The *mission paradigm* assumes that government should perform R&D in the service of a well-specified mission in which there is a national interest which is not adequately covered by private R&D. In the US, well known examples of such technology missions included the man on the moon project and defence related missions. In South Africa, we had comparable technology missions in the field of military and energy R&D during the heyday of apartheid. The new R&D strategy has identified such missions in the fields of advanced new materials, biotechnology and information and communication technology (ICT) R&D. The role of universities and other key R&D performers within the mission paradigm is to support major government initiatives. Government usually ploughs major resources into such missions and is able to marshal resources across a wide range of players in order to foster technology development and innovation within these demarcated domains.

Within the *cooperative technology policy paradigm* an active role is defined for government actors and universities in technology development and transfer. According to this view, government's role can be as one of the main research performers, including supplying applied research and technology to industry, or acting as a broker developing policies affecting industrial technology development. The cooperative technology paradigm "is an umbrella term for a set of values emphasizing cooperation among sectors" (idem: 632).

Strong proponents of the cooperative technology paradigm hold the view (sometimes seen to be controversial) that a government technology planning and coordinating role can augment productivity and innovation. As Bozeman indicates, a number of cooperative technology development policies attracted large attention in the US during the 1980s and 1990s (in challenging the market failure theory), including those pertaining to the use of federal laboratories as a partner in technology commercialisation, university-industry partnerships (including the science parks and company spin-off notions).

Within this paradigm, the role of universities and government laboratories is central. As Bozeman puts it:

> *The logic is simple: universities and government labs make, industry takes … many policies involve co-production of technology and various forms of collaboration between industry and either government or universities. But the central point of cooperative technology policies is clear: putting universities and government laboratories to greater use as progenitors of technology and applied science (idem: 633).*

After reviewing more recent lessons learnt about technology transfer and inter-sectoral cooperation, Bozeman then proceeds to present and explain the outlines of the "contingency effectiveness technology transfer" (CETT) model. The CETT model incorporates five main dimensions:

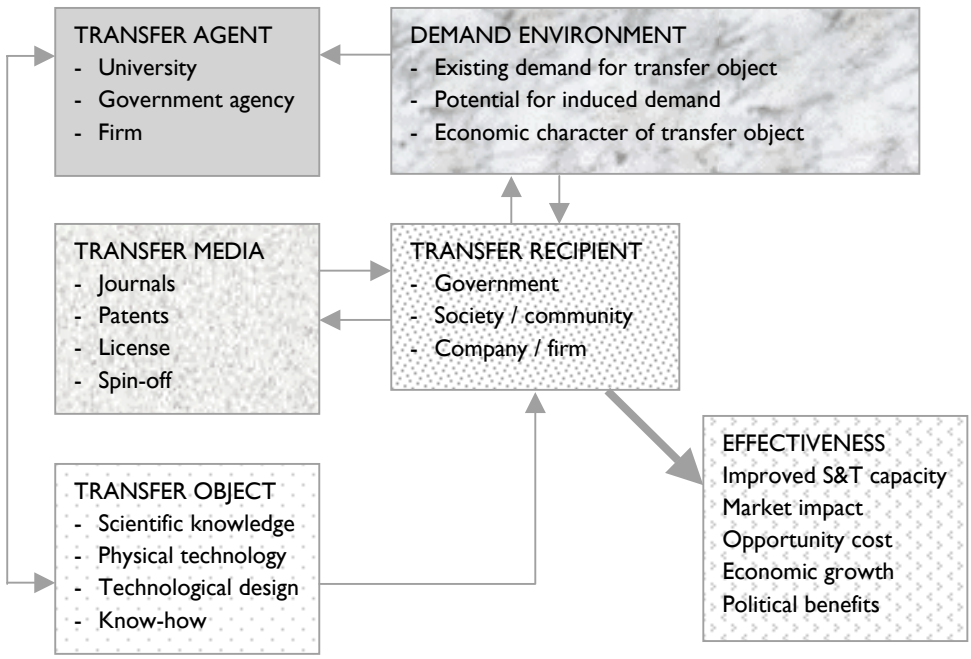
1) characteristics of the transfer agent;
2) characteristics of the transfer media,
3) characteristics of the transfer object,
4) the demand environment, and
5) characteristics of the transfer recipient (Cf. Figure 4).

