THE DEMATERIALIZATION POTENTIAL OF SERVICES AND IT: FUTURES STUDIES METHODS PERSPECTIVES

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1 Introduction

Last year, we started a research project called *Dematerialization: the potential of services and information technology*. In our review of the current discussion on the issue (Heiskanen and Jalas, *forthcoming*), we found it both broad and limited. Examples, concepts and approaches abound. There are advocations for product developers and business managers. There are even some economic and systems frameworks and models. But there is little empirical work on *which services and IT applications actually contribute to dematerialization*. There is also little research on the *feasibility* of such shifts. Furthermore, the *social consequences* of *and conditions* for such changes have not been adequately explored.

The project consists of a number of sub-projects focusing on different applications and using different research methods (e.g., interviews with service developers, expert panels, statistical analyses). A view shared by all sub-projects is that there is something promising and interesting in ideas about dematerialization, information technology and services. Yet we are sceptical about the most enthusiastic forecasts and advocations, which seem to overlook the dynamic nature of the co-evolution of technology, business practices, the economy and society. The future dematerialized service and information economy cannot be developed simply on the drawing-boards of economists and environmentalists.

Many of the enthusiastic proponents of dematerialization take an engineering and mainstream economic approach to society. They have assembled much evidence that current levels of well-being could be achieved with radically lower natural resource use. To put it bluntly, they see dematerialization as an optimization problem, which can be solved through systems design and the right incentives. But can social systems be optimized that way, and who has the power to do so? And when optimizing one subsystem, does this not spill over to others (i.e., the rebound-effect)? So, to complement the existing literature, we are trying to develop a social science perspective on the conditions and consequences of dematerialization through services and information technology.

This paper discusses both the methods used in the invidual sub-projects, and some theoretical perspectives on the whole project. First, the discussion on dematerialization is introduced, as well as our central concerns related to it. The next section presents a brief overview of the potential contribution of services and information technology to dematerialization. This is followed by a more detailed discussion of the

problem of the rebound effect. Then, the individual studies that make up the project are presented, including one study addressing the rebound effect through a time-based approach to evaluating dematerialization. The final section discusses some of the theoretical concerns of the whole project, positioning it in a futures studies context.

2 Focus on dematerialization

Dematerialization has become an important goal for ecological sustainability in recent years. A variety of interests and arguments have contributed to this focus on reducing the quantity of materials flowing through the economy.

One is the growing recognition of difficulties in assessing the relative harm of different substances and interventions. Thus, it has been argued that it would be wise, in the face of ignorance, to limit anthropogenic flows of substances to a (politically defined) proportion of the natural substance cycles (Baccini and Bruner 1988).Furthermore, some wastes are not problematic by nature, but because of their extensive amount (such as CO_2). Carbon dioxide is a waste that cannot be economically controlled at the output stage, but only by decreasing the use of carbon-rich fuels. In fact, it has been recognized that relatively few waste substances can actually be monitored and controlled at the output end, i.e., mainly those emanating from stationary, point-source sources. Thus, reducing the speed and scope of human interventions can be seen as a *precautionary approach* in the face of uncertainty.

Dematerialization can also be argued for from the perspective of global equity. Currently, one-fifth of the world population in the rich countries of the North consumes four-fifths of world resources. If developing countries were to attain northern lifestyles, natural resource flows would grow five-fold. Taking into account expected growth in population, this would translate into eight times the current global material flows by the year 2040. Such a growth in global resource mobilization and dissipation would place an insupportable strain on natural life support systems. Improving natural resource productivity by a *factor of 10* has been suggested as a solution to this quandary (Schmid-Bleek 1994; 1998).

Dematerialization has also gained interest in the wake of discussions on eco-efficiency (WBCSD 1996). This concept links economic and ecological efficiency in a discourse that is attractive to business and other stakeholders with a concern for the economy (Cramer 1998; Ad hoc committee 1996). Whereas end-of-pipe pollution control measures mainly meant more costs for industry, the concept of eco-efficiency raises the idea of cleaner production (i.e. less pollution at lower cost) to the strategic level of business management. On a macro-economic level, the appealing idea has been presented that resource productivity could be improved to the same extent as labour productivity during the past century. Thus, economic growth could be de-linked from materials use, and opportunities for employment could be enhanced (e.g., Schmidt-Bleek 1998).

