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The Business of Science

Some Theoretical Considerations when Studying the Interaction between Science and Business

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Abstract

This paper provides an outline for a theoretical framework aimed at studying and analysing the interaction between science and business. The paper draws on two different areas of research, 1) Science, Technology and Society studies (STS), and 2) the industrial network approach as presented within the IMP community. Since this paper is part of a study of the interaction between a particle physics laboratory (CERN) and industry, the empirical examples given come from this area, but the main focus is on theory.

The paper provides three (tentative) conclusions: 1) that there are strong similarities between the constructivist STS perspective and the IMP approach, which makes it interesting to combine the areas, 2) that it is useful to differentiate between different kinds of resources when studying interaction between science and business, and 3) that when studying interaction, it becomes less useful to differentiate between technological development and technology transfer.

Keywords: Business, Science, Interaction, IMP approach, STS

Introduction

In one of the major morning newspapers in Sweden, there was recently an article concerning one of the world's major basic research laboratories, CERN¹, and its new particle accelerator. The headline read "The Big Collider Ready to Solve the Mystery of the Universe²", and the machine (particle accelerator) in question, the Large Hadron Collider (LHC), is described as the world's biggest technical construction, costing the equivalent of over six billion Euros (*Dagens Nyheter*, 2008-04-20). The rhetorical question asked in the article is what we as taxpayers get for our money (*ibid.*); a question that seems to appear every time scientific funding is discussed.

Perhaps as a justification, scientific research is regularly promoted not just for the potential scientific discoveries, but also for the perceived societal benefits. The growth of scientific knowledge has been assumed to be one major reason for what some call the "Western miracle", concerning which it has been stated that "[c]lose links between the growth of scientific knowledge and the rise of technology have permitted the market economies of the Western nations to achieve unprecedented prosperity" (Rosenberg & Birdzell, 1990:18). The discussion concerning science's usefulness to society existed already several centuries ago, but even now "the relationship between science and society is still dominated by interpretations of the contribution science makes towards the enhancement of innovation, wealth creation and economic competitiveness" (Nowotny, Scott & Gibbons, 2001:31).

In the arguments concerning the usefulness of science, the nature of the science in question is very rarely considered. It should be quite evident that some scientific research lies closer to industrial application than other (take for instance the field of particle physics contra the biotech field), but all science tend to get discussed in more or less the same way. Further on, in discussions a lot of the usefulness of science tend to lie in either its capability to directly produce new innovations, or in its capability to provide technology transfer possibilities. According to Bozeman, "there has been concern about the extent to which basic research is a fruitful transfer object" (2000:643). To contradict this, Bozeman refers to a study made in the mid-90's of 219 partnerships between federal laboratories and industry, and he claims that it was found that "compared to all projects, the ones involving basic research had higher costs but also a greater likelihood of yielding a commercial technology project" (Bozeman, 2000:643). There is no mention of what kind of basic research is studied, however, and following the argument above, this could be problematic.

¹ CERN is the world's largest particle physics laboratory. It a joint venture between 20 European countries, founded in 1954, and situated on the border between Switzerland and France. For more information, go to <http://public.web.cern.ch/Public/Welcome.html>.

² Author's translation from Swedish: "Stora smållaren redo lösa universums gåta".

Another problem when it comes to the usefulness of science is the tendency to reduce scientific research into simply an input in technological development and innovation. Science and scientific research has more and more become a vehicle for technological, and thereby societal, development. At least if we are to believe policy makers. But if we take a closer look at scientific activities, in what ways can they contribute to industry? Some argue that investing in science will inevitably lead to discoveries that can be used in other contexts, and that no, or very little, adaptation is needed. Others argue that while scientific discoveries are (eventually) good for society, it may take a little while before the new inventions may be used (and useful). Despite the modifications made, both these viewpoints show a belief in technological development as a linear process. Recently, these assumptions have been contested, however, both by researchers (see e.g. Håkansson & Waluszewski, 2002) and by practitioners. According to the Director of VINNOVA³, “[t]he global society is becoming increasingly aware of the importance of the interaction between innovation and academic research. With that awareness comes an understanding that this interaction is non-linear. It is about industry making use of academic research, but equally about academic research learning about problems from industry” (Ericsson, in Nordfors et al., 2003:9).

From the quotes above, there seems to be an understanding that there is a connection between science and business, although researchers differ on what this connection contains and how it functions. The aim of the paper is to start outlining a theoretical frame that could be useful in analysing the interaction between science and business.

