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Editorial

Welcome to the first issue in the 12th volume of the *International Journal of Housing Markets and Analysis*. A core strength of this journal is the diversity of the published research in each issue whilst at the same time retaining the core focus on housing markets. This diversity is also aligned with the varying levels of housing research associated with each country which range from developing countries to fully developed (and times, congested) countries. Although developing countries have the advantage of learning from the lessons of fully developed countries, they also can observe the challenges they will potentially face because of the increased complexities and competing interests. Owing to the evolving nature of housing markets, there will always been a need for research into how to provide economically feasible and sustainably acceptable housing for an increasing global population. The increasing interest of this journal is based on this premise, being there are vastly more housing challenges than research solutions provided to-date. In today's marketplace, housing is leading the real estate and property research agendas rather than following the commercial sectors as was the case previously. Hence, there is a strong interest in housing from an ever-increasing number of stakeholders as evidenced by the nine papers in this issue.

The first paper from Australia investigated the potential for unique housing provision challenges, including housing shortages, to be addressed via the adoption of offsite construction methods. The research identified barriers associated with implementation, primarily relating to cost uncertainty, which were further complicated by the availability of limited offsite construction cost data and information accessible in the public domain. The analysis examined three offsite construction projects in detail and then identified three emerging themes relating to cost. These related to:

- the total costs of delivering residential housing project via offsite construction techniques;
- cost variations associated with offsite construction residential housing projects primarily because of uncertainties; and
- cash flow dynamics associated with residential offsite construction projects.

The second paper from Indonesia examined patterns related to decision-making relationships and dual motives for purchasing housing by first home buyers and also families. The data were sourced via questionnaires distributed to home buyers over a three-year period with the results confirming that purchasers have a consumption motive when buying a residence, and also they behave in a rational manner. In contrast, investors prefer to buy an apartment and tend to follow heuristics. It was also found that purchasing a house is an important decision in one's life; therefore, these decisions tended to involve parents or relatives.

The third paper from the USA investigated the association between speed bumps and home values. The starting point was that it is accepted that speed bumps invite varied responses from homeowners, drivers and policymakers. Initial results relating to variations in the number of bumps traversed suggest that speed bumps are associated with reduced residential property values. A subsequent examination of a second neighbourhood estimated a treatment effect of speed bump installation and underscored the original findings. An anonymous online survey was conducted to highlight factors that may drive the negative relationship between speed bumps and home values. The findings from the

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survey implied that whilst older homeowners and also homeowners with children may approve of speed bumps, the level of approval is less than the disapproval of those who do not approve of speed bumps. The fourth paper from Ghana analysed institutional and market constraints to housing development whilst highlighting the differences between the two constraints. It also sought to provide relevant public and private-sector policy recommendations for housing development. The participants in the research indicated that land tenure arrangements, land litigation risk, difficult land registration process and lengthy procedures when securing building permits and the cost of land acquisition were all major factors which significantly affected residential real estate development. In addition, difficulty in accessing development funds, an underdeveloped mortgage market, high interest rates and the expensive cost of labour and construction materials were some of the other factors constraining housing development.

The fifth paper from the USA used mathematical models to capture the spreading of epidemics to explain the expansion of mortgage default events. The authors examined the state of infectiousness and death to represent the subsequent steps of payment delinquency and default, respectively. As the local economic structure influences regional unemployment which is a strong driver of mortgage default, the analysis modelled interdependencies of regional mortgage default rates through employment conditions as well as based on vicinity. An estimation of key parameters of the model is proposed and based on a large sample of loan-level data. The findings consider the model's forecast accuracy which confirms an above average performance when compared to accepted approaches including linear regression and logit models. The findings provide important insights into the dynamics of mortgage defaults and its spatial spreading.

The sixth paper from Finland examined the externalities ranging from regional homeownership to individual-level entrepreneurship. The methodology used probit models of entrepreneurship with regional homeownership where control variables as regressors are estimated. A rental housing market deregulation experiment which caused exogenous variation in a regions' homeownership is exploited to identify causal effects on entrepreneurship. The findings confirmed that higher levels of homeownership in a region lead to greater levels of entrepreneurship. Further analysis when considering that homeownership tends to have detrimental labour market effects suggests that homeownership encourages entrepreneurship by leading to less paid work opportunities. These results support earlier studies where self-employment and entrepreneurship, especially during poor economic times, are partly motivated by poor employment opportunities.

The seventh paper examines housing markets in the UK, Australia and Japan with the focus placed on the mortgage demand behaviour of households in these regions. The emphasis of the research relates to factors that affect household mortgage demand, housing demand and also the loan to value ratio. Though homeownership is a preferred tenure and the mortgages are "recourse" loans, housing markets in these three regions operate via different mortgage market institutional structures. The findings showed that the income elasticity of mortgage demand differs despite the income elasticity of housing demand being relatively similar. Furthermore, mortgage institutions that pose constraints for borrowers also determine the extent of mortgage demand. It was also found that other factors such as demography, economic conditions also play an important role in determining levels of mortgage and housing demand. The eighth paper from Malta analysed the housing market and production sector performance using quarterly data from 2005Q1 to 2016Q4. A multivariate autoregressive distributed lag approach was used where an industrial expansion and development indicator-producer price index (*ppi*) and unemployment (*uem*) is

used with volatility index (*vix*) and fertility rate (*frate*) as control variables. The findings showed that any disequilibrium over the long-run equilibrium among these variables was subsequently corrected by movement in the housing market via real residential property prices. In instances of economic disequilibrium, the long-run impacts on the housing market are positive for *ppi* and *vix* however were negative for *frate* and *eum*. The observed direction of the impacts over the short-run was the same over the long-run for all variables.

The ninth and final paper investigates the potential existence of a long-run causal relationship between house prices and unemployment rates in eight major European countries. It was argued that there have been few studies to-date which have investigated the direct link between house prices and employment or unemployment. The methodology used a bootstrap panel Granger causality approach which accounted for cross-sectional dependence, slope heterogeneity and structural breaks to detect the direction of causality. Overall the findings supported the existence of unidirectional causality running from house prices to unemployment where the implications from this study are important for both households and also for policymakers concerned with ensuring economic and financial stability.

This journal continues to maintain the high quality of published research coupled with increased submission levels and an associated higher rejection rate. For authors, there is a strong encouragement to engage with the editor prior to submission to ensure their paper is relevant and in an acceptable format for publication. This includes ensuring the submitted paper conforms to the author guidelines for the journal which in turn will reduce the time the paper spends in the review process; for example, the length of the paper should be between 6-8,000 words to be entered into the review process. Please contact the editor directly if I can be of assistance prior to submission and/or discuss the procedure for admission into the review process. If you are interested in submitting a research paper or reviewing potential publications, please contact the editor direct at ijhma@ijhma.com.

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Investigating the cost of offsite construction housing in Western Australia

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Abstract

Purpose – Offsite construction approaches and methodologies have been proffered a potential solution for controlling "traditional" projects, especially where high levels of complexity and uncertainty exist. Given this, locations such as Western Australia (WA), where there are unique housing provision challenges, offsite construction method was considered a potential solution for not only addressing the complexity/uncertainty challenges but also alleviating the housing shortage. However, whilst acknowledging the benefits of offsite construction, recognition was also noted on perceived barriers to its implementation, primarily relating to cost uncertainty. This recognition is exacerbated by very limited offsite construction cost data and information available in the public domain. In response to this, this paper sims to provide detailed cost analysis of three offsite construction projects in WA.

Design/methodology/approach – To hold parameters constant and facilitate cross-case comparative analysis, data were collected from three embedded case studies from three residential housing projects in WA. These projects represent the most contemporary implementation of offsite in WA; where two were completed in 2016/2017 and the third project was still ongoing during the data collection of this research. The research methodological approach and accompanying data analysis component engaged a variety of techniques, which was supported by archival study of project data and evidence gathered from the offsite construction provider.

Findings – Core findings revealed three emerging themes from residential offsite construction projects pertinent to cost. Specifically, the overall cost of delivering residential housing project with offsite construction techniques, the cost variability of offsite construction residential housing projects as impacted by uncertainties and the cash flow of residential offsite construction projects based on the payment term. These three major cost drivers are elucidated in this paper.

Originality/value – This research presents new cost insights to complement the wider adoption of offsite construction techniques. It presents additional information to address the limited cost data and information of offsite construction projects available in the public domain particularly for residential housing projects (within the bounded context of WA). It also highlights the further stages needed to enhance data validity, cognisant of universal generalisability and repeatability, market maturity and stakeholder supply chains.

Keywords Housing, Costs, Western Australia, Offsite construction, Construction cost, Modern method of construction

Paper type Research paper

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Introduction

Complexity and uncertainty are "typically" intrinsic to construction projects. This also applies to house designing and building, as house building has been considered consisting a complex set of activities, involving many specialised actors and their on-site activities are typically dependent on weather conditions (Lessing, 2006). Contemporary house building typically involves complexity and hence uncertainty for builders; in some cases, the requirements for greater speed of construction has also increased as a direct result from the continuous under-supply of housing. These are major challenges facing the builder onsite. Given this, several advocates have proposed solutions which transfer as many of the actual site-based construction activities as possible to a more controlled environment (offsite); where these are later transported back to the construction site for final assembly and installation (Smith, 2010; Gibb, 1999). This is typically known as the offsite construction method. Whilst there are several hybrid variants of this approach, this philosophy has been successfully implemented in various projects, including the housing sector. In the UK housing sector for instance, offsite construction has been proffered as a viable way forward, so much so that the UK Government termed it as the modern method of construction (Egan, 1998; Latham, 1994), and similarly in Australia (Hampson and Brandon, 2004; DISR, 1999), where offsite construction was considered the way forward for the entire construction industry. Thus, it is generally perceived that offsite construction can produce superior housing products through the implementation of improved processes in the controlled environment (Steinhardt and Manley, 2016). In addition to the expectation of superior quality, off-site construction can (if appropriately managed) also increase the speed of construction by shortening quote-to-delivery cycles, removing non-value adding processes (Nawari, 2012). In essence, a controlled environment (typically a manufacturing or factory facility) offers several benefits, particularly: a higher speed of construction, improved quality of the finished product, lower costs and lower labour requirements on-site (Goulding and Arif, 2013; Mullens and Arif, 2006; Gibb and Isack, 2003).

Given the wide discussion on the potential benefit of offsite construction, there was a general expectation that offsite would be widely adopted. However, whilst pockets of growth and new businesses have emerged, on the whole, adoption and uptake has been disappointing over the years (Khalfan and Maqsood, 2014; Rahman, 2013). Scholars and researchers have identified various potential barriers, particularly in process, supply chain/procurement and knowledge (Blismas *et al.*, 2006). One of the most significant barriers to implementing offsite construction was cost uncertainty - as actors in the industry tend to hold on to well-proven methods and materials rather than developing new ones (Pan and Sidwell, 2011; Nam and Tatum, 1988). On this theme, a series of workshops in Australia revealed cost as the major constraint to the implementation of offsite construction outweighing any related drivers with offsite construction. Offsite was generally perceived to be a more expensive option because of higher initial capital outlay, design, cranage and transportation costs (Blismas and Wakefield, 2009). Informed by an earlier phase of this research that revealed the potential of offsite construction to bring solutions to the housing shortage problems in the Western Australia (WA) (Sutrisna *et al.*, 2017), this paper presents findings from a case study analysis of three housing case study projects in WA to provide additional insight into this matter. The findings presented here contribute to the currently limited availability of cost information regarding offsite construction projects – particularly residential projects.

Literature review

Typically contributing about 3-4 per cent to the Gross National Product (GDP), the construction of new houses has been considered a significant contributor to the overall developments in the Australian economy (Hsieh *et al.*, 2012). In the state of WA for instance, the Australian Bureau of statistics (ABS, 2014) has regarded the WA's capital city, Perth, as currently growing faster than any other capital city in Australia. The resources sector boom has been considered the major driver behind the strong population growth that consequently put pressure on housing availability (McKenzie and Rowley, 2013). The rapid growth in population has put more pressure on the need for housing that currently outstripped supply (Sutrisna *et al.*, 2017). Thus, an effective solution is needed to alleviate this situation.

The housing sector is typically dominated by traditional builders who can only provide a limited range of products mainly to cater for the single-family, owner-occupation market. In Australia for example, traditional masonry construction accounts for about 70 per cent of houses constructed (ABS, 2012). Thus, traditional "brick and mortar home" has been and still is the most popular choice in Australia (Sutrisna *et al.*, 2017). Unfortunately, traditional brick-and-block masonry construction is characterised by a relatively long building process and potential quality issues because of its dependency to specialised trades (such as wet trades) that often ended up with delays because of needed remedial works post completion (Roy *et al.*, 2003; Bramley *et al.*, 1995). This dependency towards specialised trades also brought its own problems when such specialised skills are in shortage. In WA for example, the availability of skilled trades still forms a significant factor to the housing provision in WA and even more so for more remote areas in the state (Sutrisna *et al.*, 2017). The traditional house-building process itself often focuses more on the uniqueness and the individuality of each project which are characterised by "unique choices of technical solutions, a limited use of platforms, uniquely combined teams and scarcely developed logistics and procurement strategies" (Lessing, 2006, p. 90). These bespoke characteristics of house building has exacerbated the high dependency towards the skilled trades (AHURI, 2015) and has limited the ability of the supply-side to provide housing and therefore further contribute to the gap between the supply and demand of housing in Australia in general and WA in particular. Thus, supply-side factors in Australia have been regarded as the main reasons for the delayed availability of new residential developments as well as raising the cost of their delivery (Hsieh *et al.*, 2012; NHSC, 2010).

The traditional approaches to house building have not been capable of delivering the needed level, particularly with the skills shortages discussed above. Increasing the supply of housing but keeping or even reducing construction cost will likely require substantial changes in the delivery technic and organisation of the house building process. However, innovating the methodology to address this will likely require more than simply tweaking the current process such as redesigning the house types. It has been argued that house-building sector can learn lessons from manufacturing industry to meet those challenges (Barlow *et al.*, 2003). Such an innovation would require a radical re-organisation of the house-building process including its supply system, viewing the end products as a composition of its component and with more roles to play by its end-users in the design process and reorganised supply chains (Barlow, 1999). One of the main alternatives considered suitable addressing the issues on supply-side of housing provision is by shifting the conventional house building method to offsite construction. In the UK housing sector for instance, the UK Government has regarded offsite construction as the modern method of construction carrying the potential to address the housing shortage in the UK (Pan *et al.*, 2008; Gibb, 1999). The term off-site construction itself typically refers to a spectrum of

construction methods that involves preconstruction of certain components outside the building site followed by the assembly of these components to their final position in the construction site (Smith, 2010; Goodier and Gibb, 2007). The preconstruction of the components is typically known as pre-fabrication and usually done in a specialised facility, i.e. a factory where materials are brought together to construct the building components. The degree of the prefabrication components used generally determines whether the offsite construction technique is applied as non-volumetric offsite construction or volumetric offsite construction (Schoenborn, 2012; Smith, 2010; Bell, 2009; Gibb, 1999). The non-volumetric offsite construction typically includes the use of individual or combined prefabricated building components such as columns, beams, slabs or wall panels. The volumetric offsite construction typically involves the offsite construction and site installation of standing alone building or parts of the building in the form of pods and modules. When combined, the use of both non-volumetric and volumetric offsite construction components in the same project is typically referred to as hybrid. In some cases, the term "hybrid" has also been used to describe the use of offsite construction components and in-situ construction in the same project. In this paper, from this point forward, the term "hybrid" is used to describe a combination of volumetric and non-volumetric offsite construction in the same project.

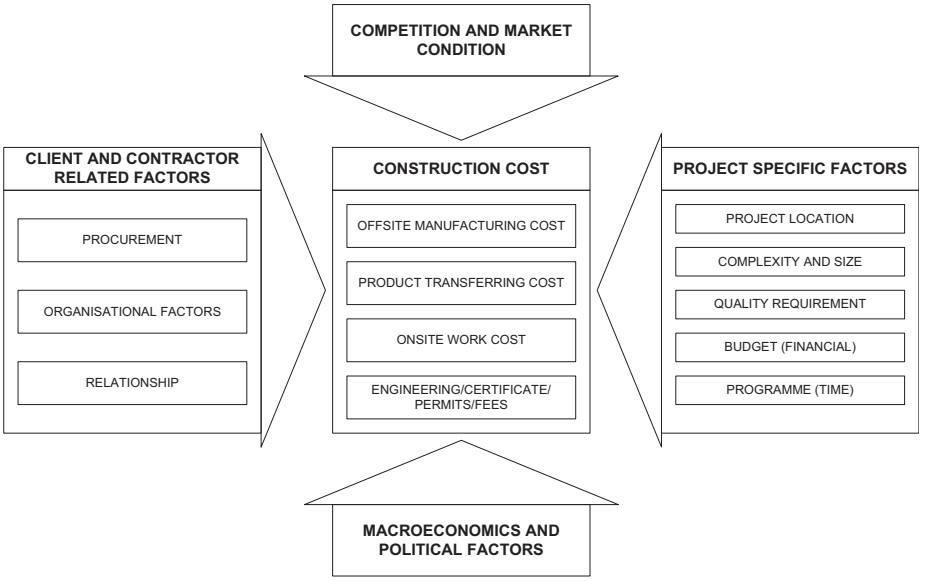
The benefits of implementing offsite construction techniques are mainly originated from the philosophy to migrate the execution of onsite construction activities into a controlled environment. This enables a better planning of these activities to achieve the required specification and quality through manufacturing processes. By migrating the delivery of these onsite construction activities into a controllable factory environment, it is expected that a high degree of efficiency/productivity, safety and quality could be achieved whilst at the same time reducing waste and impact of the construction towards the environment (Khalfan and Maqsood, 2014; Smith, 2010). Conducting the construction activities in the controlled environment is also expected to reduce the effect from the weather conditions (Schoenborn, 2012; Lu, 2007). As in typical manufacturing processes, the activities in the factory can be highly standardised and broken down into simpler tasks and hence can be done by workers with lower skills as long as supervised by other skilled or qualified workers. Therefore, the offsite activities are no longer relying so much towards skilled trades because of the possibility of using semi-skilled or lower-skilled operatives (Nadim and Goulding, 2009). All of these potential benefits should, in theory, resulted in a high uptake of offsite construction including in the housing sector. However, it has not been the case. It has been estimated, for example, that only 3 per cent of the new houses built in Australia used significant prefabrication (Steinhardt and Manley, 2016). Many researchers and scholars have strived to understand the reasons behind the relatively low uptake of offsite construction in many construction industries (Arif and Egbu, 2010; CRC for Construction Innovation, 2007; Kelly, 2009; Pan *et al.*, 2008; Nadim and Goulding, 2010, 2011; Rahman, 2013) and most of their findings revealed cost of implementing offsite techniques as one of the most prevalent factors.

There are considerable numbers of research and publications about construction cost studies (Warsame, 2006) but not many shed lights on the offsite construction cost. Among the rather limited publications, it was reported in these studies that the main cost related issues/perceived issues revolve around the potentially higher initial investment/cost particularly in the earlier part of the offsite project (Pan and Sidwell, 2011; Nadim and Goulding, 2010; Goodier and Gibb, 2007). Thus despite the promotion of the longer term view of the whole life cycle costing for offsite construction projects (Blismas *et al.*, 2006), there appears to be a reluctance, particularly from the builder side, to be exposed to an unfamiliar flow of activities and hence its cost stream. Whilst the offsite construction has been proposed as the most

suitable solution to the challenges facing the housing sector to lower its lifecycle cost in a holistic manner, the supply side actors, i.e. the house builders, are typically worried about the unfamiliar cost and cash flow streams in delivering offsite construction projects. After all, cost have been regarded the major characteristics of constructed products and significantly contributed to the inertia in construction, i.e. a general tendency to use well-proven methods and materials (Pan and Sidwell, 2011; Nam and Tatum, 1988). The argument made by these scholars is that the lack of publicly available cost data and information has contributed to the reluctance of the house builders to adopt offsite construction techniques. Therefore, there is a need to research and disseminate the cost involved in delivering offsite construction projects particularly in house building projects.

Regarding the total development cost of housing, a study in Australia revealed the construction cost as typically the most significant cost, between 42.8-65.8 per cent, compared to other cost including land, service and finance, government charges and margins (Hsieh *et al.*, 2012; Urbis, 2011). When zooming into construction cost, it is generally accepted that construction cost is typically determined by numerous factors that could influence its magnitude. The main reason for so many factors affecting construction cost is the fact that construction is a multidisciplinary industry and hence involving many stakeholders (Chan and Park, 2005). Because of this, construction cost is not only depending on a single factor but a group of variables that are interconnected with the characteristics of the project and to the construction team as well as the external forces such as the macroeconomics and market conditions (Warsame, 2006). These relationship and interconnectivity of factors relevant to the cost of offsite construction projects are generally captured in Figure 1.

Figure 1 depicted and grouped together influencing factors that have been previously identified and reported by various researchers and scholars. Some of the significant factors affecting construction include: required construction time, contractor's planning capability,



Source: Adapted from Warsame, 2006

Figure 1. Construction cost components in offsite construction projects and factors influencing the construction cost

procurement methods, market conditions, technological and project design, contractor's expertise and management ability and the required level of construction sophistication (Elhag *et al.*, 2005). In addition to those, other factors are also regarded influential including project complexity, technological requirements, project information, project team requirement, contract requirement, project duration and market requirement (Akintoye, 2000). Furthermore, the quality and the constructability of the design, management techniques employed by the contractor, location of the project and the macroeconomic conditions have also been considered influencing construction cost (Williams, 2003). More specific to housing projects, further factors influencing construction cost include the extent of unionisation within the construction sector, local wages, topography of the area and local regulatory environment (Gyourko and Saiz, 2006).

