms of reference'. The first criterion is quality of research: scientific quality of publications and staff, viability of research (such as relevance to society of the research done, and the composition of the research portfolio), and research management quality. The second criterion is the organisation of research, including scientific interaction, human resource management, marketing and the management of intellectual property. The final criterion is the audit procedure itself: the quality of information the auditors receive from the institute. Auditors judge in terms of 'excellent', 'amply sufficient', 'needs attention' and 'needs immediate attention'. An audit report does not have explicit or ex-ante announced consequences for funding. Still, it is subject for debate between the board of management and the management of the institute. Copies of audit reports are sent to the Ministry of LNV.

3.3 Fraunhofer Society

Structure and organisation

The Fraunhofer Gesellschaft (FhG) is the principal technology transfer institute in Germany. Fraunhofer's mission is comparable to the ones of TNO and DLO: *Fraunhofer promotes and undertakes applied research in an international context, of direct utility to private and public enterprise and of wide benefit to society as a whole.* Currently, Fraunhofer employs about 11,000 people and it has a turnover of about 850 million euros, excluding 140 million euros government grants for building construction and long-term equipment expenditures and for defence research. Fraunhofer established several research units in the US, and some liaison offices in Asia and Europe. Foreign turnover amounts to about 55 million euro (excluding European Commission). Fraunhofer makes up about 1 percent of total R&D spending in Germany (Abramson et al, 1997).

The society is organised into independent research and defence institutes. Long-term decision making is in the hands of a senate, with representatives from science, industry, and government, among others. The executive board is responsible for short-term management.

Fraunhofer is not for profit. The institutes are organised as profit centres, but profits are re-invested in the organisation (Abramson et al., 1997).

Financing of research

Fraunhofer's main sources of turnover are direct government funding for the enhancement of scientific competence, private contract research, and contract research for the public sector including the European Commission. Currently, each of these components is of about equal size (see graph, funding for building construction and defence research not included). The bump in direct government funding versus public research contract turnover in the early 1990s is to be associated with the German reunification process (Abramson et al., 1997 p. 322).

Figure 3.2 Composition of turnover of Fraunhofer

Note: Excluding government funding for building construction and investment in equipment of and defence research funding, totalling about 15% of turnover.

Incentives

The Fraunhofer Society gets strong incentives from contract research customers, alike the Dutch organisations, since these clients are relatively well-informed about their demand and about the costs that are likely to be associated with an assignment. No explicit incentives are attached to government funding. Exemplarily, the yearly 'Agenda 2010' 3%-increase in funding is unconditional.[11] About two third of the direct government funding is allocated across institutes according to success in contract research acquisition, in particular from private clients.

[11] See, e.g., the speech of the Minister of Education and Research of September 11, 2003, in the Bundestag.

This strong incentive is passed on downward in the institute's organisation to the project manager level. The board of management of Fraunhofer assigns the remaining third of the government funding to strategic projects (Abramson et al. 1997, p.242; Evaluierungskommission, 1998; Schmoch et al, 2000).

In 1998, the government commissioned an evaluation of Fraunhofer along the lines of five terms of reference. None of these terms were quantitative and it is not clear whether any consequences had been specified in advance or what the actual consequences have been (Evaluierungskommission, 1998). However, recently, a bottom-up strategic plan process has been started. The board of management asked each institute to complement its strategic plan with performance indicators, and to organise regular and independent audits to measure these indicators (Schmoch et al, 2000). We are not aware of an initiative to assign rewards to institutes dependent on the outcomes of these audits.

3.4 VTT

Structure and organisation

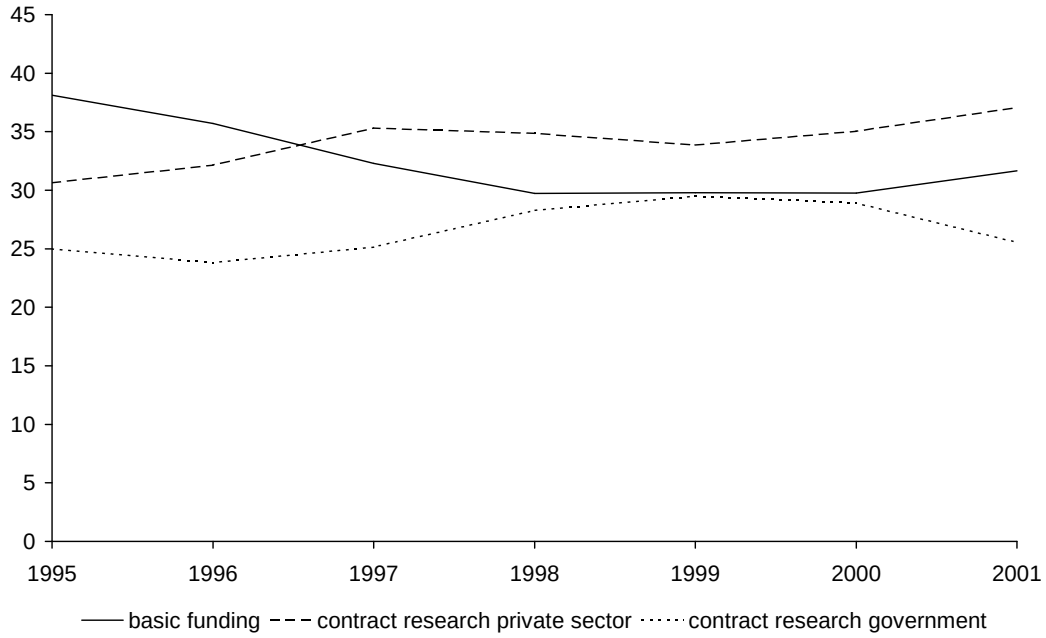
The VTT is a Finnish technology transfer institute with about 3,000 employees (2750 fte) and an annual turnover of over 200 million euros. Its mission statement reads: *Through creating and applying technology we actively enhance the competitiveness of industry and other business sectors, and thus increase the welfare of society.*