Dematerialization holds the promise of many good things at the same time: environmental conservation, global equity, business competitiveness and full employment. It sounds too good to be true. Without going into a variety of critical arguments about whether aggregate natural resource use adequately reflects environmental stress, we would like to raise two other problems that need to be

addressed: *the rebound effect*, and the *social consequences and preconditions for dematerialization*.

Overall materials consumption is not determined merely by the efficiency of materials use. Improvements in materials efficiency can be compensated by increases in consumption or by changes in the structure of consumption. In a dynamic and growing economy, when the productivity of a resource is improved, resources are freed for other uses. This is the essence of the *rebound effect*. Thus, the 'win-win-win' situation postulated by advocates of dematerialization may not be easy to reach in practice. One of the studies in our project (*Consumer services: a transition from domestic activity to marketed services*) aims to tackle the rebound paradox by developing a time-based approach to environmental evaluation (see sections 4 and 5.3).

Authors such as Lovins et al. (1999) emphasize how inefficient our economy is in using natural resources. Technically, the services that we require, such as mobility, nourishment, shelter and communication, could be produced with a tiny fraction of the current resources. This waste of resources is typically blamed on unpriced externalities, outdated economic thinking and engineering practices, 'perverse incentives' and lack of systems thinking (e.g., Schmidt-Bleek 1994; Lovins et al. 1999; Hawken et al 1999). We are advocated to make the 'efficiency leap'. This reflects a sophisticated view of engineering design, but perhaps a somewhat naïve view of the co-evolution of technology and society (see e.g., Heiskanen and Pantzar 1996). Our project aims to investigate the *social consequences and preconditions* for dematerialization, and some of our thoughts on the issue will be discussed in the final section of this paper.

3 How can services and IT contribute to dematerialization?

Services and information technology have recently gained much attention as potential sources of non-material wealth creation. There are some clear grounds for this enthusiasm: in principle, services and information technology could help to create a less materials-intensive society. However, whether their onmarch will actually reduce the consumption of natural resources is an open question. This section presents some of the arguments for and against these hypotheses.

Potential benefits of services

Some of the discussion on 'eco-efficient services' is overblownly enthusiastic. However, there is a hard core of sound reasoning in arguments for services as a means to dematerialize the economy. Services do entail some specific organizational and economic potential for dematerialization when compared with product sales:

- Services provide ways of *organizing* markets to facilitate shared and more intensive product use (e.g., car-sharing). Thus, fewer products are needed and efficiency improvements can be adopted more swifly (e.g., the lifetime milage of a car is utilized more swiftly). Furthermore, customers have access to a variety products to suit their changing needs (e.g., cars of different sizes); hence, there is no need for 'overkill'. Services conducted on a professional scale (e.g. car maintenance, car-wash) can also be operated more resource-efficiently than by

individual customers. The service model may also facilitate better end-of-life product management (e.g. recycling of used cars).

- Services also present service providers with different *economic incentives* than product sales. Revenues are not gained from producing and selling as many products as possible, but rather, material products become cost factors to be minimized. So in principle, service providers have the incentive to extend product life of, e.g., rental goods. If services go beyond rental to include product operation (results-oriented services), service providers also have an incentive to minimize operation costs. *Ideally*, a service business model would imply an aggregation of all life-cycle costs to the professional service provider, thus eliminating all information deficiencies that occur in market transactions, making energy and material costs more relevant by accumulating them in one company, and providing customers with 'pure needs-fulfillment'[1].

Potential benefits of information technology

The rapid development of information technology and communication, infrastructures and services have significantly impacted the ways in which societies are organized. The associated economic and social changes affect our work, leasure time, transport and our use of materials and information (e.g., Arnfalk 1999; Kahilainen 2000). The environmental impacts of this development, however, are still poorly understood. Are we entering the information society which is more sustainable than industrial society, or are we just using our new technology to speed up environmental deterioration?

