DO HIGHER INCOMES PAY MORE?

The effect of price - income relations on the direct and indirect energy requirement of households in the Netherlands

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Abstract

In a previous study a quite strong dependence of energy requirement on income was found. For most consumption categories it was not taken into account that the price per physical unit of product can increase with income. In this paper we explore the possible effect of this negligence. For 82 consumption sub-categories we examined the price-income relation. For 37 of these categories no significant rise of price with income was found. The other categories generally showed an increase of the price per physical unit with income. In the previous study we found an elasticity of the energy requirement related to net household income of 0.63. Extrapolating the price-income relations found in this study to all consumption categories results in a decrease of this elasticity value to 0.56 to 0.60.

Introduction

In a previous study we found a strong relationship between net household income and the direct and indirect energy requirement of households. The energy requirement elasticity related to income was found to be 0.63, i.e. a 1% increase in income results in a 0.63% increase in energy requirement. The strong relation between income and total energy requirement suggests that, with a further increase of the average income level, the average household energy requirement will probably rise as well.

In our previous energy analysis we distinguished 350 product categories, together making up nearly the total household consumption package. To each category an energy intensity (MJ/Dfl) is assigned. This energy intensity value per category is taken the same for all the income levels. However, it is conceivable that households with a higher income systematically buy products that cost more per physical unit. For instance, they may pay more for one bread or one sofa with the same physical characteristics. Products with a higher price per physical unit may have a lower energy intensity than products with lower prices. The consequence of this possible price-income effect is that the real energy requirement elasticity related to income (or expenditure level) can be smaller than the value computed by [Vringer and Blok, 1995].

In this paper we make an estimate of the possible effects on the energy requirement elasticity related to income of the possible price-income relations. In order to make this estimate we use detailed data of the Netherlands Central Bureau of Statistics on physical amounts purchased and expenditures in several product categories per income level.
We first calculate the price dependence of product prices on income; subsequently we determine the maximum effect on the energy requirement elasticity related to income. All monetary quantities are expressed in Dutch guilders (1 Dfl ≅ 0.6 US$ in 1992).

Dependency of price on income

In this section we analyse how the prices of products depend on income. To calculate the price of a product, both the expenditure on that product and the purchased amount have to be known. Such data are available from the Central Bureau of Statistics [CBS, 1995].

Method and data
The analysis made in this section can only be done homogenious product categories. We have examined the 350 consumption categories included in the Netherlands Household Expenditure Survey of 1990 [CBS, 1992] and found that only a few of these are homogeneous. More or less appropriate categories are "shoes" or "bread". But the category "furniture", for instance, is less appropriate because a lot of variants of one kind of furniture are possible. That is why we made a selection of the **sub**-categories of the 350 consumption categories. The selected sub-categories are given in Table 1. The Netherlands Bureau of Statistics has supplied data on physical amounts purchased and expenditures for each of these selected (sub-)categories, depending on income levels (divided into deciles of quintiles). From these data the price per physical unit for the consumption categories per household income level has been derived. The price elasticities of the consumption categories related to the net household income are calculated by fitting the mean values of the logarithm of the prices for the five or ten income levels according to the least squares method.

Price - income relation of the 82 consumption sub-categories

Per income category the average price per consumption item is computed by dividing the expenditure by the purchased quantity (see Table 1). The price-income relation for some of the 82 consumption sub-categories is shown in Figures 1 to 5. The open squares boxes in one of the price-income lines mark the weighted means of the income deciles (Figure 1) or quintiles (Figure 2 to 5) through which the lines are drawn. No data are plotted for income-deciles or income-quintiles with less than 20 purchases per measure point[a].

a Not all physical quantities given in Table 1 of the 82 sub-consumption categories can be counted as one item. E.g. petrol will in most cases not be bought per litre. one item consists out of more litres. For the following consumption categories a rough estimate has been made of the average quantity purchased per item; buns (5 pieces), fresh potatoes (5 kg), green beans (500 gr), tomatoes (500 gr), oranges (10 pieces), beer (per 24 bottles of 50 cl), fresh beef (250 gr), pork cutlet (250 gr), petrol (30 litre). The average quantity purchased per item of the consumption categories not mentioned here is estimated to be the same as the quantity given in Table 1.
Due to the minimum of 20 items per consumption category and per income decile/quintile, 26 points have to be excluded from further analysis. The excluded points concern the following sub-consumption categories: "sofa" (income quintile no.1), "dining chair" (1), "easy chair" (1), "electric coffee maker" (1), "refrigerator with freezing compartment" (1,2,4,5), "microwave oven" (1,2), "ceiling lamp" (1), "washing machine" (2), "computer equipment" (1), "men's sportschoes" (1), "sleeping bag" (1,2), "colour TV, size unknown" (1), "Video Cassette Recorder (VCR)" (1), "car" (1,2), "second hand car" (1,2) and "two star petrol" (1).

