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Measuring the influence of energy prices in the price formation mechanism

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ABSTRACT

Environmental economics has proposed taxation on energy as a way of mitigating the pollution caused by the production and use of energy based on fossil fuels. However, it is generally assumed that energy is an important component of production costs and that taxes on energy have a detrimental impact on the economy. This paper provides a method of analysing the extent to which energy prices influence the price formation mechanism. The model used is based on a social accounting matrix (SAM). The SAM price model identifies the role of energy prices in the cost and price definition processes. The empirical application is for the Catalan economy and shows that energy prices have a considerable influence on both production and final prices and that different forms of energy exert asymmetric impacts on costs for sectors and consumers.

1. Introduction

Over the last century, a significant increase in the use of energy obtained from fossil fuels has generated negative consequences for the environment. Of these, the most alarming environmental impact is the process of rising temperatures known as climate change. Without an effective and imminent solution to this phenomenon, there will be incalculable consequences for humanity and unpredictable costs in the near future. Indeed, climate change is one of the most crucial problems that global institutions will face in the coming years.

Implementing taxes on dirty forms of energy is viewed as an effective solution to reduce pollution and fight against climate change. From a theoretical point of view, Pigou (1920) first proposed environmental taxation as an instrument to reduce the damage done to the environment by negative externalities. As taxes artificially bring the private costs of production closer to the corresponding social costs, taxing polluting goods leads to a reduction in their harmful production and/or consumption. And among the vast array of goods produced and consumed in an economy, the most damaging for the ecosystem are those related to the production and use of energy obtained from fossil fuels.

New taxation on energy would generate a rise in its effective price that would incentivize other (cleaner) forms of energy, move the economic system towards energy efficiency and reduce negative impacts to the environment. Nonetheless, in practice some countries are reluctant to impose new taxes on the production and/or consumption of energy. The reasons for this are based on the idea that energy is an important component of production costs and this kind of intervention would therefore reduce the competitiveness of local products in global markets.

The influence of energy prices and energy costs on final price levels has been extensively analysed in the literature. In particular, the input-output model has proved to be extremely useful to analyse energy issues.[1] Also defining a linear structure, the price version of the social accounting matrix (SAM) model represents the cost transmission channels by extending the input-output framework to include not only production but also factors and households. The SAM model provides a simple representation of general equilibrium that captures the underlying connections within production, consumption and income distribution. Despite the undoubted usefulness of the SAM approach, there are few contributions in the literature that use this model to analyse price effects. The first contribution is in Roland-Holst and Sancho (1995), where it was proposed an alternative price approach to the traditional SAM quantity-oriented model. After this pioneering contribution, Akkemik (2011) evaluated the price impacts of changes in electricity prices in Turkey by using the SAM price model. Llop and Pié (2011) used the SAM price approach to simulate the effects of alternative environmental policies applied to the energy sector in Catalonia. Also for the Catalan economy, Llop (2012) proposed a SAM method to detach the effects of saving-investment in the price determination mechanism. More recently, Saari et al. (2016) used the SAM price model to evaluate the distributional impacts among ethnic groups in Malaysia

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[1] Among the energy input-output contributions, see for instance Catsambas (1982) and Wang and PcPhail (2014) for the US, Hughes (1986) for Thailand, Llop and Pié (2008) for Catalonia, and Rocchi et al. (2014) for the European Union.

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resulting from a rise in oil prices.

The aim of this paper is to evaluate the contribution of energy prices in the price formation mechanism by quantifying the extent to which energy costs affect production and consumption prices. The methodology is based on the SAM price approach that allows to identify the contribution of energy prices to the economy's prices. The proposed framework comprises a multiplier decomposition of price effects that specifically focuses on the role of energy activities. Therefore, this study extends the existing SAM price-modelling literature, as it proposes a new method for quantifying the importance of energy prices within the complex process of price transmission.[2] It also identifies the different components within the circular flow that exert an influence on prices, by paying a special attention to energy costs.[3]

The empirical application is for the Catalan economy through the use of a regional social accounting matrix for 2011 that individually shows the various energy goods. It is interesting to remark that the capacity of implementing energy taxation in the regional economy falls on different agents. In particular, the national (Spanish) government enacts the electricity and gas tax policies, while the regional government determines the taxation on water and petroleum. The disaggregation of the energy activities in the SAM, which allows to individualize the cost impacts of the distinct energy goods, it also makes it possible to identify the different price channels through which energy policy is applied, depending on the level of government competent in each case. Hence, the empirical analysis in this paper is relevant not only in terms of the quantitative impacts involved but also in terms of gaining precision in relation to the influence on energy prices of the two public agents behind energy markets.

The paper is organized as follows. The next section describes the SAM price model and decomposes the total price impacts into different interdependence relationships. The third section describes the 2011 social accounting matrix for the Catalan economy, and the fourth section shows the empirical results. A conclusion section ends the paper.

