The Danish Tax on Saturated Fat - Demand Effects for Meat and Dairy Products

Jørgen Dejgaard Jensen, Sinne Smed[1], Lars Aarup, Erhard Nielsen[2]

[1] University of Copenhagen, Department of Food and Resource Economics, contact: Jorgen@ifro.ku.dk , ss@ifro.ku.dk

[2] Coop Danmark, contact: Lars.Aarup@coop.dk, Erhard.Nielsen@coop.dk

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Abstract

Denmark introduced a tax on saturated fat in food products with effect from October 2011. This paper makes an effect assessment of this tax for some product categories affected by the new tax: meats and dairy products. This assessment is done by conducting an econometric analysis on monthly food sales data from a major retail chain in Denmark (Coop Danmark), spanning the period from January 2010 until October 2012.The econometric analysis suggests that the introduction of the tax on saturated fat led to a decrease in the intake of saturated fat from minced beef and cream products.

Keywords: fat tax, demand response, price response, beef, cream, retail sales

1. Introduction

In line with several other countries, Denmark increasingly faces health problems induced by unhealthy diets, including overweight, obesity and a number of associated co-morbidities (WHO, 2008), leading to increasing health care costs. There is an increasing awareness of the needs for public regulations to reverse this trend. Taxation of an unhealthy food is expected to increase the consumer price of unhealthy food, thus providing an incentive for the consumer to buy less of this product and at the same time, the revenue generated from such a tax can be used for financing public expenditures or reducing other taxes.

The issue of food taxation as a health promoting instrument has been considered in a number of scientific papers (see e.g. review by Mytton et al., 2012). As the actual use of food taxation as a health policy instrument has been very limited (see below), these studies are based on model simulations, derived from e.g. econometrically estimated price elasticities. For example, Smed et al. (2007) and Jensen & Smed (2007) have investigated the potential effects of alternative health-related food tax models (including a tax on saturated fat, taxes on all fats, tax on sugar or lower taxes on fruits, vegetables and/or dietary fibres) on food consumption. The finding of this is that such tax schemes may constitute a tool to change dietary behaviour, and with the potentially largest effects on lower social groups. In a simulation study, Mytton et al. (2007) found that taxing sources of saturated fat may lead to a reduction in the intake of saturated fats and despite an associated increase consumption of salt, would be a tool to avert thousands of cardiovascular deaths per annum in the UK.

In contrast, Chouinard et al. (2006) studied the impact of a fat tax on the consumption of dairy products, based on econometrically estimated price elasticities, and found a rather inelastic demand for these products, suggesting a low impact on consumption, but a high potential to generate tax revenue. A study by Allais et al. (2010) found that a fat tax has small and ambiguous effects on nutrients purchased by French households, leading to a small effect on body weight in the short run and a larger effect in the long run. Tiffin & Arnoult (2011) found that a fat tax will not bring fat intake among UK consumers in line with nutritional recommendations and that potential health impacts of a fat tax will be negligible. Finally, Nordström & Thunström (2009) found that a tax on saturated fat would be more efficient in changing consumer behaviour than a tax on all fat, but the impact on consumption would still be minor, assuming politically feasible tax levels. However, in

the above studies, it is assumed that the tax rate is perfectly transmitted to the consumer prices, and that price elasticities remain unaffected by the tax, which might not be the case in a real-life setting.

Recently, some countries have adopted the approach of introducing new taxes on foods or beverages that are considered unhealthy. In France, a tax on sugared soft drinks was introduced in 2011 (Villanueva, 2011), in Hungary taxes on different ready-to-eat foods (candies, soft drinks, energy drinks, savoury snacks and seasonings) with specified nutritional characteristics were also introduced in 2011 (Villanueva, 2011, Holt, 2011). Finland has in 2011 reintroduced taxes on sweets, which had been abolished since 1999, and more countries are considering the use of tax instruments in health promotion policies (EPHA, 2012). In Denmark, a tax on saturated fat in food products was introduced in October 2011, as a supplement to existing taxation on sugar, chocolate, candy, ice-cream and soft drinks. The fat tax in Denmark distinguished itself from the taxes mentioned above by targeting a nutrient which occurs naturally in foods, instead of targeting specific groups of food, and as such this was the first tax of its kind in the world.