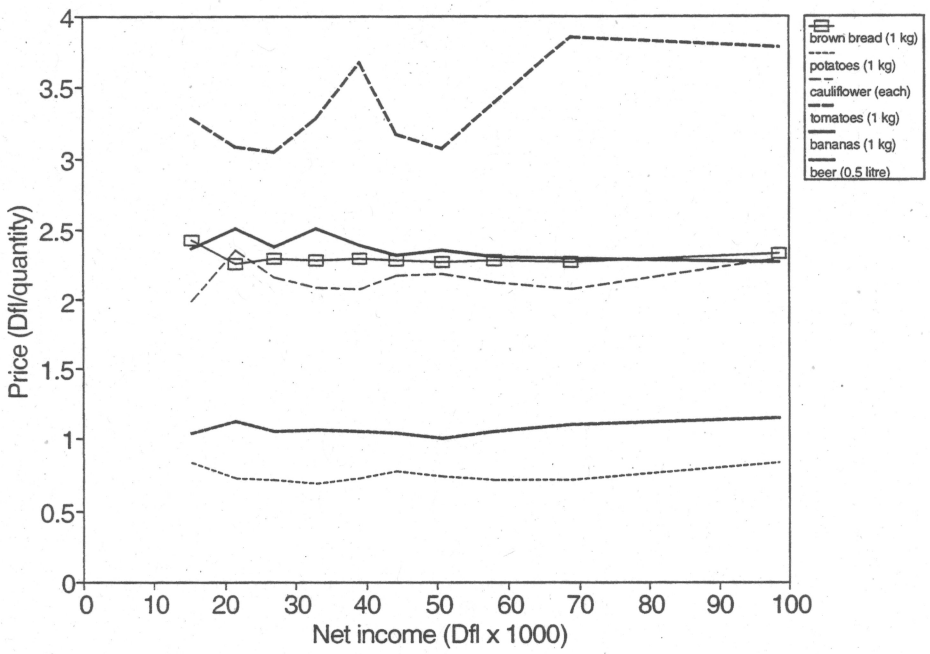

Figure 1 The relation between the price and the net household income for the consumption categories 'brown bread', 'potatoes', 'cauliflower', 'tomatoes', 'bananas', and 'beer'.

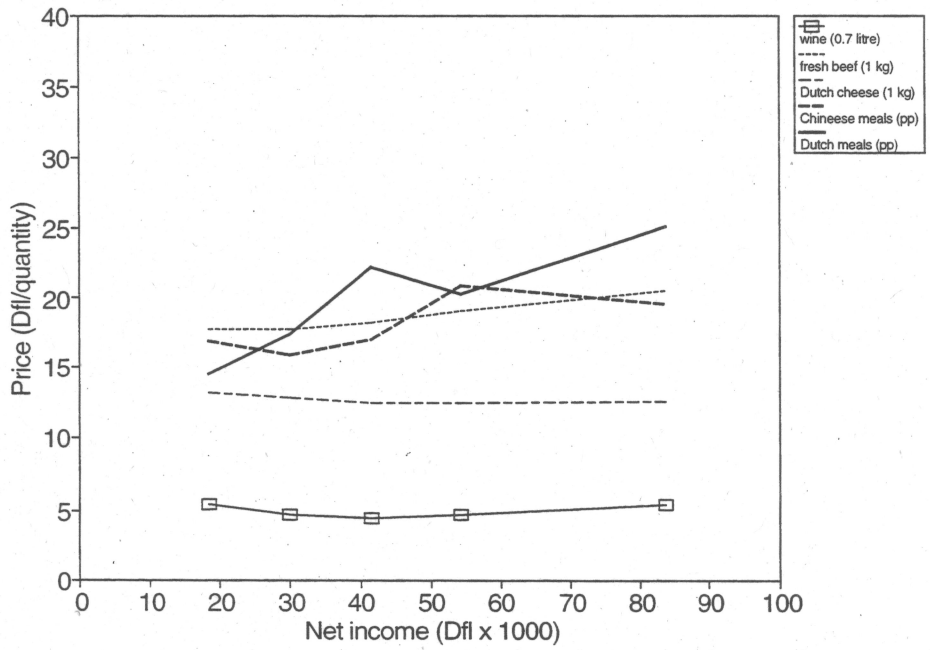

Figure 2 The relation between the price and the net household income for the co nsumption categories 'wine', 'fresh beef', 'Dutch cheese', 'Chinese meals in restaurants' and 'Dutch meals in restaurants'.

