Choosing energy efficiency – consumer response to operating costs at the point of sale

Keyword set

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Energy Consumer – Domestic
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Abstract

Consumers have a big effect on energy use through their choice of the appliances and cars that they buy. But they may buy a product without thinking about energy costs –focussing instead on the initial cost and other features. Do we know if alerting them to running costs encourages them to buy more efficient products?

There has been a continuing interest in this area, with eighteen studies published on experiments and field trials of operating costs labels since 2011, but no recent meta-analysis of this body of work. This paper reviews the recent literature to see what the evidence suggests.

The picture is complicated and quite fragmented: studies have looked at diverse products, with different proportions of up front and operational costs, some of which are have reasonably consistent energy use (eg fridges) and some with wide variations in consumer usage (eg cars). The study methods are also varied using choice experiments (in the 'laboratory', in fact generally online) and 'field studies', which have measured the actual change in consumer purchases in a physical or online shops. Moreover, researchers have presented consumers with information on a variety of operational costs: for one, five or ten years, for a given usage (distance driven for cars) or over the product's expected lifetime.

Perhaps unsurprisingly the results from these experiments are also complex and difficult to interpret: most studies found a statistically significant increase in sales from providing energy cost information but not all. Choice experiments generally found a more positive effect than field trials, probably because the researchers had greater control in both design and execution. The paper presents possible explanations for the lack of consistency in results between and within different product types.

As things stand the evidence does not seem sufficiently compelling to persuade policy makers to change energy labels to include running cost information, where they do not already. However, consumers consistently ask for this information when surveyed and the increasing availability of data online which can be accessed in a retail environment (via smart phones or tablets) means that it is becoming relatively easy to provide this information. As a result other actors (commercial or third sector) may decide to fill this gap, providing large scale field trials for researchers to analyse in future.

Introduction

Energy efficiency is generally cost effective – often a higher up front cost is offset by reduced running costs – but consumers don't always recognise that. The initial rationale for energy labels for appliances and cars was to provide information on energy performance to the consumers – in economic terms to address 'information failure' (discussed for example in Boardman et al, 2000). Energy labels are designed to address this gap by providing energy information in a consistent way to the consumer at the point of sale.

However even when consumers have information on energy use they often make 'non-rational' decisions – for example not taking into account the lower operating costs of energy efficient products, being deterred from buying them by their higher up-front cost. A solution to this could be to express the energy use on the label in terms of the operating cost – the USA mandatory label for appliances (EnergyGuide) does this (Federal Trade Commission 2018, shown in Figure 1) but this is unusual.

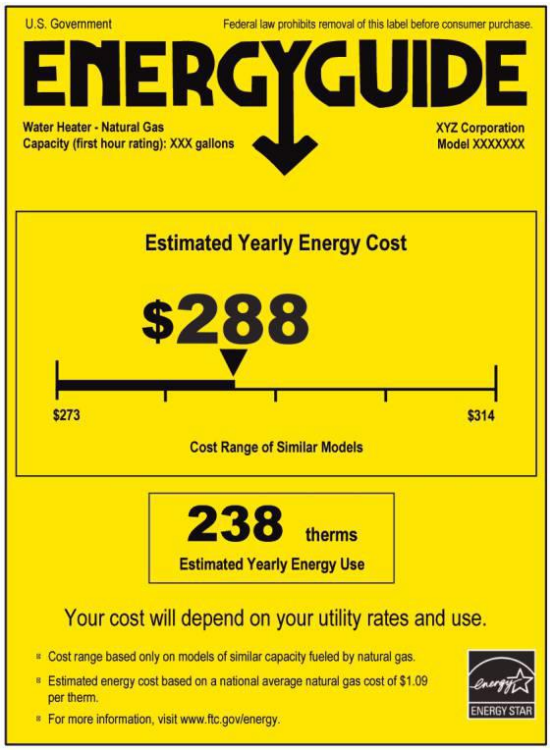

Figure 1 US EnergyGuide label for water heaters (from Newell & Siikamäki 2014)

One reason that this form of label isn't widely used is that energy prices can vary widely: geographically, within an area (if there is competitive energy supply) and over time. Another is that, for some products, there can be a wide range in usage. This may be down to personal choice or lifestyle, such as for washing machines or cars but may be due to geography/climate - for example for boilers or air conditioners. If consumers see an average energy price or usage that does not reflect their experience then the information may be more frustrating than helpful. Davis and Metcalf (2015) examined using labels tailored to each household's US state of residence and found that they led to 'significantly better choices'. Energy cost label customisation, even just for geographic factors and for large areas such as a US state is unlikely to be practicable for a 'hard copy' label – the cost would be too high; add in the requirement to keep the energy cost up to date and to account for consumers' wide range of usage and it becomes untenable.