Reflecting the main distinguishing characteristics in the offsite construction techniques compared to conventional onsite construction methods, the main differences in the cost generally lies in the shift of "onsite work cost" into "offsite manufacturing cost" and "product transferring cost". The offsite manufacturing cost has been anecdotally regarded by industry practitioners as a way of fixing the cost in the same manner as purchasing a product from the shop as opposed to subcontracting the work to a construction subcontractor. This is possibly the result of the more regimented approach in manufacturing process that involves the input from a customer order, followed by the establishment of functional components to determine the overall production schedule in which each of these functional components will be mapped to its design engineering, production engineering, purchasing of materials and the actual manufacturing works (Gries and Restrepo, 2011). Another component of construction cost in offsite construction projects is incurred because of the necessity to transfer the manufactured building components (non-volumetric or volumetric units) from the offsite facilities to the project site. This necessary transfer typically involves transportation and site handling (usually by crane) of the units to their final position in the project site (Schoenborn, 2012; Gibb, 1999). The other cost component in offsite construction projects relates to the residual construction activities still to be conducted on site involving site preparation works (such as constructing foundations) and finishing works following the installation of the volumetric units to finalise the project (Schoenborn, 2012; Smith, 2010). The last cost component in offsite construction projects involves engineering, certification, permit and fees that maybe different to that of conventional projects because of the unique characteristics of offsite construction projects (Sutrisna *et al.*, 2017). Based on the on-going discussion, these main components of offsite construction projects are considered the appropriate unit of analysis in this research.

Research methodology

In conducting an academic research, the research methodology has to be carefully designed to ensure the robustness of the entire research. Research methodology can be seen as the overarching strategy that is systematically designed and applied to deal with specific research questions. Typically, research methodology should include the explanation of the philosophical stance taken in conducting the research followed by the details of the research design that includes the sampling matters, data collection procedure, data analysis method and demonstration of the research finding's validity and reliability (Ménacère, 2016; Sutrisna and Setiawan, 2016; Sutrisna, 2009). In discussing the philosophical stance, the researchers typically declare their underlying meta-theoretical assumption in approaching the research, usually represented by their chosen ontology and epistemology paradigms. Ontology is a branch of philosophy that concerns about the nature of reality and epistemology is another branch of philosophy that focuses on how human can gain access to

reality. This research is influenced by the critical realist paradigm, recognising that human beings can have access to reality although limited whilst at the same time recognising the co-existence of objective and socially constructed reality (Sutrisna, 2009; Lomborg and Kirkevold, 2003). The ontological and epistemological stance of this research accepts the construction cost as both an objective economic entity incurred during the delivery of offsite construction projects as well as an abstract concept of how the project stakeholders ascribe values to the project and its components in defining their working together and interaction with one another to complete the project.

To contextualise the construction cost in offsite construction projects, case study has been considered a suitable research approach in this research to fully understand construction cost involved in building residential houses with offsite construction techniques. Both physical and social dimensions of a phenomenon have been known occurring in specific contexts (Robson, 2011; Sutrisna and Barrett, 2007) and embedded case study approach was considered a suitable approach to capture them within their natural context and setting (Yin, 2014). The research approach to be implemented in a research is typically underpinned by the researcher's philosophical stance as well as the nature of the research being investigated (Robson, 2011; Sutrisna, 2009; Gill and Johnson, 1997). To understand construction cost involved in building residential houses with offsite construction techniques, it was considered necessary to conduct the study using embedded case study approach, i.e. within the real world context of such projects within a single organisation.

The offsite provider selected in this study is a national modular provider with its own manufacturing facilities including in WA. For residential housing provision, there are currently 11 different standardised designs offered to their customers ranging from 147-257 m^2 and between 3-4 bedrooms whilst also catering for bespoke designs as required by customers. The archive shows that in between 2015 and 2017 for example, the offsite provider has completed 38 projects (between 9 to 17 projects/year) ranging from permanent cabins to residential houses. Majority of the residential homes were bespoke designs although resembling similarities to the offered standardised designs. This higher level of customisation represents the typical preference of the residential housing demand side in the WA. Whilst in theory the offsite construction techniques should benefit fully from the higher degree of standardisation in its manufacturing process, the reality faced by offsite providers can be quite different in such a customer driven market. There is, therefore, a need to compare the total cost of these offsite projects to the cost of conventional method of house building. To do so, a comparative analysis was performed between the actual cost incurred in these cases against the cost of the same projects using conventional onsite construction techniques. However, the uniqueness of construction outputs and its context-specific nature of location have made it close to impossible to replicate the exact project in the exact location (Emuze, 2016; Bryne and Ragin, 2013) but using a different method of construction for comparative purposes. As these two different methods of building in the same plot of land is a mutually exclusive situation, in this research, the actual cost data from the cases were compared against the theoretical cost of the same projects calculated using the methods set in Rawlinsons (2017) based on the same the design/drawings and specifications. This use of theoretical cost (based on the real cases) was considered necessary to generate an alternative scenario that otherwise will not be possible for a comparative purpose and can be considered acceptable as a means of implementing a case study (Robson, 2011).

The selection of the three cases from the same offsite provider was intended to hold the offsite manufacturing, transfer and onsite parameters constant for analysis purposes. Three residential cases in the WA built by the same offsite house provider have been selected for this purpose. These three cases were selected because of their recent construction and

completion, i.e. representing the most contemporary construction cost in offsite construction housing projects. The first two of the selected cases represent such projects in Perth metro areas in WA whilst the third case represents such projects in regional WA for comparison purposes. The profiles of the cases are provided in Table I.

As the main focus was on the construction cost of these three projects, the data collection in this research was facilitated by archival study and when necessary also supplemented by clarification discussions with the offsite construction providers. This is mainly because of the fact that the offsite construction providers in the three cases performed the role of the offsite manufacturers as well as the head contractor offering a complete package solution for the projects. Archival study is therefore considered appropriate to investigate the most contemporary construction cost in offsite construction residential projects in WA. The importance of the project archives encompassing project cost, specifications, drawings and programme to this research has justified its implementation as a standalone data collection method in this research [for further discussion on archival study as a standalone data collection in research, please refer to Bowen (2009)]. Informed by the literature review, analysis in this research was based on the main cost components of offsite construction projects, namely the (volumetric) manufacturing cost, transferring cost, onsite (residual) construction cost and engineering/certification/permits/fees as the unit of analysis, mainly to analyse the cost certainty as well as cash flow profile of offsite projects from the provider's perspective.

The archival study is considered in line with the critical realist stance of this research that accepts both objective values of cost information as well as perspectives in interpreting the archives. It is the role of the researcher to interpret meanings emerging from the findings (Sutrisna, 2009). In interpreting meanings, it was considered necessary to seek clarification of certain points with the offsite construction providers but only when needed to develop of a holistic understanding of the three projects. Because of the aim of this research to fully understand construction cost in offsite construction residential projects in WA, findings were allowed to emerge naturally from the archival study of real-life projects rather than from its stakeholder's opinions. It is, however, anticipated that the further development of this research formal interviews with the stakeholders maybe necessary to expand understanding, but this will be beyond the scope of this article. To ensure validity and reliability, the results of the analysis were communicated back to the offsite provider for further comments and feedbacks.

Findings and discussion

This section provides a general description of each case study as well as the key findings of this research explicably emerging into three central themes, namely, construction cost, cost certainty and cash flow in residential offsite projects.

Profile	Case 1	Case 2	Case 3
Project type/scope	New build 2 storey residential	New build 2 storey residential	New build 3 storey residential
Floor area	143.76 m^2	121.20 m^2	181.45 m^2
Offsite elements	4 volumetric units	4 volumetric units	6 volumetric units
Project location	Perth metro, WA	Perth metro, WA	Regional WA
Project duration	107 days	114 days	160 days*
Project value	AU$ 249,607	AU$ 259,889	AU$ 453,316*

Notes: Suggested exchange rate £1 = AU$1.613; *estimated, the project was still ongoing during data collection

Table I.
The case study profiles

General case study description

Case study 1 is a new build two-storey residential project located within the Perth metropolitan areas in the WA with floor area of 143.76 m^2. Case study 2 is also a new build 2 storey residential project located within the Perth metropolitan areas and represents the smallest floor area (121.20 m^2) among the three cases. In general, the design of the two houses can be considered functional but still with a certain degree of aesthetics maintained. Figure 2 presents an isometric view of Case study 1 and 2, respectively.

Case study 3 is the most complex out of three cases, it is a new build three-storey residential project located outside the Perth metropolitan areas, i.e. regional areas in the WA. Case study 3 represents the largest floor area among the three cases at 181.45 m^2 and intended to provide comparative figures for residential projects outside the Perth metropolitan areas (which are also typically larger than that within the Perth metropolitan area). Whilst this particular case is not directly comparable to the other two cases because of its size and locations, comparisons can still be drawn to inform the findings. Unlike the other two projects that were constructed with flat roof, this project was designed with a pitched roof for a more traditional appearance also reflecting the norms outside the metropolitan areas. This project is also the only one that was still ongoing when the data collection was conducted for all three cases. Figure 3 presents the illustration of building front elevation.

Construction cost in residential house offsite projects

The first point of investigation naturally emerging from this research was the construction cost in these three projects. Table II below presents the comparison of the construction cost from the three cases.

As previously mentioned, Case 3 project was still ongoing when the data collection was conducted. Therefore, the cost figures provided here for Case 3 is a combination between the actual cost incurred so far and the originally estimated cost. The theoretical cost was calculated to provide a comparison to the conventional method of construction based the adjusted rates from Rawlinsons (2017). From the studied cases, it appears that overall cost of implementing offsite construction is generally higher than the baseline cost. It has to be taken into account that the baseline cost here is theoretical. Thus in practice, it is not uncommon for builders to add contingency on top of their cost estimate to reflect the expected uncertainties (Sutrisna, 2004). One possible explanation for the higher cost was the inability to significantly reduce manufacturing cost because of the higher degree of customisation required. From the research's visits and confirmed in discussions with the offsite provider, it has been observed that there is a degree of standardisation in the manufacturing process but limited to the elemental level of the volumetric units and constrained in a particular project. Thus, the lack of continuous demands (volume) as well as the need to allow higher degree of customisation, has constrained the offsite provider to work more efficiently as typically expected from a manufacturing operation. When looking

Figure 2. The isometric view of Case study 1 and 2

Figure 3.
The illustrated building front elevation of Case study 3

Table II.
Construction cost in the studied cases

Cost components	Case 1	Case 2	Case 3*
Volumetric units manufacturing cost	AU$ 178,560 (71.1%)	AU$ 185,190 (71.2%)	AU$ 330,877 (73%)
Volumetric units transferring cost	AU$ 18,625 (7.4%)	AU$ 8,204 (3.2%)	AU$ 16,445 (3.6%)
Onsite construction cost	AU$ 49,104 (19.6%)	AU$ 61,284 (23.6%)	AU$ 85,946 (19%)
Engineering/certifi-cation/permits/fees	AU$ 4,734 (1.9%)	AU$ 5,211 (2%)	AU$ 20,048 (4.4%)
Total cost	AU$ 251,023 (actual)	AU$ 259,889 (actual)	AU$ 453,316 (estimated)
Theoretical cost	AU$ 225,421	AU$ 194,013	AU$ 440,924

Note: *Case 3 is an ongoing case when data was collected

for further explanation at a more macro level, a survey conducted in the US construction industry provided insights that in offsite construction projects, the general cost savings in implementing offsite construction stems from secondary/indirect cost factors such as reduced reliance on skilled trades, the ability to reduce and even avoid unexpected labour cost and onsite resources that maybe required in the project (McGraw-Hill Construction, 2011). The results suggested that it is unlikely a single project will directly benefit from implementing the offsite technique alone. An offsite construction project follows a particular supply chain model as described by Vrijhoef and Koskela (2000) with the focus on transferring activities from site to earlier stages but as a collective effort within an integrated supply chain. The supply chain model connects the entire supply chain and demonstrated the fact that it is unlikely a single project will directly benefit from implementing the technique in isolation. This suggests the actual cost benefit involves the wider supply chain and because of that, it

will require the stakeholders to take a proactive role and hence will take longer to realise the benefits at the project level.

There is a worry that offsite construction can be the more expensive option because of perceived higher design, cranage and transport cost (Blismas and Wakefield, 2009). From the studied cases, it was evident that the engineering, certification, permits and fees are relatively low and comparable to that of conventionally built residential projects (Cases 1, 2, 3). The cranage and transportation cost in more straightforward site access (Cases 2, 3) range around 3-4 per cent of the project total cost but can be significantly higher when facing a more "difficult site" (Case 1). This highlights the importance of more comprehensive preliminary site survey in reducing uncertainties (Sutrisna, 2004; Alhalaby and Whyte, 1994), which is unfortunately not yet a common practice in residential building sector. The proportion of offsite-manufactured elements in the studied cases is between 71-73 per cent with onsite residual activities between 19-23.6 per cent from the total cost and it is unclear whether this proportion is optimum. A study in New Zealand involving commercial buildings reported a strong positive correlation between the proportion of the prefabricated building elements and the cost performance of the project (Shahzad *et al.*, 2014). As the outcome of this research does not indicate any impact from the lower/higher proportion of manufactured building elements towards cost, to draw any meaningful conclusion, a dedicated study on the proportion of offsite residential projects involving volumetric units will need to be conducted.

Cost variability in residential offsite construction projects

In conducting the comparative analysis, another emerging theme was on the cost certainty in implementing offsite construction techniques to build residential projects. In a previous research project, Short *et al.* (2007) was tracking the budget history of construction case study and found that cost certainty in projects constructed with conventional model can bear significant variations from the idealised cost models. Cost variations in the three cases were identified and are presented in Table III.

	Case 1	Case 2	Case 3
Volumetric units manufacturing cost			
Budget	AU$ 168,768	AU$ 155,097	AU$ 315,581
Actual	AU$ 178,560	AU$ 185,190	AU$ 330,877
Variance (%)	−5.8	−19.4	−4.58*
Volumetric units transferring cost			
Budget	AU$ 13,216	AU$ 8,685	n/a
Actual	AU$ 18,625	AU$ 8,204	n/a
Variance (%)	−40.93	+5.54	n/a
Onsite construction cost			
Budget	AU$ 30,744	AU$ 22,765	AU$ 84,205
Actual	AU$ 47,360	AU$ 46,055	AU$ 85,946
Variance (%)	−54.05	−102.31	−2.07*
Engineering/certification/permits/fees			
Budget	n/a	AU$ 4,701	AU$ 11,794
Actual	n/a	AU$ 5,053	AU$ 12,714
Variance (%)	n/a	−7.28	−7.8*

Note: *Only from the cost incurred so far

Table III. Cost variance in the studied cases

Whilst in general the studied cases re-affirmed the limited ability of the current cost modelling practices to provide cost certainty, more specifically this study provided an insight into the myth that the manufactured portion of the offsite construction projects will be less affected by cost variance. Even in Case 3 where the actual manufacturing process has not started at the data collection time, the purchase of materials had already experienced 4.58 per cent increase form the overall budgeted manufacturing cost. These cost variances were mainly resulted from the inaccuracy in estimating the quantity of materials needed during the earlier stages (Cases 1, 2, 3) and/or unforeseen cost increase during the manufacturing processes (Cases 1, 2). From observation, it can be concluded that the higher degree of customisation has also made it more difficult for the offside providers to reliably estimate their production cost. It has been generally acknowledged that an offsite construction process must be managed in a particular way to gain the intended benefits. The failure to do so will increase the risk for waste and non-value-adding activities to occur because of poorly managed design, fabrication and site processes (Lessing, 2006). From the studied cases, it was observed that even though the offsite components were conducted in a manufacturing environment, the processes can be considered very much manual and do not involve a high degree of industrialisation. It has been accepted that the building industry need to adopt higher degree of industrialisation to its process to reduce cost with prefabrication represents the first step of development towards a full industrialisation (Richard, 2005). From the discussion with the volumetric unit manufacturer, however, the relatively low volume of production (particularly in house building) has typically made it very difficult to justify the investment for upgrading the level of industrialisation, hence the more manual approach. This lack of volume that can be linked to the higher degree of customisation as discussed in the previous section has reduced the ability of the offsite provider to achieve "economies of scale" and can be considered one of the main barriers in implementing higher level of automation in the manufacturing process to fully benefit from offsite construction techniques.

The cost of transferring the manufactured volumetric units can also vary. Whilst less significant variances can occur simply because of further negotiation with the hire companies (Case 2), more significant variances can occur from the underestimated necessity to clear access to deliver the volumetric units in their final positions on site (Case 1). One of the basic considerations in transporting the volumetric unit dimension was the capacity of the delivery vehicle that will impose physical limitations of the delivery vehicle on the dimension (i.e. width, length, height) and weight of the volumetric units (Schoenborn, 2012). The choice of transportation can impact the cost. Another significant impact to transporting the volumetric unit is the highway agency regulations. In WA for example, the maximum dimension specified by the Mainroads WA is $5.5 \times 5.5 \times 30$ m before the load is regarded as an oversize load that requires a special permit whilst a traffic escort will be required where the width of the indivisible load exceeds 5.5 m and the length exceeds 40 m (Mainroads, 2017). Following transportation, the volumetric units will be installed onsite. Therefore, the existing site condition such as the site logistics, access to site or manoeuvring space and/or any potential obstructions (such as the main power cables in Case 1) also need to be considered in transferring the volumetric units (Sutrisna *et al.*, 2017).

The engineering, certification, permits and fees aspects of offsite construction in the studied cases are comparable to that of conventional onsite residential projects despite the typical belief (Sutrisna *et al.*, 2017). On contrary, the onsite construction cost showed the most cost variances, mainly because of unforeseen site conditions that necessitated additional works to be conducted. The site activities that incurred the most cost variances in the studied cases are carpentry (Cases 1, 2), electrical, plumbing and footing (Case 2) as well

as masonry works for retaining wall (Case 3). These are not unique to offsite construction projects and minimising these potential site issues can be considered the main driver to shift the onsite activities into offsite controlled environment in the first place (Barlow *et al.*, 2003). It is, however, observed that many of these onsite cost variances (Cases 1, 2) occurred after the volumetric units have been installed onsite. This indicated the potential underestimation of these onsite works, particularly after the installation of the prefabricated volumetric units. This ranges from unforeseen rectification tasks to the planned finishing works but with unforeseen complications. Given its low uptake so far, offsite construction methods can be considered an unconventional way of working for many house builders and, therefore, it was considered important to continuously learn and capture the experience to improve practices in offsite construction projects (Meiling *et al.*2012; Pan *et al.*, 2008). These captured and shared experiences will be invaluable to mitigate potential onsite issues in offsite projects to improve cost certainty of offsite projects.

Cash flow in offsite construction residential projects

One of the main concerns for any contractors in undertaking a project is the cash flow. There is a universal view over the significance of cash flow's impacts on the success/failure of a construction project as a lack of robust construction finance planning can be the main source of significant increases in cost and time that in many cases can lead to the financial collapse of a construction project (Al-Joburi *et al.*, 2012; Singh and Lakanathan, 1992). Because of its importance to house builders, cash flow of the studied cases were analysed and presented in the Figures 4 and 5 as well as Table IV.

Because of its level of complexity, the cash flow in Case 3 is slightly more scattered than the other two case and have several elements of the construction cost overlapped. In addition, Case 3 project was still ongoing during the data collection time (have not incurred

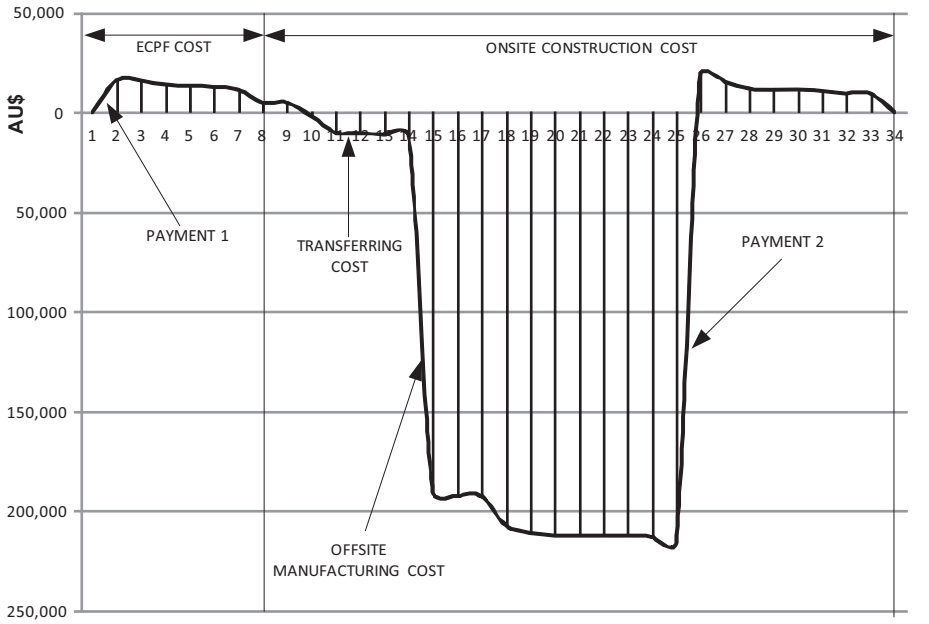


Figure 4. The net cash flow of Case 1

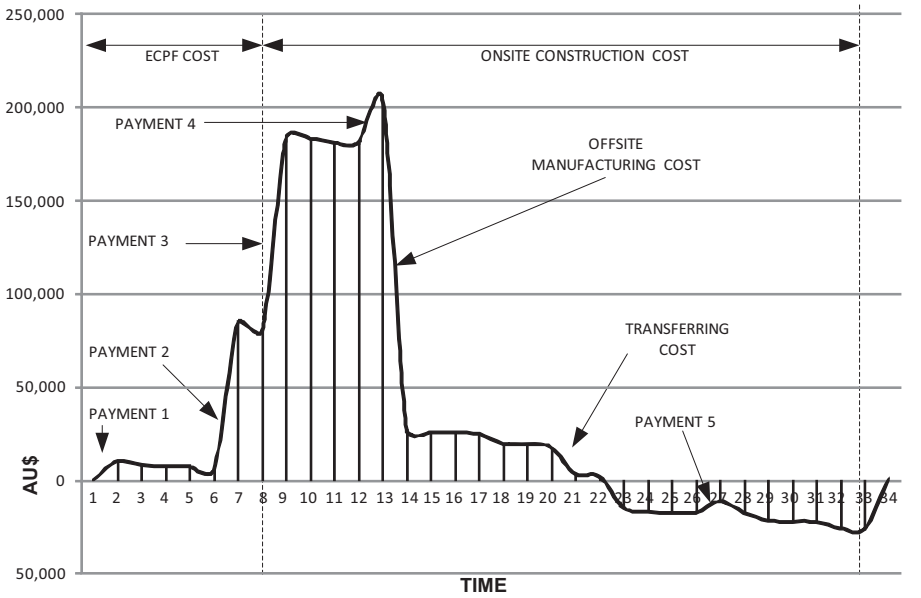


Figure 5.
The net cash flow of Case 2

Table IV.
Cash flow of Case 3

Dates	Offsite	Transfer	Onsite	Eng/cert/permit/fees	Payment	Cummulative
16/11/2016					30,554.54	30,554.54
17/11/2016				−1,900		28,654.54
30/11/2016				−2,018.50		26,636.04
16/01/2017				−375		26,261.04
23/01/2017	−33.84					26,227.20
25/01/2017					159,823.74	186,050.90
02/01/2017	−50					186,000.90
02/02/2017	−30					185,970.90
02/06/2017	−312					185,658.90
13/02/2017	−378.4					185,280.50
14/02/2017	−30					185,250.50
15/02/2017				−1,000		184,250.50
17/02/2017				−2,737.70		181,512.80
21/02/2017	−99					181,413.80
03/07/2017	−110					181,303.80
15/03/2017	−30					181,273.80
21/03/2017	−96.12					181,177.68
23/03/2017			−3,560	−540		177,477.68
27/03/2017	−195					177,282.68
29/03/2017			−5,779.10			171,503.58
04/12/2017	−50					171,453.58
18/04/2017	−29.36					171,424.22
24/04/2017			−1,929			169,495.22
27/04/2017				−3,295.89	72,860.83	239,060.16

the main cost of manufacturing activities yet for example). Therefore, unlike the other two cases presented here in the net cash flow diagrams, the cash flow in Case 3 is presented in a tabular format. The data used to develop the cash flow diagrams and table were not based on the time when these activities occurred in the project (based on programme/schedule) but was based on the actual payment/invoice due dates to represent the real movement of the cash in and out the project from the manufacturer/contractor's point of view.

