Department of Economics, University of Warwick

Monash Business School, Monash University

as part of

Monash Warwick Alliance

The effect of housing costs on household transportation

Faye Khammo

Warwick-Monash Economics Student Papers

March 2023 No: 2023/44

ISSN 2754-3129 (Online)

https://warwick.ac.uk/fac/soc/economics/research/wmesp/

Recommended citation: Khammo, F. (2023). The Effect of Housing Costs on Household Transportation. *Warwick Monash Economics Student Papers* 2023/44.

[1] Warwick Economics would like to thank Lory Barile, Gianna Boero, and Caroline Elliott for their contributions towards the selection process.

The Effect of Housing Costs on Household Transportation

Faye Khammo[*]

Abstract

We use individual-level panel data from Australia and a novel fixed-effect instrumental variable approach to estimate the causal effect of housing cost on five measures of household transportation; work commute time, relocation, and the respective expenditure share on motor vehicle fuel, public transport and taxi, and total transportation. The instrumental variable exploits arguably exogenous variation in housing costs induced by foreign investments that flow differentially into regions according to the past geographical distribution of immigrants. We find that rises in housing costs, measured by the composite opportunity costs faced by representative renters and owners living in an area, increase an individual's work commute time and the probability of relocation, and lead to a shift in the individual's expenditure away from fuel towards public transportation.

Keywords: Housing cost; Transportation cost; Commute time; Household relocation; Transportation expenditure; Transportation mode

JEL classifications: R20; R21; R40; F21

[*]Contact information: fayekhammo@outlook.com

Acknowledgments: I am extremely grateful to my supervisor, Liang Choon Wang, for his dedicated support and guidance. I am also grateful to Vinod Mishra, and seminar participants at Monash University, for their feedback and helpful suggestions. I thank Liang Choon Wang and Jun Sung Kim for providing data that contributed to this paper.

This paper uses unit record data from Household, Income and Labour Dynamics in Australia Survey [HILDA] conducted by the Australian Government Department of Social Services (DSS). The findings and views reported in this paper, however, are those of the author and should not be attributed to the Australian Government, DSS, or any of DSS' contractors or partners.

This paper uses data supplied by Securities Industry Research Centre of Asia-Pacific (SIRCA) on behalf of RP Data.

1. Introduction

The housing-transport affordability crisis is a major global economic issue. Growth in household expenditure share on housing and transportation has persisted over the past decade - on average, reaching over one third of total household expenditure in the European Union and Organisation for Economic Co-operation and Development (OECD) countries (OECD, 2019). Existing studies suggest that the housing crisis may be generating spillover effects, adversely influencing other housing-associated costs including commuting time, transportation expenditure, and household relocation – in particular, affecting vulnerable groups in society from low socio-economic backgrounds (Li, Dodson & Sipe, 2018; Mitra & Saphores, 2019; Winke, 2021). If rising housing costs exacerbate transportation costs, there are important policy implications regarding the distribution of low-cost transportation access for the affected households, to more effectively reduce the stress and financial burden they face (Jin, Kim, & Jin, 2022; Vidyattama, Tanton, & Nepal, 2013). However, given that housing and transportation costs influence each other, empirically identifying the effect of housing costs on transportation is particularly challenging.

This paper investigates the causal effect of housing costs on various measures of household transportation - work commute time, relocation, and the respective expenditure share on fuel, public transport and taxi, and total transportation. To address potential reverse causality and identify this causal relationship, we contribute to the literature by introducing a novel fixed-effect instrumental variable approach. Using individual-level panel data from Australia and focusing primarily on outcomes of native-born individuals, we exploit arguably exogenous variation in housing costs which are driven by foreign investments from various countries that flow differentially into local government areas (LGA) according to the past settlement patterns of immigrants from these countries. The instrument relies on the tendency for foreign investors to invest in LGAs with a greater share of immigrants from their home country. In particular, non-resident foreign investors exhibit country-of-origin bias in their locations of real estate investment (Badarinza & Ramadorai, 2018), while real estate agents in areas with large enclaves of immigrants tend to tailor their services to these foreign investors (Rogers, Lee, & Yan, 2015). Our instrumental variable provides arguably exogenous variation in housing costs because our FE-IV approach, after controlling for individual fixed effects, utilises historical settlement patterns of immigrants to distribute national-level foreign investments into different LGAs and focuses on Australian-born individuals who are less likely to directly affect or be directly affected by national-level foreign investments into Australia.

This paper contributes to the literature on the spillover effects of housing cost changes by using a composite housing cost measure to capture the representative opportunity cost that both owners and renters face for living in a particular housing market. The composite housing cost weights the average market prices for rent and average market mortgage repayment costs by the share of renters and owners in each LGA, respectively. While a branch of prior literature uses average property prices as a measure of housing costs, it ignores the costs faced by renters (e.g. Atalay, Edwards, & Liu, 2017; Mitra & Saphores, 2019; Tsai, 2018). Similarly, papers using rental prices ignore the costs for mortgagors and owners (e.g. Mattingly & Morrissey, 2014; Winke, 2021). More importantly, rental price is a flow measure capturing the ongoing cost of housing for renters, while property price itself is not a flow measure capturing the ongoing cost of housing for owners. Thus, the composite housing cost provides a more generalisable measure of the ongoing opportunity cost of housing for a representative person living in a particular housing market.

