Impact on Car Ownership of Local Variation in Access to Public Transport

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Paper (number 123) prepared for the ERSA 2006 Conference, Volos, Greece,
August 2006

Abstract

This paper reports on a project funded by the Volvo Research and Education Foundation. It is international in nature and focuses on the impact of urban public transport, and light rail in particular, on restraining the growth of (or even reducing) local car ownership rates. The recent Censuses of the UK (2001) and France (1999) make these two countries particularly suitable, but the project examined other countries and urban transport systems too. We were especially interested in the `high quality' alternatives to light rail, including other urban rail, or enhanced forms of bus. Especially in Britain, the investment costs in new light rail systems have led to Government disquiet and reluctance to approve funding.

The empirical work consists of econometric estimates using small area data, mainly from Censuses, reinforced by GIS mapping of urban transport access on the local small area. 300 metre and 600 metre zones of good access can then be used in the econometrics, alongside socioeconomic indicators of the economically active population. Results from a wide range of cities suggest that good access does indeed reduce car ownership below what would be expected given the local socioeconomic profile. These findings have important implications for environmental and transport policy.

1. Background and some comments on the literature

This paper reports results from an international comparative project on urban public transport, funded by Volvo Research and Educational Foundation, whose support is gratefully acknowledged. The main collaboration is with Prof. C. Hass-Klau of the University of Wuppertal. Earlier reports (Hass-Klau and Crampton, et al, 2002, 2003, 2004, 2005) on related topics (including projects using other financial support) may be obtained through the website <www.etphassklau.co.uk>. A forthcoming report covering the car ownership research reported on here will include a substantial number of other countries and cities.

Car ownership has played a prominent role in all transport modelling. However the aspect of its impact that this paper focuses on, namely the effect of good public transport access on car ownership, has been neglected in the literature. It was still thought useful and important to review briefly some of the other approaches that can be found in the specifically economic literature on car ownership.

The clearest theoretical outline of how car ownership and use decisions fit into standard microeconomic theory is in De Jong (1990). He stressed that the option to be a non-car-owner made the standard budget set non-convex (by adding an extra point with more consumption of other goods and zero car consumption to an otherwise conventional budget set). In the 1990 paper he uses a Dutch micro data set on car use for 2,847 households and constructs maximum likelihood (ML) estimates using a censored limited dependent variable of car use. The latter has a discrete (own or not) and continuous character (if you own, how much do you use it). He confirms that the fixed costs of car ownership mainly affects the decision to own, whereas variable running costs affect intensity of use.

Pendyala et al (1995) also used Dutch data, but a panel survey on 485 individuals in the mid-1980s. A carefully specified ML model of an ordered response probit type was set up for the same kind of household data on car ownership familiar to British and French Census researchers, and as used in this paper below. The Pendyala paper focuses on the asymmetries in car ownership behaviour, and the inadequacy of traditional cross-sectional models that have symmetry built in. The most significant household variables turn out to be income, and the number of drivers in the household. The four `urban types' that come close to catching the ease of access to public transport (e.g. residing in a large metropolitan area with highly developed multi-mode transit system) turn out to have only patchy significance.

Not dissimilar in spirit is the paper by Dargay et al (1999), using a `pseudo-panel' (repeated cross-sections, aggregated into age cohorts). This uses UK Family Expenditure Survey data with about 500 households per age cohort, and 16 cohorts. A number of different time series models (from OLS to REM-AR1) confirms expected results for car purchase and running costs, and income, with long run elasticities being bigger than short run. But again, the `urban type' is only significant in picking out the strength of a rural residence to raise car ownership. Metropolitan residence as such was statistically weak.

Goodwin (1993) also uses micro data, namely a series of surveys carried out in South Yorkshire over 1981-1991 on bus trip rates and car ownership rates by household, covering the period (early 1980s) when South Yorkshire had sustained the cheapest bus transport in Britain, followed by the periods when this policy position was unwound and replaced by bus deregulation and severely controlled subsidy. Goodwin found that car ownership was indeed sensitive to the bus pricing and service strategy, but his main point was the relative volatility of car ownership at an individual level compared to the monotonic rise conventionally assumed. For example, in each of the three-year survey periods, about one third of the people who were living in households with 2 or more cars at the start of a three-year period had fewer cars at the end of the period. Much of this would reflect combinations of household and family change as well as job loss. (The 1980s was a period of industrial meltdown in South Yorkshire). In the midst of this `churning', cheap public transport did also have its own effect.