However the widespread adoption of digital technology, particularly smart mobile phones and tablets, makes accessing data at the point of sale and then customising it to an individual user's requirements relatively simple and cheap. Several countries with established energy efficient product policy programmes, such as China and Australia, require suppliers to register details of all the regulated products that they sell on a database, at least some part of which is accessible to the general public. The EU is in the process of introducing such a database for all energy labelled products. This is due to be operating from January 2019 and to be fully populated by the end of the year (European Commission, 2017). Chinese and Indian energy labels already include a QR code that individuals can use to access additional information on their smart phones or tablets.

Digi-Label, a H2020 (EU) funded project, is developing a tool that is intended to exploit these EU data once it becomes available: Soyez et al (2016) describes the rationale to develop such the tool and Kardel (2017) summarises the development further. The smart phone and online tool allows users to customise the information: adjusting usage and energy prices to their match their own, choosing to show costs over one year or a longer period. The tool also ranks products (of the same size and functionality) by running costs.

The situation is therefore developing so making information on running costs of energy using products available to customers, with energy costs and usage that can be adjusted to be relevant to them, relatively cheap and

straightforward. The questions then arise: what information, on which products and how should it be presented? The rest of this paper attempts to answer these questions based on the findings of recently published research.

Previous reviews

Energy efficient goods often have higher capital costs as well as lower running costs; generally the latter more than offset the former so that the Total Cost of Ownership, TCO, is lower. However the TCO depends upon the discount rate used to evaluate future gains. There is extensive literature on the way consumers discount future gains and losses and what influences this (one example being Loewenstein & Thaler 1989). One aspect of particular relevance, first noted by Thaler (1981); is that the size of the future gains matters. Thaler found empirically that " as the size of the reward increases the implicit discount rate falls". That is, small rewards are considered as relatively unimportant and heavily discounted; large rewards are not. Subsequent research, for example by Green et al (1997) has confirmed this effect and explored the psychological reasons for it.

The impact of providing information on operating costs or life cycle costs (LCC), on purchasing behaviour has been of interest to researchers for many years. Kaenzig and Wüstenhagen (2009) developed a conceptual model for how LCC information influences the decision of consumers to buy more energy efficient goods – shown in Figure 2. They then analysed the empirical evidence of the effect of LCC information, looking at ten studies from 1979 to 2008 covering a range of products including fridges, cars, heaters and fuel cells. They found that disclosing operating cost information generally increased the likelihood of purchase of the more energy efficient option but that there were variations that influenced the results, including:

1. How the information was displayed – the information was more effective if it was easily understood
2. The relative size of operating and capital costs - operating costs presented over a longer period were more effective
3. Consumers attitudes to environmental issues (for some studies)
4. In two studies done by the same researchers using a similar method around the same period on consumers' purchase of cars and household appliances (respectively Wüstenhagen and Sammer 2007 and Sammer and Wüstenhagen 2006) found that the effect of information on the former was less.

Overall their conceptual model was validated by the data.

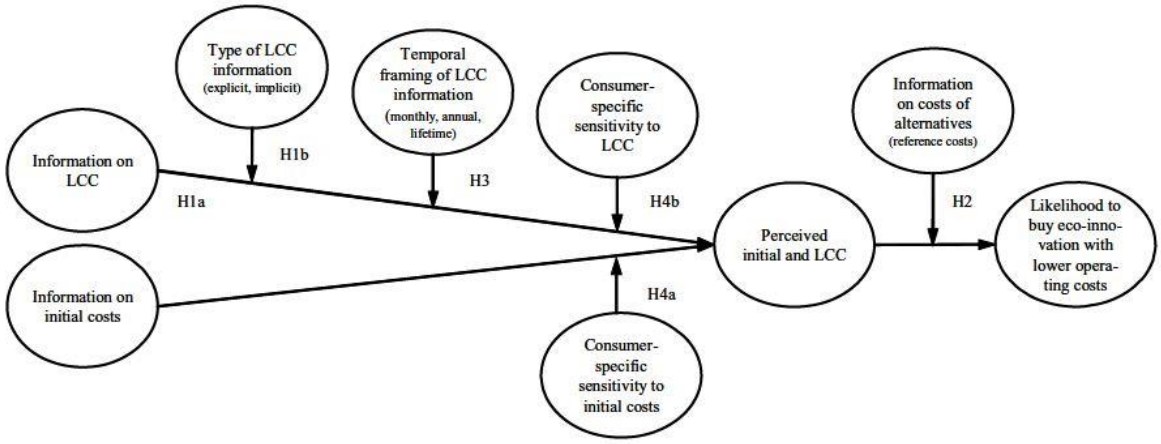

Figure 2 Kaenzig and Wüstenhagen's conceptual model of the influence of life cycle cost (LCC) information on consumer investment decisions regarding eco-innovation (for example more energy efficient products)

