The determinants of the energy efficiency potential and its exploitation

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ABSTRACT

Aim of the paper is an analysis of the theoretical basis of the energy efficiency gap, and an assessment of the policies and instruments adopted in the field of energy efficiency. The approach is based on literature review, and on the analysis of: energy consumption data, efficiency policies and targets in the European Union and in Italy. The paper highlights how economic theory generally undervalues the supply-side role, and specifically the strategic decisions taken by the producers about the energy efficiency of goods. It also confirms the difficulties to assess the results of energy efficiency policies, and to choose and balance the economic instruments they adopt.

Keywords: energy efficiency; efficiency gap and energy paradox; environmental taxes; standards; incentives.

INTRODUCTION

The energy efficiency gap is universally considered the main theoretical foundation for the assessment of the unexploited potential of energy savings both for economic systems and individual consumers. There is consensus in the economic literature that "much-unadopted technology is cost-effective at current prices" (Jaffe-Stavins 1994, p. 92). Fluctuations in energy prices obviously influence the size of the gap, but the conclusion that many investment opportunities exist is common in the literature (Tietenberg 2009). In this context, it is very important to distinguish the energy paradox from the energy efficiency gap (Gerarden et al. 2015). The first is referred to energy-efficiency technologies that would pay-off for individual consumers but are not adopted, while the second is referred to technologies that would be socially efficient. The difference between these two concepts should influence public policies and the choice of economic instruments.

The energy efficiency gap and the energy paradox

While the individual energy paradox necessarily contributes to the social energy efficiency gap, the opposite is not necessarily true. For example, negative externalities that are not internalized in energy prices may explain the social energy efficiency gap, but not the energy paradox in individual choices.

The energy efficiency gap is attributed in literature to a market failure due to externalities. This allows to classify these externalities as the main cause of the problem, and Pigouvian taxes and emission rights as preferable solutions.

But even after the introduction of taxes or emission rights a not perfectly rational behavior may still persist for a number of reasons: (1) uncertainty on energy savings and their value; (2) liquidity constraints; (3) lack of information; (4) bounded rationality.

The uncertainty mainly concerns the evolution of energy prices, the useful life of the asset, and its use in that period. The liquidity constraint is particularly stringent for goods and services, such as housing, which have a high investment cost, on which a change in the level of energy efficiency has a huge impact. The information is lacking, or imperfect, especially with regard to energy consumption and potential savings. Data are not always complete and accurate due to measurement errors, and / or lack of precision on the conditions of goods and /or services use. In presence of heterogeneity of consumers, this may cause wide differences between estimated consumption and actual consumption. Bounded rationality raises problems in data processing with consequent mistakes. The phenomenon of Mpg illusion is one of the most known in literature, but not the only (Larrick-Soll, 2008). Even heuristics that consumers frequently follow in the act of purchase are cognitive mechanisms that can be seen as a consequence of bounded rationality.

We should add now another point of discussion: goods have often multiple attributes. And different customers give different "salience" to these attributes at the moment of purchase. This behavior inevitably determines "inattention" for the attributes that are less influent in the decision of purchasing. If energy efficiency is one of the less relevant attributes then it becomes difficult to distinguish "lack of information" from "inattention".

Consider now that customers' preferences are heterogenous, and firms are aware of this when they operate market segmentation and adapt the range of products offered (Gerarden et al. 2015). To conclude this point, it must be said that: (a) if consumers ignore energy efficiency, firms "underprovide energy efficiency in equilibrium" (Sallee 2012, p. 2); (b) consumers that pay little or no attention to energy efficiency will perceive an increase in the selling price due to the improvement of efficiency, but they will not perceive the efficiency improvement that is the cause.

How to measure rationality of consumers

You don't need to be an expert in the field of empirical research to suggest the questions to answer: (1) How "salient" is energy efficiency in the selection and purchasing of goods? (2) Are those consumers that are influenced by energy efficiency able to calculate the costs of energy consumption of the good during its useful life? (3) How much would they be willing to pay for more energy efficiency?

