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The affordability of household transport costs: quantifying the incidence of car-related economic stress in Great Britain

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Abstract
There is increasing concern for the affordability of daily mobility costs, notably by car. In this paper, we use the term 'car-related economic stress' (CRES) to refer to households spending a disproportionate amount of money on car travel. We propose two indicators to investigate CRES in Great Britain, both of which are based on widely available, continuous surveys. First, a 'Low-Income-High-Costs' metric, inspired by the UK government indicator of fuel poverty, and applied to the *Living Costs and Food Survey*. We complement this with the analysis of a material deprivation-based measure of CRES, based on the *EU Statistics on Income and Living Conditions*. Our analysis suggests that, in 2012, CRES affected between 6.7% and 9% of households in Great Britain, corresponding to between 1.7 and 2.3 million households. Low population density and difficult access to public transport are associated with a higher risk of CRES. In terms of social profile, households at risk of CRES are not so different from the average of the population, but are clearly distinct from low income households with low motoring costs and from households who cannot afford cars. Our analysis identifies a number of socio-economic factors (household size, presence of children, underemployment, disability) which may increase the ratio between car travel needs and household income, thus increasing the risk of economic stress.

1. Introduction

Rapidly fluctuating oil prices, stagnating real incomes and increasing car ownership among low-income groups have drawn increasing attention to questions of affordability in transport. In developed countries, research has focused mostly on households who need (or might need) to spend a disproportionate amount of money on car-based mobility in order to access essential services and opportunities. In this paper, we refer to this phenomenon as 'car-related economic stress' (CRES) (Mattioli & Colleoni, 2015). We propose two indicators to investigate CRES in Great Britain, both of which are based on widely available, continuous surveys. The first indicator is applied to the ONS *Living Costs and Food Survey* (LCFS), and is inspired by the current official UK government indicator of (domestic) fuel poverty. It defines households at risk of CRES as those with low income and high motoring costs. The second indicator is applied to the *EU Statistics on Income and Living Conditions* (EU-SILC). It defines households at risk of CRES as those who own a car despite being 'materially deprived'. Our goals are: (i) to quantify the incidence of CRES in Great Britain; (ii) to identify the distinguishing features, both spatial and *socio-economic*, of households at risk of CRES.
The paper is structured as follows: in Section 2, we briefly review previous research on CRES and identify research gaps. In Section 3, we offer a critique of previous metrics of transport affordability proposed in the British context. Sections 4 and 5 present the indicators and the research findings, which are then discussed in Section 6.

2. Background

Transport and social exclusion is an area where the UK has been world-leading, both in terms of research and policy (Lucas, 2012). However, attention has focused largely on low mobility individuals, carless households and social groups that are generally considered more at risk of social exclusion.

There is however increasing recognition that the costs of daily mobility, notably by car, can have important negative economic impacts. These can lead households to curtail expenditure in other essential areas and/or to restrict activity spaces, both of which can result in social exclusion. There is also a concern for the social and distributional impacts of rapid increases in the cost of motoring, e.g. as a result of fuel price spikes. Different terms are used in the literature to indicate transport affordability problems, including 'forced car ownership' (Currie & Senbergs, 2007), 'transport poverty' (RAC, 2012; Sustrans, 2012), 'oil vulnerability' (Dodson & Sipe, 2007), 'commuter fuel poverty' (Lovelace & Philips, 2014), 'transport energy precarity' (Jouffe & Massot, 2013) and 'transport affordability' (Lucas *et al.*, in press).

In this paper, we use the term 'car-related economic stress' (CRES) (Mattioli & Colleoni, 2015) to refer to a subset of transport affordability problems, related to expenditure on motoring. This is consistent with existing research on developed countries, which has largely focused on the affordability of owning and operating motor vehicles (Lucas *et al.*, in press).

Another feature of existing research on CRES is the emphasis on questions of spatial planning and urban form. Researchers have tended to identify vulnerable *areas*, which would benefit from improved public transport and local supply of services, with research consistently showing that CRES and vulnerability to fuel price spikes are more severe in car dependent suburban and rural areas (Currie & Senbergs, 2007; Dodson & Sipe, 2007; Jouffe & Massot, 2013; Lovelace & Philips, 2014; Mattioli & Colleoni, 2015; Nicolas *et al.*, 2012; Sustrans, 2012). The work has less to say about the *social groups* who suffer the worst stress and would be the most vulnerable to fuel price spikes.

While CRES and oil vulnerable households are often defined *a priori* as low-income, to the best of our knowledge only a few studies have delivered insights into other socio-demographic traits. Nicolas *et al.* (2012) have investigated the cost burden of daily mobility in Lyon, finding higher costs for employed households (notably farmers and blue-collar workers) and large households with children. Mayer *et al.* (2014) have investigated patterns of combined (transport and domestic energy) energy poverty in Strasbourg, finding that households with children and social housing residents are more affected. Lovelace and Philips (2014) estimate that in York the 'commuter fuel poor' are on average slightly older than other households.

In this paper, we aim to provide further insights into the socio-economic characteristics of households at risk of CRES in Great Britain. In doing this, we aim to stress that there is both a geographical and a *social* dimension to transport disadvantage and CRES.