Consistent with the literature regarding the higher initial investment/cost particularly in the earlier part of an offsite project (Pan and Sidwell, 2011; Nadim and Goulding, 2010; Blismas and Wakefield, 2009; Goodier and Gibb, 2007), the net cash flow in Case 1 shows a relatively long period for the offsite construction provider of being exposed to a negative cash flow situation. Whilst the impact of negative cash flow exposure towards success of the project delivery and the survival of construction companies have been covered rather extensively in the literature, the advance payment and payment cycle on project cash flow as well as the trends and patterns of negative cash flow have rarely been addressed in the literature (Al-Joburi *et al.*, 2012). The term of payment in Case 1 was 6.5 per cent deposit to get the project started followed by 93.5 per cent payment upon the handover of the project. This "turnkey" style of payment term captured in Figure 4 has exposed the offsite construction provider to a negative cash situation for most of the project period. Whilst the project duration can be considered typically shorter than conventional onsite residential construction, it was evident that this payment term is not financially sustainable for the company and hence the change of payment term in subsequent projects (Cases 2, 3). This new payment term requires:

- 6.5 per cent deposit;
- 34 per cent at the purchase of materials stage (2 weeks prior to build start date);
- 29 per cent at the lock up stage (water tight structure completed);
- 15.5 per cent at the internal fix stage (internal work including walls, cabinetry, painting, tiling, and so on);
- 10 per cent at the transport stage (volumetric units ready to be transported); and
- 5 per cent at handover stage.

As identified in Cases 2 and 3, the final agreement for payment was not rigidly applied as the six payments above, but can be negotiated with individual client. The new payment term, however, has helped the offsite construction provider to stay comfortably in the positive cash flow situation. Even in Case 2 where the onsite construction turned out to be significantly more than the originally planned, the new payment term has helped to reduce the impact towards the offsite construction provider. There was not any data available, however, on how the implementation of this new payment terms impacted on the company's competitiveness in the market place. The majority of the engineering, certification, permit, fees cost items occur in the earlier part of the project whilst the onsite construction activity cost occur right after that, all through the remaining of the project duration. By far, the payment for the offsite manufactured volumetric units is a single point of expenses that dramatically impacted on the cash flow. Therefore, the term of payment to be agreed with client should take into account these major cost/expenses "points" during an offsite construction project.

Conclusion

Offsite construction has been hailed as a potential solution for alleviating the housing imbalance in WA. This was mainly because of the perceived superiority of offsite

construction compared to conventional onsite house building methods. Additional benefits included the delivery of higher quality products with high level of standardisation, shorter delivery time and less reliance towards the increasingly reduced availability of skilled trades. Despite these benefits, the uptake of offsite construction has been lower than expected. Looking into the roots causes of this low uptake, one of the main reasons was found to be the reluctance of the supply side actors, i.e. the house builders, to adopt a relatively "unfamiliar" building method, where they were worried about unfamiliar costs and cash-flow streams for delivering offsite construction projects. This is exacerbated by the limited availability of cost information regarding offsite construction projects, particularly residential projects. This research was set to address this matter and shed light on this discourse by focussing on three embedded case studies of residential projects implementing offsite construction techniques in WA. Whilst the studied cases are quite unique in terms of their design and location, they can be considered "representative" of typical practices, level of demand, level of manufacturing's standardisation and automation of offsite house building in WA.

The findings reported here provide important insight for house builders intending to implement offsite techniques. Three emerging themes pertinent to the cost relevant matters of residential offsite construction projects emerged in this research. First, the findings confirmed that the overall cost of delivering a residential project with offsite construction techniques is generally higher than the cost of delivering a residential project using conventional onsite method (theoretical estimation). Whilst the general rules of thumb are to shift as many construction activities into offsite-controlled environment, the findings from the studied cases have provided evidence that migrating 71-73 per cent building elements into offsite construction execution in residential projects did not significantly reduce the overall cost compared to theoretical baseline. Whilst acknowledging the potential for higher degree of standardisation in the offsite house's designs to further capitalise from the repetitive nature of manufacturing process that may reduce production cost, in many cases the cost benefits from implementing the offsite construction may not be directly quantifiable for a single project in isolation but in the longer term the entire supply chain should benefit from this so-called "modern method of construction". Second, the findings also revealed that the onsite construction activity portion of an offsite construction residential project (also known as the "residual onsite activities") could still expose the project towards uncertainties whilst the offsite-manufactured parts of the projects may not be necessarily immune to the cost variance. As a low level of standardisation and automation was found in the case study, upgrading the level of industrialisation in the manufacturing process can potentially reduce the cost variance, but such investment will require a certain level of production volume to justify the financial investment (achieving "economies of scale"). Notwithstanding this, the uncertainties can also impact on the process of transferring the manufactured volumetric units to its final position on site. This has highlighted the importance of preliminary site investigation to increase the likelihood for smooth transfer. The third strand concerns with the cash flow of residential offsite construction projects. To minimise the exposure to a negative cash flow situation, the offsite construction providers should negotiate or set up a payment term that takes into account the major points when significant cost can be expected to occur as identified in this paper.

With the view to facilitate a wider adoption of offsite construction techniques in WA, Australia and beyond, further research will be needed to further investigate the cost aspects discussed above. The findings of the research reported in this paper present a foundation for further research on residential housing projects. A further investigation to realise the benefits of implementing offsite construction methods for

the entire supply chain is needed. Other directions for further research include establishing the optimum level of standardisation and manufacturing automation balanced against the volume of production required to achieve the economies of scale, determining the optimum level of site investigation needed to support a smooth transfer process from the offsite manufacturing facilities to the final position on site, evaluating the maturity of the offsite manufacturing supply chain and capturing the experiences from previous projects implementing offsite construction techniques to compile a repository for wider dissemination. In terms of cash flow management of offsite construction housing projects, determining the balance between payment terms to minimise the risks of exposure to negative cash flow but maintaining competitiveness in the market place at the same time is another direction for further investigation. Until sufficient development towards these aspects have been achieved, it is likely that myths, beliefs and reluctance around cost related matters will continue to hinder the uptake of offsite construction techniques as the modern method of construction.

References

AHURI (2015), "Labour in the housing construction sector", *Australian Housing and Research Institute (AHURI) Research and Policy Bulletin*, No. 187, March 2015.

Akintoye, A. (2000), "Analysis of factors influencing project cost estimating practice", *Construction Management and Economics*, Vol. 18 No. 1, pp. 77-89.

Alhalaby, N.H.M. and Whyte, I.L. (1994), "The impact of ground risk in construction on project finance", in Skipp, B.O. (Ed.), *Risk and Reliability in Ground Engineering, Proceedings of the Institution of Civil Engineers Conference*, *London*, 11-12 November 1994, *Thomas Telford*, *London*.

Al-Joburi, K.I., Al-Aomar, R. and Bahri, M.E. (2012), "Analyzing the impact of negative cash flow on construction performance in the Dubai area", *Journal of Management in Engineering*, Vol. 28 No. 4, pp. 382-390.

Arif, M. and Egbu, C. (2010), "Making a case for offsite construction in China", *Engineering, Construction and Architectural Management*, Vol. 17 No. 6, pp. 536-548.

Australian Bureau of Statistics (2012), "Private sector construction industry", *Australia*, 2011-2012, available at: www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/8772 (accessed 15 August 2017).

Australian Bureau of Statistics (2014), "Regional population growth", 2013-2014, available at: www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/3218 (accessed 15 August 2017).

Barlow, J. (1999), "From craft production to mass customization: innovation requirements for the UK housebuilding industry", *Housing Studies*, Vol. 14 No. 1, pp. 23-42.

Barlow, J., Childerhouse, P., Gann, D., Hong-Minh, S., Naim, M. and Ozaki, R. (2003), "Choice and delivery in housebuilding: lessons from Japan for UK housebuilders", *Building Research and Information*, Vol. 31 No. 2, pp. 134-145.

Blismas, N. and Wakefield, R. (2009), "Drivers, constraints and the future of offsite manufacture in Australia", *Construction Innovation*, Vol. 9 No. 1, pp. 72-83.

Blismas, N., Pasquire, C. and Gibb, A. (2006), "Benefit evaluation for off-site production in construction", *Construction Management and Economics*, Vol. 24 No. 2, pp. 121-130.

Bowen, G.A. (2009), "Document analysis as a qualitative research method", *Qualitative Research Journal*, Vol. 9 No. 2, pp. 27-40.

Bramley, G., Bartlett, W. and Lambert, C. (1995), *Planning, the Market and Private Housebuilding*, UCL Press, London.

Bryne, D. and Ragin, C.C. (Eds) (2013), *The SAGE Handbook of Case-Based Methods*, Sage, London.

Chan, S. and Park, M. (2005), "Project coast estimation using principal component regression", *Construction Management and Economics*, Vol. 23 No. 3, pp. 295-304.

CRC for Construction Innovation (2007), "Off-site manufacture in Australia: current state and future Directions", in Blismas, N. (Ed.), *Off-site Manufacture in Australia*, Cooperative Research Centre for Construction Innovation.

DISR (1999), *Building for Growth: An Analysis of the Australian Building and Construction Industries*, Department of Industry, Science and Resources, Canberra.

Elhag, T.M.S., Boussabinaine, A.H. and Ballal, T.M.A. (2005), "Critical determinants of construction tendering costs: quantity surveyors' standpoint", *International Journal of Project Management*, Vol. 23 No. 7, pp. 538-545.

Emuze, F. (2016), "Using case-based methods in construction research with complementarities", in Ahmed, V., Opoku, A. and Aziz, Z. (Eds), *Research Methodology in the Built Environment: A Selection of Case Studies*, Taylor and Francis, Oxford, pp. 107-126.

Gibb, A.G.F. (1999), *Offsite Fabrication: Prefabrication, Pre-assembly and Modularisation*, Whittles Publishing, Caithness.

Gibb, A. and Isack, F. (2003), "Re-engineering through pre-assembly: client expectations and drivers", *Building Research and Information*, Vol. 31 No. 2, pp. 146-160.

Goodier, C. and Gibb, A. (2007), "Future opportunities for offsite in the UK", *Construction Management and Economics*, Vol. 25 No. 6, pp. 585-595.

Goulding, J.S. and Arif, M. (2013), "Research road map report: offsite production and manufacturing, Publication 372", *International Council for Research and Innovation in Building and Construction*, ISBN 978-90-6363-076-8.

Gries, B. and Restrepo, J. (2011), "KPI measurement in engineering design – a case study", *International Conference on Engineering Design*, ICED11, 15-18 August 2011, Technical University of Denmark, Copenhagen, Denmark.

Gyourko, J. and Saiz, A. (2006), "Construction costs and the supply of housing structure", *Journal of Regional Science*, Vol. 46 No. 4, pp. 661-680.

Hampson, K. and Brandon, P. (2004), *Construction 2020: A Vision for Australia's Property and Construction Industry*, Cooperative Research Centre for Construction Innovation, Brisbane, Australia.

Hsieh, W., Norman, D. and Orsmond, D. (2012), "Supply-side issues in the housing sector", *RBA Bulletin*, September Quarter 2012, Reserve Bank of Australia, pp. 11-20.

Kelly, A. (2009), "Your guide to specifying Off-site manufacture: maximising value and minimising risk", BAA, Report Revision 2 (accessed 17 August 2009).

Khalfan, M.M.A. and Maqsood, T. (2014), "Current state of off-site manufacturing in australian and chinese residential construction", *Journal of Construction Engineering*, Vol. 2014, available at: http://dx.doi.org/10.1155/2014/164863

Lessing, J. (2006), "Industrialised house-building: concept and processes", Licentiate thesis, Department of Construction Sciences, Division of Design Methodology, Lund University, Lund Sweden.

Lomborg, K. and Kirkevold, M. (2003), "Truth and validity in grounded theory – a reconsidered realist interpretation of the criteria: fit, work, relevance and modifiability", *Nursing Philosophy*, Vol. 4 No. 3, pp. 189-200.

Lu, N. (2007), "Investigation of the designers' and general contractors' perceptions of offsite construction techniques in the United States construction industry", Unpublished Doctoral dissertation, Clemson University.

McGraw-Hill Construction (2011), "Prefabrication and modularization: increasing productivity in the construction industry", *Smart Market Report Series*, McGraw-Hill Construction, Bedford, MA.

McKenzie, F.M.H. and Rowley, S. (2013), "Housing market failure in a booming economy", *Housing Studies*, Vol. 28 No. 3, pp. 373-388.

Mainroads, W.A. (2017), *Class 1 Restricted Access Vehicles Oversize Period Permit Operating Conditions*, Government of WA, Mainroads Western Australia, available at www.mainroads.wa.gov.au/UsingRoads/HeavyVehicles/Permits/OversizeMass/Pages/osom.aspx (accessed 29 July 2017).

Ménacère, K. (2016), "When more does not mean better: selecting a research methodology and methods", in Ahmed, V., Opoku, A. and Aziz, Z. (Eds), *Research Methodology in the Built Environment: A Selection of Case Studies*, Taylor and Francis, Oxford, pp. 11-31.

Mullens, M.A. and Arif, M. (2006), "Structural insulated panel: impact on the residential construction process", *Journal of Construction Engineering and Management (ASCE)*, Vol. 132 No. 7, pp. 786-794.

Nadim, W. and Goulding, J.S. (2009), "Offsite production in the UK: the construction industry and academia", *Architectural Engineering and Design Management*, Vol. 5 No. 3, pp. 136-152.

Nadim, W. and Goulding, J.S. (2010), "Offsite production in the UK: the way forward? A UK construction industry perspective", *Construction Innovation*, Vol. 10 No. 2, pp. 181-202.

Nadim, W. and Goulding, J.S. (2011), "Offsite production: a model for building down barriers: a European construction industry perspective", *Engineering, Construction and Architectural Management*, Vol. 18 No. 1, pp. 82-101.

Nam, C.H. and Tatum, C.B. (1988), "Major characteristics of constructed products and resulting limitations of construction technology", *Construction Management and Economics*, Vol. 6 No. 2, pp. 133-147.

National Housing Supply Council (2010), *2nd State of Supply Report, Department of Family*, Housing, Community Services and Indigenous Affairs, Government of Australia, Canberra.

Nawari, N.O. (2012), "BIM standard in off-site construction", *Journal of Architectural Engineering*, Vol. 18 No. 2, pp. 107-113.

Pan, W. and Sidwell, R. (2011), "Demystifying the cost barriers to offsite construction in the UK", *Construction Management and Economics*, Vol. 29 No. 11, pp. 1081-1099.

Pan, W., Gibb, A.G. and Dainty, A.R. (2008), "Leading UK housebuilders' utilization of offsite construction methods", *Building Research and Information*, Vol. 36 No. 1, pp. 56-67.

Rahman, M.M. (2013), "Barriers of implementing modern methods of construction", *Journal of Management in Engineering*, Vol. 30 No. 1, pp. 69-77.

Rawlinsons (Ed.) (2017), *Australian Construction Handbook 2017*, 35th ed., Rawlinsons Construction Cost Consultants and Quantity Surveyors, Perth, WA.

Richard, R.-B. (2005), "Industrialised building systems: reproduction before automation and robotics", *Automation in Construction*, Vol. 14 No. 4, pp. 442-451.

Robson, C. (2011), *Real World Research: A Resource for Users of Social Research Methods in Applied Settings*, 4th ed., Wiley-Blackwell, Hoboken, NJ.

Roy, R., Brown, J. and Gaze, C. (2003), "Re-engineering the construction process in the speculative house-building sector", *Construction Management and Economics*, Vol. 21 No. 2, pp. 137-146.

Schoenborn, J. (2012), "A case study approach to identifying the constraints and barriers to design innovation for modular construction", Doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Shahzad, W.M., Mbachu, J. and Domingo, N. (2014), "Prefab content versus cost and time savings in construction projects: a regression analysis", *Proceedings of the 4th New Zealand Built Environment Research Symposium (NZBERS), Auckland, New Zealand*, 14 November 2014.

Short, C.A., Barrett, P., Dye, A. and Sutrisna, M. (2007), "Impacts of value engineering on five capital arts projects", *Building Research and Information*, Vol. 35 No. 3, pp. 287-315.

Smith, R.E. (2010), *Prefab Architecture: A Guide to Modular Design and Construction*, John Wiley and Sons, Hobboken, NJ.

Steinhardt, D.A. and Manley, K. (2016), "Adoption of prefabricated housing – the role of country context", *Sustainable Cities and Society*, Vol. 22 No. 2016, pp. 126-135.

Sutrisna, M. (2004), "Developing a knowledge based system for the valuation of variations on civil engineering works", Unpublished PhD thesis, Research Institute in Advanced Technologies, University of Wolverhampton, Wolverhampton.

Sutrisna, M. (2009), *Research Methodology in Doctoral Research: Understanding the Meaning of Conducting Qualitative Research*, in Ross, A. (Ed.), ARCOM Doctoral Workshop, Liverpool, 12 May 2009, pp. 48-57.

Sutrisna, M. and Barrett, P. (2007), "Applying rich picture diagrams to model case studies of construction projects", *Engineering, Construction and Architectural Management*, Vol. 14 No. 2, pp. 164-179.

Sutrisna, M. and Setiawan, W. (2016), "The application of grounded theory methodology in built environment research", in Ahmed, V., Opoku, A. and Aziz, Z. (Eds), *Research Methodology in the Built Environment: A Selection of Case Studies*, Taylor and Francis, Oxford, pp. 231-245.

Sutrisna, M., Lofthouse, B. and Goulding, J. (2017), "Exploring the potential of offsite construction to alleviate constraints to house building in Western Australia", *Proceeding of the International Research Conference: shaping Tomorrow's Built Environment*, *the University of Salford in conjunction with CIB*, *Salford*, 11-12 September 2017, pp. 896-907.

Urbis (2011), *National Dwelling Cost Study*, Urbis Pty Ltd. for the National Housing Supply Council, Australia.

Vrijhoef, R. and Koskela, L. (2000), "The four roles of supply chain management in construction", *European Journal of Purchasing and Supply Management*, Vol. 6, pp. 169-178.

Warsame, A. (2006), "Supplier structure and Housing construction costs", Report 5:73, Building and Real Estate Economics, Department of Infrastructure, Royal Institute of Technology, Stockholm, Sweden.

Williams, T.P. (2003), "Predicting final cost for competitively bid construction projects using regression models", *International Journal of Project Management*, Vol. 21 No. 8, pp. 593-599.

Yin, R.K. (2014), *Case Study Research: Design and Methods*, 5th ed., Sage Publication. Thousand Oaks, CA.

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Dual process of dual motives in real estate market Indonesia

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Abstract

Purpose – The dual process of thinking between conscious processes and unconscious processes generate a different decision. Thinking consciously produces rational decisions. However, a person's cognitive limitation makes him or her simplify complex scenarios and think implicitly result in making decision in heuristics or rules of thumbs. This paper aims to evaluate patterns of decision-making relationships and dual motives for home purchasing by first home buyers and family life cycle in Indonesia.

Design/methodology/approach – Collecting data was done by distributing questionnaires to home buyers within three years (2013-2016). Further data were processed using ANOVA based on group of dual motives, time for buyer and family life cycle.

Findings – The results show that buyers have consumption motives in buying a residence and they behave rational, while investors prefer to buy an apartment and tend to behave heuristics. Dual motives of time for buyers are not significant to decision model. Family life cycle is significant to decision model based on dual motives.

Originality/value – This is an unpublished dissertation study to qualify for graduation.