The paper will provide a *theoretical* discussion concerning how the interaction between science and business can be studied and analysed. The main part of the paper will draw on previous IMP research. The primary focus is interaction between business and science, but this also entails a discussion concerning the usefulness of science for business (which has already been introduced above). One of the most commonly used concepts when discussing the usefulness of science is technology transfer (from science to industry). In order to have any technology to transfer, however, technological development is needed, and, within the IMP literature, technological development has mostly been studied from a resource perspective. Therefore, the focus of discussion concerning IMP literature will focus mainly on resources and resource development. Before we continue with the IMP literature, however, a few comments will be made on literature concerning studies of science and technology, literature within the STS field.

³ “VINNOVA, the Swedish Agency for Innovation System, is the national government agency for promoting sustainable growth by financing RTD and developing effective innovation systems” (Nordfors et al., 2003).

Some Theoretical Considerations from the STS Perspective

Emerging in the 1960's, the field of science, technology and society (STS) studies draws on the research of a number of researchers from quite disparate research areas, such as sociology, anthropology, history, history of technology, history of ideas, as well as economics, psychology and law. What joins these researchers, however, is the belief that science, technology and society are interdependent. One of the early STS researchers claims that the “scholarly tide” of STS goes against positivist, rationalistic and instrumental views of science giving rise to technology, and instead moves towards a view of science and technology as “human achievements”, which are context specific and based on negotiations (Edge, 1995:5). Cutcliffe and Mitcham state that “[i]n this “contextual” view, STS presents science and technology as neither wholly autonomous juggernauts nor simply as neutral tools ready for any utilization whatsoever. Instead, sciences and technologies are seen as value-laden social processes taking place in specific contexts – interactively shaped by, and in turn shaping, the human values reflected in cultural, political, and economic institutions.” (2001:3)

Being a fairly young field of research, there are still controversies within STS studies. According to Fuglsang, there are three main perspectives in STS. The difference between them lies in how science, technology, and society relate to each other. The first perspective can be described as “science and technology shape society”, the second “society shapes science and technology”, and the third perspective introduces “an interactive view of the science, technology and society relationship” (Fuglsang, 2001:36). There is thus a difference in causality between the perspectives, and it is the interactive perspective that will be discussed further in this paper.

Another way to differentiate between perceptions within STS is promoted by Bijker, who makes a distinction between what he calls the standard view and the constructivist view of science and technology (2001:22-23). In table 1, some of the differences between the views are presented (where the constructivist view also goes back to the way in which Edge (1995) described the STS area of research).

Table 1 **Contrasting Views of Science and Technology**

Standard View of STS	Constructivist View of STS
Clear distinctions between the political and the scientific/technical domain	The domains are intertwined; what is defined as technical or as a political problem will depend on the context
Scientific knowledge is discovered by asking methodologically sound questions, which are answered unambiguously by nature	The stabilisation of scientific knowledge is a social process

Technology develops linearly, e.g., conception → decision → operation	Technology development cannot be conceptualised as a process with separate stages, let alone a linear one
Distinction between technology's development and its effects	The effects of technology are part of the construction process and have vice versa effects for the shaping of the technology
Clear distinction between development and control of technology	Technology is context-dependent and development and control are therefore difficult to separate

Source: Adapted from Bijker, 2001:22-23

As can be seen from table one, some of the aspects that are important within the constructivist view of STS are; the dismissing of the linear model, the belief in context-specificity, the blurring of categories and borders, and the interactivity between development and control of technology. If we were to find concepts for these aspects, the following words could be used – *non-linearity*, *context*, *complexity*, and *interaction* – all of which are important concepts within the IMP perspective presented below. Before we move on to the IMP approach, there is one more aspect that has to be touched upon, namely (scientific) resources, and how they are regarded within the constructivist view of STS. It was mentioned already in the introduction that resources are an important building block within the IMP perspective. STS researchers also discuss resources, however, although they may not use that exact word, but it is indeed still interesting to look at resources from the STS perspective.

Resources and STS

Instead of giving a comprehensive account of how different researchers within the STS field describe resources, this part of the chapter will introduce a couple of examples aimed at highlighting resource definition and concept use. The first example will deal with what can be characterised as scientific resources, while the second example will introduce a more technical resource.