The organisation consists of six independent research units. Several strategic technology themes operate on the level of the entire organisation. A board of representatives from ministries, industry, and VTT itself has a steering and guiding role, and decides upon the allocation of government funding. Executive decisions are made by the director general and the executive directors of the research units.

Financing of research

VTT depends for about 32 percent on direct government funding, down from 38% in 1995. This decline has to be attributed to a volume increase in contract research turnover. The relative contribution of private sector turnover grew from 31% of total turnover in 1995 to 37% in 2001, and also the share of foreign clients, including the European Commission, steadily expanded. The proportion of the public sector in turnover remained stable at around one quarter (see graph).

Figure 3.3 Composition of turnover of VTT



Incentives

The level of direct government funding is a discretionary policy instrument of the Ministry of trade and industry. No indicators or targets are set in advance; hence no explicit incentives come along with this funding.

Similar to the organisations discussed above, stronger incentives come from the demand side of the private and public contract research market. Although in some cases VTT may adversely exert its monopoly power as a unique organisation in the Finnish research market, well-informed clients with access to alternative suppliers of knowledge impose checks and balances. Internal incentives associated with the distribution of government funding over institutes and projects are relatively soft. The major share of this funding is allocated on the basis of needs rather than performance. To be precise, board and management decide according to the research intensity of the institutes' technology strategies. Still, the other part of government funding is allocated according to the number of researchers in a particular institute and therefore offers a reward for success in the contract research market. Moreover, merit payment is part of the reward system (Niskanen and Neuvonen, 2001).

In 1993, the Ministry of Trade and Industry requested an evaluation of VTT. This evaluation was 'not initiated with any particular aim in mind, but rather as a response to a vague dissatisfaction' (Luukkonen, 1998). The evaluators concluded that the structure of VTT at the time led to high overhead costs and inflexibility, and synergies between the research laboratories were left unexploited. The evaluation resulted in a profound reorganisation: 34

laboratories were reorganised into nine new research institutes. The Ministry commissions a new evaluation this year (2004).

VTT research institutes organise regular audits themselves (see e.g. Bender et al, 1997).

3.5 A comparison

A comparison of these four technology transfer institutes reveals major similarities:[12]

- All institutes undertake applied research with the aim to contribute to the benefit of society, including the competitiveness of firms and industries.
- All receive substantial government funding that is earmarked in the sense that no explicit competition is held.
- For none of the institutes the amount of this government funding is conditional upon pre-specified, measurable and verifiable performance (output) indicators.
- Part of the government funding supports research programmes for which the government is a relatively well-informed principal.
- From time to time, all institutes are subject to some form of ad-hoc government-commissioned evaluation. Evaluation criteria are not specified in advance. The evaluation may or may not lead to recommendations with or without implications for government funding.
- All boards of management hire external committees to evaluate the research units of the institute, but again implications are unclear.
- A major share of turnover of all institutes comes from contract research for (semi-)public and private clients. These clients have at least some bargaining power vis-à-vis the institutes, because they are relatively well-informed about the attainable price quality ratio and because they have some opportunities to move to alternative suppliers of knowledge (e.g. other (foreign) technology transfer institutes, universities, and private consulting engineers).
- The boards of management all reward units for success in doing contract research and for success in research grants competitions (e.g. the European Framework Programme) through the allocation of government funding (relatively successful units receive a larger share) and reward pay.
- All institutes enter in national and European research grant competitions. These tender competitions, if won, typically require matching from own resources. The incentives associated with these competitions therefore extend to the government funding required to match the research grants that the institutes win.
- All institutes are ultimately not for profit. But profits occur when institutes bargain prices from costs upward to willingness to pay. Institutes re-invest these rents.

[12] Sample selection clearly is an important explanation: we choose to cover these four technology transfer institutes because they are generally seen as counterparts.