The objective of this paper is to investigate, whether the Danish tax on saturated fat was effective in reducing consumers' intake of saturated fat. Furthermore, it is an aim to study how the tax triggered different mechanisms in consumption, and the relative importance of these different mechanisms. We investigate these effects by studying the impact on the composition of consumption within three different types of food products containing considerable amounts of saturated fats, namely minced beef and two types of cream.

The rest of this paper is organized as follows. The next section describes some key features of the Danish fat taxation scheme, and the subsequent section provides a description of data and methodology. Following the methodological section, results of the analysis are presented, and finally the paper is rounded off with a discussion and questions for further research.

2. The Danish tax on saturated fat

The tax on saturated fat was part of a larger tax reform taking place in Denmark in 2010. The overall aim of this reform was to reduce the pressure of income taxation rates for all people actively participating in the labour market and to finance this by, among other things, increased energy and environmental taxes and increased taxes to reduce adverse health behaviour.[1] The so-called health taxes included upward adjustments in existing taxes on sweet products, soft drinks, tobacco and alcohol.

A novelty in the tax reform was the introduction of a tax on saturated fat in foods. The fat tax was a tax paid on the weight of saturated fat in foods, if the content of saturated fat exceeded 2.3 grams per 100 gram.[2] The threshold of 2.3 grams saturated fat per 100 gram implied that all kinds of drinking milk were exempt from taxation. The tax was levied on food manufacturers and food importers, but was expected to be transmitted to the consumer prices. Foods determined for exports or animal fodder were exempt from the tax. The tax was set at 16 DKK (2.15 €) per kg saturated fat, which was topped up by 25 per cent VAT. The tax came into force on the 1st of October 2011[3].

Fatty products, such as butter and margarine, cream, cheese and meats were the food commodities for which prices were most affected by the fat tax, due to their high content of saturated fat. One study (Jensen & Smed, 2013) has investigated the impacts of the saturated fat tax on the consumption of butter, butter-blends, margarine and oils, based on household purchase data. Their study found that the tax led to significant reductions in the consumption of butter and

[1] For more on the overall tax-system change see http://www.skm.dk/public/dokumenter/engelsk/Danish%20Tax%20Reform_2010.pdf

[2] The fat tax is described in Smed (2012) and in https://www.skat.dk/SKAT.aspx?oId=1950194&vId=0 (in English)

[3] The tax was repealed again by the end of 2012 for political reasons (see Vallgårda et al., 2014)

margarine, but also that the tax induced some structural shifts in different store types' market shares for these products.

In Denmark, a large share of the meat sold in retail stores is distributed from the manufacturers or importers to the retailers in the form of whole carcasses, and then further processed and cut in the retail stores. Hence, in many cases it was not possible to put the levy directly on individual cuts of meat without considerable extra costs. Instead, animal-specific coefficients for content of saturated fat in the meat could be applied when determining the taxable base. The regulation allowed for a differentiated taxation according to content of saturated fat, based on official food composition tables or specifically documented fat contents, as long as this was done consistently for the whole carcass. As the latter option was significantly more demanding with regard to administration, this option was only used for a small share of the Danish meat market.

Table 1 illustrates the magnitudes of the tax rate, relative to the average retail prices of different types of foods in 2010-2011.

Table 1. Calculation of fat tax in meat and dairy products

	Saturated fat content		Price	Tax-induced price change			
	Differen-tiated[1]	Standar-dized[2]	before tax	€/kg		per cent	
				Diff.	Stand.		Stand.
	per cent	per cent	€/kg	tax	tax	Diff. tax	tax
Minced beef, 3-7%	2.1%	5.2%	10.07	0.06	0.14	0.6%	1.4%
Minced beef, 8-11%	4.0%	5.2%	9.40	0.11	0.14	1.2%	1.5%
Minced beef, 12-16%	6.0%	5.2%	7.38	0.16	0.14	2.2%	1.9%
Cream, 4-9%	4.3%		8.05	0.11		1.4%	
Cream, 10-26%	11.8%		8.72	0.32		3.6%	
Cream, 38%	24.9%		9.40	0.67		7.1%	
Sour cream, 4-9%	4.3%		8.05	0.11		1.4%	
Sour cream, 10-26%	11.8%		8.72	0.32		3.6%	
Sour cream, 38%	24.9%		9.40	0.67		7.1%	
Minced pork, 8-11%	3.8%		8.05	0.10		1.3%	
Butter	51.8%		9.40	1.39		14.8%	
Margarine	31.3%		4.03	0.84		20.9%	
Cheese, 20+	7.1%		6.71	0.19		2.8%	
Cheese, 40+	14.6%		8.72	0.39		4.5%	

1. Coefficients based on actual fat content
2. Coefficients based on animal-specific average fat content
Source: Coop Danmark and www.foodcomp.dk

Among these product groups, butter has the largest content of saturated fat, and the consumer price of butter could hence be expected to be affected the most, in absolute terms. But also the price of margarine was affected significantly by the tax, and as the before-tax price of margarine was considerably lower than the price of butter, the relative price change for margarine was larger than for butter. The fat tax constituted 7.1 per cent of the price of high-fat cream (38%), and 1-2 per cent of the price for low-fat cream (4-9%).

