

## RETHINKING THE DISSEMINATION OF SCIENCE AND TECHNOLOGY<sup>1</sup>

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### Introduction

Questions about the social and cultural basis of science and technology have received new impetus with the recent increase in government concerns about the utility of these enterprises. These concerns are, of course, just the recent manifestation of long-standing interest in the product of science and technology. The particular focus of current attention, especially evident in recent policy proclamations by government agencies in the UK and Europe, construes the problem in terms of the exploitability of the products of science and technology. Typically, questions are being raised about the ways in which science and technology can contribute towards wealth creation and industrial competitiveness.

In this context, it is important to assess what these concerns presume about the nature of science and technology and, crucially, what they presume about the nature of the relationship between science and technology and its potential beneficiaries. This relationship is variously described in terms of the "impact", "outreach", "application", "transfer" (and so on) of the fruits of scientific research and technological development. As a short-hand generic term for these alternative terms, we shall refer in this paper to the "dissemination" of "research and technology development" (RTD).

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<sup>1</sup>. This paper is based on an earlier presentation "Towards a new concept for RTD dissemination" made as part of the work of the Cafe de Paris study group of the EC Think Tank on Interfaces Between Research, Technology and Society. Particular thanks to my colleagues Nikos Gangas, Jose van Eijndhoven, Jorge Calado, Tarja Cronberg and Fritz Meyer-Krahmer.

The aim of this paper is to critically assess the models which inform calls for improved RTD dissemination, and suggest the basis for a new approach to the problem. The rationale for this aim is threefold. Firstly, although attempts to understand the mechanisms for the successful/effective dissemination of RTD have a long history, there is general agreement that we have as yet no satisfactory solution. Secondly, existing models of RTD dissemination tend to be based on outmoded views of the nature and organisation of RTD. There are, in other words, empirical grounds for suggesting we need to rethink the nature of dissemination. Thirdly, an interesting and unexpected confluence of recent social science research presents the opportunity for a new synthesis of theoretical ideas drawn from a variety of different areas. The argument is organised to follow these points in succession.

### **RTD Dissemination: a long-standing problem**

In its widest interpretation, RTD dissemination is spoken of as crucial to industrial competitiveness and wealth creation. In the UK, the recent White Paper (1993) was the latest in a series of statements from government to promote innovation, technology transfer and wealth creation. The growing recognition of the importance of promoting these activities was signalled by the establishment within the Department of Trade and Industry (DTI) of a discrete Innovation Unit in 1991, largely staffed by industrial secondees, which has sought further to raise the profile of such issues. By 1992, innovation was sufficiently important to feature in the manifestos of all three main political parties. The field has also assumed increased importance in the priorities of ESRC, most recently through the series of Innovation Lectures, publication of the 'Innovation Agenda', which reviewed recent ESRC funded work in the area (Smith, 1993), and discussions of the establishment of a new research programme on the Management of Innovation, to parallel that established under the auspices of SERC's ACME Programme.

These initiatives have taken place in the context of a much repeated story about the failure to make good upon the results of research and technology development. The general form of the story is as follows, where X is the home nation or set of nations and Y stands for the competitor nation:

X's ability to produce high-quality discoveries and innovations is not matched by its ability to capitalise on them. This is a major failing which has/will have dire consequences for X's economy. Because of this failing, opportunities for wealth creation and for increasing competitiveness are squandered. Worse, they are appropriated and developed for market by Y.

For example, in this account X might be "the UK" and Y could be any of a range of competitors, including "Germany" or "other European countries". By contrast, in the context of pro-European collaboration, if X is "the UK", then Y is "the USA" and/or "Japan". If the story has a familiar ring to it, it is because it turns out that similar versions are current within many other countries, in the EC at least, for example, Netherlands, Germany and Portugal<sup>2</sup>. The political appeal of these accounts is organised around self-other contrasts expressed in nationalistic terms.

### **Problems with linear models of RTD dissemination**

As the importance of innovation has been recognised so, increasingly, has the complexity of the issues which need to be addressed. Several commentators, including Newby (1992), have questioned the long-established notion, expounded by Schumpeter, that innovation can be seen as a three-stage linear process, involving discovery of new ideas, transfer into a commercial environment and diffusion into new products. From recent evidence, it is becoming clear that both the origins and process of innovation are mixed. The speed of technology transfer may be determined as much by market pressures as scientific discovery, and the problems faced are much wider than a lack of suitable inventions, or of investment to exploit them. Thus emphasis is shifting from the notion that innovation is a technological problem, to recognise that, whatever the rate of discovery, it needs to be accompanied by appropriate management mechanisms.