Still, the four institutes differ. First, there are notable but qualified differences in sources of turnover: see table 3.1. TNO obtains a relatively large share of turnover from contract research in the private sector. The relatively large share of direct government funding for DLO incorporates a relatively large share of research programmes for which the Ministry is a relatively well-informed principal. Fraunhofer's share of basic funding resembles those of TNO and VTT, but it excludes Fraunhofer's additional government funding for buildings and equipment and for defence research. The category 'other turnover' is relatively large for DLO, and turnover from private sector contract research is relatively small. However, both numbers may be flawed because the other institutes categorise turnover from consulting differently. The institutes perform 'task required by law' to a different extent. Funding for these tasks is usually included in the direct government funding.

Table 3.1 Turnover in 2001, by source of funding, percentage of total turnover

	TNO	DLO	Fraunhofer[a]	VTT
Total turnover (million euro)	467	349	853	214
Direct government funding	34	44	36	32
Includes: basic funding	15	5		
programme funding	12	29		
specific tasks demanded by law	7	10		
Contract research public sector	13	9	31	27
European Commission and Framework Programme	3	4	4	4
Contract research private sector	49	23	33	37
Other sources		20		
Total	100	100	100	100

[a] Excluding government funding for building construction and investment in equipment (12% of turnover) and defence research funding (4% of turnover).
Sources: Annual Reports.

Second, the institutes differ in the incentives the boards of management associates with the distribution of government funding over the research units. TNO and Fraunhofer decentralise a major share of this funding proportional to the unit's turnover from contract research; VTT distributes the funding mainly according to the needs expressed by the units strategies; DLO primarily follows the demands of the Ministry of LNV as laid down in the commissioned research programmes. Put differently, within TNO and Fraunhofer, research units have strong and explicit incentives to acquire as much contract research as possible and to turn government funding into knowledge that will attract most contract research. VTT's research units face incentives to demonstrate investment needs which may or may not align with current contract research turnover. DLO's units have incentives to meet the Ministry's demand for knowledge best.

Third, the institutes differ in price setting policy.[13] Whereas TNO and VTT start bargaining at a price equal to the total costs of the research contract, excluding the costs of building up the knowledge stock, DLO starts for private contract research clients with a surcharge of 15 to 30 percent to recover part of the costs of the knowledge stock involved in the assignment.

In conclusion, a bird's eye view reveals that the four technology transfer institutes have much in common. A closer inspection shows, however, differences in incentives, in sources of funds, and in pricing strategies. These comparison results should be applied only with caution, at least because data do not always compare very well.

[13] Unfortunately, we do not have information about the price-setting behaviour of Fraunhofer.

4 Effectivity of technology transfer institutes

4.1 A first impression?

We are not aware of studies that measure the precise impact of technology transfer institutes on welfare. This would be a difficult task. First, it is not a priori clear what would be the relevant measure of output (as reflected in the lack of measurable goals set for these institutes). Second, the process of innovation is complex, so that the contribution of each component, including the technology transfer institute, is hard to single out.

We may point at innovation survey results to sketch a picture of effectivity. The share of innovative firms in manufacturing that considered the government and private non-profit research institutes such as technology transfer institutes as a very important source of innovation, is smaller in the Netherlands, equal in Germany, and larger in Finland than EU average (Eurostat, 2001). This may signal underperformance of Dutch technology transfer institutes, since these are large compared to their international counterparts (CPB, 2002). Furthermore, one out of four innovating firms in the Netherlands consulted a public or private non-profit research institute, but only a tenth of these firms considered this source very important (CBS, 2001). A study for Finland reports that VTT is important for almost 20 percent of the innovations identified in the study (Niskanen and Neuvonen, 2001).

These numbers are illustrative at best. International innovation surveys are no exception to the rule that cross country statistics are hampered by problems of comparability (Cornet and Gelauff, 2002). Moreover, questionnaire data are often subject to self-reporting biases. Even if we have high quality data on output, measurement of the contribution of technology transfer institutes to output would be difficult since information about the counterfactual (what would have happened without the institute?) is lacking.[14]

We conclude that this type of statistics does not help much in judging the effectivity of technology transfer institutes. We therefore turn to an indirect way of studying effectivity by having a critical look at the incentive structures of these institutes.

[14] Cornet and Webbink (2004) discuss how policy experiments can help to deliver unbiased information about the effectivity of policy.

4.2 The effectivity of the incentive structure of technology transfer institutes

Market failure motivates public policy

Section 2 showed that market failures in technology transfer motivate public policy, including government funding for technology transfer institutes. Hence, there exists a potential for improvement upon the market outcome through public policy.

Additional incentives to technology transfer thus may yield additional welfare. Are the incentives that technology transfer institutes face effective in attaining this welfare gain? We successively discuss the incentives attached to direct government funding and to contract research turnover, the internal incentive structure designed by the board of management, and other sources of incentives.

