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Direct rebound effect of residential gas demand: Empirical evidence from France

Fateh Belaïd[a,b], Salomé Bakaloglou[b,c], David Roubaud[d,e,*]

[a] Paris-Est University, France
[b] Scientific and Technical Center for Building, France
[c] Montpellier University, France
[d] Montpellier Business School (MBS), France
[e] Montpellier Research in Management (MRM), France

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ABSTRACT

Energy policymakers are increasingly concerned about energy efficiency improvements, as such improvements are considered to be a key strategy in reducing energy demand in the residential sector. However, energy efficiency investments may not yield the expected energy-savings due to the rebound effect concept, which leads to lower savings than expected when energy-efficiency increases. Using the standard OLS regression and autoregressive distributed lag cointegration (ARDL) approach, this paper provides estimates of the magnitude of the rebound effect for residential gas consumption in France. Using 1983–2015 annual time-series data, the methodology is based on estimates of the gas demand elasticity with respect to service price. The empirical findings indicate that the variables used in the model are cointegrated and suggest the presence of an obvious rebound effect in residential gas use. More specifically, estimates of the direct rebound effect in residential gas demand are approximately 53% in the short-run and approximately 60% in the long-run. Our findings reject the hypothesis of a backfire effect regarding residential gas use in France and hence suggest incorporating carbon taxation, energy efficiency and alternative energy in the formulation of an energy-saving policy to facilitate the transition towards a low-carbon economy in France.

1. Introduction

In the context of the 2015 Paris climate change agreement, 195 countries have committed to limit global warming to no more than 2 degrees above pre-industrials levels. To do so, contracting parties have presented their national contributions and committed to review it every five years, with each new contribution including a progression in comparison to the previous one. The French government committed to reduce its greenhouse gas emissions by 40% by 2030 and by 75% by 2050 compared to the 1990 level.[1] To achieve these goals, France has undertaken to increase to 32% the contribution of renewable energies to its final energy consumption by 2030 and to reduce energy consumption by 50% by 2050.

According to recent estimations, household daily living activities account for more than a third of the total energy consumption and more than a fifth of greenhouses gas (GhG) emissions in France (Bélaïd, 2017). As the current trend in French residential energy consumption indicates that the 2015 Paris agreement objectives will not be reached, strategic orientations and roadmaps have been redefined by sector to implement a low-carbon transition process between 2015 and 2028. Given its important potential for GhG emissions reduction and energy savings, the greatest effort is required by the building sector, with a goal to reduce its GhG emissions by 54% by 2028.

In terms of policy strategies, two levers can be mobilized to reduce energy consumption of the residential sector. First, improving the energy efficiency of both new and existing dwellings would reduce the final energy needs of buildings. Second, energy saving behaviours can be fostered. In France, the slow turnover of the building stock (~1%) and the low energy performance of the existing park have guided the sectorial energy policy. As a result, improving the energy efficiency of the existing dwelling stock has been designated as one of the core strategies for reducing energy consumption and its related carbon emissions. With regard to the Paris Climate Conference (COP21), the latest French law for energy transition and green growth set the objective of energy refurbishment for 500,000 dwellings per year from 2017 onward. In addition, in 2017, France devoted 1.7 billion euros to

* Corresponding author.
E-mail addresses: fateh.belaid@cstb.fr, fateh.belaid@univ-littoral.fr (F. Belaïd), Salome.bakaloglou@cstb.fr (S. Bakaloglou), d.roubaud@montpellier-bs.com (D. Roubaud).

[1] The energy transition law for green growth, published in the official journal of August 2015.

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fund CITE, a tax credit for energy retrofitting, as a way to encourage households to undertake energy-efficient renovations or adopt renewable energy (FMEST, 2017).

Improving the energy efficiency of the housing stock has long been considered as an effective strategy to reduce residential energy demand and achieve sustainability policy goals. Nevertheless, an increase in housing energy efficiency does not necessarily translate into an equal decrease, in absolute terms, in energy demand as energy efficiency savings can be undermined by changes in consumer attitude and behaviour, i.e., the rebound effect.

The variations in household behavioural responses to improvements in energy efficiency often lead to a mismatch between the real reductions in energy use and what has been forecast without consideration of behavioural and market aspects. More information and data on attitudinal factors could help to improve the prediction of domestic energy use.

The rebound effect depicts an attitudinal and a behavioural response to an improvement in energy efficiency. Therefore, the scope of the savings depends on the efficiency-induced attitudinal and behavioural effects. Although the rebound effect concept has fairly old origins that date back to the seminal works of Jevons (1865), the rebound effect phenomenon has been gaining in popularity since the early 1980s, when it was rediscovered in both policy and academic areas. In fact, the positive causal relationship between energy efficiency and energy demand was identified by Jevons (1865) after having been literally overlooked for more than a century.