3. Metrics of transport affordability for the UK

The UK has long institutionalised the notion of 'fuel poverty' to refer to the lack of 'affordable warmth' in the home. Following the pioneering work of Boardman (1991), in 2001 the government adopted a definition of fuel poverty stating that a household is fuel poor "if it would need to spend more than 10 per cent of its income to achieve adequate energy services in the home" (Hills, 2012, p. 29).

In such a context, researchers and NGOs have put forward the notion of 'transport poverty', building on an analogy between (institutionally recognised) fuel poverty and (neglected) transport affordability issues, proposing metrics that mimic Boardman's 10% indicator. The RAC foundation (2012) has proposed to consider households 'transport poor' when "more than ten percent of their expenditure goes on transport (both personal and public)". The sustainable transport charity Sustrans (2012) has mapped the incidence of the 'risk of transport poverty' in England, based on a composite index which takes into account: (i) access to bus and train stations; (ii) access to essential services by modal alternatives; and (iii) "the number of households that would need to spend 10 per cent or more of their income on the costs of running a car (whether or not they are actually running one)". Based on this methodology, they estimate that nearly 1.5 million people in England are affected. Lovelace and Philips (2014) propose four metrics of 'oil vulnerability', including an index of 'commuter fuel poverty', which is defined as spending more than 10% of income on commuting.

Three kind of criticism can be made of these metrics. First, the original rationale for Boardman's 10% threshold was that the median value of the expenditure on domestic energy in Britain in 1988 was 5%, and twice the median was "deemed to represent a disproportionate level of expenditure" (Boardman, 2010, p. 231). Even within the fuel poverty literature, it is controversial whether applying a fixed threshold based on figures from 1988 is

still appropriate (Boardman, 2010; Hills, 2012; Heindl & Schuessler, 2015). It is clearly even less defensible to apply such a threshold to transport, where expenditure is typically higher[1].
Second, Boardman's notion of a cost burden threshold was borne out by the observation that home energy costs are regressively distributed: low-income households typically spend a higher share of income on it than richer households (Boardman, 2010, p. 22). The reverse is true for transport and motoring expenditure, which generally account for a larger share of income among richer households. As a result, while low-income households are overrepresented among those who spend more than 10% of their income on domestic energy services, the opposite is true for transport and motoring expenditure[2].
Finally, indicators of transport affordability that mimic Boardman's 10% indicator have been proposed almost exactly at the same time as a new indicator of fuel poverty was adopted by the UK government. This is arguably better suited to application in the transport sector.

3. A 'Low-Income-High-Costs' metric of CRES

The LCFS is the latest in a long series of consumption and expenditure surveys that have been conducted each year in Great Britain (excluding Northern Ireland) since the 1940s. The dataset includes detailed information on (weekly equivalent) household expenditure and income. In this study, we use the 2012 dataset (N=5,593) to estimate an indicator of CRES that is modelled on the *current* official UK government indicator of domestic fuel poverty (Hills, 2012). To the best of our knowledge, this is the first attempt to develop a Low-Income-High-Costs indicator *specifically for transport*.
Following increasing criticism of the '10% indicator', the UK government adopted a new measure, the 'Low-Income-High-Costs' (LIHC) indicator (Hills, 2012). This defines fuel poor households as those who (i) have "required fuel costs that are above the median level" and (ii) "were they to spend that amount they would be left with a residual income below the official poverty line" (i.e. 60% of the median) (Hills, 2012, p. 9). It is important to stress that measures of fuel poverty in the UK refer to *required* (rather than actual) energy costs. These are modelled based on normative standards of adequate energy services, combined with information on the energy performance of home energy appliances and the building (Walker *et al.*, 2015). Importantly, "this means that households whose actual expenditure is low because they cannot afford enough fuel to be warm are not wrongly considered not to be in fuel poverty (while) households who have high expenditure while wasting energy are not considered to be fuel poor" (Hills, 2012, p. 30).
In keeping with the logic of the Hills indicator, in this paper we adopt a definition of LIHC households as those that fall *below an income threshold and above a cost threshold*. With regard to *costs*, the indicator considers the expenditure for 'running motor vehicles' reported in the LCFS dataset. This includes expenditure on motor fuels as well as other variable costs of motoring (e.g. vehicle road tax, insurance, repairs, parking fees, etc.). We do not include fixed costs (e.g. vehicle purchase) for two reasons. First, most sampled households do not report any expenditure for car purchase in the 12 months before the interview, while a minority reports very high values, and this might skew the analysis. Second, previous studies have shown that the purchase of a car is a luxury good, with wealthier households spending a higher share of their income on more expensive cars, which are also substituted more frequently (Demoli, 2015).
A key difference between the LIHC domestic fuel poverty measure and the transport indicator proposed here is that we consider *actual*, rather than *required*, expenditure. As it has been noted elsewhere (Mayer *et al.*, 2014; Jouffe & Massot, 2013; Stokes & Lucas, 2011) determining normative standards of required travel (and related costs) is a formidable challenge, which is beyond the scope of this study. This means that our indicator does not identify 'underspending' households, who spend less than they should on motoring because they curtail travel to essential activities. Arguably, however, this is not such a limitation, since much transport and social exclusion research to date has focused on low mobility groups and suppressed travel demand. Our indicator complements the insights of existing research with an examination of households spending a disproportionate amount of money on running

