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Housing Wealth Effects: Cross-sectional Evidence from New Vehicle Registrations

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Abstract

Understanding the relationship between housing wealth and consumption is important, because it informs the extent to which fluctuations in house prices might affect the broader economy. We investigate the relationship between housing wealth and consumption using postcode-level variation in house prices and administrative data on new passenger vehicle registrations as a proxy for consumption. In our preferred specification, we estimate an elasticity of new passenger vehicle registrations with respect to gross housing wealth of 0.4–0.5, and an average marginal propensity to consume (MPC) for new passenger vehicles of about 0.06 cents per dollar change in gross housing wealth. Assuming new vehicle registrations and total consumption have the same sensitivity to changes in housing wealth implies an MPC for total consumption of 2 cents per dollar change in gross housing wealth. But US evidence indicates that new vehicle consumption is particularly sensitive to changes in housing wealth. Assuming the same is true for Australia, our estimates imply an MPC for total consumption of less than 0.25 cents. Notably, we find evidence that the relationship between house prices and new vehicle registrations is heterogenous in income, with low-income households having a higher propensity to purchase a new vehicle following a rise in housing wealth than high-income households. This implies that the distribution of changes in house prices is relevant for understanding its effect on aggregate consumption.

JEL Classification Numbers: E21, E32, E60
Keywords: consumption, house prices

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1. Introduction

There is broad agreement among policymakers and academics on the positive correlation between house prices and consumption, but there is disagreement on the magnitude of the relationship. Some authors argue that changes in house prices are likely to have only a modest effect on consumption. If home ownership is merely equivalent to prepayment of expected future rents, then house price fluctuations have only a small effect on net wealth for households expecting to own their home for a long period of time (Sinai and Souleles 2005). But others argue for a sizeable effect of house prices on consumption (e.g. Case, Quigley and Shiller 2005). For credit-constrained households, increases in house prices may facilitate higher consumption by relaxing collateral constraints (Aoki, Proudman and Vlieghe 2004; Iacoviello 2004; Browning, Gørtz and Leth-Petersen 2013). Understanding the magnitude of the relationship between house prices and consumption is important, because it informs the extent to which developments in the housing sector can have broader macroeconomic effects.

The recent house price collapse in the United States lends weight to the view that fluctuations in house prices can have large macroeconomic effects. Mian, Rao and Sufi (2013) estimate that the decline in US house prices over the 2006 to 2009 period caused 40 per cent of the decline in US consumption over the same period, relative to trend. In accompanying work, Mian and Sufi (2014) estimate that during the 2002 to 2006 boom phase low-income households aggressively liquefied housing wealth to fund higher consumption. A key question is whether the large and heterogeneous effects of housing wealth on consumption estimated by Mian *et al* (2013) and Mian and Sufi (2014) are specific to that particular US boom-bust house price cycle. The 2002 to 2006 boom in US house prices was accompanied by a sharp increase in subprime mortgage lending and lax screening of borrowers (Keys *et al* 2010), while the subsequent collapse in housing wealth triggered a wave of mortgage defaults, bank failures, and a sharp tightening of lending standards. It is possible that these events amplified the usual effect of

housing wealth on consumption, and differentially affected high- and low-income households.

We revisit the relationship between house prices and consumption using Australian data for the period 2006 to 2011. Average house prices in Australia rose at about 4 per cent per annum over our sample period. This contrasts with the collapse in US house prices over the 2006 to 2009 period studied by Mian *et al* (2013). Compared with the United States, non-conforming (subprime) mortgage lending remained a small share of the total lending in Australia. While the United States entered a deep economic slump in 2008, Australia experienced around average rates of economic growth over our sample period.

We use a cross-sectional identification strategy that exploits postcode-level variation in house prices and consumption for Australia's three largest cities, Sydney, Melbourne and Brisbane.[1] We match postcode-level changes in house prices to administrative data from the Australian Bureau of Statistics (ABS) Motor Vehicle Census (an annual compilation of state motor vehicle registry data), from which we can infer the annual number of new (and near-new) cars registered by postcode. Disaggregated consumption data are difficult to come by, and new vehicle registrations are the only high-quality postcode-level consumption measure available in Australia. Official consumption data are available at no more than a state level of disaggregation, while biases in self-reported consumption data from household surveys can be large (see Koijen, Van Nieuwerburgh and Vestman (2015)). Survey data are likely to be particularly unreliable for durable goods consumption because sample sizes are typically too small to make reliable inference about infrequently purchased items. We show in the next section that new vehicle and total consumption growth tend to be synchronised, indicating that new vehicle registrations is a useful proxy for total consumption. Notably, Mian *et al* (2013) estimate motor vehicles to be the most responsive consumption good to a change in housing wealth. Under the assumption that this is also true for

1 Like other studies using cross-sectional variation in house prices and consumption, some caution is warranted in using our estimates to make inference about aggregate behaviour. If general equilibrium considerations are important, the response of consumption to an economy-wide change in housing wealth may differ from relative changes in housing wealth. For example, monetary policy does not respond to relative changes in conditions across postcodes, but may respond to macroeconomic developments associated with changes in aggregate housing wealth.

Australia, our estimates can be used to provide an upper bound on the relationship between total consumption and changes in housing wealth.

Our estimation period is aligned with the 2006 and 2011 Census of Population and Housing (the Census), allowing us to include a rich set of postcode-level control variables, including income, the unemployment rate, housing tenure, usual monthly mortgage repayments, and the level of education. This is a key strength of our analysis compared with earlier work, because it reduces the likelihood that the effect of changes in house prices on consumption that we estimate is caused by a third factor that simultaneously affects both house prices and consumption (see King (1990)). In our preferred specification, we divide Sydney and Melbourne into sub-city regions (e.g., north, south, east and west for Sydney), and identify housing wealth effects using only variation in house prices within each region. Each region is geographically small, so this controls for unobserved factors affecting consumption growth within localised areas. This contrasts with much of the existing literature, which uses cross-state or cross-city variation in house prices.

We find a robust postcode-level relationship between growth in house prices and new passenger vehicle registrations. The relationship is robust to the inclusion of local-area fixed effects and the full set of control variables. In our preferred specification, we estimate an elasticity of new passenger vehicle registrations with respect to house prices of 0.4–0.5, with a relatively high degree of precision. To estimate a marginal propensity to consume (MPC) for new vehicles, we first scale the number of new passenger vehicles registered by the average price of a new passenger vehicle. We then regress the dollar change in new passenger vehicle consumption on the dollar change in postcode-level house prices and controls. We estimate an average MPC for new vehicles of about 0.06 cents per dollar increase in house prices. (In general, we refer to new vehicle *consumption* when referring to dollar values, and new vehicle *registrations* when referring to quantities.)

Using our results to infer the relationship between house prices and total consumption requires us to take a stand on the relationship between new passenger vehicle consumption and total consumption. If new passenger vehicle consumption has the same sensitivity to a change in house prices as total consumption, then we can get an aggregate MPC by scaling our estimate by the ratio of total consumption to new vehicle consumption. Doing so implies

an aggregate MPC of 2 cents per dollar change in gross housing wealth. But if housing equity is more commonly used to finance durable than non-durable consumption, the aggregate MPC will be smaller. For example, if new vehicle consumption is twice as sensitive to a change in house prices as total consumption then our estimates imply an aggregate MPC of about 1 cent per dollar change in house prices. Mian *et al* (2013) estimate for the United States that new vehicle consumption is much more sensitive to a change in housing wealth than total consumption. Based on their estimates of the relative sensitivities of new vehicle and total consumption to a change in housing wealth, our estimates imply an aggregate MPC for Australia of 0.14 cents per dollar change in house prices. Thus, based on the US evidence that new vehicle consumption is particularly sensitive to changes in housing wealth, our results suggests that the MPC for total consumption is likely to be less than 0.25 cents. This is much smaller than the 5–7 cent range estimated by Mian *et al* (2013), and most Australian estimates, which fall in the 2–4 cent range. We discuss the Australian literature in detail in Section 7.

Notably, we identify heterogeneity in the response of households to changes in house prices: each $1 000 increase in annual postcode-level income reduces the estimated MPC for new passenger vehicle consumption by about 0.001 cents. At median household income, the estimated MPC for new vehicles is 0.1 cents, declining to about 0.025 cents at the 95th percentile of household income. Our finding that the MPC is larger for low- than for high-income households suggests that the heterogeneous effects identified by Mian *et al* (2013) are not specific to institutional features of the US housing finance system, or to the 2002 to 2009 boom-bust house price cycle. Thus, in general it is important for policymakers to monitor not only aggregate changes in housing wealth, but also the distribution of changes. From an academic perspective, our results lend support to the need for models that incorporate heterogeneity in MPCs across households. We believe our results represent the first non-US evidence that the MPC out of a change in house prices is decreasing in income.

Exploiting variation in housing-tenure type across postcodes, we attempt to estimate whether the effect of house prices on new vehicle registrations is via a standard wealth effect or a collateral constraints channel. A housing wealth effect is expected for those who own their home outright or with a mortgage, but only households with a mortgage are likely to be collateral constrained. In contrast to

Windsor, Jääskelä and Finlay (2013), we find that the estimated effect of changes in house prices on new vehicle registrations is similar for households owning their home outright to those with a mortgage, although the difference between the effects is imprecisely estimated. We find no evidence of a positive relationship between new vehicle registrations and house prices for renters, indicating that our results are not spurious or caused by a third factor increasing both new vehicle registrations and house prices, such as income shocks.