Rohling and Schubert (2013) have since published a literature review of the effects of energy labels on consumers' choices of appliances. This was more general – looking at the different categories of labels (endorsement vs comparative and so on) rather than focusing on those which included operating cost data. They also suggested a way of classifying the experiments, which is shown below (with example references) and used in this paper:

1. **Field Experiments**
    a. **Field Experiments - Consumers' Actual Purchase Decisions** Kallbekken et al. (2012)
    b. **Field Experiments - Consumers' Purchase Intentions** Deutsch (2010)

2. **Surveys** Heinzle (2012).part one
3. **Choice Experiments** Heinzle (2012) part two, Newell and Siikamäki (2014)

What is the recent evidence?

Eighteen recent studies (published since Kaenzig and Wüstenhagen's review) were identified in a systematic search of the literature. The source for fifteen of these studies, which are included in the analysis, is shown in Table 1. Most of these were published in peer reviewed journals; some are published reports or working papers.

Table 1 Literature source for each study

No	Country	Reference	Year	No	Country	Reference	Year
1	United Kingdom	Bull	2012	9	USA	Allcott & Taubinsky	2015
2	Germany	Heinzle	2012	10	USA	Dumortier et al	2015
3	Norway	Kallbekken et al	2012	11	Ireland	Carroll et al	2016
4	10 EU member states	Codagnone et al	2013	12	Germany	Andor et al	2017
5	United Kingdom	DECC et al	2014	13	Germany	Rodemeier et al	2017
6	USA	Camilleri & Larrick	2014	14	USA	Ungemach et al	2017
7	USA	Newell & Siikamäki	2014	15	Switzerland	Stadelmannm, & Schubert	2018
8	Australia	Grimmer et al	2015				

Three additional studies were found in the literature survey but have not been included in this analysis: Min et al (2014), YAECI (2015); Hardisty et al (2016). These studies were not as robust as the fifteen listed above, either because they used a small number of participants or lacked a control group.

The characteristics of the studies selected for analysis are listed in Table 2. in terms of: the product coverage, a description of the experiment and a summary of the findings. Some of the studies included more than one type of experiment – where this is the case the details of all are presented. Running and capital costs are given, where provided in the literature to give a sense of scale, both overall (important in itself given the evidence presented by Thaler and others) and to give the scale of the operating costs relative to capital costs. Costs are indicative (rounded to two significant figures) and given in the currency used in the experiment. Energy costs are given where available to give context. ND means No Data is stated in the research.

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Table 2 Characteristics of recent studies

ref	Product coverage	Presentation of operational costs	Range of operational costs	Range of capital cost	Energy cost	No of part-icipants	Trial classification	Result
1	Washing machines	Annual water and electricity costs+ lifetime costs	Lifetime costs, relative to arbitrary fixed point, -£150 to £210	£210 to £460	ND	465	Choice experiment	Including operational costs in the information presented to participants encouraged the selection of more EE products; the effect was small but statistically significant. Presenting lifetime cost information was more effective than annual information.
2	Televisions	Annual + lifetime (10 years) operating costs	Lifetime €180 to €660	€550 to €900	€0.2/kWh	257 208	Survey Choice experiment	Disclosing energy operating costs over the lifetime of a product encourages consumers to pay a higher price premium for energy-efficient TVs than disclosing annual energy operating costs, which itself is more effective that information in the form of "watts"
3	Tumble dryers (TD) and fridge freezers (FF)	Lifetime operating costs	FF difference in costs €250, TD €625	ND	ND	See description below	Field experiment actual	No effect for fridge freezers; 5%, statistically significant increase in average energy efficiency for tumble dryers
4	Cars (conventional, electric, and hybrid)	fuel costs for 5 years + 'lost' savings on fuel + costs per mile or km	ND[1]	ND	ND	405 8000	Choice experiment Choice experiment	Including running costs in some form is effective (statistically valid) in increasing efficiency of purchase. No clear picture on which method of presenting information is more effective – some variation by car type.
5	Washing machines, (WM) washer dryers (WD) and tumble dryers TD, (condenser, C and vented, V)	Lifetime (9 years) operating costs (electricity only)	WM £150 to £310 WD £870 to £1400 CTD £200 to £730 VTD £550 to £600,	WM £200 to £1420 WD £360 to £800 CTD £190 to £1100 VTD £160 to £330,	£0.13/kWh	See description below	Field experiment actual	There was a small but statistically significant decrease in the average energy efficiency of wash dryers but no statistically significant change for other appliance types.