Australia provides a particularly suitable setting for us to examine the causal effect of housing costs on various measures of household transportation for several reasons. Firstly, our study relies on data collected from an Australian longitudinal panel data set - the Household Income and Labour Dynamics in Australia (HILDA) survey - spanning 18 years when Australia experienced significant growths in housing prices and transportation costs. Specifically, the data set provides several comprehensive measures of transportation at the individual-level; work commute time, relocation behaviour, and household expenditure on different modes of transportation. The panel also enables us to include individual fixed effects to control for time-invariant characteristics across individuals in the sample. Secondly, Australia has a relatively open foreign investment policy as well as a diverse set and large share of immigrants, which provide an ideal setting for our instrumental variable. In particular, with respect to the property market, foreign investors can purchase land to build a new dwelling, redevelop an existing dwelling or purchase newly built dwellings, upon approval from the Foreign Investment Review Board (FIRB) (Gauder, Houssard, & Orsmond, 2014). Moreover, there is a diverse immigrant population in Australia, being home to overseas-born individuals from over 200 countries, who comprise 29% of the entire population (Australian Bureau of Statistics [ABS], 2022). These characteristics allow for sufficient flow of foreign investment and variation in immigrant composition across LGAs for the instrument to predict housing costs.

Our main findings reveal significant effects on commute time, relocation, and expenditure share on specific transportation modes, in response to a rise in housing costs in a given LGA. Specifically, we find that work commute time and the probability of an individual relocating both increase in response to housing cost increases. When we separately examine households that relocated since the previous year, and those who have not relocated, we find that in response to rising housing costs, relocators experience a greater increase in work commute time compared to non-relocators. The analyses of transportation expenditure show that individuals are shifting away from motor-vehicle transportation towards public transport and taxi as housing costs rise. The heterogeneity analysis highlights that individuals with a lower level of education face larger effects of housing costs on transportation costs compared to highly educated individuals.

A central theme in the existing literature is the trade-off between housing and transportation costs incurred by households - greater affordability for one is strongly associated with weaker affordability for the other. Specifically, regions with more developed transportation infrastructure are associated with higher housing costs, due to the attractiveness of transport accessibility, while areas with worse transportation infrastructure that are further away from the employment centres tend to have lower housing costs (Renne, Tolford, Hamidi, & Ewing, 2016; Saberi, Wu, Amoh-Gyimah, Smith, & Arunachalam, 2017; Schouten, 2021). Although past papers highlight the negative correlation between housing and transport affordability, the channels through which the relationship transpires are ambiguous. We contribute to the literature by identifying a unidirectional causal impact of housing costs on household transportation costs, by employing the instrumental variable approach. Another branch of literature provides evidence of the potential for reverse causality: the effect of transportation infrastructure improvements on real estate prices, showing that premiums on property values increase in response to transportation infrastructure developments (Agostini & Palmucci, 2008; Bao, Larsson, & Wong, 2021; Liang, Koo & Lee, 2021). Indeed, we find that the pooled OLS and fixed-effect estimations substantially underestimate the negative effect of housing costs on transportation costs compared to the FE-IV estimation. Thus, the effect of transportation infrastructure on housing prices may be dampening the effect of the relationship under investigation - highlighting the importance of our identification strategy.

A strand of housing-transport literature also investigates the causal effect of rising housing costs on specific transportation measures. For example, Mitra & Saphores (2019) use structural equation modelling to study the causal relationship between median home values and the likelihood of long commuting time using one year's data. Similarly, using a difference-in-differences approach, Winke (2021) examines the causal effect of local rental prices on household relocation behaviour. Winke (2021) finds that more expensive housing may lead households to relocate to lower-cost housing regions further away from the city and with poorer transportation infrastructure - while Mitra & Saphores (2019) suggest households living in lower housing cost regions are more likely to commute long distances. We advance this strand of literature by examining several measures of transportation, including work commute time, relocation, and household expenditure shares on different modes of transportation with the help of a novel fixed-effect instrumental approach and the composite housing cost measure.

2. Data

To estimate the effect of housing costs on transportation, we utilise data from several sources. We use the Household Income and Labour Dynamics in Australia (HILDA) longitudinal panel dataset for individual-level data on five measures of transportation outcomes – average weekly work commute hours, household relocation since the previous year, expenditure share on motor vehicle fuel, expenditure share on public transport and taxi, and total transport expenditure share. The main period of interest in this study begins from 2002, when HILDA started collecting transport variables. Commute time and relocation variables are available from 2002 onwards, while expenditure variables are available from 2005 onwards. To calculate household expenditure share on transportation, we first sum the total annual household-level non-housing expenditure in several categories including motor vehicle fuel, public transport and taxi, groceries, alcohol, tobacco, clothing, education, utilities, insurance, and healthcare. We then take the expenditure on motor vehicle fuel, public transport and taxi, and total transport expenditure, to create three different variables for their respective shares of total expenditure.

The key explanatory variable is the composite housing cost, which was introduced by Saberi et al. (2017). The composite housing cost is the sum of two components, the rental and mortgage components, representing the average housing cost for a household living in a given LGA and year. The rental component weights the average market rent faced by households by the share of renters, for the given LGA and year – where the average market rental cost is the mean annual rental cost of residential property. The mortgage component weights the average market mortgage cost by the share of ownership - where the average market mortgage cost is the product of the mean mortgage rates and the mean residential property price. Note that we include households that are either mortgagors or outright owners in the share of ownership. An outright homeowner does not pay any explicit rent or mortgage repayment; however, the market interest cost on the average property price measures the opportunity cost of full homeownership in the LGA in a particular year. Similarly, this opportunity cost is also what mortgagors face for living in the LGA in a particular year.