From a business perspective, the provision of new IT based applications instead of "traditional" products and services is regarded as one promising means to reduce natural resource use and to increase eco-efficiency. These IT based applications, which also have the potential to decrease the environmental impacts of our activities, include, among others, videoconferencing, telework, and electronic commerce. Frequently mentioned environmental benefits associated with the use of IT include travel reduction and lower material and energy intensity of products and processes (EC 1998; Arnfalk 1999). IT is also an important component in the shift towards more immaterialized services (Kahilainen 2000).

Basically, IT applications may facilitate dematerialization in two main ways. They may either improve the efficiency of existing operations (e.g., logistics) or create totally new, dematerialized ways of operating which substitute the old ones (such as digitalization of printing processes). Further advantages of IT applications include better information management and movement; IT breaks down traditional barriers to information flow, location, costs, and time (EC 1995).

[1] It is obvious that this ideal is often not met in real life. Rental cars or equipment are no different from ones that are sold and professional products are not necessarily more energy-efficient than consumer ones. Even aggregated materials and energy costs are not necessarily relevant enough to make a difference, and of course, energy and material costs are only a fraction of the external costs related to resource consumption. Furthermore, the changed incentives only work when the service provider can control resource use through product and service design and operation. When users' behaviour, such as building residents', is crucial to natural resource use, shifting the responsibility for costs to service providers (e.g., including energy bills in rents), only makes matters worse.

Qualifications to the arguments for services and IT

So as not to deceive ourselves, these optimistic claims require quite a few qualifications. In reality, there is very little concrete evidence that services and information technology have actually accomplished any dematerialization. In contrast, in spite of a considerable growth in information technology and the service sector, the total material requirements of the Finnish economy seem to have actually grown slightly, rather than declined (Mäenpää and Juutinen 2000, see also Cleveland and Ruth for some more general counter-evidence). Even the least material kinds of services seem to require a supporting infrastructure of goods, materials and energy.

It is also worth noting that most old and new services, including those using information technology, have been or continue to be developed with little or no consideration for the environment (e.g. Welford et al. 1999). Having the *means* to use less materials does not mean that they will be *adopted*, nor does it guarantee that their adoption *will actually lead to dematerialization* (everybody remembers the 'paperless office'!). So it would be overly optimistic to claim that all services, and all information technology, lead to dematerialization. One of the most wicked problems in this context relates to the rebound effect, which is discussed in the next section.

4 The rebound-effect in the service discussion

The improvements in materials efficiency can be compensated by increases in consumption or by changes in the structure of consumption. Rebound effects refer to a situation in which an efficiency gain creates incentive or potential for additional consumption[2]. There is very little empirical work on the rebound-effect even though the importance of the issue is recognised. Examples of rebound effect allow one, however, to recognise some of the fixed macro level axes that rebound effects are thought to revolve around. These axes are alternative modelling concepts for what is considered to constrain the size of the economy.

1) Purchasing power (Malaska, 1997, Wernick et al, 1996) – it is frequently mentioned that savings for example in energy consumption will be directed at other, potentially more energy intensive areas or that energy saving equipment increase the use of the products such as fluorescent lights.
2) Production capacity – as there are exit costs in production activities, a lower demand on materials will lower the price of the materials and create an incentive for increases in consumption.
3) Employment (Norgård 1994 , Littig 1999) – as labour productivity increases or some products can be eliminated altogether, there are constant needs to find new jobs. Some of the new jobs may be associated with lowering materials inputs of existing processes, but some prompt increases in consumption.
4) Time-use (Georg 1999, Littig 1999) – Individual consumption is determined by the structure of time-use and by the associated consumption. Therefore any time-saving product or service has an implicit potential for increasing consumption.

[2] In line of this definition e.g. population growth and economic growth are not considered as an rebound-effects although they clearly do compensate efficiency gains. The rebound-term is also used in the wider sense of anything that increases total material requirement.

The rebound-axes have two kinds of implications. One is the negative effect that if an activity is removed from the economy, the space is filled with another one, which lessens the positive impact that was envisioned. The positive implication is that an introduction of a new activity leads to the elimination of a potentially more resource intensive one. The implications depend on how fixed the axes are. Purchasing power and capacity utilisation are less fixed, and thus they do not provide a strong hold in the long run.