Keywords Heuristics, Rational, Dual motives, Dual process, Family life cycle, Time for buyer

Paper type Research paper

Introduction

Every individual makes decision using logic or heuristic. The rule of logic is associated with reasoning, whereas heuristic is associated with intuition (Gigerenzer and Gaissmaier, 2011). Decisions that are made with the absence of rationality but emotional lead an individual in making mistakes when making a decision (Kahneman and Tversky, 2000; Gilovich *et al.*, 2002). This condition occurs because of a dual process thinking that consists of a conscious (controlled) or explicit process and an unconscious or implicit process that results in rational decision-making or irrational decision. The decision of explicit or rational thinking (reasoning-system 2) is a decision that maximizes alternative choices (Fishburn, 1970; Keeney and Raiffa, 1976). However, when facing a large number of data and information, the cognitive ability of an individual is not able to analyze optimization in a complex way. Cognitive limitation causes an individual to simplify a complex scenario and think implicitly (intuition-system 1) which results in making heuristic or rules of thumbs decision (Kahneman and Tversky, 1974; Einhorn and Hogarth, 1981; Jungermann, 1983).

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de Bruin and Flint-Hartle (2003) show that property investors in New Zealand behave heuristically to overcome the complexity of cognitive information processing. The higher the complexity of the problem, the more limited the search for information by heuristic behavior. Information processing system is limited by a short-term memory so that heuristic behavior extracts information when evaluate it. As a result, decisions are made to be biased and inefficient (Simon, 1978a). Case *et al.* (2012) also stated that investors in real estate market act irrational. They buy a house at a high price with the hope that the future price will increase. Investors do not take into account the risks properly and act as if increasing price can guarantee the future (Fitzpatrick and McQuinn, 2007). This condition shows investors' behavior changes from rational to irrational, however, not at the same time. Investors' knowledge develops gradually during searching process, so that investors should decide their position in making decision naturally due to their environment (Polic, 2009). Thus, certain behaviors that may be rational for a particular individual cannot be equated to other individuals' behaviors, depending on the degrees of rationality of each person (Simon, 1993).

The functions of the house are consumption and investment (Henderson and Ioannides, 1983). The growth of the net wealth of the individual will affect the motives of consumption and investment when deciding the purchase of the house. A house that is occupied by its owner is bought for consumption motive, regardless the investment motive. On the other hand, when choosing portfolio, a house is considered as an asset investment; regardless the consumption motive (Shiller, 2007), to lessen risking portfolio mixed assets (Seiler *et al.*, 1999; Hoesli *et al.*, 2001). Consumption motive occurs because of many factors; pleasure, satisfaction and non-economics benefit from the occupied house. Whereas, investment motive occurs because of potential financial gain and wealth accumulation when purchasing second house, even though Higgins (2013) stated that first house or second house cannot always be categorized as investment if it is an asset in balance and part of family financial plan (in Wiens, 2013, June).

Dual motives model from Henderson and Ioannides was investigated further by Ioannides and Rosenthal (1994) to measure housing demand in America, and the result showed that portfolio motives model which is consumption motive, is the stimulus decision in purchasing houses. On the contrary, the result in Arrondel and Lefebvre's (2001) research in measuring housing demand in France using the same dual motives model showed that the stimulus decision in purchasing houses is investment motive. When the research was conducted in Spain, this model cannot explain the reason for the purchase of a house (Arrondel *et al.*, 2007). Inconsistent results show the weaknesses of the Henderson and Ioannides models, as they cannot always reflect the portfolio perspective of purchasing decisions in those three countries. The existence of contradictions on the results of dual motives research above makes it necessary to conduct further research on the property market in Indonesia.

Demographic factors of age, education, income, family size (Ioannides and Rosenthal, 1994; Arrondel and Lefebvre, 2001) as well as decision-making behavior are stimuli of purchasing decisions. First home buyers (FHB) need a house for living, but they are in financial trouble because their income is relatively low. The amount of income and the approved loan will determine the price of the house that can be purchased, so considerations of house selection related to financial decisions are done rationally (Goss, 2010; Monico, 2013). Whereas, not FHBs are already on better economic level, their household burden has started to decrease. The investment stimulus is stronger than consumption because the family can set aside their income as savings and has accumulated their wealth (Hood, 1999). However, Burns (2009) points out when investors are searching for a particular residence and location, they involve emotional and sentimental factors. Investors are not involved in formal and comparative risk analysis, so it is not effective to process risks and uncertainties at optimally.

Financial information such as ratio loan to value and capitalization rate also encourage investors to act irrationally.

This research was conducted in Surabaya as one of the second largest cities after Jakarta, the capital city of Indonesia. Also, Surabaya has stable economic growth and conducive security conditions. In addition, Surabaya was also selected as one of the cities of five cities in Asia including Colombo, Sri Lanka; Faisalabad, Pakistan; Irbid; Chittagong, Bangladesh with the purpose of property investment (Pamudji, January 2015). Surabaya experienced an increase in house prices in the first quarter – 2017 (qtq 3.04 per cent) and is predicted to be the highest of 7.67 per cent per year compared to cities in Indonesia (Bank Indonesia, 2017). This research will examine the factors of dual motives that are inconclusive because they have not yet observed the dual process in a person when making decision. Previous research was also very limited to discuss dual motives and dual process at time for buyer and its relation with family life cycle. The composition of the writing is as follows. It is started with a literature review on real estate behavioral, dual process measurement, dual motives of housing wealth accumulation and building hypotheses. The third section shows the research's methodology followed by data analysis and discussion. The final section is a conclusion and suggestion for further research.

Literature review

Behavioral real estate

Investment is a sacrifice to make to get an expected profit for the future (Jaffe and Sirmans, 1989). Types of investment are distinguished between financial investments and real investments. Real estate is one of the investment products which is approved because of needs in real estate market and integrated stock market. Even Seiler *et al.* (1999) and Hoesli *et al.* (2001) recommend investors to do diversification portfolio on real estate product to lessen direct real estate risk in mixed assets portfolio such as stock, bond, option or futures. Investors who do direct real estate also get volatility risk which decreasing through diversification escalation, and total return portfolio escalation (Byrne and Lee, 2003).

Traditional financial theory states that investors act rationally by calculating all available information in decision-making process (Kishore, 2006). However, information flow and real estate market knowledge are not consistent. This happens because real estate market is inefficient; value is determined by market and price is made from negotiation. Investors act based on intuition or emotion in decision-making process (Diaz, 1990, 1997; Gallimore, 1994, 1996; Wolverton, 1996; Hardin, 1999; Levy and Schuck, 2005). Hereafter, there will be a shifting research to behavioral finance which tries to explain the inability of expected utility maximization theory that talks about investors' behavior in efficient market. Behavioral finance evolves to explain economic decision which is done by an individual by combining behavior theory, cognitive psychology, conventional economy and financial theory. Behavioral finance seeks to overcome inconsistency in research's outcome about human's behavioral, either in individual or group, by explaining why and how of the impact to market which might be inefficient.

Farlow (2004) showed determinants of house prices in efficient market are income, interest rate, demographic changes, credit availability, and tax structure. Case and Shiller (1989, 1990) stated that change in house's price has strong positive autocorrelation until three-year period, yet change in house's price fundamentally is still low. Brown and Matysiak (2000) examined the effect of momentum in property index, which return from the previous years was 80 per cent, can explain today's profit. Thus, today's returns can be predicted using previous data like Clayton's (1998) research. This matter proved that real estate market is efficient. On the other hand, Quigley (1999) said that economic fundamental is very important as determinant of house's prices, but model can only explain 10 – to 40 per cent the changes in property's

price. The changes in house's price is very fluctuating, and that fluctuating is not explained fundamentally but decided by individual's behavior and financial institution. That is to say, future's price of a house cannot be predicted based on today's information. More to practical sides, real estate market has lack of liquidity higher than equity market and bond. Accumulation cost, processing information and real estate trading fees are higher than stock and bond trading fees. This condition illustrates weak form efficient in real estate market.

An individual's behavior in real estate market determined decision-making process which involves psychology factor and investment in micro level (decision-making process by individual and group) and macro level (financial market role). Investors' decision-making process combines quantitative aspect (purpose) and qualitative (subjective) which based on specific feature from investment product or financial service. Investors, based on cognitive factor (mental process) and affective (emotional) by individual (or group), make valuation and decision based on past events, personal belief and preferences. An individual experiences shifting in making decision from rational to psychological and social (Bargh, 2002; Farragher and Kleinman, 1996; Miles *et al.*, 1989), so it is needed to have further analyze on one's behavior which against rational approach.

Potentials in bias source decision-making rational choice are many factors such as individual factor, social or structural. First, individual has limited cognitive abilities to process information and making estimation, resulting in making heuristic decision to simplify complex environment (Corbin, 1980; Hogarth, 1981; Meyer and Eagle, 1982). Second, social source bias, like brokers or lenders, give undesirable or unintentional information for their own personal interest (Palm, 1982; Smith and Clark, 1980; Smith and Mertz, 1980), resulting rational decision become bias by decision environment (Kreibich and Petri, 1982). Third, structural source bias are deeply rooted in the norms of the society. Implication of social settings in society is not based on personal egoism but is in line with society's hope (Bassett and Short, 1980; Pipkin, 1981; Sheppard, 1980).

Wofford (1985) illustrates investors' cognitive process in making investment decision in real estate market. Perception and expectation are processed through several of "filters" (heuristic, characters, beliefs, and bias). Hereafter, investment's purpose and decision-making are influenced by those processes. It is much easier when investors understand the psychological process to lessen decision-making bias. Furthermore, Pyhrr *et al.* (1989) showed real estate investors often failed to consider important factors in decision-making process. Difficulties and lack of information make investors concentrate on few main assumptions related to future condition, evaluate with rules of thumb and then make decisions. Most of the investors exaggerate about today's information, resulting in too optimistic with their decision, whereas information that are not favorite causes decisions that are made pessimistically. Investors have irrational and bias preferences because they cannot control risks and uncertainties. As a result, investors use intuitive ability in processing uncertainties so there is no rational decision-making.

Robbins (2001) stated that decisions happen because of reaction of problems, differences between today's statement and desired condition; therefore, it is needed to consider an alternative. However, decision-making process by an individual shows independent difference from cognitive ability (intelligence) with motivation difference or personality (Galotti *et al.*, 2006). Decision-making by an individual creates basic micro economic analysis which makes an individual to have various styles to make decision driven by rationality (Edwards, 1967; Mellers *et al.*, 1998; Simon, 1992). Therefore, a good decision is determined not only by experience and decision makers' skill but also by adequacy and validity of the information such as data or knowledge that is gained from different environment (Ahmad *et al.*, 1999).

Dual process measurement

Limited cognitive ability directs an individual to take decision in heuristic way as a shortcut (Shah and Oppenheimer, 2008) especially in complex and uncertainty environment (Ritter, 2003) by decreasing valuation complexity in predicting values of consideration in a simple way (Kahneman and Tversky, 1974). An individual performs heuristics due to limited time to search for information and effort to be issued; thus, a heuristic decision leads to a trade-off of loss of accuracy due to speed and austerity of cognition (Shah and Oppenheimer, 2008). In 1996, Epstein *et al.* (1996) developed cognitive experiential self-theory, a theory that measures one's preferences to two cognitive styles, to rational experiential inventory (REI). REI-40 is designed to asses preferences information processing. First is the rational style, measuring adaptation from scale need for cognition (Cacioppo and Petty, 1982), which emphasizes on consciousness and analytical approach. Second is the experience style that is measured with scale faith intuition which emphasizes on pre-conscious, affective and holistic approach.

First measurements of dual process in REI-40 were rational ability which is an individual's thinking ability using logic and analytic, and rational engagement which is the involvement of an individual in decision-making on pleasure of analytical thinking using logic. Second, experiential ability is the ability of an individual based on intuition and feelings, and experiential engagement is the involvement of an individual in decision-making based on feelings and intuition. Rational thinking is symbolized as slow, deliberative/consultative, following the rules, especially verbally and consciously. Whereas, intuition is symbolized as a pre-conscious, closely related to affective, fast, operating automatically and holistically. An individual's emotional response on an incident has chronological reaction; experience system, automatically and immediately, searches for a memory bank which connected to a related incident. Memories and feelings of the individual influence the process as well as the trends of further behavior. If positive feelings are recalled, individuals will automatically think and have a tendency to reproduce feelings. If an individual recalls negative feeling, he or she will automatically think and have the tendency to avoid feelings. Thus, experiential significantly related to interpersonal relationship that are positive, creative and emotional expression (Epstein, 1990, 2008; Evans, 2008; Hammond, 1996; Hogarth, 2005; Kahneman, 2003; Kahneman and Frederick, 2002; Sloman, 1996; Stanovich and West, 2000) (cited in Witteman *et al.*, 2009).

Dual motives of housing wealth accumulation

Real estate investment is a commitment of individual funds with the aim of maintaining and increasing capital and gain profit. The expected benefit of real estate investors is income consisting of active income (income from individual direct activities, e.g. salaries, bonuses, commissions) is called active investors; passive income (income from indirect activity by individual, e.g., rental income, dividend) is called passive investors; and portfolio income (interest income, stock dividend, capital gains, royalties) (Cortesi, 2013). Haight and Singer (2005) stated that investment on real state needs hard work because investors must have skills, knowledge, and power to find the right property, evaluate it, set the finance, manage the property or find the buyer. House investment is financial investment where an individual is motivated to own a house because the needs to have a shelter according to the individual's financial capability.

Shiller (2007) stated home buyers have different goals due to investment stimuli or consumption stimuli. Investors are property buyers who want a portfolio on some properties and do not have to stay on all those properties (Haughwout *et al.*, 2011). Whereas, consumption motive is a desire to own a house which will be used for one's own. One of the stimuli to do house-purchasing for consumption interest is social and emotional side of the

house ownership. The value of large transactions but low frequency occurs on the purchase of houses, especially by household buyers. Home is considered as the greatest asset in most families, as well as a sense of security, independence and privacy (Rahman, 2010). The house is owned for a long time of at least 15 years even 50 years (Snively, 2009). Psychological factor in the buyer's self is the feelings of freedom to do activities according to the buyer's wishes such as decorating the house and interacting with the neighbors to build social communities in selected housing environments (Campbell and Cocco, 2005). Snively (2009) points out several reasons for house as consumption needs; first, the appreciation of house prices does not result in an increase in the wealth of homeowners, whereas the rise in house prices is an indicator of the owner's net wealth. If the increase is higher, it will allow a person to fund more consumption including using a loan to have a higher value asset. Second, the availability of credit funds or the use of equity funds to finance not only house purchases with consumption motives but also purchases for investment. Third, according to Campbell and Cocco (2005), buyers experience changes in consumption influenced by income, house prices, debt repayment ability, interest rates and inflation.

Investment or consumption decision involves a trade-off process when selecting a house location. Highly earned individuals or families choose desirable locations with better quality on public areas and facilities, whereas individuals or families with lower income choose less desirable locations. Individuals or families choose a house location based on the current level of wealth and "match" conditions as well as the stages in the family life cycle. Empirically, socioeconomic characteristics (household size, age of household members, education and income) also affect the preferences and choices of location in such individuals or families (Haavio and Kauppi, 2011). Table I shows families grouping according to marriage age which is also named as family life cycle stages.

McCarthy's (1976) study shows different house needs according to the family life cycle. Newly married young families or families who already have young children buy a house for shelter. While families who are married with children at school age, or growing up, even their children are married and do not live with the parents, have different house needs. Marriage and children are the main factors that encourage a person to make the first home purchase; people have the tendency to choose a residence that is not in the area with investment opportunities. Psychologically, home buyers intend to stay for a long time, have a feeling of freedom to do activities as they wish, to be able to socialize with neighbors to build a social community in a desired housing environment, younger families have a

Table I. Marriage age scheme of family life cycle stage

No.	Family life cycle stage	Explanation	Age group (year old)	Marriage age (year old)
1	Honeymooners	Married couples, with children or not yet with children	14-20	0-5
2	Full Nest 1	Couples with the eldest aged less than 6 years old	21-30	6-10
3	Full Nest 2	Couples with the eldest aged 6 – 12 years old	31-40	11-15
4	Full Nest 3	Couples with the eldest aged 13- 20 years old	41-50	16-20
5	Empty Nest 1	Couples with at least one child is living with the parents	51-60	21-25
6	Empty Nest 2	Couples with all children no longer live with the parents	61-70	26-30
7	Dissolution	Couples who have been living alone, one spouse had died, and do not live with the child	71+	31+

Source: Spanier *et al.* (1979)

stronger relationship between house prices and consumption needs than older families. Younger families are bound to need a minimal house size because it is related to financial needs and loans that must be provided. Considered financial needs are utilities fee, maintenance fee, mortgage, insurance and property tax which have to be paid along the ownership (Campbell and Cocco, 2005).

Case *et al.*'s (2012) research showed buyers act irrationally when buying house with investment purpose. Media information influences decision-making. Investors find it easy to memorize newest information which resulting in making bias decision. Investors prefer known investment product by ignoring basic investment principles and diversification to reach optimization (Barberis, 2001). However, Henderson and Ioannides (1983) use portfolio choices model and prove owner-portfolio is inefficient because there is too much investment on houses. This result indicates that house owner is irrational in his or her financial decision. On the other hand, inefficient portfolio is the result of rationality from the balance of consumption benefit and distortion of house product investment portfolio (Brueckner, 1997). Consumption decision is based on the needs of information and rational thinking; it involves a group of activities which connected one another to choices of some available alternatives:

H1. When an individual buys a house with consumption motive, the decision model tends to be rational compared to an individual with investment motive.

House is needed by every individual or families as a residence. Marriage is one of the reasons for an individual to purchase a house for the first time. However, the condition of FHB with relatively low income and savings faces credit constraints when buying a house. FHB does a lot of consideration before deciding rationally, such as source of fund to pay the down payment, the amount of income that can cover monthly instalment, potential on changes in economic condition which affects on the amount of the loan interest rate and increased income. FHB's position that is limited financially push them to act unhurried (Goss, 2010; Monico, 2013). FHB make some alternatives for house choices which will be purchased suitable to their financial capability. FHB are willing to choose houses with so-so location for adjusting the fund they own (Fisher and Gervais, 2007; Kupke, 2008). The level of an individual's wealth which has been accumulated encourages the occurrence of portfolio motives, second or subsequent house investment as diversified investment products. The purpose of the investment is capital gain, rental income or retired wealth (Fisher and Gervais, 2007). In purchasing process, not FHB party does not involve in risk and return analyzing, prioritize experiences and has limited information and knowledge gained. Therefore, not FHB act with their own intuition. Decisions are made in heuristic way (Burns, 2009; Gigerenzer and Gaissmaier, 2011):

H2. An individual who buys a house for the first time with consumption motive, his or her decision model tend to be rational compare to an individual who buys a second house and subsequent with investment motive.

McCarthy's (1976) research describes the difference of housing needs based on families' life cycle. Newly married couples buy their first house for living. This also applies to families who have small, little children. Consumption motive in a younger family group is more dominant than investment motive. Level of education and high income allow a person to get a loan for purchasing houses. However, younger families with consumption motive have limitation on income and wealth, resulting in failure in credit application when purchasing a house. FHB condition in younger families, with its limitation, make consideration from various choices' alternatives rationally before making decision (Arrondel *et al.*, 2007; Goss, 2010; Monico, 2013). Whereas, married couple with school-age children, grown up, or even

the children have already married and no longer living with the parents, have different housing needs (McCarthy's, 1976). Those kinds of families groups have investment motive more dominant than consumption motive; depends on the income and possessed wealth. Established families decide to buy their second house and the next house and subsequent as investment portfolio. Purchased house is expected to provide rental income or capital gain when it is resold. However, the effect of previous transaction experiences and information from brokers or developers leads older families to act using experience system, so that older families' decisions are inconsistent in the processing of risk and return information on purchased houses. Purchasing decision is made irrationally (Burns, 2009):

H3. An individual who buys the first house with consumption motive on younger families, his or her decision model tend to be rational compare to an individual who buys second house and subsequent in older families with investment motive.

Methodology

This study uses primary data by distributing questionnaires to buyers of houses or apartments who had made transactions in the past three years (2013-2016). Respondents are domiciled in Surabaya, but the location of the purchased property is located in all areas in Indonesia. Respondents search is done incidentally at the property broker's office, the developers' office and by the online way through Google forms, due to the unavailability of official data on the number of property purchased transactions during the study period. The period of spreading questionnaire was four months since May-September 2016 because in those months, developers often held exhibition of housing, open house and gathering event. The process of seeking respondents by visiting direct respondents such as door-to-door system is more effective than using the letter. Questionnaires can be collected from 254 respondents, then selected based on transaction time of three years and purchased transactions only at house or apartment. Further data that can be processed were 231 questionnaires.

The research questionnaire used REI 40 as a measure of buyer rationality. Before the item was distributed on the questionnaire, REI 40 was translated into *Bahasa Indonesia* by involving linguists and psychologists who gave inputs to the questionnaire so that it can be understood easily by the respondents. Then, the data are tested for its validity and reliability before analyzing data using ANOVA which contained in SPSS program. This research did not develop predictive model so it did not require econometric model. The use of ANOVA is more appropriate to confirm differences in between group decision models. Table II shows the operational definition of the research variables used in this study.

Data and results

Table III shows data of descriptive respondents who have consumption and investment motive based on Time For Buyer (TFB), Family Life Cycle (FLC), dual process, age, education, income and number of family. The majority of respondents are not FHB, dominated by younger families, married below 10 years, has a rational decision-making model. Buyers are dominated by 31-40 years old people, have bachelor degree, have an income of 10-25 million Rupiahs and most of them have the number of family members borne by three people.