Our finding of heterogeneity in MPCs by income is consistent with a collateral constraints channel. Low-income households are more likely than high-income households to have low wealth, and so be subject to binding collateral constraints. This implies that a dollar increase in house prices is more likely to reduce borrowing constraints and raise consumption for low- than for high-wealth households. But a precautionary saving motive can also explain a relatively larger MPC for low-wealth households: the MPC out of changes in wealth decreases in the level of wealth for a prudent consumer (Carroll 2001). Given that a range of theoretical models can explain a relationship between housing wealth and consumption, we remain agnostic about the relative importance of different channels from housing wealth to consumption.

2. Data

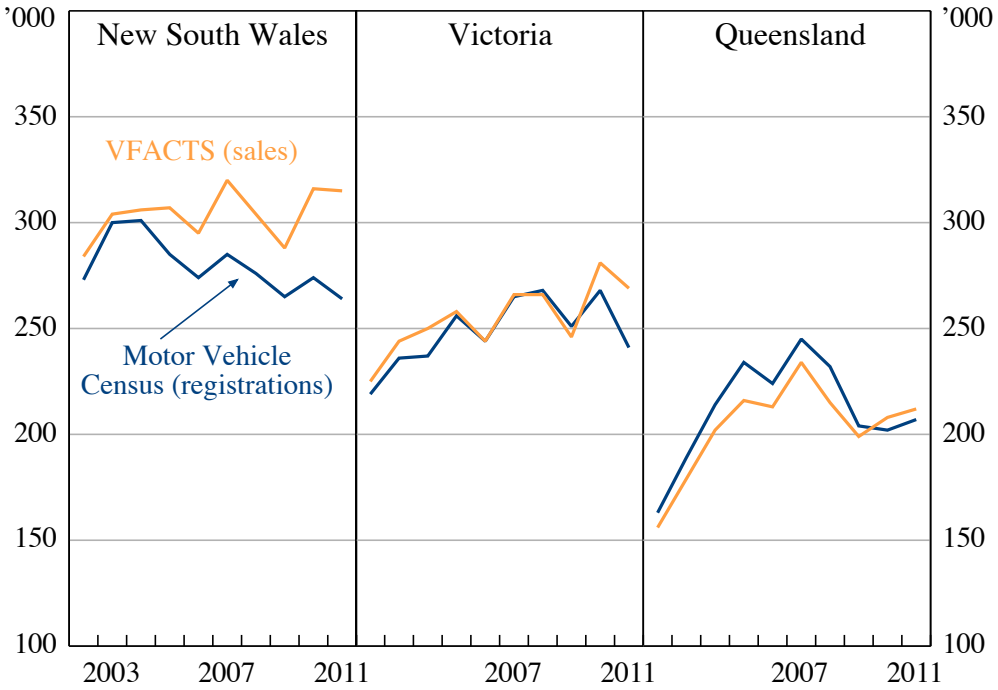
2.1 Data Sources

We rely on three main data sources for information on new passenger vehicle registrations, house price changes, and other covariates. We describe each data source in turn below.

New passenger vehicle registrations: The ABS Motor Vehicle Census provides an annual snapshot of vehicle registrations in Australia, sourced from each state's motor vehicle registry, disaggregated by postcode of the owner. The dataset reports the number of vehicles in each postcode by year of manufacture, from which we

can infer the number of new (or near-new) vehicles registered.[2] Figure 1 shows that, except for NSW, there is a close correspondence between the Motor Vehicle Census data and VFACTS new vehicle sales data, sourced from car dealers.[3] We focus on passenger vehicles to exclude light commercial vehicles and trucks, but we cannot separate private and commercial passenger vehicle registrations. Housing wealth may be a source of finance for some small business vehicle purchases, but otherwise the combination of private and commercial registrations introduces noise into our data. We also exclude a small number of postcodes with more than three times the average level of per capita new passenger vehicle registrations, which are likely to be business-centric postcodes.

Figure 1: Motor Vehicle Sales and Registrations



Sources: ABS; Authors' calculations; FCAI/VFACTS

2 New vehicles sold until April each calendar year are mostly manufactured in the previous year. This corresponds closely to the 31 March ABS Motor Vehicle Census date used prior to 2011. From 2011, the Census date shifted to 31 January, effectively allowing us to infer only the first ten months of new car sales. Because this measurement change applies equally to all postcodes and our identification uses cross-sectional variation, the effect of this measurement change is absorbed into the constant term in our regressions, and does not affect our results.

3 Data for other states, not shown, also show a close correspondence. We are not sure why the VFACTS data exceed the Motor Vehicle Census data for NSW. The cross-sectional variation used in our analysis swamps the trend difference evident between the data sources for NSW as a whole.

Dwelling prices: We use Australian Property Monitors (APM) unit-record data on property sales for Sydney, Melbourne, and Brisbane to construct annual estimates of the mean price of dwellings in each postcode. At an annual frequency, there are a sufficiently large number of transactions in each postcode to form reliable estimates of mean dwelling prices. We adjust the data to control for quality differences between the housing stock and the properties sold each year. Following Hansen (2009), the following hedonic price adjustment model is fitted to data for each city:

$$ln(p_{ijt}) = x'_{it}\beta + \sum_{t=1}^{T}\sum_{i=1}^{I}\lambda_{it}\delta_{ijt} + \varepsilon_{ijt},$$

where δ_{ijt} is a dummy variable equal to unity if property j in postcode i is sold in year t, and p_{ijt} is the sale price. The vector of explanatory variables x'_{it} includes controls for the property type (apartment or house), number of bedrooms, and sale mechanism (auction or private treaty).[4]

Property type is interacted with each explanatory variable, allowing the effect of housing characteristics on price to differ for apartments and houses. The coefficient λ_{it} is used to construct p^h_{it}, the hedonically adjusted average sale price in postcode i in year t, for a property with the baseline set of characteristics.[5] These coefficients are used to calculate year-average growth rates in house prices. Because the population share of housing characteristics differs at the postcode level, the estimates p^h_{it} do not correspond to the average postcode-level house price. See Hansen (2009) and Genesove and Hansen (2014) for further details on hedonic price adjustment of Australian house price data.

Census of Population and Housing: The Census provides a rich set of control variables at the postcode level: population, income, housing tenure type, usual monthly mortgage repayments, education level, and the unemployment rate. We choose to estimate housing wealth effects over the 2006 to 2011 period, to align with the census years.

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4 Thanks to Matthew Read for help with the house price data.

5 Assuming p_{ijt} is log-normally distributed, $p^h_{it} = exp(\mu + \lambda_{it} + var(\varepsilon_{ijt})/2)$, where μ is the baseline set of characteristics.

Summary statistics are reported in Table 1.

Table 1: Summary Statistics – By Postcode

	Mean	Median	Std dev	Percentile	
				10th	90th
Average house price, $'000, 2006	460.3	410.8	195.3	278.1	708.8
Δ average house price, $'000, 2006–11	146.3	132.8	84.6	58.0	246.5
Percentage change in average house price, 2006–11	28.1	26.7	11.3	14.9	43.0
Percentage change in average house price, 2001–06	37.6	35.6	13.4	23.9	57.8
Percentage change in average house price, 1996–01	55.8	54.7	14.0	41.9	73.4
Per capita new passenger vehicles purchased, 2006	0.054	0.043	0.058	0.028	0.076
Δ per capita new passenger vehicles purchased, 2006–11	–0.006	–0.003	0.031	–0.016	0.004
Percentage change in new passenger vehicles purchased, 2006–11	–8.9	–7.3	25.3	–29.9	9.5
Mean income, $'000 pa, 2006	82.5	78.1	19.5	59.1	109.2
Δ mean income, $'000 pa, 2006–11	7.0	7.8	5.8	0.2	13.4
Median income, $'000 pa, 2006	74.5	67.6	22.6	46.8	96.2
Δ median income, $'000 pa, 2006–11	3.7	3.9	10.4	–9.1	14.3
Unemployment rate, 2006	5.3	4.6	2.4	3.0	8.6
Δ unemployment rate, 2006–11	0.5	0.6	0.8	–0.5	1.5
Per cent of households who rent, 2006	29.3	27.2	13.3	14.5	48.3
Per cent of households with a mortgage, 2006	31.3	29.1	10.7	20.0	47.1
Per cent of households owning outright, 2006	39.3	39.8	9.2	26.5	51.5
Per cent of people with a bachelor's degree or higher, 2006	18.4	16.1	11.0	6.7	35.0
Per cent of people with a certificate qualification, 2006	7.1	7.2	1.8	4.6	9.4
Distance to CBD, km	19.3	17.5	12.1	5.2	38.4
Waterfront dummy	0.2	0.0	0.4	0.0	1.0

Note: Data are weighted by postcode population in 2006
Sources: ABS; APM

2.2 Identification of Housing Wealth Effects

Following Mian *et al* (2013), our identification approach uses postcode-level variation to estimate the relationship between house prices and consumption (proxied by new vehicle registrations). Ideally, we would like to estimate the causal effect of changes in housing wealth on consumption. This requires house price variation at the postcode level that is uncorrelated with determinants of consumption growth other than housing wealth. A key concern for all studies attempting to identify housing wealth effects is a third factor, such as income growth, that simultaneously affects both consumption and house prices. Failing to control for such third factors would lead us to overestimate the size of the direct effect of house prices on consumption.