[1] According to LCFS 2012, British households spent on average £23.20 per week on 'electricity, gas and other fuels', as compared to £64.10 on transport (of which £36.40 on the 'operation of personal transport').
[2] By overlooking this fact the RAC foundation (2012) comes to the odd conclusion that 21 million households - no less than *80%* of British households - are in 'transport poverty', and that these are overrepresented among *higher income* groups.

motor vehicles. While it is possible that some of them are spending more than they ought to, we assume that wasteful 'overspending' is not so common among households whose resources are very limited.
Another difference between our LIHC indicator and Hills' original measure regards the cost threshold. Following Heindl and Schuessler (2015), we do not define 'high costs' as more than the median of (equivalised) costs, but rather as more than twice the median the *share of income* spent on 'running motor vehicles'. As in the LCFS 2012 dataset the median is 6.5%, we set the threshold at 13%. The resulting indicator can be construed as a compromise between the old '10%' and the new LIHC indicator.
With regard to *income*, our approach is virtually identical to Hills': we subtract from household income net housing expenditure and 'running motor vehicles' expenditure. The remaining income is divided by the modified OECD 'after housing costs' equivalence scale factors. The poverty line is set at 60% the median of the equivalised income (121£ per week in the 2012 dataset).

		LILC	LIHC	HILC	HIHC	*Total*
	TOTAL	*13*	*9*	*65*	*13*	*100*
Household size	**1**	18	9	64	10	*100*
	2	8	8	69	15	*100*
	3	12	10	64	14	*100*
	4 or more	14	11	62	12	*100*
Children	**0**	12	8	67	13	*100*
	1+	15	13	61	11	*100*
Full- or self-employed members	**0**	22	12	58	8	*100*
	1+	5	7	72	17	*100*
Members in part-time employment	**0**	14	9	66	12	*100*
	1+	10	11	64	15	*100*
Unemployed members	**0**	10	8	68	13	*100*
	1+	41	16	34	9	*100*
Age of household reference person	**15-29**	24	10	53	13	*100*
	30-39	14	11	63	13	*100*
	40-49	12	10	65	13	*100*
	50-59	13	10	62	15	*100*
	60-69	7	7	70	16	*100*
	70+	11	7	74	9	*100*
Recipients of DLA (mobility)	**0**	13	9	65	13	*100*
	1+	9	9	73	9	*100*
Ethnic origin of HRP	**White**	11	8	67	13	*100*
	Not white	27	15	48	10	*100*
Sex of HRP	**Male**	11	9	66	14	*100*
	Female	16	9	64	11	*100*
Category of dwelling	**Detached**	4	9	71	17	*100*
	Semi-detached	9	9	67	15	*100*
	Terraced	18	10	61	11	*100*
	Purpose-built flat maisonette	22	9	63	7	*100*
	Part of house converted flat	28	4	61	7	*100*
	Others	12	9	64	16	*100*
Tenure type	**Owned outright**	6	8	73	14	*100*
	Owned with mortgage / rental purchase	4	7	73	17	*100*
	LA / Housing Association rented	29	13	52	6	*100*
	Other rented	29	13	51	8	*100*
	Rent free	9	16	62	13	*100*

Table 1 – Distribution of the LIHC indicator in different social groups (LCFS 2012, N=5,593)

In LCFS 2012, 9.0% of households are LIHC. This corresponds to roughly 2.3 million households in Great Britain. The rest of the sample is split between 'Low-Income-Low-Costs' (LILC, 12.8%), 'High-Income-Low-Costs' (HILC, 65.5%) and 'High-Income-High-Costs' households (HIHC, 12.7%). Table 1 shows the incidence of LIHC and the other three groups for different social groups. The table suggests that, at a descriptive level, there is a number of characteristics that are shared by both 'low income' groups. Both LIHC and LILC are overrepresented among: large households (with four or more members); households with children; households with no member in full or self-employment; households with unemployed members; households with a non-white 'household reference person' (HRP). In the first instance, these characteristics can be thought of as drivers of 'low income'. On the other hand, LIHC appears to be different from the LILC group in many respects. For

example, it is not overrepresented among single-person households. It is overrepresented among households where at least one member is employed part-time, and this is true also for the HIHC group. Also, while LILC households are strongly overrepresented among young adults in their twenties, differences are much less pronounced for LIHC, which has an incidence of at least 10% in all age bands below 60 years old.

We use the presence of recipients of the mobility component of the UK government's Disability Living Allowance (DLA) as an indicator of mobility difficulties in the household. While DLA recipients are underrepresented in the LILC group, this does not apply to LIHC. Similarly, unlike LILC, LIHC is not overrepresented among households with a female reference person. While both low income groups are overrepresented among those who rent their accomodation, this is much less pronounced for LIHC than for LILC. Finally, LILC are overrepresented among those living in terraced housing and flats, but this does not apply to LIHC, whose incidence is at least 9% in most categories of dwelling.

Since the descriptive variables reported in Table 1 are strongly associated with each other, we present the results of two logistic regression models in Table 2. The first (left column) includes the full LCFS sample in the analysis, and models the probability of belonging to the LIHC group, as opposed to any other group in our classification. The goal here is to identify the characteristics that distinguish LIHC households *from the average of the population*.

The goodness of fit of the model is rather low with a McFadden's Pseudo R^2 value of 0.08. This is partly because the model does not include some potentially powerful predictors[3], but could also be interpreted as indicating that the LIHC group is not so different from the rest of the British population, with respect to the variables included in the model.

