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Barriers and drivers to energy efficiency – A new taxonomical approach

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ABSTRACT

This paper develops a new systematic classification and explanation of barriers and drivers to energy efficiency. Using an 'actor oriented approach', the paper tries to identify (a) the drivers and barriers that affect the success or failure of energy efficiency investments and (b) the institutions that are responsible for the emergence of these barriers and drivers. This taxonomy aims to synthesise ideas from three broad perspectives, viz., micro (project/end user), meso (organization), and macro (state, market, civil society). The paper develops a systematic framework by looking at the issues from the perspective of different actors. This not only aids the understanding of barriers and drivers; it also provides scope for appropriate policy interventions. This focus will help policy-makers evaluate to what extent future interventions may be warranted and how one can judge the success of particular interventions.

1. Introduction

Energy development is a barometer of economic development. Countries pursuing economic growth are expected to resort to increasing levels of energy use. Achieving these levels of energy production and utilisation through present technologies is not only difficult and expensive, but also environmentally unsustainable. Various studies indicate that increased energy efficiency can bridge the gap between growing demand and reduced energy supply without adversely affecting the quality of service [1,2]. However, as the past experience has shown, this may not happen, unless the issues that hinder the penetration of efficient technologies are addressed [3–5]. There is a gap between the theoretical opportunities for cost-effective energy efficiency investments and the levels that can be achieved practically. The origins of the gap seem to lie in the set of barriers which may be divided into categories such as financial, legal, organizational, or informational.[1] These barriers prevent investments in energy efficient technologies. It is also certain that there are drivers that help increase investments.[2] The barriers hinder the penetration of energy efficient technologies, even though these technologies have been shown to be economically cost-effective. If policies to encourage investments in improved energy efficiency are to be successful, understanding the nature of these barriers and drivers is essential. These policies must succeed both in highly regulated energy markets as well as in the context of liberalizing energy markets in increasing the development of a broad-based energy service industry.

The aim of the present paper is thus to examine the nature of barriers and drivers for energy efficiency. It also analyses the circumstances under which they arise, their relative importance in different contexts, and the way in which different actors intervene to overcome these barriers. The paper reviews current perspectives on barriers and drivers, classifies them according to their influencing patterns, and provides supporting evidence for their prevalence. Finally, the paper tries to evaluate the effectiveness of different institutions for improving energy efficiency. The debate on barriers and drivers is contentious and is characterized by disagreement over basic theoretical and conceptual principles. Hence, the primary objective of this work is to develop a new systematic theoretical framework.

2. Energy efficiency issues

2.1. Debate

There has been a long running debate over the issue of energy efficiency (EE) between energy economists and energy analysts. One issue concerns the rebound effect [6]. Although definitions vary, this effect describes the following linkage: the efficient use of energy leads to an increase in the use of energy. This may partly

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[1] A barrier is a pull factor that inhibits investment in energy-efficient technologies. *Barriers* can be considered as the obstacles to private investment. Barriers should not be confused with *Risk*, which can be defined as a special category of barrier with a probability distribution. To be more specific, it can be defined as an uncertainty connected to the future value of the variable, which could be political, legal, financial, and so on.

[2] *Drivers* can be considered as the factors that promote private investment in energy efficiency, In other words, every factor that facilitates the implementation (feasibility) of a project and/or increases the returns/reduces the risk (profitability) of an investment can be considered as a driver. On the other hand, every factor that does the opposite is a barrier.

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offset the savings in energy usage achieved by the EE improvement. The rebound effect is rooted in neoclassical economic theory. The extent of the rebound effect depends on the price elasticity of demand. In this regard Saunders [7] has argued that 'energy efficiency gains can increase energy consumption by two means: by making energy appear effectively cheaper than other inputs; and by increasing economic growth, which pulls up energy use.' This debate on EE grew more intense in the 1990s, spurred by global warming concerns, which necessitated promotion of EE. The argument for EE, however, can be considered independent of environmental concerns. One market failure that distorts energy use is under-pricing of energy by regulators, but there are also other market failures resulting from imperfect information and split incentives (landlord–tenant) [3]. The reality is that while EE improvements are often technologically feasible, they require significant changes in institutional arrangements and ways of thinking. What this means is that, while technologies are already available, the problem lies in their application.