The consequences of the "standardized approach" to calculation of meat taxation rates are also illustrated in table 1. According to the regulation, beef is taxable at a rate corresponding to a saturated fat content of 5.2 per cent, but there is considerable variation in the "true" content of saturated fat in different types of beef. For example, lean minced beef (3-7% total fat content) contains about 2 per cent saturated fat, whereas fatty minced beef (12-16% total fat) contains about 6 per cent saturated fat. Hence, lean beef can be considered to be "over-taxed", whereas high-fat beef is "under-taxed" in the "standardized" approach.

Because lean meat is generally higher priced than high-fat meat, the saturated fat tax still (from a partial perspective) implies a larger relative price increase for fatty meat than for lean meat, and hence probably a stronger economic incentive to reduce the consumption of high-fat meat. But this incentive could have been stronger, if the "true" fat contents had been applied.

3. Methodology

We aim to analyse the effects of the Danish fat tax on the consumption of two product categories directly affected by the tax: minced beef and cream products, based on standard economic theory on consumption behaviour.

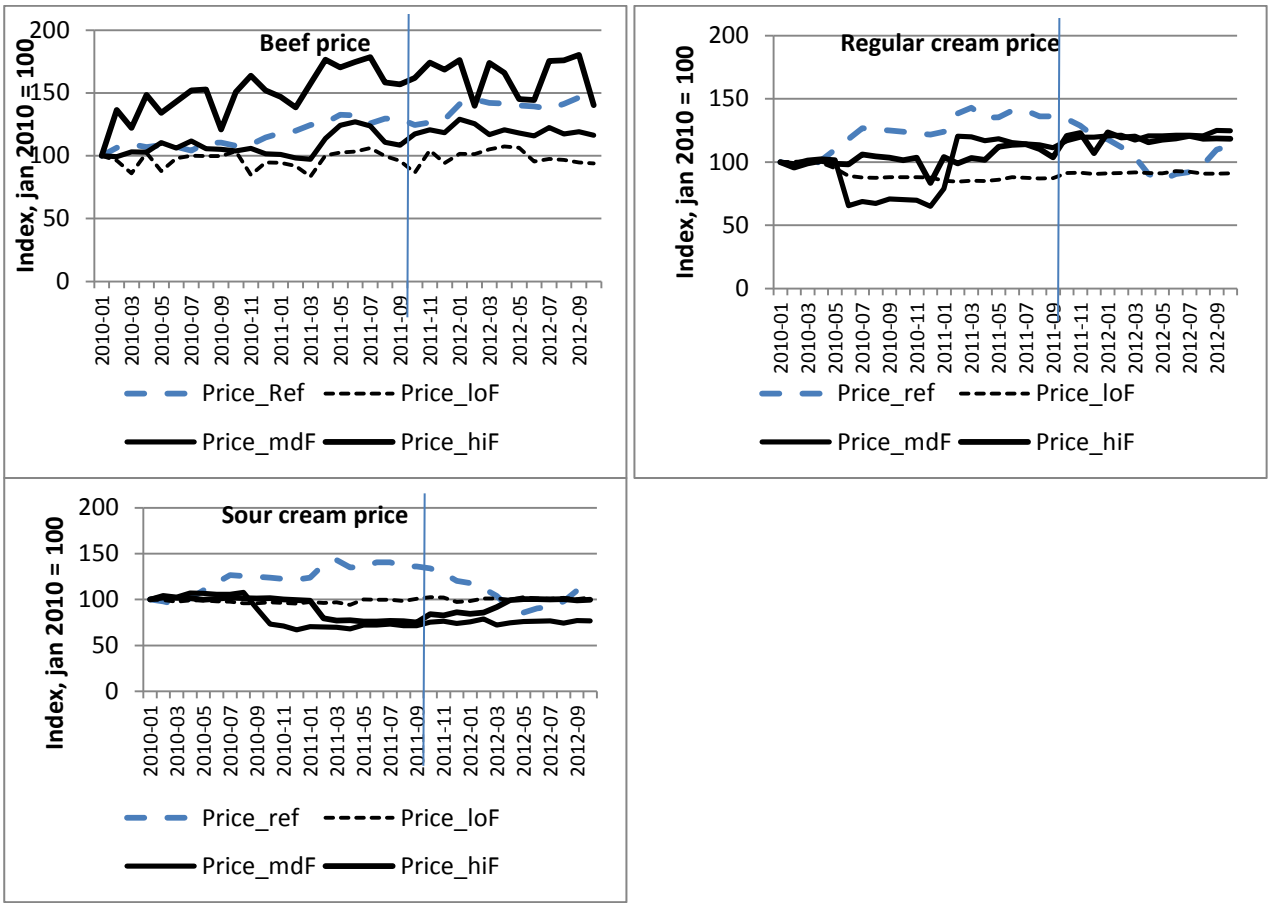
Table 2. Descriptive statistics of variables before and after October 1, 2011