The most important problems with linear models include the following. Firstly, they tend to presume a more or less complete separation of RTD production from the communities of likely consumers. Against this, it emerges from more recent

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<sup>2</sup>. In EC countries such as Greece, the situation is somewhat different because there is no significant R&D base for exploiting innovations; instead, other countries in the EC are seen as the legitimate market for home-grown ideas.

research that the production of RTD results itself can have a decisive influence on dissemination and exploitation processes (Schmoch *et al.*, 1993).

Secondly, linear models tend to presume a more or less unidirectional flow of RTD results from areas of production to those of consumption (uptake, exploitation, use, etc). But the flow of knowledge can also be in the reverse direction with basic research agendas being set by demand-driven identification of application problems. Thirdly, linear models tend to presume the more or less unchanging character of “the results” during the process of transfer (dissemination, outreach, etc). The image deployed is rather akin to the exchange of bricks. But evidence suggests consumers are resourceful redefiners of “the results” and that results with no apparent significance to producers can yield great exploitative value. Fourthly, linear models assume a “deficit model”, that is, that potential recipients of RTD results are necessarily lacking knowledge of results and developments and that it is in their interests to acquire it. But initiatives like the UK Public Understanding of Science have shown this to be false; that consumers’ own definitions of the relevance and use of appropriate knowledge are often paramount (Irwin, 1994; Irwin and Wynne, forthcoming). Fifthly, linear models tend to presume a more or less monolithic community of consumers/users when in fact these are structured in complex and not yet well understood ways. Producers’ (often implicit) conceptions of consumers may be a crucial indicator of likely success of “dissemination”.

Some of these deficiencies of the linear model are widely acknowledged. Indeed, much energy has been expended in attempts to modify the original model (for example, Irvine and Martin, 1984; Dosi, 1988; Rothwell and Gardiner, 1988; Ropohl, 1989; Roy and Cross, 1983; Kline, 1985; Kline and Rosenberg, 1986; for a discussion see Schmoch *et al.*, 1993 p 61 ff). However, most attempts to derive alternatives have concentrated on ways of elaborating the model, rather than rethinking its base assumptions. In addition, only the first and second of the above-mentioned criticisms have been given full consideration. As a result, the literature comprises a large number of small modifications of the original linear scheme. Schmoch *et al.* (1993, chapter 5) chronicle these modifications. Their discussion displays the evolution of increasingly baroque models through the acquisition of amendments and additions, feedback loops, parallel “chain” linkages, funnelled

focussing of connections and so on. The more sophisticated variants include “communication” as a variable, but this tends to appear as no more than a sub-process within the general dynamic of adding value. It is thus questionable whether such efforts escape the central commitment to linearity.

The alternative approach we wish to sketch out here takes the view that the processes we want to capture cannot be adequately represented in terms of boxes and lines: it is precisely the nature of these linkages that needs to be rethought. The system we are trying to understand is sufficiently complex that breaking it down into discrete boxes and linear processes will inevitably do an injustice to its essential features<sup>3</sup>.

### **Changes in the nature and organisation of RTD**

At the same time, it is clear that existing knowledge about, and models of, the RTD dissemination process, are premised on a view of RTD which is increasingly out of date. The classic conception of the problem starts with the results of RTD and then asks how to bring these to the market. It is this view which informs the linear models. However, the modern RTD system is quite different from that imagined by the linear models. It is now a modern, science-based system which is interdisciplinary, network-dominated, demand-driven, application-oriented and international. Recent years have also seen the rise of many intermediary institutions, public bodies like governments and government agencies. It follows that dissemination is much more complex than has been imagined. “Dissemination” is not just dissemination of existing RTD, but needs to include future possible technologies.

### **The wider theoretical significance of “dissemination”**

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<sup>3</sup>. There is also an argument (for which I am grateful to Jorge Calado) which suggests that linear models are basically inappropriate for what are essentially processes of communication and interaction: if one bears in mind that communication implies change, not only of the message being passed, but also of the subjects implied in the process. The linearity of line/box models was designed for systems (electrical, etc) which presumed unchanging signals and a conservation of energy. But by definition, there is no law of conservation of information: information is essentially entropic. Hence any linear model of communication is doomed.

We have suggested the need to seek alternatives to linear conceptions of dissemination which also recognise key changes in the nature and organisation of RTD. A key intuition arising from critiques of the linear models (and their variants) is that “dissemination” might be usefully addressed as one specific instance of a much more general problem: namely, the production, transfer, uptake and consumption of cultural artefacts in general. Research and technology is one such cultural artefact. Different aspects of the same general problem include dissemination, valorisation and exploitation. The following definitions of these terms are taken from the European Parliament Report (Vol. I of the Evaluation Panel Documentation: part C: p. 7):

Dissemination: distributing the knowledge widely by publications, data banks, networks, seminars, exhibitions, and the training and mobility of researchers.

