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Energy Efficiency Policies and the Jevons Paradox

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ABSTRACT: Energy and climate change policies are often strongly based on achieving energy efficiency targets. These policies are supposed to reduce energy consumption and consequently, associated pollutant emissions, but the Jevons paradox may pose a question mark on this assumption. Rebound effects produced by reduction in costs of energy services have not been generally taken into account in policy making (there is only one known exception). Although there is no scientific consensus about its magnitude, there is consensus about its existence and in acknowledging the harmful effects it has on achieving energy or climate targets. It is necessary to address the rebound effect through behavioral, legal and economic instruments. This paper analyzes the main available policies to minimize the rebound effect in households with special emphasis on economic instruments and, particularly, on energy taxation.

Keywords: Rebound effect; Energy efficiency; Environmental taxation
JEL Classifications: Q2; Q3; Q4; Q5

1. Introduction

Energy efficiency improvements are in many countries a key part of the strategy to reduce energy consumption and to tackle global warming. This is based on the idea that energy efficiency improvements lead to lower energy consumption and, consequently, to a reduction in the emission of greenhouse gases (IPCC, 2007).

Governments invest much effort on national energy efficiency policies, both addressed to the productive sector and to households, as part of the solution for environmental and energy problems. These gains in efficiency, induced in part by technological progress, have also contributed to promote economic growth while reducing resource consumption and emissions of pollutants into the atmosphere. However, a rebound effect takes place, which is an increase in energy consumption following an energy efficiency improvement. In extreme cases, when energy efficient improvements lead to overall energy consumption increases, this is called Jevons paradox (Jevons, 1865; Brookes, 1978; Khazzoom, 1980, 1987, 1989; Khazzoom and Miller, 1982; Greening *et al.*, 2000; Freire-González, 2010; and others).

This means that promoting energy efficiency, without additional measures, does not necessarily produce energy savings nor reduce pollution or, in any case, reductions in energy consumption are not proportional to the efficiency improvement. It is necessary to consider energy efficiency measures in a broader context, defining its role within energy policy, and include additional measures to minimize the rebound effect. This implies an explicit purpose and intention to reduce resource consumption and pollutant emissions when applying energy efficiency measures.

The rebound effect is rarely taken into account in the official analysis of potential energy savings from energy efficiency improvements, despite the recent interest of some organizations such as the European Commission to begin to consider and minimize it (Maxwell *et al.*, 2011). An exception is its consideration within the United Kingdom policy to improve the thermal insulation of households. This provides for the possibility that some of the potential benefits of the measure will result in higher internal temperatures, rather than reducing energy consumption (DEFRA, 2007). But, direct rebound effect is usually ignored in most cases due to lack of knowledge, as are the potential indirect and economy-wide effects.[1] These effects are more uncertain, although they could be of greater magnitude than direct effects (Semboja, 1994; Dufournaud *et al.,* 1994; Hertwich *et al.*, 2004; Washida, 2004; Glomsrød and Taojunan, 2005; Hanley *et al.,* 2006; Allan *et al.,* 2006; Barker *et al.,* 2007).

When developing energy efficiency improvement policies, policy makers must begin to consider the rebound effect explicitly. Energy policies are ineffective in terms of results achieved, if the rebound effect is not taken into account. Furthermore, they involve high opportunity cost, because public resources used in efficiency measures might be causing unwanted effects. In this sense, ex-post analysis of the policies should be performed in order to verify their actual effectiveness.

As discussed in this article, energy efficiency technology policies that cause higher direct rebound effect require an additional control for other policy variables such as energy prices. It can be addressed either through environmental taxation or other measures including: awareness, information and consumer behavior or legal instruments.

If these additional measures are not implemented, the potential energy savings and carbon emissions will be less effective. Although the rebound effect might not result in "backfire" (i.e. a net increase in energy consumption), environmental taxation measures and the control of other variables would lead to exploitation of the potential savings resulting from an energy efficiency improvement; otherwise, the policy would lose effectiveness.

From several studies (Alfredsson, 2004; Druckman, *et al.,* 2010; Freire-González, 2011), it is known that, although there is a low direct rebound effect, the re-spending effect of monetary savings achieved from energy efficiency improvements could lead to higher indirect rebound effect. Therefore, in these cases, it is also important to implement policies to control the rebound effect that avoids a possible backfire and maximize the potential energy efficiency improvements.