Measuring the level of rationality of buyers of houses and apartments by using REI 40 which classifies the question items into two, namely, rational and experential. Rational group is measured from two subs; rational ability – individual's thinking ability using logic and analytical, and rational engagement – individual's involvement in making decision on pleasure of analytical thinking using logic. Experential group is measured from two subs;

Variable	Keterangan
Dual motives	1 = Consumption; 0 = Investment
Time for buyer	1 = First-home buyer; 0 = Not first-home buyer
Family life cycle	1 = Younger family (less than 10 years marriage); 0 = Older family (more than 10 years marriage)
Dual process	10-item rational ability and 10-item rational engagement (REI 40) 10-item experential ability and 10-item experential engagement (REI 40) 1 = very not true; 2 = not true; 3 = true enough; 4 = true; 5 = very true (inverse item no. 3, 4, 5, 6, 7, 8, 10, 11, 16, 18, 19, 21, 23, 24, 25, 27, 31, 32, 33,34, 39)
Age	1 ≤ 20 years; 2 = 21-30 years; 3 = 31-40 years; 4 = 41-50 years; 5 = 51-60 years; 6 > 61 years
Education	1= until Undergraduate; 2 = Postgraduate
Income	1 ≤` Rp.3m; 2 = Rp.3-5m; 3 = Rp.5-10m; 4 = Rp.10-25m; 5 = Rp.25-50m; 6 > Rp.50m
No. of family	Number of family

Table II. Research variable

experiential ability which is individual's ability based on intuition and feeling, and experiential engagement which is individual's involvement in making decision based on his or her feeling and intuition. Both groups were searched for their average score on a continuum scale, then used in the ANOVA test. Scale 1 leads to the tendency of heuristic decision-making models and Scale 5 leads to the tendency of rational decision-making models. The test of decision-making model of dual motives is listed in Table IV. Testing of decision-making model of dual motives and Time for Buyer (TFB) is listed in Table V. Testing of decision-making model of dual motives and Family Life Cycle (FLC) is listed in Table VI.

Homogeneity test is performed before ANOVA test on variable of dual motives. Levene statistical motive of ownership (L = 2.685, p-value = 0.103) shows that the data have the same variance (homogeneous). The result of F test on the motive of ownership (F = 3.408; p-value = 0.066) showed that there are statistically significant differences in decision-making model on consumption motive (M = 2.7190) and investment motive (M = 2.6041). Therefore, an individual with consumption motive has a decision model that tends to be rational compared to an individual with investment motive.

Table V shows homogeneity tests on interaction groups of dual motives and TFB (L = 1.035, p = 0.378) shows data have the same variance. F test results in the dual motives and TFB interaction group (F = 1.238; p = 0.297) showed no statistically significant differences in the decision model. Post hoc intergroup tests did not show significant differences in decision-making model. Therefore, the decision model of the individual who buys the first house with consumption motive has no difference than the individual who buys the second house and then with investment motive.

Table VI shows homogeneity test in dual motive interaction group, TFB and FLC (L = 4.331, p = 0.001) show data having unequal variance, therefore, different test using Welch test. The Welch test's result in the dual motives interaction group, TFB and FLC (W = 3,839; p = 0.004) show significant differences in the decision model. Post hoc intergroup test of FHB with consumption motive in younger families (Group 1) was significantly different (p = 0.047) statistically under 5 per cent against second and subsequent home buyers who had an investment motive in older families (Group 6) and not FHB group who has consumption motive in younger families (Group 2) is significantly different (p = 0.003) statistically below five per cent against second and subsequent home buyers who have an investment motive in older families (Group 6) in

	Consumption	Investment
Time for buyer		
First-home buyer	42	13
Not first-home buyer	88	88
Family life cycle		
Younger family	97	51
Older family	33	50
Dual process		
Rational	120	86
Heuristic	10	15
Age		
≤20 years	2	2
21-30 years	53	19
31-40 years	45	31
41-50 years	20	32
51-60 years	10	18
>61 years	0	1
Education		
Until undergradute	112	80
Postgradute	18	21
Income		
<Rp.3m	6	3
Rp.3-5m	30	9
Rp.5-10m	29	15
Rp.10-25m	34	29
Rp.25-50m	17	26
>Rp.50m	14	19
No. of family		
1	27	9
2	33	17
3	29	36
4	24	23
5	13	9
6	5	6

Table III. Respondents' demographic data

the retrieval model buying decision. Different test results were also found in not FHB group that had an investment motive in younger families (Group 5) against the not FHB group with an investment motive in older families (Group 6) ($p = 0.025$) in the decision-making model. Thus, FHB with consumption motives in younger families tend to have rational decision model than FHB in older families with investment motives.

Discussion

Dual motives vs decision model

Every individual believes his or her thoughts are truly rational; however, bias occurred while processing in rational system because rational system does not provide creative ideas to be created as information resource. When a person reacts to an incident emotionally, the order of reaction will automatically directed to experience system and instantly looking for a memory bank that related to related incident. An individual's memories and feelings

influence the process and the tendency of further behavior; therefore, the experience system has a positive or negative effect on the rational system. That process is proven to occur also in individuals who buy a house. This study proves that buyers who are driven by a factor of necessity; rather than renting a house or living in a relative's/parents' house, will make a purchase on a house. Buyers choose a house with many considerations to be a residence that provides comfort like Koklic and Vida's (2009) research.

Those many considerations are processed in a longer time by collecting much information from parents or relatives, friends or newspaper, brochure or internet. Buyers' experience in searching process for a desired house in a time will affect their experience in another time. Buyers will consider their financial ability such as availability and capability in terms of paying. Numbers of consideration will make buyers tend to use rational system in making decision. Also, buyers with experience in doing property transactions more than once in limited time tend to decide rationally (Frederick and Loewenstein, 1999; Read, 2004).

From investors' point of view, purchasing a house or apartment is portfolio allocation. Investors aim to earn additional income from the lease, to earn profits when the house is later sold (capital gain) and to prefer the property as investment products than other products. The time required to make decision is shorter for investors; through property brokers, home exhibitions and product launching. This media creates the interaction of

Variable	Sum of squares	df	Mean square	Hypothesis	*F*	Sig.
Panel A: Table ANOVA						
Dual						
Between groups	0.751	1	0.751	*H1*	3.408	0.066
Motives						
Within groups	50.458	229	0.220			
Total	51.209	230				

Panel B: Mean					
Decision model	Variable	Categories	Mean	*SD*	*N*
	Dual motives	Consumption	2.7190	0.44616	130
		Investment	2.6041	0.49779	101

Table IV. ANOVA findings for dependent variable in decision-making model for *dual motives*, TFB and FLC

	Sum of squares	df	Mean square	Hypothesis	*F*	Sig.
Panel A: Table ANOVA						
Between groups	0.824	3	0.275	*H2*	1.238	0.297
Within groups	50.385	227	0.222			
Total	51.209	230				

Panel B: Mean				
	Group	Mean	*SD*	*N*
Decision-making model	Consumption, FHB	2.7519	0.41812	42
	Consumption, *Not FHB*	2.7033	0.46043	88
	Investment, FHB	2.5838	0.55295	13
	Investment, *Not FHB*	2.6070	0.49252	88
	Total	2.6687	0.47186	231

Table V. ANOVA findings for dependent variables in decision-making models on variable interaction of dual motives and TFB

Table VI. ANOVA findings for dependent variables decision-making models in variable interaction of dual motives, TFB and FLC

	Sum of squares	df	Mean square	Hypothesis	F	Sig.
Panel A: Table ANOVA						
Between groups	4.438	5	0.888	*H3*	4.270	0.001
Within groups	46.771	225	0.208			
Total	51.209	230				

Panel B: Mean	Group	Mean	SD	*N*
Decision-making model	Group 1 (C, FHB, YF)	2.7519	0.41812	42
	Group 2 (C, NFHB, YF)	2.7920	0.34744	60
	Group 3 (C, NFHB, OF)	2.5132	0.60363	28
	Group 4 (I, FHB, YF)	2.5627	0.58476	11
	Group 5 (I, NFHB, YF)	2.7805	0.42735	40
	Group 6 (I, NFHB, OF)	2.4720	0.49695	50
	Total	2.6687	0.47186	231

investors and developers or intermediaries, so that the position of investors will be influenced and encouraged to make decisions as soon as possible with "lure" of profits that can be obtained immediately. The influence of spouse, children and friends, even oneself really affects in making decision if it is dominated by emotional factor. As a result, the condition encourages investors to use the experience or intuition system in purchasing houses because problem-solving is made quickly and tends to ignore information, especially in situations with high complexity level, uncertainty and time-pressure (Gigerenzer and Gaissmaier, 2011; Tversky and Kahneman, 1973; Kahneman and Tversky, 1974).

Time for buyer vs decision model

Newly married FHB or married but not yet have children have preferences that are inclined to the motive of consumption, which is the desire to have a house as a place to build a new family and to live comfortably. FHB have a dream to build households independently without being dependent on parents, so FHB seeks information and takes into considerations the house to be purchased for the first time. Decisions are adjusted to the condition of the limited funds they have. Therefore, when FHB makes a purchase, they need more time to think and make comparisons on existing options before they finally decide. Whereas, not FHB are more dominated by investment motives, although second and subsequent home purchases are not always categorized as investment, if it is used as a family asset (Wiens, 2013, June). Financial capability and the high amount of wealth motivate an individual to invest. Repetitive house-purchasing directs not FHB to use experience system compare to their rationality in making decision. However, dual process on TFB cannot be distinguished significantly. Information processing process on FHB and not FHB using rational system and experience system at the same time simultaneously interact (Foxall and Goldsmith, 1994; Campbell and Cocco, 2005; Scanlon and Whitehead, 2010; Epstein *et al.*, 1996).

Family life cycle vs decision model

Group 1, FHB with consumption motive in families of under 10 years old age (younger families) and not FHB in younger families with consumption motive (Group 2) tend to be rational in making purchasing decision compared to not FHB with investment motive in

older families (Group 6). Married families with additional family members are encouraged to purchase a house with considerations; to have one instead of to rent one, are no longer have reasons to stay with parents or insufficient house capacity. Therefore, the purchased house is used as a place to live and live comfortably with the nuclear family. However, in certain cases, parents live together in the house, so the environment around the purchased house is adjusted to the buyers' – and maybe the parents of the buyers – wish.

Purchases that occur by young families aged around 20 years old are affected by their financial condition, which sometimes involve financial support from parents or relatives. The process of product selection and family deliberation takes a considerable time before it is decided. As a result, younger families tend to be rational in making decision. On the other hand, if the financial condition is better, then the family will be at ease to make faster purchasing decisions. Not FHB in younger families with sufficient funds tend to have an investment motive in the property than other investment products (stocks, bonds). They will consider the risks and returns of the houses or apartments they bought carefully because they understand that their experience is still limited, such as planning the cost of moving to a popular area with reputation considerations. While married families of more than 10 years with good financial condition have the ability to accumulate wealth from income earned, the investment motivation is more dominant than the consumption motive. House investment is considered to have prospects in the future if it is located in popular location. Another benefit of house investment is obtaining rent income or higher capital gain due to the popular location (Hutchison, 1994; Seelig *et al.*, 2009; Tan, 2009). Increased knowledge and investment experience allow older families to make better investment decisions by studying risks more accurately and understanding risks and returns relationship in the real estate market that are deemed to be more stable than the stock market better (Fishbein and Ajzen, 1975; Foxall and Goldsmith, 1994). However, the emotional factors that bind older families related to the location and environmental conditions around them; social conditions and personal relationships with neighbors, will lead the older families to act irrational to fulfill their desires. The tendency to live in the environment, the communities they recognize and the proximity of children and grandchildren encourage older families to use intuition in making decisions.

Conclusion

Buyers with consumption motives are more likely to be rational in deciding house purchases than buyers with investment motives, as well as interactions with family stages. Younger individuals or families tend to be more rational in decision-making than individuals or older families who tend to decide heuristics. However, there is no difference at Time for Buyer. Purchasing a house is an important decision in one's life so that decisions are tend to involve parents or relative. The habit of living in a large family structure along with several levels of family structure makes oneself tends to make decisions by involving a deliberative process. However, in families with excellent financial capabilities and no complex family structure, decisions can be personally defined. Research on the behavior of buyers or property investors need to be developed to make the real estate market more efficient. The behavior of buyers or investors who tend to be heuristic needs to be understood further so that government and developers can prevent the happening of bubble market. The risk of loss in dual process of purchasing decision can be suppressed by the developers, the government, as well as the buyers themselves, especially in the availability of fund purchases. Government's control on financing in the property sector plays an important role so that developers, buyers and investors who use loans take rational rather than emotional considerations. The developer can also determine the strategy of selling residentials and apartments according to individual needs at the stage of his or her life cycle.

References

Ahmad, A.M., Ahmad, F., Din, G., Razak, H.A. and Noor, N.A.M. (1999), *Pengantar Pengurusan*, Universiti Utara Malaysia, Sintok.

Arrondel, L. and Lefebvre, B. (2001), "Consumption and investment motives in housing wealth accumulation: a French study", *Journal of Urban Economics*, Vol. 50 No. 1, pp. 112-137.

Arrondel, L., Badenes, N. and Spadaro, A. (2007), "Consumption and investment motives in housing wealth accumulation of Spanish households", Working Paper: Preliminary Draft, pp. 1-24, available at: www.uib.cat/depart/deaweb/webpersonal/amedeospadaro/workingpapers/Arrondel_Badenes_Spadaro.pdf

Bank Indonesia (2017), "Survei Harga Properti Residensial di Pasar Primer: Triwulan I – 2017", Divisi Statistik Sektor Riil, Departemen Statistik, Bank Indonesia, available at: www.bi.go.id/id/publikasi/survei/harga-properti-primer/Pages/SHPR-Tw.I-2017.aspx

Barberis, N. (2001), "Investors seek lessons in thinking", *Financial Times*, Mastering Investment part six, 18 June.

Bargh, J.A. (2002), "Losing consciousness: automatic influences on consumer judgment, behavior and motivation", *Journal of Consumer Research*, Vol. 29 No. 2, pp. 280-285.

Bassett, K. and Short, J.R. (1980), *Housing and Residential Structure*, Routledge and Kegan Paul, London.

Brown, G.R. and Matysiak, G.A. (2000), "Real estate investment", *A Capital Market Approach*, Pearson Education, Harlow.

Brueckner, J.K. (1997), "Consumption, investments motives, and the portfolio choices of homeowners", *The Journal of Real Estate Finance and Economics*, Vol. 15 No. 2, pp. 159-180.

Burns, L.M. (2009), "The effect of the first home owner's grant on the Perth housing market", Thesis of Bachelor Degree, School of Economics and Finance, Curtin University of Technology, Perth.

Byrne, P. and Lee, S. (2003), "The impact of real estate on the terminal wealth on the UK mixed-asset portfolio", Working paper 05/03, Department of Real Estate and Planning.

Cacioppo, J.T. and Petty, R.E. (1982), "The need for cognition", *Journal of Personality and Social Psychology*, Vol. 42 No. 1, pp. 116-131.

Campbell, J.Y. and Cocco, J.F. (2005), "How do house prices affect consumption? Evidence from micro data", NBER Working Paper No. 11534, Massachusetts Avenue, Cambridge.

Case, K.E. and Shiller, R.J. (1989), "The efficiency of the market for single-family homes", *The American Economic Review*, Vol. 79 No. 1, pp. 125-137.

Case, K.E. and Shiller, R.J. (1990), "Forecasting prices and excess returns in the housing market", *Real Estate Economics*, Vol. 18 No. 3, pp. 253-273.

Case, K.E., Shiller, R.J. and Thompson, A. (2012), "What have they been thinking? Homebuyer behavior in hot and cold markets", Cowles Foundation Discussion Paper No. 1876, Yale University, CT.

Clayton, J. (1998), "Further evidence on real estate market efficiency", *Journal of Real Estate Research*, Vol. 15, pp. 41-57.

Corbin, R.M. (1980), "The secretary problem as a model of choice", *Journal of Mathematical Psychology*, Vol. 21 No. 1, pp. 1-29.

Cortesi, G.R. (2013), *Mastering Real Estate Principles*, 6th ed., Kaplan, Inc., Dearborn Real Estate Education, Fort Lauderdale, FL.

De Bruin, A. and Flint-Hartle, S. (2003), "A bounded rationality framework for property investment behaviour", *Journal of Property Investment and Finance*, Vol. 21 No. 3, pp. 271-284.

Diaz, J. III. (1990), "How appraisers do their work: a test of the appraisal process and the development of a descriptive model", *Journal of Real Estate Research*, Vol. 5 No. 1, pp. 1-15.

Diaz, J. III. (1997), "An investigation into the impact of previous expert value estimates on appraisal judgment", *Journal of Real Estate Research*, Vol. 13 No. 1, pp. 57-66.

Edwards, W. (1967), "The theory of decision making", in Edwards, W. and Tversky, A. (Eds), *Decision Making*, Penguin Books, Harmondsworth, pp. 13-64.

Einhorn, H.J. and Hogarth, R.M. (1981), "Behavioral decision theory: processes of judgement and choice", *Annual Review of Psychology*, Vol. 32 No. 1, pp. 52-88.

Epstein, S. (1990), "Cognitive-experiential self-theory", in Pervin, L. (Ed.), *Handbook of Personality Theory and Research*, Guilford, New York, pp. 165-192.

Epstein, S. (2008), "Intuition from the perspective of cognitive-experiential self-theory", in Plessner, H., Betsch, C. and Betsch, T. (Eds), *Intuition in Judgment and Decision Making*, Erlbaum, New York, pp. 23-37.

Epstein, S., Pacini, R., Denes-Raj, V. and Heier, H. (1996), "Individual differences in intuitive-experiential and analytical-rational thinking styles", *Journal of Personality and Social Psychology*, Vol. 71 No. 2, pp. 390-405.

Evans, J.S.B.T. (2008), "Dual-processing accounts of reasoning, judgment, and social cognition", *Annual Review of Psychology*, Vol. 59, pp. 255-278.

Farlow, A. (2004), "UK house prices: a critical assessment", Paper presented at the Credit Suisse First Boston Housing Market Conference, 12 May 2003, pp. 1-22, available at: www.andrewfarlow.com/part1ukhousing.pdf

Farragher, E. and Kleinman, R. (1996), "A re-examination of real estate investment decision making practices", *Journal of Real Estate Portfolio Management*, Vol. 2 No. 1, pp. 31-39.

Fishbein, M. and Ajzen, I. (1975), *Belief, Attitude, Intentions and Behavior: An Introduction to Theory and Research*, Addison Wesley, Reading, MA.

Fishburn, P.C. (1970), *Utility Theory for Decision Making*, Wiley, New York, NY.

Fisher, J.D.M. and Gervais, M. (2007), "First time home buyers and residential investment volatility", Working paper presented to Federal Reserve Bank of Chicago, 29 November, pp. 1-7, available at: www.google.com/search?q=fisher+and+gervais+2007&ie=utf-8&oe=utf-8&client=firefox-b

Fitzpatrick, T. and McQuinn, K. (2007), "House prices and mortgage credit: empirical evidence for Ireland", *The Manchester School*, Vol. 75 No. 1, pp. 82-103.

Foxall, G.R. and Goldsmith, R.E. (1994), *Consumer Psychology for Marketing*, Routledge, London.

Frederick, S. and Loewenstein, G. (1999), "Hedonic adaptation", in Kahneman, D., Diener, E. and Schwarz, N. (Eds), *Well-Being: The Foundations of Hedonic Psychology*, Russell Sage Foundation Press, New York, NY, pp. 302-329.

Gallimore, P. (1994), "Aspects of information processing and value judgement and choice", *Journal of Property Research*, Vol. 11 No. 2, pp. 97-110.

Gallimore, P. (1996), "Confirmation bias in the valuation process: a test for corroborating evidence", *Journal of Property Research*, Vol. 13 No. 4, pp. 261-273.

Galotti, K., Ciner, E., Altenbaumer, H., Geerts, H. and Woulfe, J. (2006), "Decision- making styles in a real-life decision: choosing a college major", *Personality and Individual Differences*, Vol. 41 No. 4, pp. 629-639.

Gigerenzer, G. and Gaissmaier, W. (2011), "Heuristic decision making", *Annual Review of Psychology*, Vol. 62 No. 1, pp. 451-482, doi: 10.1146/annurev-psych-120709-145346.

Gilovich, T., Griffin, D. and Kahneman, D. (2002), *Heuristics and Biases: The Psychology of Intuitive Judgment*, Cambridge University Press, New York, NY and Cambridge.

Goss, D. (2010), "Pathways into first-home-ownership", Refereed papers presented at the 4th Australasian Housing, *Sydney*, 5th-7th August 2009.

Haavio, M. and and Kauppi, H. (2011), "Owner-occupied housing as an investment, regional house price cycles, and residential sorting", Discussion papers, Bank of Finland Research, pp. 1-84, available at: www.suomenpankki.fi/en

Haight, G.T. and Singer, D.D. (2005), The real estate investment handbook, *The Frank J. Fabozzi Series*, John Wiley and Sons, Hoboken, NJ.

Hammond, K.R. (1996), *Human Judgment and Social Policy: Irreducible Uncertainty, Inevitable Error, Unavoidable Injustice*, Oxford University Press, Oxford.

Hardin, W.G. III. (1999), "Behavioural research as an academic pursuit: lessons from other disciplines and implications for real estate", *Journal of Property Investment and Finance*, Vol. 17 No. 4, pp. 333-352.

Haughwout, A., Lee, D., Tracy, J. and Klaauw, W.V.D. (2011), "Real estate investors, the leverage cycle, and the housing market crisis", Federal Reserve Bank of New York, Staff Report No. 514, available at: www.econstor.eu/bitstream/10419/60965/1/668533382.pdf

Henderson, J.V. and Ioannides, Y.M. (1983), "A model of housing tenure choice", *American Economic Review*, Vol. 73 No. 1, pp. 98-113.

Hoesli, M. MacGregor, B. Adair, A. and McGreal, S. (2001), "The role of property in mixed asset portfolios (MAPs)", RICS Foundation, RS0201.

Hogarth, R.M. (1981), "Beyond discrete biases: functional and dysfunctional aspects of judgemental heuristics", *Psychology Bulletin*, Vol. 90 No. 2, pp. 197-217.

Hogarth, R.M. (2005), "Deciding analytically or trusting your intuition? The advantages and disadvantages of analytic and intuitive thought", in Betsch, T. and Haberstroh, S. (Eds.), *The Routines of Decision Making*, Mahwah, Erlbaum, NJ, pp. 67-82.

Hood, J.K. (1999), "The determinants of home ownership: an application of human capital investment theory to the home ownership decision", *Honors Projects*, IL Wesleyan University, Bloomington, p. 71, available at: http://digitalcommons.iwu.edu/econ_honproj/71

Hutchison, N.E. (1994), "Housing as an investment", *Journal of Property Finance*, Vol. 5 No. 2, pp. 47-61.