Valorisation: perfecting and promoting the invention and developing it for industry to exploit.

Exploitation: licensing as widely as possible an invention or process, for profit or cost and time saving.

In order to develop a new theoretical framework, it is important to recognise that all these different aspects of the general problem share a key feature: *each of these activities involve the modification of social relations between participants dealing with technical knowledge and artefacts*. This means that we require a theoretical framework capable of explaining both the social relations between participants who are members of (often quite different) social organisations, but who are negotiating over the “same” technical artefact.

Our strategy is first to develop the general theoretical model and only then to consider the particular differences between different specific activities. We believe this approach also lessens the likelihood of advancing further piecemeal solutions. In the next section, we illustrate the benefits of tackling the problem in a broader frame, with reference to the example of technology transfer.

### **The example of technology transfer**

Despite a voluminous literature on the opportunities and problems of technology transfer (for example, Bell, 1992; Bell *et al.*, 1992), central questions remain unanswered. There is at least some emerging consensus that the problems of successful technology transfer are not solely (and perhaps not at all) technological. But the extent to which they can be considered cultural and social rather than, say, economic, has yet to be pursued systematically. Needless to say, if a significant cultural basis for the problems of technology transfer can be demonstrated, this will have important implications for policy.

In the case of technology transfer, several possible imperfections have already been identified in the transfer process. Within both higher education and industry, it has been argued that there is both a lack of will to co-operate (reinforced, perhaps, by a difference in career structures, conservative attitudes and short-termism), or a lack of knowledge of the mechanisms available. Others have pointed to the need for a clearer strategy in both universities and industry and to the lack of a clear financial incentive when a proper cost-benefit analysis is conducted (Kirkland, 1993).

In the UK, several of these factors are outlined in a recent ESRC publication under the 'Innovation Agenda' initiative (Smith, 1993), which also lists a series of basic questions which need to be addressed by social scientists. Whilst highlighting the role of marketing as a key issue, alongside that of government policy, training, international comparison and management strategy, however, the "Agenda" does not fully embrace another issue, which we regard as essential. That issue is the means by which technology is actually communicated between producer and user. Relatively little consideration has been given to how this process takes place and what obstacles – managerial, cultural and linguistic – it encounters. In particular, we have no detailed understanding of the ways in which communication is affected by the culture of the various different institutions involved.

The complexity of the issues involved in technology transfer, together with the signal failure of most attempts to achieve any more than piecemeal solutions to the problem, suggest the need for fresh strategic theoretical thinking.

### **Configuring the users**

Recent work in the sociology of technology has adopted an ethnographic perspective to study the process of technological development (for example, Cooper *et al.*, 1993). A key finding is that the process of innovation and development is especially affected by culturally specific preconceptions of likely “users”. That is, organisations operate with certain, often implicit, presumptions about the identity, needs and capabilities of possible consumers of their products. Within organisations, different groups hold different preconceptions about users. So notable contrasts pertain between, for example, hardware engineering and technical writing sections of the same computer manufacturing company. This means that the process of innovation, design and development is especially prone to, and indeed can be characterised as, a struggle between competing conceptions of the user. The upshot of this process (of “configuring the user” – Woolgar, 1991) is that certain preconceptions become “built into” the product, and it is these which affect the nature of communication between producers and consumers and, ultimately, the product’s reception and uptake. The success of the final product depends in some measure upon the extent to which preconceptions about users match the actual characteristics of potential consumers (Woolgar, 1993).

This model underlines the importance of understanding sources of preconceptions about “outsiders” (and, specifically, about “users”). The focus on organisational culture examines the ways in which the knowledge, belief and practices of participants generate and sustain certain images of the people and groups beyond the organisation. It pays particular attention to the ways in which the views and attitudes are represented (sometimes explicitly) and to the distribution of knowledge about outsiders. Who, for example, are the credited authorities on what outsiders expect from the organisation? What is the role of the various intermediary agencies established to liaise between the organisation and its possible audiences?

In the particular case of innovation within the university sector this theoretical model poses specific questions about the nature of communication within and beyond the university, and about the ways in which preconceptions (perhaps even ignorance) about possible users of new developments may affect technology transfer. To what extent do competing conceptions of “outside” use for an evolving idea affect its chances of transfer? Which aspects of the research culture in

universities are most critical in defining possible users? What is the role of the various intermediary agencies (industrial liaison offices, research managers) in effecting communication of the results of innovative research? What are the effects on innovation in universities of outside (government) initiatives to promote greater contact with industry and commerce (cf Cooper and Woolgar, 1993b)?