Government funding, incentives, and information asymmetry

Section 3 showed that direct government funding of technology transfer institutes is not conditional upon pre-specified, measurable and verifiable performance indicators. In particular, governments do not prescribe explicit and measurable criteria that reveal which technologies must be transferred in what way to whom and which technology transfer does not need public support because commercial incentives are strong enough. For the programme funding part of government funding, this lack of explicit incentives is compensated to some extent by soft and implicit pressures-to-perform from relatively well-informed Ministries. For example, DLO's relatively large programme funding is subject to interference of a relatively well-informed Ministry of LNV, and a relatively well-informed Ministry of Defence governs TNO's defence research programme.

Such a lack of explicit performance indicators is consistent with a view of the government being less informed about what technology transfer serves society best than the technology transfer institutes themselves, exceptions proving the rule. A principal who is aware of her ignorance settles for soft incentives, since strong incentives will focus the organisation on what is measurable rather than on what is beneficial (Prendergast, 1999; Koning et al, 2004). It is also consistent with the observation that the government should soften incentives if the organisation is risk averse, all other things equal (Baker et al, 1994). The downside of soft incentives is, clearly, a serious risk of ineffectivity and inefficiency; a risk somewhat limited through the reputation mechanism and ad hoc evaluation committees that may reveal persistent underperformance.

Does this view hold true? We will argue in section 4.3 that the answer to this question may very well be 'no'. Even though government is ignorant about how to tackle the knowledge gap, performance indicators do exist that reduce the burden of the information asymmetry

substantially. This opens the way to explicit and strong incentives attached to these indicators. Technology transfer institutes will then employ their information advantage on technology transfer to produce a very good output as measured by the performance indicators (Raith, 2004).

Contract research, incentives, and competition

Contract research clients, private and public alike, are relatively well informed about the services they want to purchase from technology transfer institutes at what price quality ratio. Sources of information include: own knowledge about the technology, evaluation of performance in previous research contracts, research offers from competing institutes (public and private, domestic and foreign). This information builds bargaining power and helps clients to exert strong incentives for the technology transfer institutes to cater for their needs effectively and efficiently.

Private contract research clients are likely to exert stronger incentives than public customers. Commercial firms ultimately face competition on their product markets and on the capital markets. Firms pass on these incentives to their suppliers, including the suppliers of knowledge. Civil servants authorised to conclude research contracts do not feel strong incentives from customers of the public interest. Indeed, by definition the government steps in because purchasing power for a public good is absent. Nor do tax payers who carry the burden of the public contract research budget exert strong incentives for critical procurement to government representatives.

Two reasons may prevent a technology transfer institute from being effective towards public and private contract research clients. The first reason is the lack of competition for an institute selling a unique product. A monopoly may be a licence for ‘a quite and easy life’, i.e. for delivering low quality at high prices. In particular, technology transfer institutes can exercise market power by setting prices above the marginal costs of a research contract. Clients willing to pay more than the costs, but less than such set prices, are not being served, although serving them is welfare enhancing. Economists call this ineffectivity a ‘dead-weight loss’.

Does this first argument matter in practice? Technology transfer institutes generally are a unique source of innovative power, and they are meant to be so. At the same time, they do face some competition from other (foreign) technology transfer institutes, from contract researchers from universities, from private technology transfer institutes, and from clients’ intramural research groups. Overall, however, competitive threats seem to be limited.[15]

[15] Observe that, if serious competitors are present, public funds for technology transfer activities are likely to be allocated more effectively and efficiently through some form of tender competition.

The second reason is the opportunity to use government funding to crowd out private technology transfer activity, i.e. to stifle competition of effective and efficient but privately funded technology transfer firms. Technology transfer institutes may take expensive[16] government funding to build knowledge bases that private firms build or would have build themselves, and may use this cost advantage to compete them away in the market. Economists call this ineffectivity 'crowding out' or 'a lack of additionality'.

Does this second argument matter in practice? First, the number of anti-competitive complaints filed against TNO appears to be small.[17] Second, technology transfer institutes have policies not to price below some cost account.[18,19] Such pricing policies reduce the opportunities to unfair competition. Finally, audit committees typically assess crowding out though measurement of knowledge base characteristics that should be different for private technology transfer firms. Technological maturity is an example of such a characteristic. Measurability of crowding out opens the way for incentives against crowding out (see the discussion of policy options in section 5). To our knowledge, governments do not expose technology transfer institutes to such incentives, at least not explicitly, and neither do the boards of management vis-à-vis the business units. In conclusion, this evidence does not point at substantial crowding out, but we judge the amount and quality of the evidence as weak. In any case, the opportunity to exert explicit incentives against crowding out is currently left unused.

In sum, contract research clients are relatively well-informed purchasers of knowledge services. Private contract research client impose strong incentives to technology transfer institutes to deliver value for money, i.e. to be effective and efficient. The incentives provided by public contract research clients are likely to be weaker those provided by private clients; their strength depends upon the quality of the incentives within the public client's organisation. Technology transfer institutes are unique recipients of government funding for technology transfer and often unique suppliers of knowledge. This uniqueness brings a risk of ineffectivity and inefficiency: the institute may become a slack monopolist. Furthermore, publicly funded technology transfer institutes may crowd out privately funded technology transfer activity. An opportunity to exert explicit incentives against crowding out is currently left unused (see section 5).