To construct the composite housing cost – we integrate data from several sources. First, CoreLogic property transaction data for each LGA and year from 2002 to 2019, sourced from the Securities Industries Research Centre of Asia-Pacific (SIRCA), provide the mean property price and mean rental price.[1] The prices are representative of the average market rent or purchase price faced by a household in a given LGA and year. Second, the Australian Bureau of Statistics' (ABS) census community profiles are used to provide data on the number of property renters and owners for every LGA in Australia. We use the tenure data to construct the respective share of renters and owners for each LGA and year, which are used as weights in the composite measure. Since our study is based on annual level data, and census data is only available at the quinquennial frequency, we interpolate and extrapolate the Census data for the missing inter-Census years. Third, indicator lending rates sourced from the Reserve Bank of Australia (RBA) provide the monthly average mortgage rate from 2002 up to 2019. Specifically, the banks' standard variable owner-occupier rate is used to create an average annual national mortgage rate to form part of the composite housing cost measure. We use the variable rate as this is representative of the market interest rate. The owner-occupiers rate is used as we want to capture the cost of housing - not the cost of investment in the housing market. In order to convert the monthly mortgage data to annual level data, we average the mortgage rate over the relevant twelve-month period. Lastly, for an individual who relocated to a different LGA since the previous wave (approximately 14.5 percent of the sample), we use the current housing cost of their previous LGA from which they left, rather than the current housing cost of their current LGA, so that the housing cost they currently face is not

[1] We supplement the SIRCA rental data with Census and HILDA rental data for when SIRCA data are missing for certain LGAs in some years.

driven by their decision to relocate. Henceforth, we use the term, housing cost, to refer to the composite housing cost.

Our instrumental variable requires data from two key sources. First, we use the ABS' LGA census community profiles to collect information on the number of foreign-born individuals from every listed country in the census and the number of native-born individuals for 672 LGAs in Australia.[2] The country of birth of individuals in 1991 is used to calculate the historical immigrant settlement distribution across LGAs. More specifically, this is the share of total immigrants from a given country that are living in the given LGA in 1991. Second, we source foreign investment data from the ABS' international investment position time series data from 2002 to 2019. Total foreign investment includes foreign direct investment, portfolio investment, financial derivatives and other investment.

3. Methodology

3.1 Empirical strategy

We are interested in estimating the following fixed-effect specification:

$$T_{ijt} = \beta \, ln \; H_{jt} \; + \pi_i + \gamma_t + \varepsilon_{ijt} \qquad (1)$$

The dependent variable, T_{ijt}, is the transportation cost faced by an individual i, in LGA j, in year t. We use five different outcome measures of transportation cost: average weekly work commute hours, household relocation since the previous year, expenditure share on motor vehicle fuel, expenditure share on public transport and taxi, and total transport expenditure share. The key explanatory variable, $ln \; H_{jt}$, is the logarithm of the housing cost faced on average by a household in a given LGA and year. The HILDA longitudinal panel data set enables us to control for any time invariant characteristics or preferences across individuals, by incorporating individual fixed effects (π_i). Time fixed effects (γ_t) are incorporated to control for changes occurring in the year t that have a uniform effect on all households in Australia, such as national-level price shocks. The time fixed effects address the issue of the estimated effects being driven by national-level policy shocks or general price level fluctuations (e.g. food and petrol price shocks). The error term ε_{ijt}

[2] Given that some LGA borders are inconsistent across census years, we merged some LGAs to produce LGAs with consistent borders for census years 1991 to 2016.

captures any other individual and LGA specific time-varying unobserved influences. We also use clustered standard errors at the LGA-level.

We are interested in β , which measures the change in transportation costs in response to a 100 percent change in housing costs. For the purpose of interpretation and relevance, we focus on $\beta \cdot 0.1$, to measure the change in transportation costs in response to a 10 percent change in housing costs. For the causal interpretation of β, the housing cost must be exogenous to other unobserved influences of transportation costs (i.e., ε). However, this assumption may not hold due to reverse causality. For example, transportation infrastructure improvements within an LGA over time can influence both the transportation and housing costs. Infrastructure improvements may likely impact transportation costs through reducing expenditure or commute time. The favourable infrastructure changes are likely to increase housing costs within the region, due to increased transport accessibility and therefore higher demand for housing in these regions. Therefore, lower transportation costs may lead to higher housing costs. Considering this example, the fixed effect estimates are likely to underestimate the effects of housing cost on transportation costs. In sum, transportation costs and housing costs are likely to be jointly determined, which may introduce endogeneity bias if Equation (1) is estimated via a fixed effect estimator.

3.2 Identification strategy

To address potential endogeneity bias in the fixed-effect specification, we employ a fixed-effect instrumental variable approach by first constructing the following instrument for housing costs:

$$z_{jt} = ln \left[\sum_{c=1}^{n} \frac{F_{jc1991}}{F_{c199}} FI_{ct}\right] \qquad (2)$$

There are two key components to this instrument. Firstly, we define FI_{ct} as the total national-level foreign investment in Australia from foreign country c in year t. Recall that foreign investment includes direct investment, portfolio investment, financial derivatives, and other investment. Therefore, the purchase of property and the establishment of a new business in Australia are captured by this measure. As reported by the Department of Foreign Affairs and Trade (2022), real estate activities are the second largest Australian industry attracting foreign investment. Thus, we expect foreign investment to have a strong influence on housing market prices. Secondly, we compute the share of total immigrants born in country c that are living in LGA j for census year

1991, $\frac{F_{jc1991}}{F_{c1991}}$. We utilise the historical immigrant settlement distribution, instead of current immigrant settlement distribution, to avoid reverse causality.