This particular model advances the general contention that the success of technological innovations depends upon the social relations between producers and consumers, and on the mechanisms for communication between them. In particular, the model emphasises the importance of these relations as they bear upon views of the technical capacity and utility of the cultural artefacts in question.

### **The certainty trough**

In his study of nuclear missile accuracy-MacKenzie (1990) describes the certainty trough: the idea that certainty about assessments of missile accuracy varies according to one's distance from the site of their production. In particular, those nearest the site of production exhibit greater uncertainty than those somewhat removed the process; as we move yet further away, however, the certainty again increases: those uncommitted to this particular technological institution are even more sceptical than those producers who live day to day with the contingencies of production (figure 1).

A major problem across a wide range of scholarship, ranging from the sociology of scientific knowledge to cultural studies in general, is how best to tie together what is known separately about the social processes of production and of consumption. The certainty trough has the important advantage of describing relations between producers and consumers in terms of their relative perception of the technical capacity of artefacts with which they are both concerned. One important implication is that effective "transfer" will only occur if the pattern of relations is such that a body of "configured" users has more confidence in the product than the designers themselves. In the case of the particular problem of RTD dissemination, effective "dissemination" will only occur if there is a pattern of

relations such that there exists a body of configured users who have more confidence in the RTD than the producers themselves<sup>4</sup>.

Figure 2 suggests that a crucial factor in the achieved pattern of relations between producers and consumers, and hence between disseminators and disseminatees, is the management of the social organisational boundary that lies between them. “Successful” products will exhibit a curve with a sharp drop in uncertainty as we move away from the site of production. The sharp drop may correspond to well-defined pathways between consumers and the producing organisation: a technical support hot line, well-controlled means of access and so on. By contrast, less successful products may exhibit a relatively flat curve. These we might call less robust: the effect of such products is that any consumer has an equal measure of (un)certainty, regardless of their distance from the site of production (figure 3). In the extreme, in cases of monumental failure, we might imagine an inverted “U”. Here the potential consumers are a lost cause, all of them being more sceptical than the producers themselves.

There is encouraging preliminary evidence to suggest that the conceptual value of the certainty trough bears generalisation, at least within the rubric of technological innovation. For example, a recent study of the production of a new range of personal computers found that the acclaimed success of the new product depended upon careful social management of the cultural boundaries between the company and its user base, particularly as this involved the maintenance of insiders’ preconceptions about the character of “users” (Woolgar, 1991, 1993).

More intriguing is the possibility that the same scheme bears elaboration to include other forms of cultural artefact. Fairly clearly, we can envisage the application of the scheme to the reception and uptake of other sorts of technological innovation. More generally, however, we can ask under what circumstances might we expect a well-configured set of potential users, in other words a well-defined certainty trough, for any cultural artefact? This move builds on the central presumption of social studies of science and technology that scientific knowledge and technical

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<sup>4</sup>. Note here that the y axis of the graph measures relative levels of (un)certainty, rather than of “truth”. It is not the case, therefore, that we are suggesting that configured users are necessarily being duped by the producers of the artefact.

systems should be understood as cultural artefacts. The suggestion, here, however, is that the extended treatment of technical objects as cultural artefacts – in particular, the added scepticism involved in considerations of the nature, quality and usefulness of artefacts – might benefit our understanding of the transfer of cultural artefacts in general. The specific questions which follow from this include the relative merits of artefacts deriving from different areas of academic research. What differences in patterns of social relationship account for the differential reception and use of the cultural artefacts arising from, say, technological and social scientific research? Why do the products of the former seem so much more robust than those of the latter? Are preconceptions of likely audience substantially different between the two domains? To what extent can differences in the transfer of these cultural artefacts be explained solely in terms of patterns of producer-consumer relations?

### **Social relations and the RTD text**

The certainty trough is better construed as an “aid to the sluggish imagination”<sup>5</sup>, than as a formal “model”. Indeed, one of the major implications of our earlier criticism of linear models of innovation was not that they *inaccurately* depicted the innovation process, but that they committed a *conceptual error* in assuming that models of any kind were appropriate. Clearly, then, the use of the certainty trough scheme requires caution: it makes assumptions about the correspondence between levels of certainty and “success”; it contains no clear account of what is meant by “distance” from the site of production; and is certainly not intended as the basis for a new metric. More important, it only begins to hint at the mechanisms for the “management” of the social organisational boundaries between producers and configured users/consumers. It is also clear that a vast range of kinds of “social relation” need to be specified in detail; the emphasis thus far has been primarily on the nature and role of producers’ preconceptions about users.

