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# **HOW PRICES AFFECT SCOTTISH HOUSEHOLD DEMAND FOR MILK PRODUCTS AND THEIR LOW CARBON ALTERNATIVES?**

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## **Abstract**

The Scottish milk chain is the highest green house gas emitter out of the dairy chain. This paper studies the effect of prices on household carbon footprints of both Scottish urban and rural households and the subsequent demand for milk products. Household time series data for 2006–2011 and carbon footprint data were used to estimate a static demand model. Results suggest that a 1% increase in net milk prices equates to a likely carbon footprint reduction of 4,684.13t CO<sub>2</sub>e /y for urban households. Both households were found to substitute into the lower carbon alternative of soya milk when whole milk prices increase.

**Keywords:** Consumer demand, Carbon footprint elasticity, Demand models, Carbon footprints

## **1. Introduction**

There is growing concern about the resilience of Europe's food systems in the face of threats from climate change and resource scarcities. In addition, there is great interest on tools that allow reversing or mitigating some of the growing imbalances. For instance, one of these cases is modifying relative prices (e.g. through taxes) to improve nutrition or to reduce the carbon footprint of consumers' diet. However, there is still the need to build evidence on consumers' response to these tools.

In 2007 the Scottish milk food chain emitted approximately 806 Kt CO<sub>2</sub>e which represents the largest green house gas (GHG) emitter within the Scottish dairy chain (which consists of: milk, cheese, butter, cream, yoghurt and ice cream) (Sheane et al., 2011). The overall dairy product group has been identified as one of the major contributors of greenhouse gas (GHG) emissions (Audsley et al., 2009) which highlights how household demand for milk products can have a potentially detrimental effect upon climate change.

The purpose of this paper is to understand the effects on both urban and rural households of a change in prices on household demand for different milk products and how this subsequently changes the household carbon footprint.

## **2. Literature Review**

There appears to be a general lack of research on Scottish household demand for low carbon food products. However Scottish Government research (sourced from Kantar Worldpanel) highlights that for 2010 only 20.8% of Scottish consumers "try to buy environmentally friendly products" versus the UK figure of 21.4% (Scottish Government, 2012). The term "Environmentally friendly products" seems ambiguous unlike the Carbon Trust's footprint which has a clear meaning (the meaning will be discussed in the Data section). While the demand side for milk products is the central theme of this paper it is important to highlight how Scotland is "essentially self sufficient in liquid milk" (Sheane et al. 2011:4). This reduces the problem of having to take into account non domestic milk production emissions.

There appears to be only two papers which use An Almost Ideal Demand System in relation to the carbon footprint of different products. The two papers identified are (Sall et al., 2012) and (Edjabou et al., 2013).

### 3. Data

Scottish household data has been obtained from Kantar Worldpanel and covers the years 2006 to 2011. Each year in the dataset is composed of thirteen periods<sup>1</sup>. The food categories for stages one and two were created through aggregating the Kantar data according to the Expenditure and Food survey codes (EFS). The first two stages of food groups used in this study closely resemble the groups in Tiffin et al (2011). The focus of this study is on stage three whereby four milk products have been selected (Semi skimmed, Skimmed, Soya and Whole milk) based on the Kantar descriptions and not EFS codes<sup>2</sup>.

The Scottish Government's six fold urban rural classification has been used in order to provide a comparison between the two areas. All the data were expressed in per capita terms and a Kantar weighting factor is used.

The carbon footprint data is sourced from Tesco Plc and complies with PAS 2050 cradle to grave carbon foot prints (Tesco plc, 2012). The British Standards Institute (BSI) PAS 2050 carbon footprint is made up of 63 different Green House Gases (GHGs). The four milk products have differing carbon footprints with Whole milk having the highest and Soya milk the lowest. There is quite a different in carbon footprint between Soya milk and Organic Soya milk. However Organic Soya milk appeared to have very few observations within the kantar dataset relative to Soya milk and was therefore omitted from this study.

### 4. Methods

This paper will use the static almost ideal demand system (AIDS) in the form of equation (1)<sup>3</sup> which allows for long run consumer behaviour to be studied through the use of price and expenditure elasticities.

$$w_{itk} = \alpha_i + \beta_i \ln \left( \frac{m_{itk}}{P_t} \right) + \sum_{j=1}^N \gamma_{ij} \ln p_{jt} + \sum_{k=1}^K \varphi_{ik} D_{kt} t + u_{itk} \quad (1)$$

The static AIDS model has been adapted by Wan et al (2010) who have created R package "Erer" (Sun, 2014). This package has been used in this paper to obtain the elasticities of the different milk products. The advantage with using Package "Erer" is the availability of diagnostic tests such as the Breusch-Godfrey (Wan et al., 2010). The authors' paper studied the demand for imported beds in the USA and found that a degree of product substitution occurs in the bed market (Wan et al., 2010).