Our identification approach has several strengths that help us to identify the direct effect of changes in house prices on consumption. First, the alignment of our estimation period with the Census means we are able to control for a number of third factors that are likely to simultaneously affect both house prices and consumption, such as income growth and the change in the unemployment rate. This contrasts with Mian *et al* (2013), who do not include the unemployment rate as a control variable in their postcode-level analysis. The larger MPCs that they estimate for low- compared with high-income postcodes could in part be attributable to low-income postcodes being more susceptible to unemployment. Second, there is little serial correlation in relative house price growth at the postcode level. The lack of serial correlation implies that postcode-level relative price changes are highly persistent and largely unpredictable based on lagged relative price growth.[6] This is important, because the permanent income hypothesis predicts that consumption growth is only affected by unanticipated changes in wealth. Third, we include regional fixed effects in our regressions and identify the relationship between house prices and new vehicle registrations using only within-city variation.

The within-city variation in house prices that we exploit is weakly spatially correlated. Table 2 reports the degree of spatial correlation in postcode-level house price growth, based on Moran's *I* statistic, within each region shown (e.g. Sydney,

6 The correlation between postcode-level house price growth over the periods 1996 to 2001 and 2001 to 2006 is –0.06; the correlation between house price growth over the periods 2001 to 2006 and 2006 to 2011 is 0.13.

north). Moran's *I* statistic is a generalisation of the standard Pearson correlation coefficient, lying between minus one and plus one. A statistic of plus one indicates perfect clustering, minus one indicates perfect dispersion, and zero indicates random assignment. The degree of spatial correlation is statistically significantly different than zero for most cities and regions, but it is economically small.[7]

If households in adjacent postcodes are similar, they should experience common economic shocks, inducing a positive correlation in house price growth across adjacent postcodes. We interpret the absence of strong spatial correlation in house price growth as a sign of plausibly exogenous variation. But to the extent that we have not been able to fully account for third factors causing comovement in house prices and growth in new vehicle registrations, our estimated effects should be interpreted as an upper bound on the direct effect of house prices on consumption.

Table 2: Moran's *I* Statistic
Log change in house prices – 2006 to 2011

	I statistic	Standard error	Obs	Population 2006 '000
Sydney	0.133***	(0.007)	218	2 807
North	0.144***	(0.022)	63	707
South	–0.025	(0.027)	28	471
East	0.089***	(0.023)	53	576
West	0.290***	(0.019)	74	1 052
Melbourne	0.077***	(0.012)	216	2 514
South	0.034	(0.032)	87	1 056
East	0.107***	(0.016)	91	952
West	0.043***	(0.031)	36	489
Brisbane	0.099***	(0.011)	123	1 306

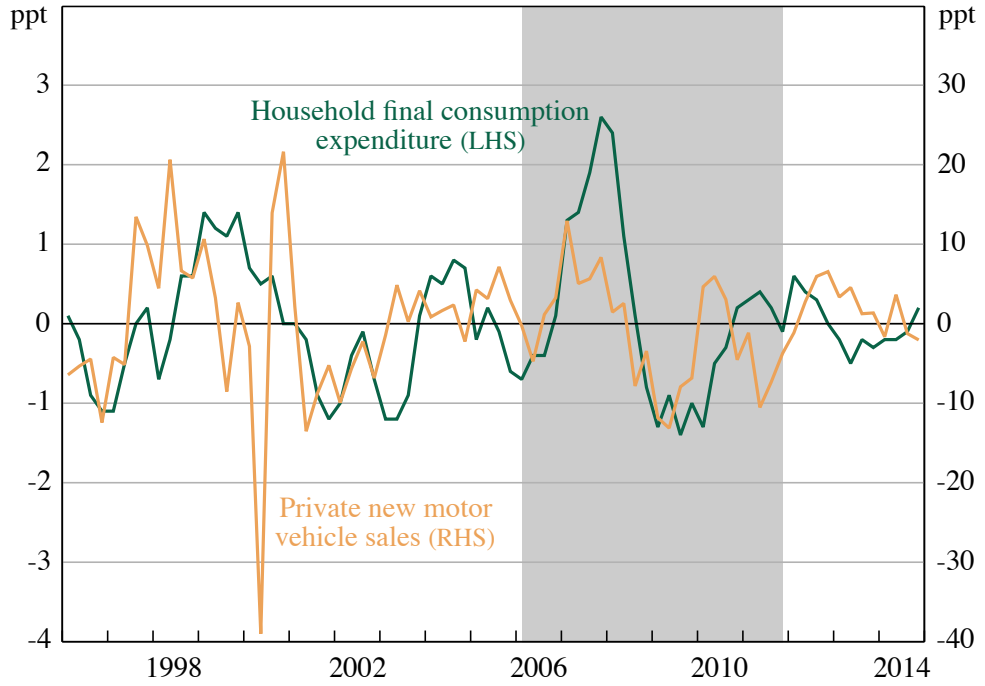
Notes: Moran's *I* statistic is a measure of spatial correlation: a value of one indicates perfect clustering, a value of minus one indicates perfect dispersion, and a value of zero indicates random assignment; ***, **, and * indicate statistical significance at the 1, 5, and 10 per cent levels, respectively
Sources: APM; Authors' calculations

7 Geocoded latitude and longitude coordinates for each postcode are used to calculate pairwise distances between postcodes. For computational feasibility, we use an 11km bandwidth for pairwise comparisons. Brisbane is treated as a single region, because it has about half as many postcodes as Sydney and Melbourne.

2.3 Relationship of New Vehicle Registrations to Total Consumption

Our identification scheme relies on new vehicle registrations being a suitable proxy for total consumption. Figure 2 shows the cyclical behaviour of total household consumption and private new motor vehicle sales. (Figure 2 shows aggregate sales data because registrations data are unavailable at a quarterly frequency.) The cyclical component is the deviation of the log of each series from a Hodrick-Prescott filter trend. The timing of new vehicle sales can be particularly affected by temporary factors, such as the introduction of the GST in 1999/2000, but overall there is a strong correlation between new vehicle sales and total consumption. For the 2006 to 2011 sample period used in our analysis, the correlation between the cyclical components of new vehicle sales and total consumption is 0.56. Notably, new vehicle sales is much more cyclically sensitive than total consumption, as indicated by the respective scales for the lines in Figure 2. This is consistent with the finding by Mian *et al* (2013) that new vehicle sales are much more sensitive to changes in housing wealth than is total consumption.

Figure 2: Consumption and Private Motor Vehicle Sales
Deviation from trend



Note: Series have been de-trended using a Hodrick-Prescott filter with a smoothing parameter λ=1 600, as is standard for quarterly frequency data
Sources: ABS; Authors' calculations; FCAI/VFACTS

2.4 Stability of Key Covariates over Time

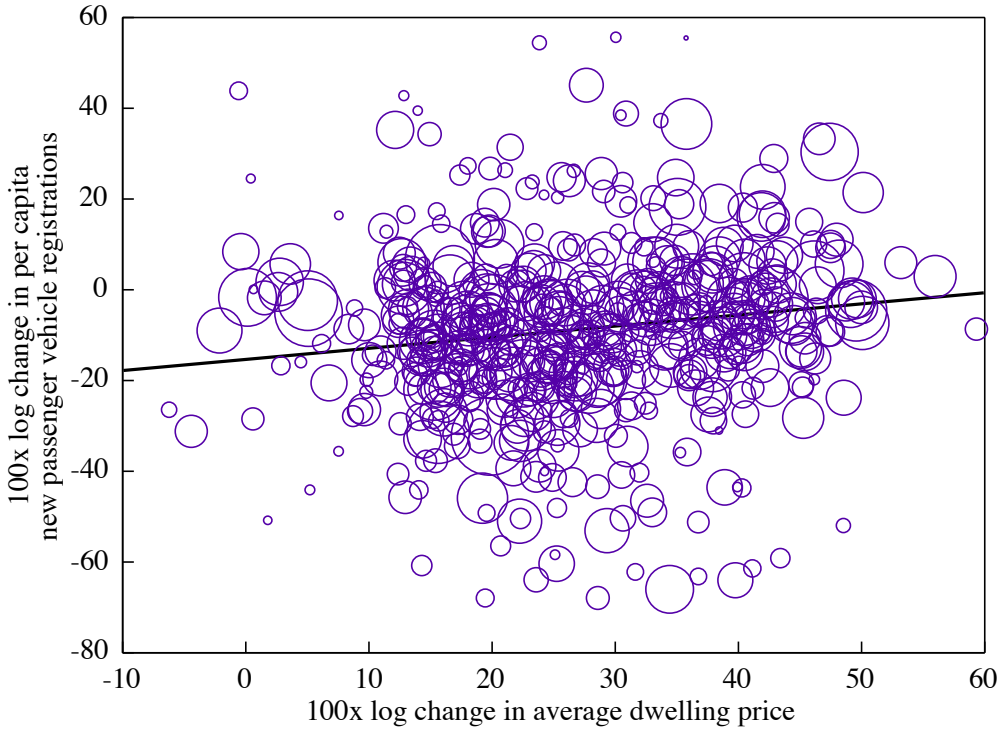
While we exploit variation in new vehicle registrations and house price growth across postcodes, we also make use of the fact that some covariates are relatively stable through time. In particular, we rely on there being predictable differences across postcodes in the home ownership share and the level of income. On average, about 70 per cent of households own their home either outright or with a mortgage, and the correlation in ownership shares at the postcode level for 2006 and 2011 is 0.98. As expected, there are also highly predictable differences in the level of income through time: the correlation between postcode-level median income in 2006 and 2011 is 0.96. We make use of these predictable differences in income across postcodes when seeking to identify heterogeneity in MPCs by income level.