From this perspective, some policies and measures that are being implemented in many countries should be re-evaluated in order to improve energy efficiency. Direct rebound effect can be defined as (Dimitropoulos and Sorrell, 2006):

$$\eta_{\varepsilon}(E) = -\left[\eta_{P_S}(S) - \left(\eta_{P_K}(S)\,\eta_{\varepsilon}(P_K)\right)\right] - 1 \qquad (1)$$

where $\eta_{\varepsilon}(E)$ is the elasticity of demand for energy with respect to energy efficiency (or direct rebound effect), $\eta_{P_S}(S)$ is the elasticity of demand for useful work with respect to energy service costs, $\eta_{P_K}(S)$ is the elasticity of demand for useful work with respect to capital costs and $\eta_{\varepsilon}(P_K)$ is the elasticity of capital costs with respect to energy efficiency.[2]

Equation (1) includes the capital costs of energy services in the mathematical formulation of the direct rebound effect, that is, the cost of devices or technologies that provide the energy service. It shows the potential rebound effect when carrying out energy efficiency policies on certain energy services, such as subsidies to more efficient appliances, since they reduce the cost of devices (capital costs).

As shown in the equation, part of the rebound effect could be offset if new and more efficient equipment would be more expensive (considering the sign of efficiency elasticity of capital costs, since capital costs would increase), as long as the consumers assumed the entire cost of the energy service. A subsidy policy, which makes efficient devices cheaper than inefficient appliances, may, instead, amplify the rebound effect. This policy has been widely used to improve efficiency in industrialized countries. In Spain, for instance, there have been several plans to improve efficiency and to subsidize automobiles,[3] appliances, boilers, air conditioners or windows, among others (IDAE, 2007; IDAE, 2010). In the latest plan (IDAE, 2010), a potential rebound effect was considered. However, no additional policy to counteract it was implemented.

[1] Indirect rebound effect is the increase in energy consumption by other goods and services due to an increase in disposable income caused by energy efficiency improvements. Economy-wide rebound occurs when an energy efficiency improvement produces changes in prices, quantities, incomes and other macroeconomic variables that lead to new general equilibrium in the economy, increasing the overall energy consumption.

[2] Technical aspects of this equation and different definitions can be found in Dimitropoulos and Sorrell (2006) and Sorrell (2007).

[3] Also for road safety considerations.

A consideration of all these aspects could lead to a reformulation of the national energy policy. Policy actions are necessary to support efficiency, but additional actions are also required to control the rebound effect. So a new energy policy framework should be established considering both traditional measures of energy efficiency improvement and complementary actions to prevent unwanted side effects.

Scholars have pointed out that there is some confusion in theoretical works on the rebound effect and that empirical evidence is weak (Greening *et al.*, 2000; Sorrell, 2007; Dimitropoulos, 2007). It is, therefore, important to advance the theoretical and empirical analysis and to provide the best arguments to policy makers, but also in the design and implementation of economic, legislative and political instruments. These policies, taking into account this phenomenon, should allow the achievement of desired goals in energy and environmental policy.

It is also necessary to consider that the rebound effect should not necessarily be an adverse effect. If the goal of improving energy efficiency is strictly economic, that is, to promote economic growth without considering energy consumption, the rebound effect would become a desirable result. This is not the situation when the policy target of efficiency is to reduce energy consumption and pollution and to mitigate climate change. Notwithstanding, the policies to control the rebound effect counteract economic growth. In this scenario, additional policies to control the rebound effect are useful.

This paper investigates the main economic instruments and proposals that could deal with the rebound effect in households. Section 2 shows the various kinds of policies and instruments available to control the rebound effect in households. Section 3 shows the main economic instruments, as well as a brief analysis of a possible tax to offset the rebound effect. Finally, Section 4 contains the main conclusions and suggestions for further research.

2. Policies to Control the Rebound Effect in Households

The rebound effect is the result of the economic responses when there is a reduction of the cost of provision of certain energy services, due to an improvement of energy productivity of providing energy services. Thus, many of the policies to control the rebound effect should aim at modifying the behavioral responses of economic agents if an efficiency improvement takes place.

The first step consists in recognizing the existence of the rebound effect and the need to address it when defining the objectives of energy policy to achieve a specific energy efficiency objective. In recent years, steps are being made in this direction, as shown by the interest and acceptance by official bodies like the European Commission (Maxwell *et al.,* 2011) and the European Environment Agency (EEA, 2010). In Spain the Energy Efficiency and Conservation Plan for 2011-2020 (IDAE, 2010) mentions the possibility of a rebound effect, unlike the previous plan, which did not mention its possible existence (IDAE, 2007) even though in practice it does not consider the rebound effects in the calculations of the savings produced by the previous plans.