One possible initial answer to some of these questions is suggested by recent attempts to construe science and technology as a text (Woolgar, 1991; Cooper and Woolgar, 1993a). In broad terms, the designers/producers of the text can be

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<sup>5</sup>. A phrase borrowed, I think, from Garfinkel.

viewed as its authors, and the consumers/readers/users of the text are its readers<sup>6</sup>. Thought of in this way, “social relations” relate to the nexus of identities, expectations and actions which are normatively established in the reading of the technology text. Drawing on the textual analysis of writers like Anderson, Sacks and Smith, we can say that features of the organisation of the text provide for a community of preferred readers and readings. By analogy, the suggestion is that the very form of a technology can be understood as providing for an expected set of users and uses. This is not to say, deterministically, that such features compel particular usages. Instead, it proposes that socially sanctioned attitudes towards (and uses of) the technology are established. Users are still, in principle, free to do whatever they wish with (to) the technology, but their actions are adjudged against a normative moral framework of “correct” usage (Cooper and Woolgar, 1993a).

Like the certainty trough, this line of argument construes the differential perceptions of technology between producers and consumers in terms of the social relations that exist between them. However, it also goes further towards proposing ways in which the management of the social organisational boundary between producers and users is significant in the interpretation and use of the technology.

## **Conclusion**

It is clear that a significant opportunity presents itself for a theoretical synthesis of hitherto disparate approaches to the processes which we have referred to in this paper as the “dissemination” of RTD. In particular, we can envisage a synthesis predicated on the assumption that the problem of RTD dissemination can be usefully considered as a specific instance of the more general problem of communication across social organisational boundaries. The generality of this rubric also allows consideration of other related problems, such as the conditions for the effective “outreach” and “dissemination” of research in general. The

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<sup>6</sup>. Of course, the situation is much more complicated than this. For example, with respect to the role of intermediaries – those who occupy strategic positions between producer and consumer – marketing people, opinion formers, journalists, reviewers, purchasers – and those who by commenting on the nature, capacity, use and success of technology intervene in its reading/interpretation and use. Nonetheless, the central idea of the metaphor – that the technology is authored/designed on the one hand and read/interpreted/used on the other brings to centre stage the question of the extent to which the character of the technology determines/gives rise to/influences its use.

synthesis can proceed both by bringing together theoretical arguments and models from a range of different areas of scholarship and experience, by evaluating these arguments against a range of recent empirical studies, and by drawing on the growing body of practical experiments in new ways of facilitating and valorising the results of RTD.

The indications are that rethinking the problem will lead us seriously to reconsider the very concept of “dissemination”; as well as cognate terms like outreach, transfer, uptake, valorisation, exploitation and so on. This is because these terms carry increasingly inappropriate connotations. The notion of dissemination, like transfer, connotes a process whereby an unchanged item is conveyed from one arena to another. (The image is equivalent to an exchange of bricks between two removed parties.) All the problems of linearity follow from this. Speaking about the “interface” (between technology and society) – a term currently favoured within some EC circles – moves us in the right direction, but perhaps gives insufficient emphasis. It is clear that the notion of dissemination needs to be exorcised, not merely tinkered with! It needs to be replaced by a more holistic notion of interaction and communication between partial worlds (Gangas, 1994). Producers and consumers of RTD are in a complex and constantly shifting relation with each other; necessarily, then, their interaction and communication will have a significant social and cultural basis.

This reframing of the question suggests we need to explore the arguments in relation to a variety of literatures all of which can then be seen to bear upon the particular problem of RTD dissemination. These literatures include, for example: 1) social studies of science and technology, especially constructivist and sceptical currents 2) public understanding of science 3) academic industry relations 4) innovation studies 5) EC sponsored research into the “interfaces between research, technology and society” (VALUE Programmes) 6) reader response relations 7) cultural studies and 8) requirements analysis.

Clearly, if a significant social and cultural basis for the problems of RTD dissemination can be demonstrated, this will have important implications for policy. As we have indicated, the issues of concern can be most effectively dealt with by framing them within a more general model of the dissemination, transfer,

uptake and consumption of cultural artefacts. This means that our new approach can contribute to more general theoretical problems of the production and consumption of a range of artefacts, for example, within debates about the effects of the increasing demands for accountability of academic research, and the consequences for academic-industry relations.

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