[16] The government is raised through taxation that distorts investment and allocation decisions. Available evidence suggests that the marginal welfare costs of raising a public fund is about 115-150% of the size of the fund (Lattimore, 1997)

[17] A lack of complaints suggests, but does not prove, fair competition, since firms that would have entered the market may have been deterred, and such firms do not complain by definition.

[18] Pricing policy at TNO is not price below total costs net of the cost of building and maintaining the knowledge base. DLO Is required by law to charge at least this cost level plus a mark-up to cover some of the costs of the knowledge stock.

[19] See footnote 20 for a discussion of the pros and cons of (dis)incentives to set prices above marginal costs.

The board of management, incentives, and asymmetric information

The boards of management of technology transfer institutes attach strong incentives to the allocation of government funding over the research units (section 3). This is consistent with the view that these boards are able to define good performance measures, i.e. that they can successfully tackle the information asymmetries vis-à-vis the research units. The boards reward research units for performance relative to other research units (see section 3.5).

Are these incentives right? That is not clear. They are not completely wrong, in the sense that they do not reward performance that is obviously in contrast with the mission of a technology transfer institute. But they may also not be completely right. In particular, none of the boards exposes the research units to explicit and strong incentives to focus the knowledge base on what would not have been provided for by private technology transfer firms. For example, the external committees that evaluate the research units on behalf of the board, do measure this additionality to some extent. However, their findings do not seem to have direct and explicit consequences for basic funding.

One may hold the opinion that the board of management designs an incentive scheme that is by definition optimal vis-à-vis the mission. By definition, since the boards is hired to perform this task. This opinion, however, neglects that also a board of management performs according to the incentives it faces. The boards of management do not face the strong incentives from the contract research market, since these incentives are felt at the research unit level. Neither do they face strong explicit incentives from the government (see above). Boards are subject to ad-hoc evaluations, but these do not exert strong incentives since the evaluation criteria are not specified in advance. Major decisions of the board are subject to approval of the supervising board; still, the supervisors do not inflict explicit incentives upon the management. But the boards do face implicit incentives: reputation and post-career concerns may help to induce governance of technology transfer institutes for the public benefit.

In sum. On the one hand one may hold the view that the boards of management of the technology transfer institutes effectively divert public funds for technology transfer to the public good, for two reasons. First, the boards are in the best position to attach incentives to public funding, since they have the best information about what benefits the public interest. Second, the boards do attach incentives to the funding of the research units, and these incentives are not adverse to effectivity, to put it in the negative. On the other hand, one may argue that the absence of explicit incentives for the boards themselves does not contribute to effectivity.

More sources of incentives: intrinsic motivation and (post) career concerns

The above discussion already revealed the reputation mechanism as an alternative way to explicit incentives. But there are more alternative sources of incentives that may motivate

technology transfer institutes to perform well. First, technology transfer researchers and managers may simply love to promote the public interest and work effectively and efficiently also without explicit incentives. Psychologists label this ‘intrinsic motivation’ (Deci and Ryan, 1985; Frey, 1997). Researchers may be intrinsically motivated to deliver technology transfer at a scientific level, and this may be the kind of technology transfer private organisation do not provide for. Managers may be intrinsically motivated to differentiate the product portfolio from what private technology transfer firms offer. Professional codes of conduct may enhance intrinsic motivation. Second, researchers and managers may foster effectivity and efficiency out of (post) career concerns. That is, future rewards for demonstrated good performance give incentives to act effectively and efficiently today.

Although intrinsic motivation and (post) career concerns may support effectivity and efficiency, we are unaware of evidence of such contribution, let alone evidence that these sources of incentives compensate for the lack of explicit incentives attached to government funding.

Conclusion

Research clients are well-informed customers that exert relatively strong incentives to deliver value for private money. This does not imply that society gets value for government funding, since technology transfer institutes may direct public funding to crowd out privately funded technology transfer activities. Governments do not attach explicit incentives to their funding. This absence indicates a serious risk of ineffectivity and inefficiency of technology transfer institutes.

Several mechanisms mitigate these risks, however evidence about the extent of reduction is lacking. First, the boards of management of the technology transfer institutes exert some explicit incentives for effectivity (e.g. technology assessments, research grant competitions). Still, the boards themselves are not subject to explicit incentives to design an effective incentive mechanism for the research units. Second, reputation is a long-run signal of effectivity and efficiency, and a severe decline in reputation is unlikely to remain unnoticed and forgiven by the government. In particular, some Ministries may be relatively well-informed about the results an institute can attain from a research programme, and thus may exert implicit incentives to serve the public interest well. Third, intrinsic motivation and (post) career concerns may motivate researchers and managers of technology transfer organisation to act in the public interest.