In the purchasing power argument the rebound-effect revolves around the fact that savings in material use are not associated with lower size of the economy. Even in a state of zero growth the savings in some area will be directed at consumption in others. A target of constant growth obviously means that there is more room for increased consumption. The positive purchasing power argument is used when it is claimed that, for example, increasing telephone bills are a sign of dematerialization. However as there is no fixed size of the economy, the link between increased consumer expenditure in a dematerialised service and the future total material requirement remains unclear. The axis of purchasing power does not allow predictions of where the rebound-effect appears.

Production capacity has more a technical nature. These investments in production capacity are thought to define the total material requirement. Thus a reduction in the materials-use in some applications will be compensated by an increasing use of the material in other applications. The positive rebounds of production capacity are less obvious even in a short time window. An example from the forest industry could be that the increasing use of wood in construction may limit the material available for pulp and paper processing which is an energy intensive way of using the production capacity of forests. This rebound-axis has a specific character. The effect will take place in the use of the same material that was affected by the efficiency gain. The effect will also be limited in time since the production capacity will be adjusted in time to the changed demand of the material.

The employment axis may be more rigid that of purchasing power. It is subject to change due to changes in labour productivity, but on the other hand, shorter working hours may compensate for this change[3]. Such reductions in materials use that also increase labour productivity or eliminate work tasks thus have a rebound-effect. On the other hand there are such material efficiency improvements that require additional labour input. Telemedicine or Internet banking could be examples of the former and product remanufacturing of the latter. As specific labour force is associated with specific experience, capabilities and geographic location, the appearance and nature of the rebound effect is not totally independent of the efficiency gains.

Time-use is a more robust axis that the three previous ones. As total material requirement can be allocated to final consumption[4], i.e. to slots of time in the time-budget of private consumers, any timesaving products or services will open a new slot

[3] Authors such as Schor (1991) present evidence that the decline of working hours has ceased or that hours are even increasing. Together with labour productivity, this makes the robustness of the employment axis weak.

[4] Final consumption consists of private consumption and of the input for the public services, which in turn are consumed by private consumers

for additional consumption[5]. Similarly, a new activity with a low resource-intensity will lead to a reduction of total material requirement. The increased use of mobile phones or the Internet could be assessed from time-use point of view. How much time is used to the activity? Is it concurrent with some previously existing activity, such as travelling? Or has it acquired a time slot from some other activities and what were their resource intensities?

The time-use effects of given technology have many dimensions. E-mail, for example, can be seen as an new technology that increases the time used for communication, but it can also be seen as a tool to organise one's consumption in a more effective way thus increasing the resource intensity of time-use. Predictions about the areas in which a time-use rebound would take place are also difficult, but possible inertial aspects of time budgets allow some considerations. Some research has, for example, claimed that the daily commuting time has historically remained quite constant and therefore swifter roads tend to increase the commuting distances (Vilhelmsson 1997).

The time-use axis thus provides an interesting new way to assess the potential of new services from the point of view of reductions in total material requirement. The concept of time-use in environmental discussion is rare, but the notions of changes in life-style and structure of consumption are tightly bound with the time allocations of consumers (e.g. Littig 1999, Georg 1999). An important implication of the time-use approach is that the question of sufficiency can be approached without going into the debate of "basic needs". The use of time can be seen as one definition of the meaning of life, and thus the ultimate purpose of materials use and consumption.

Indications of the rebound effect in the service orientation

Even though the service discussion has many elements that are significant from the the rebound point of view, an analytical approach is lacking. One of the core assumptions is that service orientation would enable efficiency gains in material use through the use of additional labour input. Examples in which producers are fleet managers and have an incentive to maintain, upgrade and remanufacture their products qualify for this. The total productivity remains intact, while there are opposite changes in labour and material productivity. As there are no changes in the aggregate costs there would not be a rebound tendencies around purchasing power. When seen for the employment point of view, the example would provide a double dividend while there would be initial material reduction and, secondly, the extra labour force would be employed without additional material input.

However, the most viable service examples have a productivity effect. Productivity improvement, be it labour, capital or material productivity creates a rebound tendency around the purchasing power axis. Labour productivity could be envisioned in many IT applications. Another example is chemical leasing in which expert services can be offered to multiple customers. Capital productivity is at the heart of shared use of goods, which is one of the central themes of the discussion. As proposed above, labour productivity has a second effect in that it frees labour force for other activities with additional material input.