Another area in the debate on EE concerns government intervention. Gunn [8] who investigated the paradigms of EE stated that it is important to recognize that the primary debate is over the optimal level of governmental intervention in energy markets rather than over the optimal level of EE. There are many forms of government intervention such as subsidies and taxes; special purpose loans; facilitation (information systems; market-friendly regulation; approved suppliers); guarantees for specific risks, or offering insurance; and arranging objective non-partisan product information (e.g., energy labelling). The justification and degree of governmental intervention is a matter of debate in the international literature [3,4,9]. Barriers attributed to market failures make governmental intervention necessary and justifiable. However, not all forms of market failure come in the purview of governmental actions. Haugland et al. [10] argue that most barriers merely reflect 'unaccounted (transaction) costs' or simply result from the consumers' liberty to choose freely their convenience and service levels and willingness to accept a higher energy bill for their personal taste or lifestyle. Therefore, governmental intervention might be questionable.

A large body of international literature attempts an empirical approach to this whole question with different objects of investigations and findings [11–14]. These studies have shown that governmental stimulation of the implementation of new technology by promoting associated research and development may be counterproductive. Although it leads to technological progress it may hinder corporate investments in new technology. Firms may favor to wait till the technology is out of the government's grip or for the next generation of technological developments. However, in the case of restructuring the electricity market, pro-interventionists question whether the market alone is able to overcome EE barriers. It is argued that governmental support in promoting EE and load management can be advantageous. Further advocacies in support of government intervention can be found in the evaluation of US energy labelling programmes [13]. Altogether, the challenge of reconciling government and free market contributions with regard to the energy market and EE remains.

2.2. Characterization of energy efficiency potential

With regard to EE potential, a distinction has to be made between: (a) the *economic* potential: achievable by removing market failures; (b) the *technological* potential[3]: achievable by the additional removal of 'non-market barriers'; and (c) the *hypothetical* potential: achievable through the additional elimination of market failures in fuel and electricity markets [15]. This framework is summarised in Fig. 1 where various potentials towards EE are represented. The market potential is the efficiency improvement that can be expected to be realized for a projected year under a given set of conditions (e.g., energy prices, consumer preferences and energy policies). The market potential reflects barriers and market imperfections that prevent the efficiency potential from being fully realized.

The economic potential is the energy saving that would result if during each year of the period in question, all replacements, retrofits and new investments were shifted to the most energy-efficient technologies that are still cost-effective at given energy market prices. The economic potential implies a well-functioning market, with full information and competition between investments in energy supply and demand. It also assumes that the barriers to such competition have been corrected by energy policies. It is assumed that as a result of such policies, all users have easy access to reliable information about the cost-effectiveness and technical performance of existing and emerging options for energy efficiency.

The technical potential represents achievable energy savings under theoretical considerations of thermodynamics, where final energy consumption is kept constant, and energy losses can be minimized through process substitution, heat and material reuse, and avoiding heat loss. This can be considered as hypothetical potential and represents achievable energy savings that result from implementing the most energy-efficient technology available at a given time, regardless of cost considerations and reinvestment cycle.

The narrow social optimum in the market for energy efficient technologies represents the rate of energy efficiency uptake that would be observed if all barriers that were deemed to be irrational on a cost-effective basis were eliminated, i.e., if individuals and institutions adopted all measures that could leave them economically better off given the current pricing environment [16,17]. In this situation, the primary objective is to get energy prices right. The true social optimum would include additional efficiency diffusion that would likely to be seen by considering environmental externalities.

2.3. Energy efficiency – the private investor's perspective

In this section, we discuss the role of barriers from the private investor's perspective where questions such as environmental externalities play a secondary role. A barrier will only be overcome if it is low enough to be acceptable and the investor is convinced of this fact. This is especially important, as risks are notoriously difficult to judge. In addition, the investor will often, out of self-preservation, have to take account of the 'worst-case' risk, which is a far bigger deterrent than the 'probable-risk'. Thus, we can distinguish the barriers to private financing as profitability-related, feasibility-related, information-related, and risk-related [18].

Profitability-related barriers are those that lessen the financial viability of energy efficiency projects, thereby reducing the willingness of profit-oriented private investors to commit money to such projects. Fig. 2 shows the factors and their relationship that enable the private investor to accept or reject an energy efficiency project. The components making up gross project revenue can include: (a) project performance (e.g., amount of energy saved), (b) sales volume (e.g., number of energy efficient devices sold), (c) price (e.g., price of energy efficient devices), (d) tariff (e.g., electricity tariff), and (e) collection rate (e.g., rate of loan collection on energy efficient equipment sales, rate of utility bill collection). The components of project cost include development and operating cost.

[3] A technical barrier is one where the new technology might be found wanting or become rapidly outdated.