Major findings from recent years have produced evidence of the existence of a rebound effect regarding energy consumption in the residential sector (Berkhout et al., 2000; Greening et al., 2000; Khazzoom, 1980; Thomas and Azevedo, 2013), indicating that improving the energy efficiency of the dwelling has behavioural side effects that can drastically reduce its benefits in terms of energy consumption reduction. Indeed, the rebound effect reflects the propensity of households to increase their comfort, that is, energy demand, when home energy efficiency is improved. Today, the existence of the rebound effect in the residential sector is well known, but its magnitude is still a major focus of economics research. In a great majority of the cases, the rebound effect can induce a loss of more than 30% of the energy savings achievable with an energy efficiency investment. Therefore, as the energy road map strongly focuses on the energy efficiency improvement of the existing dwellings stock, to be aware of the magnitude of the potential non-achieved energy savings, it seems of critical significance to measure the extent of the rebound effect.

In this paper, we focus on the rebound effect regarding gas consumption in the residential sector. Gas is the second most used energy for individual energy uses (see Fig. 3) and accounts for more than 30% of the national energy consumption. In France, gas is consumed primarily for heating and cooking needs, and thus, because of the important share of energy consumption dedicated to heating, we assume that gas consumption is a good proxy for heating energy consumption. Accordingly, this paper focuses on the measurement of the magnitude of the rebound effect for this particular energy use. More precisely, we focus on the challenge of measuring the magnitude of the direct rebound effect, which is the additional gas use attributable to the increased energy service demand when the implicit price of gas declines due to energy efficiency improvement, whereas the indirect rebound effect is the increase in gas use following a change in the demand of other services due to improved energy efficiency.

The main hypothesis of this study is that household attitude and behaviour are among many factors that limit expected energy-savings from energy efficiency investment in what is known as the rebound effect. By embarking on this path, this study contributes to the existing literature on the rebound effect phenomenon in several ways. First, this study examines the magnitude of the direct rebound effect with respect to gas demand in France. To the best of our knowledge, empirical research on this rebound effect in France is rather sparse, if not inexistent, due to the lack of information and availability of data on residential energy use. Second, using the ARDL co-integration approach, which has a distinct advantage compared with other co-integration approaches (e.g., Engle and Granger, 1987; Johansen and Juselius, 1990), this research provides estimates of the magnitude of the residential gas rebound effect both over the short- and the long-run. One distinguishing advantage of the ARDL testing approach is its ability to estimate the long-run economic relationship irrespective of whether the explanatory variables are I(0) or I(1). Moreover, the ARDL procedure is the familiar with F-statistics or Wald tests in a generalized Dickey-Fuller type regression used to test the significance of lags of the variables under consideration in a unrestricted equilibrium error correction model (Pesaran et al., 2001; Bélaïd and Youssef, 2017).

Third, based on the recent advances in time series econometrics this study contributes to previous research works by investigating the backfire hypothesis, both in the short-run and in the long-run. The findings refute the backfire hypothesis in both the short-run and long-run, which implies that improvement in energy efficiency helps to reduce residential gas demand in France.

Finally, from a policy-making perspective, this study helps better understandwhat type of strategies (e.g., refurbishing existing dwellings, providing assistance to poor households, providing additional information and data on household lifestyles and behaviours, incorporating housing policy into residential energy policy, etc.) could be used to improve residential energy efficiency schemes.

The remainder of the paper is organized as follows. Section 2 provides a brief overview of the French residential energy efficiency policy. Section 3 reviews the literature and presents the theoretical background. Section 4 introduces the data and the modelling procedure. Section 5 presents our empirical results and discusses their implications. Section 6 concludes and provides some possible policy implications of our main findings.

2. Overview of the French residential energy-efficiency scheme and domestic energy demand

In France, the residential dwelling stock is composed of approximately 33.5 million housing units (Bélaïd, 2017). This stock is responsible for 30% of the global French energy demand (45 Mtoe in 2015) and for 20% of the greenhouse gas emissions emitted in 2014 (CGDD, 2015). The share of each sector in the French total final energy consumption is displayed in Fig. 1.

Because of the huge energy-savings and GhG emissions reduction potential, the residential sector has been designated a major target for energy transition. The Energy Transition for Green Growth law (2015)

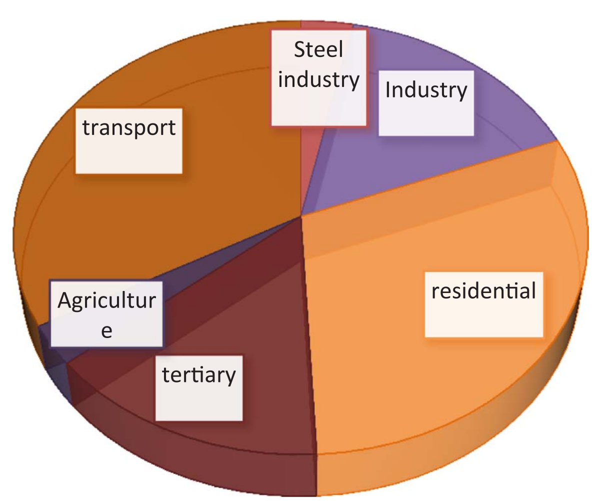

Fig. 1. Share of each sector in the total final energy consumption of France in 2015. Source: Bilanenergetique de la France-2015, Statistique développement durable.