[5] The time-use argument rests on the assumption that the size of the economy is based on demand. In the case of the purchasing power, capacity utilisation and the employment arguments, the size of the economy is determined by supply.

The service discussion also has links to the time-use axis. Services that are produced by households could be produced in the markets more effectively from the materials-use point of view. There are many reasons for the potential efficiency gains, which include shared, more intensive and professional use of the goods, economics of scale et cetera. However, as the shifts also affect the time-use of consumers, they have a rebound effect. The notion of service orientation also contains an assumption of changes in the time-budget of consumers.

5 Approaches to assessing the contribution of services and information technology

The research project consists of three empirical sub-studies: (1) consumer services: a transition from domestic activity to marketed services, (2) the potential of services to dematerialize office work and (3) the dematerialization potential of electronic grocery shopping. In the following, we outline the research approaches adopted in these individual studies.

5.1 Consumer services: a transition from domestic activity to marketed services (Mikko Jalas)

The service discussion widely presumes that consumer services can be produced more effectively by professional service providers (e.g. Gradel, 1998). However, a more market oriented approach has also implications for the time-allocation of consumers. The aim of the consumer services sub-project is explore the role of time-use as a way to get a hold of potential rebound-effects that relate to a service oriented economy (see chapter 4). Time-use effects can be studied case by case, but generalisations seem difficult make. Time-use surveys provide a source of statistical data, which is explored by the current project.

Statistics Finland has conducted time-use surveys in 1979 and in 1987-88 (Niemi et al 1991) and the next survey is scheduled to be published in 2001. The Finnish studies have been based on diaries of a statistical sample of the population. Many cross-national time-use studies have been conducted, and a proposal for common activity classification exists (EUROSTAT 1999, Bediako&Vanek, 1998). The quality of the international time-use data is improving and there are also possibilities for longitudinal research (Harvey, 1998)

Statistical work has been undertaken to merge the results of input-output tables with consumer expenditure data (Nurmela 1993, Wilting&Biesiot 1998, Mäenpää 2000). Combining this work and time-use data should enable to one study the *resource intensity of final consumption activities*. However, the combination is not straightforward. The Finnish time-use data have not been collected simultaneously with consumer expenditure data. Combinations of the expenditure and time use data have been done in previous studies (Harvey,1998). Whether a sufficient level of detail can be reached in the statistical grouping of the Finnish data is still an open question.

In more detail, the aim is to test the arguments of the service discussion in respect to the data of household consumption in Finland in 1987-1990, and in particular in respect to the:

- Absolute materials flows
- Flows in respect to consumer expenditure
- Flows in respect to time use
- Investment costs in respect to time use

New Finnish time-use data will be available in 2001 and as such the present project also aims to develop a methodology to use time-use data in when investigating societal material flows.

Further research questions of the current project relate to the feasibility of a market-oriented shift. The post-war Europe has, in fact, experienced a shift for marketed services to self-services, in which market labour was replaced by the labour of the consumers and consumption became more capital intensive (Gershuny, 1978). As this trend intuitively seems to run counter to a trend of service orientation, its is relevant to review the literature on the evidence and prerequisites of the both trends.

Business-to-business services: the contribution of services to the dematerialization of office work (Minna Halme, Eva Heiskanen)

More and more people today work in different kinds of offices. In Finland, office buildings consume about one-fifth of the heating energy (about 32 GWh) and a similar share of the electricity (about 14 GWh) consumed by the service sector (Motiva 2000)[6]. Offices are increasingly equipped with sophisticated – and rapidly outdated – electronic equipment, and according to one estimate, Finnish government offices consume 87 kgs of office paper per employee. Other relevant material flows related to office work are generated by on-the-job car use and business trips.

Although office work is jokingly called 'paper-pushing', few of the materials used in offices have much to do with the output of office work. Producing documents is not the main reason why we have offices. Mostly, materials are used in offices as a supporting infrastructure, which enables the jobs of administration, communication, and the delivery of financial, legal and other services.

