Distributional impacts of a CO2 fuel tax on different household income quintiles in Austria

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Introduction

We aim to investigate the distributional, economic, and environmental impacts of different types of CO2 taxes and tax rebate schemes with focus on petrol and diesel consumption for mobility demand among different household income quintiles in Austria.

Transport activities contributed 29% to total GHG emissions in Austria in 2015 and it will thus be crucial to reduce emissions in this sector in order to meet national and international GHG mitigation targets such as the Paris Agreement (Umweltbundesamt, 2016). From an economic perspective CO2 fuel taxes should induce a decreased demand for kilometers driven by private cars (i.e. either due to a direct reduction in mobility or a switch to other modes of transportation such as public transportation or bicycling), which should, ceteris paribus, lead to a reduction in GHG emissions. An important aspect that has gained attraction in recent years is the distributional impact of CO2 taxes on different household income quintiles (Flues and Thomas, 2015; Klenert and Mattauch, 2016; Wang et al., 2016; Wier et al., 2005). A uniform CO2 tax can have a regressive impact on lower income quintiles if they spent a higher share of their income on fuel consumption than compared with higher income households (e.g. for QNT2 and QNT3 in Figure 1), and/or if they react less sensitive to changes in fuel prices (i.e. they show lower demand elasticities with respect to fuel price changes than higher income quintiles). Furthermore, tax rebate schemes have been found to substantially affect distributional impacts (Wang et al., 2016). Finally, the net impacts on GHG emissions are further affected by macro-economic feedbacks due to changes in private consumption and different tax rebate schemes.
Figure 1: Share of consumption of coke & refined petroleum products with respect to household income by quintiles in Austria for the year 2012. QNT1 = lowest income quintile; QNT5 = highest income quintile.

Method

The DYNK model

The effects described above are modeled by applying the econometric dynamic input-output (IO) model DYNK for Austria (see Kratena et al., 2013 for details on the model philosophy). The DYNK model approach is a hybrid between a classical IO and a CGE model and is characterized by the integration of rigidities and institutional frictions (e.g. wage bargaining; liquidity constraints, and imperfect competition) as well as a long-run full employment equilibrium. The model describes the inter-linkages between 62 industries as well as the consumption of five household income groups by 45 consumption categories. In contrast to static IO models DYNK simulates (i) household demand reactions via nested demand functions, (ii) changes in factor inputs via a trans-log production function, and (iii) wage bargaining via wage curves. The household consumption block model, which is fully integrated in the macro-economic part of the model, differentiates between (i) durables, (ii) energy consumption, and (iii) non-energy non-durable consumption. Energy consumption is linked to the durable stock and the energy efficiency embodied in this stock. Furthermore, an environmental module provides a consistent link between consumption and the Austrian energy balance and it has been successfully used for energy and environment related analyses (Jackson et al., 2014; Kratena, 2015; Sommer and Kratena, 2016).

Major data sources for DYNK are Statistics Austria (make and use tables, government expenditure and revenues, employment, energy balance), the World Input-Output Database (to estimate the production function), EUROSTAT (household income and wealth, government debt, household consumption by quintiles), EU-SILC (household income by quintiles), and the IEA (energy prices).
Modelling demand for mobility

We follow Wadud et al. (2009) in modelling fuel demand (in TJ per capita) for each household income quintile:

\[
\ln(TJ_q) = c_q + \gamma_{yd,q} \ln \left( \frac{yd_q}{pop_q} \right) + \gamma_{pf,q} \ln(pf) + \gamma_{eff,q} \ln(ef) + \gamma_{stock,q} \ln \left( \frac{stock_q}{pop_q} \right)
\]

Equation (1) assumes that fuel demand (in TJ per capita) for different household income quintiles (depicted by the index \(q\)) is a reaction to changes in income per capita \(\frac{yd_q}{pop_q}\), fuel price \(pf\), efficiency \(eff\), and vehicle stock per capita \(\frac{stock_q}{pop_q}\). As Equation (1) is specified as a log-log model, the coefficients can be interpreted as demand elasticities for fuel (petrol or diesel) which are differentiated for each income quintile: \(\gamma_{yd,q}\) is the income per capita elasticity, \(\gamma_{pf,q}\) the own-price elasticity for fuel (petrol or diesel), \(\gamma_{eff,q}\) the elasticity with respect to efficiency (if it is smaller than one it captures a rebound-effect), and \(\gamma_{stock,q}\) the elasticity with respect to vehicle stock per capita. The most important elasticity for this application is, obviously, the fuel price elasticity, as this is the variable that will be mostly affected by the introduction of a CO2 tax. Efficiency is an exogenous input and will be kept fixed (at least for comparative scenario analysis). Vehicle stock and income might change as they are endogenously modeled in DYNK, especially in the long-term.

Figure 2: Changes in fuel demand with respect to 1% changes in the exogenous variables according to the elasticities reported by Wadud et al. (2009) and by own estimations that did not take into account different income quintiles.

Figure 1 illustrates that the fuel price elasticity, as estimated by Wadud et al. (2012) and based on the US Consumer Expenditure Survey (1984-2003), follows an inverted U-shape, i.e.
the lowest income quintile reacts most strongly to changes in fuel prices (ca. -0.35% demand for a 1% change in fuel price), this effect is attenuated in the second and third quintile (--0.22% and -0.20%, respectively), but becomes stronger again in the fourth and fifth quintile (-0.26% and -0.29%, respectively). A similar pattern has also been found by Wang and Chen (2014) with respect to vehicle miles travelled, based on cross-sectional data of the 2009 National Household Travel Survey (NHTS) from the USA. Due to lack of data we currently apply the elasticities reported by Wadud et al. (2012), as well as our own estimations for a single household, but aim to provide own estimations for different household income quintiles in Austria once access to an extensive consumption survey in Austria is granted. Figure 1 indicates that the elasticities by Wadud et al. (2012) do not differ substantially from our estimations based on a single household for Austria.