The case of energy policies related to insulation of households, from the Department of Energy and Climate Change (DECC) by the UK Government, is the only known example of the consideration of direct rebound effect in the expected effects of a law. In this case, the United Kingdom government includes a 15% reduction in the expected energy savings from insulation measures in households in order to account for the direct rebound effect. Additionally, DECC produced a guideline (DECC, 2010) and a spreadsheet[4] to account for the rebound effect on policies to reduce energy consumption.

Moreover, it is necessary to establish consistent definitions and measures of the rebound effects and to begin to introduce them in all the relevant fields, like households or industries, as well as for all the energy services within these areas.

Levett (2009) suggests several reasons why rebound effect is difficult to consider by policy-makers: the complexity and unpredictability of the phenomenon, the difficulty to obtain clear and unified evidence, the co-evolution of technologies and societies, irreversibility, vicious and virtuous circles, and other political reasons.

The non-achievement of energy efficiency targets identified by policy makers is sometimes

[4]It can be downloaded at (last accessed 17 November 2014):
http://www.decc.gov.uk/en/content/cms/about/ec_social_res/iag_guidance/iag_guidance.aspx

associated with the existence of direct rebound effect. Indirect rebound effect is often not identified in these analyses, but it can also amplify the reduction of the effectiveness of these policies (Alfredsson, 2004; Druckman, *et al.,* 2010; Freire-González, 2011). The inclusion of life-cycle analysis in the evaluation of environmental policy would provide a more accurate vision of this phenomenon, and the possibility of acting accordingly (Chapman, 1974; Herendeen and Tanak, 1976; Kok *et al.*, 2006). As shown in several studies (Jalas, 2002; Carlsson-Kanyama *et al.*, 2005; Cohen *et al.*, 2005; Takase *et al.*, 2005), different consumption patterns involve different energy content, not always obvious at first sight.

Although there is a lack of literature on the specific measures to minimize the rebound effect, three main categories of action can be identified (Ouyang *et al.*, 2010; Ehrhardt-Martinez and Laitner, 2010; Maxwell *et al.*, 2011): measures designed to change consumer behavior through information and awareness, regulatory instruments, and economic and energy taxation instruments. In practice, an appropriate policy mix combining different sorts of instruments may be the most effective option (OECD, 2005).

2.1. Awareness, Information and Consumer Behavior

To counteract the rebound effect it is necessary to understand human behavior when modifying prices and to properly account for consumption patterns (DEFRA, 2007; UNEP, 2010; EEA, 2010).

There are many ways to improve consumer awareness and to guide consumer preferences to encourage environmentally friendly consumption. One of the most used methods has been advertising campaigns undertaken by governments to modify behavior and consumption patterns. This can be included in the so-called “People-oriented initiatives” and could be important in avoiding the rebound effect (Ehrhardt-Martinez and Laitner, 2008; Ehrhardt-Martinez and Laitner, 2010; Lutzenhiser, 2009; Meier, 2009).

It is also interesting to provide further information on energy consumption in households, and on its cost and variations when taking certain energy saving actions, so it could encourage households to reduce the use of energy even when rebound effect exists (Dimitropoulos, 2009). In this sense, Darby (2006) shows how smart meters can influence behavior and reduce energy consumption, offering consumers the possibility to voluntarily avoid direct rebound effect. Wright *et al.* (2000) show how a better feedback on energy bills, that is, a better understanding of energy consumption and costs of actions taken at households, can produce up to 10% savings in electricity consumption for heating in cold climates.

Historically, however, in relation to energy and households, most campaigns have aimed at the acquisition of more efficient appliances or at directly promoting energy saving measures in order to reduce the overall consumption of energy which, as demonstrated, would not necessarily be effective.

Additionally, it is necessary to consider the limitations of voluntary measures. In this context, arguments such as the "tyranny of small decisions" (Odum, 1982) apply. He stated that the result of many small decisions, end up resulting in unexpected and/or undesirable effects. Therefore, some behavioral measures discussed to avoid direct rebound effect could not be completely effective. Sen (1967) postulated the "isolation paradox" which suggests that, even though there is an established socially altruistic behavior, there will always be someone who will not be well-behaved in relation to the moral problems involved in behavioral measures to tackle the rebound effect.

