



Material efficiency: An economic perspective

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ABSTRACT

This article presents an economic perspective of material efficiency, and discusses the role of public policy in providing market incentives for a more efficient use of materials. In doing so, it comments on the engineering approach to material efficiency presented by Allwood et al. (2011) in an earlier issue of *Resources, Conservation and Recycling*. We argue that concerns over potential future natural resource scarcities do not represent a strong motive for introducing policies to foster greater material efficiency but that various environmental externalities and information failures in the relevant material markets do. Moreover, in such instances policy makers should opt for policy measures that target the relevant market failures (e.g., environmental damages) as closely as possible. This normally means avoiding policies that directly encourage specific material efficiency options. Policy measures that address particular environmental problems and information externalities will enhance material efficiency in a more effective manner. This is because *ex ante* it is difficult for policy makers to know in what ways and by how much to alter material production and use.

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1. Introduction

In a recent paper appearing in *Resources, Conservation and Recycling*, Allwood et al. (2011) discussed the concept of ‘material efficiency’. Material efficiency encompasses all changes that result in decreasing the amount of engineered and processed materials used to produce one unit of economic output or to fulfill human needs more broadly. For instance, material efficiency in industrial production can be defined as the amount of a particular material needed to produce a particular product. Allwood et al. argued that so far researchers and policy makers have paid too little attention to the different strategies that can promote a more efficient use of engineering materials. Their paper therefore highlighted the importance of a number of material efficiency strategies, outlined some key issues, and attempted to encourage future research efforts in the field. The authors suggested that the need for increased material efficiency can be derived from the limited (economic) availability of natural resources as well as from the environmental benefits of less material use (e.g., reduced climate change). Furthermore, they identified a number of key technical options to address this challenge (e.g., longer product lifetimes, remanufacturing, component re-use, etc.), and discussed a number

of economic, regulatory and social barriers currently preventing the adoption of these options. Finally, the role of public policy in addressing the relevant barriers was briefly discussed.

The engineering framework on material efficiency that was outlined and discussed by Allwood et al. is both relevant and interesting; it should stimulate additional (much-needed) research in the field and hopefully even inspire private companies to develop new business models. However, the same framework, we argue, is of less use and even misleading in identifying important implications for public policy.¹ In the present paper we will instead adopt an economic perspective of the concept of material efficiency, as well as discuss some key roles for public policy.

There are two key components of the economic approach to material efficiency that are much less emphasized (or even absent) in the engineering approach. Both components concern the interaction between those who regulate the economy (i.e., government authorities), and those market actors who comply with

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¹ This paper will primarily comment on the engineering approach to material efficiency that was presented by Allwood et al. (2011), but we will not suggest that their approach is representative of all engineering studies in the field. Nevertheless, the Allwood et al. paper is of particular interest since it displayed an ambition to cover many aspects of material efficiency (e.g., technical solutions, barriers to less material use, policy instruments etc.). Indeed, Allwood et al. claimed to present a “white paper”, which is typically described as an authoritative report or guide that helps solve a problem, educate readers and help policy makers and business to make informed decisions <http://en.wikipedia.org/wiki/Decision_making>.

these regulations (i.e., firms, households, etc.). First, a key challenge for regulators in the environmental field (e.g., environmental protection agencies) is the uncertainty about the most efficient technological solutions to address environmental problems. Second, this means that one of the main tasks for environmental regulators is to provide market actors with the appropriate *incentives* to make efficient decisions on material use. Put in simple terms, while the Allwood et al. paper largely involves a search for a number of “winning technologies” to improve material efficiency, economists tend to search for “winning policies”.

We do not suggest (or believe) that economic theory represents a panacea to address all policy challenges in the environmental field, but the economic approach does provide a useful theoretical framework within which to explore the market impacts of different policy measures as well as for identifying situations in which market actors (firms and households) face too few incentives to invest in material efficiency.

The next section will briefly introduce the economic approach to material efficiency. Sections 3 and 4 will explore the underlying motives for promoting material efficiency as outlined by Allwood et al., i.e., fears of an impending material scarcity and the negative environmental impacts of material production and processing. In these sections we aim at providing an economic analysis of resource scarcity and environmental externalities, respectively, as well as discuss the potential role of public policy to address these problems. We will also comment on selected parts of the analysis presented in Allwood et al. Finally, the paper ends with some brief concluding remarks.