Based on an anthropological study of scientific culture, carried out by a French sociologist in an American laboratory, some insightful results on how scientific facts are constructed and how scientific knowledge is created were achieved. According to Latour (“the French sociologist” in question) and Woolgar,

“Scientific activity is not ‘about nature,’ it is a fierce fight to *construct* reality. The *laboratory* is the workplace and the set of productive forces, which makes construction possible. Every time a statement stabilises, it is reintroduced into the laboratory (in the guise of a machine, inscription device, skill, routine, prejudice, deduction, programme, and so on), and it is used to increase the difference between statements.” (1986:243)

The quote above indicates that scientific facts, which can also be considered one form of scientific *resources*, are created in interaction between a number of different resources, such as people, machines, programmes, routines and even the workplace itself. In another context, the same resource may never have developed, i.e. that specific scientific fact may never have been constructed. Latour develops these ideas further in his book *Science in Action* (1987), which even more clearly shows how different scientific resources interact in order to construct scientific facts.

The second example that will be given deals with the introduction of a new type of steam engine in a Swedish mine in the early eighteenth century. In the end, this introduction turns out to be an expensive failure. (Lindqvist, 1984) The introduction process is discussed in terms of technology transfer, and it is carefully showed how difficult (if not impossible) it is to transfer a technological artefact from one setting to another; too much depends on the context, on the resource interaction both at the place of origin and the place to which the artefact is supposed to be transferred, and on the complexity of the whole endeavour. In short, in this case the attempted technology transfer turns out to be at least a financial disaster, and for the “transfer” to have worked, huge investments in technological development would have been necessary.

These two short examples aim at pointing out how scientific and technological resources have been described in science and technology studies. The first example shows how a scientific resource is created in interaction between other resources, and thus how important the context is. The second

example shows the difficulties of treating resources as black boxes that can be transferred without taking the context into consideration. Now, before we move on to the next section, it is important to clarify that this paper has no intention of contrasting the STS perspective and the IMP perspective, quite the contrary. It has even been stated that the IMP perspective, or at least the part of it that deals with resources and technological development, is nothing else than another flavour within the STS field. According to Widmalm and Nissen, the IMP perspective “developed in parallel with the STS field, with which it has much in common” (forthcoming, p. 18). When it comes to studying science and technology, irrespective of whether the starting point is STS or IMP, an important notion is “*methodological relativism*”, meaning here that “scientific or technological development should be studied without regard to what has later come to be accepted as scientific truth or technological practicability” (Widmalm & Nissen, forthcoming, p. 10).

Having professed to not seeing (the constructivist view of) STS and IMP as completely different theoretical areas, but rather as different nuances of the same way of thinking, we will now move on to presenting the second theoretical perspective treated in this paper, i.e. the IMP perspective.

Some Theoretical Considerations from the IMP Perspective

The interaction between science and business can be studied from a variety of different perspectives. Within the STS field, science and technology have been studied from various angles, depending on the background of the researchers: economists, sociologists, anthropologists, historians and so on. Up until recently, however, there has been little interest in science and technology issues within business studies⁴. The following part of the paper presents an outline of some theoretical concepts which are believed to prove useful in the analysis of the interaction between science and business.

The theoretical backbone of this paper is the industrial network approach developed over several decades by researchers within the IMP group⁵. The initial IMP project, carried out in the 1970’s, brought along empirical findings that challenged the existing theoretical approaches. The main ideas contested were 1) the idea that purchases and sales could be considered isolated events, i.e. simple transactions, 2) the idea that marketing could simply be described – and carried out – using the 4 P:s, 3) the idea that any group of actors can be considered homogenous, and 4) the idea that marketing and purchasing processes are independent of each other, and thus can be studied and explained

⁴ An exception worth mentioning is the research carried out at the STS Centre at Uppsala University, which combines an industrial network, or IMP, approach with literature within the STS field (see www.sts.uu.se for more details).

⁵ For more information on the IMP group and its research, see www.impgroup.org

separately (Ford & Håkansson, 2006b:249). Instead, ideas concerning (long-term) relationships, interaction between customers and suppliers, heterogeneous actors, and interdependent activities were introduced (ibid). Over the years, different researchers have focussed on different aspects of the industrial network approach, but these basic theoretical underpinnings have remained the same. I will not give a detailed description of the development of the industrial network approach, however, but instead focus on the concepts that are the most important for the purpose of the paper.

The following text will provide a few snapshots of important aspects. These are, in the order they are presented, the following ones:

- Some comments on the basic ontological and epistemological assumptions of the IMP approach
- The introduction of the *resource* concept (from an IMP perspective)
- Developing *resources*, i.e. *technological development*
- Transferring *resources*, i.e. *technology transfer*

As many researchers using the IMP approach uses neoclassical market theories as the antithesis of the network approach, there is where we will begin.

