Economic instruments and consumption

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In this report we start with a brief description of the project, which consists of three parts. We then discuss each part of the project in turn. For the original project proposal see `http://www.ekoninternt.se/proj/consumption/`. Note that the end of the project has been moved to 31 August 2019.

1. The project

The overall objective of this project is to suggest effective instruments to help achieve the goals of the Swedish government—in particular with regard to climate and resource use—highlighting relationships between production, consumption, and polluting emissions. The project has three subobjectives: to build a macroeconomic model of the economy to help us understand and predict patterns of energy and resource use; to perform microeconomic studies of patterns of demand for individual goods; and to investigate the importance of consumption externalities in determining labour supply.

Existing macroeconomic models can account for trends in global energy use purely on the basis of firms' production functions, by assuming a high degree of substitutability between inputs. But they fail when confronted by further data, which show that household preferences cannot be ignored. Our macroeconomic model—including a novel model of preferences—shows how the effects of different policy measures reverberate through the economy. The macroeconomic model builds on strong assumptions about preferences for energy-intensive goods. There is minimal empirical evidence regarding such preferences. Econometric studies of patterns of demand for air travel will support the macroeconomic model, showing effects of specific policies, such as raising the cost of air travel. We have two separate approaches, the first focusing on measurement of the income elasticity of demand for air travel using household data, and the second focusing on the price elasticity of demand using the effect of the introduction of the Swedish flight tax. In the final part of the project we will investigate the extent to which labour may be oversupplied due to a consumption race, implying that lower labour supply is a good thing, and giving a new argument in support of the high-tax European socioeconomic model. This would turn the 'double dividend' argument on its head: environmental taxes lead to lower labour supply, which is a spin-off benefit rather than a drawback!

2. The macroeconomic model

Regarding the macroeconomic model we discuss completed work at some length, then turn briefly to future plans.

2.1. Completed work

A paper which summarizes current progress with the macroeconomic model was recently published: Hart (2018).[1] Please see this paper for further details, including references for the data in the figures below.

In the macroeconomic model we focus on the failure of the aggregate share of energy in GDP to decline, despite the long-run decline in the price of energy relative to labour, and claim that a shift in consumption patterns over time towards goods of high energy intensity

[1] See `https://www.sciencedirect.com/science/article/pii/S0095069618301876`.

must be an important part of the explanation, since careful scrutiny shows that alternative explanations—such as the idea that directed technological change has led to slow growth in energy-augmenting knowledge—are insufficient. In Figure 1 we show energy-share data globally, and for the UK and USA. And in Figure 2 we show evidence of shifts in consumption patterns in the US transport sector, where passenger miles have tracked GDP but at the same time vehicles within each category have become larger, heavier, and more powerful, while consumers have switched to more energy-intensive categories, especially air transport and SUVs.