3. Bivariate Analysis

Figure 3 shows a plot of the log change in per capita new passenger vehicle registrations between 2006 and 2011 against the log change in average house prices, for each postcode. In the figure, the size of the data points is proportional to the population of each postcode in 2006. The wide variation in house price growth across postcodes is highly informative for our analysis: unweighted average house price growth from 2006 to 2011 was 28 per cent, with a standard deviation of 11 per cent. However, the small number of postcodes experiencing a fall in average house prices between 2006 and 2011 limits the scope of the data to determine whether consumption responds asymmetrically to rises and falls in house prices.

The line of best fit shown in Figure 3 indicates that growth in per capita new passenger vehicle registrations was higher in postcodes experiencing relatively high house price growth. Each 1 percentage point increase in house prices is associated with a 0.24 per cent increase in per capita new passenger vehicle registrations. The regression shown in the first column of Table 3 indicates that this correlation is highly statistically significant.

Figure 3: New Passenger Vehicle Registrations and House Price Growth
By postcode, 2006 to 2011



Notes: Size of circles is proportional to postcode population in 2006 and the regression line is population weighted; a small number of extreme observations have been excluded from the figure
Sources: ABS; APM; Authors' calculations; FCAI/VFACTS

4. Regression Analysis

Having seen graphical evidence of a relationship between house prices and new vehicle registrations in Figure 3, we now move to a regression framework. This allows us to estimate the relationship between house prices and new vehicle registrations controlling for determinants of consumption growth other than housing wealth.

We begin by noting that, for postcode i, the relationship between a change in housing wealth and consumption is given by the following expression:

$$\Delta c_{i,06-11} = \beta^{outright} \Delta hw^{outright}_{i,06-11} s^{outright}_{i,06} + \beta^{mort} \Delta hw^{mort}_{i,06-11} s^{mort}_{i,06} \qquad (1)$$

where $\Delta c_{i,06-11}$ is the log change in consumption in postcode i between 2006 and 2011, $\beta^{outright}$ is the propensity of those owning their home outright to

consume out of a change in housing wealth, $s_{i,06}^{outright}$ is the share of outright home owners in postcode i in 2006, $\Delta hw_{i,06-11}^{outright}$ is the log change in housing wealth for outright home owners in postcode i between 2006 and 2011, and analogously for mortgagors.

For outright home owners, the change in housing wealth varies one-for-one with the change in house prices. But for households with a mortgage, home equity wealth varies more than one-for-one with house prices. For example, for a household with an initial 80 per cent loan-to-valuation ratio, a 10 per cent increase in the price of their house raises home equity wealth by 50 per cent.

Unfortunately, we do not have data on average leverage of mortgagors by postcode.[8] We take two approaches to deal with this data limitation. Under the first approach, we group outright owners and mortgagors together, implicitly ignoring mortgage debt and considering the effect of gross housing wealth on consumption. In this case, we estimate the regression:

$$\Delta c_{i,06-11} = \alpha + \bar{\beta}\Delta hp_{i,06-11}\left(s_{i,06}^{outright} + s_{i,06}^{mort}\right) + \Sigma_j \gamma_j X_{ij} + \varepsilon_i \qquad (2)$$

where $\Delta c_{i,06-11}$ is the log change in new passenger vehicle registrations in postcode i between 2006 and 2011, $\Delta hp_{i,06-11}$ is the log change in house prices over the same period, $\bar{\beta}$ is the relationship between gross housing wealth and new vehicle registrations, α is a constant term, and X_{ij} is control variable j for postcode i.

Under the second approach, we attempt to identify the reduced-form effect of a change in house prices on new vehicle registrations for mortgagors using variation

8 The Census reports data on the level of monthly mortgage payments, but we do not know loan balance. The HILDA Survey contains more detailed information on households with a mortgage, but the sample size of the survey is too small to make reliable inference about differences in loan-to-valuation ratios across postcodes. Unfortunately, the loan-level data used by Read, Stewart and La Cava (2014) is unsuited to estimating average loan-to-valuation ratios by postcode.

in housing-tenure type across postcodes. This approach implies the following regression specification:

$$\begin{aligned}\Delta c_{i,06-11} = \alpha + \beta^{outright}\left(\Delta hp_{i,06-11}s_{i,06}^{outright}\right) + \tilde{\beta}^{mort}\left(\Delta hp_{i,06-11}s_{i,06}^{mort}\right) \\ + \Sigma_j \gamma_j X_{ij} + \varepsilon_i\end{aligned} \tag{3}$$

where $\tilde{\beta}^{mort}$ is the reduced form relationship between house prices and new vehicle registrations for mortgagors. If the collateral constraint channel is significant, then $\tilde{\beta}^{mort}$ should be larger than $\beta^{outright}$, because it comprises the consumption response via both a standard wealth effects channel and a collateral constraints channel.

The vector of controls includes all relevant census variables in 2006 levels, and in differenced form for the period 2006 to 2011. The vector of controls also includes each postcode's distance to the CBD, and a dummy variable for waterfront postcodes. These geographic variables absorb any predictable variation in relative house price growth that is correlated with proximity to the CBD.[9] They also control for the possibility that households living in postcodes at greater distances from the CBD may have a higher propensity to spend an additional dollar of wealth on new passenger vehicles than households in inner-city postcodes.[10]

We express passenger vehicle registrations in per capita terms to control for differences in population growth across postcodes. We use weighted least squares to estimate each regression, with the 2006 population for each postcode as weights. This makes postcodes with a large population relatively more influential in estimating the regression parameters, which is appropriate because each postcode-level observation represents an average over a relatively large number of households.

To reduce the influence of extreme observations we exclude a small number of postcodes from our analysis: we exclude postcodes experiencing a change in per capita new vehicle registrations greater than 75 per cent in magnitude between 2006 and 2011, or more than a 0.025 magnitude change in per capita

9 See see Kulish, Richards and Gillitzer (2012) for evidence on the relationship between distance from the CBD and waterfront proximity with the level and growth rate of house prices.

10 Thanks to Anthony Richards for providing the data on waterfront postcodes.

new passenger vehicle registrations when analysing changes in the number of vehicles purchased. Extreme observations have a negligible effect on the elasticity or average MPC estimates, but do affect our ability to detect heterogeneity in MPCs across postcodes.

5. Elasticity of New Vehicle Registrations to House Prices

5.1 Contemporaneous Effect

Table 3 reports our first set of regression results.[11] The dependent variable in each regression is the log change in per capita new passenger vehicle registrations between 2006 and 2011.

Regression (2) in Table 3 reports estimates of Equation (2) without the inclusion of any control variables. The coefficient of interest is $\bar{\beta}$, the elasticity of new passenger vehicle registrations with respect to gross housing wealth in each postcode. The estimated coefficient indicates that a 1 percentage point increase in gross housing wealth is associated with about a 0.5 per cent increase in per capita new passenger vehicle registrations. This is about twice the size of the raw correlation between growth in new vehicle registrations and house prices. The effect is larger because only households owning their home outright or with a mortgage experience an increase in housing equity when house prices rise, and the effect of housing equity on consumption is assumed to operate only through home owners. Mechanically, gross housing wealth is equal to the change in house prices scaled by the home ownership share, and so varies less than one-for-one with house prices. Reassuringly, there is no evidence of endogeneity in our data between home ownership rates and house price growth: the correlation between the home ownership rate in 2006 and house price growth for the period 2006 to 2011 is very close to zero.

11 The robust standard errors reported account for sampling variability, assuming the dataset is small relative to the population. But the census data we use accounts for a large share of the total population. Interpreted as descriptive statistics, the uncertainty around our regression parameters is smaller than indicated by the robust standard errors reported. Interpreted as estimated average causal effects, additional uncertainty remains if each postcode has a potentially different sensitivity of consumption to changes in housing wealth: we do not observe counterfactual house price growth for each postcode. Abadie *et al* (2014) find that standard errors for causal inference with large datasets are generally smaller than the conventional robust standard errors we report.