Underlying Assumptions of the IMP Approach

Something that is important to consider is that the IMP approach has been developed primarily through numerous empirical studies. According to Snehota, this approach differs from the conceptions of neoclassical economics on several issues: “First, it emphasizes rich communication and interaction between market actors /.../ entailing not only information exchange but also important elements of social exchange” (2004:23). The author then continues by giving examples of elements of social exchange, some of which are: the building of trust and commitment; the need for adjustments over time, and therefore the need for continuity; and the creation of relationships between specific actors, and therefore the creation of specific interdependencies (Snehota 2004:23-24). Another characteristic that is prevalent in networks, and distinguishes the network from the market, are heterogeneous actors (with regards to e.g. production, demand and roles).

One of the reasons for interaction over time is that “relationships become a way to deal with the unpredictable and unforeseeable future. Continuous interactive market relationships permit not only access to the resources of others but also the ability to find and work out solutions to problems they meet by drawing on the experience and capabilities of others.” (Snehota 2004:24-25) The reason for

contrasting markets and networks is not to say that one is right and the other one is wrong. They emerge from very different ontological beliefs, however, and since many theories, implicitly or explicitly, still use the neoclassical market as the foundation, it is important to point out in what way the IMP approach differs. Some of these differences are therefore pointed out in table 2 below.

Table 2 **Contrasting Markets and Networks**

<i>Aspect</i>	<i>Market perspective</i>	<i>Network perspective</i>
Actors (Firms)	Independent Anonymous Individual actor too small to affect the market Homogenous actors	Interdependent Well-known counterparts Individual actor able to affect the network Heterogeneous actors
Products	Homogenous Developed by individual firms (linear technological development)	Heterogeneous Developed through interaction (interactive technological development)
Specific Characteristics	Specific and separate activities for different kinds of actors Driven by demand Single exchange episodes	Networking blurs the boundaries of activities Driven by problem-solving Relationships

Source: Håkansson, Harrison & Waluszewski, 2004; Ford & Håkansson 2006b: 25; Snehota, 2004.

A lot of the differences that can be seen between the market perspective and the network perspective in table 2 above are similar to the differences between the standard view and the constructivist view in table 1. We will come back to these similarities in the concluding remarks.

As can be seen in table 2, an important aspect of networks is *interaction*. The exchange activities of the market are replaced by repeated interaction developing into relationships. According to Ford and Håkansson, “an interaction episode is not just an island of significance in a sea of ordinariness, if for no other reason than that its significance will be impossible to assess at the time” (2006a:11). According to these authors, most interaction episodes are rather insignificant everyday business events, but it is these episodes that, taken together, form the relationship between the actors. However, any “single episode will affect each of those involved in it differently. A single episode is also likely to be interpreted differently by each of them and by others around them.” (Ford & Håkansson, 2006a:11) The interaction episodes form a pattern that can form strong relationships over time. These relationships, in turn, result in the fact that “the facile switching among easily available alternatives which is assumed in economic analysis no longer applies. History becomes important. Inertia is introduced into the system and the rules of optimum resource allocation fail as relational constraints start to bite and motives other than short term profit maximisation begin to dominate.” (Axelsson & Easton, 1992:6)

Assuming the adoption of the IMP approach, how does this affect the focus of this paper, the interaction between science and business? Is this view only valid when looking at business relationships, i.e. is there a difference when one of the parties is a research organization rather than a company? These questions will be addressed later, but first we will move on to the description of the industrial network model (also called the “ARA-model”) and the different variables it contains.

Network Models and the Resource Concept

The industrial network model (Håkansson, 1987:13-9; Håkansson, 1989:16-22) is one of the most recurring IMP constructs, and it has been used as the analytical model in a vast number of IMP publications. One of the basic assumptions is that “[a]n industrial network consists of companies linked together by the fact that they either produce or use complementary or competitive products. Consequently the network always contains an element of both co-operation and conflict.”

(Håkansson, 1989:16) In order to analyse the network, however, some variables, or tools, are needed. The tools chosen were activities, resources and actors (hence the “ARA-model”) (Håkansson, 1987).