The instrument essentially allocates the foreign investment from a given country c in year t into different LGAs based on the settlement patterns of immigrants from country c across LGAs back in 1991. According to this fixed allocation mechanism, the total foreign investment flow into a particular LGA j is the sum of the allocated foreign investment flows from a range of countries of origin. The instrument is based on the notion that foreigners invest in LGAs with greater shares of immigrants from their country. Foreign investors have a country-of-origin bias in their decisions for which regions to invest in, through a tendency for investment in regions where there is a greater share of immigrants from their background. A previous study by Badarinza and Ramadorai (2018) shows that this mechanism holds - foreign risk significantly affects housing prices in regions with a greater share of immigrants from the same country of origin as the investor. If this mechanism holds true in the context of our study, then we would see that foreign investment increases housing costs differentially across LGAs. Furthermore, local real estate agencies target foreign investors from countries with large local immigrant communities - mainly through cross-border internet communications, the employment of agents from the target immigrant background, and overseas travel, to directly reach the foreign investor market (Rogers et al., 2015). Given the catered real estate services to foreign investors, we expect housing costs to be especially sensitive to foreign investment flows.

For z_{jt} to serve as a valid instrument for housing costs, we also need z_{jt} to be conditionally exogenous. To satisfy the exogeneity condition, the instrument must only affect household transportation costs indirectly through housing costs. Firstly, it is reasonable to assume that at the individual level, people do not influence the level or distribution of national-level foreign investment in Australia. Secondly, we use the historical immigrant settlement as a fixed allocation mechanism to distribute national-level foreign investment across LGAs to avoid reverse causality. As we include individual fixed effects to control for time invariant characteristics of individuals, any influences of settlement decisions of immigrants that are potentially correlated with the unobserved influences of natives' transportation costs are also controlled for. Importantly, because we focus on the effects of housing costs on the transportation costs of Australian-born individuals, they are less likely to be directly affected by shocks to the foreign economies that influence foreign investment. Thirdly, foreign investment flows may also differentially affect transportation infrastructure across LGAs, such that areas attracting more investment may have greater improvements to their infrastructure. However, even if this holds true, it is unlikely that the level of transportation infrastructure would change within a year – as we particularly look at annual fluctuations in foreign investment, housing costs and transportation costs.

4. Results

4.1 Main results

Table 1 shows the estimates from the pooled Ordinary Least Squares (OLS) and fixed effects (FE) estimations for the effect of housing costs on work commute time, relocation, and expenditure share on motor vehicle fuel, public transportation and taxi, and total transportation, respectively. Note that the number of observations for the expenditure variables are different to observations for work commute time and relocation due to the expenditure variables only being available from 2005 onwards. Panel A reports the pooled OLS estimation including year fixed effects. We estimate a 7.4 minutes increase in weekly work commute time when an LGA's average housing cost rises by 10 percent. However, we do not find a statistically significant relationship between housing cost and relocation. Panel A shows a statistically significant relationship between housing cost and transportation expenditure shares. We interpret the results as a 0.2 percentage point decrease in motor vehicle fuel expenditure share and 0.1 percentage point increase in public transport and taxi expenditure share, when housing costs increase by 10 percent. We estimate that a 0.08 percentage point decrease in total transport expenditure share is associated with a 10 percent increase in housing costs.

Panel B of Table 1 reports the FE estimation including individual fixed effects in addition to year fixed effects. There is a statistically significant and positive relationship between housing cost and work commute time (p-value < 0.01). The estimate can be interpreted as an average 3.5 minutes increase in weekly work commute time when average housing costs increase by 10 percent in an LGA. Secondly, we estimate a statistically significant and positive relationship between housing cost and relocation, whereby a 10 percent increase in housing cost is associated with a 0.55 percentage point increase in the probability that an individual will relocate. Third, we find that as housing costs increase, expenditure share on fuel decreases, while expenditure share on public transport and taxi increases. These outcomes show that individuals shift their expenditure away from fuel and towards public transport. Furthermore, the results suggest that individuals are changing mode of transportation from motor vehicles to public transport when housing costs increase. In particular, a 10 percent increase in housing cost is associated with a 0.1 percentage point decrease in expenditure share on fuel and a 0.1 percentage point increase for public transport and taxi. Overall, transportation expenditure share decreases by 0.03 percentage points when housing cost increases by 10 percent.

[Table 1 here]

When we use the fixed-effect instrumental variable estimation, we obtain the results reported in Table 2. Panel B of Table 2 reports the first stage estimates as well as the Cragg-Donald F-statistics and Stock-Yogo weak identification test 10 percent critical value. The results show that the instrumental variable is a strong predictor of housing costs. The second stage results reported in panel A of Table 2 show that when we use an instrumental variable to deal with potential endogeneity, we find that the pooled OLS and FE estimates substantially underestimate the effect of housing cost on transportation costs. We find a statistically significant effect of housing costs on four measures of transportation costs. We estimate that a 10 percent increase in housing cost leads to a 13.6 minute increase in weekly work commute time. The FE-IV estimate is approximately four times greater than the FE estimate. Secondly, we find that the probability of an individual relocating increases by 1.44 percentage points in response to a 10 percent increase in housing cost. These findings may suggest that individuals experience a longer work commute time due to relocating in response to higher housing costs, possibly to a location further away with lower housing costs, as past studies such as Winke (2021) and Mitra and Saphores (2019) suggest.