Table 3: Housing Wealth and Consumption Growth

Dep variable: $100 \times \Delta$ log per capita new passenger vehicle registrations, 2006 to 2011

	OLS (1)	OLS (2)	OLS (3)	OLS (4)	Median (5)	Median (6)
$lhp_{2006} * s^{own}_{2006}$			12.17*	13.67**	9.80*	8.99
			(6.34)	(6.96)	(5.24)	(5.85)
$\Delta lhp_{2006-11}$	0.24***					
	(0.06)					
$\Delta lhp_{2006-11} * s^{own}_{2006}$		0.48***	0.56***	0.53***	0.42**	0.37**
		(0.08)	(0.17)	(0.18)	(0.17)	(0.17)
$\Delta lmedinc_{2006-11}$			0.05	0.03	0.08	0.00
			(0.10)	(0.10)	(0.07)	(0.07)
$\Delta s^{own}_{2006-11}$			−0.02	−0.05	−0.20	−0.41
			(0.38)	(0.40)	(0.34)	(0.35)
$\Delta repay_{2006-11}$			−1.12	11.25	0.22	31.92
			(31.30)	(33.78)	(26.19)	(26.82)
$\Delta ur_{2006-11}$			−0.22	−0.06	−1.60	−1.34
			(1.24)	(1.18)	(1.05)	(1.06)
$lmedinc_{2006}$			−2.41	−3.85	−3.31	−3.58
			(8.29)	(8.73)	(6.46)	(6.70)
s^{own}_{2006}			−1.73**	−1.89**	−1.34**	−1.26*
			(0.79)	(0.87)	(0.68)	(0.75)
$repay_{2006}$			−5.65	−4.53	−9.79	−0.30
			(12.92)	(13.65)	(11.81)	(11.89)
ur_{2006}			−2.28***	−2.26***	−1.99***	−1.84***
			(0.74)	(0.75)	(0.58)	(0.59)
$Bachelor_{2006}$			−0.61***	−0.53**	−0.46**	−0.38*
			(0.22)	(0.24)	(0.19)	(0.20)
$TAFE_{2006}$			−1.94**	−1.76*	−1.32*	−1.15
			(0.97)	(1.02)	(0.73)	(0.76)
$Distance$			0.20*	0.26**	0.23**	0.22*
			(0.12)	(0.12)	(0.11)	(0.11)
$Waterfront$			2.43	1.96	0.52	−0.37
			(1.75)	(1.92)	(1.73)	(1.84)
Observations	563	563	526	526	526	526
R^2	0.03	0.07	0.23	0.24		
Pseudo R^2					0.17	0.18
Region fixed effects				Yes		Yes
State fixed effects			Yes		Yes	

Notes: See Table A2 for a description of each regression variable; ***, **, and * indicate statistical significance at the 1, 5, and 10 per cent levels, respectively; robust standard errors in parentheses

Regressions (3) and (4) report estimates for Equation (2) including the full set of census data controls, and with state and regional fixed effects, respectively. The estimated elasticity $\bar{\beta}$ is about 0.5 for both specifications, and precisely estimated. Regressions (5) and (6) report median regression estimates. In contrast to the OLS estimator which minimises the sum of squared errors, the median regression estimator minimises the sum of absolute errors, and so is less sensitive to extreme observations. The similarity between the OLS and median regression elasticity estimates indicates that the estimated relationship between new vehicle registrations and house prices is not driven by extreme observations.

Regressions (1) and (2) in Table 4 report estimates for Equation (3), using variation in the share of outright home owners and mortgagors across postcodes to tease apart differential effects of housing wealth for outright home owners and mortgagors. The estimated elasticities $\beta^{outright}$ and $\tilde{\beta}^{mort}$ are between 0.4 and 0.6 in each regression specification, indicating a similar relationship between changes in house prices and new vehicle registrations for outright home owners and mortgagors. This evidence is only suggestive though, because the data do not allow us to precisely tease apart any differences in the effect of house prices on consumption for those owning their home outright or with a mortgage.

As a placebo test, regressions (3) and (4) in Table 4 include an interaction between the share of renters and the log change in house prices for each postcode. A positive coefficient on this variable would likely indicate that a third factor is responsible for at least some of the estimated relationship between changes in house prices and new vehicle registrations. The coefficient on the placebo renters-equity variable $\Delta lhp_{2006-11} * s^{rent}_{2006}$ is negative, indicating that the estimated positive relationship between house prices and new vehicle registrations is unlikely to be caused by a third factor. Because some renters are prospective home buyers, the negative coefficient could indicate that prospective buyers reduce consumption when house prices rise. But the relationship between new vehicle registrations and house prices for renters is imprecisely estimated, and we cannot reject there being no relationship at conventional levels of significance. To avoid the estimated relationship between housing wealth and new vehicle registrations for owners being affected by an imprecisely estimated effect for renters, we omit the renters-equity variable in other regressions, imposing our prior that there is no relationship between house prices and new vehicle registrations for renters. This has the effect of reducing the estimated elasticity of new vehicle registrations to

gross housing wealth for home owners by about 0.1, as can be seen by comparison of regressions (3) and (4) in Table 4 with regressions (3) and (4) in Table 3.

Table 4: Housing Wealth and Consumption Growth by Tenure

Dep variable: $100 \times \Delta$ log per capita new passenger vehicle registrations, 2006 to 2011

(*continued next page*)

	(1)	(2)	(3)	(4)
$lhp_{2006} * s^{own}_{2006}$			8.22	10.19
			(5.96)	(6.53)
$lhp_{2006} * s^{renter}_{2006}$			-22.98^{**}	-28.17^{**}
			(11.18)	(11.62)
$lhp_{2006} * s^{mort}_{2006}$	13.61	16.07		
	(9.94)	(10.44)		
$lhp_{2006} * s^{outright}_{2006}$	12.52^{*}	14.69^{*}		
	(7.44)	(7.92)		
$\Delta lhp_{2006-11} * s^{own}_{2006}$			0.69^{***}	0.65^{***}
			(0.20)	(0.20)
$\Delta lhp_{2006-11} * s^{rent}_{2006}$			-0.53	-0.60
			(0.56)	(0.57)
$\Delta lhp_{2006-11} * s^{mort}_{2006}$	0.45	0.49		
	(0.54)	(0.56)		
$\Delta lhp_{2006-11} * s^{outright}_{2006}$	0.63^{*}	0.57		
	(0.36)	(0.37)		
$\Delta lmedinc_{2006-11}$	0.05	0.03	0.04	0.03
	(0.10)	(0.10)	(0.10)	(0.10)
$\Delta s^{own}_{2006-11}$	-0.04	-0.07	-0.07	-0.08
	(0.40)	(0.41)	(0.37)	(0.38)
$\Delta repay_{2006-11}$	0.50	12.25	-7.77	1.27
	(33.62)	(35.32)	(31.27)	(34.37)
$\Delta ur_{2006-11}$	-0.22	-0.08	-0.79	-0.83
	(1.26)	(1.19)	(1.33)	(1.26)
$lmedinc_{2006}$	-3.33	-5.53	-1.94	-3.52
	(9.87)	(9.90)	(8.38)	(8.82)
s^{own}_{2006}	-1.80^{*}	-2.03^{**}	-4.28^{***}	-5.14^{***}
	(0.94)	(1.01)	(1.63)	(1.74)
$repay_{2006}$	-11.15	-14.48	-6.60	-5.33
	(32.20)	(33.93)	(13.68)	(14.53)

Table 4: Housing Wealth and Consumption Growth by Tenure

Dep variable: 100 × Δ log per capita new passenger vehicle registrations, 2006 to 2011

(*continued*)

	(1)	(2)	(3)	(4)
ur_{2006}	-2.25^{***}	-2.22^{***}	-2.88^{***}	-2.80^{***}
	(0.76)	(0.77)	(0.74)	(0.76)
$Bachelor_{2006}$	-0.60^{***}	-0.52^{**}	-0.46^{**}	-0.38
	(0.23)	(0.24)	(0.23)	(0.25)
$TAFE_{2006}$	-1.97^{**}	-1.82^{*}	-1.74^{*}	-1.32
	(1.00)	(1.04)	(0.97)	(1.03)
$Distance$	0.20^{*}	0.25^{**}	0.09	0.15
	(0.12)	(0.12)	(0.12)	(0.13)
$Waterfront$	2.54	2.06	3.64^{*}	3.11
	(1.73)	(1.95)	(1.90)	(2.03)
Observations	526	526	526	526
R^2	0.24	0.24	0.25	0.25
Region fixed effects		Yes		Yes
State fixed effects	Yes		Yes	

Notes: See Table A2 for a description of each regression variable; ***, **, and * indicate statistical significance at the 1, 5, and 10 per cent levels, respectively; robust standard errors in parentheses

5.2 Longevity of the Effect

The cumulative effect of a change in housing wealth on consumption depends on whether the effect on spending is sustained over time. Thus far we have focused on estimating a contemporaneous effect; in our preferred specification, we estimate an elasticity of new passenger vehicle registrations with respect to gross housing wealth of 0.4–0.5. If this reflects households using increases in housing wealth to fund a one-time increase in current spending, then current consumption growth will tend to be negatively related to past changes in housing wealth as consumption returns to its prior level. Conversely, if spending funded by an increase in housing wealth is smoothed over time, we should expect to see no relationship between past *changes* in housing wealth and current consumption growth. Finally, a positive relationship between past changes in housing wealth and current consumption is consistent with sluggishness in the adjustment of consumption to changes in housing wealth.

To investigate these possibilities, we augment Equation (2) with changes in gross housing equity over the periods 1996 to 2001 and 2001 to 2006. The correlation in house price growth between these time periods is low, providing statistical power to determine the timing of changes in housing wealth on new vehicle registrations. Estimation results are reported in Table 5. Because house price data for fewer postcodes is available for earlier time periods, Table 5 also reports estimates for the baseline regression specification using a common data sample. Reassuringly, the baseline results are little different. Growth in new vehicle registrations over the period 2006 to 2011 is negatively related to house price growth over the period 2001 to 2006, but the estimated effect is about one-third the magnitude of the contemporaneous effect. The sum of the coefficients is positive, indicating that the contemporaneous relationship between housing wealth and new vehicle registrations is largely sustained over time. Changes in housing wealth over the period 1996 to 2001 are estimated to have had a negligible relationship with growth in new vehicle registrations over the period 2006 to 2011. Overall, these results indicate that an increase in house prices is associated with an elevated level of new registrations for a sustained period of time, but that the short-run relationship is likely to be larger than the long-run relationship.