If we start with the actor concept, actors consist of companies and other institutions, *on different levels*. An actor can therefore be anything from an individual to a group of companies, depending on the focus and level of analysis. Actors perform activities, while controlling and using resources. They also have knowledge of activities and resources (and this knowledge constitutes a resource in itself). (Håkansson, 1989:17) The activities performed “do not occur in isolation; in most cases they can be seen as links in longer chains” (ibid, p. 19). It is through the activities that the resources are combined and recombined. Resources can, as will be discussed more thoroughly below, be of different kinds, but what unites them is that they all are both heterogeneous and interdependent, and that their value is created in their actual use, i.e. in interaction with other resources (Håkansson & Waluszewski, 2007).

The network model (Håkansson, 1987, 1989) has been developed further in order to include additional aspects of the network. One example is Håkansson and Snehota, who extend the model to include an analysis of activities, actors and resources on three different levels; company, relationship and network levels (1995:42-9).

Based on the interest of individual researchers, different aspects of relationships and networks have been studied. In Uppsala, for instance, there has been a strong focus on the resource element (see e.g. Waluszewski, 1989; Wedin, 2001; Baraldi, 2003). The so-called resource interaction model

(Håkansson & Waluszewski, 2002; Baraldi, 2003; Gressetvold, 2004) is a development of the resource element, where the focus is on four resource entities; two of which are considered technical and physical, i.e. *products* and *production facilities*, and two are considered social, i.e. *business units* and *business relationships* (Håkansson & Waluszewski, 2002; Gressetvold, 2004). In the following part of the paper, the attention will be focussed primarily on the resource variable of the industrial network model.

Resources in Industrial Networks

The importance of controlling resources is not anything the IMP approach has sole rights to, but the methods to acquire this control may vary depending on theoretical approach. Williamson, for instance, talks about markets and hierarchies as different modes of acquiring the resources needed, where crucial resources should be integrated within the organisation (Williamson, 1973). What the IMP approach contributes with, however, is another way to control resources: “The importance of controlling any one of these [resources] will vary at different times, as will the individual company’s opportunities for acquiring such control. This control can be exercised in two ways: either directly in that the control formally owns the resource or the right to use it (hierarchic control); or indirectly, in that the company has a close and stable relationship with a unit which possesses formal control over resources.” (Håkansson, 1989:17-18) In addition to acquiring resources, resources can be accessed through relationships.

Earlier in the text, it was mentioned that the IMP approach considers resources to be inherently heterogeneous. The concept of resource heterogeneity is not new, however. According to Baraldi, “[t]he notion of *resource heterogeneity* (Penrose, 1959) stresses that the *value of a resource* is not given by a resource itself, but by how it is combined with other resources” (2003:12). Other authors also stress the creation of value through resource combination (see e.g. Håkansson, 1989; Håkansson & Waluszewski, 2007).

Resource combination, or *resource interaction*, is also the topic of more recent work on the resource aspect of industrial networks (Håkansson & Waluszewski, 2002; Baraldi, 2003; Gressetvold, 2004; Håkansson & Waluszewski, 2007). In most studies, however, the resource interaction model has been used in order to study technological development, wherefore it will be further described in the text below.

Developing Resources

Within the IMP tradition, technological development is a subject that has been studied extensively (see e.g. Håkansson, 1987, 1989; Waluszewski, 1990; Wedin, 2001; Holmen, 2001; Håkansson & Waluszewski, 2002; Bengtson, 2003; Baraldi, 2003; Gressetvold, 2004; Håkansson & Waluszewski, 2007; and many more). One of the main tenets of this tradition is that technological development takes place in interaction. According to Håkansson, Henjesand and Waluszewski “relationships can be used to increase innovation or technological development” (2004:10). Most of the studies also show that technological development occurs when resources are combined and recombined: “Relationships are important, as they provide a framework for the resources from the two units to systematically relate to each other. Resources can be combined and confronted, and new features and uses can be found.” (ibid.) This part of the text will focus on technological development, and specifically on how (new) resource combinations lead to technological development.