A direct way to tackle this issue is to measure effectivity and to make government funding dependent on this measure. This is the subject of the following two sections.

4.3 Measuring effectivity: is the information asymmetry really so large?

If the government can not measure effectivity and efficiency well, then it makes perfect sense not to impose strong and explicit incentives on technology transfer organisations (see sections 3.5 and 4.2). Indeed, the government is likely to have less information about, e.g., the best composition of the technology portfolio and the best internal incentive structure than the board of management does. However, we observe that the technology transfer institutes have succeeded in generating measures of effectivity themselves. Some of these measures are relevant for internal assessments only (e.g. absence because of illness), but others also seem to be good measures of the contribution of the organisation to the public benefit.

One aspect of effectivity

One such a measure is the maturity of technologies. Product life cycle theory argues that a product or technology typically goes through several stages (see e.g. Auster, 1992). In its early stages, uncertainty is high, for example because it is not known whether the technology will ever be mastered or ever find an application. Firms are eager to free ride on other firms' inventions. Hence, private firms are likely to be most unwilling to invest in this stage of product development. In further stages, the technology matures. Technological uncertainty and demand uncertainty decreases to a minimum, and the rents to further development are relatively easily appropriated. Now, market incentives for innovation are likely to be relatively close to what is socially optimal.

The role of technology transfer institutes is arguably confined to the early stages, the earliest stages excluded. Matured technologies are likely to be taken up by the private market. Technology transfer institutes do not create social value added by having such technology in the portfolio. Embryonic technologies are primarily the task of universities: technology transfer institutes have a comparative disadvantage here.

Current practice suggests that the social value added of a technology portfolio is in a sense measurable, e.g. through technological maturity. The technology assessment commissioned by the board of management of TNO shows that maturity of technology portfolios can be measured on an ordinal scale, say 1 (highly embryonic) to 10 (obsolete). The U.S. Advanced Technology Program (ATP) uses life cycle theory for project selection (Powell and Moris, 2002).

External independent expert committees initiated by the government could achieve what assessment committees achieve on behalf of the board of management now. This yields a measure of one dimension of effectivity: the additionality of technology portfolios relative to what the market can attain itself.

Another aspect of effectivity

Another measure is contract research turnover. Pick a technology portfolio that would not have been established and maintained by private firms or by universities. Then welfare is increasing in the amount of contract research that builds on this portfolio and that is sold at marginal costs or more. The technology portfolio is a public good: the more it is utilised, the larger welfare, hence the more effective the organisation. Contract research turnover is easily measurable.

In conclusion, we have put forward two indicators that relate to the effectivity of technology transfer organisations:

- An independent expert opinion about the additionality of the technology portfolios relative to the market and to universities;
- Contract research turnover from firms and (semi-)public organisations that builds on these technology portfolios (a measure of utilisation).

These two measures suggest policy options to enhance the effectivity of technology transfer organisation through incentives attached to the government funding.

4.4 Three policy options

What policy will increase the effectivity and efficiency of technology transfer institutes? The previous section argued that a relatively good measure of performance does exist. This measure is not used in the current incentive structure. Hence, policy that makes government funding contingent upon this measure, strengthens the incentives for effectivity and efficiency. Success of such policy depends on the quality of the performance measure. Strong, explicit incentives attached to a poor performance measure are unproductive. Then effectivity and efficiency depends on the power of alternative sources of incentives such as the reputation mechanism and intrinsic motivation.

The first two policy options consider explicit incentives: government funding depends on some performance measure. The third policy option is continuing business as usual.

Policy option 1: Making government funding contingent on constrained contract research turnover

This policy option proposes to offer a technology transfer institute more government funding if the institute attains a higher level of what we call ‘constrained contract research turnover’ from firms and (semi-)public organisations. It considers constrained contract research turnover to be a good measure of the effectivity of technology transfer institutes. The constraint refers to the following condition: contract research turnover that builds on a technology portfolio that is

maintained, or would have been maintained by private technology transfer firms, is not eligible for a performance fee. Hence: no incentive to increase turnover by infringing on private technology transfer activities. And: an incentive to spin off activities that have become mature enough to be left to the market. The policy option reasons that contract research turnover constrained in this way is a good measure of the contribution of a technology transfer institute to the innovative power of society beyond what is or what would have been provided for by the market.

Measuring contract research turnover is relatively straightforward.[20,21] Measuring the constraint is not straightforward. This policy option proposes to let the government commission an independent expert committee. Its task is twofold: to evaluate the technology portfolios of a technology transfer institute against the constraint; and to evaluate which contract research turnover builds on these technology portfolios. Note that this option thus builds on current internal measurement practices of technology transfer institutes. The expert committee will inevitably be faced with some grey areas. However, since the objective is to measure an indicator of the institute's overall performance, the experts' opinion has to be right on average rather than for each and every part of the institute.