Table 5: Longevity of Housing Wealth Effects

Dep variable: $100 \times \Delta$ log per capita new passenger vehicle registrations, 2006 to 2011

	(1)	(2)	(3)	(4)
$lhp_{2006} * s^{own}_{2006}$	11.53	11.59	11.21	12.49
	(8.09)	(8.24)	(9.10)	(9.34)
$\Delta lhp_{2006-11} * s^{own}_{2006}$	0.62***	0.66***	0.55***	0.59***
	(0.19)	(0.20)	(0.20)	(0.20)
$\Delta lhp_{2001-06} * s^{own}_{2006}$		−0.14		−0.20
		(0.16)		(0.17)
$\Delta lhp_{1996-01} * s^{own}_{2006}$		0.06		0.04
		(0.07)		(0.07)
$\Delta lmedinc_{2006-11}$	0.07	0.09	0.06	0.07
	(0.12)	(0.12)	(0.12)	(0.12)
$\Delta s^{own}_{2006-11}$	−0.24	−0.26	−0.16	−0.20
	(0.55)	(0.55)	(0.56)	(0.56)
$\Delta repay_{2006-11}$	6.59	13.35	18.24	26.73
	(36.82)	(37.34)	(40.32)	(39.82)
$\Delta ur_{2006-11}$	−0.23	0.07	0.07	0.32
	(1.78)	(1.76)	(1.72)	(1.70)
$lmedinc_{2006}$	−3.80	−1.80	−5.70	−3.79
	(10.00)	(10.15)	(10.76)	(10.79)
s^{own}_{2006}	−1.61	−1.63	−1.50	−1.63
	(1.05)	(1.06)	(1.17)	(1.19)
$repay_{2006}$	−4.25	−3.03	−3.74	−0.82
	(15.27)	(16.22)	(15.92)	(16.88)
ur_{2006}	−2.46***	−2.23**	−2.24**	−1.95**
	(0.89)	(0.91)	(0.88)	(0.92)
$Bachelor_{2006}$	−0.55*	−0.58*	−0.49	−0.50
	(0.30)	(0.30)	(0.33)	(0.32)
$TAFE_{2006}$	−2.05*	−1.98*	−1.67	−1.56
	(1.07)	(1.07)	(1.15)	(1.16)
$Distance$	0.24	0.28*	0.28*	0.35**
	(0.15)	(0.15)	(0.17)	(0.17)
$Waterfront$	0.93	0.82	0.39	0.21
	(2.38)	(2.35)	(2.66)	(2.65)
Observations	375	375	375	375
R^2	0.27	0.27	0.28	0.28
Region fixed effects			Yes	Yes
State fixed effects	Yes	Yes		

Notes: See Table A2 for a description of each regression variable; ***, **, and * indicate statistical significance at the 1, 5, and 10 per cent levels, respectively; robust standard errors in parentheses

6. Marginal Propensity to Consume

Most of the literature estimating the relationship between changes in housing wealth and consumption focuses on the MPC out of a change in housing wealth, rather than the elasticity of consumption with respect to changes in housing wealth. We can infer an MPC for new vehicles by scaling the estimated elasticity of new vehicle consumption by the ratio of total new vehicle consumption to gross housing wealth for home owners. ABS household wealth and expenditure data, and our estimated elasticity for new vehicle consumption, implies an MPC for new vehicles of about 0.17 cents per dollar increase in gross housing wealth.[12] Because there has been a decline in the consumption-to-housing wealth ratio in recent years, the implied MPC, given the constant elasticity assumption, is smaller in more recent years. We relate this elasticity-based MPC estimate to the literature, and discuss aggregate implications, in the next section.

A drawback of inferring MPCs from elasticity estimates is the inability to test for heterogeneity in MPCs. We follow Mian *et al* (2013) in estimating an average MPC directly, and later testing for heterogeneity by level of income. Accordingly, we re-specify Equation (2) in level rather than growth rate terms. Our dependent variable is now the postcode-level change in annual per capita new passenger vehicle consumption between 2006 and 2011, and our key independent variable is the dollar change in house prices over the same period. To get a dollar value of new passenger vehicle consumption, we scale the number of new passenger vehicle registrations in each postcode by the average price of a new car. Guided

12 This calculation uses data from the 2009-10 ABS Household Expenditure Survey and the 2009-10 ABS Household Wealth and Wealth Distribution data. The elasticity of new vehicle consumption with respect to gross housing wealth is assumed to be 0.45, around the midpoint of our estimates in Table 3, and vehicle consumption is assumed to be 2.9 per cent of total consumption, its average since 2000 based on national accounts data. The price of new vehicles is assumed to be unaffected by changes in house prices.

by national accounts and VFACTS data, we assume an average new car price of $30 000.[13]

Thus far, our results have used hedonically adjusted house price data. Because these data control for quality differences between houses sold and the total housing stock, they provide the most accurate measure of the percentage change in average house prices. We are now concerned with the dollar change in house prices, and use non-hedonically adjusted average sales prices by postcode. This has only a minor effect because, at an annual frequency, differences in house price growth are similar in the hedonically adjusted and unadjusted data.

Table 6 reports parameter estimates for Equation (2). Note that the dependent variable has been scaled by a factor of 100 for ease of interpretation. The key coefficient of interest is that on the dollar change in gross housing wealth variable. Regression (1) indicates an estimated MPC for new vehicle consumption out of gross housing wealth of 0.06 cents; regression (2), which includes region rather than state fixed effects gives a similar estimate. Regressions (3) and (4) provide equivalent median regression estimates and indicate similar MPCs.[14] These direct

13 The average price of a new passenger vehicle can be estimated by dividing household final consumption expenditure – purchase of vehicles in the national accounts by the total number of sales to private buyers, sourced from VFACTS. These data indicate an average new passenger vehicle price of $38 900 in 2006 and $33 200 in 2011. The use of national accounts data to estimate an average vehicle price is problematic because the consumption measure includes dealer margins on sales of used vehicles to households, upwardly biasing our estimate. We view the change in average price between 2006 and 2011 to also be implausibly large. The CPI motor vehicles price index indicates only a 4.4 per cent decline over the same period, part of which represents estimated quality change rather than lower retail prices. To estimate a lower-bound on the average price of a new passenger vehicle, we take a sales-weighted average of prices for the top-selling passenger vehicles in 2014, using the base model list price for each vehicle type. This gives an average price of about $24 300. In the absence of alternative data we assume, somewhat arbitrarily, an average price for new passenger vehicles of $30 000 in both 2006 and 2011 – roughly the midpoint of the different estimates. If our estimate is too small, our MPC estimates should be scaled up proportionately, and vice versa.

14 It is perhaps surprising that the estimated MPC for new passenger vehicles out of a dollar change in postcode-level income is not close to unity. Individual-level transitory income shocks should cancel out at the postcode level, revealing an almost one-to-one relationship between consumption and income. Two factors likely account for the small estimated MPC out of income. Firstly, we have included a range of control variables correlated with income, such as the unemployment rate. Secondly, while measurement error in incomes is likely to be small relative to the level of income, it is likely to be large relative to changes in incomes over a five-year period, attenuating the coefficient on the income variable. Some measurement error arises because the Census collects income data as a categorical rather than a continuous variable.

estimates of average MPCs are smaller than, but similar to, the MPC implied by our elasticity estimates.

Critically, these estimated average MPCs mask substantial heterogeneity by household income. Regressions (5) and (6) augment regressions (1) and (2) with an interaction between the dollar change in gross housing wealth and household median income. The interaction term is negative, and statistically significant, indicating that low-income households are more likely to purchase a new vehicle out of a dollar change in gross housing wealth than high-income households. Using the regression estimates, Figure 4 graphs the estimated MPC for different levels of postcode-level household median income, assuming the same purchase price for vehicles across postcodes. The estimated MPC for new vehicles per dollar change in gross housing wealth is 0.12 cents for a postcode at the 25th percentile of income, 0.10 cents at the 50th percentile, and 0.03 cents at the 95th percentile. Using postcode-level mean rather than median household income gives similar estimates (see regressions (1) and (2) in Table A1). As a caveat, note that the lower propensity of high-income households to purchase a new vehicle out of an increase in housing wealth could be partly offset by high-income households purchasing relatively expensive vehicles. Unfortunately, we do not have data on average new vehicle purchase price by postcode. However, differences in average purchase prices would have to be large to offset the large differences in propensity to purchase a new vehicle out of housing wealth.

Heterogeneity in MPCs means that the aggregate MPC is different to an unweighted average of MPCs across households. A given economy-wide percentage change in house prices results in much larger dollar changes in housing wealth for high- than low-income households, because high-income households tend to own higher-valued homes.[15] Despite this, high-income households contribute relatively little to aggregate consumption growth because they have a low MPC out of housing. Below-median income households have a high MPC, but

15 The positive association between income and house value and the estimated decline in MPC with income together imply that the MPC is highest in postcodes with low average house value. A direct way to see this is to replace the income interaction term for regressions (5) and (6) in Table 6 with an interaction between the dollar change in housing equity and the level of house prices. Regressions (5) and (6) in Table A1 show that this term is negative, and statistically significant.