The model results suggest that there are no statistically significant differences (at the $p<0.10$ level) between LIHC and the rest of the sample in terms of household size and number of children, unemployed and part-time employed members, once other factors have been controlled for. However, the number of full-time or self-employed members is found to reduce the probability of LIHC. With regard to age, for otherwise similar households, the probability of LIHC peaks among households in the 40-60 age band.

The model results also suggest that LIHC households are less likely to include members with mobility difficulties and to have a female reference person than the average of the population, even after other factors have been controlled for. By contrast, the net effect of a non-white household reference person is to increase the probability of LIHC. The model also confirms that LIHC households are more likely than average to live in a rented accommodation. The results for the category of dwelling show that the net effect of living in a flat (as compared to a detached house) is to strongly reduce the probability of being at risk of CRES. This might reflect differences in urban-rural location or population density in the neighbourhood, but also lower housing costs for flats (as we are unable to control for either factor).

The second model in Table 2 (in the rightmost column) only includes households that we have defined as 'low income', modelling the relative probability of belonging to the LIHC group, *rather than LILC*. The goal is to identify the drivers of 'high costs' in the low income population. The goodness of fit is much better here (0.14), suggesting that LIHC households differ more from other 'low income' households than from the average Briton.

In detail, the net effect of the number of employed members (either full- or part-time) is to increase the probability of LIHC, while LILC households are more likely to include unemployed members. This suggests that for some households employment income is not enough to get out of poverty, after the cost burden of running motor vehicles is accounted for, while unemployment is more likely to lead to reduced car travel than to CRES. An increase in the number of children is associated with an increase in the probability of LIHC. The significant, negative coefficient for household size is a by-product of the fact that other household composition variables are controlled for. Further analysis shows that, in a model where other household composition factors are not controlled for, the probability of LIHC has a curvilinear relationship with household size, peaking among three and four member households and declining thereafter. There are no significant differences in terms of age between the two groups, after other characteristics (such as labour participation) are

[3] First, for confidentiality reasons, information on the residential location of households (including urban-rural indicators) is not included in the End User Licence version of the LCFS 2012 dataset. Second, since information on income and expenditure has been used to define the LIHC indicator, we do not include income and housing expenditure among the predictors, as this would confound interpretation.

controlled for. Similarly, the ethnic origin of the HRP does not have a significant effect in this model, suggesting that being non-white is associated with 'low-income', but not 'high costs'.

Outcome:	***Low Income, High Costs (LIHC)***			
Base outcome:	***Rest of the sample***		***LILC***	
	Coef.	***Std. error***	***Coef.***	***Std. error***
Household size: simple term	0.141	0.176	0.324	0.252
squared term	-0.010	0.030	**-0.094**	**0.047****
No. of children	0.078	0.102	**0.368**	**0.156****
No. of members full-time or self-employed	**-0.987**	**0.099*****	**0.619**	**0.159*****
No. of members employed part-time	-0.153	0.104	**0.463**	**0.144*****
No. of members unemployed	0.107	0.146	**-0.316**	**0.174***
Age of HRP (ref. cat.: 15-29): 30-39	0.322	0.214	0.285	0.249
40-49	**0.421**	**0.209****	0.223	0.254
50-59	**0.493**	**0.216****	0.281	0.254
60-69	-0.357	0.242	0.349	0.294
70+	**-0.754**	**0.252*****	-0.182	0.311
No of recipients of DLA (mobility)	**-0.415**	**0.168****	**0.846**	**0.295*****
HRP not White	**0.451**	**0.160*****	-0.038	0.215
HRP female	**-0.262**	**0.110****	**-0.431**	**0.142*****
Category of dwelling (ref. cat.: Detached)				
Semi-detached	-0.133	0.142	**-0.513**	**0.234****
Terraced	-0.232	0.154	**-1.002**	**0.233*****
Purpose-built flat maisonette	**-0.574**	**0.205*****	**-1.020**	**0.286*****
Part of house converted flat	**-1.460**	**0.440*****	**-2.120**	**0.507*****
Others	-0.299	0.402	-0.707	0.546
Tenure type (ref. cat.: Owned outright)				
Owned with mortgage / rental purchase	-0.131	0.164	-0.358	0.259
LA / Housing Association rented	**0.344**	**0.170****	**-0.873**	**0.228*****
Other rented	**0.495**	**0.186*****	**-1.095**	**0.246*****
Rent free	**0.966**	**0.433****	0.467	0.672
Constant	-1.828	0.348***	0.513	0.460
McFadden's Pseudo R^2	*0.08*		*0.14*	
N	*5,593*		*1,191*	

Notes: bold indicates statistical significance (* p<0.10; ** p<0.05; *** p<0.01).

Table 2 – Logistic regression models for the probability of belonging to the LIHC group (LCFS 2012).

Interestingly, among low-income households, personal mobility difficulties are associated with an increase in the probability of experiencing high costs. The presence of a female HRP is associated with higher probability of LILC, possibly as a result of lower license- and car-ownership rates among women. The results for the 'category of dwelling' variable strongly

suggest that the risk of CRES is significantly higher in areas of detached and semi-detached housing. Finally, it appears that being home-owners is associated with an increase (and renting with a reduction) in the probability of LIHC. Here the effect is reversed as compared to the first model, suggesting that LIHC households are more likely to rent than the average Briton, but more likely to own than other low-income households. Again, this might be due to uncontrolled differences in residential location, as urban households are more likely to rent.