There is another strand to the literature on car ownership that uses national aggregates of data on car ownership, and uses time series techniques to analyse the data. Romilly et al (1998) for instance sets up what is now a conventional Engle-Granger cointegration analysis of British data on car ownership and explanatory variables. Unit root tests and error correction models are estimated, and forecasts compared with the long-established National Road Traffic Forecasts. The cointegration models proposed by Romilly et al perform rather better than those of NRTF. The latter forecasts have formed the basis of British road infrastructure strategy for many years, so if they were based on inadequate or misspecified models, this was of some importance in policy terms.

An international study by Medlock et al (2002) using a panel of 28 countries over 1978-1995 focuses on the estimation of different values of the `saturation level' of car ownership for the various countries. A familiar S-curve often with a given saturation level has normally been imposed. The more logical approach taken by Medlock et al is to take account of the massive infrastructure variations across 28 countries to generate a variety of saturation levels, to incorporate dynamic expectations into adjustment of car ownership, and to model the `flat top' of the S-curve by means of an income elasticity that falls as income rises. They compute forecasts to 2015, finding saturation levels varying from 211 cars /'000 population in South Korea to 690 cars/000 in the USA. The policy relevance is the global environmental issue of world-wide oil use as China and India (in particular) go further into the process of development.

Finally, it is worth mentioning two papers that also address car ownership, but emphasising different policy contexts. Raphael et al (2002) uses US data on labour market outcomes to study the extent to which car ownership at an individual level can help to generate better employment outcomes. The clear econometric issue to be faced is the simultaneity, where better employment outcomes themselves generate higher car ownership. Using instrumentation to cope with this, 2SLS estimates suggest that car ownership can indeed improve the probability of employment, and the hours worked, though the average wage has patchy and sometimes perverse relationship. The authors even suggest that lower car ownership (rather than ethnic discrimination) may account for part of the poorer labour market outcomes of blacks and Hispanics in the US.

The urban planning context within which car ownership trends should and often have been researched is the basis of the recent review paper by Kain (2001). Discussion of the original urban planning role of the immensely influential (in Britain) Buchanan Report focuses on the specific case of Leeds and West Yorkshire. Again, the simultaneities implicit in car ownership modelling have been much discussed over the years, by researchers such as Button et al (1982), or Lerman and Ben-Akiva (1976). To oversimplify slightly, they boil down to `low population density causes higher car ownership, which in turn causes low density'. Decentralisation trends of employment (in addition to population), and the difficulty of forecasting them, lay behind the tendency of the Buchanan Report to overestimate car ownership growth in British cities. The other strand of Kain's paper (ibid) addresses a familiar theme, namely the overestimation of future passenger numbers for proposed urban rail systems (in this case Teheran), but this though linked is a rather different area outside the scope of our paper.

Glossary of Variables and Area definitions

Before we discuss the results of our empirical work on British and French cities, we will give a summary of variable and area definitions.

Areas.

For the following British areas, the 2001 Census data was extracted at Output Area level.

Brighton, Hove and Adur (BHAD): 3 local authorities in West and East Sussex. Brighton and Hove were recently merged and given City status, as well as being unitary authorities under English local government reorganisation;

Greater Manchester (GM11): the whole of Greater Manchester County plus the Derbyshire district of High Peak (the extra district was included to fully include the local commuter rail system);

Tyne and Wear (TW7): the whole of Tyne and Wear County plus the Northumberland districts of Tynedale and Castle Morpeth;

Croydon Area (CBSM): the 4 London Boroughs of Croydon, Bromley, Sutton and Merton;

West London proposed tram area (WLT): the 4 London Boroughs of Kensington and Chelsea, Hammersmith and Fulham, Ealing, and Hillingdon;

For the following French areas, the data was obtained at IRIS level (considerably larger than UK Output Areas).

Ile de France, Département 92, Hauts-de-Seine;

Ile de France, Département 93, Seine-St-Denis;

Ile de France, Département 94, Val-de-Marne.