Ioannides, Y.M. and Rosenthal, S.S. (1994), "Estimating the consumption and investment demands for housing and their effect on housing tenure status", *Review of Economics and Statistics*, Vol. 76 No. 1, pp. 127-141.

Jaffe, A.J. and Sirmans, C.F. (1989), *Fundamentals of Real Estate Investment*, 2nd ed., Prentice Hall, Englewood Clifts, NJ.

Jungermann, H. (1983), "The two camps of rationality", in Scholz, R.W. (Ed.), *Decision Making under Uncertainty*, North-Holand/Elsevier, Amsterdam, pp. 63-86.

Kahneman, D. (2003), "A perspective on judgment and choice: Mapping bounded rationality". *American Psychologist*, Vol. 28, pp. 697-720.

Kahneman, D. and Frederick, S. (2002), "Representativeness revisited: Attribute substitution in intuitive judgment" in Gilovich, D.G.T. and Kahneman, D. (Eds), *Heuristics and Biases: The Psychology of Intuitive Judgment*, Cambridge University Press, Cambridge, pp. 49-81.

Kahneman, D. and Tversky, A. (1974), "Judgment under uncertainty: heuristics and biases", *Science (New York, N.Y.)*, Vol. 185 No. 4157, pp. 1124-1131.

Kahneman, D. and Tversky, A. (2000), *Choices, Values, and Frames*, Cambridge University Press, New York, NY and Cambridge.

Keeney, R.L. and Raiffa, H. (1976), *Decisions with Multiple Objectives*, Wiley, New York, NY.

Kishore, R. (2006), "Theory of behavioural finance and its application to property market: a change in paradigm", Paper presented at the Twelfth Annual Pacific Rim Real Estate Society Conference, Auckland.

Koklic, M.K. and Vida, I. (2009), "A strategic household purchase: consumer house buying behavior", *Managing Global Transition*, Vol. 7 No. 1, pp. 75-96.

Kreibich, V. and Petri, A. (1982), "Locational behavior of households in a constrained housing market", *Environment and Planning A*, Vol. 14 No. 9, pp. 1195-1210.

Kupke, V. (2008), "Factors important in the decision to buy a first home", 14th Pacific Rim Real Estate Society Conference, *Kuala Lumpur*.

Levy, D. and Schuck, E. (2005), "The influence of clients on valuations: the clients' perspective", *Journal of Property Investment and Finance*, Vol. 23 No. 2, pp. 182-201.

McCarthy, K.F. (1976), *The Household Life Cycle and Housing Choices*, The Rand Corporation, Santa Monica, CA.

Mellers, B.A., Schwartz, A. and Cooke, A.D.J. (1998), "Judgment and decision making", *Annual Review of Psychology*, Vol. 49, pp. 447-477.

Meyer, R.J. and Eagle, T.C. (1982), "Context-induced parameter instability in a disaggregate stochastic model of store choice", *Journal of Marketing Research*, Vol. 19 No. 1, pp. 62-71.

Miles, M., Pringle, J. and Webb, B. (1989), "Modeling the corporate real estate decision", *Journal of Real Estate Research*, Vol. 4 No. 3, pp. 47-66.

Monico, M. (2013), "Australian attitudes and behaviours towards buying their first home", RAMS First Home Buyers' Pulse Check Survey 2013, RAMS Financial Group, Sydney, available at: www.rams.com.au/uploadedfiles/content/about_rams/media_centre/2013/rams-first-home-buyers-pulse-check-survey.pdf

Palm, R. (1982), "Homebuyer response to information content", in W.A.V., Clark (Eds), *Modelling Housing Market Search*, St. Martin's Press, New York, NY, pp. 187-208.

Pipkin, J.S. (1981), "The concept of choice and cognitive explanations of spatial behavior", *Economic Geography*, Vol. 57 No. 4, pp. 315-329.

Polic, M. (2009), "Decision making: between rationality and reality", *Interdisciplinary Description of Complex Systems*, Vol. 7 No. 2, pp. 78-89.

Pyhrr, S.A., Cooper, J.R., Wofford, L.R., Kapplin, S.D. and Lapides, P.D. (1989), *Real Estate Investment: Strategy, Analysis, Decision*, 2nd ed., John Wiley and Sons, Hoboken, NJ.

Quigley, J.M. (1999), "Real estate prices and economic cycles", *International Real Estate Review*, Vol. 2 No. 1, pp. 1-20.

Rahman, M.M. (2010). "The Australian housing market: understanding the causes and effects of rising prices", *Policy Studies*, Vol. 31 No. 5, pp. 577-590.

Read, D. (2004), "Utility theory from Jeremy Bentham to Daniel Kahneman", Working Paper Department of Operational Research No. LSEOR 0464, London School of Economics and Political Science.

Ritter, J.R. (2003), "Behavioral finance", *Pacific-Basin Finance Journal*, Vol. 11 No. 4, pp. 429-437.

Robbins, P.S. (2001), *Organizational Behavior*, 9th ed., Prentice-Hall, New York, NY.

Scanlon, K. and Whitehead, C.M.E. (2010), "The economic rationality of landlords", *Housing Economics Working Group, 2006*, LSE Research Online, Copenhagen, Denmark, pp. 1-28, available at: http://eprints.lse.ac.uk/29951/

Seelig, T., Burke, T., Penningar, S. and Morris, A. (2009), "What motivates households to invest in the private rental market", *AHURI Research and Policy Bulletin*, Vol. 115, pp. 1-4.

Seiler, M.J., Webb, J.R. and Myer, F.C.N. (1999), "Diversification issues in real estate investment", *Journal of Real Estate Literature*, Vol. 7 No. 2, pp. 163-179.

Shah, A.K. and Oppenheimer, D.M. (2008), "Heuristics made easy: an effort-reduction framework", *Psychological Bulletin*, Vol. 134 No. 2, pp. 207-222, doi: 1.1037/0033-2909,134.2.207.

Sheppard, E. (1980), "The ideology of spatial choice", *Papers in Regional Science*, Vol. 45 No. 1, pp. 193-213.

Shiller, R.J. (2007), Understanding Recent Trends in House Prices and Home Ownership, NBER (National Bureau of Economic Research, Inc), Working paper No. 13553, pp. 1-46.

Simon, H.A. (1978a), "Information processing theory of human problem solving", in Estes, W.K. (Ed.), *Handbook of Learning and Cognitive Processes*, Erlbaum, Hillsdale, NJ, Vol. 5 pp. 271-295.

Simon, H.A. (1992), "Decision making and problem solving", in Zey, M. (Ed.), *Decision Making: Alternatives to Rational Choice Models*, Sage Publications, Newbury Park, pp. 32-53.

Simon, H.A. (1993), "Decision making: rational, nonrational and irrational", *Educational Administration Quarterly*, Vol. 29 No. 3, pp. 392-411.

Sloman, S.A. (1996), "The empirical case for two systems of reasoning", *Psychological Bulletin*, Vol. 119, pp. 3-22.

Smith, T.R. and Clark, W.A.V. (1980), "Housing market search: Information constraints and efficiency", in Clark, W.A.V. and Moore, E.G. (Eds), *Residential Mobility and Public Policy*, Sage Publications, Beverly Hills, CA, pp. 100-125.

Smith, T.R. and Mertz, F. (1980), "An analysis of the effects of information revision on the outcome of housing-market search, with special reference to the influence of realty agents", *Environment and Planning A*, Vol. 12 No. 2, pp. 155-174.

Snively, S. (2009). "Workshop: After the boom – Where to from here?, What is housing – (consumption good, investment good, asset class, industry, infrastructure) and what role does it play as an automatic stabilizer?, Price Waterhouse Coopers", Reserve Bank of New Zealand, available at: https://repository.digitalnz.org/system/uploads/record/attachment/421/what_is_housing____consumption_good__investment_good__asset_class__industry__infrastructure___and__what_role_does_it_play_as_an_automatic_stabilizer_.pdf

Spanier, G.B., Sauer, W. and Larzelere, R. (1979), "An empirical evaluation of the family life cycle", *Journal of Marriage and Family*, Vol. 41 No. 1, pp. 27-38.

Stanovich, K.E. and West, R.F. (2000), "Individual differences in reasoning: implications for the rationality debate?", *Behavioral and Brain Sciences*, Vol. 23, pp. 645-726.

Tan, T.H. (2009), "Homeowning motivation in Malaysia", *Journal of Accounting-Business and Management*, Vol. 16 No. 1, pp. 93-112.

Tversky, A. and Kahneman, D. (1973), "Availability: a heuristic for judging frequency and probability", *Cognitive Psychology*, Vol. 5 No. 2, pp. 207-232.

Wiens, C.E.T. (2013), "The experts: should you think of your house as an investment?", *The Wall Street Journal*, available at: www.wsj.com/articles/SB10001424127887323949904578538012957595402 (accessed 27 November 2016).

Witteman, C., van den Bercken, J., Claes, L. and Godoy, A. (2009), "Assessing rational and intuitive thinking styles", *European Journal of Psychological Assessment*, Vol. 25 No. 1, pp. 39-47.doi 10.1027/1015-5759.25.1.39.

Wofford, L.E. (1985), "Cognitive processess as determinants of real estate investment decision", *The Appraisal Journal*, July, p. 393.

Wolverton, M. (1996), "Investigation into price knowledge induced comparable sale selection bias", Doctoral thesis, Georgia State University, Atlanta, GA.

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A bump in the road: speed bumps' impact on property values

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Abstract

Purpose – Speed bumps invite varied responses from homeowners, drivers and policymakers. Parents of small children like speed bumps, if they slow the passing traffic, but prospective home buyers may reject a home with a speed bump nearby, contemplating the traversal of it thousand times during an ownership period. The purpose of this study is to empirically identify the effect of speed bumps on home values.

Design/methodology/approach – Analysis presented here is based on an examination of home sales prices and exploits variation in the number of speed bumps traversed and the installation of speed bumps to identify the effect of speed bumps on home values. An anonymous online survey is also used to shed light on drivers of the empirical results.

Findings – Initial results exploiting variation in the number of bumps traversed suggest speed bumps are associated with reduced residential property values. An estimated treatment effect of speed bump installation underscores the original findings. Finally, survey results imply that older homeowners and homeowners with children may favor speed bumps but less than the disfavor of those who do not.

Research limitations/implications – The research presented here applies to speed bumps in residential areas and on streets not considered through streets.

Practical implications – The findings suggest that planners should investigate options such as medians and roundabouts instead of speed bumps.

Social implications – These results suggest that communities can be visually improved and home values lifted through the removal of speed bumps and installation of other traffic control devices.

Originality/value – This research is valuable to residential developers, planners and neighborhood associations across the country.

Keywords Difference-in-difference, Online survey, Residential property values, Home sales prices

Paper type Research paper

1. Introduction

Speed bumps present a quandary: at a first glance, home values may be enhanced as new speed bumps are installed, providing a perception of greater public safety for homeowners living nearby. Homebuyers (and sellers) price a speed bump premium into the home. Parents of small children may be attracted to a home "protected" by speed bumps, but potential buyers may resent the hassle of passing over a bump several times a day. The informed homebuyer contemplates the inconvenience, degradation of gas mileage, increased emergency vehicle response times and potential damage to the car's suspension. As well, that homeowner may have to deal with cars driving around the speed bumps (potentially several feet into a yard) and with the noise that attaches to a car moving slowly, or quickly, over a bump. A family with children may be willing to pay a premium for a road populated with speed bumps, boosting demand; other potential purchasers may avoid speed bumps altogether and buy elsewhere, decreasing demand.

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But, what of the overall impact of these speed bumps on property values? In this study, the relationship between property values and speed bumps is examined[1]. Our main contribution, consistent with remarks often heard in realtor communities, is that the net effect of most speed bumps is negative. Our findings suggest that speed bumps have an adverse effect on home values. If a community is dedicated to slowing traffic, other traffic measures such as islands or roundabouts should be considered.

2. Background

Despite the pervasiveness of speed bumps, in communities across the country, research on their effects on property values is limited. Speed bumps invite heated discussions in homeowners' association meetings, but home price impacts of speed bumps are typically overlooked[2].

Popular press stories such as Shopes (2008) discuss speed bumps and report the celebratory and damning comments of nearby homeowners – depending largely upon their feelings about speed bumps and speeders. However, these non-scientific stories typically provide little statistical evidence. One notable exception is an empirical investigation by Bretherton *et al.* (2000) of speedbumps in Gwinnett County, GA. That study suggests that speedbumps have no measurable effect on home prices. The analysis uses ten subdivisions in which speedbumps were installed and compares them to a matched comparison subdivision. Subdivisions were matched using price range, housing style, year built and school district. Unfortunately, these matches do not include other potential factors such as changes in traffic or congestion or the construction of amenities nearby. While these factors may not invalidate a statistically significant result, they do potentially undermine the legitimacy of a null result.

To examine the effect of speedbumps on home prices, Bretherton *et al.* (2000) match up subdivisions in which speedbumps were installed with subdivisions without speedbumps and compare the changes in average resale price before and after bumps were installed. They find no consistent pattern of price changes. To confirm their null result, resale values are regressed on a binary variable for subdivisions that have or will have speedbumps, a binary variable for whether observation has speedbumps at that time, year, and year squared. Only the coefficient for whether the observation has speedbumps is reported for each of the ten regressions run for the matched subdivisions. None of the coefficients are significant and Bretherton *et al.* conclude that "it cannot be demonstrated that installing speed humps will affect property values." Unfortunately, their model does not control for property characteristics, and it does not include an interaction term between treatment groups (subdivision that has or will have bumps) and post-treatment period interaction; such inclusion would be necessary to provide difference-in-difference type identification of the effect of installing speedbumps[3].

Aside from anecdotal or limited survey evidence, there is little published research that either celebrates or condemns speed bumps. Kokowski and Makarewicz's (2006) model the noise caused by vehicles traversing speed bumps but do not relate that noise to property values. Barley (2009) notes that fuel efficiencies are reduced, and air pollution increased, as a result of speed bumps; but, again, she does not address the effect of speed bumps on property values.

There is a substantial literature addressing other factors that affect home prices and that background literature provides a useful context for thinking about the impacts that speedbumps have on home prices. Externalities influencing home values that share the same intellectual "space" as speed bumps include traffic speeds and safety, noise levels and transit times. Each of these is expected to influence a homebuyer's decision, and each, in turn, is influenced by speed bumps.

It is reasonable to assume that properties located in a safer area would be valued more highly than those in less safe areas; the extant literature supports this premise. Buck *et al.* (1991) and Troy and Grove (2008), among others, document the negative relationship between crime and property values. Radetskiy *et al.* (2015) affirm the value of a gated community, even after controlling for "amenity differentials" in their sample; the greater values observed are a function not just of community pools and tennis courts, but of the perception of greater safety provided by the gates at the neighborhood's entrance. Their work implies that to the extent that speedbumps improve the perceptions of the safety within a neighborhood, buyers may become more motivated and speedbumps may be value enhancing[4].

While speedbumps can contribute to perceptions of greater safety, and higher values, there are also potential downsides; increased traffic times, compromised emergency vehicle ingress and egress, obstructions of pedestrian and bicycler progress, and noise come to mind. Antic *et al.* (2013) examine speedbump impacts on vehicle speeds and find that speeds are reduced, but studies such as one by Broadbent and Salmon (1991) suggest that vehicle speeds at the high speed end of the distribution may actually increase, as additional speed reduces the vertical jarring of some bumps. Pau and Angius (2001) study the installation of speedbumps in Italy and find that vehicles often maintain high rates of speeds even after bumps are installed. While there may be a general consensus that speedbumps reduce vehicular speeds, there are other unintended consequences as drivers react to impediments in their path.

Other evidence indirectly supports the idea that an informed buyer considers a number of property features, alongside proximate speed bumps, in making her buying decision. Benson *et al.* (1998) show that waterfront views impact property values positively, as expected; South African data gathered by Potgieter and Cloete (2010) suggests views, in any direction, that favorably impact contoured residential property values. However, the value of these amenities decreases quickly as Benson *et al.* find; "quality" views increase value by as much as 60 per cent, but low-quality views might add only 8 per cent. Conroy and Milosch (2011) find evidence of a coastal location premium that deteriorates quickly, and Major and Lusht (2004) find a value gradient for beach access; homes more removed from physical beach access witness more rapid declinations in value than is observed as a home's "view" is diminished. Speed bumps slow traffic, effectively adding distance; that impact should be echoed with lower values due to the speed bumps.

In addition to potential buyers pricing in travel times, the noise and visual detraction of the bumps may also have an effect on the demand for homes nearby. Jensen, Panduro, and Lundhede (2014) finds an approximately 5 per cent reduction in property values from wind turbine noise and a 3 per cent reduction from a view of a wind turbine. In this vein, the disruption of a streetscape from a speedbump, the signage that sometimes accompanies those traffic controls, and the noise (Kokowski and Makarewicz's (2006) of speed bump traversals combine to negatively impact home values. With speed bumps visible nearby, residential buyers become less motivated, and residential values fall.

The literature on the effect of speedbumps may be thin, so we consider tangential work to fashion a context in which to consider speed bumps' effect on home prices. Negative perceptions of speed bumps may reduce demand for homes nearby. However, perceptions that speed bumps enhance safety make an empirical examination necessary to see if the "protection" provided by speedbumps increases demand more than the declinations attaching to the factors considered above. Measuring the net effect and significance of those speed bump perceptions is the purpose of this study.

3. Data and methodology

Daily price and volume information exists for most financial assets and traded commodities. Such is not the case with real estate. The real estate market is inefficient. It is less structured than the capital markets; the real estate market includes a limited number of buyers and sellers trading dissimilar products in a highly regulated market noted for its high transaction costs and abbreviated flows of information and costly "frictions." Real estate, then, is illiquid – hard to convert to cash – and the ability of real estate prices to reflect quickly or fully relevant market factors is reduced, relative to "typical" capital markets like the NYSE or Nasdaq.

A particular piece of real estate may "trade" only a few times in an entire lifetime, and as such, the employment of customary tools to measure risk or value is compromised. However, this inefficiency of the real estate market, where prices do not fully or quickly reflect relevant market factors, does not preclude meaningful statistical examination of factors suspected to be correlated with, or to directly influence, home prices. In this study, we use three approaches to tease out the relationship between the presence of speedbumps and home prices: a linear regression approach using variation in the number of speedbumps crossed between an arterial road and the property, a difference-in-difference approach examining the effect of installing speedbumps, and finally, an online survey to reveal some potential underlying drivers of the results from the first two approaches. Home price data have been gathered from private (Wilmington Regional Association of Realtors) and public (county records online) data sources, for two neighborhoods in Wilmington, NC.

3.1 Sales models and data

The following function is used to measure the strength and direction of the relationship between speed bumps and property values. The premise is that if speed bumps affect home values, the effect will accumulate with more and more speed bump traversals. In addition to factors found to be meaningful in prior research, the number of speed bumps crossed between the subdivision entrance and the observation home – as portrayed in Figure 1 – are included in the following model:

$$\begin{aligned} Log(sales\,price_i) = {} & \alpha + \beta_1\, bumps_i + \beta_2\, living\,area_i + \beta_3\, bedrooms_i + \beta_4 bathrooms_i \\ & + \beta_5\, multistory_i + \beta_6\, shared\,driveway_i + \beta_7\, distance_i \\ & + \Sigma\beta\; sale\,year_i + \varepsilon_i. \end{aligned} \tag{1}$$

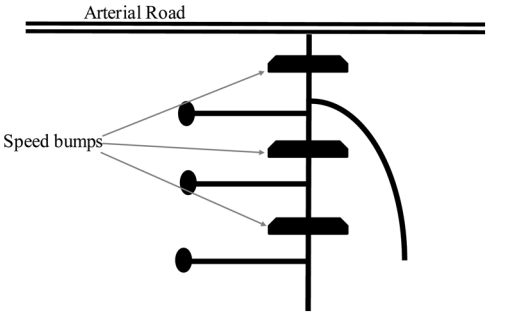

Figure 1.
Stylized layout of bumps crossed subdivision

The dependent variable in the model is the log of the sale price for each home. A variation of the model uses the log of the price per-square-foot as the dependent variable[5]. The relatively narrow range of observed sample values in the neighborhood suggests that this sample is itself normally distributed.

To remove housing unit-level variation and help identify the impact of speed bumps on home prices, a subdivision with a single entrance and exit path, combined with minimal variation between home styles and sizes, was chosen [The use of a single, homogeneous subdivision helps to alleviate the modeling concerns of Sah *et al.* (2016)]. Sales data from late 2001 to December 2013 were gathered for this subdivision; 64 sales took place over this period[6].

Descriptive data on these sales are provided in Table I. The average sale price in the sample is just over $250,000. The main variable of interest, speed bumps (*bumps*), is a discrete variable, ranging from one to four, capturing the number of bumps crossed between the entrance of the subdivision and the home. Table I shows that just under two (1.77) bumps are crossed between the subdivision's entrance and the driveway for the typical house in the subdivision.

Controlling for each house's size and style, the living area in square feet (*living area*), number of bedrooms (*bedrooms*), and number of bathrooms (*bathrooms*) were recorded. Homes averaged just under 2,000 square feet, with around three bedrooms and two and a half baths. A binary variable for houses with more than one story (*multistory*) was also included; most homes (over 90 per cent) were one-story. A weak premise exists that multi-story homes, particularly those without elevators, may be undesirable. It was expected that living area, bedrooms and bathrooms would all have positive correlations with sales price. Because the subdivision is a relatively new development, homes in our sample were, on average, less than five years old (4.41 years), and around three-eighths (0.375) were new when sold. No meaningful relationship between home age and value was expected or discovered with our sample.