In addition, it is important to consider other additional difficulties when implementing energy efficiency measures, despite the advantages in economic and environmental terms they suppose in principle. This is known in the literature as the "energy efficiency paradox".

Although Linares and Labandeira (2010) recognize that the causes of this paradox are unclear and, therefore, the policies that should be carried out are not clear either, they show the possible causes. These are firstly market failures, and secondly, the lack of consideration of issues related to human behavior and society. In summary, the authors point out the following reasons:

- Low prices of energy (in part, due to externalities not being considered).
- Higher than expected investment costs.
- Uncertainty and irreversibility of investments.
- Errors of information, including asymmetric information (imperfect or myopic).
- Limited rationality.
- Slowness of technology diffusion.
- Principal-agent problem.

- Capital market imperfections.
- Heterogeneity of consumers.
- Divergence between the social and private rates of discount.

2.2. Legal Instruments

Together with awareness, it is important to make sure that consumers have appropriate and sufficient information to make rational decisions. In this sense, new regulations should be developed to pursue this goal.

Regulations should be focused on improving consumer information and on reducing energy intensity of economic sectors through establishing limits or prohibitions on the use and consumption of resources (Schneider, 2008) or on pollutant emissions (Sorrell, 2007), setting goals, etc.

Regarding information, for example, and considering the re-spending effects on consumption patterns of households, it is important that Governments develop specific legislation, and force producers to carry out life-cycle analyses in terms of energy consumption, pollutants emissions or other relevant environmental impacts of their products, and label them accordingly.[5]

In addition, it would be important to know the destinations of the savings derived from energy efficiency measures and associated financial products, with additional information on the total energy consumption of these destinations in order to take decisions with higher levels of information.

2.3. Economic Instruments

Given the characteristics of the rebound effect, economic instruments and specifically environmental taxation can play a key role in modifying behaviours and, therefore, preventing it or minimizing its effects. There are difficulties in establishing a tax to compensate the rebound effect, because it varies among technologies, sectors, countries and income groups, and there are no estimates for all of them. But, it would be appropriate to develop an appropriate taxation framework that considered and minimized the rebound effect when carrying out energy efficiency policies.

The main objective of the taxation instruments would be to increase the costs of providing the useful work of the various energy services, while improving efficiency. Similarly, the rebound effect could also be minimized through energy prices policies. In effecting these steps, there is no reduction in the cost of the energy service perceived by consumers (or its reduction is minimized) and then they do not react by increasing its consumption (or increased consumption is also minimized). Nevertheless, to ensure that energy efficiency improvements are adopted, taxation would be on adopters and on non-adopters, creating thereby an incentive to energy efficiency.

At this point it is important to mention that, as Levett (2009) states, a tax or a prices measure that tried to compensate the rebound effect could have perverse effects on incentives in technical innovation in the sense that firms will not benefit from them, removing manufacturers' incentive to improve efficiency. Those possible effects should be taken into consideration when implementing a tax scheme to minimize the rebound effect.

Given the importance of avoiding the rebound effect, the next section will analyze these economic tools in more detail, with a schematic analysis of a tax that would offset the rebound effect.

3. Economic Instruments to Control the Rebound Effect

As mentioned in the previous section, economic instruments are important to counteract the rebound effect. Specifically, taxation and price instruments in general, applied to energy have special importance. Rebound effect produces an undesirable increase in consumption. This increase is due to the implicit reduction of the cost of the useful work of an energy service for the user. This means that one can get the same amount of useful work at a lower cost, although the price of energy does not change in the short term.

It is important to note that, depending on the different political targets, the best option should not necessarily be to completely cancel the rebound effect. This should not be the case if, for example, the objective of an energy efficiency policy would be economic growth. On the contrary, if the objective was to translate energy efficiency into full reduction of energy consumption, it would be necessary to offset it.

[5] There is a vast literature on life cycle energy analysis which can be used to quantify the indirect rebound effects. A special issue of Sustainability published in 2011 reported the state-of-the-art in this literature (Finkbeiner *et al.*, 2010; Brandão *et al.*, 2010; Acosta-Alba and Van der Werf, 2010; Halog and Manik, 2011).

3.1. Taxation Considerations to Address Direct Rebound Effect

A taxation that fully counteracted the direct rebound effect would be one that compensated for the reduction of cost due to the improvement of the energy efficiency. That is, a taxation that would keep constant the generalized cost of providing useful work.