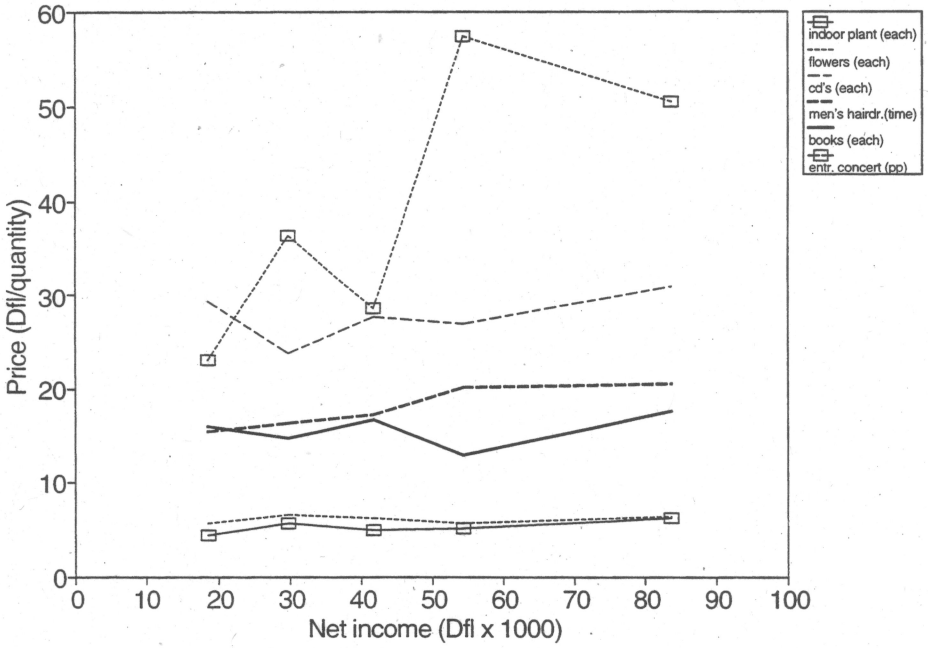

Figure 3 The relation between the price and the net household income for the co nsumption categories 'indoor plants', 'flowers', 'compact discs', 'men's hairdresser', 'books' and 'entrance of concerts'.

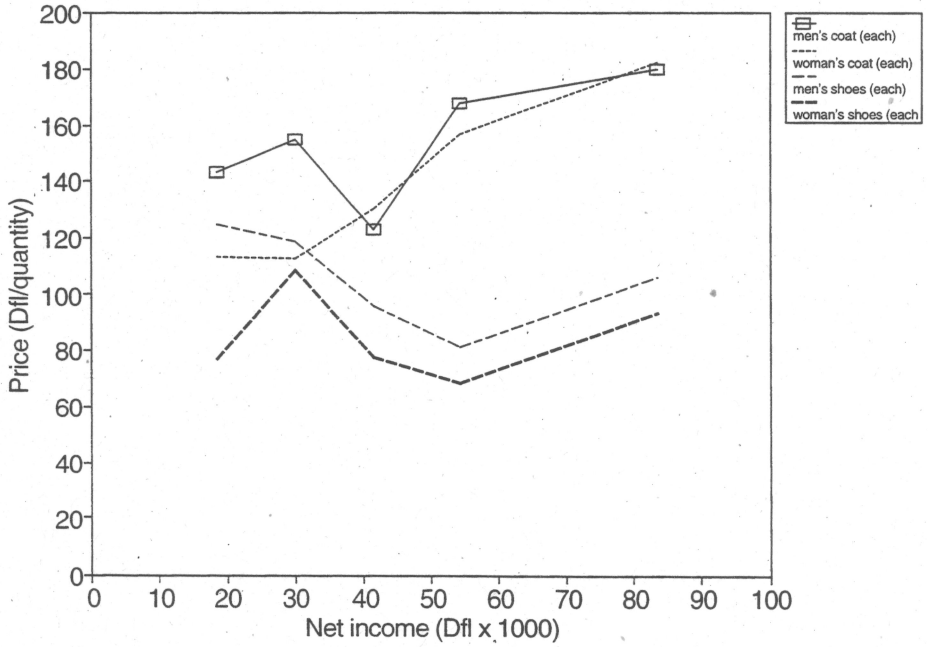

Figure 4 The relation between the price and the net household income for the co nsumption categories 'men's coats', 'woman's coats', 'men's shoes' and 'woman's shoes'.