4. A material deprivation-based measure of CRES

Since 2004, the EU-SILC survey is conducted every year in EU member states and associated countries. The survey covers a range of topics including income, housing expenditure, labour market situation and material deprivation. It is used as the source of data for the official social indicators of the EU. While there is no specific focus on transport-related social exclusion in EU-SILC, some information on transport is collected as it is relevant to other research agendas. A series of items on material deprivation are included in each wave of EU-SILC. The material deprivation scale is an indicator of absolute poverty, which takes into account whether households are able to afford the following nine items: to face unexpected expenses; one week annual holiday away from home; to pay for arrears; a meal with meat, chicken or fish every second day; to keep home adequately warm; to have a washing machine; to have a colour TV; to have a telephone; to have a personal car. Households who cannot afford at least three out of the nine items are considered to be in 'material deprivation'.

We exploit information on material deprivation to build an indicator of CRES, using the British sample of EU-SILC 2012 (N=9,201)[4]. We define as ‘at risk of CRES’ households who own at least one car *despite* being in material deprivation (MD). The assumption here is that these households are (at least potentially) trading off motoring expenditure against expenditure in other essential areas. In 2012, 6.7% of households in Great Britain - corresponding to roughly 1.7 million households - were in this situation. Besides the ‘Car, MD’ group, the indicator allows us to distinguish three further groups: (i) car owning household not in material deprivation (non MD car owning households, 70.1%); (ii) households who do not own a car because (they state that) they ‘cannot afford it’ (10.6%); (iii) households who do not own cars for other reasons (12.6%).

Table 3 shows how the incidence of ’Car, MD’ and the other three groups varies according to several variables. The table suggests that, at a descriptive level, all groups other than non MD car owners are overrepresented among low-income groups, immigrant households, households who rent their home and families with at least a member with mobility difficulties. They are also overrepresented among households who spend more than 40% of their income on housing, and would therefore be classified as in ‘housing cost overburden’ according to the official EU indicator. On the other hand, the 'Car, MD' group has several characteristics that distinguish it from that of households who cannot afford cars, Indeed, it is overrepresented among large households, households with children, and in the middle age bands (30 to 50 years old), while 'non-afforders' are strongly overrepresented among singles, younger adults (in their 20s) and households with a female HRP.

With regard to participation in the labour market, EU-SILC allows us to calculate the official EU indicator of 'work intensity'. This measure is equivalent to the ratio between the number of 'worked' and ‘workable’ months, in the 12 months preceding the interview, for working age members. It ranges between 0 ('jobless households') and 1. Households with a work intensity value lower than 0.2 are defined as 'low work intensity' and are considered *ipso facto* 'at risk of poverty or social exclusion' in EU statistics. Table 3 shows that both groups of carless households are strongly overrepresented among jobless households. Households without cars for reasons other than affordability are overrepresented also among households with no working age member (mostly pensioners). By contrast, the largest share of households at risk of CRES is observed among low work intensity households.

With regard to geographical variables, the table unsurprisingly shows that non MD car owners are overrepresented in intermediate and thinly populated areas, and carless households in densely populated areas. The share of households at risk of CRES, however, is relatively stable at 6-7% across different types of area. A similar pattern is observed for the type of dwelling.

[4] In order to ensure comparability with LCFS, we exclude households from Northern Ireland from the analysis.

		Car, no MD	Car, MD	No car, cannot afford	No car, other reasons	*Total*
	TOTAL	*70*	*7*	*11*	*13*	*100*
Household size	**1**	52	5	17	27	*100*
	2	79	5	8	8	*100*
	3	74	9	9	7	*100*
	4+	78	11	7	4	*100*
Minors	**0**	70	5	10	15	*100*
	1+	70	11	12	6	*100*
Work intensity	**Jobless household**	26	12	35	27	*100*
	Low WI	46	18	24	13	*100*
	Medium WI	80	9	6	5	*100*
	High WI	82	5	5	8	*100*
	No working age member	69	3	10	19	*100*
Age of HRP	**16-29**	48	(7)	28	17	*100*
	30-39	69	9	12	10	*100*
	40-49	72	9	10	9	*100*
	50-59	77	8	6	8	*100*
	60-69	79	5	7	9	*100*
	70+	67	(2)	9	22	*100*
Health-related activity limitation	**No members**	77	5	9	10	*100*
	1+	58	11	13	18	*100*
Immigration status of HRP	**No immigration**	72	6	9	12	*100*
	Immigration	57	10	17	16	*100*
Sex of HRP	**Male**	76	7	8	10	*100*
	Female	62	7	14	17	*100*
Equivalised disposable income quintile group	**Lowest**	45	12	25	17	*100*
	Second	58	11	14	17	*100*
	Third	71	7	8	14	*100*
	Fourth or highest	89	2	2	7	*100*
Type of area	**London**	54	7	16	23	*100*
	Other densely populated	68	7	12	13	*100*
	Intermediate area	75	7	9	10	*100*
	Thinly populated area	84	6	(3)	7	*100*
Dwelling type	**flat (building >=10 dwellings)**	37	(4)	26	33	*100*
	flat (building <10 dwellings)	46	7	23	24	*100*
	semi-detached house	72	8	9	10	*100*
	detached house	92	3	(2)	4	*100*
Accessibility to public transport	**Easily**	70	7	11	13	*100*
	With difficulty	71	7	9	14	*100*
Tenure status	**Outright owner**	82	2	4	11	*100*
	Owner paying mortgage	89	6	2	3	*100*
	Rent at market rate	51	10	21	18	*100*
	Rented at reduced rate / free	35	12	27	26	*100*
Housing cost burden	**<40% income**	73	6	9	12	*100*
	>40% income (overburden)	44	10	25	21	*100*

Table 3 – Distribution of 'Car ownership / material deprivation' indicator in different social groups (EU-SILC 2012, UK excluding Northern Ireland, N=9,201). Percentages based on 20 to 49 observations (unweighted sample) are shown in brackets.