Variables (British)

The dependent variables in both the British and French estimates were the % of households owning no car (PHHNC), or 2 or more cars (PHH2C);

PCSEC2: % of employed population in the Socioeconomic Class `Lower Manager Professional';

PCSEC6: % of employed population in the Socioeconomic Class `Semi-Routine Occupation';

PCSEC2: % of employed population in the Socioeconomic Class `Routine Occupation';

MBUS300: dummy variable =1 if centroid of the Output Area lies within 300m of Metro Bus route in BHAD, = 0 otherwise. A total of 7 Metro Bus Routes exist in BHAD.

MBUS3600: dummy variable =1 if centroid of the Output Area lies between 300m and 600m of Metro Bus route in BHAD, = 0 otherwise.

Equivalent definitions are applied for SUBUS300, and SUBUS3600 in GM11 and TW7; these Superbus identities were given to us by our senior contacts within the Passenger

Transport Authority. There were 2 of each in GM and TW. In CBSM, the author selected a single route within the Boroughs with 4 coincident high frequency bus routes (HFBUS). In West London, the route of the proposed tram is currently a high frequency bus route (WLRBUS).

MAINR300: dummy variable =1 if centroid of the Output Area lies within 300m of main line rail station, = 0 otherwise.

MAIN3600: dummy variable =1 if centroid of the Output Area lies between 300m and 600m of main line rail station, = 0 otherwise.

Equivalent definitions are applied in GM11 for Metrolink tram (METLK), Tyne and Wear Metro (METRO), and Croydon Tramlink (TRAMLK).

In the 2 London cases, variables TUBE300 and TUBE3600 are included to represent 300m and 300-600m access to the London Underground.

<u>Variables</u> (French)

PCADPROF: % of Active Population within `Cadres Professionels';

PWKERS: % of Active Population within `Ouvriers';

Transport access variables were defined as for Britain; separate variables were collected for the stations of the METRO, the RER, mainline rail (SNCF). Within Dep92 the stops of the tram is represented by T2, within Dep93 the tram is T1, within Dep94 we use the stops of the segregated busway Trans-Val-de-Marne (TVM).

Discussion of Results

Tables 1 and 2 present results of econometric estimates, for the 5 English cases we examined in detail, and the 3 cases from the Ile de France. It should be stressed that sample sizes are much larger for the British cases than for the French (because the sub-areas were much smaller for the British analysis), and statistical significance accordingly stronger for the British examples.

They include a variety of urban tram, possible future tram (which might possibly generate `anticipation' effects on residential structure and local car ownership), and busway alternatives, as well as `super-bus' (high frequency bus) operating side by side with tram and mainline rail. In the Ile de France, where 3 Départements in the inner ring around the City of Paris are examined, we have 2 examples of modern tram (the T2 and T1 respectively in D92 and D93) and one of segregated busway (D94), operating side by side with the Metro, RER, and mainline rail (SNCF). Here, there are therefore 4 alternative types of urban public transport, and we try to estimate the impact on car ownership of `good' access, within 300m, and `less good' access (between 300m and 600m).

One econometric issue we did not yet have time to explore is that of selection bias. Given that the public transport stations or routes are known, it is possible that part of the econometric effect we identify here as an impact of public transport access on car ownership may in fact be something rather different. If certain subsets of the population, for example, simply did not have a driving license (or did but chose not to drive), then they would in general select residences that were well served by public transport. In practice, they would mostly look to reside in areas well served by public transport connecting to their place of work. But since local detail on % holding a driving license is not available as a Census variable, we cannot make progress on using standard selection bias econometric corrections, such as the Heckman approach. This type of econometric factor is probably best left to the analysis of micro data, where driving status may be accurately known, rather than sub-area Census data. It could be suggested however that the effects of public transport access found here are so powerful that it would be unlikely to be wholly or largely the effect of selection bias.

For each city the estimates are computed for 2 different dependent variables, namely the percentage of households who own no car, and the percentage who own 2 or more cars. Although the coefficients in these two runs have a strong tendency to vary in opposite directions, at this stage we made no attempt to model all 3 divisions of household car ownership (that is 0, 1, 2+ cars), and make use of the adding-up identity. It is however very helpful that both the British and French Censuses present car ownership data in exactly comparable form.