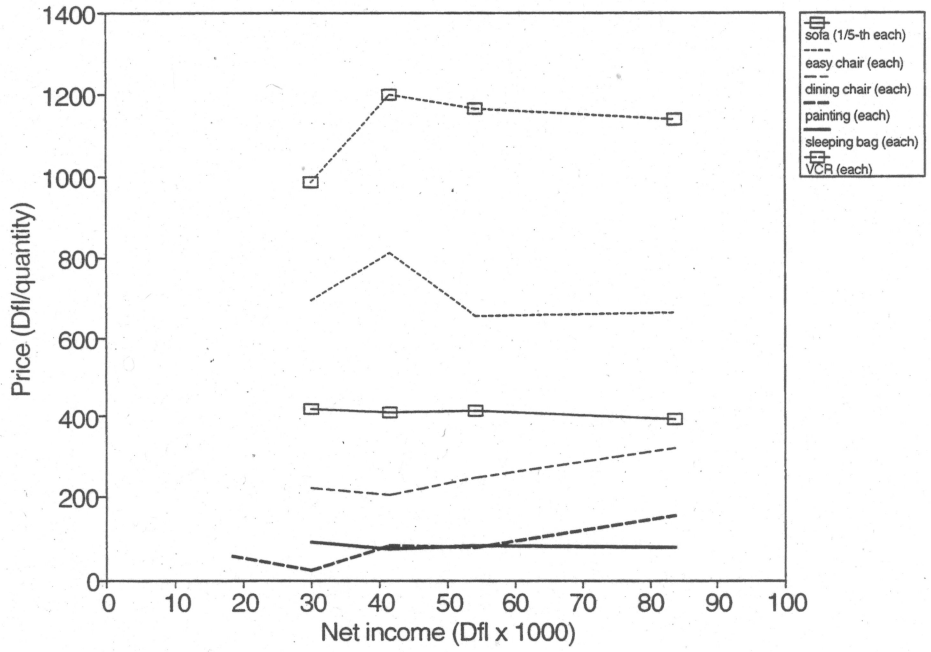

Figure 5 The relation between the price and the net household income for the consumption categories 'sofa's', 'easy chairs', 'dining chairs', 'paintings', 'sleeping bags' and 'VCR's'.

As can be seen in Figures 1 to 5 the dependency of price per product on net household income is not the same for every consumption category. For some consumption sub-categories a negative (e.g. sofa's and men's shoes) and others a positive price-income relation (e.g. men's and women's coats) is found. Also for some consumption sub-categories (nearly) no price-income relation like "brown bread" and "flowers" is found.

The price elasticity related to income

The price elasticities of the consumption categories related to the net household income are calculated by fitting the mean values of the logarithm of the prices for the five or ten income levels according to the least squares method[a].

In many cases the standard deviation in the price elasticity is quite high compared to the price elasticity itself, and the probability is high that the price elasticity does not differ from zero. Hence, if the standard deviation

[a] Data points consisting of less than 20 purchases are excluded from our analysis.

of the price elasticity of a consumption category is found to be larger than 50% of the elasticity itself, the elasticity is assumed to be zero. By doing so, 45 of the 82 consumption sub-categories turn out to have a valid price elasticity (see Table 2). Under these conditions the average weighted and unweighed price elasticity of all the 82 sub-consumption categories have a value of respectively 0.16 and 0.11 respectively. Table 1 shows several figures of the 82 consumption sub-categories for an average household.

Table 1 The expenditure [CBS, 1995], energy intensity [Vringer and Blok, 1995], energy requirement, average price (derived from [CBS, 1995]), price elasticity and its standard deviation for the 82 consumption sub-categories. The categories of which only the quantity and/or expenditure values are known for the quintile income groups instead of decile income groups are marked with an asterisk. If the standard deviation of the price elasticity of a consumption category is found to be larger than 33%, but smaller than 50% of the elasticity, the values of the price-elasticity and its standard deviation are written in italics.

