Unobserved Components of Fuel Consumption: Welfare Implications of Transport Price Changes

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Non-technical summary

We formulate and estimate a microeconometric model of household transport demand, which allows for latent separability of fuel consumption between urban and rural areas. Latent separability is crucial for transport price change assessments since external costs related to air pollution from fuel usage differ between urban and rural areas. The estimation results are then used for calibration of a simulation model.

The model assesses impacts of changes in passenger transport prices on fuel consumption, external effects of air pollution, household welfare and on public finance in a transition country. An exemplar calibration is taken for the five largest cities in the Czech Republic. The welfare components are summed using the Kaldor-Hicks type of social welfare measure with equal weights for all changes in the real income of individuals.

Since most of structural parameters of our simulation exercises are estimated by econometric methods, we explicitly deal with uncertainty in these parameters. Most studies rely on the certainty-equivalence principle and report results for the mean values of estimates. We consider this practice as incomplete because public or policymakers might be risk-averse. Instead, we numerically integrate the welfare measure used to derive the whole distribution of welfare consequences of selected policies. This enables us not only to characterize the expected value of the welfare consequences, but also to characterize the probabilistic distribution conditional on estimated parameters and some risk-averse measures. Moreover since the model is nonlinear in parameters, the expected value computed by integration of the whole distribution (as in our paper) differs from the estimated welfare computed using mean values of estimates. We find that the mean computed using the certainly-equivalence approach overestimates the true mean of the distribution of the welfare, which is not so surprising because of the concavity of the utility function.

We show that ignoring the different price elasticities of fuel consumption in the urban and rural areas can lead to serious errors. Model simulations suggest that the increase in the excise tax on fuels seems to be the best option to regulate air pollution externalities. In cities, where operation costs of public transport are significantly subsidized, this tool should be accompanied with a fare increase as well, because of costs of public funds. A decrease in fares is not likely to be welfare improving because of small induced modal split and high requirements of public funds needed to cover such policy.

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Extended abstract

The transport sector in the Czech Republic has been changing since the beginning of the transition from the centrally planned economy to the market economy. There is substantial evidence (Czech Hydro meteorological Institute, 2005) that these changes, which have led to the increased transport intensity and the modal split, contribute to negative impacts of transport on human health and the environment, especially in cities. This suggests a need for regulation. This paper aims at assessing selected policy measures on transport behavior and related external costs from air pollution.

Hereby, the paper formulates and estimates a microeconomic model of transport behavior of households and public agencies. The model is calibrated and simulated for the five largest cities in the Czech Republic. The paper especially concentrates on regulation of external costs associated wit health and environmental impacts of transport. The derived welfare measure is composed of three components: external costs, costs of public funds (which include a change in subsidies to public transport providers and a change in budget revenues) and compensating variations of households, which are summed using the Kaldor-Hicks type of social welfare measure with equal weights for all changes in the real income of individuals.

To calibrate the model, three main sets of the structural parameters need to be estimated: (i) household transport demand system, (ii) the cost function of public transport providers and (iii) marginal external costs.

A theoretically-consistent quantification of external costs of air pollution from transport is a relatively novel research agenda in the Czech Republic. According to our best knowledge, such a quantification to date has been calculated using the ExternE methodology under the research project of the Ministry of the Environment of the Czech Republic 'Quantification of external costs of energy use for the Czech Republic' done by the Charles University Environment Center (2005) and we use the results of this project to calibrate the relevant part of the model.

To estimate the parameters of the cost function of public transport providers, we follow the workhorse approach initiated by Williams (1979). The model is applied to a panel of the largest Czech cities spanned for eight years. We estimate the elasticity of the average costs with respect to various input prices (such as fuel prices and the wage rate in the transport sector) and with respect to the performance, thus identifying economies of scale. Since for some years we do not have an access to the relevant wages (i.e. to wages in the transport sector in the region), we apply the unobserved component model in which the economy-wide wages in the transport sector and the average wage in the region serve as proxies for the unobserved wage in the transport sector in the region. We show that the structural parameters of the unobserved component model are identified and that the minimum distance estimation yields consistent estimates. Our results suggest slightly increasing returns to scale in the public transport providers sector.

To estimate the demand system we use a latently separable model suggested by Blundell and Robin (2000). This enables us to identify different price elasticities of the fuel demand according to its usage: we find that the own fuel price elasticity for commuting in cities is higher than the elasticity for non-urban transport. Although this difference is intuitive because

of different substitution possibilities in urban and rural areas, we are able to document that the difference is statistically significant. This difference between the two elasticities is crucial for the simulations, since external costs of the fuel usage in cities are much higher than the fuel usage in rural areas.

Since most of structural parameters of our simulation exercises are estimated by econometric methods, we explicitly deal with uncertainty in these parameters. Most studies rely on the certainty-equivalence principle and report results for the mean values of estimates. We consider this practice as incomplete because public or policymakers might be risk-averse. Instead, we numerically integrate the welfare measure used to derive the whole distribution of welfare consequences of selected policies. This enables us not only to characterize the expected value of the welfare consequences, but also to characterize the probabilistic distribution conditional on estimated parameters and some risk-averse measures. Moreover since the model is nonlinear in parameters, the expected value computed by integration of the whole distribution (as in our paper) differs from the estimated welfare computed using mean values of estimates. We find that the mean computed using the certainly-equivalence approach overestimates the true mean of the distribution of the welfare, which is not so surprising because of the concavity of the utility function.

We consider the following three scenarios:

Scenario 1 is defined as an increase in the excise duty on fuels, which affects the consumer price of motor fuels. We define the two subscenarios - the baseline involves an exemption for public transport providers from the increased duty (Scenario 1a), while the alternative formulation does not exempt public transport providers from this increased excise duty on fuels (Scenario 1b). Thus, the alternative scenario implies a cost increase for the public transport providers. We assume that fares of public transport will change to balance off the cost increase.

Scenario 2 simulates a situation where the transport sector faces an unexpected rise in fuel prices (such as an exogenous shock to world oil prices). Although similarly to Scenario 1, this implies an increase in the price of motor fuels and therefore in costs of public transport providers (and we assume that this rise is transmitted to fares), budgetary implications of these two scenarios differ. Because the fuel tax rate is levied on a physical amount (it is a unit tax per liter), the revenues in Scenario 2 decrease as a consequence of raised fuel prices.

Scenario 3 evaluates a decrease in public transport fares. This scenario is included since some environmentalists argue for a substantial reduction in public transport prices. This can, on the one hand, induce a shift toward a more environmentally friendly modal split for passenger transport; on the other hand, it may represent a serious budgetary pressure. We attempt to quantify the welfare effects in this scenario.

Model simulations suggest that the increase in the excise tax on fuels seems to be the best option to regulate air pollution externalities. In cities, where operation costs of public transport are significantly subsidized, this tool should be accompanied with a fare increase as well, because of costs of public funds. A decrease in fares is not likely to be welfare improving because of small induced modal split and high requirements of public funds needed to cover such policy.

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