In Table 4, we present the results for two logistic regression models, with the same approach adopted in Section 3. The first model contrasts households in the 'Car, MD' group with the rest of the EU-SILC sample. Unsurprisingly, the model results suggest that households at risk of CRES have lower income than the average Briton. It also appears that low work intensity is (weakly) associated with an increase in the probability of belonging to this group, even after controlling for intervening factors. The presence of members with mobility difficulties has a similar effect. The probability of owning a car despite material deprivation has a curvilinear relationship with the age of the HRP: for a typical household, it increases until approximately 45 years, and declines thereafter. However, it appears that there are no statistically significant differences between the group of interest and the rest of the population in terms of household size, presence of children, as well as sex and immigration status of the HRP.

Outcome:	*Car, MD*			
Base outcome:	*Rest of the sample*		*No car, cannot afford*	
	Coef.	*Robust Std. Error*	*Coef.*	*Robust Std. Error*
Household size: simple term	0.076	0.151	**0.799**	**0.195*****
squared term	0.004	0.021	**-0.068**	**0.030****
No. of minors	0.073	0.091	0.000	0.139
Household Work Intensity (ref. cat.: Jobless household): Low WI	**0.387**	**0.211***	0.389	0.241
Medium WI	0.154	0.184	**0.962**	**0.236*****
High WI	0.234	0.183	**0.714**	**0.259*****
No working age / applicable member	-0.061	0.275	0.546	0.336
Age of HRP: simple term	**0.117**	**0.026*****	**0.168**	**0.031*****
squared term	**-0.001**	**0.000*****	**-0.002**	**0.000*****
Presence of members with health-related activity limitation	**1.016**	**0.117*****	**0.539**	**0.164*****
HRP immigrated to country	0.191	0.145	0.045	0.193
HRP female	-0.110	0.108	**-0.634**	**0.150*****
Equivalised disposable income: simple term	**-0.043**	**0.012*****	0.040	0.030
squared term	**-0.001**	**0.000*****	-0.001	0.001
Type of area (ref. cat: London): Other densely populated area	-0.269	0.218	0.035	0.277
Intermediate area	-0.201	0.226	0.379	0.292
Thinly populated area	-0.118	0.265	**1.319**	**0.374*****
Dwelling type (ref.cat.: flat in building>=10 dwellings): flat (building<10 dwellings)	**0.767**	**0.272*****	**0.895**	**0.306*****
Semi-detached house	**1.261**	**0.282*****	**1.600**	**0.300*****
Detached	**0.627**	**0.326***	**1.957**	**0.401*****
Accessibility to public transport (ref. cat.: Very easily): Easily	0.131	0.112	0.174	0.158
With some difficulty	0.177	0.163	0.300	0.251
With great difficulty	**0.432**	**0.219****	0.390	0.339
Tenure status (ref. cat.: Outright owner): Owner paying mortgage	**0.615**	**0.206*****	**1.151**	**0.315*****
Rent at market rate	**1.179**	**0.235*****	-0.216	0.329
Rent at reduced rate / free	**1.132**	**0.206*****	-0.061	0.292
Housing cost burden ratio (% of income): simple term	**0.027**	**0.007*****	**0.028**	**0.010*****
squared term	**-0.0003**	**0.00001*****	**-0.0003**	**0.0001****
Constant	-6.607	0.738***	-8.531	0.918***
McFadden's Pseudo R^2	0.18		0.27	
N	8,883		1,535	

Notes: bold indicates statistical significance (* p<0.1; ** p<0.05; *** p<0.01)

Table 4 - Logistic regression models for the probability of belonging to group of car owning households in material deprivation (EU-SILC, UK excluding Northern Ireland).

With regard to geographical and access variables, the model shows that the probability of CRES is highest for households living in semi-detached housing, even after controlling for

other factors. Reporting that public transport is accessible 'with great difficulty' is also associated with a higher probability of owning a car despite material deprivation. Once these factors are controlled for, the effect of the type of area is not statistically significant, although the sign of the coefficients would suggests (against expectations) that the probability is highest in London. With regard to tenure, both being a mortgage borrower and a renter are associated with a higher probability of CRES, as compared to owning outright – even at constant levels of housing cost burden. In fact, the probability of owning a car despite material deprivation has a curvilinear relationship with housing cost burden: for a typical household, it increases until approximately a 40% ratio is reached, and declines thereafter.

The second model (in the rightmost column in Table 4) contrasts the 'Car, MD' group with 'non-afforders'. The goal here is to identify factors that might lead households who struggle to afford the costs of motoring to buy and use cars, despite having to curtail expenditure in other essential areas. The goodness of fit for this model is very good (Pseudo R^2=0.27), and higher than for the first model[5] (0.18). This suggests that households at risk of CRES differ more from households who cannot afford car ownership than from the average Briton.