There are a number of services available that could potentially decrease the natural resource intensity of office work. These include:

- Flexible use of office space
- Furniture and equipment rental
- Outsourcing of activities (e.g., copying)
- Mainframe computer systems, Internet updates, document management services
- Energy saving services, waste counselling
- Car sharing
- Telework, teleconferencing

[6] According to a Dutch study reported in van den Hoed (1997), heating, lighting, paper use and business travel and commuting are the most energy-consuming functions in offices.

Our study aims to find out what the dematerialization potential of such services and applications is in Finland. For this, we need to review the current use of such services, and the potential they have for saving resources. For example, we need to find out whether rental furniture and equipment actually has a longer service life than owned products, and what kinds of trips actually can be replaced with teleconferencing. It is also important to investigate how such services fit into the work flow and culture of different kinds of offices.

Many of these services are today not widely in use. Thus, we also aim to investigate what could motivate customers to demand more dematerialized services, and suppliers to develop and market such service offerings.

Our method consists of *market surveys* and *case studies*. We need to survey suppliers to offices: how many are providing resource-efficient services, how do these services work, and who are their main clientele? This in itself is quite a job, as very few of the resource-efficient services are marketed as such. In addition, we plan to use detailed case studies to investigate the conditions for increasing the role of resource-efficient services: what are facilitating, and what are obstructing factors in supplier and customer organizations?

5.3 Dematerialization potential of electronic grocery shopping (Anna Kärnä)

Electronic commerce is among the revolutionary new services that information technology enables. We see e-commerce as a new service innovation that may contribute to dematerialization. Currently, business-to-business applications are more developed than the e-commerce services targeted at consumers. Our interest in this project is, however, in the consumer applications. Electronic grocery shopping is among one of these emerging consumer services.

Grocery shopping is activity performed by each of us every week. Its often an unplanned, unefficient activity which takes considerable time and effort. At the same time, small grocery shops have given way to large hypermarkets which are often located so far away that a car is needed to access them. People commute to hyper-markets in the same way as they commute to work. The stores themselves (all infrastructure related to building, car parks, plumbing, access roads, warehouses, packages, etc.) use more materials per unit sold than ever before (EC 1998).

Therefore, a shift from traditional to electronic grocery shopping includes several interesting dematerialization potentials. How will it influence logistics? How will digital information exchange influence the quality and amount of product information (also environmental information) provided to consumers? Will the efficiency of business operations improve due to electronic orders and deliveries? And how will the new type of market place influence consumption (e.g., 24 hours shopping possibility)?

Our first aim is to analyse what kind of electronic grocery shopping service models exist currently in the Finnish market. Our interest is in finding out why and how these services have been developed. We aim to *personally interview* different *actors* who have been involved in the process of developing and operationalizing electronic grocery shopping services (e.g., trade representatives, Internet service providers,

logistics providers). We are interested in the actors' perceptions on the current and future benefíts and obstacles related to the electronic grocery service development, and whether environmental aspects play any role in this new business development.

The second aim is to organize group discussions for Finnish experts in electronic commerce business and research field in order to define more precisely the environmental benefits and burdens related to electronic commerce, and electronic grocery shopping in particular. Expert visions on the development of e-commerce up to the present and in the future are explored together with foresights of what the key dematerialization components of electronic commerce are.

We feel that it is important to bring the views and perceptions of practitioners in the field, and of the expert community, into the day-light because the development and adoption of electronic commerce is still in its early phases. Most attention until now has been focused on the technical development of these services and not on the usability or attractiveness of these services to consumers which is, however, crucial if we want to achieve true dematerialization. This depends on at least of two factors: how many people have access to Internet based services as well as how quickly and widely these new services are adopted (how desirable and easy- to-use these services are).

It is not clear at all under what conditions electronic commerce could substitute traditional trade and lead to reduced environmental impacts. However, we believe along with the principles of constructive technology assessment, that the development of electronic grocery shopping (technical innovation) and society are not separate but influence each other closely. Therefore, the institutional conditions influencing the development and adoption of electronic shopping services have to be carefully analysed.