Addressing the next factor, several homes located in the subdivision have unique driveways (*shared driveway*) such that a homeowner uses a neighbor's driveway, at first, to reach their house, potentially affecting their home's value; these properties are identified by the binary, *shared driveway* variable. Impacts of this factor on home values, after taking into account home size and distance from the entrance, are uncertain, as the difficulty of recognizing the driveway could be a negative factor, but the additional seclusion implied by

Variable	Mean	Std. Dev	Min	Max
Sales Price	251,234	53,867	167,500	362,500
Price Per Sq. Ft.	130.6	27.9	62.9	186.5
Bumps	1.77	0.83	1	4
Living Area	1942	272	1,545	2,963
Bedrooms	3.27	0.62	2	5
Bathrooms	2.41	0.53	2	4
Multistory	0.078	0.271	0	1
Shared Driveway	0.172	0.380	0	1
Distance	0.55	0.094	0.35	0.74
N	64			

Note: Measures in Table I provide the average values (means), and the lowest (min) and highest (max) observed values for each factor

Table I. Descriptive statistics for the multi-bump neighborhood

the shared driveway may be positive. Distance from the entrance (*distance*) is controlled for, as homes farther from the subdivision's entrance are typically in a quieter and more attractive location, generating a higher selling price. Homes average over half a kilometer from the entry-point to the subdivision, with the farthest home being three-quarters (0.74) of a kilometer from the entrance.

A final set of factors, controlling for the year of sale, between 2002 and 2013, is included in the model to account for the impact of the sale's timing on the sales price. Time fixed effects should also capture the effects of low interest rates in any particular year. The error term completes the model.

In addition to the number of bumps crossed, as modeled above, a difference-in-difference approach, using data from a neighborhood that installed speed bumps *after* the homes were built, is used to compliment and validate results from the model presented in equation (1). The following function is used to estimate the impact of installing speed bumps upon selling prices:

$$\begin{aligned} Log(sales\,price) = \alpha + \beta_1\, bumps_i + \beta_2\, post\,installation_i + \beta_3\, bumps\,x\,post\,installation_i \\ + \beta_4\, living\,area_i + \beta_5\, bedrooms_i + \beta_6\, bathrooms_i + \beta_7\, multistory_i \\ + \beta_8\, distance + \sum \beta\, subdivision\,indicator_i + \varepsilon_i. \end{aligned} \tag{2}$$

Two versions of the dependent variable are again used, the log of the sales price and the log of the sales price per square foot. The variable of interest in equation (2) is the coefficient on *bumps* × *post installation*. The *bumps* variable is a binary variable indicating whether the home is "protected" by speedbumps; this allows for a different intercept for the speedbumps-treated homes and the control group. The coefficient on the *post installation* variable captures how prices have changed from the period before installation and after. However, the *bumps* × *post installation* term is equivalent to an indicator for homes located in the speed bump neighborhood after the bumps were installed, it is the variable of interest and picks up the effect of installing speed humps. Other prosaic variables shown in the literature to affect home prices are included as control variables, similar to equation (1), with binary subdivision fixed effects appended[7].

To estimate equation (2), sales data from a subdivision that added speed bumps, and surrounding subdivisions without the bumps, were gathered. The subdivision in which speed bumps were added is located off a through street about a mile from a major arterial road, and the comparison subdivisions are located directly across the through street or next to the "adding" subdivision. Sales data were gathered on homes from 1998 through 2015. In total, 348 observations are included in this second sample. Sales in 2004 were dropped as that is the year the local government indicated the bumps were installed. Because a difference-in-difference model compares values before an event to one after, sales prices are adjusted for time trends by converting to 2015 prices using county median sales prices for each year. Similar to the model in equation (1), home-specific control variables are included. Descriptive data for the neighborhood adding the speed bumps are listed in Table II. The homes in this second subdivision have a mean value of just over $182,000, lower than the values observed in the first multi-bump neighborhood.

In Table II, alongside the modestly lower overall home prices, we observe a far greater variation in prices than was seen in the first neighborhood. Minimum prices of less than $100,000, and a maximum price of close to $600,000, are seen. The homes in this second

Table II. Descriptive statistics for the neighborhood adding speed bumps

Variable	Mean	Std. Dev	Min	Max
Real Sales Price	182,118	69,593	86,629	590,963
Real Price Per Sq. Ft.	116.5	50.12	50.88	326.83
Bumps	0.31	0.46	0	1
Post Installation	0.55	0.50	0	1
Bumps x Post Installation	0.20	0.40	0	1
Living Area	1,635	422.0	628	2910
Bedrooms	3.07	0.57	1	5
Bathrooms	2.77	0.77	2	5
Multistory	0.46	0.50	0	1
N	348			

Note: Measures in Table II provide the average values (means), and the lowest (min) and highest (max) observed values for each factor

neighborhood were modestly smaller and they were older, on average, than the homes in the first sample.

3.2 Sales results

The model in equation (1) was estimated using ordinary least squares, with estimation results presented in Table III. The most interesting result is the negative, and significant, relationship between home values and the number of speed bumps crossed. This casts into meaningful relief the anecdotal remarks offered by some realtors when discussing speed bumps: many prospective homebuyers do not like speed bumps, and, on average, property values in this sample seem to suffer as the result of a community's inclusion of those traffic controls.

Recalling how the speed bumps factor was constructed – equaling between 1 and 4 depending upon the number of speed bumps traversed by the homeowner as he or she traveled from the subdivision's entrance to the home. With the typical home resting "behind" 1.77 speed bumps crossed by the driver approaching the home, an adverse value impact of over 8 per cent is implied. These results are meaningful and warrant consideration by any stakeholder in the home, whether she be a lender, an owner or a policymaker.

As with a library of prior research, the living area and number of bedrooms and bathrooms were all positively associated with home values; the relationship between living area and price per square foot was negative, as common sense would suggest. The larger a home, on average, the less value added by each additional square foot.

Other results given in Table III deserve mention. An interesting discovery was the size and power of the distance factor. Homes most removed from the subdivision's entrance (0.74 kilometers) illustrated sales values that, *ceteris paribus*, were approximately 40 per cent higher than those just inside the entrance ($100[e^{0.73} - 1] \times [0.74\text{-}0.35]$). But, as that "removal" typically included the traversal of more speed bumps, that value enhancement was not "free." If not for the speed bumps, home values would increase as distance from the noise and activity of the arterial road outside the entrance increases.

Sales year factors conclude the results portrayed in Table III. Sales taking place between 2005 and 2008 are particularly significant, as the coefficient values for those years are the highest of the years listed. Those factors lend additional credence to the specification of the model, as the regional property values peaked in 2006-2008 and then began to decline.

Dependent Variable	Log Sales Price Coef.	t-stat.	Log Price per Sq. Ft. Coef.	t-stat.
Bumps	−0.046***	(−3.16)	−0.050***	(−3.53)
Living Area	0.000***	(3.28)	−0.358***	(−9.88)
Bedrooms	0.030*	(1.70)	0.025	(1.49)
Bathrooms	0.038**	(2.02)	0.032*	(1.72)
Multistory	−0.049	(−1.16)	−0.036	(−0.89)
Shared Driveway	−0.073**	(−2.47)	−0.073**	(−2.56)
Distance	0.730***	(4.36)	0.726***	(4.31)
Sale Year 2002	0.060	(1.36)	0.063	(1.64)
Sale Year 2003	0.125***	(2.81)	0.113***	(2.90)
Sale Year 2004	0.153***	(3.38)	0.150***	(3.82)
Sale Year 2005	0.447***	(8.09)	0.430***	(8.88)
Sale Year 2006	0.519***	(10.96)	0.511***	(12.41)
Sale Year 2007	0.522***	(10.57)	0.517***	(11.86)
Sale Year 2008	0.570***	(7.93)	0.570***	(9.49)
Sale Year 2009	0.397***	(9.02)	0.387***	(10.13)
Sale Year 2010	0.236***	(3.64)	0.248***	(3.74)
Sale Year 2011	0.222***	(3.90)	0.219***	(4.01)
Sale Year 2012	0.251***	(4.65)	0.237***	(4.72)
Sale Year 2013	0.232***	(3.23)	0.228***	(3.75)
Constant	11.406***	(157.25)	4.825***	(67.82)
N	64		64	
R^2	0.938		0.946	

Notes: t statistics in parentheses; $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, The dependent variable in the model is the log of the sale price for each home or price per square foot. Sales data are from 2001 to December of 2013. The main variable of interest, speed bumps (*bumps*), is a discrete variable capturing the number of bumps crossed between the entrance of the subdivision and the home. *Living area* is the square footage of the home, and *bedrooms* and *bathrooms* are as one would expect. *Multistory* indicates a home with more than one level and *shared driveway* is a binary variable for a home that partially uses a neighbor's driveway. *Distance* represents the distance from the subdivision entrance to the home's driveway in KM. Time fixed effects are represented by *Sale Year* variables. The model is estimated with OLS and robust standard errors

Table III. Bumps crossed regression results

The lowest coefficient values are for 2003 and 2004, the period before the most rapid price increases in the study area, and across the country.

Turning to the results of the difference-in-difference model in equation (2), we find supporting evidence of speed bumps harming home prices. Those results are portrayed in Table IV. The variable of interest in the difference-in-difference model is *bumps* × *post installation* as it shows the difference in home prices from before and after the bumps were installed. The evidence suggests real home prices decreased by approximately 7.5 per cent for homes in the subdivision installing speed bumps. This result is consistent with the mean detriment from crossing bumps of approximately eight per cent from estimating equation (1) above. This recognition affirms the adverse impact. A buyer seems to include the presence of the proximate speed bumps in her or his purchase decision, and that inclusion leads to a lower offer.

3.3 Survey model

To put the empirical results in context, a short, anonymous, online survey was conducted in July 2016; it used Amazon's Mechanical Turk (mTurk) platform. Amazon's mTurk is a

Dependent variable	Log Real Price Coef.	t-stat	Log Real Price/Sq. Ft. Coef.	t-stat
Bumps	0.104***	(3.52)	0.132***	(4.22)
Post Installation	0.021	(1.05)	0.017	(0.80)
Bumps x Post Installation	−0.074**	(−2.20)	−0.073**	(−2.03)
Living Area	0.162***	(4.66)	−0.499***	(−10.80)
Bedrooms	0.047	(1.61)	0.039	(1.20)
Bathrooms	0.057***	(3.29)	0.060***	(3.12)
Multistory	0.117***	(3.14)	0.130***	(3.14)
Distance	0.052	(0.72)	−0.022	(−0.27)
Constant	10.335***	(100.41)	3.961***	(33.16)
Subdivision Controls	Yes		Yes	
N	348		348	
R^2	0.849		0.829	

Notes: t statistics in parentheses $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$; The dependent variable is log of sales price and log of the sales price per square foot. *Bumps* is a binary variable indicating whether the home is "protected" by speedbumps, *post installation* indicates sales taking place after the speedbumps have been installed in the treaded subdivision and *bumps* × *post installation* is an indicator for homes located in the speed bump neighborhood after the bumps were installed. Other variables include living area in thousands of square feet, number of *bedrooms*, number of *bathrooms* and a binary variable to indicate *multistory* homes. Distance measures the distance from the subdivision entrance to the observed property and subdivision fixed effects are included but omitted from presentation

Table IV. Difference-in-difference estimation results

"micro task" website matching a decentralized workforce with small tasks that can be completed remotely. Individuals register with Amazon and choose which of the offered tasks they would like to complete. Tasks range from entering data off scanned business cards to touching up digital photos. For academic researchers, these workers are a potential source of survey respondents[8]. Examples of research using mTurk include Elias, Lacetera *et al.* (2015); Tinkler and Woods (2013); Chandler and Kapelner (2013); and Kuziemko *et al.* (2013).

An advantage of mTurk respondents over other sources of convenience samples is that respondents are geographically and demographically diverse. Dalya and Nataraajanb (2015) suggest that mTurk is a reliable and inexpensive source of survey data, and Buhrmester *et al.* (2011) find mTurk participants to be more demographically diverse than traditional internet samples. To assure the validity of our sample, we include a couple attention-check questions in the survey and, in the vein of Rouse (2015), we provide respondents the opportunity to tell us to delete their data without any penalty.

Over the course of a week, with the survey open at different intervals, 243 responses were submitted to a 15-item survey. The survey asked whether respondents currently owned or rented and whether they lived in an apartment or single-family home. The survey also asked about the neighborhood type and income level of the respondent. Importantly, it asked how the respondent viewed speed bumps. Of the submitted observations, five were dropped as respondents checked the box for "delete my data." After removing those surveys, no responses failed our attention-check question of asking for a specific word from one of the questions.

However, some inconsistencies in the data were associated with the use of a slider bar to indicate how much more or less a respondent would be willing to pay for speed bumps in the neighborhood. Observations where respondents allowed that they viewed bumps in front of

their house or on their route home "unfavorably" or "very unfavorably," yet suggested they were willing to pay for the bumps, were removed from the sample; there were 42 of these. In addition, respondents that maxed out the slider for their willingness to pay (or willingness to accept if a negative response) were also removed. This left 191 useable surveys.

We included three questions regarding speed bumps with Likert-type response options: how would you view bumps in front of your home, on your main route home and in your neighborhood. Table V presents a tabulation of responses to these three questions. The responses give us an indication as to what might be driving the findings where speed bumps are significantly negatively associated with home prices.

Responses in Table V are presented by response category, with an average of the respondents' *price response*, in thousands, presented for each category. Responses presented in parentheses are a subset and include only current homeowners.

Table V is telling and provides a centerpiece for our findings. It frames the feelings of respondents either in favor of, or in opposition to, speed bumps. For each of the three questions asked, negative feelings towards speed bumps are underscored; more respondents viewed the bumps unfavorably or very unfavorably than those taking a more favorable position. In addition, the magnitude of their *price response* to bumps was stronger, suggesting an asymmetric market response with a stronger negative response than positive on the part of potential buyers.

While casual observation suggests that there are strong believers on both sides of the speed bump issue, the survey data suggest a stronger *negative* response than *positive* response to speed bumps, as evidenced by the larger number of respondents opposed to speed bumps. In addition, the magnitude of the response is stronger for those viewing speed bumps unfavorably and much larger for those who viewed them very unfavorably. When considering bumps directly in front of the home, the negative response is roughly twice as large as the positive response for those that view the bumps favorably or very favorably. Results are similar for responses to speed bumps on the main route home.

Table VI presents summary statistics for the survey respondents. Characteristics illustrated in the table include number of *children*, respondent *age* (as indicated by binary age ranges with age 26-35 being the omitted group), *household income* in thousands, *price range* of home if they were to look for a home at time of survey, whether the respondent leases a car (*lease car*), is *male*, drives a *truck or SUV*, uses a *bicycle* or *walks* as their primary form of transportation. The mean *price response* to speed bumps is negative, with just under half the respondents having children. Income measures aligned closely with averages in the study region. Most of the respondents were male, and very few leased their cars. A surprisingly small portion (just over 11 per cent) of the respondents drives trucks. Smaller portions walk or ride their bikes to work. We would expect those that have children to favor speed bumps. We would expect car leasers to be indifferent, but as less than 3 per cent reported leasing their cars, this factor was not expected to be meaningful.

The price response for speed bumps is slightly negative but not significantly so. Further investigating the drivers' support (or lack thereof) for speed bumps, we regress *price response* on respondent characteristics using the model below:

$$\begin{aligned} \textit{Price response}_i = {} & \alpha + \beta_1\, \textit{children}_i + \Sigma B_j\, \textit{age range}_i + \beta_5\, \textit{household income}_i \\ & + \Sigma \beta_k\, \textit{price range}_i + \beta_{11}\, \textit{own car}_i + \beta_{12}\, \textit{male}_i + \beta_{13} \textit{truck or suv}_i \\ & + \beta_{14}\, \textit{bicycle}_i + \beta_{15}\, \textit{walk}_i + \varepsilon_{i.} \end{aligned} \tag{3}$$

The dependent variable in equation (3), *price response*, is the respondent's stated willingness to pay for speed bumps in a subdivision or willingness to accept, in the case

Table V. Willingness to pay for speed bumps

Question	Very unfavorably	Unfavorably	Impartially	Favorably	Very favorably
	Response Count/Amount Willing to Pay for Bumps ($000s)				
In the event you were purchasing a home, how would you view speed bumps directly in front of the home?	32 | −9.19 (18 | −9.89)	38 | −5.87 (14 | −4.86)	57 | −0.91 (22 | −2.23)	54 | 4.59 (21 | 3.52)	10 | 7.16 (5 | 3.2)
In the event you were purchasing a home, how would you view speed bumps in your neighborhood on your main route home?	16 | −12.94 (7 | −16.14)	50 | −7.06 (23 | −6.57)	69 | 0.25 (29 | −0.45)	50 | 5.08 (18 | 3.17)	6 | 2.67 (3 | 5.0)
	Substantially less	*A little less*	The same	A little more	*Substantially more*
Suppose you are considering buying a home as your primary residence. If there are speed bumps in the neighborhood in which you are looking, would be willing to pay:	5 | −20.2 (2 | −26.0)	39 | −10.31 (16 | −9.38)	122 | 0.08 (53 | −1.55)	24 | 8.33 (9 | 8.78)	1 | 20 (0 | NA)

Note: Numbers to the left of the vertical bar indicate the number of responses for each question/answer combination and numbers to the right of the vertical bar represent the average price response for those respondents. Numbers in parentheses reflect responses from current owners of single-family homes, a subset of the responses immediately above and not in parentheses. For example, 32 of the 191 survey respondents viewed speed bumps directly in front of a home very unfavorably, and were willing to pay $9,190 less for a home with a speed bump in front of it than for one without a speed bump. The rest of the table is interpreted in a similar manner

Table VI. Survey summary statistics

Variable	Mean	Std. Dev	Min	Max
Price response to bumps	−1.762	9.323	−28	28
Children	0.429	0.845	0	4
Age 18-25	0.206	0.406	0	1
Age 26-35	0.550	0.499	0	1
Age 36-45	0.148	0.356	0	1
Age 46-60	0.095	0.294	0	1
Household income	55.87	47.825	3	250
Price range				
Under $100K	0.397	0.491	0	1
100-200	0.333	0.473	0	1
200-400	0.206	0.406	0	1
400-600	0.048	0.214	0	1
600-900	0.011	0.103	0	1
900+	0.005	0.073	0	1
Own car	0.831	0.376	0	1
Male	0.656	0.476	0	1
Truck or SUV	0.111	0.315	0	1
Bicycle	0.026	0.161	0	1
Walk	0.090	0.287	0	1
N	*191*			

Note: Measures in Table II provide the average values (means), and the lowest (min) and highest (max) observed values for each factor

the respondent holds a negative view of speed bumps and requires a discount to purchase a home "protected" by speed bumps. Price response can be a positive or negative value depending on a respondent's view of speedbumps. Variables explaining a respondent's *price response* to speed bumps include the number of *children* living in the home, a respondent's *age by range*, *household income* and *price range* of homes in which the respondent would be interested. The number of *children*, *age* of respondent and *household income* are all expected to be positively related to *price response* for speed bumps; households with more children are likely to place a higher emphasis on reduced vehicle speeds, and the upper end of the age spectrum is assumed to be more patient with traversing the bumps.

Additional explanatory variables include ownership of the vehicle (measured as a binary variable set equal to 1 if a respondent *owns* his or her vehicle), gender (measured as binary variable for *male*) and whether the primary form of transportation is a *truck or SUV*, a *bicycle* or *walking*, with transportation via car serving as the reference group. Ownership of one's vehicle is expected to elicit a negative *price response* as owners factor in the cost of maintenance to their vehicles, while *truck or SUV* is expected to be elicit a positive *price response* as the cost of the bumps in terms of time and maintenance may be attenuated with the larger vehicle. Bicyclists are expected to oppose speed bumps, as they are potentially difficult to traverse on a bicycle, and reaccelerating requires physical effort, whereas walkers are expected to favor speed bumps in response to the slowing of traffic sharing the roadway.

3.4 Survey results

Results for equation (3) are given in Table VII.

Variable	Dep Var: Price Response to Bumps ($000s) Coef.	t-stat
Children	1.792**	(2.00)
Age 18-25	1.840	(0.93)
Age 36-45	3.295	(1.64)
Age 46-60	4.411***	(2.67)
Household Income	−0.00450	(−0.29)
Price Range		
Under $100k	−0.643	(−0.41)
$200-400k	2.618	(1.29)
$400-600k	−1.587	(−0.43)
$600-900k	6.721***	(2.78)
$900k+	2.147	(1.13)
Own Car	−6.775***	(−2.66)
Male	1.375	(0.86)
Truck or SUV	−2.258	(−1.21)
Bicycle	−8.271**	(−2.02)
Walk	−2.396	(−0.76)
Constant	1.552	(0.54)

Notes: *N = 191*; *R Squared = 0.120*; *t* statistics in parentheses; $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$; *Price response* is the respondent's stated amount they are willing to pay or require in compensation to have speedbumps in the area of their home. C*hildren is the number* living in the home, *age by range*, *household income* and *price range* of homes in which the respondent would be interested are as one would expect. *Owns* is a binary variable indicating ownership of the respondent's vehicle, and the primary form of transportation is indicated by *truck or SUV*, a *bicycle* or *walking*, with transportation via car serving as the reference group. *Male* is a binary gender variable

Table VII. Willingness to pay for speed bumps

Coefficient estimates suggest respondents are factoring in both positive and negative feelings about speed bumps. To the extent that bumps reduce speeds, one would expect families with children to support speed bumps, an expectation supported by the positive and significant coefficient on *children*. Older, potentially more patient, respondents seem to favor the speed bumps. Those between the ages of 36 and 45 favor bumps at a level of statistical significance just outside traditionally accepted levels ($p = 0.11$), and residents over the age of 46 are willing to pay significantly more than 25 to 35 year old, the reference group. Respondents interested in more valuable homes – those in the $600,000-900,000 range – exhibited greater *price response* for speed bumps than did their less well-situated peers. However, the small number of respondents in this category brings the robustness of this result into question.