Resources have been defined in different ways in different IMP studies, but there is a consensus regarding many of the features: that resources are heterogeneous, that there are different kinds of resources – some physical/tangible, and others social/intangible. Knowledge is also a concept that is widely used, mostly when social resources are discussed, but it is also an inherent part of the physical resources. According to Håkansson, “[n]ew knowledge in terms of new product or process ideas often emerges at the interface between different knowledge areas. In exchange situations different kinds of knowledge come together (are combined or confronted) to create innovative situations.” (1987:4)

There are different ways to achieve technological development through the combination and recombination of resources. A “new combination of two resources can generate interesting new products, which in turn will affect the value of the resources. Or an old solution may be applied to a new problem so that new uses for old resources are created, and so on. Thus the value of one resource is determined by the other resources with which it is combined in various activities. All of this means that knowledge and learning about resources are also important functions.” (Håkansson, 1989:18-19)

So far, ample evidence of earlier studies’ perception of resources has been given, but in order to actually analyse resource interaction, a more precise analytical tool, is needed. The 4R model (Baraldi, 2003) or the “four resource entities model” (Gressetvold, 2004) may provide an answer. It is beyond the scope of this paper, however, to delve even further into the different resource models, so we will now move on to discussing another concept that is very popular within policy discussions

concerning investments in basic science, namely technology transfer. Technology transfer is a concept that has been studied extensively within many fields of research, but has been almost invisible within IMP research. In the concluding remarks, some comments will be made regarding the usefulness of the technology transfer concept within the IMP field, but first the concept will be presented.

Transferring Resources

The resources, as well as technologies, used by any organisation in its activities must of course come from somewhere. Either the organisation develops its own resources/technologies, or it receives the resources/technologies used from somewhere else. This seems very simplistic at first, but the discussion concerning technological development and technology transfer is far from simple. This part of the paper will start out with an introduction to the concept of technology transfer, followed by a discussion concerning what technology transfer would be from an IMP perspective, ending with a comparison between the two and a discussion concerning problems with technology transfer.

When doing a study of the technology transfer literature, it soon becomes apparent that a lot of it focuses on a unidirectional flow from the inventor/producer to the recipient/user of the technology/knowledge in question. In the descriptions of this process, what is transferred is also commonly “black-boxed”, so that the technology is something already packaged and static. Adhering to an IMP view of *resources* means looking at the technology in question like something that is not fixed and pre-packaged, but rather something that develops and (perhaps) changes in the process of transferring it. It means looking at the interaction between counterparts rather than at the technology as such, because there will be no “technology as such”.

There are authors that tend towards an “interactive view of technology transfer”, and some of these studies have even been carried out at CERN. According to Hameri, “the transfer of technological knowledge is not a one-sided phenomenon, from fundamental research to industry, but a two-fold process where the interference and cumulative effect of information from both parties provides solutions and new insight with both an epistemic and an economic impact” (1996:53). More recently, another article based on CERN material defines technology transfer as: “Intentional, goal-oriented interaction between two or more persons or social units, during which technological knowledge and or artefacts are exchanged, and during which the sum total of technological knowledge possessed by the parties stays stable or increases” (Autio, Hameri & Vuola, 2004:108-109). According to this definition, technology transfer is *interactive*, but it is also *intentional* and *goal-oriented*. In order for

something to be called technology transfer, the outcome thus has to be planned beforehand. This idea therefore presupposes that technology transfer is something manageable; something that can be planned, executed and evaluated. But if we stay true to the idea that technology transfer is an interactive process, then the outcome cannot be planned beforehand and the interaction will more often than not lead to unexpected consequences. This argument, in turn, means that describing the technology transfer as a linear process or activity is impossible. Interactivity, by necessity, entails a movement back and forth between the counterparts, which also means that a linear description would not encompass the complexity of the interaction. This idea is also supported by Mowery and Rosenberg when they claim that “[r]ather than a unidirectional, one-time occurrence of transfer of basic scientific knowledge to application, the processes of innovation and knowledge transfer are complex and interactive ones, in which a sustained two-way flow of information is critical” (1989:8).

According to Seaton and Cordey-Hayes, there are a number of limitations to the most commonly used models for technology transfer (1993:47). One of the limitations concerns the tendency to “offer ‘technology’ primarily in terms of technical and economic attributes, i.e. as a product” (ibid). This limitation relates to the inclination to black-box technologies. Another limitation is the tendency to “underestimate the importance of the interactive processes and mechanisms between the donor /.../ and the recipient, necessary for successful transfer. They fail to recognize that successful transfer seldom involves just a simple one-off transaction but is a process or a dialogue between a variety of actors in the two parties and involves a continuing relationship to the point where real benefit accrues to the recipient” (ibid). In this quote, technology transfer is thus seen as an interactive process, but the focus of the article is still on increasing the donor’s awareness of the recipient’s situation, rather than on the process as such (Seaton & Cordey-Hayes, 1993).