It must be noted, however, that there are no statistically significant differences between the two groups in terms of income, suggesting that househols in the group of interest are *not* wealthier than their carless counterparts (as one might have expected). The coefficients for age confirm that, in this model as well, the risk of CRES typically peaks for households with 45 years old HRP. Household size is typically associated with an increase in the probability of owning a car despite material deprivation, although it decreases for very large households. The zero and non-significant coefficient associated with the presence of minor children means that this does not have a net effect *over and above* household size (which is held constant).

CRES households are also more likely to include members with mobility difficulties and less likely to be female-headed than households who cannot afford cars. Once other factors have been controlled for, the probability of owning a car despite material deprivation (rather than not being able to afford it) peaks for households with medium work intensity (0.2-0.5).

With regard to geographical and access variables, the coefficients are in the expected direction. Households in thinly populated areas are significantly more likely to be at risk of CRES (rather than being 'non-afforders') as compared to London residents. Similarly, the probability of the group of interest increases as one moves from large to small block flats, and then to semi-detached and detached housing. Once these factors are controlled for, accessibility to public transport shows no statistically significant effect.

An increase in the share of income that is spent on housing is typically associated with higher relative probability of owning a car despite material deprivation. Even after this is controlled for, households with a mortgage are significantly more likely to belong to the group of interest, as compared to owners outright. The coefficients are negative, although not statistically significant, for renters.

5. Discussion and conclusion

In this paper, we have proposed two indicators of car-related economic stress for the UK, both of which are based on widely available, continuous surveys. While our analysis is limited to Great Britain and 2012, this approach opens up the possibility to trace trends over time and (for EU-SILC) to compare Britain with other EU countries. The 'low-income-high-cost' metric that we propose is inspired by British fuel poverty research, but avoids the limitations of previous indicators which have just mimicked fuel poverty metrics.

With regard to the size of the population affected, the two approaches yield rather consistent results: in 2012, between 6.7% and 9% of households in Great Britain - i.e. 1.7-2.3 million households - were at risk of CRES. This is in the same ballpark as official estimates of fuel poverty (affecting 2.28 million, i.e. 10.4% of households in England in 2012; DECC, 2014). Yet transport affordability issues have attracted nowhere near the same amount of policy and research attention as domestic energy. We find this dichotomy important as households clearly trade-off expenditure across a range of goods and services which include both transport and domestic energy.

With regard to the spatial patterning of CRES, our findings broadly confirm previous research. The regression models suggest that living in low-density building types (a proxy for

[5] According to McFadden (1979, p. 35) values of .2 to .4 “represent an excellent fit”.

density in the neighbourhood) and/or in areas of low population density, as well as difficult access to public transport are all factors typically associated with a higher risk of CRES. This effect is particularly clear when comparing the group of interest with 'low-income-low-cost' households, or with households who cannot afford cars. This suggests that the built environment characteristics of the local area may have the effect of pushing households into 'unaffordable' car ownership and use. On the other hand, one needs to consider households' agency in trading off between accessibility and mobility costs when making residential location choices, and the structural workings of housing and land markets.

In this context, it is worth discussing the relationship between CRES, housing expenditure and tenure type. Our results suggest that a high cost burden ratio and mortgage ownership are associated with an *increase* in the relative probability of CRES (as compared to not being able to afford). One might have expected the opposite - i.e. higher housing costs among households who cannot afford cars - based on the assumption that households trade off housing and transport expenditure. This is clearly not the case, at least in the EU-SILC sample. However, this finding is consistent with previous research that has highlighted the dynamic links between CRES and access to home ownership, notably in car-dependent areas (Dodson & Sipe, 2007). It is possible that some households 'climbing the housing ladder' find themselves in a situation where both housing and transport contribute to economic stress and material deprivation. Another possible explanation of the association between CRES and home ownership is that it reduces households' ability to move to adapt to changing job circumstances, thus possibly constituting an aggravating factor.

While multivariate results show a clear association between low density and CRES, descriptive analysis shows that the share of affected households does not vary so much across different types of areas, types of dwelling and levels of public transport access. This stems from composition effects: low-income households are more at risk of CRES, and they tend to be overrepresented in flats and (in Britain) in dense urban areas where access to public transport is easier.

With regard to the social profile of households at risk of CRES, it appears that they are not so different from the average of the population, but they are clearly distinct from low income households with low motoring costs and from households who cannot afford cars. Indeed, our results confirm previous research suggesting that larger households with children and employed adults are more exposed to transport affordability problems (Mayer *et al.*, 2014; Nicolas *et al.*, 2012). We also find that households with adults aged 40-50 typically have the highest risk of CRES.

Our research highlights two further factors that might push (low income) households into CRES. The first is the presence of members with mobility difficulties. It is possible that at least some forms of disability result in high reliance on cars, even when this means a heavy burden on household finances. The second is underemployment: the risk of CRES is higher for households where working-age adults are working less than they could, either because of part-time or because they did not work for at least part of the year. Part-time employment might lead to a high expenditure share by reducing income (as compared to equivalent full-time employment) but requiring the same costs for commuting[6]. Low work intensity might have a similar effect, by making car ownership and use necessary to access workplaces, even if income is lower. This calls for a more nuanced understanding of the relationships between (different types of) employment, car ownership and transport disadvantage. It also higlights the possible links with debates in social policy research on 'in-work poverty' (Ponthieux, 2010).