2. Analytical framework

The influence of energy in the price formation mechanism is analysed using a SAM price model capable of jointly defining the relations between production prices and consumption prices. The SAM price model is constructed from the accounting identities reflected in a social accounting matrix by following a linear structure of price impacts.

A SAM shows an economy's income and expenditure flows in a square format in which the rows and columns add up to the same amount.[4] In a social accounting matrix, receipts appear in the rows and expenditures in the columns and the different accounts reflect different economic agents and are placed in an identical order horizontally and vertically. Appendix A describes the structure of the SAM used in the multiplier analysis.

The SAM price model is built around the structure reflected in Table A1 and the adoption of hypotheses about the relationships between sectors and agents. Specifically, income and payments are assumed to have a constant structure. Also, the accounts of the SAM are divided into two different categories: endogenous accounts and exogenous accounts.[5] In order to show the circuits via which energy participates in the price and cost definition mechanism, the model definition considers as endogenous the first three accounts in Table A1.[6] In addition, as the SAM used in the empirical application shows a unique aggregated account for households, block X_{33} in Table A1 is assumed to be null.

Reading down the columns of the SAM and using matrix notation, the following model of prices can be defined[7]:

$$P = PA + v = v[I - A]^{-1} = vM. \tag{1}$$

In this expression, A is the matrix of normalized coefficients and, according to the SAM structure used, it has the following components:

$$A = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & 0 \end{bmatrix},$$

where A_{ij} represent the column coefficients calculated by dividing the transactions in the SAM (X_{ij}) by the corresponding column total (Y_i). In addition, $P = (P_1\ P_2\ P_3)$ denotes the row vector of prices for endogenous accounts, and $v = P_4 A_4$ is the vector of exogenous costs, where $A_4 = [A_{41}\ \ A_{42}\ \ A_{43}]$.

In expression (1) above, $M = [I - A]^{-1}$ is the matrix of price multipliers. Despite the fact that this matrix matches the multipliers matrix in the SAM quantity models, the interpretation of the elements in the two approaches is completely different. The SAM price model reflects the cost transmission so M is read across the rows; the SAM quantity model, on the other hand, reflects the income impacts, so M is read down the columns.

In order to isolate the energy contribution within the price formation mechanism, matrix A of structural coefficients is divided into two submatrices that show different economic channels. Specifically, the coefficients corresponding to energy production (A_1) are separated from the coefficients of the other sectors of production and consumption (A_2). This leads to the following division of the structural coefficients:

$$A = A_1 + A_2 = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & 0 & 0 \\ A_{31} & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 \\ 0 & A_{22} & A_{23} \\ 0 & A_{32} & 0 \end{bmatrix}.$$

Expression (1) can then be modified by applying the division of the matrix of coefficients as follows:

$$P = v[I - A_1 - A_2]^{-1} = vM_1M_2M_3. \tag{2}$$

where $M_1 = (I{-}A_1)^{-1}$, $M_2 = (I + D)$, $M_3 = (I{-}D^2)^{-1}$ and $D = A_2(I{-}A_1)^{-1}$. In expression (2), matrix M has been split into three multiplicative matrices containing different economic channels of price transmission. As shown in the related literature, the decomposition of the multiplier matrix can vary widely depending on the division of the coefficients matrix. In particular, the SAM price model has been used to reflect the price channels between production, consumption and factors (Roland-Holst and Sancho, 1995; Akkemik, 2011; Llop and Pié, 2011) and to detach the price effects of saving-investment (Llop, 2012). Differently to the previous SAM price contributions, the analysis used in this study isolates the energy sectors and identifies the role of energy prices within the price definition process.

By applying matrix algebra, block M_1 has the following structure:

[2] Though Akkemik (2011) followed a similar purpose, the multiplier decomposition is different than the one proposed in this paper. In particular, Akkemik's decomposition jointly considers all sectors of production. To detach the energy contribution within total price impacts, the method defined in this study individually considers energy sectors. This allows to completely isolate the energy influence within the price formation mechanism.

[3] Despite the input-output literature has extensively identified individual sectors within the input-output relationships (Miller and Blair, 2009), most contributions have used quantity-oriented methods. The approach in this paper is an extension of the related literature as, on the one hand, it proposes a price version to detach energy prices and it uses a SAM structure, on the other.

[4] See, for example, Pyatt (1988).

[5] The traditional endogeneity assumption in SAM quantity-based models (Pyatt and Round, 1979) endogenously considers sectors, households and factors of production. The same criterion of endogeneity is used in the price version of the SAM model proposed by Roland-Holst and Sancho (1995). Llop (2012) later extended the endogenous accounts to reflect the price transmission of saving and investment by including the capital account in the endogenous part of the SAM price model.

[6] This endogeneity assumption, which in fact endogenously defines production, consumption and value added, is in line with Roland-Holst and Sancho (1995), Akkemik (2011) and Llop and Pié (2011). Unlike this conventional approach, the present division of agents focuses on the energy sectors and individually isolates the corresponding energy accounts.

[7] See Roland-Holst and Sancho (1995) for details.