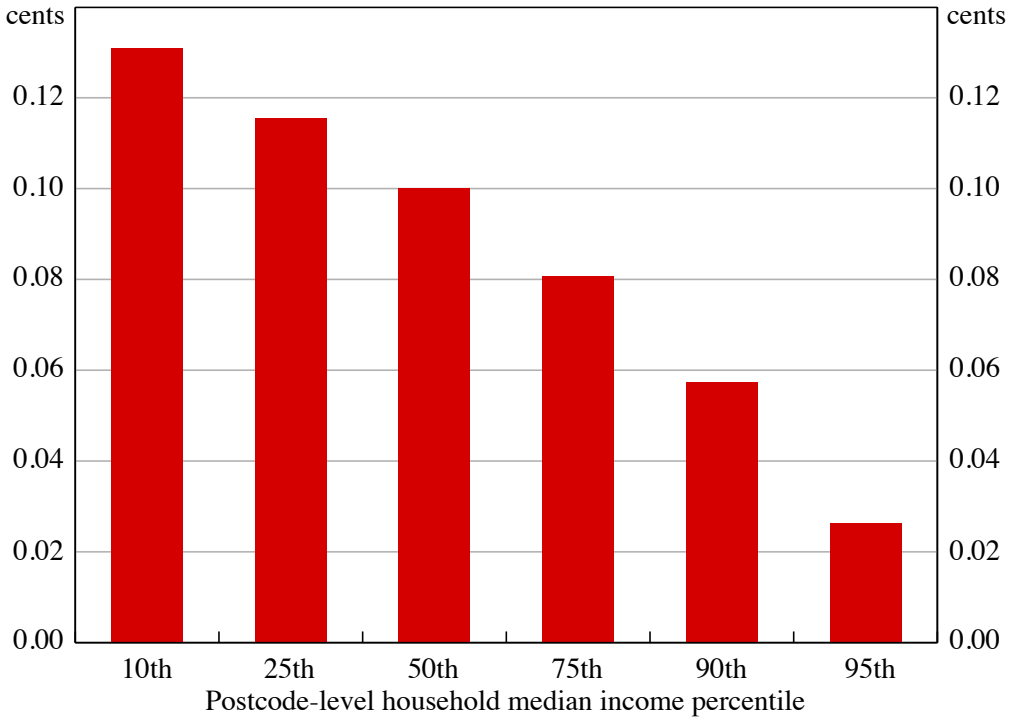
Table 6: MPC out of a Change in Gross Housing Wealth

Dep variable: 100 × dollar change in new passenger vehicle consumption, 2006 to 2011, $'000

	OLS	OLS	Median	Median	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
$hp_{2006} * s^{own}_{2006}$	−0.017	−0.013	−0.024*	−0.022**	−0.011	−0.008
	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)
$\Delta hp_{2006-11} * s^{own}_{2006}$	0.060***	0.061***	0.071***	0.064***	0.199***	0.201***
	(0.021)	(0.022)	(0.020)	(0.019)	(0.061)	(0.063)
$\Delta hp_{06-11} * s^{own}_{06} * medinc_{06}$					−0.001**	−0.001**
					(0.001)	(0.001)
$\Delta medinc_{2006-11}$	0.296**	0.291*	0.176	0.062	0.284*	0.279*
	(0.150)	(0.158)	(0.117)	(0.103)	(0.148)	(0.156)
$\Delta s^{own}_{2006-11}$	−0.855	−0.909	−0.477	−0.577	−0.736	−0.795
	(0.545)	(0.558)	(0.502)	(0.450)	(0.536)	(0.549)
$\Delta repay_{2006-11}$	1.068	1.384	1.272	1.605	1.363	1.637
	(1.998)	(2.303)	(1.926)	(1.724)	(1.972)	(2.259)
$\Delta ur_{2006-11}$	−0.670	−0.969	−0.729	−1.027	−0.413	−0.712
	(1.557)	(1.446)	(1.508)	(1.330)	(1.553)	(1.449)
$medinc_{2006}$	0.001	−0.007	−0.141	−0.129	0.197	0.202
	(0.134)	(0.151)	(0.113)	(0.102)	(0.160)	(0.188)
s^{own}_{2006}	−0.232	−0.264	−0.059	0.020	−0.329	−0.353*
	(0.195)	(0.184)	(0.178)	(0.169)	(0.200)	(0.188)
$repay_{2006}$	−1.534	−1.507	−0.397	−0.869	−1.376	−1.369
	(0.937)	(0.997)	(0.841)	(0.738)	(0.914)	(0.965)
ur_{2006}	−1.690**	−1.635*	−1.981**	−1.975***	−1.217	−1.164
	(0.848)	(0.946)	(0.770)	(0.696)	(0.866)	(0.984)
$Bachelor_{2006}$	−0.685**	−0.629	−0.301	−0.130	−0.722**	−0.679*
	(0.334)	(0.383)	(0.268)	(0.240)	(0.335)	(0.387)
$TAFE_{2006}$	−1.402	−1.087	−1.973*	−2.104**	−1.629	−1.336
	(1.460)	(1.549)	(1.048)	(0.966)	(1.428)	(1.504)
$Distance$	0.155	0.231**	0.093	0.186	0.245**	0.316***
	(0.114)	(0.115)	(0.119)	(0.115)	(0.118)	(0.121)
$Waterfront$	2.689	2.408	3.004	2.567	2.803	2.621
	(2.298)	(2.499)	(2.436)	(2.206)	(2.315)	(2.525)
Observations	498	498	498	498	498	498
R^2	0.240	0.242			0.250	0.252
Pseudo R^2			0.167	0.186		
Region fixed effects		Yes		Yes		Yes
State fixed effects	Yes		Yes		Yes	

Notes: See Table A2 for a description of each regression variable; ***, **, and * indicate statistical significance at the 1, 5, and 10 per cent levels, respectively; robust standard errors in parentheses

Figure 4: **MPC for New Passenger Vehicles per Dollar Change in Gross Housing Wealth**
By percentile



Sources: ABS; APM; Authors' calculations

own a relatively small share of the housing stock by value, and so make a smaller contribution to aggregate consumption growth than their numbers would suggest.

Much of the existing literature has emphasised heterogeneity in MPCs by household age, rather than income (e.g. Browning *et al* 2013; Windsor *et al* 2013). The heterogeneity in MPC by income that we identify is not a result of age being an omitted variable. While there is a strong correlation between age and income at the household level, at the postcode level – our unit of observation – the correlation between average age and median income is low. Including categorical age dummies as additional explanatory variables has a small effect on the estimated heterogeneity in MPC by income class (see regressions (3) and (4) in Table A1).[16]

16 The MPC for middle-age (41–55 years of age) households is estimated to be a little larger than for young (23–40 years of age) and old households (55 and over), but the lack of variation in average age across postcodes means that the effect is imprecisely estimated.

7. Aggregate Implications and Relation to the Literature

Our findings are most comparable to Mian *et al* (2013) and Mian and Sufi (2014), who also use geographic variation to identify housing wealth effects. During the 2006 to 2009 collapse in US house prices, Mian *et al* (2013) estimate an MPC per dollar change in housing wealth for new motor vehicle consumption alone of 2.3 cents. Mian and Sufi (2014) estimate a smaller but still large MPC out of housing wealth for motor vehicles of 1.6 cents during the 2002 to 2006 boom in US house prices. In contrast, our directly estimated average MPC for new passenger vehicle consumption is 0.06 cents per dollar change in gross housing wealth, and the MPC implied by our elasticity estimate is 0.17 cents. Features specific to the 2002 to 2009 US house price cycle may account for the much larger US estimates. The collapse in house prices over the 2006 to 2009 period was unusually large, and the United States entered a deep and prolonged recession in 2008, both of which may have amplified the usual effect of housing wealth on consumption. Mian and Sufi (2014) show that, during the boom phase, households with low credit scores aggressively liquefied housing wealth. They also find that spending out of housing wealth was concentrated in low-income postcodes.

We can impute an aggregate MPC out of housing wealth by making an assumption on the relative size of the MPCs for new passenger vehicles and total consumption. If the MPCs out of housing wealth are the same for new vehicle and other consumption, we can simply scale our estimated MPC by the ratio of aggregate consumption to new passenger vehicle consumption. Doing so implies an MPC of 2 cents per dollar change in gross housing wealth. (New passenger vehicle consumption is 2.9 per cent of household final consumption expenditure.[17]) We view this as an upper bound on the MPC for total consumption. For the United States, Mian *et al* (2013) estimate that spending on motor vehicles accounts for 43 per cent of the overall MPC out of housing wealth, despite new vehicles being a small share of total consumption. The relatively large MPC out of housing wealth for motor vehicles is consistent with the importance of access to credit for the purchase of durable goods.[18] The MPC estimates by consumption category in Mian *et al* (2013) imply an aggregate MPC in Australia of only 0.14 cents

17 This represents an average over the period since 2000.

18 Parker *et al* (2013) estimate the 2008 stimulus payments in the United States to have had a relatively large effect on auto spending.

per dollar increase in gross housing equity (multiply the MPC of 0.06 cents for new passenger vehicle consumption by 1/0.43). Given that Mian *et al* (2013) provide the only available information on the sensitivity of different components of consumption to a change in housing wealth, this is our best estimate of the MPC for total consumption. Accordingly, we view an MPC for total consumption of 2 cents as an upper bound but, based on the evidence from Mian *et al* (2013) that new vehicle consumption is particularly sensitive to housing wealth, our results suggest that the MPC for total consumption is likely be less than 0.25 cents per dollar change in gross housing wealth.