2. Material efficiency or an efficient use of materials?

In economics it is recognized that economic and environmental outcomes are effectively the result of the millions of choices that firms and households make every day (e.g., what to produce, what raw materials to use, where to eat, what means of transportation to use, etc.). For this reason it is essential to investigate the relevant decision-making processes and the types of incentives these actors face. At a general level firms and households do face incentives to economize on the use of those goods and resources that carry a positive price. Materials typically fall into this category. Still, from an economic perspective public policy instruments influencing material efficiency may be desirable if significant market failures (externalities) exist that distort decisions on material purchase and use (e.g., [Perman et al., 2011](#)). Several types of such failures can be identified in the case of materials production and use.

These include: (a) inefficient market prices due to the absence of internalized environmental costs; (b) different types of information failures, not the least the presence of asymmetric information; (c) innovation-related market imperfections; and (d) non-environmental technological externalities that could affect, for instance, the reuse or the recycling of products (see also [Gillingham et al., 2009](#)). Some of these market failures are briefly mentioned in the Allwood et al. paper, but many of the most important policy implications are not addressed. In Section 4 we will revert to a discussion of how to address the presence of environmental and non-environmental technological externalities (i.e., categories (a) and (d) above). It is therefore useful to briefly comment on the other two categories in this section.

The presence of asymmetric information, i.e., where one party in a market transaction has more information than another, may lead to so-called adverse selection ([Akerlof, 1970](#)). In the context of materials use adverse selection would imply that the sellers of recyclable materials or used products that would provide clear *ex post* benefits to consumers are unable to perfectly transfer this

information to buyers since the quality of the goods is (at least partly) unobserved. Assuming that suppliers are divided between those who offer low quality and high quality products, respectively, adverse selection favors the sellers of low quality products who are able to exploit their information advantage over buyers. Sellers will thus have incentives to put low quality products on the market. Analogously, even though buyers have a high willingness-to-pay for high quality, the sellers with high-quality products will not be able to attain a high enough price.

Since adverse selection represents an information problem, information-based measures are the natural candidates for policy intervention. For instance, in the energy efficiency field energy labeling programs make it easier for buyers of energy-using equipment to choose among suppliers, and similar programs could be implemented in the case of material use. It should be noted that the presence of significant information asymmetries may motivate the implementation of policy measures irrespective of the environmental impacts of materials use. These types of information problems thus distort decisions on materials use as such.

The innovation-related market imperfections arise from the fact that new knowledge (e.g., learning-by-doing effects following the adoption of a new technology) often is a public good. For instance, initial buyers of re-used materials generate information that is of value to others and then can be appropriated by others at a low (or no) cost. Because this value is not rewarded in the free market, early adoption may be slower than what is economically efficient ([Jaffe et al., 2003](#)). In this case the role of public policy is to internalize these ‘knowledge spillovers’. In the case of new knowledge through R&D this is in part addressed by patents and by subsidizing R&D activities, while the type of adoption externalities exemplified above could motivate public demonstration projects and procurement programs. We agree with Allwood et al. that increased public R&D on material efficiency should be encouraged, not the least basic research with significant knowledge spillovers across the different sectors of the economy. In this paper, though, we will primarily focus on policies that encourage efficient material use given existing knowledge.

So far the discussion has rested on the assumption of perfectly rational households and firms. Still, the scientific literature (e.g., in cognitive psychology, behavioral economics) often shows evidence of systematic departures from this assumption in individual decision-making ([Shogren and Taylor, 2008](#)). These include, for instance, so-called bounded rationality, which describes a situation where, say, households are rational decision makers, but they are limited by their cognitive ability to process information about different purchase alternatives. Bounded rationality thus implies that individuals apply different rules of thumb in their decision-making rather than assessing the full consequences of all potential choices.

Bounded rationality may be present in many forms. Most notably, many decisions take the form of a choice between retaining the status quo and accepting an alternative that is advantageous in some respects and disadvantageous in others. Research in the behavioral sciences has often shown evidence of inertia in decision-making processes, implying that individuals tend to have a bias toward the present situation and thus neglect potential cost savings (e.g., [Samuelson and Zeckhauser, 1988](#)). For instance, the perception that regrets will be worse, *ceteris paribus*, after an active decision compared to a passive situation can be interpreted in terms of omission loss.

Status-quo biases may help explain the presence of low consumer demand for re-manufactured products or products that are based on recycled materials. At its most extreme, the very terms “recycled” or “used” may have negative connotations in that they cause cognitive associations with risks of inferior quality. This kind of ‘status-quo bias’ can have many sources. Known as reference

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