Allcott (2011) analyzed the behavior of American car buyers using similar questions. The first important evidence is that: "American consumers devote very little cognitive attention to fuel costs when they purchase autos". The second evidence is that buyers who are to some extent interested in fuel consumption suffer from "MPG Illusion": they underestimate the difference in fuel costs for low consumption vehicles, and overestimate the difference between high consumption vehicles. The level of knowledge of the current prices of fuel is good, and the ability to predict prices, when compared to the values in the "future markets", is satisfactory, although there are noteworthy "exceptions". The final decision still seems mainly based on vehicle's attributes different from its efficiency (ibid, p. 101). Previous research had also found that most American drivers had no precise idea of their annual expenditure for fuel, and therefore: "Car buyers do not have the basic building blocks to make calculated decisions about better fuel economy "(Turrentine-Kurani 2007, p. 1222).

Houde (2013) contains a critical review of econometric studies aimed at measuring the energy paradox in the case of goods with multiple attributes. The origin of the problem is the fact that some attributes are not observed by the researcher but are considered by the consumer in its choice. The fact that econometric studies find a negative willingness to pay for an increase in fuel economy might be consistent with recent trends in car sales. To the extent that car buyers give their preference to engine power, size and comfort of the vehicle, the econometric analysis confirm the existence of a trade-off between these attributes and fuel consumption in the choice process.

The problems with environmental taxes

Environmental taxes and efficiency standards are the most widely suggested and applied economic instruments to correct market failures and behavioral failures.

The first problem with environmental taxes concerns the determination of the "marginal social damage", an essential parameter for securing an efficient level of taxation. Related problems are how to assess emissions and how to collect the tax. The scandal of NOx emissions from diesel engines should have made all conscious that vehicles, like many other plants and equipment, are emitting at the same time numerous pollutants that have among them non-linear relationships. Moreover: "emissions vary importantly according to how a vehicle is operated and maintained, and damages vary according to weather conditions, location and many other factors" (Greene 1998, p. 596). And the externalities associated with transportation also include congestion, accidents and more. Obviously, the taxation of a proxy of the pollution, such as fuel consumption, does not fully represent actual emissions with their social costs.

A second order of problems concerns the effects of taxation on purchase choices and user behavior. To raise taxation up to the level that is required to close the efficiency gap would almost certainly have undesirable effects on the utilization of the taxed good or service. Busse et al. (2012) have studied these aspects in the case of private vehicles. They show that there is a strict link between gasoline prices and car sales by class of consumption. When gasoline prices go up total sales fall while the market share of more efficient models grows. And vice versa. They do not say, however, whether this is sufficient to counteract the externalities, and whether (and how) the supply of vehicles is influenced. It is reasonable that conditioning depends on the persistence of the gasoline price effect on sales, which is difficult to estimate because prices fluctuate frequently. However, in the decade considered by Busse et al. (2012), average consumption of new vehicles remained almost constant between 21.5 and 23 miles per gallon (mpg), despite the price of gasoline had a clear growth trend (ibid, p. 225-226).

The goals of product standards

If energy efficiency is not a salient attribute, innovation aimed at reducing energy consumption may not reach the maximum that the state of technology and the markets would allow. If it is true that environmental taxes and prices of emission rights should grow high before influencing purchasing decisions and product strategies, it is also true that product standards are more exposed to the rebound effect and the heterogeneity of consumers. However, the main objective of the standard is the product offered and, in particular, its energy efficiency. The undeniable weaknesses on the demand side may be addressed later.

Standards are designed and implemented in relation to their goals. For example, the US Corporate Average Fuel Economy standards (CAFE) has been in charge for more than 30 years. When it was introduced its goal was to reduce the US dependence on imported oil. More recently, when the administration decided to tighten the standard, the goal was the reduction of CO_2 emissions from new vehicles. These social goals led to the adoption of a low discount rate in the regulatory impact analysis, which has been much criticized by many economists. But the main goal of the fuel economy standard is not to correct the energy paradox of consumers. The administration wants to influence the choices of the car industry, and the cost-benefit analysis only seeks to evaluate the consequent impact on car buyers.

It is much more important to verify if standards can stimulate firms to substantial technological innovation or simple adaptation. At present, it seems that strategies of adaptation are largely dominant.

Some empirical evidence from markets

It seems that only a technological leap can determine large reductions in energy consumption. This is exactly what happened to televisions between 2008 and 2012 (Howard-Baron, 2012). The combined action of automatic brightness control, LED backlights and local dimming –that all manufacturers readily adopted - radically changed the image on the screen and the design of the television, while the average unit consumption dropped from 500 watts to 108 watts. But the marketing of television is still focused on other “salient” attributes: screen size, image quality, and price. We are also entering in a market phase in which the average consumption of a new television set could increase again due to a larger screen size and a higher resolution display (ibid p. 192).