Statistically significant effects are also found for the effect of housing cost increases on household expenditure share on different modes of transportation. In particular, we observe a 0.22 percentage point decrease in expenditure share on motor vehicle fuel, and a 0.16 percentage point increase in expenditure share on public transport and taxi. Our findings suggest that individuals are shifting their expenditure away from motor vehicles and towards public transport, which may be an alternative explanation for the longer work commute time given that public transport is the more time-consuming transportation mode. Lastly, Table 2 reports insignificant results for the effect of housing costs on total transportation expenditure share. A possible explanation is the decrease in motor vehicle fuel expenditure share is offset by the increase in public transport expenditure share, leading to no significant change in total transportation.

[Table 2 here]

4.2 Heterogeneity: Relocation

We extend our analysis further to investigate the heterogeneity in the effect of housing costs on transportation costs, to understand which groups are most impacted by rising housing costs. Our estimates for the effect of housing costs on work commute time and relocation suggest that relocation may be at least partially driving the increase in commuting time. Therefore, in Table 3 we extend the analysis to investigate the effect of housing cost on commute time for two restricted samples; (A) individuals who have relocated since the previous year, and (B) individuals who have the same address as the previous year.

On average, we find that individuals who have relocated since the previous year experience a 38.6 minute increase in their weekly work commute time in response to a 10 percent increase in housing costs in their LGA, compared to a 10 minute increase for individuals who have not relocated. Our reported results therefore suggest that relocators experience a greater increase in work commute time. The second stage estimates indicate that, in response to rising housing costs, only non-relocators decrease their expenditure share on motor vehicle fuel, and increase their expenditure share on public transport and taxi on average, while relocators do not experience a significant change in expenditure share for any specific mode of transport. These results suggest that individuals who do not relocate continue to bear the higher housing cost, and may consequently switch to lower-cost transportation modes to relieve the financial burden. Table 3 reports opposite effects of housing costs on total transportation expenditure share for relocators compared to non-relocators. On average, relocators experience an increase in total transport expenditure share of 0.4 percentage points, while non-relocators experience a decrease of 0.1 percentage points. Our findings may suggest that relocators are moving to areas further from work that have lower housing costs, leading to an overall increase in transportation expenditure share as they need to commute longer distances to get to work, for example. On the other hand, non-relocators experience a decrease in transport expenditure share as they do not change location, and shift their mode of transport away from cars towards a cheaper mode of transport, public transport, to help endure the burden of higher housing costs.

[Table 3 here]

4.3 Heterogeneity: Education level

Next, we extend our analysis of heterogeneous effects to differentiate between individuals with a high education and low education level, as reported in Table 4. We use the individual's education level in their initial year of joining the sample, and hold that level constant for all years in the analysis. Initial education level is used as a proxy for income and skill-level, as it is less endogenous in the context of our model.

Panel A of Table 4 reports the FE-IV estimates restricted to individuals with a high level of education. We define a highly educated individual as one who, as reported in their initial wave of joining the HILDA survey, has completed any level of education above high school; certificate III or IV, diploma, bachelor, or a postgraduate degree. We report the FE-IV estimates restricted to Australian-born individuals with a low level of education in Panel B of Table 4. We define an individual with a low level of education as one who reports high school or below as their highest level of education. Table 4 reports that the effect of housing costs on work commute time is greater for individuals with a lower level of education, who experience almost double the magnitude of the effect for highly educated individuals. We find that the effect of housing costs on relocation likelihood is insignificant for both high and low education levels. This may be due to the limitation of a smaller sample size when restricting the sample by relocation behaviour and education level.

In our analysis of heterogeneity across education levels for expenditure share on transportation, we find that the effect of housing price growth is greater in magnitude for lower educated individuals for both expenditure share on fuel and public transport and taxi. In particular, motor vehicle expenditure share decreases by 0.19 percentage points for highly educated individuals, compared to 0.2 percentage points for low educated individuals, in response to a 10 percent increase in housing prices. Public transport and taxi expenditure share increases by 0.06 percentage points for highly educated individuals, compared to almost triple the effect for low educated individuals, who on average experience a 0.17 percentage point increase, in response to a 10 percent increase in housing costs. Therefore, we find that the effect of housing costs rising on the shift from motor vehicle expenditure to public transport expenditure is greater for lower-educated individuals. This shift towards public transport may also explain the greater increase in commute time for lower-educated individuals compared to higher-educated individuals. We observe a smaller decrease in overall expenditure share on transportation for individuals with a low education level, which may be partially attributed to the greater relative increase in their expenditure on public transport and taxi. Overall, Table 4 reports that lower educated individuals face a greater transportation cost burden in response to housing cost increases, compared to higher educated individuals.

[Table 4 here]

4.4 Heterogeneity: Metropolitan and nonmetropolitan areas

We also examine whether there are heterogeneous effects of housing costs on transportation for individuals who live mostly in the metropolitan compared to non-metropolitan areas. Table 5 Panel A reports the FE-IV estimates restricted to individuals who, for the majority of the 18-year period, lived in metropolitan areas - Panel B reports the same for non-metropolitan areas. The results demonstrate no substantial heterogeneity in the effects of housing costs on work commute time across metropolitan and non-metropolitan regions – both groups experience increases in their work commute time. However, the estimates show that in response to rising housing costs, the probability of relocating decreases for individuals living in metropolitan areas, whereas this probability increases for individuals located in non-metropolitan regions. We also find that the shift away from motor vehicle transportation towards public transportation is greater for individuals living in metropolitan areas. The findings suggest that individuals living in non-metropolitan areas respond to rising housing costs by relocating, which may be driving their commute time increase, whereas those living in metropolitan areas turn to switching transportation modes to help bear the higher housing cost burden, also contributing to longer commute times.