The MPC for total consumption implied by our work is smaller than most prior Australian research. Using the HILDA Survey, Windsor *et al* (2013) estimate an MPC of 3–4 cents per dollar change in house prices for younger home owners in Australia, which they interpret as evidence of a collateral constraints channel. In contrast to Mian *et al* (2013), they estimate similar MPCs out of housing wealth for durable and non-durable consumption. Their MPC estimates for non-durable consumption are surprisingly large, and may reflect the use of self-reported consumption data. Based on a panel of Australian states, Dvornak and Kohler (2007) estimate a similar MPC to Windsor *et al* (2013), reporting that a permanent one dollar increase in housing wealth raises annual consumption by around 2.5 cents. In contrast to both Windsor *et al* (2013) and Dvornak and Kohler (2007), we have followed Mian *et al* (2013) in estimating the relationship between housing wealth and consumption in differences rather than levels form. We suggest that estimates in levels form are likely to overestimate the magnitude of the relationship between house prices and consumption because they do not difference out or adequately control for economy-wide trends in current and expected incomes that independently affect both house prices and consumption. Thus our different methodology may explain why our estimates are small in the context of the existing Australian literature.

Fisher, Otto and Voss (2010) find more mixed evidence. They estimate that a transitory component accounts for a large share of the variation in housing wealth, using the cointegration technique developed by Lettau and Ludvigson (2003), and in the pre-2004 period find little evidence of a relationship between transitory variation in housing wealth and consumption. They find some evidence of a relationship between housing wealth and consumption in the post-2004 period, but caution that evidence of cointegration is weak.

8. Conclusion

We have used postcode-level variation in house prices and new passenger vehicle registrations to investigate the relationship between house prices and consumption. We make use of a rich set of control variables, such as postcode-level income growth and unemployment rates, to help identify the direct effect of housing wealth on consumption. The use of new passenger vehicle registrations as a consumption measure is dictated by our identification strategy, but we nonetheless believe it is well-suited to identifying the relationship between housing wealth and consumption. Vehicle registration data are comprehensive and are measured with minimal error. Furthermore, US evidence indicates that consumption of new vehicles is one of the most prominent uses of housing wealth.

We have identified a robust cross-sectional relationship between changes in housing wealth and new vehicle registrations. In our preferred specification, we estimate an elasticity of new passenger vehicle registrations with respect to gross housing wealth of 0.4–0.5, and we estimate an average MPC for new passenger vehicles of about 0.06 cents per dollar change in gross housing wealth. Our estimated MPC for new vehicles is much smaller than comparable US estimates for the 2002 to 2009 period, possibly because changes in lending standards and the financial crisis amplified the usual relationship between housing wealth and consumption.

Assuming new vehicle and total consumption have the same sensitivity to changes in housing wealth implies an MPC for total consumption of 2 cents per dollar change in gross housing wealth. But US evidence indicates that new vehicle consumption is particularly sensitive to changes in housing wealth. Assuming the same is true for Australia, our estimates imply an MPC for total consumption of less than 0.25 cents. This contrasts with existing Australian research, which has tended to find MPCs for total consumption in the 2–4 cent range.

Notably, the estimated relationship between new vehicle registrations and housing wealth is about four times larger at the 25th percentile of the income distribution than at the 95th percentile. Thus, the effect on aggregate consumption of a change in housing wealth depends on its distribution across income groups. We believe this is the first evidence outside of the United States of heterogeneity in MPCs by income group for housing wealth.

Appendix A: Additional Results

Table A1: MPC out of Housing Wealth – Additional Results

Dep variable: 100 × dollar change in new passenger vehicle consumption, 2006 to 2011, $'000

(*continued next page*)

	(1)	(2)	(3)	(4)	(5)	(6)
$hp_{2006} * s^{own}_{2006}$	−0.010	−0.007	−0.009	−0.007	−0.014	−0.010
	(0.011)	(0.012)	(0.010)	(0.012)	(0.010)	(0.011)
$\Delta hp_{2006-11} * s^{own}_{2006}$	0.240***	0.244***	0.228	0.293	0.100***	0.101***
	(0.081)	(0.088)	(0.206)	(0.224)	(0.031)	(0.032)
$\Delta hp_{2006-11} * s^{own}_{06} * medinc_{06}$			−0.002**			
			(0.001)			
$\Delta hp_{2006-11} * s^{own}_{06} * meaninc_{06}$	−0.002**	−0.002**		−0.002**		
	(0.001)	(0.001)		(0.001)		
$\Delta hp_{2006-11} * s^{own}_{06} * hp_{06}$					−0.000*	−0.000*
					(0.000)	(0.000)
$\Delta hp_{2006-11} * s^{own}_{06} * young_{06}$			−0.060	−0.073		
			(0.263)	(0.255)		
$\Delta hp_{2006-11} * s^{own}_{06} * old_{06}$			−0.010	−0.052		
			(0.262)	(0.268)		
$\Delta medinc_{2006-11}$			0.279*		0.302**	0.297*
			(0.158)		(0.150)	(0.158)
$\Delta meaninc_{2006-11}$	0.169	0.164		0.156		
	(0.338)	(0.349)		(0.358)		
$\Delta s^{own}_{2006-11}$	−0.661	−0.720	−0.823	−0.754	−0.869	−0.925*
	(0.563)	(0.592)	(0.559)	(0.601)	(0.546)	(0.559)
$\Delta repay_{2006-11}$	1.099	1.461	1.627	1.470	1.282	1.573
	(2.129)	(2.424)	(2.287)	(2.436)	(1.993)	(2.287)
$\Delta ur_{2006-11}$	−0.658	−0.874	−0.799	−0.958	−0.571	−0.874
	(1.593)	(1.510)	(1.481)	(1.521)	(1.554)	(1.446)
$medinc_{2006}$			0.208		0.036	0.030
			(0.181)		(0.139)	(0.158)
$meaninc_{2006}$	0.167	0.173		0.167		
	(0.229)	(0.295)		(0.286)		
s^{own}_{2006}	−0.294	−0.318*	−0.376*	−0.339	−0.274	−0.301
	(0.205)	(0.189)	(0.209)	(0.207)	(0.195)	(0.183)
$repay_{2006}$	−1.039	−1.046	−1.242	−0.983	−1.452	−1.430
	(1.057)	(1.113)	(1.154)	(1.217)	(0.929)	(0.984)

Table A1: MPC out of Housing Wealth – Additional Results

Dep variable: 100 × dollar change in new passenger vehicle consumption, 2006 to 2011, $'000

(*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)
ur_{2006}	−1.524	−1.497	−1.237	−1.584	−1.541*	−1.478
	(0.981)	(1.175)	(1.024)	(1.175)	(0.855)	(0.959)
$Bachelor_{2006}$	−0.643*	−0.595	−0.657	−0.572	−0.702**	−0.651*
	(0.356)	(0.427)	(0.414)	(0.442)	(0.335)	(0.386)
$TAFE_{2006}$	−1.755	−1.526	−1.414	−1.579	−1.495	−1.180
	(1.426)	(1.456)	(1.576)	(1.514)	(1.453)	(1.537)
$Distance$	0.219	0.288**	0.307**	0.282**	0.177	0.251**
$\Delta hp_{2006-11} * s_{06}^{own} * meaninc_{06}$	(0.135)	(0.132)	(0.125)	(0.134)	(0.114)	(0.116)
$Waterfront$	2.363	2.151	2.653	2.173	3.113	2.844
	(2.337)	(2.525)	(2.533)	(2.535)	(2.333)	(2.533)
Observations	498	498	498	498	498	498
R^2	0.239	0.241	0.252	0.242	0.243	0.245
Region fixed effects		Yes	Yes	Yes		Yes
State fixed effects	Yes				Yes	

Notes: See Table A2 for a description of each regression variable; ***, **, and * indicate statistical significance at the 1, 5, and 10 per cent levels, respectively; robust standard errors in parentheses

Table A2: Description of Regression Variables

hp_{2006}	Average unadjusted dwelling price in postcode *i* in 2006 ($'000)
lhp_{2006}	Average of the log of hedonically adjusted dwelling price in postcode *i* in 2006
$medinc_{2006}$	Median per annum income in postcode *i* in 2006 ($'000)
$meaninc_{2006}$	Mean per annum income in postcode *i* in 2006 ($'000)
s_{2006}^{own}	Share of households who own a dwelling in postcode *i* in 2006, equal to $\left(s_{2006}^{mort} + s_{2006}^{outright}\right)$
s_{2006}^{rent}	Share of households who rent in postcode *i* in 2006
s_{2006}^{mort}	Share of households who own a dwelling with a mortgage in postcode *i* in 2006
$s_{2006}^{outright}$	Share of households who own a dwelling without a mortgage in postcode *i* in 2006
$repay_{2006}$	Average repayment-to-income ratio for mortgagors in postcode *i* in 2006
ur_{2006}	Unemployment rate in postcode *i* in 2006
$Bachelor_{2006}$	Share of people with a bachelor's degree or higher in postcode *i* in 2006
$TAFE_{2006}$	Share of people with a certificate qualification in postcode *i* in 2006
$Distance$	Distance of postcode *i* to the nearest CBD
$Waterfront$	Indicator for whether postcode *i* is situated next to a waterfront
$Young_{2006}$	Share of people aged between 23 and 40 in postcode *i* in 2006
Old_{2006}	Share of people aged over 55 in postcode *i* in 2006

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