A multistage budgeting approach based on Carpentier et al (2001) methods has been used in order to obtain unconditional expenditure elasticity results with the assumption of weak separability in stages two and three. However the price elasticities reported in this study are conditional.

The idea behind using a carbon elasticity arose from the nutrient elasticity adapted by Huang (1996) to measure how a change in the price or income subsequently affects the consumption of different nutrients<sup>4</sup> (Tiffin et al., 2011). Equation 2 demonstrates how a nutrient elasticity matrix (N) can be calculated by the food share of each nutrient (S) multiplied by the demand price elasticities (D) (Huang, 1996).

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<sup>1</sup> 13 periods of four weeks have been used due to the coverage of many years

<sup>2</sup> Previous work (linked to this study) using the EFS groups at stage three found the categories did not match the carbon footprint data and poor elasticity results were obtained.

<sup>3</sup> Equation 1 is based on the static model from Wan et al (2010) which in turn is based on Deaton and Muellbauer (1980)

<sup>4</sup> Nutrient availability

$$N = S \times D \quad (2)$$

Equation 2 has been adapted to account for carbon elasticity whereby Carbon elasticity matrix (N) is equal to the matrix of food share of carbon (S) multiplied by matrix of Marshallian (accounts for both price and income effect) demand price elasticities (D).

## 5. Results & Discussion

The carbon price elasticity can be inferred from using the Scottish milk food chain emission value of approximately 806 Kt CO<sub>2</sub>e (cradle to grave) (Sheane et al. 2011). The carbon elasticities and actual carbon equivalent reductions are presented in Table 1. A net price increase of 1% for all urban milk products could reduce GHG emissions by 4,684.13 t CO<sub>2</sub>e /y. This demonstrates that price increases can reduce households' carbon footprint. This may appear an obvious result; however the importance of substitution relationships between products has potential to make a price increase have either a positive or negative effect on household carbon footprints.

The results from Table 2 and 3 demonstrate that whilst some variables are not statistically significant the variables which are significant are negative for their respective own price elasticities. This suggests that the negativity condition has been met. The Hicksian price elasticities give a better idea of the substitution effects. A 1% increase in the price of whole milk will result in urban households increasing their demand for lower carbon Soya milk by 0.04% while the figure is slightly higher for rural households of 0.33%.

In Table 2 and 3 the long run unconditional expenditure elasticities was calculated as the conditional elasticities indicated that urban semi skimmed milk (represents the largest share of the milk group according to Table 4) was a luxury good with an elasticity of 1.12. The long run unconditional expenditure elasticity using three stages also suggests that semi skimmed milk is a luxury good since it has an elasticity expenditure of 1.4. For milk products this may seem unusual however a recent UK study finds that the expenditure elasticity of the milk group (in a level 2 of an AIDS model) has an expenditure elasticity greater than one (Tiffin et al., 2011). The authors attribute this result to households reducing their demand for milk when milk prices increase whilst the situation is different for cheese whereby the expenditure elasticity is less than one (Tiffin et al., 2011). This study found a similar finding for cheese being very much a normal good with an unconditional expenditure elasticity of 0.24 for urban households and 0.51 for rural households.

The Breusch-Godfrey and Breusch-Pagan test results found that serial correlation and heteroscedasticity are likely present in the model.

**Table 1.** Carbon footprint elasticities (adjusted for population representation of area)

Product	Urban carbon footprint elasticity	Implied reduction t/CO <sub>2</sub> e/y 1/	Rural carbon footprint elasticity	Implied reduction t/CO <sub>2</sub> e/y 1/
Semi Skimmed	0.04 3/	330.73 3/	-0.82	1,186.27
Soya	1.07	7,051.13	-0.46	667.08
Whole	0.13 3/	866.28 3/	-0.14	196.97
	-0.54	3,546.35	0.70	1,022.09 3/
	Total	4,684.13	Total	1,028.22

Notes:

1/ Total decrease in t/CO<sub>2</sub>e/y when considering the entire milk supply chain from cradle to grave.

2/ Elasticity is not statistically significant.

3/ Values were positive implying a t/CO<sub>2</sub>e/y increase (this is a likely result of a strong complementary relationship).

**Table 2.** Urban areas - Demand elasticities for milk 1/

	Marshallian elasticities								Hicksian elasticities								Expenditure elasticities	
	Semi skimmed	Skimmed	Soya	Whole	Semi skimmed	Skimmed	Soya	Whole	Semi skimmed	Skimmed	Soya	Whole						
Semi skimmed	-1.50	***	0.12	***	-0.02	0.26	***	-0.82	***	0.255	***	0.01	0.56	***	1.40	2/		
Skimmed	0.98	***	-0.63	***	-0.22	***	-58	***	1.25	***	-0.58	***	-0.21	***	-0.46	***	0.55	2/
Soya	-0.17		-2.89	***	-1.14	***	0.71		0.56		-2.74	***	-1.15	***	1.03	*	1.51	2/
Whole	0.67	**	-0.33	***	0.03		-1.35	***	1.263	***	-0.21	***	0.04	*	-1.09	***	1.23	2/

Notes:

1/ Statistical significance: '\*'=10%, '\*\*'=5% or '\*\*\*'=1%.