In formal terms and in terms of Dimitropoulos and Sorrell (2006), developments on the methodological and theoretical aspects of the rebound effect, the price of the energy service P_S is equal to the price of energy P_E in relation to energy efficiency ε :[6]

$$P_S = P_E / \varepsilon \quad (2)$$

In this case, taxation should compensate the increase of efficiency (ε'), i.e., increasing the price of the energy service. Therefore, being *t* the tax, after the efficiency improvement, it should get:

$$P_S = \left(P_E + t\right) / \varepsilon' \quad (3)$$

$$\varepsilon' \geq \varepsilon$$

Moreover, the generalized cost of useful work, which theoretically would be relevant to the decision of a rational consumer, can be defined as the sum of several components (Dimitropoulos and Sorrell, 2006):

$$P_G = P_S + P_K + P_M + P_T , \quad (4)$$

where P_G is the generalized cost of useful work, P_K are the annualized capital costs, P_M are the operating and maintenance costs, and P_K are the costs in terms of time; P_G includes all the costs of providing the energy service.

Although the other components remain constant, the energy efficiency improvement produces a reduction of the cost of the energy service and, therefore, of the generalized cost of useful work. This is the cost at which individuals would increase the energy consumption of the service itself and/or their available income would be increased. From equation (3):

$$t = \frac{P_E}{\varepsilon}\varepsilon' - P_E \quad (5)$$

From equation (3), the next expression can be obtained:

$$t = \left(\frac{\varepsilon'}{\varepsilon} - 1\right) P_E \quad (6)$$

After an increase of the efficiency, the tax would increase according to the proportion represented by the new energy efficiency compared to the previous one. The developed taxation would fully offset the direct rebound effect, leading to a maximum effectiveness of the energy efficiency improvements. This would mean a reduction in energy consumption and, therefore, a reduction in resource consumption and in emissions of greenhouse gases.

It is also important to bear in mind that this tax has a different nature and could differ, being higher or lower, from an optimal Pigouvian tax (Pigou, 1920), defined from the externalities caused by energy consumption. In relation to Levett (2009) and concerns on possible perverse effects of a possible tax to address rebound effect, the proposed tax affects the cost of energy and, therefore, its effect on less energy-efficient activities will be more significant than that on the most efficient ones, reinforcing incentives towards technical innovation.

3.2. Taxation Considerations in Addressing the Indirect Rebound Effect

As demonstrated above, the taxation reasoning for the direct rebound effects only considers the perspective of the final consumers (households). Even without considering economy-wide rebound effects, it is necessary to consider a broader view and to analyze indirect effects.

Using a model to capture the re-spending effects that generates the indirect rebound effect (Freire-González, 2011), the new budget balance can be expressed as:

$$\sum_{i=1}^{n} \left(x_i\, p_i\right)' = y - \left(x_E\, p_E\right)' - s , \quad (7)$$

[6] Energy efficiency here is measured in terms of the thermodynamic efficiency of a system providing an energy service. Several measures can be, therefore, used. In the mathematical expression it is a dimensionless measure.

where x_i is the amount of the good *i*, p_i is the price of the good *i*, x_E is the amount of energy and P_E is the price of energy. The purpose of taxation is that monetary energy spending after the energy efficiency improvement remains the same as before the improvement, decreasing the amount of energy consumed. Therefore:

$$\left(x_E p_E\right)' = x_E\left(p_E + t\right) \tag{8}$$

Introducing this tax in the price of energy, expression (7) would be like:

$$\sum_{i=1}^{n}\left(x_i\, p_i\right) = y - x_E\left(p_E + t\right) - s \tag{9}$$

This way, the re-spending effect in households would not occur, as the reduction in spending that households make on the energy sector would be offset by an energy tax, which would maintain consumption patterns and, therefore, would not produce indirect effects. However, there would be an additional re-spending effect from the public expenditure that would occur due to the revenue raised by the tax.

3.3. The Re-Spending Effect of Public Spending

As shown, an energy tax could be a useful tool to offset the reduction of the cost of the energy services derived from energy efficiency improvements and, therefore, to avoid possible re-spending effects. This is one source of indirect rebound effects; the other source would be the indirect energy consumption in the life-cycle of capital needed to improve the efficiency (Sorrell, 2007).

However, one key aspect would be the way in which revenues obtained from the tax are spent, since this would have several macroeconomic effects. It could cause distortions in the economy, an income transfer from households to the public sector and an additional re-spending effect produced by the destination of the public expenditure.