[1] The Appendix containing this information was published by the EC but not in form that could be accessed by the author

ref	Product coverage	Presentation of operational costs	Range of operational costs	Range of capital cost	Energy cost	No of part-icipants	Trial classification	Result
6	Cars (technology not stated)	Volume and cost of fuel for 500 miles + 15,000 miles[2] + 100,000 miles driven	$14k-25k per 100,000 miles (lifetime) $10-31k per 100,000 miles (lifetime)	$17-27k $17-47k	$4.00/US gallon	424 484	Choice experiment Choice experiment	More likely to select the fuel efficient vehicle (between a base model and a fuel efficient) when fuel economy was presented in terms of gas cost than gas consumption. This metric effect was strongest when expressed for the lifetime cost (corresponding to 100,000 mile)s Preference for more efficient vehicle smaller when fuel costs expressed on the 500 miles scale, absent when expressed on the 15,000 miles scale and strongest on 100,000 miles.
7	Water heaters (electric and natural gas[3])	Annual fuel costs CO_2 emissions	$110 to $560	$390 to $1400	Electricity $0.115/kWh natural gas $1.14/therm	1200	Choice experiment	Including cost of energy information increased willingness to buy more energy efficient appliances and was more important than physical energy use (kWh) or CO_2 emissions
8	Televisions	5 year energy costs + carbon offset costs[4]	ND	ND	ND	2500	Choice experiment	Providing operating cost had no effect on likelihood to purchase
9	Lamps (Incandescent lamps (GSL) and Compact Fluorescent Lamp (CFL))[5]	Annual energy costs + TCO for 8 years	TCO $48 for GSL, $12 for CFL	$1 for GSL $4 for CFL, $	ND	1500 1000 (see below for details)	Choice experiment Field experiment actual	Information on cost increased CFL market share by12% The impact on instore sales of CFLs was not statistically significant
10	Cars (conventional, conventional hybrid, plug in hybrid and electric)	Total monthly cost of ownership[6] + 5 year fuel savings	5 year fuel cost: mid sized car $2,700-9,000 mid sized SUV $4,000 - $12,000	mid sized car $20-35k mid-sized SUV $29-46k	$3.50/ US gallon $0.12/kWh	2759	Choice experiment	Intention to purchase more energy efficient car increased by TCO but not by 5 year fuel savings
11	Tumble dryers	5 year energy use cost[7]	€200 to €510	€180 to €700	€0.19/kWh	See description below	Field experiment actual	Found a reduction in the mean energy consumption of sales but the difference is not statistically significant.

[2] Initial pilot work with consumers found that 15,000 was approximately the average annual mileage and as cars are expected to be owned for 8 years 100,000 approximates the lifetime usage.

[3] Consumers were only asked to choose between one water heater type, which matched that they already had – there was no comparison of gas with electric

[4] Information was presented in simulated 'print ads' rather than on a label.

[5] The capital costs were matched ie the consumers was offered a set of 4 GSL lamps or 1 CFL lamp

[6] Travelling 15,000 miles per year over a 10 year period and logarithmic depreciation of the car with a residual value of 15%,. For financing ,assumed a down payment of 10%, a loan period of 60 months, and an interest rate of 5%.

[7] Researchers would have preferred a period of 10 years, but the retailer partner found this unacceptable

ref	Product coverage	Presentation of operational costs	Range of operational costs	Range of capital cost	Energy cost	No of part-icipants	Trial classification	Result
12	Refrigerators	Annual operating cost	€22 to €56	€170 to €450	ND	5000	Choice experiment	Adding cost data increases choice of the more energy efficient appliances
13	Lamps (incandescent, (GSL) and LED)	Annual operating costs	LED €1 GSL €8	LED €6 approx ND GSL	ND	1000	Choice experiment	Willingness to pay more for the LED bulb when given information on annual operating costs increases in a way that is statistically significant.
14	Cars	annual fuel costs (15,000 miles/year) + Greenhouse Gas Rating, GGR (separately or in combination)	$2.2 - $4.0k	$26-34k	$3.7/US gallon	340 800 600	Choice experiment Choice experiment Choice experiment	Consumer was likely to have a preference for the more fuel efficient car if both pieces of environmental information were presented.
15	Freezers (F), tumble dryers (TD) and vacuum cleaners (VC).	Annual operating costs + lifetime cost gains or losses in electricity costs compared to average	Annual F CHF 26 to 60 TD CHF 30 to 52, VC CHF 5 to 12	F CHF 580–2500 TD CHF 420–2400 VC CHF 89–500	0.2CHF/kWh	840 (see below for details)	Field experiment actual	Freezer sales were unaffected by the display of either label. The display of either energy label led to a statistically significant reduction in the mean default electricity consumption of purchased tumble dryers (the difference between the two types of label was not statistically significant.) For vacuum cleaners, both labels led to an energy reduction but the non-monetary EU Energy Label induced a statistically significantly larger reduction in mean default electricity consumption than the monetary lifetime-oriented energy label.