In Bozeman's own words: "… the model says that the impacts of technology transfer can be understood in terms of who is doing the transfer, how they are doing it, what is being transferred and to whom" (idem: 637). Table 5 elaborates on the dimensions and provides examples of each.

Table 5: Dimensions of the CETT model

Dimension	Focus	Examples
Transfer agent	The institution or organization seeking to transfer the technology	Government agency, university, firm
Transfer medium	The vehicle, formal or informal, by which the technology is transferred	License, copyright, person-to-person, formal scientific literature
Transfer object	The content and form of what is transferred	Scientific knowledge, technological device, process, know-how and specific characteristics of each
Transfer recipient	The organisation or institution receiving the transfer object	Firm, agency, consumer, user group, institution and associated characteristics
Demand environment	Factors (market and non-market) pertaining to the need for the transferred object	Price for technology, substitutability, relation to technologies now in use, subsidy, market shelters

Figure 4: The contingency effectiveness model of technology transfer (CETT)



In the remainder of his review article, Bozeman discusses the main findings and lessons learnt from recent scholarship on each of these five dimensions. We summarise only some of the most salient conclusions that he draws.

1) Characteristics of the transfer agent

- Etzkowitz (1994, 1998) focused on cultural changes within the new entrepreneurial university environment and shows a culture more conducive to industrially relevant work.
- Various studies (e.g. Lee, 1996) found much less enthusiasm amongst university faculty for business partnerships.
- Slaughter and Rhoades (1996) have focused on the effects of the cooperative paradigm on the structure of academic work, including salary distributions by field and faculty research choices. They suggest that more divisions - especially between the humanities and the natural sciences/engineering - are appearing because of these.
- In earlier studies by Bozeman and Coker (1992) they found that three types of effectiveness related to the transfer agent:

> *Number of licenses related chiefly to the size of the lab; getting technologies out the door was best explained in terms of the missions of the laboratories and the composition of their R&D; market impact, measured in terms of commercialized technology, was best explained by research diversity and degree of commercial orientation of the lab. (idem: 640)*

2) Characteristics of the transfer medium

- In a comprehensive study of transfer media, Roessner (1993) found that the most important category of interaction was contract research, followed by cooperative research. Few firms valued licensing and more formal interactions.
- The verdict on science parks as a transfer medium remains ambiguous. In a recent study by Felsenstein (1994) it was found that location in a science park seems to provide no direct contribution to innovation but does confer status and prestige and these indirectly promote technology transfer and information flows.
- Not surprisingly, numerous studies increasingly recognize the role of human capital and training in technology transfer. Bozeman refers, amongst others, to work by Bessant and Rush (1995) on consultants, the study of Hicks (1993) on personnel exchange and secondment, and his own work (Bozeman *et al* 1995) on informal relations among bench-level scientists.

3) Characteristics of the transfer object

- Grant and Gregory (1997) have analysed the transfer of 'tacit knowledge' – an area that is receiving new attention – and found that the extent of transfer of tacit knowledge often has a major impact on the effectiveness of manufacturing technology transfer.

- An issue that has also received much attention is the extent to which transfer objects achieve commercialisation and what is their rate of commercial success. Various studies in the US (Roessner, 1993; Bozeman *et al* 1995, Geisler and Clements, 1995) have in fact shown that a minority of interactions are motivated by the prospect of directly realized commercial products. In addition, relatively few projects actually results in the company's commercialisation of technology transferred to the company.
- Where commercialisation is successful, Bozeman (1997) has found that projects were more likely to lead to a commercialised product if they were initiated by either the companies' R&D manager or by top managers in the company.
- Interestingly enough, Rogers and Bozeman (1997) in a study on 219 federal laboratory-industry partnerships, found that projects which involved basic research had higher costs but also a greater likelihood of yielding a commercial technology project.

4) Characteristics of the demand environment

- It is often assumed that the demand for technology is either market-push or market-pull. However, as Dalpe *et al* (1002) show, the role of the public sector as the first user of technological innovations is equally important.
- In a study of technology transfer in the biomedical industry, Azzone and Maccarrone (1997) found that the critical demands for technologies and technical competencies is a major factor in determining market impact technology transfer success.