	Consumer price (net of discounts etc.) (DKK/kg)		Purchased quantity (kg/store/month)		Budget share	
	Before Oct. 1, 2011	After Oct. 1, 2011	Before Oct. 1, 2011	After Oct. 1, 2011	Before Oct. 1, 2011	After Oct. 1, 2011
Minced beef					**1,00**	**1,00**
Low-fat (≤7% fat)	65,25	66,65	103,8	151,6	0,30	0,34
Medium-fat (7-11% fat)	48,63	54,13	164,6	202,2	0,42	0,42
High-fat (≥12% fat)	40,72	44,52	145,6	148,2	0,28	0,24
Regular cream					**1,00**	**1,00**
Low-fat	10,99	11,18	37,1	31,2	0,05	0,03
Medium-fat	17,80	22,36	40,2	61,3	0,09	0,14
High-fat	24,09	27,72	366,8	385,7	0,83	0,81
Sour cream					**1,00**	**1,00**
Low-fat	19,25	19,79	74,0	71,5	0,54	0,59
Medium-fat	23,53	18,48	43,8	35,3	0,41	0,36
High-fat	17,58	17,84	4,4	4,0	0,05	0,06

The data used in this paper originates from Coop Danmark, one of the largest food retailer corporations in Denmark (representing a market share of about 40 per cent of total food retailing in Denmark), spanning 5 large retail chains: Kvickly, SuperBrugsen, Dagli'Brugsen, Fakta and Irma, of which the former four are located all over the country, and Irma is located in the eastern part of the country (Sealand). The data used covers the period from 1st of January 2010 to 31st of October 2012 and is a balanced panel that contains observations from 1293 stores. For each store, monthly records of sales volume and sales, as well as information about specific campaigns are available at

barcode level[4]. For the econometric analysis, data for minced beef, regular cream and sour cream with different fat contents have been used. Descriptive statistics for these data are given in table 2.

The descriptive statistics show that the prices of minced beef and regular cream tended to be higher after October 1, 2011, when the tax on saturated fat was introduced, whereas no general pattern was seen for the prices of sour cream before and after introduction of the tax. For beef, the average price increases seem to have been stronger for medium-fat beef and weakest for low-fat minced beef, a similar pattern was observed for regular cream, whereas for sour cream, the prices of low- and high-fat varieties remained almost unchanged and the average price of medium-fat sour cream decreased, but figure 1 reveals that this development does not seem to be closely related to the introduction of the fat tax.



Note: LoF ~ low-fat variety, MdF ~medium-fat variety, HiF ~high-fat variety, ref ~reference

Figure 1. Price developments, January 2010-October 2012

According to table 2, the average purchase of both minced beef and regular cream was higher in the period after the tax was introduced than before, which may come as a surprise, as these products are both taxed. It should however be kept in mind, that the figures presented in table 2 are not corrected for seasonal variation, fluctuations in supply conditions, trends, etc., which is done in the econometric analyses below. We should also keep in mind that these figures represent sales of minced beef and cream from COOP's stores, and interpreting these figures as representative of the

[4] An alternative would be to use household consumption data, which would (in principle) address the consumption effects more directly. On the other hand, the applied retailer sales data enable a high level of detail in terms of e.g. fat per cent, and accuracy in measurement is considered to be very high.