It is worth describing the field experiments with consumers' actual purchase decisions in more detail than could be included in Table 2, as they differed considerably in how they were conducted:

- Kallbekken et al (2012)
  the experiment was implemented in six 'mega stores' of a retailer, with all other stores providing a control group. (The non-random assignment of the treatments is tackled by employing the synthetic control method in the analysis). In addition to the product labelling sales staff were trained on energy efficiency. The experiment ran for five months.
- DECC et al (2014)
  the experiment was implemented in 38 stores with 19 undergoing the intervention and 19 as controls. Sales staff were given training with more detailed training in the intervention stores. The trial ran for 10 months but due to initial implementation issues the sales data was only analysed for the final six and a half months. Sales of appliances during the trial are shown in Figure 3.

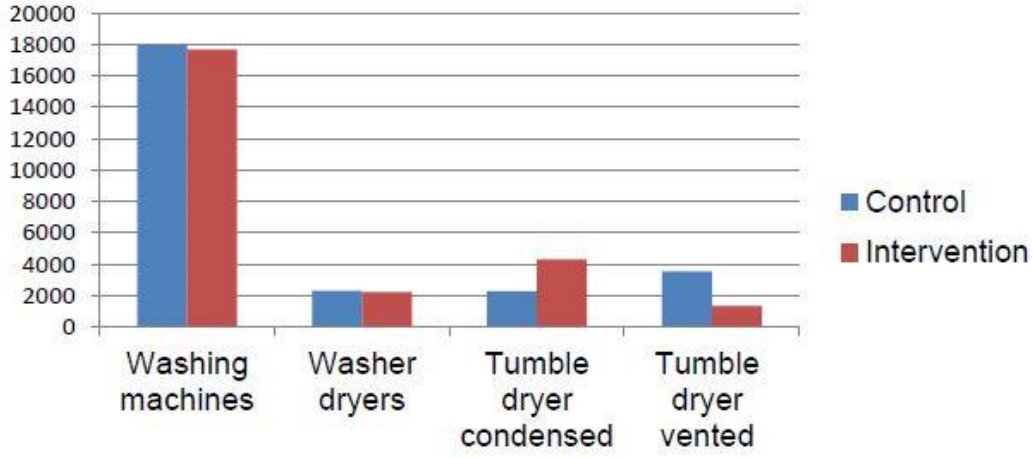

Figure 3 DECC (2014) Number of sales per appliance type in control and intervention stores

- Allcott & Taubinsky (2015)
  Three research assistants (RAs) worked in four large stores of a home improvement retailer over 5 months. The RAs approached customers in the stores' "general purpose lighting" areas to ask if they were prepared to answer some questions in return for a discount. The customers were randomly split into treatment and control groups; the treatment group were given information on annual energy costs for GLS and CFL lamps, as well as answering survey questions. Respondents were randomised into two groups receiving either: a standard coupon (10% off any lamps), and a rebate coupon (30% off CFLs). The use of the discount coupons was tracked.
- Carroll et al (2016)
  The three month trial took place in four of a retailer's outlets (Treatment stores were non-randomly selected by the retailer and were all located in the Greater Dublin area, selected due to their close proximity to head office). The retailer's 16 remaining stores, which were located throughout Ireland, were employed as the control group. The labelling and analysis focused on 20 models of appliances which captured 95.3 % of retail sales during the trial period. The authors noted some experimental restrictions which may have biased the results, most notably, non-random treatment store assignment and lack of control and information on the availability of individual models at the store level.
- Stadelmannm, & Schubert (2018)
  The experiment was a field study with a Swiss online retailer of home electronics. The researchers displayed the information from the EU energy label (but not the graphic image) [8] for 4 weeks and then replaced this with their self-designed monetary lifetime-oriented energy label for 4 weeks. This process was repeated 3 times (total trial length 6 months). The sales of these product groups for the 12 weeks preceding the trial were used as control data – assuming seasonal effects for these products were not significant. Sales numbers of each product type were similar for each 12 week period.