5) Characteristics of the transfer recipient

- According to Bozeman, studies that have compared business and non-profit or government technology recipients have consistently found significant differences in process, barriers to effectiveness and indeed understandings of what count as effectiveness (Kingsley and Farmer, 1997).
- There is evidence that the cooperative technology policy paradigm is taking hold - at least in the US. In their study interviewing companies' research directors and chief technical officers about sources of external technical knowledge, Roessner and Wise (1994) found that universities fared better than federal laboratories or other firms. However, with respect to sources of technical knowledge for new products and production processes, respondents rated in-house R&D as most important, with universities and government agencies being ranked well below such sources as customers, competitors, suppliers and consultants.

In his final section, Bozeman discusses six effectiveness criteria: "Out of the door" transfer; market impact (e.g. on sales or profitability of the firm); economic development, political effects, opportunity costs and scientific and technical human capital. The advantages and disadvantages of each of these criteria are discussed. At the end of his review, Bozeman points out that despite hundreds of research studies on technology

transfer over the recent decades, many topics are still neglected. Although we have learned much, we still know very little about many aspects of the technology transfer process. We quote him in full:

> *We still know almost nothing about technology transfer politics, including distributional outcomes of technology-based economic development. We have little understanding of many critical impacts, such as developments in scientific and technical human capital, occurring over long time periods. We know little about the impact of technology transfer activities on institutions, their designs and their full range of capabilities. (2000:650)*

This concludes our rather detailed discussion of Bozeman's CETT model. In the final section, we present an adapted version of the model and introduce the notion of RUTT - research utilization trajectory.

A modified version of the CETT model

Bozeman himself points to the fact that the terms 'technology transfer' and 'knowledge transfer' are often used loosely and interchangeably. Following on the basic precepts formulated above, we propose a more generic version of CETT that can in fact be applied to all forms of knowledge transfer. We believe that the same five dimensions that apply to technology transfer can be applied to the transfer of all forms of knowledge. We have argued that technological knowledge or knowledge applications is one form of research output - non-epistemic output. We don't think that there is any plausible reason why the transfer of different forms of knowledge (theoretical/ empirical/technological) would not conform to the same logic. The basic structure and logic of the production and utilisation of knowledge which was outlined in Figure 5.1, we would argue, is adequately captured in the more dynamic perspective of the CETT model.

However, we do suggest one refinement or modification to the CETT model that derives from our slightly larger perspective on the processes of knowledge utilisation *and* knowledge production. One of the assumptions that underlie Figure 5.1 is that the mode of research does affect the mode of research utilisation. To capture the fact that different modes of research can and indeed do influence the way in which research outputs are utilised differently, we introduce the notion of 'research utilisation trajectories' (RUTTs). A RUTT depicts the more specific pattern of utilisation (including dissemination and diffusion) of research that is related to differences in modes of research. At least three types of RUTTs can be distinguished: the basic research utilisation trajectory (Figure 5), an applied research utilisation trajectory (Figure 6) and a (technology) development utilisation trajectory. The latter is not discussed separately because it is in fact identical to the technology transfer model discussed by Bozeman.

This expansion of the CETT model suggests that it would be more appropriate to refer to it as the contingency effectiveness knowledge transfer model (CEKT), of which technology transfer is one limiting case and basic and applied research are others.