This far into the discussion, it may be useful to point at the particular aspects that separate “traditional” and “interactive” technology transfer. If we start with the “traditional” view, the technology is something pre-defined that can be regarded as a product, or a “black box”. An interesting problem that emerges with an interactive perspective is that the technology becomes, at the same time, the result or product of interaction, an element in interaction and a reason for interaction. The technology is a result of the process and therefore not defined beforehand. Moving on to the transfer process, the first perspective will provide us with a linear process, where the technology is moved from A to B in an intentional, goal-oriented manner. From the previous text, it has already been concluded that an interactive view of technology transfer deals with an interactive process with unintended consequences. The process will result in something, but this cannot be planned beforehand. These arguments are summed up in table 3.

Table 3 Different Perspectives on Technology Transfer

	<i>'Traditional' Technology Transfer</i>	<i>'Interactive' Technology Transfer</i>
<i>Technology (T)</i>	An already existing product, A 'black box'	T is, at the same time: - an outcome/product of interaction - an element in interaction - a reason for interaction
<i>Defining T</i>	Defined beforehand	Only possible afterwards, produced in interaction
<i>The Technology Transfer (TT)</i>	Moving T from A to B, A linear process	An interactive process
<i>Outcome (of TT)</i>	Intentional, planned beforehand, goal-oriented	Result of a process, with unintended consequences

These two perspectives on technology transfer share a lot of their traits with different perspectives on technological development. An important point to make, however, is that “interactive” technology transfer has a lot in common with technological development (from an IMP perspective). It can therefore be questioned whether it is useful at all to discuss technology transfer within the IMP approach, because from an interactive perspective, all successful technology transfer includes aspects of technological development. Based on this perspective, transferring a technology successfully means development. We will come back to this question in the concluding remarks, but first we will address some problems related to technology transfer (and with defining the concept).

Problems with Technology Transfer

The first problem concerning the concept of technology transfer has to do with the differentiation between the technology on the one hand and the knowledge about the technology on the other. Is it possible, or useful, to disentangle the two? According to Bozeman, “simply focusing on the product is not sufficient to the study of transfer and diffusion of technology; it is not merely the product that is transferred but also knowledge of its use and application” (2000:629). If we take the approach that technology is always transferred together with the relevant knowledge, we do not have to differentiate between them. The position taken in this paper is therefore that “when a technological product is transferred or diffused, the knowledge upon which its composition is based is also diffused. Without the knowledge base the physical entity cannot be put to use. Thus, the knowledge base is inherent, not ancillary” (ibid). This stance has a couple of implications, 1) that if somebody were to attempt to transfer a technology without the exchange of sufficient knowledge, it would turn out a failure, and 2) that successful transfer of technology by definition means successful transfer of knowledge needed. The second implication becomes relevant also from an IMP perspective –

successful technological development per definition means that enough knowledge has been shared (through interaction) to allow for a successful use of the technology in question.

Apart from the knowledge aspect, there are other problems with technology transfer. The first one concerns how to distinguish the technology from its context. According to Bozeman, “whether technology transfer or knowledge transfer, a perpetual challenge is demarcating the transfer object from its environment” (2000:629). If you cannot distinguish the object from the environment, you are faced with another problem: “If the technology transfer fails, is it because a different social technology has been transferred or is it because the technology has been less successful in a different setting?” (ibid.) In other words, have you successfully transferred a technology, which does not work in the new setting, or have you failed already in the first step, when defining the technology? If we translate this into IMP terminology, the question becomes whether the new combination of resources (social and/or physical) could create the same, or more, value than the old combination. Resources are unique, and the recombination of a resource in a new setting is not necessarily successful.

The second problem concerns the capabilities of the receiving company. According to Seaton and Cordey-Hayes, “technology transfer will be successful only if an organization has not only the ability to acquire but also the ability to assimilate and apply ideas, knowledge, devices and artefacts effectively. Organizations will respond to a technological opportunity only in terms of their own perceptions of its benefits and costs and in relation to their own needs and to technical, organizational and human resources” (1993:48). These arguments come very close to discussions about the absorptive capacity of organisations, i.e. “the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen & Levinthal, 1990:128). Mowery and Rosenberg present the same ideas when they state that “[t]he ability to adopt a new technology, to evaluate a new technique, or even to pose a feasible research problem to an external research group may require substantial technical expertise within the firm” (Mowery & Rosenberg, 1989:8).

A third problem with technology transfer can be found in trying to measure the impacts of the transferred technology, because these “impacts are usually numerous and they are almost always difficult to separate from other parts of organizational life” (Bozeman, 2000:627). This means that even if technology has been transferred, it might not be recognised. Another aspect of this is that the transfer can be considered unsuccessful, but that something else has been transferred in its stead. This can of course be both positive and negative.