[8] Swiss online stores are not required to display the EU energy label. This is a requirement in EU Member States

Results – the effect of running cost information on consumer purchases

Most of the studies found that consumers were more likely to buy or to express a preference for energy efficient products when presented with operating cost information. Within this overall picture there is great deal of variation - some studies found no effect at all; some an effect, within the same experiment, for some product groups and not others; some found an effect for presenting the information over one time period but not for others.

Discussion of results

The number of variables in the design of experiments: choice of product; experiment type; period of operating cost presented; means that that no two studies are directly comparable, which makes it difficult to draw any firm conclusions. Some of the possible reasons for these variations are discussed below.

Reason for undertaking the experiments

The differences between the papers is partly driven by the range of motivation of the researchers; while the primary interest of some was the issue that is the point of the paper – (does operating cost information change purchase behaviour?); others were concerned by the effect of signposting in activating environmental concerns in purchasing (Ungemach et al 2017) or evidence that a subsidy of CFLs was justified (Allcott & Taubinsky 2015). In these cases the introduction of cost data was a means to a different end, which means that the discussion of the issue of concern to this paper was not always addressed fully.

The type of intervention

The studies have used two main intervention methodologies: choice and field experiments.
Field experiments with actual purchase replicate the real world more closely – which is an advantage in terms of giving a clearer indication of what might happen if the label were adopted but is intrinsically difficult to control. This means the experimental design is always not exactly as the researchers would wish. Beyond that the circumstances will always intervene to make the situation imperfect. Another intrinsic complication is that these are real products with a host of other attributes beyond price and energy efficiency, which can influence customers (discussed in more details below). In principle these effects can be accounted for by good use of control groups but it is impossible to create a control group in the field that provides the same level of confidence as in a 'lab' environment where much more of the situation is under the researchers' control.
Choice experiments provide an artificial environment so they are a poorer indication of what might happen if a label was introduced. However, the greater degree of control means that it is easier to provide a robust control group and to separate out different effects. For example, some researchers presented only a pair of options for consumers to purchase, which is not realistic for a real purchase situation but does allow discrete aspects to be investigated. Similarly experimenters can control exactly what information the participants receive, for example some researchers chose to use real world data for costs and energy performance and included brand names; others presented realistic data but in isolation from other factors that might influence consumers decisions. Brand is often an important factor in purchase decisions as discussed in Brocklehurst (2015). The effect of brands on choice should be accounted for by the use of a control group –however this may be imperfect. Further, in a choice experiment researchers can randomise the order of the choices that participants are presented with such that this effect of order is eliminated. Again this effect should be reduced by the use of a control group but may not be removed completely.
Thus comparing the two types of trials you might expect the results to be more clearly positive from the choice experiment than the field experiment, reflecting the greater degree of experimental control.
However the product type would be expected to affect the result too because of:

- the scale of savings possible (discussed below),
- the degree of correlation of capital cost with energy efficiency (discussed below) and
- the nature of the purchasing decision for the product (discussed below)

The ideal would be to compare results for the same product for different trials types. This applies to two product groups in studies included in this analysis:

- washing machines (field experiment, DECC et al 2014; choice experiment Bull 2012).
- lamps (choice experiment and field experiment Allcott & Taubinsky 2015; choice experiment, Andor et al 2017)

In both these cases the choice experiments found an effect; the field experiments didn't. This suggests the hypothesis may be correct, but with such limited data it is not possible to be definitive.

Scale of operational savings and relative scale of upfront savings and costs

As discussed in the section on previous reviews the scale of operational savings presented is expected to impact the discounting consumers apply to savings from reduced running costs. This is affected by the period of the savings presented and the particular range of the products used in the trials. For the former the situation is not clear cut – generally speaking using a longer period, generated a great response as expected. But in some cases quite modest, annual savings had an effect (eg Newell and Siikamäki 2014) and in one case, Camilleri and Larrick (2014), increasing the interval (from 500 to 5,000 miles), and therefore the scale of the costs, removed the effect before recovering it again at a higher interval (100,000 miles). Products with similar scale of annual costs also derived a range of responses – possibly due to the product specific effects (efficiency correlating with upfront costs; the nature of the purchasing decision – see below).

The author would expect the scale of operational savings relative to that of the upfront cost to have an impact but has not seen any reference to this in the literature. If the operational costs are of the same order or higher than the capital costs then it would seem likely that this would be more likely to influence consumers' decisions than if they were a fraction of them. However, there is no clear indication that this is the case:

- Some studies with similar order operating and capital costs found an effect, others did not.
- Some studies with the operating costs considerably smaller than capital costs found an effect, other did not

so this hypothesis is unproven.

Does high energy efficiency correlate with higher upfront costs for products in these studies?