Futures studies perspectives

A central tenet of futures studies is that the future is not predetermined, but that the future is made. This is in line with our research problem. On the basis of the evidence we have found, there is certainly nothing pre-determined or inevitable about dematerialization (with or without services and IT). It is a matter of choosing a course of action, but whose choice, and what course of action?

Furthermore, dematerialization in terms of efficiency in materials use cannot be the only goal in society. Efficiency is a virtue, but it is not an end in itself. 'Eco-efficiency' is usually defined as the ratio of benefits to environmental costs, with 'benefits' frequently defined in monetary terms. From a societal perspective, such a definition is inadequate: the goal of society cannot be merely to circulate as much money as possible. Thus, the relationship between materials use and social goals, such as consumer welfare or employee satisfaction, needs to be addressed. People's views of what they want in life, and what are appropriate ways of reaching for it, also place constraints on which measures are acceptable to further dematerialization.

One of the typical methods of futures studies is the use of economic models and trend analyses to forecast the future. Today, there are a number of materials models

available (e.g., Mäenpää and Juutinen 2000, Hoffren 1999). However, economic activity itself is black-boxed in macroeconomic models, due to the high level of data aggregation. If we assume that some services and some IT applications can lead to dematerialization under some conditions, it would be very difficult discover this in a conventional economic model. The sub-study on *consumer services* aims to contribute to statistical analyses and forecasts of dematerialization by linking materials use to consumer time-use patterns.

Much of the hopes of dematerialization through IT and services are placed on private enterprise, consumers and citizens. Services and IT should change the way business is done, and wealth is created, and well-being is pursued, in the economy. Of course, public policy can support or obstruct the desirable courses of action, but they need an understanding of how the economic actors behave to devise incentives and instruments. What kind of changes in their operating environment do the relevant actors notice, and how do they interpret them? What kind of considerations go into their decisions?

Futures studies also typically use *expert-based methods*, such as Delphi panels. In our project, the study on the dematerialization potential of *electronic commerce* aims to use an expert panel to appraise the environmental and social consequences of electronic grocery shopping. However, defining experts in this context is a difficult task: is not the 'tacit knowledge' of those working in the area in practice one source of expertise (see e.g., Kivisaari and Lovio 2000)?

Innovation research is one line in futures studies that emphasizes the role of market actors – and dematerialization through services and IT can certainly be viewed as the development of new social and technical innovations. Current research views innovations as the outcomes of co-operation and negotiation in technological communities (Rosenkopf and Tushman 1994) or innovation networks (Kivisaari and Lovio 2000), which include users, producers and their stakeholders, as well as public policy makers. The sub-studies on *electronic commerce* and *office services* aim, in this vein, to investigate the views and activities of market actors, to see how services that contribute to dematerialization emerge – or fail to emerge.

Dematerialization has been argued for on the basis of social goals. However, much of the current literature on dematerialization is technical or economic by nature. Actors are viewed as rational and utility maximizing. Studies in the social shaping of technology show, however, that technologies do not develop along the lines of abstract technical or economic rationality. Rather, conflicting and ambiguous aims of a broad range of actors shape the trajectories of the co-evolution of technology and society (Kemp et al 1996; Williams and Edge 1996). Furthermore, radical innovations often have long development times, and require the development of the requisite skills, infrastructure and institutional changes (Kemp 1994).

Our exploration of the dematerialization potential of IT and services could thus perhaps be cast in the terminology of technology assessment. In this context, we could perhaps classify our approach as 'problem-based technology foresight' (see Rask et al. 1999). The problem is reaching a factor 10 (of some other figure) reduction in overall natural resource use. Specific services and IT applications are perhaps solutions, but selecting the right ones, understanding how they can emerge, and evaluating the

societal outcomes requires an exercize in evaluating the consequences in close connection with the actors themselves – an approach which is frequently called constructive technology assessment (Schot 1992; Rip et al. 1995).

Current thinking in futures studies methodology seems to emphasize participation, stakeholders and a broad-based debate – but often, the need to combine these with more analytical and expert-based data collection is acknowledged (Cronberg 1996; Kuusi 1999; Rask et al. 1999). While the present project is more expert-based and limited to actual service developers and their customers, in the future we hope to be able to broaden the debate to include the views of a broader constituency.

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