Index number	expend-diture (Dfl)	energy-intensity (MJ/Dfl)	energy requirement (MJ)	price (Dfl)	price elast.	sd.dev pr.el.	Consumption category
v110011	193	4.0	773	2.29	0		brown bread (800 gr)
v110113	66	4.0	264	0.39	*0.07*	*0.03*	buns (each)
v110712*	14	5.7	79	1.61	0		self-raising flower (500 gr)
v111011	75	4.4	330	0.74	0		fresh potatoes (1 kg)
v111112	22	9.4	210	1.14	0		lettuce (head)
v111211	29	4.6	135	2.16	0		cauliflower(each)
v111311	18	5.3	97	3.99	0		green beans (1 kg)
v111511	25	15.3	385	3.39	*0.10*	*0.04*	fresh tomatoes (1 kg)
v112011	102	5.1	520	2.18	0		apples (1 kg)
v112111*	22	4.2	93	2.89	0		strawberries (500 gr)
v112211*	18	5.6	99	0.40	0		oranges, hand (each)
v112212*	24	5.6	133	0.30	*0.05*	*0.02*	oranges, for making juice (each)
v112213	38	5.6	212	0.41			oranges unspecified (each)
v112301	40	4.3	173	2.35	*-0.04*	*0.02*	bananas (1 kg)
v112811*	20	5.1	104	3.50			peanuts (500 gr)
v113513	127	3.4	431	2.57	0		coffee, percolated (250 gr)
v114023	35	7.0	242	1.93	*0.05*	*0.02*	orange juice, pure (1 litre)
v114111	208	3.1	643	1.07	0		beer (50 cl)
v114121*	156	4.0	625	4.97	0		wine (70 cl)
v115000*	65	11.0	718	0.66			margarine (250 gr)
v116010*	144	5.6	809	18.80	0.09	0.02	fresh beef (1 kg)
v116123	51	6.5	332	11.61	0		pork cutlet (1 kg)
v116124*	62	6.5	406	1.74	0		chop (each)
v116712	69	5.1	352	2.10	0		ham smoked (100 gr)
v118012	137	6.3	863	1.12	0		milk, low-fat (1 litre)
v118600*	214	5.8	1240	12.64	-0.03	0.01	dutch cheese (1 kg)
v118613				13.82	-0.05	0.01	dutch mature cheese (1 kg)
v119311	74	3.8	280	0.95	0		coffee outdoors (each)
v119321*	100	3.8	381	2.07	0		alcoholic drinks outdoors (each)
v119422*	58	4.1	237	18.48	*0.14*	*0.06*	chinese meals outdoors (pp)
v119423	306	4.1	1249	22.95	0.36	0.06	dutch meals outdoors (pp)
v119511*	43	4.1	177	1.68	0.12	0.03	ice cream outdoors (each)
v222221	57	15.6	892	5.20	0.29	0.07	indoor plants (each)
v222222	161	15.6	2506	6.29	*0.13*	*0.04*	flowers (bouquet)
v224022*	109	3.2	348	2175.20	-0.06	0.01	sofa (each)
v224023*	38	3.2	123	641.00	0		easy chair (each)
v224033*	19	3.2	61	239.63	0.40	0.08	dining chair (each)

Table 1 (cont.)