Danish population should be done with care, as we have not been able to adjust for possible changes in consumers' selection of shops etc., which might imply a risk of biased effect estimates.

Looking at COOP's customers' allocation of spending budget within these food categories, represented by "budget shares", table 2 shows a movement from high-fat varieties (hiF) towards low- (loF) or medium (mdF) fat varieties for all three product categories, after the tax was introduced (although an increase in the budget share for high-fat sour cream was observed).

In figure 1, the price developments of the different product varieties are plotted against a reference price (Ref) for each product category. The reference price is presumed to represent a relevant price variable that is closely linked to the international markets, and hence is assumed not to be influenced by the Danish fat tax. For beef, we use an index for the farm-gate price of cattle for slaughtering (Statistics Denmark, Statistikbanken), and as a reference for cream (both regular and sour) prices, we use the German butter price (CIAL), reflecting the assumption that the alternative use of the cream would be to process it to butter for exports. For minced beef, the prices of medium- and low-fat product varieties tend to follow the price of slaughter cattle, whereas the average price of high-fat minced beef exhibits a completely different pattern.

Econometric model

We assume separability in utility in the sense that the composition of consumption within each of the three product categories is assumed to be independent of prices and consumption within other product categories. Due to its flexibility and feasibility properties in terms of estimation and in imposing and testing theoretical properties such as linear homogeneity, adding-up and Slutsky symmetry, we choose the Linearized Almost Ideal Demand System (LAIDS) functional form for each of the three product categories

$$w_{it}^b = \alpha_i^b + \sum_j \alpha_{ji} \cdot \ln p_{jt}^b + \alpha_{yi} \cdot \left(\ln y_t^b - \ln P_t^b\right) \ , \ln P_t^b = \sum_j w_{jt}^b \cdot \ln p_{jt}^b \qquad (1)$$

Commodity i's expenditure share w_i can be described as a linear function of the logarithmic prices ($\ln p$) and the total real consumption expenditure within the commodity category, ($\ln(y/P)$). Taking departure in sales from retail stores, the sale from store b is an approximation of the "representative" consumer's expenditure in this store. α's are parameters to be estimated.

The tax on saturated fat can be investigated by augmenting the LAIDS model in the following way

$$w_{it}^b = \alpha_i^b + \theta_i^b \cdot \tau_t + \sum_j \left(\alpha_{ji} + \theta_{ji} \cdot \tau_t\right) \cdot \ln\left(p_{jt}^b + \beta_{jt} \cdot \phi_j \cdot \tau_t\right) + \left(\alpha_{yi} + \theta_{yi} \cdot \tau_t\right) \cdot \ln\left(y_t^b / P_t^b\right) \qquad (2)$$

Introducing the saturated fat tax (the dummy variable τ =1 from October 1, 2011 and onwards, otherwise zero) affects the price of product j, depending on the product's content of saturated fat, ϕ_j, and the extent to which the store passes the tax on to the consumer price, represented by the parameter β, which might be expected to be close to unity (Jensen & Smed, 2013). The price change will in turn affect the demand, represented by the price effect parameter α_{ij}. But to the extent that introduction of the tax affects consumers' demand more directly, the model also accounts for three effects - a modification of the price effect, given by the parameter θ_{ji}, a modification of the income (or budget) effect, represented by the parameter θ_{yi}, as well as a general shift in demand level, represented by the parameter θ_i. These parameters are quantified by means of econometric analyses.

From the LAIDS model, we can derive expressions for price elasticities (ε_{ji}), evaluated at the mean budget shares $\left(\overline{w}_i, \overline{w}_j\right)$.

$$\varepsilon_{ji} = \frac{\partial q_i}{\partial p_j} \cdot \frac{p_j}{q_i} = \frac{\left(\alpha_{ji} + \theta_{ji} \cdot \tau_j\right) + w_j}{w_i} - \delta_{ij} - w_j \cdot \left(1 + \frac{\alpha_{yi} + \theta_{yi} \cdot \tau_i}{w_i}\right) \quad (3)$$

δ_{ij} is the Kronecker delta ($=1$ *for* $i = j; = 0$ *for* $i \neq j$).