What is not quite comparable is the socioeconomic data, simply because the British and French Censuses classify occupations differently. The purpose of the whole econometric exercise is to control for the socioeconomic character of a sub-area, so that the impact of public transport access on car ownership can be examined separately. After some experimentation, we use for both the British and French cases the socioeconomic class proportions of the employed population. For the British cases, 3 different classes (out of 7) were worth reporting; for the French cases, just 2 classes (out of 6, but one of these is agricultural employment, negligible in these urban contexts). The difference is that in the British cases, the SEC2 class (smaller manager-professional groups) has inconsistent signs in the association with car ownership, whereas SEC6 and SEC7, which are both less well paid groups, are associated with low car ownership (i.e positive coefficients in the `no car' runs and negative in the `2+ cars' runs).

In the three French cases, the PCADPROF (% Cadres Professionels in the Active Employed) is significantly associated with high car ownership in all three cases, but less strongly with low car ownership. The low income group PWKERS (% Ouvriers) carries the expected sign in 5 out of 6 runs, i.e. positive coefficient in the `no car' runs and negative in the `2+ cars' runs.

Population density/ hectare was included in all runs and consistently comes out as significant with the expected sign, high density encouraging `no car' and discouraging `2+ cars', with other variables controlled. One would expect (though data is not available to test for it explicitly) that population density would be collinear with difficulty and even cost in parking a car.

The conclusions for public transport access are more mixed. This might be expected, given that several of the tram schemes are very recent, and household car ownership behaviour has considerable inertia. The general conclusion would be that while rail modes of urban transport carry an advantage in discouraging car ownership, the strongest version of this is the long-established high capacity CBD-serving underground form, especially the London Underground and the Paris Metro. It is also true that good access to the long-established bus routes seem to have a powerful effect in reducing car ownership.

We would crudely summarise our public transport access findings as follows, for the 5 British and 3 Ile de France cases:

- in Brighton, both the high frequency Metro Bus and mainline rail access are significant, but bus access significantly more so;
- in Greater Manchester, Metrolink tram, Superbus, and mainline rail are all significant in their impact on car ownership, with Superbus strongest and mainline rail weakest;
- in Tyne and Wear, Metro tram, Superbus and mainline rail are all significant, but (the more long-established) Metro strongest;
- in the 4 London Boroughs in and around Croydon, all 4 urban transport modes are significant, with the London Underground (the `Tube') leading the way;
- in the 4 London Boroughs in and around the proposed West London tram, the London Underground is clearly and significantly most powerful in its impact on car ownership, though being close to the high frequency bus route (that would under the proposal become the tram route) is also significant;
- in D92 (Hauts-de-Seine), the Paris Metro and mainline rail are highly significant. The T2 tram began service since the 1999 Census anyway (in 1997), so one should not be surprised by its insignificance. The RER seems significantly effective in discouraging high car ownership;
- in D93 (Seine - St. Denis), only the Paris Metro and the RER are significant as expected. Oddly, the T1 tram, opened in 1992 from St. Denis-Bobigny (now further south to Noisy-le-Sec) has the expected significance in the 300-600m. access range, but not 0-300m. This may possibly be a result of the pattern of publicly planned housing in this very ethnically mixed suburb.
- in D94 (Val-de-Marne), the Metro and RER are significant as expected, but not access to the Trans-Val-de-Marne segregated busway.

Finally it is worth noting the size of the coefficients estimated. Given that the access variables are modeled in dummy variable form, with a sub-area whose centroid lies within 300m access (or 300-600m) being given value 1. The access coefficient then is interpreted as the direct impact on the `no car' or `2+ cars' percentage, having controlled for population density and socioeconomic characteristics. The mature urban rail forms that serve the central Business District well, such as the London Underground and the Paris Metro, come up with a coefficient roughly 7-17% higher in the `no car' proportion of households for within-300m access, and only slightly lower for 300-600m access. In the British examples where mature modern light rail is present (Tyne and Wear and Greater Manchester) significant values nearly as big as this are found. Interestingly, the impact effects for 300-600m. access are almost always lower than for 300m access, as expected. Transport policymakers favoring a bus strategy will be satisfied that mature high frequency bus routes (often locally called Super- or Metro- bus) are just as effective as tram in reducing car ownership. Of course, all of the examples of tram included in these estimates are much newer than the long-established bus corridors.