The policy option asks the government to pre-specify the consequences of the findings of the expert committee and the level of contract research turnover. Many details are feasible. Let us give one example, just for illustration. The expert committee evaluates the maturity of technology portfolios on a scale 1 (highly embryonic) to 10 (obsolete) and assesses the amount of contract research turnover that builds on each technology portfolio. Constrained contract research turnover is computed by summing all turnover that builds on technology portfolios with maturity 1 to 4 with weight 1, all turnover that builds on technology portfolios with maturity 5 and 6 with weight ½, and all turnover that builds on technology portfolios with maturity 7 to 10 with weight 0. Next period government funding is set equal to an amount that is independent of performance plus 0.3 times the constrained contract research turnover.

[20] Still, two alternatives come to one's mind. Measuring turnover against realised prices gives incentive to focus on contract research for which clients are willing to pay most and this is, presumably, contract research with the largest social value added. Moreover, it gives incentives to price discrimination; this is socially beneficial, since it allows for a reduction of government funding and hence for a reduction of the distortion of taxation needed to collect these funds. But it also gives incentives to exploit the uniqueness of the technology portfolio through monopolistic behaviour, reducing utilisation below the social optimum. The second alternative is to measure turnover against costs (excluding the costs of the technology portfolio). The pros and cons are the reverse of the first alternative.
This trade-off is material to policy option 1, since this option proposes explicit incentives to turnover, and turnover is volume times price. But the trade-off is also relevant to policy options 2 and 3.

[21] It seems reasonable to exclude contract research turnover commissioned by clients operating from abroad. Indeed, in this policy field it is not the aim of the Dutch government to increase welfare of foreigners. Contracts from foreign direct investment (FDI) in the Netherlands, e.g. Dow Chemical Benelux, would qualify, since it seems reasonable to assume that knowledge intensive FDI substantially contribute to Dutch welfare.

Policy option 2: Making government funding contingent on the quality of the technology portfolio

This policy option proposes to offer a technology transfer institute more government funding if the institute increases the quality of its technology portfolios. It considers this quality to be a good measure of the effectivity of technology transfer institutes. Quality is to be measured by an independent expert committee commissioned by the government. Current technology assessments held by technology transfer institutes themselves suggest that quality is measurable. The measure could have many dimensions (scientific quality, marketability, technological maturity, and so on), and it could be measured on an ordinal scale ranging from A (very high) to F (very low). The policy option asks the government to pre-specify the consequences of the quality measurement of the expert committee for government funding.

Note that this policy option is a generalisation of policy option 1. Indeed, if the government defines 'quality' as 'constrained contract research turnover', then we are back in policy option 1. The major difference between these policy options is that policy option 1 attaches incentives to an output measure of technology transfer institutes, while policy option 2 focuses on rewards for intermediate output.

Policy option 3: Continuing the current situation

This policy option preserves the current incentive scheme, i.e. the absence of explicit incentives for the use of government funding. This option fits the idea that measures of effectivity and efficiency of technology transfer institutes are highly imperfect, so that explicit incentives are dysfunctional. The government then has to settle for implicit incentives, and it has to rely on the reputation mechanism and on intrinsic motivation, including the reputation and intrinsic motivation of the board of management, and on the performance of the internal incentive schemes they design.

4.5 A comparison of the three policy options

Each policy option has advantages and disadvantages. We identify four sets of pros and cons.

The first and critical set relates to the measurability of effectivity and efficiency of the use of government funding for technology transfer. Explicit incentives directed at a highly imperfect measure of performance are dysfunctional, since the institute will focus on what is measured rather than what is social beneficial. Implicit and soft incentives to government funding, on the other hand, do not guarantee a motivation to deliver the best social value for tax payers' money. For example, on the one hand, incentives based on an output measure are to be preferred to incentives based on a measure of throughput, since outsiders typically have an informational disadvantage relative to the management of the institute how to achieve goals best. On the

other, if the output measure is highly imperfect and the throughput measure is not too bad, then the balance shifts towards the latter. Policy options 1 and 2 presuppose that an expert committee can measure constrained contract research turnover respectively the quality of the technology portfolio at acceptable measurement costs. Current internal measurement practices of technology transfer institutes seem to confirm such measurability.
Any measure of effectivity and efficiency that includes contract research turnover (as in policy option 1 and possibly also policy option 2) presumes a high quality of contract research demand. If the quality of demand is low, then strong incentives to contract research turnover put a premium on low quality work. This is clearly against the public benefit. In section 4.2 we argued that the quality of public contract research demand may well be lower than the quality of private demand, since bureaucracies may be less demanding customers. This observation does not run counter policy option 1 and 2, however. Indeed, a natural way to address this issue is either to improve the incentives within public organisations, or to exclude public contract research turnover from the performance indicator.

Furthermore, any measure of effectivity and efficiency that relies on expert opinion (as in policy option 1 and 2) presumes that the expert committee is independent from improper influences, both from the government and from the technology transfer institute. Foreign members can improve the independence of an expert committee, possibly at the expense of the committee's knowledge of the specific context.