In order to also account for a likely switch towards more public transportation in case of higher fuel prices we model demand for public transportation (in € for each household income quintile) as a function of household income \(YD_q\), fare prices \(pp\) and fuel prices \(pf\):

\[
\ln(Pub_q) = c_q + \gamma_{yd} \times \ln(YD_q) + \gamma_{pf} \times \ln(pp) + \gamma_{pf} \times \ln(pf)
\]

Values for the demand elasticities for public transportation with respect to household income \(\gamma_{yd}\), fare prices \(\gamma_{pf}\) and fuel price \(\gamma_{pf}\) are taken from a meta-study by Holmgren (2007) and are currently not differentiated by household income quintiles. Short-run elasticities reported in European studies are, on average, -0.62 for household income, -0.75 for fare price changes and 0.40 for fuel price changes. Confidence intervals are also reported by Holmgren and will be used for sensitivity analyses in future simulations.

**Preliminary scenario results**

Research for this study is still on-going. Hence we can only provide a first glimpse at probable scenario assumptions and first simulation results. We expect to have final results ready before summer 2017. For this exercise, we implement a uniform €50/t CO2 tax for petrol and diesel consumption for private mobility in DYNK’s base year 2012. Assuming current fuel efficiency values in Austria (8.10 l/100km for petrol and 6.93 l/100km for diesel) this would be equivalent to an increase in fuel prices by 0.13€ per liter petrol and 0.14€ per liter diesel, i.e roughly about a 10% increase in fuel prices in Austria. We further assume that the government keeps tax revenues from private consumption neutral, i.e. the increase in revenues from a CO2 tax is accompanied by a compensation scheme. Here we assume that the VAT for products without a CO2 tax is reduced so that the total tax revenue from private consumption is the same in each scenario. We will explore further compensation schemes in the future, such as lump-sum payments or reductions in social contributions.
Figure 3: Impact of a €50/CO2t fuel tax on GHG emissions from petrol and diesel consumption.

Figure 3 shows the impacts of a uniform CO2 tax on GHG emissions both for the quintile differentiated approach and the single household approach. It illustrates that not accounting for different behavior among households may, in this case, slightly underestimate the effects of a CO2 fuel tax (-2.2% instead of -1.6%). The different reactions of the households follow the own-price elasticities illustrated in Figure 1 as endogenous changes in income and vehicles purchased remain negligible in this comparative analysis. Changes in income and their consecutive impact on fuel demand may become more significant when we explore the impacts of a CO2 tax along a 10 to 20 year period. Demand for public transportation increases by ca. 1.6% for each income quintile.

Macro-economic impacts remain small in this comparative static scenario analysis. Most changes are below ±0.5% in most cases. For example, total private consumption (real) increases by 0.34% (mostly due to the VAT reduction and positive feedbacks on labor compensation), industry output (real) by 0.22% and GDP (real) by 0.15%. Consequently, we see only small macro-economic feedbacks on total CO2 emissions from final energy use. Total CO2 emissions from final energy use decrease by 0.2%, whereby total households decrease their CO2 emissions by 1.5% and industries increase their CO2 emissions by 0.3%.
Figure 4: Distributional Impact of a €50/CO2t fuel tax among the five household income quintiles (quintile differentiated approach).

Figure 3 indicates that low-middle (QNT2) and middle (QNT3) income quintiles share a – relative to their income share – higher burden with respect to the CO2 fuel tax than the lowest (QNT1) and highest (QNT5) income quintiles. The impact is small (e.g. 12.2% vs. 13.0% for QNT2 and 17.2% vs. 18.3% for QNT3), but could become more substantial with higher CO2 taxes. The share of CO2 taxes on household income are 0.25% for QNT1, 0.33% for QNT2, 0.33% for QNT3, 0.31% for QNT4 and 0.30% for QNT5. These results currently do not account for dynamic effects on income, which might enhance the distributional effects.

Discussion and outlook

Our current simulations indicate that a uniform €50/CO2t tax with a VAT tax rebate reduces fuel related GHG emissions by -2.2% and that it has a weak inverted U-shape distributional impact on household income quintiles in Austria. The inverted U-shaped impact may be the result of different possibilities of substitution among the income quintiles. Lower income groups (if overwhelmingly situated in urban areas) may be able switch to public transportation more easily than middle-income quintiles (if they reside in suburban areas with inadequate public transportation access), while the highest income group can easily avoid ‘recreational’ vehicle use or switch to alternatives such as air travel. The latter option might be a valid argument for travel options in the USA, but will rather be the exception in small countries such as Austria. Hence, we will try to obtain own estimations for household income quintiles in Austria once suitable data is available. Weak distributional impacts for fuel CO2 taxes are in accordance with a recent literature review by Wang et al. (2016).
While different price elasticities strengthen the distributional effects, the initially quite equal share of fuel consumption with respect to household income among the income quintiles (see Figure 1) attenuates distributional impacts at the beginning. We thus aim to investigate further the impact of a uniform CO2 tax in a more dynamic setting (e.g. with a 10 to 20-year time horizon), as well as to look at the impact of progressive CO2 tax (e.g. a CO2 tax based on kilometers driven: the first 3000 km are tax free to allow for subsistence usage but then start to increase progressively) as well as different tax rebate schemes (e.g. reduction of social contributions or lump sum payments instead of VAT).

References


