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Effects of an environmental tax on meat and dairy consumption in Sweden

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ABSTRACT

This study evaluated the environmental impacts of introducing an environmental tax on meat and dairy consumption in Sweden. Three meat products (beef, pork and chicken), four dairy products (milk, fermented products, cream and cheese) and four pollutants generating environmental damage (greenhouse gases (GHG), nitrogen, ammonia and phosphorus) were included in the analysis. The unit tax applied corresponded to between 8.9% and 33.3% of the respective price per kg product in 2009. Consumer response to the tax was calculated by econometric estimates of the almost ideal demand system (AIDS) for meat and dairy products, using per capita consumption data and prices. The results indicated relatively inelastic own price elasticities and high income elasticities for all meat products and slightly lower for dairy products. Simultaneous introduction of a tax on all seven products decreased emissions of GHG, nitrogen, ammonia and phosphorus from the livestock sector by up to 12%.

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Introduction

Global meat production increased by 245% and dairy production increased by 70% between 1961 and 2001, and is likely to continue to increase in the near future, driven by economic development in many countries (Steinfeld and Gerber, 2010). Several studies have reported detrimental environmental effects of meat and food production, such as climate change from greenhouse gas (GHG) emissions and impaired water quality from nutrient leaching (e.g. FAO, 2006; Galloway et al., 2008; Gerber et al., 2013). FAO (2006) found livestock to be responsible for 18% of total GHG (or carbon equivalents, CO_2/e) emissions worldwide, although this figure was revised downwards to 14.5% by Gerber et al. (2013). However, McMichael et al. (2007) concluded that 22% of total anthropogenic GHG emissions come from agriculture, with 80% of those from livestock. In addition to GHG emissions, Galloway et al. (2008) point out the important role of the agricultural sector in the increasing threat of reactive nitrogen on global scale. The need to reduce consumption of meat and dairy products for environmental reasons has been emphasised by several researchers (e.g. UNEP, 2009; Röös and Tjärnemo, 2011; Cederberg et al., 2013; Bajželj et al., 2014; Hedenus et al., 2014.). Hedenus et al. (2014) concluded that it will be difficult to reach worldwide climate targets without dietary changes.

The negative environmental externalities of meat and dairy production could, in principle, be mitigated by means of a Pigovian tax (Pigou, 1957). This would involve an increase in the consumer prices corresponding to the marginal damage costs, so that meat and dairy commodities carry their associated social costs. Such a tax would provide incentives to reduce environmentally damaging practices in animal food production, and at the same time promoting the dietary changes needed.

The aim of this study was to evaluate the effects of a Pigovian tax on meat and dairy consumption in Sweden. Total consumption of beef, pork and chicken in Sweden increased from 460 000 to 725 000 tons[2] between 1990 and 2009, which is an increase of 58% (Swedish Board of Agriculture, statistical database). In addition to GHG, this study included nitrogen, ammonia and phosphorus emissions, which have been causing eutrophication in inland and coastal waters, particularly in the Baltic Sea, since the early 1970s, resulting in algae blooms and oxygen depletion. According to our calculations, Swedish meat and dairy production accounts for approximately 18.5% of total nitrogen, including nitrogen from ammonia emissions, and 8.3% of total phosphorus released into the Baltic Sea from Sweden. Given the large proportions of agricultural and arable land that are needed for livestock production (worldwide

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[2] Taking population increase into account, which increased from 8 590 630 in 1990 to 9 340 682 in 2009 (Statistics Sweden, 2010).

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33% of arable land and 70% of agricultural land FAO (2006)) the real percentage is likely to be much higher.

The environmental impacts of introducing a Pigovian tax on beef, pork and chicken, as well as milk, fermented dairy products, cream and cheese, were determined as consumer response to price changes, which was assessed by econometric analyses using the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980). The analysis was conducted in two stages, with total food demand as the first upper stage, and meat demand as one of the second, lower stages, and dairy demand as the other lower stage (Edgerton, 1997; Carpentier and Guyomard, 2001). Based on estimated price and income elasticities, the effects of an environmental meat and dairy tax on emissions of GHG, nitrogen, ammonia and phosphorus was determined.

Starting in the 1920s, there is a large body of literature on analyses of economic instruments for combating environmental damage, applied e.g. to water pollution, climate change and biodiversity conservation (see e.g. Helfand et al., 2003 for a review). Based on this literature, one could argue in favour of differentiated taxes according to pollutant emissions and environmental impacts by each polluter (e.g. Baumol and Oates, 1988). However, when considering difficulties in monitoring each firm's pollutant emissions and associated environmental damage, uniform taxes on outputs can be less costly to society (e.g. Schmutzler, 1997; Gren, 2004; Kampas and White, 2004). A decision on whether to implement a tax on the consumption or the production side also had to be made. An argument in favour of consumption taxes in a small country like Sweden is the issue of competition from imported products, which would be severe if a tax was to be imposed on the production side. Swedish production would decrease, consumption would probably remain constant, and emissions would be exported, as net imports of meat and dairy products increased. The net effect of emission mitigation might then even be zero if policies were implemented on the production side (e.g. Van Doorslaer et al., 2015).