A second set of pros and cons relates to the risk that performance rewards give incentives to 'go for the easy work'. Consider policy option 1. The objection argues that with explicit incentives the institutes will transfer those technologies with the largest ratio of constraint contract research turnover to funding demand. On the short run, this is true but as such not contrary to the public interest. And if for some reason it is not in the public interest, then the best way to act is to incorporate this reason in the computation of the measure of effectivity. For example, if the public interest calls for technology transfer institutes that focus on small and medium-sized businesses rather than on large firms, then this preference can be incorporated in the computation of constrained contract research turnover. In the long run, the objection does not hold, since after the 'easy work' has been done, technology transfer institutes will turn to activities that give them an admittedly lower but still positive return.

A third set of pros and cons relates to the incentive to focus too much on short term relative to long term technology transfer projects. This risk is real if policy makers can change the incentives at short notice. Uncertainty about the rewards of high future output reduces the incentives to long term investments. This risk is also real if it is impossible to translate incentives for long-term investments at the level of the institutes into corresponding long-term

investment incentives for management and researchers. The risks have to be weighted against the benefits of enhanced incentives.

A fourth set of pros and cons relates to the government budget control. If an effective and efficient use of government funds is rewarded with additional funding, then good performance is a risk to the public treasurer. This risk can be mitigated by rewarding for relative performance rather than absolute performance: this requires a comparison with other instruments of innovation policy.[22] A more fundamental answer is not to consider this risk as an objection, but as a deliberate and well-spent reward for a contribution to the public good.

All in all, policy option 1 merits particular attention, for two reasons. First, constrained contract research turnover seems to be strongly correlated with the value added society expects from technology transfer institutes (section 4.3). Hence, incentives imposed upon this output measure are likely to promote effectivity and efficiency of technology transfer institutes. Second, current practice shows that this indicator is measurable indeed (section 4.3), hence policy option 1 stands positive on the first and critical set of pros and cons.

[22] For example, and for illustration only, the treasurer could fix the combined budget for the national technology transfer institute and the nation R&D tax credit. A good absolute performance of the technology transfer institute that is worse than the performance of the R&D tax credit yields a budget cut for the institute.

5 Conclusions

Technology transfer institutes build bridges between science and society (industry and public organisations) to foster the utilisation of scientific knowledge and to articulate knowledge demand of private and public parties. Market incentives to invest in technology transfer fall short of the socially optimal incentives because of knowledge spillovers and coordination problems. Hence, government funding for technology transfer institutes is legitimate.

A comparison of four technology transfer institutes (Dutch TNO and DLO, the German Fraunhofer Society, and the Finnish VTT) reveals major similarities in the incentive structure. In particular, for none of the institutes the amount of government funds is conditional upon a pre-specified performance indicator. Incentives provided by the government are soft and implicit. Contract research clients, on the other hand, provide strong incentives to deliver value for private money.

This incentive structure does not necessarily bring effectivity and efficiency from a welfare point of view. The absence of explicit incentives attached to government funds indicates a risk that public funds crowd out private funds for technology transfer, and a risk that public funds are used inefficiently. These risks are mitigated, however, by internal incentive scheme on behalf of the board of management, by the reputation mechanism, and by intrinsic motivation and (post) career concerns.

Explicit incentives contribute to effectivity and efficiency if performance is measurable. We presented two indicators that taken together make up a favourable candidate for a measure of effectivity and efficiency of the use of government funding to foster technology transfer:

- An independent expert opinion about the additionality of the technology portfolios relative to the market (and to universities);
- Contract research turnover as a measure of utilisation of those technology portfolios.

The analysis then established three policy options:

- **Policy option 1**: Make government funding contingent on constrained contract research turnover. The constraint refers to the following condition: ineligible for a reward is contract research turnover that builds on a technology portfolio that, according to an independent expert committee commissioned by the government, is (or could have been) created by private technology transfer firms.
- **Policy option 2**: Make government funding contingent on the quality of the technology portfolio. Quality is to be measured by an independent expert committee commissioned by the

government. Quality could have many dimensions, and may include the two dimensions that constitute Policy option 1 (contract research turnover and experts' opinion on additionality).

- **Policy option 3**: Continue the current situation. The government settles for implicit incentives, and relies on the reputation mechanism and on intrinsic motivation and on the resulting performance of the internal incentive schemes.

The critical policy dilemma is to weigh the benefits of increasing incentives for effectivity and efficiency against the costs of misdirected incentives. Current internal performance assessment practice suggests, however, that serious opportunities for external measurement effectivity and efficiency of technology institutes do exist. To be precise, constrained contract research turnover seems to be a good indicator of the social value added technology transfer institutes are expected to deliver, and it is a measurable indicator. Consequently, this paper argued that policy options that make government funding contingent on such measure (in particular Policy option 1) deserve careful consideration in the policy debate on the governance of technology transfer institutes.

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