[Table 5 here]

6. Conclusion

In this paper, we propose a novel fixed effect instrumental variable approach to identify the causal effects of housing costs on five measures of transportation costs – work commute time, relocation, and expenditure share on motor vehicle fuel, public transport, and total transport. Our identification strategy relies on the differential effects of foreign investment inflows on housing costs across LGAs that are channelled through the historical distribution of immigrants across LGAs. Our FE-IV results indicate that rises in housing costs lead to an increase in transportation costs in the form of longer work commute times and an increase in the likelihood to relocate. Furthermore, our results show that in response to higher housing costs, households reallocate their budget away from motor vehicle fuel expenditure towards public transport and taxi expenditure. These FE-IV estimates are much larger than those based on pooled OLS and FE estimators, suggesting that reverse causality is likely to be present in the OLS and FE estimators.

When examining heterogeneity in the causal effect, our findings highlight that households that relocate experience a greater increase in commuting time in response to higher housing costs. Our results also indicate that households who relocated experience an increase in their overall transportation expenditure share, potentially attributable to the longer commute distances after moving to lower cost housing areas. Non-relocators, on the other hand, experience a decrease in overall expenditure share on transport, which may be due to the reallocation of budget away from motor vehicle fuel to public transport, a lower-cost transportation mode. Furthermore, our results indicate that lower educated individuals are more impacted by the housing cost rises in the form of bearing the cost of longer commute times and a shift from motor vehicle transportation to public transportation. We find no heterogeneity in the effects of housing cost increases on the work commute time between individuals predominantly living in metropolitan and non-metropolitan areas - however the results demonstrate that non-metropolitan individuals are more likely to relocate in response to higher housing costs, whereas the probability of relocation decreases for metropolitan individuals.

One potential limitation of our study is the exogeneity of our instrumental variable, as there is no formal test to prove that the exclusion restriction is satisfied. One potential mechanism to consider is that foreign investment that differentially flows into LGAs across Australia may affect factors other than housing costs, such as economic activity, which may impact on households' incomes and therefore expenditure behaviour. There may also be concern that as foreign investment differentially flows into LGAs, the population size may also fluctuate differentially, leading to congestion in increasingly populated LGAs. Similarly, there may also be other time varying unobserved influences that are correlated with population size, such as time-varying local price responses driven by the market structure of an area. Future research investigating the effect of housing costs on transportation costs can expand on this paper by analysing the sensitivity of the relationship to differential fluctuations in population size at the LGA-level, and time-variant characteristics such as age and income. However, Kim and Wang (2022), investigating the differential effect of exchange rate fluctuations on local housing price growth, found that their results are similar after controlling for the effects of immigrant population inflows and macroeconomic variables.

Another potential limitation of this paper is that composite housing cost is measured with errors. For example, we use the market mortgage interest rate to capture the opportunity cost faced by outright homeowners, but in reality, the opportunity cost could be the market saving interest rate. We also ignore other potential costs incurred by homeowners, such as costs on renovations, repairs, and other maintenance. Future research can examine whether our results are sensitive to the accounting of these other costs. Nevertheless, as long as our instrument satisfies the exogeneity condition, our FE-IV approach addresses the potential estimation bias due to this measurement error problem in the explanatory variable.

There are policy implications from our findings of heterogeneity in the effects of housing cost growth on transportation costs – in particular, lower-educated individuals face higher transportation costs in the form of longer commute times and a greater shift in mode of transportation toward public transport. Therefore, transportation cost assistance in the form of public transport concessions directed towards lower-income individuals may assist with the management of an increase in public transport expenditure in response to higher housing cost burden. Furthermore, from the shift in expenditure share away from motor vehicle fuel, towards public transport, we gather a shift in mode of transportation. Therefore, if we consider that individuals are using more public transport in response to housing cost increases, the implementation of more frequent bus, tram, and train timetables, as well as the expansion of routes and transport infrastructure, would assist in decreasing transportation costs in the form of commute time and expenditure. Moreover, tax revenue collected from foreign investors, including stamp duty and foreign purchaser additional duty can be redistributed to partially fund the transport financial assistance to lower-income individuals and transport network improvements.

References

Agostini, C. A., & Palmucci, G. A. (2008). The Anticipated Capitalisation Effect of a New Metro Line on Housing Prices. *Fiscal Studies*, *29*(2), 233–256. https://doi.org/10.1111/j.1475-5890.2008.00074.x

Atalay, K., Edwards, R., & Liu, B. Y. J. (2017). Effects of house prices on health: New evidence from Australia. *Social Science & Medicine*, *192*, 36–48. https://doi.org/10.1016/j.socscimed.2017.09.008

Australian Bureau of Statistics. (2022, April 26). *Australia's Population by Country of Birth*. https://www.abs.gov.au/statistics/people/population/australias-population-country-birth/latest-release

Badarinza, C., & Ramadorai, T. (2018). Home away from home? Foreign demand and London house prices. *Journal of Financial Economics*, *130*(3), 532–555. https://doi.org/10.1016/j.jfineco.2018.07.010

Bao, H. X., Larsson, J. P., & Wong, V. (2021). Light at the end of the tunnel:The impacts of expected major transport improvements on residential property prices. *Urban Studies*, *58*(14), 2971–2990. https://doi.org/10.1177/0042098020967308

Department of Foreign Affairs and Trade. (2022, May). *Australian industries and foreign direct investment*. DFAT. https://www.dfat.gov.au/trade/resources/investment-statistics/australian-industries-and-foreign-investment

Foreign Investment Review Board. (2022). *Australia's Foreign Investment Policy*. Australian Government. https://firb.gov.au/sites/firb.gov.au/files/2022-06/Australias_Foreign_Investment_Policy-20220701.pdf

Gauder, M., Houssard, C., & Orsmond, D. (2014). *Foreign Investment in Residential Real Estate*. Reserve Bank of Australia. https://www.rba.gov.au/publications/bulletin/2014/jun/pdf/bu-0614-2.pdf

Jin, E., Kim, D., & Jin, J. (2022). Commuting time and perceived stress: Evidence from the intra- and inter-city commuting of young workers in Korea. *Journal of Transport Geography*, *104*, 103436. https://doi.org/10.1016/j.jtrangeo.2022.103436

Kim, J. S., Wang, L. C. (2022, August). *The Differential Effects of Exchange Rate Fluctuations on Local Housing Price Growth: Evidence from Australia.* Unpublished Manuscript.