Index number	expend-diture (Dfl)	energy-intensity (MJ/Dfl)	energy requirement (MJ)	price (Dfl)	price elast.	sd.dev pr.el.	Consumption category
v224225*	16	6.1	99	43.92	*0.68*	*0.25*	garden chair (each)
v224513*	21	5.3	112	26.12	0		synthetic floor covering (1 m2)
v224713*	13	3.0	39	61.29	*0.79*	*0.36*	painting (each)
v225215*	23	4.8	109	56.78	0		quilt cover (each)
v225224*	21	2.4	50	31.26	0		pillow (each)
v226016*	8	2.9	24	82.00	0.14	0.03	electric coffee maker (each)
v226337*	9	6.8	62	26.62	0.51	0.07	pots and pans (each)
v226618*	29	2.8	82	735.75	-0.17	0.05	microwave oven (each)
v226814*	9	4.3	40	116.63	*0.57*	*0.25*	standing lamp (each)
v226821*	19	4.3	82	61.32	0.42	0.08	ceiling lamp (each)
v226912*	14	2.3	32	2.27	0		light bulb (each)
v227011*	23	3.1	71	206.82	0		vacuum cleaner (each)
v227111*	62	3.1	192	1240.80	0.24	0.05	washing machine (each)
v330000*	40	3.9	156	160.48	0		men's coats (each)
v330300*	87	2.5	217	31.84	0		shirts (each)
v330600*	66	3.0	199	140.96	0.33	0.07	woman's coats (each)
v333116*	77	5.9	455	11.35	0.22	0.02	cloth for making clothes (meter)
v335000*	48	1.6	77	96.58	*-0.20*	*0.09*	men's shoes (pair)
v336000*	84	1.6	134	82.90	0		woman's shoes (pair)
v441203	95	6.9	654	7.91	0.13	0.03	washing powders (per pack)
v441214	15	6.8	103	1.87	0.03	0.03	washing-up liquid (per pack)
v443011*	24	1.4	33	18.53	0.20	0.03	men's hairdresser (a time)
v443015*	34	1.4	47	25.10	0.27	0.06	woman's hairdresser (a time)
v446326*	84	1.7	143	383.27	-0.14	0.02	glasses without prescr. (each)
v550414*	90	2.0	179	182.69	0		computer equipment (each)
v550612*	116	2.4	279	15.55	0		books (each)
v551410*	7	2.2	14	73.11	0.46	0.05	men's sportschoes (pair)
v551623*	5	6.2	34	90.17	*0.09*	*0.04*	sleeping bag (each)
v551812*	33	4.9	160	125.54	*0.24*	*0.09*	hotel lodging (excl. holl.) (night)
v551914*	84	4.6	386	52.14	0		lodging in home country (day)
v552114*	101	6.1	618	78.54	0.32	0.09	lodging abroad (day)
v553111*	23	2.0	47	37.65	0.54	0.15	entrance concert (a time)
v553116*	26	2.0	52	44.81	*0.24*	*0.10*	entrance theatre (per spending)
v553618*	92	2.3	211	1313.57	0.26	0.08	TV colour size unknown. (each)
v553733*	69	2.7	186	1147.50	*0.14*	*0.05*	VCR (each)
v554017*	124	1.9	236	27.90	0		compact disc (each)
v557211*	125	1.9	238	521.38	0.32	0.07	bicycle (each)
v557601*	1506	2.4	3613	25092.00	*0.17*	*0.07*	car (each)
v557621*	443	2.4	1062	8850.00	0.61	0.16	second hand car (each)
v558113*	372	22.4	8338	1.66	0.01	0.00	4 star petrol (1 litre)
v558114*	78	22.4	1755	1.01	-0.05	0.02	diesel oil (1 litre)
v558115*	62	22.4	1393	0.50	0.11	0.02	liquefied petroleum gas (1 litre)
v558116*	28	22.4	631	1.52	0		two star petrol (1 litre)
v558117*	292	22.4	6543	1.62	0		lead free petrol (1 litre)
v558118*	132	22.4	2965	1.58	-0.04	0.01	petrol unspecified (1 litre)

Most of the 'food' consumption categories[a] have a low price elasticity or the standard deviation is relatively too large to give a reliable figure for the price elasticity. The average unweighed price elasticity of all the 32 'food' consumption categories, including the categories of which the price elasticity is assumed to be zero, is found to be 0.03. The average unweighed price elasticities of all the 18 'household effects' and the 21 'education, recreation and transport' sub-consumption categories are much higher, respectively 0.22 and 0.16.
Table 2 gives an overview of the sensivity of the results for the reliability criteria.

Table 2 The average weighted and unweighed price elasticity for all 82 consumption categories and the number of consumption categories with a valid price elasticity given for three maximum values of the standard deviation of the price elasticity.

acceptable st. error in the price elasticity (%)	average price elasticity for all 82 categories unweighted		number of consumption categories with a valid weighted price
no constraint	-	-	82
100	0.11	0.16	58
50	0.11	0.16	45
33	0.07	0.10	29

The maximum effect on the energy requirement elasticity related to income

In this section we make a calculation of the maximum effect on the energy requirement elasticity related to income. In the previous article [Vringer and Blok, 1995] the assumption is that all products within a consumption category have the same energy intensity. The calculation made in this paper is based on an alternative assumption; using the same energy requirement per quantity of product. The energy requirement per quantity of product is independent of the price, differs per consumption category and includes price - income effects.

[a] The sub-consumption categories with an index number starting with v1... belong to the main consumption category "Food", v2... belong to "Household effects", v3... to "Clothing and footwear", v4... to "Hygiene" and v5... to "Education, recreation and transport".

First we discuss the assumptions we made in our previous article; subsequently we discuss the alternative assumptions and the effects of the price elasticities on the energy requirement elasticity.