Figure 5: The basic research utilisation trajectory

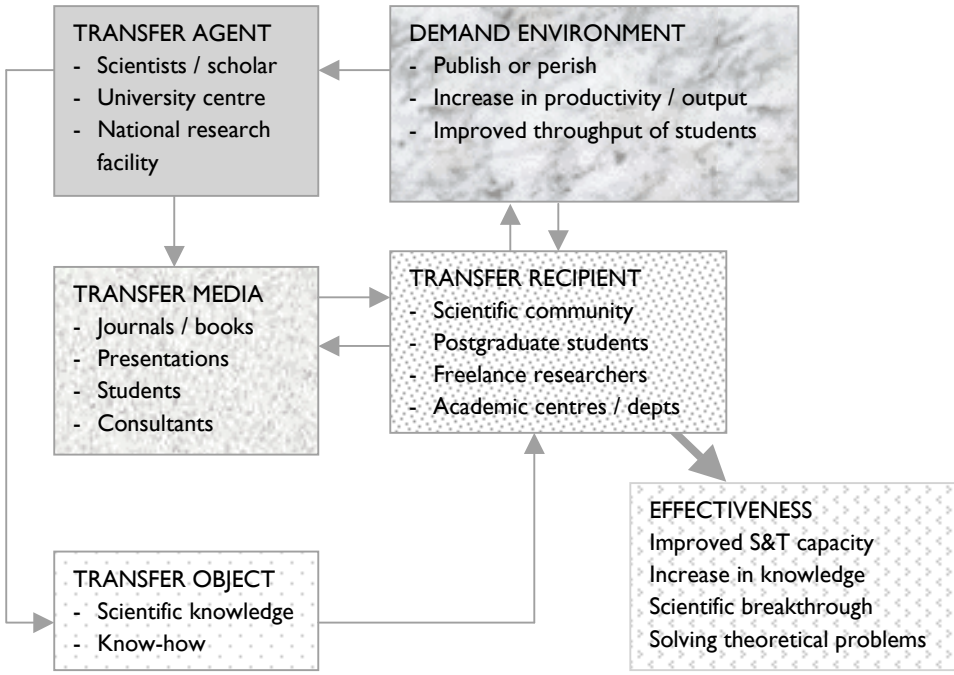
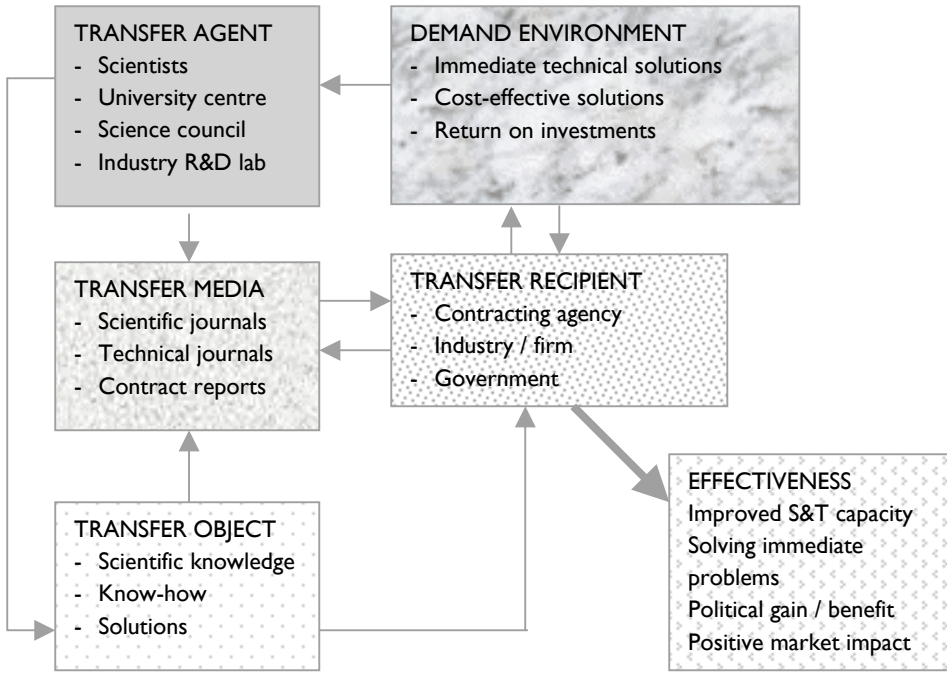


Figure 6: The applied research utilisation trajectory



In summary, the contingency effectiveness knowledge transfer (CEKT) framework outlined above highlights the following aspects of knowledge utilization:

- The ways in which (scientific) knowledge are utilised depend both on the modes of knowledge production (basic, applied, strategic, developmental) and the scientific domain.
- Scientific research produces two kinds of outputs: epistemic products (new knowledge) and non-epistemic products (knowledge applications, technologies). This means that the utilisation of knowledge includes both the application and use of research findings (epistemic) and research-based products (non-epistemic).
- The CEKT-framework identifies five dimensions that are present in all knowledge utilisation (or transfer) processes: the transfer agent, the transfer medium, the transfer object, the transfer recipient and the demand environment. The ultimate effectiveness of knowledge utilisation depends on the peculiar interplay of each of these dimensions.
- The CEKT-framework also introduces the notion of 'research utilisation trajectories' (RUTTs). The notion of a RUTT captures the unique dynamics of the utilisation of research within different paths or trajectories. It highlights the fact that the peculiar dynamics within each of the 'basic research utilisation trajectory' 'applied research utilisation trajectory' and 'technology development trajectory' is sufficiently different to necessitate a more differentiated treatment of knowledge utilisation issues.

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