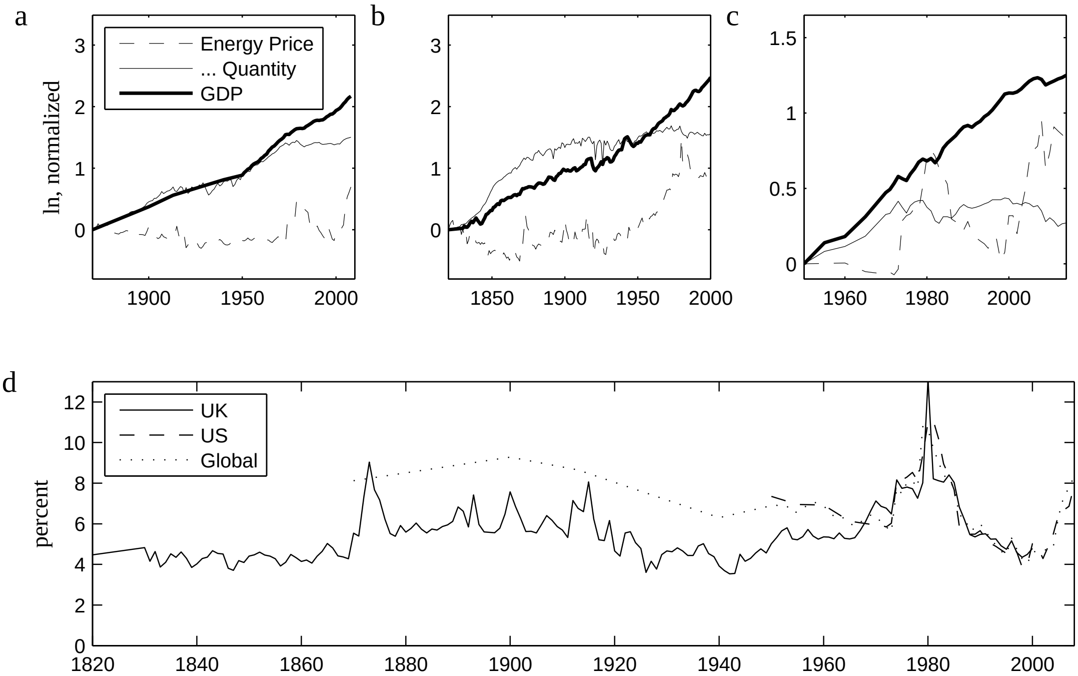

Figure 1: Primary energy from combustion. Price and quantity per capita compared to GDP per capita: (a) global; (b) U.K.; (c) U.S. And (d) the factor shares in the three cases.

To explain this shift we propose a novel model in which the shift in consumption patterns consists not just of increasing consumption of existing energy-intensive goods, but also the production and consumption of completely new such goods. The switch is driven by a combination of income and substitution effects.

In the model economy, policy-induced rises in the price of energy will reduce energy consumption, as will policy-induced increases in the growth rate of energy-augmenting knowledge. However, technology policy is more effective if it can be directed towards goods which lie towards the lower end of the distribution of energy intensities. The reason is that an increase in the energy-efficiency of such goods causes their price to decline (albeit weakly), inducing consumers to substitute towards consumption of these goods. The resulting drop in consumption of energy-intensive goods leads to a 'reverse-rebound' effect: an increase in energy-augmenting knowledge in production of good i, A_{ri}, by a factor x leads to a reduction of total energy consumption R by *more* than $R_i(1 - 1/x)$. On the other hand, somewhat paradoxically, increases in the energy-efficiency of the most energy-intensive goods (such as air transport) are much more likely to lead to rebound or even backfire, i.e. an increase in total energy consumption. Because these goods are assumed to be on the cusp of affordability, their price elasticity of demand is extremely high.

Our analysis shows that a shift towards energy-intensive consumption, including new energy-intensive goods, has occurred over the industrial period, and is to some extent continuing even in the most advanced economies. Our model proposes an explanation for this shift—a combination of substitution and income effects—but we present little evidence of the veracity of the model. For concrete policy recommendations the model should be backed up by microeconometric evidence on the causes of the shifting consumption patterns in relevant sectors, especially for high-energy products on the cusp of affordability. In order to accurately