Light bulbs are another interesting case. Compact fluorescent lamps (CFLs) with low energy consumption are available on the market from many years, but the majority of customers is still buying less efficient models. The Commission Regulation n. 244/2009 contains the requirements for efficacy, functionality and information of these products. In the European Union sales of CFLs peaked in 2010, and have been falling since then. In 2013 the number of CFLs sold were less than in 2007. In the same period sales of halogen light bulbs has grown by 477%, and it is to mention that “halogen lamps are approximately 20% more efficient than incandescent lamps while CFLs are approximately 400% more efficient “(Bennich et al. 2014, p. 17). It is not easy to understand how producers influenced this market evolution: they may have scarcely invested in R&D to eliminate some well-known defects of CFLs, and they may have not done efforts to reach economies of scale and reduce production costs and selling prices. According to the Test Report halogen lamps have slowed the market adoption of energy-efficient lighting and reduced the expected energy savings (Bennich et al. 2014).

The case of buildings is important for the level of energy consumption and for some specificity. The European Union estimates that buildings are "responsible for 40% of energy consumption and 36% of CO_2 emissions". The housing stock consists mainly of old buildings - "about 35% of the EU's buildings are over 50 years old" - with low energy performance, on average about 5 times higher than those of new buildings. Dieckhoener (2012) explains the origin of the problem of energy efficiency in housing with two specific reasons: (a) liquidity constraints and high interest rates that limit access to credit; (b) information asymmetries particularly where there is a "landlord-tenant" relationship. The information given with energy certification could hardly change the situation, even if the data supplied were reliable. Incentives should be granted after a more careful selection, to avoid free riding and windfall profits particularly from those who own the house where they live. It seems that investment decisions and consumption behavior of owners, landlords and tenants could be more sensitive to an "environmental" taxation of fuels. Obviously, if you could not consider the effects on income distribution of such a tax, and the impact on the housing sector of the incentives.

Some empirical evidence from policies in the European Union and in Italy

An ex-post assessment of energy efficiency policies is needed to check the distance from targets and to balance the economic instruments. Energy consumption depends from many factors as: economic activity, available income and energy prices; technological progress and diffusion of processes and products; weather conditions, habits, and lifestyles. A business as usual scenario is the common benchmark for an assessment of policies implemented to achieve energy efficiency targets. However, it will not be easy to separate the impact of policies from the impact of the other factors mentioned above.

Scenarios can be referred to four categories of potential energy savings, that go from a broader technical potential, that is based on the state of the art, to a more limited potential of energy savings that are realistically achievable and are referred to investments that need only modest incentives (Sreedharan 2013). Usually the size of the efficiency gap at a microeconomic level is estimated by engineering studies, that suffer serious limits of precision and reliability (Allcott-Greenstone 2012, p. 5). They tend to overestimate the energy efficiency of new assets compared to existing ones, and to underestimate the rebound effect on consumption after the adoption of more efficient goods (Lucas et al. 2014).

In the European Union, Member States should reach a political target of a 20% improvement in energy efficiency at 2020, that is considered to be within the limits of a realistically achievable potential of energy savings. Actual figures were derived from the “Primes 2007” scenario. Without any intervention, consumption in the European Union would reach 1,842 Mtoe of primary energy and 1348 Mtoe of final energy (ISI et al 2014, Table 2, p. 10). In this scenario the “20% efficiency gap” was equal to 368 Mtoe of primary energy and 270 Mtoe of final energy at 2020. According to the latest official data available from Eurostat, in 2012 the consumption of primary and final energy in EU-27 were respectively 1,573 Mtoe and 1,099 Mtoe, and the missing “efficiency gap" was reduced respectively to 100 and 30 Mtoe. EU targets are not very far.