Liang, J., Koo, K. M., & Lee, C. L. (2021). Transportation infrastructure improvement and real estate value: impact of level crossing removal project on housing prices. *Transportation*, *48*(6), 2969–3011. https://doi.org/10.1007/s11116-020-10157-1

Li, T., Dodson, J., & Sipe, N. (2018). Examining household relocation pressures from rising transport and housing costs – An Australian case study. *Transport Policy*, *65*, 106–113. https://doi.org/10.1016/j.tranpol.2017.03.016

Mattingly, K., & Morrissey, J. (2014). Housing and transport expenditure: Socio-spatial indicators of affordability in Auckland. *Cities*, *38*, 69–83. https://doi.org/10.1016/j.cities.2014.01.004

Mitra, S. K., & Saphores, J. M. (2019). Why do they live so far from work? Determinants of long-distance commuting in California. *Journal of Transport Geography*, *80*, 102489. https://doi.org/10.1016/J.JTRANGEO.2019.102489

The Organization for Economic Cooperation and Development. (2021). *Hc1.1 Housing-Related Expenditure of Households*. https://www.oecd.org/els/family/HC1-1-Housing-related-expenditure-of-households.pdf.

Renne, J. L., Tolford, T., Hamidi, S., & Ewing, R. (2016). The Cost and Affordability Paradox of Transit-Oriented Development: A Comparison of Housing and Transportation Costs Across Transit-Oriented Development, Hybrid and Transit-Adjacent Development Station Typologies. *Housing Policy Debate*, *26*(4–5), 819–834. https://doi.org/10.1080/10511482.2016.1193038

Rogers, D., Lee, C. L., & Yan, D. (2015). The Politics of Foreign Investment in Australian Housing: Chinese Investors, Translocal Sales Agents and Local Resistance. *Housing Studies*, *30*(5), 730–748. https://doi.org/10.1080/02673037.2015.1006185

Saberi, M., Wu, H., Amoh-Gyimah, R., Smith, J., & Arunachalam, D. (2017). Measuring housing and transportation affordability: A case study of Melbourne, Australia. *Journal of Transport Geography*, *65*, 134–146. https://doi.org/10.1016/j.jtrangeo.2017.10.007

Schouten, A. (2021). Residential Location and Household Spending: Exploring the Relationship Between Neighborhood Characteristics and Transportation and Housing Costs. *Urban Affairs Review*, 107808742110288. https://doi.org/10.1177/10780874211028814

Tsai, I. C. (2018). Housing price convergence, transportation infrastructure and dynamic regional population relocation. *Habitat International*, *79*, 61–73. https://doi.org/10.1016/J.HABITATINT.2018.07.004

Vidyattama, Y., Tanton, R., & Nepal, B. (2013). The Effect of Transport Costs on Housing-related Financial Stress in Australia. *Urban Studies*, *50*(9), 1779–1795. https://doi.org/10.1177/0042098012468342

Watson, N., &Wooden, M. P. (2012). The HILDA Survey: a case study in the design and development of a successful Household Panel Survey. *Longitudinal and Life Course Studies*. https://doi.org/10.14301/llcs.v3i3.208

Winke, T. (2021). Housing affordability sets us apart: The effect of rising housing prices on relocation behaviour. *Urban Studies*, *58*(12), 2389–2404. https://doi.org/10.1177/0042098020943482

Table 1: The effects of housing cost on household transportation - pooled OLS and fixed effects estimations

			Expenditure share		
	(1) Work commute time	(2) Relocation	(3) Motor vehicle fuel	(4) Public transport and taxi	(5) Total transport
A. Pooled OLS estimation					
ln(housing cost)	1.235***	-0.001	-0.020***	0.012***	-0.008
	(0.084)	(0.010)	(0.002)	(0.001)	(0.001)
Individual fixed effects	No	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	178,211	178,211	152,558	152,558	152,558
R-squared	0.020	0.000	0.042	0.031	0.019
B. Fixed effects estimation					
ln(housing cost)	0.581***	0.055***	-0.010***	0.008***	-0.003**
	(0.080)	(0.016)	(0.001)	(0.001)	(0.001)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	178,211	178,211	152,558	152,558	152,558
R-squared	0.003	0.005	0.027	0.004	0.020
Number of persons	19,152	19,152	17,906	17,906	17,906

Notes: Robust standard errors clustered at the LGA-level are reported in the parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 2: The effects of housing cost on household transportation - FE-IV estimation

			Expenditure share		
	(1) Work commute time	(2) Relocation	(3) Motor vehicle fuel	(4) Public transport and taxi	(5) Total transport
Second stage:					
ln(housing cost)	2.270***	0.144**	-0.022***	0.016***	-0.006
	(0.266)	(0.068)	(0.004)	(0.003)	(0.005)
First stage:					
IV- foreign investment	0.092***	0.092***	0.086***	0.086***	0.086***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Cragg-Donald F statistic	15357.41	15357.41	11825.81	11825.81	11825.81
Stock-Yogo 10% critical value	[16.38]	[16.38]	[16.38]	[16.38]	[16.38]
Observations	178,211	178,211	152,558	152,558	152,558
Number of persons	19,152	19,152	17,906	17,906	17,906