2/ Unconditional elasticities calculated using statistically significant elasticities from previous budgeting stages

**Table 3.** Rural areas - Demand elasticities for milk 1/

	Marshallian elasticities								Hicksian elasticities								Expenditure elasticities	
	Semi skimmed	Skimmed	Soya	Whole	Semi skimmed	Skimmed	Soya	Whole	Semi skimmed	Skimmed	Soya	Whole						
Semi skimmed	-1.09	***	-0.03		-0.09	***	0.01		-0.46	***	0.12	**	-0.07	***	0.40	***	1.21	2/
Skimmed	-0.09		-0.20		-0.		0.24		0.49	**	-0.05		-0.15	***	-0.30		1.12	2/
Soya	-2.68	***	-1.30	***	-0.80	***	-0.00		-2.04	***	-1.14	***	-1.00	***	4.18	***	1.22	2/
Whole	0.50	**	-0.312	**	0.02		-1.11	***	1.00	***	-0.19		0.33	***	-1.51	***	0.96	2/

Notes:

1/ Statistical significance: '\*'=10%, '\*\*'=5% or '\*\*\*'=1%.

2/ Unconditional elasticities calculated using statistically significant elasticities from previous budgeting stages

**Table 4.** Share of product within stage 3 milk products

Product	Urban	Rural
Semi skimmed	0.60	0.59
Skimmed	0.12	0.15
Soya	0.01	0.02
Whole	0.27	0.24

## 6. Conclusion

This paper offers a greater insight into how net price increases of 1% could reduce urban household carbon footprints by 4,684.13 t CO<sub>2</sub>e /y. Whilst this may not seem a large decrease in GHG it does help to demonstrate how changing consumer demand can help to reduce overall GHG emissions within a particular food group.

A price increase of whole milk will encourage both Scottish urban and rural households to substitute into the lower (and less fattening) carbon milk alternative of soya milk. A pricing policy which increases the price of whole milk by even 1% could result in increased demand for soya milk in both urban (albeit a relatively small increase) and rural areas. Therefore there is scope to investigate applying a potential pricing mechanism to Scotland such as a carbon consumption tax in order to reduce overall GHG emissions.

## References

- Audsley, E, Brander, M, Chatterton, J, Murphy-Bokern, D, Webster, C, and Williams, A. (2009). How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050. World Wide Fund for Nature (WWF-UK). <http://www.fcarn.org.uk/fcarn/publications/how-low-can-we-go>. Accessed 29 March 2013.
- Carpentier, A. and Guyomard, H. (2001). Unconditional elasticities in two-stage demand systems: an approximate solution. *American Journal of Agricultural Economics* 83(1):222-229.
- Deaton, A. and Muellbauer, J. (1980). An Almost Ideal Demand System. *American Economic Review* 70(3): 312-326.
- Edjabou, L. D. and Smed, S. (2013). The effect of using consumption taxes on foods to promote climate friendly diets - The case of Denmark. *Food Policy* 39: 84-96.
- Huang, K. S. (1996). Nutrient elasticities in a complete food demand system. *American Journal of Agricultural Economics* 78(1): 21-29.
- Sall, S. and Gren, I. M. (2012) Green consumption taxes on meat in Sweden (Working paper). Swedish University of Agricultural Sciences (SLU). <http://pub.epsilon.slu.se/9294/>. Accessed 16 January 2013.
- Scottish Government. (2012) Food and Drink in Scotland: Key Facts 2012.
- Sheane, R, Lewis, K, Hall, P, Holmes-Ling, P, Kerr, A, Stewart, K, and Webb, D. (2011) Identifying opportunities to reduce the carbon footprint associated with the Scottish dairy supply chain - Main report. Scottish Government. <http://www.scotland.gov.uk/Publications/2011/02/22152837/0>. Accessed 30 April 2013.
- Sun, Changyou. (2012) Empirical Research in Economics with R (Package 'erer'). <http://cran.r-project.org/web/packages/erer/erer.pdf>. Accessed 15 February 2014.
- Tesco plc. (2012) Tesco product carbon footprints.
- Tiffin, Richard, Balcombe, Kelvin, Salois, Matthew, and Kehlbacher. (2011) Estimating Food and Drink Elasticities. Department for Environment Food and Rural Affairs (Defra). <http://www.defra.gov.uk/statistics/foodfarm/food/>. Accessed 25 February 2012
- Wan, Y., Sun, C., and Grebner, D. L. (2010). Analysis of Import Demand for Wooden Beds in the U.S. *Journal of Agricultural and Applied Economics* 42(4): 643-658.