Previous assumptions, excluding price-income relations

In our previous article the total energy requirement of a household (E) is calculated, according to formula (1), out of the expenditure (S_i) of category i and the energy intensities (ε_i) of the consumption categories:

$$E = \sum_{i=1}^{350} \varepsilon_i * S_i \qquad (1)$$

Here we assume that ε_i is a constant for each consumption category and does not depend on income. Only the energy requirements of the consumption categories "house", "natural gas" and "electricity" are calculated by [Vringer and Blok, 1995] on the basis of physical quantities.

The energy requirement elasticity related to income level is defined according to formula (2).

$$E_{tot} = c * S_{tot}^{\alpha} \qquad (2)$$

in which:

E_{tot}	=	total energy requirement
S_{tot}	=	net household income
α	=	elasticity
c	=	a constant

The elasticity of the energy requirement related to income level is calculated by fitting the mean values of the energy requirement for the income levels according to the least squares method. The result is an elasticity of the total household energy requirement related to income of 0.63. [Vringer and Blok, 1995].

Alternative assumptions, including price-income relations

We calculate the elasticity of the energy requirement related to income including price-income effects, by assuming that the same energy quantity is required per physical quantity (in among others kilogrammes, litres, pieces) product. The cumulative energy requirement has to be calculated with formula (3) instead of formula (1).

$$E_x = \sum_{i=1}^{350} \frac{\varepsilon_i}{\left(\frac{I_x}{I_m}\right)^{\alpha_i}} * S_{ix} \qquad (3)$$

in which:

E_x	=	cumulative energy requirement of income level x for all 350 consumption categories
ε_i	=	Energy intensity of the consumption category i
S_{ix}	=	expenditure of consumption category i for income level x
x	=	average income of the households belonging to income level x
I_m	=	average income level of all households
α_i	=	price elasticity related to income of consumption category i

Note that the alternative assumption, using the same energy requirement per quantity of product, is also an extreme assumption. The real elasticity of the energy requirement related to income may be larger than the value computed according to this assumption. E.g. it is plausible that a more expensive coat is made from more and/or better cloth with a higher energy requirement (see also the discussion).

Effects of the price elasticity on the energy requirement elasticity related to income

The energy intensities in the sources of [Vringer and Blok, 1995] are based on average products and average prices. Price-income relations are implicitly assumed to be zero. But according to Table 2, 45 of the 82 consumption sub-categories seem to have a significant price -income effect. To obtain the effect of the price elasticities from Table 1 on the energy requirement elasticity related to income, we first summarized the energy quantity per income decile of the 82 consumption sub-categories including (formula 3) and excluding (formula 1) the effects of the price elasticities related to income. Next per income decile the difference in energy requirement for the 82 consumption sub-categories is extrapolated to all consumption categories, excluding those categories which already had been

calculated on the basis of physical quantities (house, electricity and natural gas).

The expenditure on all the 82 consumption sub-categories represent on average nearly Dfl. 7,700.-, about 17% of the average net household income of 1990 [CBS, 1992]. These Dfl. 7,700.- are connected with nearly 49 GJ per average household per year, 20% of the total cumulative energy requirement of an average household in 1990 according to [Vringer and Blok, 1995].
The energy requirement calculated by [Vringer and Blok, 1995] of the house, natural gas and electricity is not based on financial figures, but calculated on the basis of the area of living space, the average used m^3 natural gas and kWh electricity as recorded in the expenditure survey [CBS, 1992]. The energy requirement of those categories together, 97 GJ (40% of the total cumulative household energy requirement), can not be influenced by the price - income effects.

If the difference in the total cumulative energy requirement of the 82 consumption sub-categories between the two calculation methods is extrapolated to the total energy requirement for the different income levels, excluding the consumption categories 'house', 'electricity' and 'natural gas', the energy elasticity related to income is 0.60. This is somewhat lower than the value of 0.63 found by [Vringer and Blok, 1995]. The extrapolated effect on the energy elasticity related to net household income is shown in Figure 6.