It isn't clear how many of the products fit the 'expected' pattern of a more energy efficient product costing more initially but having reduced operating costs. Some of the studies demonstrated this:

- Bull (2012) for washing machines, Stadelmannm, & Schubert (2018) for freezers.
- The studies of different lighting types; incandescent lamps have a much lower upfront cost and higher operating as against CFLs or LEDs,
- as do 'greener' car technologies

and the researchers using choice experiments could select pairs or groups of products where this situation does apply.

However there were products in studies where this may have been assumed to apply but proved not to be the case, for example:

- Stadelmannm, & Schubert (2018) found that for the selection of the vacuum cleaner market sold by the Swiss online retailer they were working with, that price was negatively correlated with energy efficiency.
- None of the appliance groups in the retail study reported by DECC et al (2014) showed strong correlations of price with energy efficiency (the report does not present R^2 factors but does include scatter plots.) On the contrary, in the case of condensing tumble dryers the scatter plot suggests a weak negative correlation.

Demonstrating that the more energy efficient products cost less to operate may still encourage consumers to buy the more efficient item, even when the energy efficient product did not have a great upfront cost; but they are not addressing a barrier of the reluctance to pay more initially for them which the cost information is intended to address and thus may have a weaker effect.

All the field experiments and some of the choice experiments used market data but most did not provide data on price vs efficiency of the products so it not possible to tell how widespread this issue is.

The type of product influencing the purchasing decision

Previous studies have found that the process for a consumer purchasing a car is different to that for purchasing an appliance such as washing machine or lamp (Codagnone et al 2013; Brocklehurst 2015). In particular, individuals identify with their car in a way that they don't with their appliances and this can bring a complicating factor to the car purchasing decision; this may make it less susceptible to additional information encouraging in a more 'rational' decision. .

The author would also suggest that buying a TV, which is used for entertainment, is a different process to that of buying a utilitarian appliance such as a water heater or a washing machine. The consideration of operating costs may feel appropriate when buying the latter in a way it doesn't for the former.

Neither of these differences is seemingly born out in the evidence presented here; all of the car studies and one of the two TV studies found an effect due to providing cost data; many of the appliance studies found none. However, there is the proviso that all the car and TV studies are choice experiments, which, as discussed above,

are more likely to find an effect than field experiments, whereas the experiments for appliances and lamps are about evenly split between choice and field experiments.

A further feature of product choice, which is not discussed in any of the papers included in the analysis, is that for some of the products, while the service provided by the more energy efficient product is the same, the technology delivering it is notably different. This applies to the lighting examples, where incandescent lamps are compared with CFLs and LEDs, and for cars, where 'conventional', petrol-only fuelled cars, are compared with hybrid or electric cars. Individual consumers may have a number of reasons why they prefer one technology to another, beyond the cost and environmental concerns which are being tested in these studies. These may be 'emotional' (eg an attachment to the 'old' technology or an excitement about the new), and/or practical (eg concerns about slow start up time for CFLs or difficulty in accessing charging points for electric vehicles). One would expect these attributes to have a greater effect in an actual purchase than in the laboratory setting of the choice experiment, where there are no practical consequences from the buying choice.

There are too few studies included in this review to be able to test this premise:

- both the car studies that explicitly included a range of technologies are choice experiments.
- the two lighting studies included only two choice experiments and one field experiment

How different is the information from what consumers are used to?

The 'background level' of energy labelling for products in the countries of the studies varies; most of the products in most of the countries had some well-established form of energy or carbon labelling already; some of these (for example the US label for appliances, EnergyGuide and US label for vehicles (see Figure 4)) explicitly addressed cost as well as energy use. None of the studies discussed this as a factor but the author suggests that this might have had an effect. While the **difference** in information in the experiment for the treatment vs the control group might be the same, the consumer may still be familiar with this type of information and this may influence the result. That is, if consumers are used to associating higher efficiency with lower operating costs then the specific information provided in the experiment may have less impact. Again, the studies under review are too limited to be able to test this.