Notes: See Section 3 for a detailed description of how the foreign investment IV is constructed. Robust standard errors clustered at the LGA-level are reported in the parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 3: Heterogeneity – Relocators and non-relocators

		Expenditure share		
	(1)	(2)	(3)	(4)
	Work commute time	Motor vehicle fuel	Public transport and taxi	Total transport
A. Relocators				
Second stage:				
ln(housing cost)	6.437***	0.019	0.023	0.041*
	(1.221)	(0.020)	(0.014)	(0.025)
First stage:				
IV-foreign investment	0.025***	0.020***	0.020***	0.020***
	(0.003)	(0.003)	(0.003)	(0.003)
Individual fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Cragg-Donald F statistic	158.47	88.89	88.89	88.89
Stock-Yogo 10% critical value	[16.38]	[16.38]	[16.38]	[16.38]
Observations	25,077	20,781	20,781	20,781
Number of persons	7,182	6,269	6,269	6,269
B. Non-relocators				
Second stage:				
ln(housing cost)	1.671***	-0.026***	0.015***	-0.011**
	(0.245)	(0.004)	(0.002)	(0.005)
First stage:				
IV-foreign investment	0.134***	0.131***	0.131***	0.131***
	(0.008)	(0.008)	(0.008)	(0.008)
Individual fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Cragg-Donald F statistic	24677.49	20894.56	20894.56	20894.56
Stock-Yogo 10% critical value	[16.38]	[16.38]	[16.38]	[16.38]
Observations	147,266	126,237	126,237	126,237
Number of persons	17,697	16,563	16,563	16,563

Notes: Panel A reports FE-IV estimates when restricting the sample to individuals who have relocated since the previous year. Panel B reports the same for individuals who have the same address as the previous year. Robust standard errors clustered at the LGA-level are reported in the parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 4: Heterogeneity – High and low education levels

			Expenditure share		
	(1) Work commute time	(2) Relocation	(3) Motor vehicle fuel	(4) Public transport and taxi	(5) Total transport
A. High education level					
Second stage:					
ln(housing cost)	1.327***	0.117	-0.019***	0.006*	-0.013*
	(0.421)	(0.103)	(0.006)	(0.003)	(0.007)
First stage:					
IV- foreign investment	0.091***	0.091***	0.087***	0.087***	0.087***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Cragg-Donald F statistic	5824.92	5824.92	4703.83	4703.83	4703.83
Stock-Yogo 10% critical value	[16.38]	[16.38]	[16.38]	[16.38]	[16.38]
Observations	71,771	71,771	61,108	61,108	61,108
Number of persons	7,163	7,163	6,739	6,739	6,739
B. Low education level					
Second stage:					
ln(housing cost)	2.200***	0.032	-0.022***	0.017***	-0.005
	(0.422)	(0.063)	(0.006)	(0.003)	(0.007)
First stage:					
IV-foreign investment	0.095***	0.095***	0.086***	0.086***	0.086***
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Cragg-Donald F statistic	6714.65	6714.65	4694.71	4694.71	4694.71
Stock-Yogo 10% critical value	[16.38]	[16.38]	[16.38]	[16.38]	[16.38]
Observations	74,930	74,930	61,464	61,464	61,464
Number of persons	7,653	7,653	6,909	6,909	6,909

Notes: Panel A reports FE-IV estimates when restricting the sample to individuals with a high level of education. Panel B reports the same for individuals who have a low education level. Robust standard errors clustered at the LGA-level are reported in the parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 5: Heterogeneity - Metropolitan and non-metropolitan areas

			Expenditure share		
	(1) Work commute time	(2) Relocation	(3) Motor vehicle fuel	(4) Public transport and taxi	(5) Total transport
A. Metropolitan areas					
Second stage:					
ln(housing cost)	2.066***	-0.152*	-0.026***	0.015***	-0.011
	(0.409)	(0.090)	(0.006)	(0.004)	(0.008)
First stage:					
IV- foreign investment	0.083***	0.083***	0.077***	0.077***	0.077***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Cragg-Donald F statistic	7853.65	7853.65	5927.72	5927.72	5927.72
Stock-Yogo 10% critical value	[16.38]	[16.38]	[16.38]	[16.38]	[16.38]
Observations	121,330	121,330	104,349	104,349	104,349
Number of persons	13,018	13,018	12,202	12,202	12,202
B. Non-metropolitan areas					
Second stage:					
ln(housing cost)	2.337***	0.457***	-0.018***	0.017***	-0.000
	(0.297)	(0.054)	(0.006)	(0.002)	(0.006)
First stage:					
IV-foreign investment	0.107***	0.107***	0.101***	0.101***	0.101***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Cragg-Donald F statistic	7843.30	7843.30	6187.86	6187.86	6187.86
Stock-Yogo 10% critical value	[16.38]	[16.38]	[16.38]	[16.38]	[16.38]
Observations	56,881	56,881	48,209	48,209	48,209
Number of persons	6,134	6,134	5,704	5,704	5,704

Notes: Panel A reports FE-IV estimates when restricting the sample to individuals who live in metropolitan areas for the majority of the sample period. Panel B reports the same for individuals who live in non-metropolitan areas for the majority of the sample period. Robust standard errors clustered at the LGA-level are reported in the parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.