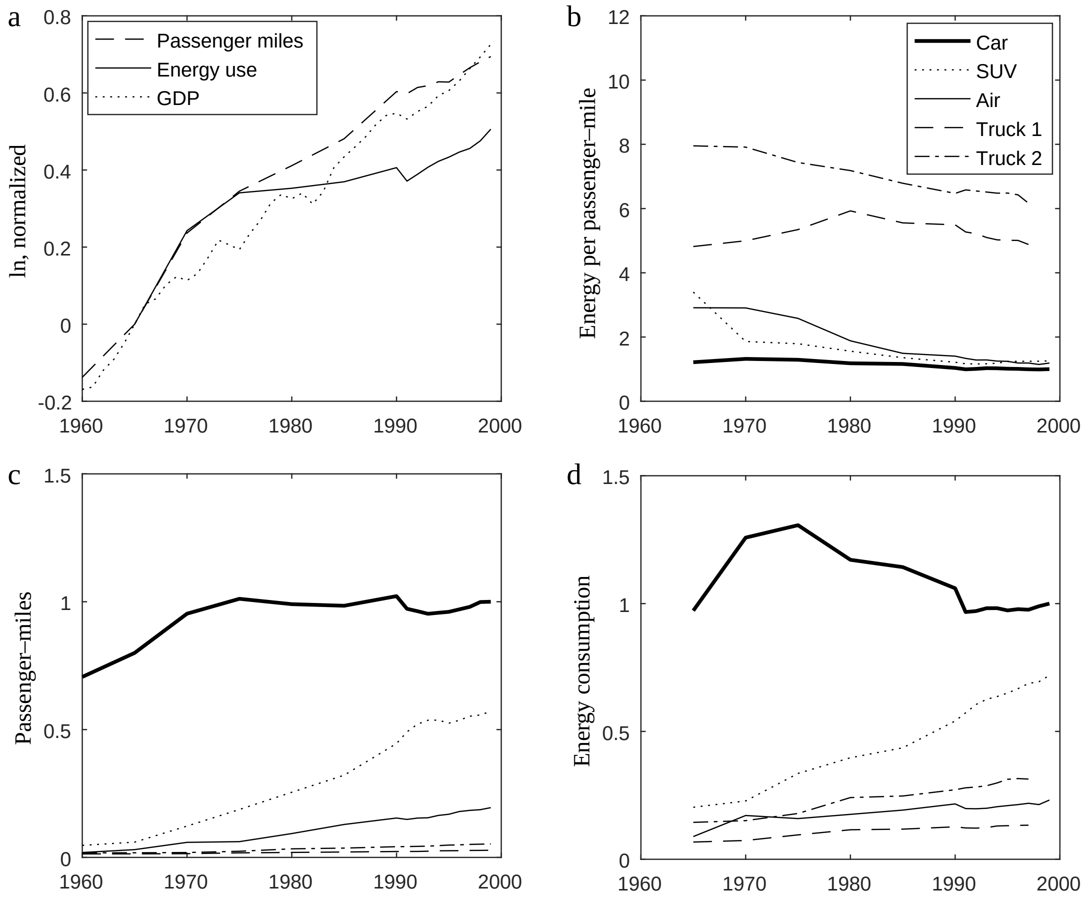

Figure 2: Aggregate data for passenger-miles and energy consumption in the U.S. for private vehicles and air travel (combined): (a) Growth in total passenger–miles and energy use, compared to GDP; (b) Changes in energy per passenger–mile for different transport categories; (c) Changes in passenger-miles by category; (d) Total energy consumption by category.

measure income effects such studies need to build on household data. Preliminary work on air travel in Sweden with a double-hurdle model (first choose whether to be an air traveller, then choose how much to fly) shows that the decision to become an air traveller is strongly dependent on income, suggesting that there is an important overall role for income effects.

The model predicts that if the energy price tracks the wage in the future, this will brake the growth in energy consumption but not stop it. Such an increase in energy price could be cancelled out if energy efficiency stops rising. This is bound to happen in some sectors, such as lighting and motive power, where the laws of physics impose strict limits on what is achievable, limits which we are already approaching. This points to the need for new models of directed technological change which base the innovation possibilities frontier on evidence rather than assumption (*cf.* Hart (2013) and Nordhaus (1973)). In the most pessimistic scenario—with long-run growth but a slowdown in growth of energy efficiency—the model would predict that the relatively stable global energy consumption since 1974 may be only a temporary phenomenon, with consumption set to rise again in the future absent price rises or policy interventions.

2.2. Future plans

There are two stands planned for future development of the macroeconomic model. The first of these is to publish a more accessible paper (perhaps in the journal *Ecological Economics*) based on the same work as the recently published paper. The second is to extend the existing research. This extension should be based partly on the results of the econometric work described below. Furthermore, we must take account of changes in the relative prices of different types of good caused by factors other than increasing energy efficiency. For instance, energy-intensive goods such as air transport may become cheaper over time because they are very capital-intensive, and technological progress is likely to be faster than average in capital-intensive industries.

3. Patterns of demand for air travel

The studies on patterns of demand for air travel are carried out by Jonathan Stråle with support from Rob Hart. We are carrying out two studies, one focused on income elasticity, and the other focused on price elasticity.

3.1. The Income Elasticity of Leisure Air Travel: a Censored Quantile Regression Approach

Background

The purpose of this research is to provide reliable estimates of the income elasticity of demand for leisure air travel. As explained in the recently published paper by Hart (2018), a paper that is also part of the overall project and described in more detail in Section 2, it is important to understand to what extent income and price changes are driving the shift towards energy-intensive goods, to be able to provide the necessary policy recommendations. This research therefore aims to answer one of these questions, namely what is the income elasticity of leisure air travel, one of the most energy intensive consumption goods?

Previous research on this (see e.g. Gallet and Doucouliagos (2014) for an overview) provides estimates with a very large variance, which likely has to do with issues of consistency of the estimates stemming from poor data and the use of simple regression methods which ignore issues of e.g. censoring and endogeneity. The main contributions of this research will therefore be a more reliable estimate of the income elasticity of leisure air travel due to the use of household level data (as compared to aggregate level data) and the use of an appropriate method that addresses the bias that comes from the fact that only part of the population is in fact engaging in the consumption of leisure air travel. In addition to this, our method will also provide heterogeneous estimates of the elasticity along the conditional distribution of leisure travel expenditure. It will in other words be possible to estimate different income elasticities for individuals with high and low expenditure on leisure air travel.