Our indicators differ radically with regard to the role of low income. LIHC deliberately excludes households above the poverty line (after housing and 'running motor vehicles' costs) from the group of interest. By contrast, in the EU-SILC indicator, households at any income level can be at risk of CRES, as long as they are materially deprived. The results of the EU-SILC analysis suggest that the incidence of CRES is significant even among the middle classes (7% in the third quintile group - Table 3). They also suggest that households who own a car despite material deprivation are not richer than those who say that they cannot afford one. This lends some credibility to the idea that they are 'forced' into expensive car ownership by their life situation and/or residential location.

[6] This is particularly relevant as in 2012 25.5% of all households in Great Britain (39.8% of employed households) included at least one member working part-time according to LCFS.

One possible interpretation for some of the socio-economic factors highlighted in this section is the following: the risk of CRES increases as the ratio between the (car) travel needs and the household's income base increases. Household size, presence of children and underemployment are all factors that potentially increase this ratio. The results also suggest that CRES is associated with factors (middle adulthood, large household size, children and access to home ownership) which are typical of a certain stage of the family life cycle. While it is well-known that this stage results in a greater need for car ownership and use, our findings suggest that this can have significant economic consequences, at least for households on low to middle incomes. Arguably, this calls for the adoption of a life-course perspective to the study of transport disadvantage and economic stress.

References

BOARDMAN, B. (1991) *Fuel poverty: from cold homes to affordable warmth.* Pinter Pub Limited.

BOARDMAN, B. (2010) *Fixing fuel poverty. Challenges and solutions*. London: Earthscan.

CURRIE, G. & SENBERGS, Z. (2007) Exploring forced car ownership in metropolitan Melbourne. *Australasian Transport Research Forum 2007*.

DECC (2014) *Annual Fuel Poverty Statistics Report, 2014*. Department of Energy and Climate Change.

DEMOLI, Y. (2015) The Social Stratification of the Costs of Motoring in France (1980-2006). *International Journal of Automotive Technology and Management.* 15 (3).

DODSON, J. & SIPE, N. (2007) Oil vulnerability in the Australian city: assessing socioeconomic risks from higher urban fuel prices. *Urban Studies*. 44 (1), p. 37-62.

HEINDL, P. & SCHUESSLER, R. (2015). Dynamic properties of energy affordability measures. *Energy Policy.* 86, p. 123-132.

HILLS, J. (2012). *Getting the measure of fuel poverty. Final Report of the Fuel Poverty Review.* London: CASE report 72.

JOUFFE, Y. & MASSOT, M.-H. (2013) Vulnérabilités sociales dans la transition énergétique au croisement de l'habitat et de la mobilité quotidienne. *1er Congrès Interdisciplinaire du Development Durable.* Namur.

LOVELACE, R. & PHILIPS, I. (2014) The 'oil vulnerability' of commuter patterns: A case study from Yorkshire and the Humber, UK. *Geoforum.* 51, p. 169-182.

LUCAS, K. (2012) Transport and social exclusion: Where are we now? *Transport Policy.* 20, p. 105-113.

LUCAS, K., MATTIOLI, G., VERLINGHIERI, E. & GUZMAN, A. (in press). Transport poverty and its adverse social consequences. *Proceedings of the Institute of Civil Engineers*.

MATTIOLI, G., & COLLEONI, M. (2015) Transport Disadvantage, Car Dependence and Urban Form. In PUCCI, P. & COLLEONI, M. (eds.), *Understanding Mobilities for Designing Contemporary Cities* (pp. 171-190). Springer.

MAYER, I., NIMAL, E., NOGUE, P. & SEVENET, M. (2014) The Two Faces of Energy Poverty: A Case Study of Households' Energy Burden in the Residential and Mobility Sectors at the City Level. *Transportation Research Procedia.* 4, p. 228-240.

MCFADDEN, D. (1979). Quantitative methods for analysing travel behaviour of individuals: some recent developments. In HENSHER, D. A. & STOPHER, P. R. (eds.), *Behavioural travel modelling*. London: Croom Helm.

NICOLAS, J.-P., VANCO, F. & VERRY, D. (2012). Mobilité quotidienne et vulnérabilité des ménages. *Revue d'Économie Régionale & Urbaine. 2012/1*, p. 19-44.

PONTHIEUX, S. (2010). Assessing and analysing in-work poverty risk. In ATKINSON, A. B. & MARLIER, E. (eds.), *Income and Living Conditions in Europe*. Luxembourg: Publication Office of the European Union.

RAC (2012). *21 million UK households in transport poverty*. [Online] Available from: http://www.racfoundation.org/media-centre/transport-poverty. [Accessed: 25th November 2015].

STOKES, G. & LUCAS, K. (2011) *National Travel Survey Analysis.* Working Paper No. 1053, TSU Oxford.

SUSTRANS (2012) *Locked out. Transport poverty in England.* [Online] Available from: http://www.sustrans.org.uk/lockedout. [Accessed: 25th November 2015].

WALKER, G., SIMCOCK, N. & CHARD, R. (2015). Distributing demand: the needed, the normal and the underspent. *2nd International Days of the Sociology of Energy* (pp. 164-167). Tour: François-Rabelais University.

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