This new public sector spending (or savings), will generate, just as it would happen in households, a re-spending effect that would lead to an indirect rebound effect. This confirms the impossibility to completely remove the static direct and indirect rebound effect. Even, if there were perfect information and a tax revenue intentionally and completely spent in the sector with a lower drag coefficient in an input-output framework, there would be some rebound effect.

Notwithstanding, a correctly defined tax could minimize it. A possibility would be to conceive it as earmarked, and revenues should be used to subsidize those households with the best environmental practices, in terms of sustainable consumption or those industries (or companies) in sectors with low drag coefficients in terms of energy consumption. Earmarked green taxes tend to benefit from broader public acceptance, and this increases their political viability (European Environment Agency, 2005).

One dynamic and revenue neutral instrument that could be used in this context to encourage the productive sectors to reduce their energy intensity is a feebate[7] scheme (Davis *et al*., 1997, Puig-Ventosa, 2004). Feebate systems aim at fostering those activities, practices or products that are deemed more environmentally friendly at the expense of others that are less environmentally friendly. They do so by means of a simultaneous use of both fees and rebates. In this case the less energy efficient activities or services compared to the average would be charged a fee and the collected amount would be transferred to the most ecological services in the form of rebates. These systems could generate a continuous incentive to improve the energy intensities in purchasing intermediate goods and services. Energy policymakers should be careful when implementing such a measure as it could cause distortions in the economy such as changes in prices. It also could impact different income levels unequally, and potentially increase other environmental impacts. Furthermore, it affects the type of energy used, or has perverse incentives to innovation, etc. Despite the theoretical suitability of the tax in terms of reducing the rebound effect and the energy consumption globally, one of the main problems is that it could present redistributional issues, as it may imply a transfer of income from households to firms. To prevent this issue, such a measure could be accompanied by changes in direct taxation of households and firms.

[7] Combination of fee and rebate.

These and other factors should be considered in depth before implementing such a measure. Ex-ante and ex-post impact analysis techniques should be used in considering the most suitable policy options in different scenarios.

Regarding implementation feasibility, there are difficulties in terms of information concerning the magnitude of the direct rebound in different energy services, areas, income groups or over time. Therefore, it is difficult to design a tax that effectively counteracts the reduction of the cost of energy due to energy efficiency improvements in a particular area. However, it would be feasible to complement the energy efficiency programs for specific energy services with taxation considerations. Levett (2009) considers that the ideal taxes or energy prices to neutralize energy efficiency rebound effects are unrealistic, but high and rising energy prices will strengthen those feedbacks that will tend to reduce energy use, and weaken those feedbacks that will tend to increase it.

4. Conclusions

A thorough revision of energy policies aimed at reducing consumption of resources and tackle global warming is necessary. As stated in the literature, policies to improve energy efficiency are less effective than expected, because of the rebound effect. To be effective, policies must be accompanied by other measures such as an effective communication and awareness of the citizens, regulatory instruments and/or an appropriate taxation. An effective combination of traditional efficiency measures with new policies oriented to tackle the rebound effect would maximize the effectiveness of the policy objective of reducing energy consumption.

A tax to minimize the rebound effect would indirectly increase the cost of the energy service through an increase of the energy price, hence the reduction of the cost from the improvement in the energy efficiency would be offset by this energy price increase. This ensures that the demand of the service does not increase and thus, direct energy consumption would be reduced as much as it was expected to. Despite the difficulties of establishing a proper taxation, the use of these instruments could compensate for the rebound effect and make energy efficiency measures more effective.

A taxation policy aimed at tackling the rebound effect in households, for example an indirect tax to compensate for the reduction of the cost of energy service due to efficiency improvements in households, in addition to the appropriate spending policy, should be accompanied by an industrial policy to foster the productive sectors to reduce their direct and indirect energy consumption.

An appropriate combination of various instruments could minimize indirect rebound effects in households, because avoiding the monetary savings in households prevents the increase in consumption patterns due to improved efficiency. It is also necessary to include the rebound effect in the ex-ante and ex-post analysis of energy efficiency policies, and into the models and governmental programs.

This paper suggests the role of energy taxes to minimize the rebound effect. One of the most important aspects that also have been highlighted is the relevance of the re-spending effect of the revenue, which might in turn lead to an increase in energy consumption. Most efforts in the rebound effect research have been oriented to methods and to obtain evidence of its existence and magnitude. Although it is necessary to continue to advance in this direction, the lack of research in relation to policies to address it, suggests a whole new area of possible research with strong practical implications.

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