Before moving on to the last part of the paper, some summing up of the most important points so far is in order. One of the starting points of the paper was that science is more and more expected to benefit society in a direct way. One of the possible alternatives is to become more involved in business development through the means of (scientific) discoveries that can lead to technological development. This paper advocates an interactive approach, based on IMP research, in order to, by way of studying resource interaction and development, analyse the interaction between science and business.

The Business of Science – Some Concluding Remarks

This paper has provided an attempt to outline a theoretical frame for studying and analysing the interaction between science and business. In this final part of the paper we will move from “the big picture” to smaller details when the theoretical frame is discussed. Therefore, we will start with a few comments on the integration between an STS approach and the IMP approach, and thereafter move on to some of the specifics within the IMP approach.

The first finding in the paper is that there are many similarities between what is labelled the constructivist view of STS (Bijker, 2001) and the IMP network perspective, and there are also a lot of similarities in the way they are contrasted with another perspective. There are three main issues that will be highlighted here (although many more can be found):

- 1) *The problem with linearity.* Both the constructivist view and the network perspective dismiss the notion that there is a simple, linear relation between science, technology and society/business. In addition, there is no simple, linear process that can be planned behind technological development – it is much more intricate than that.
- 2) *The problem with drawing boundaries.* Just as networking blurs the boundaries of activities (IMP), there are no clear distinctions between different scientific, technical and political domains (STS). There are no objective boundaries, and all definitions are subjective as well as context-specific.
- 3) *Development and control of technology.* According to the IMP view, technology is developed through interaction, and it can also be controlled through stable relationships (and therefore through interaction). This interaction, however, will lead to a continual development of the technology in question, because by simply interacting, things will change. When it comes to the constructivist view (STS), two points are made: i) that the development and the effects of a technology cannot be separated, and ii) that technology is context dependent and therefore it

is difficult to separate development and control. These statements could have been made by IMP researchers as well.

The similarities between the two view should make a combination of the two fruitful, especially since A) there is still a lot to do for researchers who want to use the IMP approach to study science, and B) there are very few studies if the business side within the STS field.

The second finding relates to the *definition of resources*. By categorising resources according to the resource interaction model, and by studying *interaction* between resources, new insights into how science and business interact (and also whether if, and then when and in what way, science can be useful to industry). Without relating the finding to any empirical material, only a few suggestions as to how to use the model will be made. The first one concerns interaction between the involved parties, on an actor level, in order to pass on (scientific and/or technological) knowledge. This interaction can also be discussed in terms of *interaction between social entities*, or intangible resources. The second factor concerns interaction on a resource level, *between different kinds of physical entities*, or tangible resources. It has been pointed out that “science can represent an important contribution in the development of a new research tool. But its role as user is of equal importance from a business perspective. Without the academic institutions’ involvement in testing of new prototypes, without their use of new solutions in research, and without their producing research publications, there will never be a user side for a new scientific research tool. In these cases science has an interesting double role; it can be the source of knowledge but also the valuator of the usefulness of new knowledge.” (Håkansson & Waluszewski, 2007:7) This quote shows both that there is interaction between physical entities as well as social ones, and that interaction is the key to development.

The third finding has to do with *development of resources*. If we accept the theories concerning interaction as the base for science’s usefulness to industry, then we have to revisit the concept of technology transfer. As has been shown in the paper, the concept of technology transfer builds on the notion that technology, or technological knowledge, can somehow be bundled up, packaged and moved. Provided that technological knowledge is not “transferred” but shared in interaction, then the very concept of technology transfer becomes less useful. When interacting, the knowledge shared will be developed and adapted to the new situation, and both parties will contribute to this development. If we, as scholars, study this process, we are not studying transfer of technology. Instead, what we study is technological development. This also means that it becomes unnecessary to distinguish between technology transfer and technological development – because there will be no transfer without development.

This paper has provided a first step in the creation of a theoretical frame for analysing the interaction between science and business. Although a lot of aspects need to be developed much further, the initial findings show promise that, by allowing an STS view to influence the framework, and by focussing on the resource aspect of industrial networks, an analytical frame can be developed. A frame that, by combining and recombining knowledge, will help develop our knowledge about business and science. In order to achieve that goal, however, further work has to be done on the STS perspective, so that both theoretical approaches are made justice.

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