Conclusions

The literature on local impacts of public transport access on car ownership is rather thin, although car ownership itself has been extensively studied in aggregate, either as a time series or international cross section. The development of different forms of urban public transport in various countries raised the possibility of testing econometrically for local impacts on car ownership, having controlled separately for population density and socioeconomic variables. Results are obtained for 5 major urban cases in Britain, and 3 cases in the suburbs of Paris, where light rail, other forms of urban rail, or high frequency bus are included in the supply. In the clear majority of estimations, good public transport access reduces local car ownership, having controlled for population density and socioeconomic structure. Remaining econometric problems would concern low car ownership selection bias, which has not been addressed here.

Table 1 Econometric Estimates for 5 British Cities
(** 99% significant, * 95% significant, 2-tailed t-test)

(a) Brighton, Hove, Adur local authorities, Sussex, Census Output Areas.
Dependent Variable = PHHNC (% Households with no car)
n obs = 1124

Variable	Coefficient	Standard Error	Mean X
Constant	-13.8		
Pop density/hectare	.083**	.005	93.4
PCSEC2	.472**	.073	31.4
PCSEC6	.793**	.086	13.2
PCSEC7	.885**	.098	7.76
MBUS300	11.4**	.94	.56
MAINR300	3.16*	1.49	.068
MBUS3600	4.91**	1.23	.142
MAINR3600	3.45**	1.04	.157
% Adj Rsq	46.2		
St. Error of e	12.4		

Brighton, Hove, Adur local authorities, Sussex, Census Output Areas.
Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 1124

Variable	Coefficient	Standard Error	Mean X
Constant	61.9		
Pop density/hectare	-.071**	.0047	93.4
PCSEC2	-.455**	.058	31.4
PCSEC6	-.569**	.068	13.2
PCSEC7	-.711**	.078	7.76
MBUS300	-8.58**	.749	.56
MAINR300	-4.04**	1.18	.068
MBUS3600	-4.97**	.98	.142
MAINR3600	-3.00**	.82	.157
% Adj Rsq	47.4		
St. Error of e	9.8		

Table 1 Econometric Estimates for 5 British Cities
(** 99% significant, * 95% significant, 2-tailed t-test)

(b) Greater Manchester area local authorities (GM11), Census Output Areas.
Dependent Variable = PHHNC (% Households with no car), n obs = 8662

Variable	Coefficient	Standard Error	Mean X
Constant	.253		
Pop density/hectare	.033**	.0038	52.9
PCSEC2	-.037	.033	24.4
PCSEC6	.812**	.032	17.3
PCSEC7	1.09**	.029	14.3
METLK300	13.1**	1.41	.011
MAINR300	3.34**	.851	.029
SUBUS300	20.5**	1.058	.019
METLK3600	10.1**	.860	.029
MAINR3600	2.40**	.490	.095
SUBUS3600	17.1**	1.059	.019
% Adj Rsq	54.7		
St. Error of e	13.3		

Greater Manchester local authorities (GM11), Census Output Areas.
Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 8662

Variable	Coefficient	Standard Error	Mean X
Constant	51.9		
Pop density/hectare	-.0488**	.0032	52.9
PCSEC2	.0994**	.027	24.4
PCSEC6	-.761**	.026	17.3
PCSEC7	-.882**	.024	14.3
METLK300	-12.83**	1.17	.011
MAINR300	-3.69**	.707	.029
SUBUS300	-14.38**	.879	.019
METLK3600	-9.20**	.714	.029
MAINR3600	-2.67**	.407	.095
SUBUS3600	-13.00**	.880	.019
% Adj Rsq	59.0		
St. Error of e	11.05		

Table 1 Econometric Estimates for 5 British Cities
(** 99% significant, * 95% significant, 2-tailed t-test)

(c) Tyne and Wear area local authorities (TW7), Census Output Areas.
Dependent Variable = PHHNC (% Households with no car), n obs = 4080

Variable	Coefficient	Standard Error	Mean X
Constant	1.32		
Pop density/hectare	.0735**	.0052	53.7
PCSEC2	-.0544	.043	23.2
PCSEC6	.854**	.041	18.8
PCSEC7	1.119**	.038	15.6
METRO300	12.69**	1.06	.039
MAINR300	8.469**	2.97	.0047
SUBUS300	8.469**	1.29	.025
METRO3600	9.298**	.663	.106
MAINR3600	5.098**	1.78	.013
SUBUS3600	8.973**	1.18	.030
% Adj Rsq	63.7		
St. Error of e	12.8		

Tyne and Wear area local authorities (TW7), Census Output Areas.
Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 4080