The design of efficient food taxes on consumption has been investigated in numerous studies, in which the tax is applied mainly to effect dietary changes for improvement of health (e.g. Schroeter et al., 2008; Nnoaham et al., 2009; Nordström and Thunström, 2011; Briggs et al., 2013). However, very few studies have examined the design and effects of environmental taxes on meat and dairy consumption (Wirsenius et al., 2011; Edjabou and Smed, 2013). Wirsenius et al. (2011) considered consumption taxes in the EU on animal products and Edjabou and Smed (2013) designed taxes for a large set of food items in Denmark, in order to regulate GHG emissions and promote an environmental friendly diet. Both studies made use of estimated price elasticity and income elasticity of the included food products for simulating effects on GHG emission of different tax levels, an approach adopted in the present study. The main novel contribution of our study is the inclusion of nitrogen, ammonia and phosphorus emissions, in addition to GHG, when determining tax levels for meat and dairy, and estimating the associated impacts on pollutant emissions. The econometric approach used followed the literature by constructing an AIDS model for estimating demand and income elasticity of the meat products (Deaton and Muellbauer, 1980).

There were some limitations to our analysis. While we recognise the need to consider the entire food chain and a larger set of food items, when regulating pollutant emissions, we chose to study animal food products. Meat was a main focus, which was motivated by findings by Wirsenius et al. (2011) indicating that a tax on ruminant meat contributed most of the mitigation effect of a GHG-weighted tax on animal food. Edjabou and Smed (2013) confirmed that the largest decrease in GHG emissions is obtained from a tax on beef. However, excluding dairy products was not possible given the high emission levels from, for example, cheese. Our aim was to include nitrogen, ammonia and phosphorus and in our estimations, and thus extending the analysis reported by Wirsenius et al. (2011) and Edjabou and Smed (2013). Another limitation of the study is the calculation of average damage costs of pollutants instead of the theoretically correct marginal damage cost. The reason is the lack of data.

This paper is organised as follows. In Section 'Model specification of meat demand, meat tax and emission reductions', we present the approach used for calculating effects of environmental taxes and the AIDS model used to estimate demand and income elasticity. In Section 'Estimation of meat demand', data and regression results on the demand system are presented, while Section 'C alculation of environmental meat tax' presents calculations of average emission levels and average damage costs per kg meat and dairy products. The results are presented in Section 'Impact of meat taxes on pollutant emissions', followed by a discussion and summary in the sixth section.

Model specification of meat demand, meat tax and emission reductions

The modelling framework and the subsequent empirical analyses consisted of three main steps: (i) derivation of demand for animal products before the tax, (ii) calculation and introduction of the tax and derivation of the new demand for meat and dairy products, and (iii) estimation of emissions of environmental pollutants before and after the introduction of the tax. Starting with the first step, we used the non-linear AIDS model to calculate demand and income elasticities on per capita level (Deaton and Muellbauer, 1980). This was conducted in two stages (e.g. Edgerton, 1997). In the first stage, a demand system of aggregated food groups was estimated. In the second stage, we estimated two separate systems, one for meat products and one for dairy products. Final uncompensated elasticities take both changes within the food group, and changes to other groups of food into account.

In the model framework, share of total consumption of each meat product in each period of time, $s_{j,t}$ (where $j = 1, \ldots, n$ products) was expressed as a function of a constant, α_j and logged prices of all commodities and total expenditure X_t. The AIDS model was thus:

$$s_{j,t} = \alpha_{j,t} + \sum_{k=1}^{m} \gamma_{j,k} \ln p_{k,t} + \beta_j (\ln X_t - \ln P_t) \tag{1}$$

where $k = 1, \ldots, m$ products within the group of commodities, $s_{j,t} = p_j q_j / X_t$, $X_t = \sum_{j=1}^{m} p_j q_j$ is total expenditure for each year for each commodity group, and the price index $\ln P_t$ was:

$$\ln P_t = \alpha_0 + \sum_{j=1}^{n} \alpha_{j,t} \ln p_{j,t} + \frac{1}{2} \sum_{j}^{n} \sum_{k}^{m} \gamma_{j,k} \ln p_{j,t} \ln p_{k,t} \tag{2}$$

The parameters are to fulfil adding-up restrictions as well as homogeneity and symmetry conditions, $\sum_j^n \alpha_j = 1$ and, $\sum_j^n \beta_j = 0$ where β_j shows the change in budget shares when expenditure changes. Furthermore, $\gamma_{j,k}$ indicates the change in budget share when the price changes and the homogeneity restriction requires that $\sum_{j=1}^{m} \gamma_{j,k} = 0$. Symmetry conditions imply that a change in price of good j has the same marginal effect on the budget share of good k as a price change of good k has on the marginal change of budget shares of good j, i.e. that $\gamma_{j,k} = \gamma_{k,j}$.

Price and income elasticity calculations for the two-stage demand system were performed using definitions in Green and Alston (1990) and the multistage elasticities from Edgerton (1997). In the following, the subscript M denotes uncompensated, Marshallian elasticity, H compensated Hicksian elasticity and I income elasticity for each state separately, which are defined as:

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