If the θ parameters differ from zero, the tax has an influence on the price elasticities. Hence, we can decompose the effect of the tax on consumption of commodity i into two components: a price change component given by the expression

$$\frac{q_i^1}{q_i^0}\Big|_{price} = \prod_j \left(\frac{p_j^1}{p_j^0}\right)^{\varepsilon_{ij}^0} \Rightarrow \Delta\left(\frac{q_i^1}{q_i^0}\right)\Big|_{price} = \prod_j \left(\frac{p_j^1}{p_j^0}\right)^{\varepsilon_{ij}^0} - 1 \quad (4)$$

and a component originating from the changes in elasticities driven by the θ_{ji} and θ_{yi} parameters

$$\frac{\partial\left(q_i^1/q_i^0\right)}{\partial \varepsilon_{ij}} = \ln\left(\frac{p_j^1}{p_j^0}\right) \cdot \left(\frac{p_j^1}{p_j^0}\right)^{\varepsilon_{ij}^0} \Rightarrow \Delta\left(\frac{q_i^1}{q_i^0}\right)\Big|_{elast} = \sum_j \ln\left(\frac{p_j^1}{p_j^0}\right) \cdot \left(\frac{p_j^1}{p_j^0}\right)^{\varepsilon_{ij}^0} \cdot \left(\varepsilon_{ji}^1 - \varepsilon_{ji}^0\right) \quad (5)$$

The total effect to be derived from the tax can be calculated as the sum of these two terms.

The augmented LAIDS models for demand were estimated as a simultaneous system of three price equations and two budget share equations for each commodity group (due to adding-up, the budget share equation for the high-fat varieties were skipped). Price equations were estimated with the tax dummy, reference prices, season (monthly) dummies and a variable representing temporary price campaigns as explanatory variables. Furthermore, inspired by Jensen & Smed (2013), a pre-tax dummy (=1 in September 2011) was included to capture possible price campaigns prior to the introduction of the tax. The budget share equations of the LAIDS model contained prices, real budget term, season dummies, tax dummy, pretax dummy, as well as interactions between prices, real budget and tax dummy. The equations were estimated as fixed effects models, using 3SLS (treating prices, budget shares and real budget as endogenous variables) and imposing linear homogeneity and symmetry.

4. Results

Table 3 summarizes econometric estimates of the partial influence of the tax dummy on the prices of different varieties of beef, regular cream and sour cream, when we control for general market developments and seasonality. More detailed estimation results are displayed in Appendix table A1, and the full set of estimated parameters can be obtained from the authors upon request.

The estimation results indicate similarities across the three commodity groups, with insignificant or small negative effects for low- and medium-fat varieties, and 13-16 % price increases for high-fat varieties. Compared with the "theoretical expectation", cf. table 1, the effects of the tax on prices of high-fat varieties exceed our a priori expectations.

Table 3. Estimated effect of fat tax on consumer price

	Low fat variety		Medium fat variety		High fat variety	
Beef	-1%	N.S.	-4%	N.S.	16%	***
Regular cream	-2%	***	-2%	***	14%	***
Sour cream	-1%	***	1%	***	13%	***

*: significant at 5% level, **: significant at 1% level, ***: significant at 0.1% level, N.S.: not significant at 5% level

Price elasticities derived from the estimated AID demand models are shown in table 4 (more detailed results are displayed in Appendix table A2, and a full set of results can be obtained from

the authors upon request). Elasticity estimates are calculated both before and after the introduction of the tax (with the coefficients to interaction terms between tax dummy and prices or budget constituting the difference), in order to assess the potential effects of the tax on these price elasticities, and hence on the underlying preference parameters of the consumers.

Most estimated elasticities are consistent with a priori expectations, including e.g. negative signs of own-price elasticities (with low-fat beef prior to the fat tax as an exception). For example, the results show that the own-price elasticity of low-fat regular cream was -0.898 before October 1, 2011, and -1.013 after this date. Cross-price elasticities between different fat varieties of beef were positive, suggesting that substitution effects dominate real budget effects of price changes. Somewhat different patterns were found for the purchase of regular cream and sour cream, as some cross-price elasticities were negative, suggesting less substitutability between cream products with different fat contents than between different beef varieties. Overall, the estimated elasticities did not seem to change very much as a consequence of the fat tax, although the difference was found to be statistically significant for more than half of the elasticities.