Variable	Coefficient	Standard Error	Mean X
Constant	48.7		
Pop density/hectare	-.0732**	.0038	53.7
PCSEC2	-.0235	.031	23.2
PCSEC6	-.701**	.030	18.8
PCSEC7	-.710**	.028	15.6
METRO 300	-8.59**	.775	.039
MAINR300	-4.64*	2.2	.0047
SUBUS300	-4.51**	.94	.025
METRO 3600	-6.70**	.49	.106
MAINR3600	-3.05*	1.3	.013
SUBUS3600	-4.12**	.87	.030
% Adj Rsq	61.4		
St. Error of e	9.38		

(d) Croydon area 4 London Boroughs (Croydon, Bromley, Sutton, Merton), Census Output Areas.

Dependent Variable = PHHNC (% Households with no car), n obs = 3363

Variable	Coefficient	Standard Error	Mean X
Constant	-5.60		
Pop density/hectare	.0925**	.0048	69.4
PCSEC2	.283**	.043	32.3
PCSEC6	.554**	.053	11.3
PCSEC7	1.11**	.061	6.53
TRAMLK300	6.18**	.92	.046
MAINR300	7.87**	.75	.075
HFBUS300	8.72**	.92	.048
TUBE300	10.15**	1.93	.010
TRAMLK3600	5.11**	.72	.081
MAINR3600	4.37**	.50	.19
HFBUS3600	3.16**	.93	.047
TUBE3600	7.50**	1.16	.030
% Adj Rsq	42.2		
St. Error of e	11.1		

Croydon area 4 London Boroughs (Croydon, Bromley, Sutton, Merton), Census Output Areas.

Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 3363

Variable	Coefficient	Standard Error	Mean X
Constant	66.1		
Pop density/hectare	-.123**	.0050	69.4
PCSEC2	-.442**	.045	32.3
PCSEC6	-.469**	.055	11.3
PCSEC7	-1.14**	.064	6.53
TRAMLK300	-7.46**	.96	.046
MAINR300	-8.38**	.78	.075
HFBUS300	-7.25**	.96	.048
TUBE300	-9.10**	2.0	.010
TRAMLK3600	-5.99**	.75	.081
MAINR3600	-5.19**	.52	.19
HFBUS3600	-2.71*	.97	.047
TUBE3600	-8.81**	1.2	.030
% Adj Rsq	43.1		
St. Error of e	11.6		

(e) West London proposed tram area 4 London Boroughs (Kensington+Chelsea, Hammersmith+Fulham, Ealing, Hillingdon), Census Output Areas.

Dependent Variable = PHHNC (% Households with no car), n obs = 2954

Variable	Coefficient	Standard Error	Mean X
Constant	-4.38		
Pop density/hectare	.0119**	.00087	130.9
PCSEC2	.598**	.058	33.1
PCSEC6	.678**	.071	10.4
PCSEC7	.766**	.085	7.2
MAINR300	2.49	1.47	.038
WLRBUS300	6.23**	.97	.093
TUBE300	18.0**	.87	.135
MAINR3600	.243**	.90	.110
WLRBUS3600	2.02*	.89	.113
TUBE3600	13.7**	.68	.268
% Adj Rsq	27.0		
St. Error of e	15.1		

West London proposed tram area 4 London Boroughs (Kensington+Chelsea, Hammersmith+Fulham, Ealing, Hillingdon), Census Output Areas.

Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 2954

Variable	Coefficient	Standard Error	Mean X
Constant	52.7		
Pop density/hectare	-.00778**	.00069	130.9
PCSEC2	-.548**	.046	33.1
PCSEC6	-.345**	.056	10.4
PCSEC7	-.603**	.068	7.2
MAINR300	-3.97**	1.2	.038
WLRBUS300	-4.38**	.78	.093
TUBE300	-12.6**	.70	.135
MAINR3600	-1.43*	.72	.110
WLRBUS3600	-1.32	.71	.113
TUBE3600	-9.89**	.55	.268
% Adj Rsq	23.9		
St. Error of e	12.0		

Table 2 Econometric Estimates for 3 Ile de France Departments (D92, D93, D94)
(** 99% significant, * 95% significant, 2-tailed t-test)

(a) Department 92 (Hauts-de-Seine, Ile de France), Census level IRIS .
Dependent Variable = PHHNC (% Households with no car), n obs = 606