A detailed "decomposition analysis" was realized to identify and to quantify the causes of the variations in energy demand that took place in the period 2008-2012 (ISI et al. 2014). The decrease of primary energy consumption in Member States was 100 Mtoe almost entirely due to a reduction in final energy demand of 70 Mtoe concentrated in the industrial and transport sectors. The driving forces of the reduction would have been efficiency, especially in private transport, domestic heating and industrial activities for an estimated 50 Mtoe, and the drop of the economic activity caused by the economic crisis for over 30 Mtoe, mainly in industry and transport of goods. The same study provides estimates of the maximum potential reduction of final consumption in 2030, which seem to be concentrated in the domestic and transport sectors. According to the study, energy consumption in transport sector would grow significantly if nothing would be done, but the measures already taken at European level –above all the regulation of CO_2 emissions from new cars-should have substantial effects given the expected increase in fuel economy, and the rate of fleet renewal. The civil sector and the tertiary sector are the sectors where the distance from targets is wider in major Member States. Probably because most of the consumption depends on the building stock, which is very slow in improving its energy performance.

Also in Italy the efficiency targets at 2020 were almost reached as early as 2012. Given the decrease of energy consumption in the last two years, even the more ambitious goals of National Energy Strategy (SEN) can be reasonably considered achieved. Nevertheless, the Italian Government is still confirming the need to achieve additional savings of primary energy up to 20 Mtoe at 2020 (Ministero dello Sviluppo Economico, 2013 and 2014). Half of savings are expected from standards and other actions in the field of mobility. The other half comes from various kinds of incentives principally white certificates and tax deductions. What is really striking is the share of total savings expected from the industrial sectors: about one third. This is quite different from the scenarios drawn in the European Study, where the industrial sector achieves higher shares of savings only if the measures taken to promote energy efficiency are minimal. You may think that in Italy there is an economic potential of energy efficiency to exploit in the industrial sector but this contradicts the comparison between targets and available data on consumption, and the results obtained by white certificates in the industrial sector in 2010 and 2011 (2012 Clô). The last annual report on white certificates observed: "a shift in the participation in the mechanism towards the technologies and projects related to the industrial sector" (GSE 2014). This is the result of a precise mechanism change that encourages efficiency investments in the industrial sector, but creates the opportunity of windfall profits (GSE 2014, p. 86) and increases the costs of the white certificates scheme to be recovered from natural gas and electricity bills (AEEG 2014).

CONCLUSION

Because there are so many barriers to investment in energy efficiency: “limiting government intervention to one specific instrument may be insufficient, since it could simply cause another barrier to become binding constraint. Thus, government intervention may need to invoke multiple instruments” (Tietenberg 2009, p. 311).

An environmental tax linked to an energy efficiency goal would raise complex problems as: the efficient determination of the marginal social damage; application and control of the tax, especially in presence of many emission points; the right balance between direct and indirect effects of the efficiently determined tax on energy consumption of products and on their utilization rate. In the end, no administration really wants to impose an environmental tax with this energy efficiency goal, so the gap remains, and the effects on the supply side are minimal. This is one reason because standards are a preferable solution in many cases. A second reason is that standards can bypass many behavioral problems caused by the energy paradox, as for vehicles: “evidence that consumers do not take into account future fuel costs implies that a regulatory structure similar to current law might - contrary to conventional economic analysis - be optimal policy” (Bubb-Pildes 2014, p. 1676). A third reason is that standards can stimulate product innovation by firms: “Supplier incentives to provide energy-efficient goods and services are, after all, not the same as consumer incentives to purchase energy-efficient goods and services.” (Blumstein-Taylor 2013, p. 2). In every case: “care must be taken to insure that the technology is available… at costs … that are not much greater than the .. savings to consumers. (And) Care must be taken to insure that manufacturers have the time necessary to respond efficiently in changing over capital equipment and testing out new (product’s) designs” (Greene 1998, p. 610).

In the European Union standards are decided by the Commission and the Parliament. So incentives becomes the preferred instruments of energy efficiency policies at the national level. It is known that incentives are more likely to increase welfare if they target agents subject to the largest investment inefficiencies (Alcott-Greenstone 2012, p. 24). So it is difficult to explain why in Italy they are mainly concentrated in the industrial sectors, where they are more exposed to free riding behavior (Gillingham et al. 2010). Firms are usually more rational and have access to more information, so the conditions that justify incentives to energy efficiency investments are less stringent. In this situation, incentives could easily go to agents that would anyway invest in energy efficiency, or the available financing could become the main economic reason to invest. The concentration of incentives in the industrial sectors also increases the exposure to the law of diminishing returns. In a period of very low energy prices this is no good news for the financing of incentives.

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