Table 4. Estimated price elasticities, before and after October 1, 2011

	Elasticity wrt price of low-fat variety			Elasticity wrt price of medium-fat variety			Elasticity wrt price of high-fat variety		
	Before Oct. 1, 2011	After Oct. 1, 2011	Signifi-cance	Before Oct. 1, 2011	After Oct. 1, 2011	Signifi-cance	Before Oct. 1, 2011	After Oct. 1, 2011	Signifi-cance
Beef									
Low-fat	0,073	-0,114	***	0,552	0,781	***	0,516	0,482	*
Medium-fat	0,378	0,516	***	-0,187	-0,423	***	0,427	0,264	***
High-fat	1,092	1,037	*	0,784	0,991	***	-0,575	-0,616	***
Regular cream									
Low-fat	-0,898	-1,013	**	0,060	-0,154	***	-0,811	-0,530	***
Medium-fat	0,019	-0,060	***	-0,969	-0,962	N.S.	-0,080	0,031	*
High-fat	-0,008	0,009	***	-0,007	0,003	*	-0,995	-0,997	***
Sour cream									
Low-fat	-0,805	-0,914	***	-0,018	0,051	***	0,330	0,333	N.S.
Medium-fat	-0,246	-0,105	***	-0,935	-1,031	***	-0,038	-0,046	N.S.
High-fat	0,029	0,139	N.S.	-0,109	-0,137	N.S.	0,036	-0,729	N.S.

Note: Significance denotes the statistical significance of difference in θ_{ji} coefficient, hence a test of significant change in elasticity: *: significant at 5% level, **: significant at 1% level, ***: significant at 0.1% level, N.S.: Not significant

Using expression (4) above, we can now derive two tax-induced components in the demand response for the different beef and cream products: price effect as a direct consequence of the fat tax, and a change in the preferences, represented by a change in price elasticities. These components are shown in table 5.

From table 5, we can see that the effects of the fat tax on consumption and saturated fat intake become rather complex, when we take substitution effects and changes in preferences into account. For example, it is striking that the tax-induced price effects seem to lead to an increase in the consumption of low- and medium-fat beef, even though the prices of these varieties increase due to

the tax, because substitution effects dominate and stimulate the consumption of these beef varieties. Similar effects were found for sour cream, whereas the consumption of all fat levels of regular cream was found to decrease due to the tax.

Table 5. Decomposition of demand change since October 1, 2011

	Tax-induced own-price effects	Tax-induced cross-price effects	Changed price elasticities	Total tax effect
Beef				
Low fat	0%	8%	-1%	8%
Medium fat	0%	8%	-3%	5%
High fat	-8%	0%	-1%	-9%
Regular cream				
Low fat	0%	-10%	3%	-7%
Medium fat	0%	-10%	1%	-9%
High fat	-12%	0%	0%	-12%
Sour cream				
Low fat	0%	4%	0%	4%
Medium fat	-1%	4%	0%	3%
High fat	0%	0%	-10%	-9%
Change in saturated fat intake				
Beef		-4,1%		-1,3%
Regular cream		-11,4%	0,1%	-11,3%
Sour cream		-0,3%	-1,1%	-1,4%

Combining the demand effects with coefficients for saturated fat content in the respective product types (table 1), we can calculate the effects on saturated fat intake from the three products. As shown in table 5, the tax leads to a decrease in the intake of saturated fat for all three product categories, most pronounced for regular cream.

5. Discussion and conclusion

The above econometric analyses suggest that the introduction of a tax on saturated fat in food products in Denmark has had some effects on the retail market for beef and cream products. The results illustrate that the impacts of the tax are somewhat complex, in that substitution effects between product varieties with different contents of saturated fat play an important role, whereas shifts in consumers' preferences following the introduction of the tax play a minor role. Hence, the present study yields some support for previous simulation analyses suggesting that a fat tax has an effect on consumption (Smed et al., 2007, Jensen & Smed, 2007, Mytton et al., 2007). For example, Jensen & Smed (2007) estimated a 3-4% decrease in meat consumption as a consequence of a saturated fat tax rate comparable to that of the actual tax in real terms, whereas Smed et al. (2007) estimated a 9% decrease in intake of saturated fat as result of a tax rate about 8 DKK/kg (in year 2000-price level).

The analysis is based on a relatively short period after introduction of the tax (twelve months, corrected for seasonality effects), and hence interpretation of these findings from a long-run perspective should be done with some care. On the one hand, hoarding prior to the introduction of the tax may have affected purchases in the beginning of the taxation period. On the other hand, economic reasoning might suggest larger behavioural adjustments and reductions in consumption of

high-fat products in the longer run, both on the consumer demand side, for example because formation of new dietary patterns in response to a price change takes time, but also on the supply side, for example in terms of product reformulation towards products with a lower content of saturated fats, changed marketing strategies with more emphasis on lower-taxed products, etc. So even if the presented short-run results may provide a biased estimate of long-run effects, there is some ambiguity about the direction of such bias.