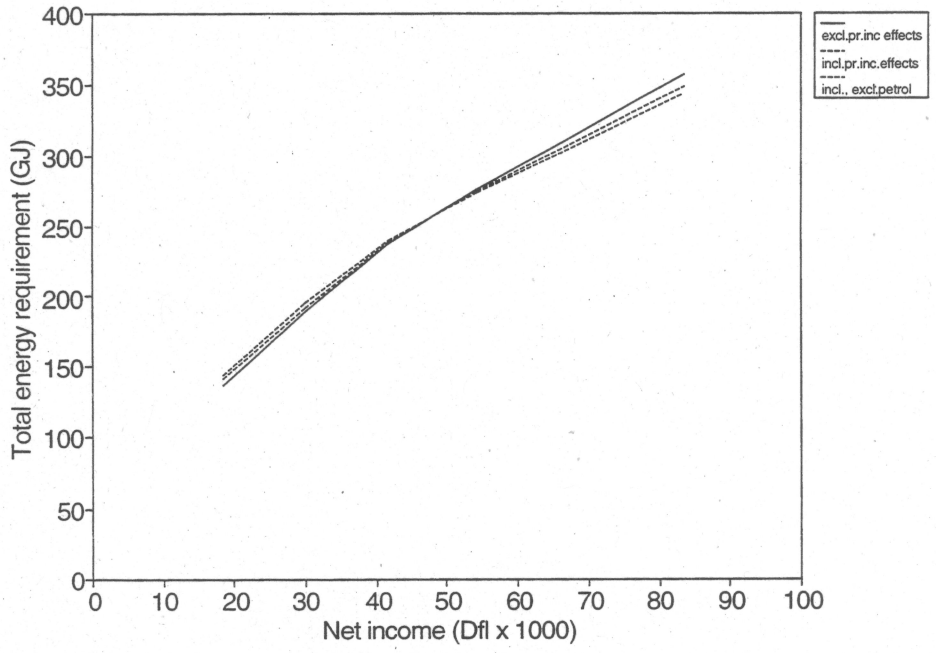

Figure 6 Total energy requirement plotted versus net household income, ex- and including the price-income effects and including the price-income effects but leaving out petrol.

The value of the energy elasticity related to income of 0.60 is based on the extreme assumption that the same energy requirement per quantity of product has been used for every consumption category, without taking into account possible price-energy relations.

The effect of leaving out the consumption categories which do contain several kinds of petrol, which cover a relatively large part of the average energy requirement of all the 82 consumption sub-categories (about 21 GJ of the 49 GJ), has been estimated. If these categories are left out in the calculation of the alternative energy requirement elasticity, this elasticity lowers from 0.60 to 0.56.

Discussion

For some product categories, especially whose physical quantities are not based on weight or volume but where they are included in the statistics per piece, it is still conceivable that households with a higher net income do pay more because the product is larger, heavier or from a higher quality. These households do not pay per definition more per kilogramme or litre. If so, the true energy elasticity related to net income will be larger than computed here.

In the alternative calculation of the energy elasticity related to income, not all the (main) consumption categories of the total consumption package are equally represented by the 82 consumption sub-categories. This means that the alternative extreme energy elasticity related to net income can be smaller or higher than computed here. On the other hand the consumption categories which do contain the more price-income dependent products seem not to be underestimated. The main consumption categories 'food', 'household effects' and 'education, recreation and transport' (with a quite large energy requirement of 40 to 49% of the total energy requirement according to [Vringer and Blok, 1995]) are over represented. The main consumption categories 'clothing and footwear' and 'hygiene and medical care' (with a relative small energy requirement of 10% of the total energy requirement according to [Vringer and Blok, 1995]) are under represented in this study.

Note that the alternative assumption made in this paper assumes no price - energy effect, which is an extreme assumption. As stated before, the real elasticity of the energy requirement related to income will be larger than the value computed according to this assumption.

Conclusions

The effect on the energy requirement elasticity related to income of taking into account the price elasticity related to income, while neglecting the price - energy requirement relation, is small. An extrapolation of the price income elasticity of 82 consumption categories, neglecting all price - energy requirement relations, shows as the lowest estimate a decrease of the elasticity of the energy requirement related to net household income from 0.63 to not lower than somewhere between 0.56 and 0.60.

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Literature

[CBS, 1992] Centraal Bureau voor de statistiek. *Budget-onderzoek 1990, micro bestand.* Voorburg/-Heerlen, 1992. (Netherlands Household Expenditure Survey 1990, computer file. Netherlands Central Bureau of Statistics, Voorburg/Heerlen, 1992.)

[CBS, 1995] Information derived from the Netherlands Household Expenditure Survey of 1990 by the Netherlands Central Bureau of Statistics (CBS). Heerlen, 1995.

[Vringer and Blok, 1995] K. Vringer and K. Blok. *The direct and indirect energy requirements of households in the Netherlands.* 1995. Energy policy, 23(10), pp.893-910.