Research strategy

To estimate the elasticities of interest, the following log–log model will be used

$$\ln T = \alpha + \beta(\tau) \ln E + \gamma(\tau) \ln X + \epsilon \tag{1}$$

where T is expenditure on leisure travel abroad, E is total expenditure (our chosen measure of income) and X is a vector of covariates such as age, location dummies, family size and year dummies. The coefficients of interest are $\beta(\tau)$, which can be interpreted as the income elasticity of the τ:th conditional quantile of the distribution of leisure air-travel expenditure. The income elasticity will therefore be allowed to be different for individuals that have e.g. low, medium and high levels of air-travel expenditure (conditional on the income and other covariates) instead of only estimating the conditional expected value, or the conditional mean, which is what usually is done.

The main issue complicating the estimation is that the dependent variable is censored at 0 as only slightly less than half of the sample have positive expenditure on leisure travel. If the standard, OLS-based methods are used to estimate the elasticities of interest they will suffer from attenuation bias by construction. To achieve consistent estimates of the income elasticity, censored quantile regression will be the method of choice.

In the case of left-censoring at 0, y is only observed if $y^* > 0$ and 0 is observed if $y^* \leq 0$. The standard estimator for this censored quantile regression model is the Powell (1986) estimator:

$$\min_{\beta(\tau)} \sum_{i=1}^{n} \rho_\tau \left(y_i - \max[0, x_i \beta(\tau)]\right) \tag{2}$$

where $\rho_\tau(\cdot)$ is a check-function such that $\rho_\tau(\lambda) = (\tau - I(\lambda < 0))\lambda$. Hence

$$\rho_\tau(y_i - x_i\beta(\tau)) = \begin{cases} \tau(y_i - x_i'\beta(\tau)) & if \;\; y > x_i'\beta(\tau) \\ (\tau - 1)(y_i - x_i'\beta(\tau)) & if \;\; y \leq x_i'\beta(\tau). \end{cases} \tag{3}$$

The estimation of the coefficients $\beta(\tau)$ is thus a minimization of asymmetrically weighted absolute residuals, which can be compared with classical regression methods that instead are based on a minimization of squared residuals.

To estimate this model, the three-step procedure developed by Chernozhukov and Hong (2002) will be used. This procedure provides consistent and efficient estimates for the censored quantile regression model at the same time as it is computationally simple compared to previous estimators that have issues with convergence.

The current research strategy will yield a more accurate estimate of the income elasticity of leisure air travel than previous research due to several reasons. Firstly, none of the existing papers in the literature addresses the issue that only a share (and usually a quite small share) of a given population chooses to fly in a given year. Ignoring this will yield inconsistent estimates by construction. This research is able to address this due to the usage of household level expenditure data (see section 3.1 for more details) where the non-consumers are visible, contrary to when aggregate data is used and the non-consumers are hidden through the aggregation. This together with the usage of a method that does not rely on strong assumptions of normality and homoskedastic error terms (contrary to e.g. Tobit, Double Hurdle or Heckman estimators) will ensure consistent estimation of the elasticity of interest, at least with regard to the issue of censored data. That household level data is used does also by itself increase the accuracy of the estimates since the data is available at the level of interest at the same time as the sample becomes vastly bigger than if aggregate data were to be used.

Data

We are using the Swedish Household Expenditure Survey (HUT), provided by Statistics Sweden for the years 2003–2009 and 2012 for this research. The data is available on household level.

Preliminary results

Jonathan Stråle will be working on producing results during May and June 2018. Results which may be indicative of what to expect can be found in Baldesi (2017), a Master's thesis supervised by Hart with assistance from Stråle. This thesis uses the same household data, but a simpler methodology. Baldesi finds an expenditure-elasticity of demand for air travel of around 2.5, well above previous estimates in the literature, but broadly consistent with our expectations based on our interpretation of the long-run aggregate data showing very steep increases in air travel.