Variable	Coefficient	Standard Error	Mean X
Constant	21.9		
Pop density/hectare	.0270**	.00302	155.1
PCADPROF	-.195**	.0420	27.5
PWKERS	.469**	.0663	13.8
METRO300	11.9**	1.22	.069
SNCF300	7.29**	1.46	.046
RER300	2.37	1.59	.036
T2_300	-.253	2.07	.021
METRO3600	7.84**	1.01	.116
SNCF3600	4.26**	.912	.130
RER3600	1.23	1.07	.084
T2_3600	-1.13	1.47	.043
% Adj Rsq	57.3		
St. Error of e	7.18		

Department 92 (Hauts-de-Seine, Ile de France), Census level IRIS .
Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 606

Variable	Coefficient	Standard Error	Mean X
Constant	13.7		
Pop density/hectare	-.0288**	.00246	155.1
PCADPROF	.404**	.0341	27.5
PWKERS	-.0214	.0540	13.8
METRO300	-9.06**	.994	.069
SNCF300	-5.72**	1.19	.046
RER300	-4.66**	1.30	.036
T2_300	-1.06	1.69	.021
METRO3600	-6.47**	.826	.116
SNCF3600	-3.46**	.742	.130
RER3600	-2.27**	.867	.084
T2_3600	-1.13	1.20	.043
% Adj Rsq	62.4		
St. Error of e	5.84		

(b) Department 93 (Seine-St. Denis, Ile de France), Census level IRIS .
Dependent Variable = PHHNC (% Households with no car), n obs = 604

Variable	Coefficient	Standard Error	Mean X
Constant	7.71		
Pop density/hectare	.0279**	.00429	121.2
PCADPROF	.0365	.105	9.3
PWKERS	.646**	.0621	28.2
METRO300	16.9**	1.77	.055
SNCF300	-1.87	3.62	.012
RER300	5.32*	2.26	.030
T1_300	1.98	2.05	.038
METRO3600	15.7**	1.46	.091
SNCF3600	2.01	2.19	.033
RER3600	2.40	1.45	.079
T1_3600	6.77**	2.26	.030
% Adj Rsq	51.0		
St. Error of e	9.4		

Department 93 (Seine-St. Denis, Ile de France), Census level IRIS .
Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 604

Variable	Coefficient	Standard Error	Mean X
Constant	27.5		
Pop density/hectare	-.0312**	.00315	121.2
PCADPROF	.209**	.0773	9.3
PWKERS	-.282**	.0455	28.2
METRO300	-8.87**	1.30	.055
SNCF300	.578	2.65	.012
RER300	-6.25**	1.66	.030
T1_300	-1.37	1.50	.038
METRO3600	-9.31**	1.07	.091
SNCF3600	-1.03	1.61	.033
RER3600	-2.45*	1.06	.079
T1_3600	-3.32*	1.66	.030
% Adj Rsq	48.2		
St. Error of e	6.9		

(c) Department 94 (Val-de-Marne, Ile de France), Census level IRIS .
Dependent Variable = PHHNC (% Households with no car), n obs = 521

Variable	Coefficient	Standard Error	Mean X
Constant	7.28		
Pop density/hectare	.0537**	.00416	110.7
PCADPROF	.0820	.0553	17.4
PWKERS	.494**	.0597	19.3
METRO300	7.48**	1.81	.036
RER300	6.85**	1.86	.033
TVM300	.87	1.90	.031
METRO3600	9.04**	1.04	.125
RER3600	6.55**	1.06	.115
TVM3600	-2.54	1.80	.035
% Adj Rsq	48.9		
St. Error of e	7.4		

Department 94 (Val-de-Marne, Ile de France), Census level IRIS .
Dependent Variable = PHH2C (% Households with 2+ cars), n obs = 521

Variable	Coefficient	Standard Error	Mean X
Constant			
Pop density/hectare	-.0622**	.00435	110.7
PCADPROF	.181**	.0579	17.4
PWKERS	-.206**	.0624	19.3
METRO300	-8.00**	1.89	.036
RER300	-6.82**	1.94	.033
TVM300	-2.89	1.99	.031
METRO3600	-7.85**	1.09	.125
RER3600	-7.16**	1.10	.115
TVM3600	.24	1.88	.035
% Adj Rsq	47.6		
St. Error of e	7.77		

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