For pragmatic reasons, the empirical analysis has focused on the consumption of minced beef, as well as regular and sour cream, which represent a significant market volume within a limited number of specific product items. It should be kept in mind that also a range of other food products, including especially other dairy products and meat products, are directly affected by the fat tax – but also a whole range of processed foods, e.g. ready-meals, bread, pastries, processed foods, snacks, etc. are affected, because they are based upon ingredients, which are subject to taxation. Further, the tax may give rise to substitution effects with regard to product categories that do contain less saturated fat, and such substitution effects may enhance or undermine the direct incentive effects of the tax.

We should also mention that the present analysis interprets changes in sales from one (major) retail supplier as changes in consumption, which of course should be done with care, because this interpretation hinges on a number of critical assumptions, including that all that is bought is also consumed, and that retail chains' market shares in the considered products remain stable. It has not been possible to investigate these assumptions within the framework of the present analysis, but it would be an issue worthy of further investigation.

Several representatives of political parties and industry lobbies have been making the point that increased food taxation has led to increased border trade, and that such border trade offsets the direct consumption reduction effect of the tax. Economic theory would suggest a substitution effect between purchases domestically and across the border, if the price of domestically sold products increases, ceteris paribus. Although this may be a valid point for citizens living close to the border, most citizens in Denmark would face considerable transaction costs to go outside the country to buy fats. This could also be an issue worthy of further investigation in future research.

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Table A1. Selected econometric estimation results, price equations

	Tax dummy	Reference price	Linear trend	Intercept	R^2
Beef price (logs)					
log price, low-fat variety	-0,027	-0,075	-0,013	0,072	0,526
s.d.	0,027	0,102	0,009	0,013	
log price, medium-fat variety	-0,033	0,590	-0,025	-0,006	0,054
s.d.	0,030	0,113	0,004	0,015	
log price, high-fat variety	0,710	-3,522	-0,007	0,069	0,176
s.d.	0,040	0,151	0,014	0,020	
Regular cream price (logs)					
log price, low-fat variety	-0,017	-0,013	-0,004	0,014	0,325
s.d.	0,003	0,012	0,000	0,002	
log price, medium-fat variety	-0,023	0,075	0,013	0,036	0,722
s.d.	0,006	0,024	0,001	0,004	
log price, high-fat variety	0,142	0,311	-0,001	0,005	0,752
s.d.	0,002	0,005	0,000	0,001	
Sour cream price (logs)					
log price, low-fat variety	0,080	0,305	0,033	-0,007	0,741
s.d.	0,013	0,039	0,001	0,007	
log price, medium-fat variety	0,725	3,604	-0,130	-0,019	0,297
s.d.	0,032	0,094	0,001	0,016	
log price, high-fat variety	0,132	0,035	-0,001	-0,005	0,913
s.d.	0,012	0,036	0,001	0,006	

Table A2. Selected econometric estimation results – budget share equations

	Minced beef		Regular cream		Sour cream	
	Low fat	Medium fat	Low fat	Medium fat	Low fat	Medium fat
Log(price_lowfat)	0,0728	-0,0736	0,0042	0,0022	0,0540	-0,0478
	0,0032	0,0031	0,0023	0,0007	0,0029	0,0027
Log(price_medfat)	-0,0736	0,1385	0,0022	0,0038	-0,0478	0,0579
	0,0031	0,0039	0,0007	0,0015	0,0027	0,0032
Tax dummy	-0,1593	0,0992	-0,0029	0,0033	-0,0979	0,0848
	0,0023	0,0029	0,0004	0,0008	0,0095	0,0101
Pretax dummy	-0,0852	0,1733	-0,0281	0,0433	-0,2017	0,1428
	0,0129	0,0167	0,0049	0,0077	0,0224	0,0235
Plow*tax	0,0009	-0,1600	0,0003	-0,0046	0,0495	-0,0475
	0,0175	0,0216	0,0024	0,0051	0,0302	0,0311
Pmed*tax	-0,0545	0,0638	-0,0048	-0,0090	-0,0490	0,0465
	0,0032	0,0031	0,0014	0,0017	0,0029	0,0029
R^2	0,0638	-0,1063	-0,0090	0,0003	0,0465	-0,0425
Mean square error	0,0031	0,0039	0,0017	0,0038	0,0029	0,0030