3.2. The effect of flight taxes on the demand for air travel

Background

The purpose of this research is to find an answer to how price changes of air travel affects its demand at the same time as it will evaluate the effect of the new Swedish air-fare tax on the demand for air travel. It thereby addresses the other issue of importance presented by Hart (2018). Despite its importance, no reliable estimate for the price elasticity of air travel, nor the effect of flight taxes on air travel, is readily available. Existing studies (see e.g. Brons et al. (2002) for an overview) on the matter suffer from endogeneity problems, low quality data and external validity issues at the same time as most of them are quite old. The present project will use the exogenous variation generated from a new flight tax to estimate both the effect of flight taxes on the demand for air travel as well as estimating a consistent price-elasticity on both an aggregate and route level.

Research Strategy

The basis for the present project is the introduction of a new flight tax that has been implemented for all commercial flights from Swedish airports by April 1^{st} 2018. This tax has three tax-levels that are distance based, which together with the fact that it is a completely new type of tax that only affects air travel from Sweden gives rise to several possible natural experiments. In the present project, two main settings will be used: one where the behaviour of air travellers from Sweden is compared with the behaviour of air travellers in a completely untreated area and the other being a comparison between the behaviour of air travellers to destinations on two sides of a tax-zone threshold. The main method of estimation will be the Differences-in-Difference (DD) framework together with an Instrumental Variables (IV) approach, the specifications of which will be given below.

For total effects, the following reduced form equation with an intention-to-treat interpretation of π will be used:

$$Y_{gt} = \alpha_g + \lambda_t + \pi T_{gt} \times After_t + \boldsymbol{X}_{gt} + \upsilon_{gt} \tag{4}$$

Where: Y_{gt} is the number of passengers, $g = 1$ if treatment group and $g = 0$ if control group, $T_g = 1[treated]$ and $After_t = 1[t \geq April\ 1^{st}\ 2018]$, $\boldsymbol{X}_{gt}$ is a vector of control variables (potentially) needed for the trends to be parallel, α_g is group-specific fixed effects (group dummy variable) and λ_t is time-specific fixed effects (time dummy variables)

To estimate price effects, an IV-estimation will be done where the first stage becomes:

$$Z_{gt} = \omega_g + \rho_t + \gamma T_{gt} \times After_t + \boldsymbol{X}_{gt} + \eta_{gt}, \tag{5}$$

where Z_{gt} = price variable. The resulting equation of interest thus becomes:

$$Y_{gt} = \theta_g + \delta_t + \beta Z_{gt} + \boldsymbol{X}_{gt} + u_{gt}, \tag{6}$$

where the effect of prices on number of passengers, β, is found by the IV-estimation of the system.

Data

The data that will be used in this research is in part a novel data set that is currently being created by web-scraping the air-travel comparison web-page Expedia for route specific flight prices. In addition to this, route-specific data on the number of passengers will be obtained from Eurostat. This data is provided on a monthly level. Since the data is currently being collected we will not have any preliminary results until early 2019 at the earliest.

4. Optimal labour supply

In the final part of the project we study optimal labour supply taking account of consumption externalities. Partly due to signals from Naturvårdsverket, we have given this part of the project lower priority so far. The research we have done so far focuses on the effects of changing labour supply on energy demand (for instance through demand for air transport) rather than optimal labour supply *per se*.

In particular, we have a draft paper, *Retirement, leisure time and energy intensity of consumption*, by Jonathan Stråle, the purpose of which is to use the substantial increase of leisure time that occurs at retirement to investigate how increased leisure time affects the demand for air travel. In this paper, US data is be used instead of Swedish data.[2] The model to be estimated is:

$$\textit{Air-travel expenditure} = \beta_0 + \beta_1 \textit{Retired} + \mathbf{X}'\gamma + \epsilon \tag{7}$$

[2] The Consumer Expenditure Survey provided by the US Bureau of Labor Statistics.

where *Retired* is a dummy variable taking the value 1 if the individual is retired and 0 otherwise and $\mathbf{X}'$ is a vector of control variables. To get a consistent estimate of β, an instrumental variable (IV) approach is used where the retirement status of an individual is instrumented by the age of that individual.

Preliminary results indicate that retirement significantly increases the expenditure on air travel by on average 200–250 USD per year if the full sample, including the non-flyers, is used and with on average 1300–2000 USD per year if the sub-sample of only individuals with a positive expenditure on air travel is used. This result indicates that increased leisure time potentially increases the energy intensity of consumption.

With regard to future plans, we will continue with the work described above. With regard to optimal labour supply and links to the overall tax system, there is synergy with the Mistra program *Sustainable consumption: From niche to mainstream*, of which Hart is a member. Exactly when this work will start, and what priority is should have within Naturvårdsverket's project, is an open question.

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