CAN TECHNICAL IMPROVEMENT IN MOTOR VEHICLES REDUCE REFINED FUELS USE? A PARTIAL AND GENERAL EQUILIBRIUM ANALYSIS

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Overview

Gordon (2016) stresses that technical progress in household consumer services has been a major, typically underestimated, element in the improvement in the standard of living in the US since 1870. These services can be thought of as self-produced and consumed directly by households. Following Gillingham et al. (2016), we apply this conceptual approach to the provision of household energy-intensive services, such as domestic space heating and light which we operationalise using the specific example of private transport, which is produced using refined fuel and motor vehicles. We are particularly interested in the way in which improvements in the efficiency of vehicles and fuel affect the implicit price and quantity consumed of private transport and the subsequent derived demand for fuel and vehicles. More especially, we wish to investigate the way in which an increase in the efficiency of vehicles affects the consumption of fuel. This is highly relevant in the context of policy initiatives to reduce carbon emissions whilst maintaining economic growth.

We focus on the question of whether a reduction in energy use could result as an endogenous response to efficiency improvements in the other inputs. We analyse this initially using a partial equilibrium model. A simple relationship is adopted between vehicle and fuel use in the production of private transport, and between private transport and all other goods in the determination of the household consumption vector. This analysis holds household income and the prices of all inputs and other consumption goods constant. The approach is then extended through simulation using a Computable General Equilibrium (CGE) model, parameterised on UK data. This framework allows the incorporation of endogenous changes in nominal income, market prices and supply responses. Efficiency improvements in household consumption will affect the implicit price of the corresponding household service. However, these prices are not normally used in the standard calculation of the consumer price index (*cpi*), leading to potential underestimations of the economy-wide impact of household efficiency improvements (Gordon, 2016). In a final set of simulations, we recalculate the *cpi* using the endogenous price changes for private transport services. This reduction in the *cpi* has implications for the determination of the real wage and produces additional positive competitiveness effects.

Methods

We use a partial equilibrium model of household's consumption to model the choice of a household that maximises miles travelled by using the input of refined fuels and motor vehicles. The housenol's budged is allocated between private transport and all other consumption goods. Using this model we study the implication of technical improvement in motor vehicles for refined fuels and private transport demand. This depends on the elasticity of substitution between refined fuels and vehicles and on the price elasticity of demand for private transport services.

We incorporate the partial equilibrium model in a CGE model for the UK. This allows us to assess the impact of technical improvement in motor vehicles on fuels use, where fuels and vehicles are used in different proportions, and where market prices and nominal income are not fixed. Moreover, enables the study the economy-wide implications of such technical and to asses under which circumnstances this can deliver both a reduction in fuels use and a stimulus to the economy. The CGE model is a recursive dynamic (with possibility of introducing forward looking behaviour) specifically designed for the analysis of energy and environmental disturbances.

The model accounts for 30 different productive sectors, including 6 supply chain energy industries, and includes information about five Scottish household income groups, the UK Government and imports and exports to the rest of the EU (REU) and to the rest of the World (ROW). The production function reflects the classical KLEM constant elasticity of substitution (CES) function. Here capital (K) and labour (L) form value added, while energy (E) and materials (M) constitute intermediate inputs. The consumption function reflects the partial equilibrium specification developed in this paper, where total gross consumption is allocated at each period in time within private transport and all the other goods. In turn, private transport is composed of refined fuels and motor vehicles. This allows the capture of the implicit price of private transport.

Using the CGE model, we simulate the impact of a 10% technical progress in motor vehicle used by households. We gradually move from the partial to the general equilibrium, by initially maintaining the fixed market prices assumption, via the use of a fixed real wage labour market closure. Then we endogenise market prices and repeat the same simulation, in a context where wages are determined according to a wage curve. Here we also adjust the calculation of the *cpi* to include the implicit price of private transport, following Gordon (2016).

Results

The partial equilibrium model shows that technical progress in motor vehicles reduces fuels use when the elasticity of substitution between the two inputs in greater than one. However, this also requires that the elascitity of substitution between private transport and all other goods is smaller than the elasticity of substitution between fuels and vehicles.

The CGE simulations confirm that when considering improvements in the efficiency in the production of private transport, a vehicle-saving technical improvement can lead to a reduction in fuel consumption, depending upon the values of key elasticities. However, such a reduction in both the fuel-intensity of private transport and the use of refined fuels is not brought about by an exogenous improvement in fuel efficiency, but as an endogenous reaction to an improvement in the efficiency of a good closely linked, either as a substitute or complement, in this case motor vehicles. This shows the importance of modelling energy-intensive household services in general, and private transport in particular, as the output of a number of inputs. Moreover, in determining the overall impact of technical progress in motor vehicles on the demand for fuel, it is fundamental to take into account changes in the demand for private transport. Such changes in the quantity demanded of the energy-intensive service generate an additional increase or reduction in the derived demand for the input goods.

When the *cpi* is calculated using the conventional method, the macroeconomic impact of the technical improvement simply reflects the switching of demand between different commodities within the household budget. Commodities, which have, directly or indirectly, more domestic content will have a larger impact on GDP. In the present case, this switching depends on the degree of substitution between private transport and the composite commodity “all other goods”, and between fuel and vehicles in the production of private transport. When, as a result of the efficiency change, the consumer reduces expenditure on the consumption of all other goods competing with private transport, and increases the consumption of fuel, GDP falls. When the adjusted *cpi* is used, the price of private transport, which is normally unobserved, reduced the *cpi*. With a fixed real wage, we then report an increase in competitiveness and a productivity-led economic stimulus. This is because the nominal wage falls. This reduces domestic prices, stimulating the demand for exports, and reducing the demand for imports. It also leads to some substitution of labour for capital. When workers are able to bargain, the real wage will rise as the unemployment rate falls, limiting the reduction in the *cpi*, the nominal wage and the subsequent increase in economic activity.

Conclusions

In this paper we have four main aims. First, we attempt to model the use of energy-intensive consumer services in a more appropriate manner than the conventional approach in the literature. Second, we analyse the impact of an efficiency improvement in the provision of this energy-intensive service. We distinguish between energy- and vehicle-improving technical changes and discuss this in a partial and general equilibrium context.

Third, we investigate, through simulation, the conditions under which an increase in the efficiency of vehicles in the production of private transport reduces the fuel use in the economy as a whole. The empirical results from our CGE modelling show that when the elasticity of substitution between motor vehicles and refined fuels is greater than the elasticity of substitution between private transport and all other goods, as long as any positive aggregate output effects are not too large, the consumption of refined fuels falls.

Fourth, we consider the impact of technical change in the household consumption sector on the aggregate level of economic activity. Where the consumer price index is calculated in the standard way, the aggregate effect on economic activity is very small and can be positive or negative. This impact is driven solely by the changes in the composition of household demand and the direct, indirect and induced domestic content of the affected sectors. However, when the price of private transport, which is normally not observed, is included in the calculation of *cpi*, the fall in the price index reduces the nominal wage and improves competitiveness in the economy as a whole. This produces a positive stimulus to employment and GDP.

References

Gillingham, K., Rapson, D., and Wagner, G. (2016). The Rebound Effect and Energy Efficiency Policy. Review of Environmental Economics and Policy, 10(1):68-88.

Gordon, R. J. (2016). The Rise and Fall of American Growth: TheU.S. Standard of Living since the Civil War. The Princeton Economic. History of the Western World. Princeton University Press.