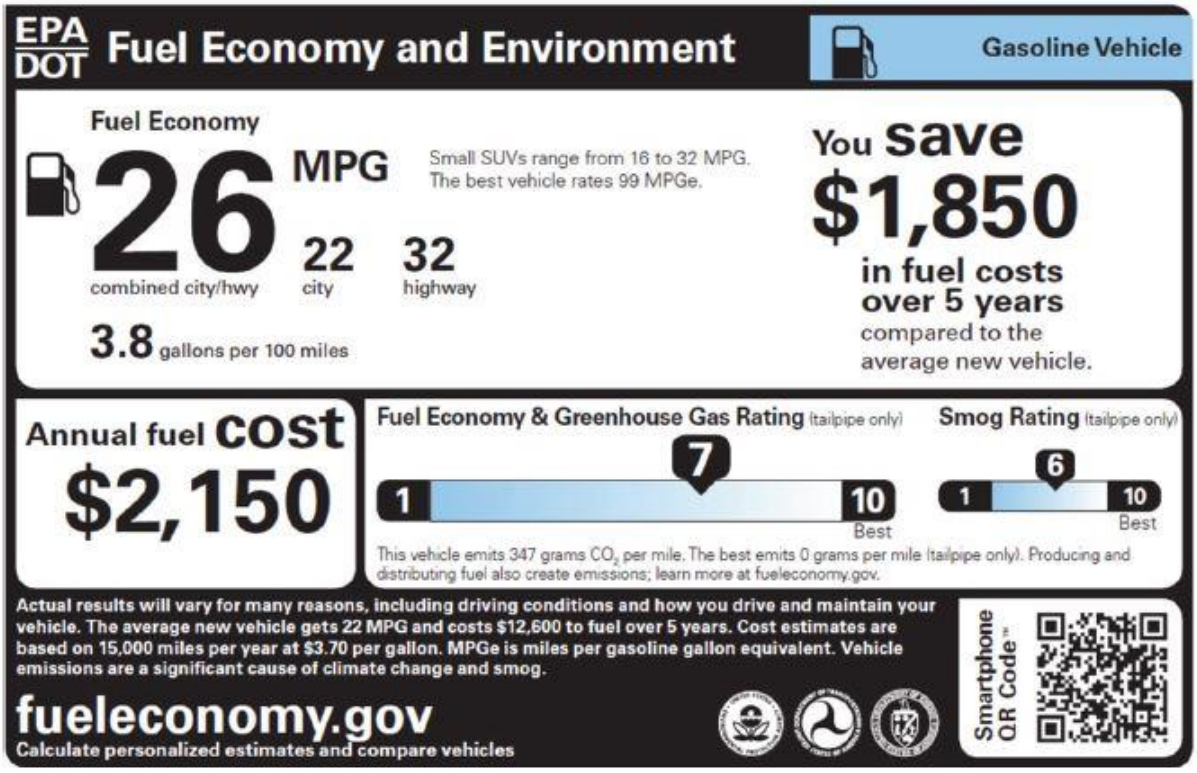

Figure 4 U.S. Environmental Protection Agency Fuel Economy and Environment Label for Gasoline Vehicles (from Ungemach et al 2017)

Conclusions

Kaenzig and Wüstenhagen's 2009 paper on this topic presented a persuasive model for purchasing decisions and a promising if uncertain indication that this might be correct. Their work suggested that presenting the right (scale) operating cost information in a way that is easy for consumers to assimilate will increase the likelihood of the purchase of more energy efficient products. It was hoped that the relatively large number of recent studies (18 in nine years, as against twelve from 1979 to 2009) would provide clearer evidence to support the model and hypothesis. This has not proved to be the case: while most studies found a statistically significant effect, several did not.

This paper has discussed possible reasons for the variations in results, namely:

- the reason for undertaking the research (influencing the design of the experiment and how the results are presented)
- the type of intervention – field or choice experiment
- the scale of operational savings presented to the consumer (in absolute terms and relative to initial costs)
- whether energy efficiency correlates with initial cost for the products included in the studies
- the type of product influencing the purchasing decision and
- how different the information in the experiment is from the 'background' information that consumers are used to seeing.

The small number and the diversity of the studies has not made it possible to draw firm conclusions on any of these points; the most persuasive evidence is for the second point – the choice experiments are more likely to find a positive result than a field experiment.

Where does this leave us?

Researchers

Given the ongoing interest and possible significant advantages of providing cost data it seems likely that there will be more studies in this area. The author would welcome this while urging researchers to consider a broader range of influences when designing, undertaking and analysing their experiments (for example, examining whether energy efficiency is correlated with higher upfront cost). Also perhaps there needs to be more consistent design of studies in this area? If these conditions were both met then the conclusions that could be drawn from their results would be clearer.

Policy makers

The evidence for the benefit of providing running cost information is not strong and, in itself, is not likely to persuade policy makers to change the format of existing labels or to require suppliers to provide additional information, via mobile technology.

However, when surveyed, consumers have consistently asked to be given running cost information (see for example Harris Interactive 2007 and Dünnhoff and Palm 2014). In response and given the increasing ease of providing it, environmental, consumer and/or commercial organisations in the EU and elsewhere may well develop ways of doing this that are free to the consumer. In which case, a series of large scale field trial experiments may result!

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