Though the portion of the sample leasing their cars is small, the results are as expected; owners of their vehicles require a reduction in home price to compensate for traversing speed bumps compared to those who lease their vehicles, presumably because they are factoring in maintenance costs from the car being rattled by the bump. Bicyclists also exhibit a negative response to speed bumps, as the bumps break the momentum of bicycles, provide a safety hazard and require physical effort to traverse. The few respondents that walk as their main form of transportation are not significantly attuned to speed bumps. This indifference is at first surprising; one would expect a pedestrian to want the speed bumps to slow down cars, but that same "walker" may be averse to tripping across an ill-placed traffic control or be unconcerned as they

travel on alternate paths without bumps. Gender had no explanatory power with respect to someone's willingness to pay for speed bumps.

4. Conclusion

Our results suggest that the benefits of speed bumps (slower speeds, children's or overall safety) are outweighed by the perceived costs (noise, emergency vehicle ingress and egress, annoyance, air quality and car damage). We find evidence of a negative effect using three different approaches: examining the number of speed bumps crossed while traveling to a house, home prices before and after speed bumps were installed and a survey asking respondents to indicate their willingness to pay for speed bumps. The speed bumps may well proxy for other negative features of a home's neighborhood, such as high-speed traffic or congestion (policymakers might confess to installing speed bumps to detour traffic around an area), but the relationship is clear: *ceteris paribus*, lower prices are paid for homes near speed bumps.

The two neighborhoods examined in this study consisted of similar homes within the neighborhood and a single entrance such that the speed bumps could not be easily avoided with a different route to or from work or school. Future research could extend the analysis to "through streets" using pre- and post-installation sales data. The effect of speed bumps on home values may well be positive for speed bumps located on through streets as the benefit of slowing through traffic may outweigh the private cost of residents being inconvenienced. In addition, the causes of the negative effect could be parsed out by examining areas that installed speed bumps versus other "traffic calming devices," such as islands or landscaping to discern whether the effect comes from the opportunity cost of time necessitated by slower vehicle speeds or from the perception and frustration of traversing the speed bumps. It is conceivable that if the latter is the main driver of speed bumps' negative effect on home values, then other traffic calming measures may well have a neutral or even a positive effect.

The findings presented here are noteworthy, in that they suggest there is some validity to arguments made by detractors of speed bumps; the important issue is how large an effect the bumps have on property values. While promotors and detractors of speed bumps might enthusiastically affirm the attractiveness of their positions – celebrating slower traffic speeds on the one hand and affirming negative quality-of-life impacts on the other – the net effect of those positions appears to be a reduction in the values of homes near speed bumps. The results portrayed here suggest that the decision to install speed bumps ought to not simply be a reflection of the efforts by well-meaning interests; speed bump impacts other than purportedly slower traffic speeds need to be considered. Air quality, noise, vehicle damage, emergency vehicle ingress and egress and low-light injuries to unsuspecting cyclists or pedestrians come to mind. Those factors are presumably at the core of the negative relationship we observe between speed bumps and home values. Our research suggests that speed bumps are the wrong tool to fulfill noble objectives.

Notes

1. "Speed bumps" in this study refer to speedbumps, speed humps, traffic-slowing tables, raised pedestrian cross-walks and any other engineering edifice in the center of the road that might at some point be referred to as a "speed bump."

2. The authors' experiences during the course of this research are telling, though admittedly unscientific. In short, homeowners across the Southeast have strong feelings, both for and against, speed bumps.
3. The type of road, thru street versus terminal, and whether there are ways to easily navigate around the bumps should be controlled to draw the conclusion of a null effect.
4. Tester *et al.* (2004) suggest that speedbumps reduce the odds of children being struck and injured by a vehicle in their neighborhood.
5. The model estimation using *log price per square foot* as the dependent variable includes *living area* as a control variable to allow for diminishing returns to square footage. See Palmquist (1984) for an early exploration of the topic.
6. Including all control variables, the sample leaves over 40 degrees of freedom and is sufficiently large to make valid inferences.
7. The shared driveway variable included in equation (1) is omitted from equation (2) because the sample did not contain any homes with a shared driveway.
8. Each respondent was paid $0.30 for a completed survey, a completed survey possible in under 2 min.

References

Antic, B., Pesic, D., Vujanic, M. and Lipovac, K. (2013), "The influence of speed bumps heights to the decrease of vehicle speed – Belgrade experience", *Safety Science*, Vol. 57, pp. 303-312.

Barley, S. (2009), "What speed is green?", *Climate Change – The Blog of Bloom*, available at: www.bbc.co.uk/blogs/climatechange/2009/04/what_speed_is_green.html (accessed 6 June 2017).

Benson, E.D., Hansen, J.L., Schwartz, A.L. and Smersh, G.T. (1998), "Pricing residential amenities", *The Journal of Real Estate Finance and Economics*, Vol. 16 No. 1, pp. 55-73.

Bretherton, W.M., Edwards, V. and Miao, J. (2000), "The economic impact of speed bumps on housing values", *ITE Journal*, pp. 50-54.

Broadbent, K. and Salmon, A.M. (1991), "An experiment with road bumps", *Highway and Transportation*, Vol. 11, pp. 5-8.

Buck, A.J., Deutsch, J., Hakim, S., Spiegel, U. and Weinblatt, J. (1991), "A von Thunen model of crime, casinos, and property values in New Jersey", *Urban Studies*, Vol. 28 No. 5, pp. 673-686.

Buhrmester, M., Kwang, T. and Gosling, S.D. (2011), "Amazon's mechanical turk: a new source of inexpensive, yet high-quality data?", *Perspectives on Psychological Science: a Journal of the Association for Psychological Science*, Vol. 6 No. 1, pp. 3-5.

Chandler, D. and Kapelner, A. (2013), "Breaking monotony with meaning, motivation, in crowdsourcing markets", *Journal of Economic Behavior and Organization*, Vol. 90, pp. 123-133.

Conroy, S.J. and Milosch, J.L. (2011), "An estimation of the coastal premium for residential housing prices in sand diego county", *The Journal of Real Estate Finance and Economics*, Vol. 42 No. 2, pp. 211-228.

Dalya, T.M. and Nataraajanb, R. (2015), "Swapping bricks for clicks, crowdsourding longitudinal data on amazon turk", *Journal of Business Research*, Vol. 68 No. 12, pp. 2603-2609.

Elias, J.J., Lacetera, N. and Macis, M. (2015), "Sacred values? The effect of information on attitudes toward payments for human organs", *NBER Working Paper*.

Jensen, C.U., Panduro, T.E. and Lundhede, T.H. (2014), "The vindication of don quixote: the impact of noise and visual pollution from wind turbines", *Land Economics*, Vol. 90 No. 4, pp. 668-682.

Kokowski, P. and Makarewicz, R. (2006), "Predicted effects of a speed bump on light vehicle noise", *Applied Accoustics*, Vol. 67 No. 6, pp. 570-579.

Kuziemko, I., Norton, M.I., Saez, E. and Stantcheva, S. (2013), "How elastic are preferences for redistribution? Evidence from randomized survey experiments", *NBER Working Papers*.

Major, C. and Lusht, K.M. (2004), "Beach proximity and the distribution of property values in shore communities", *Appraisal Journal*, Vol. 72 No. 4, pp. 333-338.

Palmquist, R.B. (1984), "Estimating the demand for the characteristics of housing", *The Review of Economics and Statistics*, Vol. 66 No. 3, pp. 394-404.

Pau, M. and Angius, S. (2001), "Do speed bumps really decrease traffic speed? An italian experience", *Accident Analysis and Prevention*, Vol. 33 No. 5, pp. 585-597.

Potgieter, R.M. and Cloete, C.E. (2010), "The impact of a view on the value of vacant residential lots", *The Appraisal Journal*, Vol. 78 No. 4, pp. 333-349.

Radetskiy, E.L., Spahr, R.W. and Sunderman, M.A. (2015), "Gated community premiums and amenity differentials in residential subdivisions", *The Journal of Real Estate Research*, Vol. 37 No. 3, pp. 405-438.

Rouse, S.V. (2015), "A reliability analysis of Mechanic turk data", *Computers in Human Behavior*, Vol. 43, pp. 304-307.

Sah, V., Conroy, S.J. and Narwold, A. (2016), "Estimating school proximity effects on housing prices: the importance of robust spatial controls in hedonic estimations", *The Journal of Real Estate Finance and Economics*, Vol. 53 No. 1, pp. 50-76.

Shopes, R. (2008), "Speed humps calm traffic but stif outrage", *The Tampa Tribune*.

Tester, J.M., Rutherford, G.W., Wald, Z. and Rutherford, M. (2004), "A matched case-control study evaluating the effectiveness of speedhumps in reducing child pedestrian injuries", *American Journal of Public Health*, Vol. 94 No. 4, pp. 646-650.

Tinkler, S. and Woods, J. (2013), "The readability of principles of macroeconomics textbooks", *Journal of Economic Education*, Vol. 44 No. 2, pp. 178-191.

Troy, A. and Grove, J.M. (2008), "Property values, parks, and crime: a hedonic analysis in baltimore, MD", *Landscape and Urban Planning*, Vol. 87 No. 3, pp. 233-245.

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Developer constraints on housing supply in urban Ghana

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Abstract

Purpose – This study aims to document the major underlying forces prohibiting housing development in urban Ghana. Previous studies in Ghana have not empirically examined these constraints, but an empirical examination of these factors would help to formulate proper policies to address the housing shortage problems in Ghana. This paper fills this gap.

Design/methodology/approach – Using a purposive sampling technique, the authors surveyed the chief executive officers (CEOs) of private real estate development companies within Accra and Tema with a Likert scale questionnaire to measure the severity of the factors hindering housing development in these areas.

Findings – The results show that real estate developers consider the supply problems in housing to be driven mainly by formal and informal institutional factors. A large percentage of the CEOs reported that land tenure arrangements, lengthy procedure involved in securing building permits and process of land acquisition and registration in Ghana were the major factors that significantly affected housing supply. The difficulty in accessing development funds, underdeveloped mortgage market and high interest rates were some of the market-based factors constraining housing development.

Originality/value – This study empirically examines the factors that hinder housing development in Ghana, making a clear distinction between the market and institutional forces. The paper proposes policy recommendations for a more effective and direct government intervention to improve urban housing supply.

Keywords Institutions, Ghana, Constraints, Market factors, Urban, Housing supply

Paper type Research paper

Introduction

Housing is a social condition that enhances the well-being of people (UN-Habitat, 2016). It is considered a catalyst for economic growth because of the high multiplier effect and the many linkages it has with the overall economy (UN-Habitat, 2005). The UN-Habitat (2016) estimates that about 40 per cent of the world's population will require access to decent accommodation by 2030. The report further argues that this translates to about 96,150 housing units being provided daily. In most developing economies, including Ghana, where there are huge housing deficits (Owusu-Ansah, 2012; Ametefe *et al.*, 2011), the importance of urban housing policy research cannot be overstated.

The total housing stock in Ghana as of 2010 was estimated at 3,393,745 housing units for a total of 5,467,136 households (Statistical Service of Ghana, 2012). The Statistical Service

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of Ghana (2012) indicated that 57.5 per cent of these houses were in rural areas. However, 49.1 per cent of the entire Ghanaian population lives in rural areas, which suggests that there is a lot of pressure on the existing, inadequate housing stock in urban areas. Indeed, the population per house is estimated to be around 7.3 people with about 51.5 per cent of the households residing in rooms in compound houses (Statistical Service of Ghana, 2008). Due to the rapid population growth, estimated at 2.4 per cent annually (Statistical Service of Ghana, 2008), and increasing urbanization, the supply of housing, especially for low- and middle-income households, has become one of the most crucial problems facing the country. Ghana's housing deficit at the end of 2012 was estimated at 1.7 million dwellings with an annual national budget requirement of GHC4.32bn[1] to meet this deficit (Statistical Service of Ghana, 2012).

The housing deficit problem in Ghana is not new, and a number of empirical studies have been conducted on the issue (Ofori, 1989; Konadu-Agyemang, 1991; Tipple and Korboe, 1998; Karley, 2002; Asare and Whitehead, 2006; Arku, 2009; Arku *et al.*, 2012). These studies suggest that the housing shortage limits access to both home ownership and tenancy. The housing deficit in Ghana is more pronounced in the larger, more populous cities like Accra, Tema and Kumasi. This is due to rapid rural–urban migration and relocation of non-Ghanaians from other countries (Luginaah *et al.*, 2010). This arrival of new residents has led to overcrowding, especially in low-income neighborhoods (Arku *et al.*, 2012), and poor housing without proper waste disposal, sanitation or drainage (Grant and Yankson, 2003; Awanyo, 2009; Arku *et al.*, 2012).

The supply of new residential construction by private real estate developers can make a major contribution to the delivery of new homes and help reduce the problem of housing, especially in developing markets. This study, thus, aims to understand the barriers to housing development and as to whether the constraints are mainly market-driven or institutional-based, from the viewpoint of private real estate developers[2]. Empirical identification of the constraints would be fundamental to urban housing policy. In this paper, we hypothesize that institutional factors are the principal reasons for real estate developers' reluctance to initiate new housing developments in Ghana. As North (1990) rightly points out, the effectiveness of the rules and constraints within which a market functions has a great influence on the performance of economies. Where there are strong institutions, economically efficient property rights emerge over time. Institutional changes and reforms and transparent legal systems that allow for the enforcement of property rights would tend to raise the productivity and foster economic growth (North, 1990).

In the light of this hypothesis, the objectives of this paper are:

- to unearth the institutional and market constraints to housing development in Ghana, highlighting the differences between the two; and
- to provide appropriate public- and private-sector policy recommendations for housing development in Ghana.

We document that a large proportion of study participants reported that land tenure arrangements, land litigation risk, difficult land registration process, lengthy procedure involved in securing building permits and cost of land acquisition were the major factors that significantly affected residential real estate development. The difficulty in accessing development funds, underdeveloped mortgage market, high interest rates and high cost of labor and construction materials are some of the other factors constraining housing development. The paper adds to the literature on housing in Ghana, where there is a sparsity of research to inform policy interventions. It draws attention to the fact that stronger and more efficient institutions could help solve the housing problem. Even though some studies

exist on the supply of housing in Ghana, this study adopts a different approach, in that it categories the housing supply problems into economic and institutional factors so that these problems could properly be addressed. It also provides evidence about challenges in urban housing development in Ghana from the viewpoint of people who are directly engaged in the housing production process (real estate developers). This should help inform policy to put developer-driven housing within reach of the majority of the urban population. This is because real estate developers play an important role in the housing value chain in Ghana, and their current housing output needs to be increased. The Center for Affordable Housing Finance in Africa (2017) projects that, aside from South Africa, private real estate developers in Sub-Saharan Africa do not have the capacity to produce 500 housing units annually. The critical and growing need for housing in urban Ghana requires a concerted effort on the part of developers and government institutions working together to support the development of housing products, policies and regulations.

The remainder of the paper is structured as follows. The next section reviews the general literature on the housing market in Ghana, and this is followed by the research methodology section. The penultimate section presents the empirical results. The concluding remarks are in the final section.

An overview of the housing sector in Ghana

The nature of Ghana's housing market

As in 2014, Ghana's housing deficit stood at 1.7 million units and a minimum of 170,000 housing units would have to be built annually to meet the demand (Daily Graphic Online, 2014). Table I shows the estimated housing deficit as against the relative low supply of housing over the years.

As shown in Table I, the supply of housing lacks behind demand. Additionally, the deficit continues to expand over the years. Successive governments in Ghana have made efforts to provide residential accommodation for residents. This led to the formation of the State Housing and Tema Development Corporations, with their contribution mainly in Tema and its environs (Tipple *et al.*, 1998). Even though, since 1990, the government has continually attempted to provide more housing units, it has failed regarding efficiency and reducing costs in supply (Tipple *et al.*, 1998). The government's focus on providing housing has now moved from the social dimension – a way of providing accommodation to workers, to more of an economic activity. There has also been involvement from the private sector and some state-owned enterprises in the provision of housing (Tipple and Korboe, 1998; Tipple *et al.*, 1998; Konadu-Agyemang, 2001a; Arku, 2006; Grant, 2007; Arku *et al.*, 2012).

Traditionally, in Ghana, urban housing has been dominated by multi-inhabitant compound housing. This many-roomed compound housing is a reflection of Ghanaian cultural values and practices of communal living (Tipple *et al.*, 1998). Approximately 90 per

Year	Deficit	Delivery	% of delivery	Need
1980s	250,000	70,000	22	133,000
1998	300,000	30,000	25	140,000
2000	700,000	25,000-30,000	21	199,000
2008	1,000,000	37,000	22	150,000
2010	1,200,000	199,000	23	300,000

Source: Kwofie *et al.* (2011)

Table I. Estimated housing stock and deficit in Ghana

cent of the housing stock in Ghana is built informally through the compound housing system and private individuals (Arku, 2009).

In addition to the traditional compound housing, the government contribution to housing, and private individuals using the *ad hoc* arrangement to build and occupy, the role of private real estate development companies who build for profit has become increasingly important in Ghana's housing supply. The Ghanaian housing market is currently attracting investors (developers) into real estate development. These large real estate developers are often motivated by the need for substantial profits (Awanyo, 2009). Therefore, the houses supplied by such developers are very expensive for most Ghanaians. Grant (2007) in particular notes that, because the houses developed by the private developers are very expensive, housing units are mostly purchased by Ghanaian expatriates residing in western countries.

A majority of the Ghanaian population is below the middle-income bracket, and the mortgage market is not well developed. Moreover, short-term commercial interest rates charged by banks are very high, ranging between 30 and 40 per cent (Konadu-Agyemang, 2001b; Grant, 2007; Arku *et al.*, 2012). In addition to government negligence in increasing the housing supply, the undeveloped mortgage system and high short-term commercial interest rates, the high cost of land and land acquisition problems due to general indiscipline in the market (Gough and Yankson, 2011) and high interest rates on construction loans (Arku *et al.*, 2012) also limit housing supply.

Most commercial banks in Ghana provide housing finance schemes for individuals and employees in targeted companies and corporations. The Home Finance Company (HFC), for example, was established in the mid-1990s to provide housing finance schemes for low-income earners. Its loans typically have a concessionary real interest rate, but the company requires applicants to buy their houses from formal real estate developers. As these real estate developers are economic agents aiming to maximize their profits, the houses tend to be expensive for the buyers.

Market forces that influence housing supply

Before any housing development can take place in a market economy, real estate developers must consider a broad range of factors, both market and institutional. Among the market factors are construction costs, cost and availability of financing, current and future house prices and the level of market demand on completion, which is determined by time on the market, interest rate, GDP per capita, unemployment rate and inflation rate (Hutchison and Disberry, 2015; Owusu-Ansah, 2014). Institutional factors also include the availability and tenure of land and planning regulations (Owusu-Ansah, 2014).

The cost of construction (hard costs) comprises the costs necessary to build the physical structure on the land. These include the availability and costs of labor and raw building materials. When these are available and cheap, then, all things being equal, developers are encouraged to increase production and vice versa. Housing development is very capital-intensive. Most real estate developers find it difficult to raise the capital needed to initiate and complete any residential development, and so must borrow from banks and other financial institutions. When funds are readily available and the cost of getting them cheap, real estate developers will be encouraged to increase production, all other things being equal.

The current and future house prices and the level of market demand on completion can also affect the level of development to be initiated. When the current house prices are high and will increase in the future, with the cost of construction remaining the same, developers' profit margins will increase, and they will initiate more production of houses, all other

things being equal. When the cost of borrowing is reduced and the prices of houses remain relatively stable, then, all other things being equal, the level of demand will increase, which will lead to an increase in housing production.

Institutional factors

By "institutions", we refer to humanly developed constraints that define their interaction; these could be both formal and informal (North, 1990). Institutions have an impact on housing provision, especially in developing markets. Some of the institutions include district, municipal and metropolitan assemblies; planning agencies and authorities; building control; and financial institutions (Hutchison and Disberry, 2015). Availability and tenure of land (Abdulai and Ndekugri, 2007) and planning regulations (Owusu-Ansah, 2014) are the two main institutional factors found to inhibit housing development in developing countries.

In the case of Ghana, the complex and informal land tenure system inhibit real estate development (Kasanga, 1988). The traditional landholding system makes it difficult to access land for real estate development (Abdulai and Ndekugri, 2007). According to Ollennu (1962), in customary Ghanaian land law, all lands have owners. The complex tenure arrangements often lead to multiple claims to ownership of land. The categories of land ownership in Ghana include:

- private lands held by individuals, families (clans) and tribes ("stool", or "skin", lands);
- public lands, or state or government lands, mostly acquired through eminent domain by the government using the State Lands Act 1962 (i.e., Act 125) for public use; and
- vested lands acquired by the state and held in trust for the initial owners (Abdulai, 2010).

Purchasing developable land in Ghana can be a convoluted process. To acquire a public land, an application is often made to the Lands Commission and the required fees paid. With vested lands, the application is also made to the Lands Commission, but the fees are payable to the Office Administrator of Stool Lands (OASL) for the appropriate beneficiaries. In acquiring clan or "stool/skin" lands, the application is processed by the local chief in charge of that particular area. The eventual registration of the land is handled by the Land Commission when the title process is completed. This complex and lengthy process hinders real estate development.

Research approach

The survey process

We designed a self-administered Likert-scale questionnaire with three sections and made it available to real estate developers and some government officials in the land sector. We also provided reassurance in those instructions about steps that would be taken to ensure the confidentiality of the answers. We used a purposive sampling technique to select respondents who were based either in Accra or Tema. This technique was used because we targeted respondents with expert knowledge in the subject matter, thus to suit the purpose of the study. Questionnaires were sent out to all the 61 active members of the Ghana Real Estate Development Association (GREDA) within Accra and Tema. Out of this, 54 representing approximately 89 per cent returned the questionnaires with complete responses. We also administered the questionnaires to three institutional heads working with the government. The first section of the questionnaire elicited demographic

information, including respondents' age, gender, level of education, company or institutional affiliation, job title, years of experience in current company or institution and work location. We placed demographic questions first on the questionnaire to ease respondents gradually into answering the actual questions.

In the second section, we asked the respondents to reflect on the major underlying forces prohibiting housing development in urban Ghana. We asked them to do so from the perspective of commercial real estate developers and not individuals building their own houses. Respondents did not have difficulty following these instructions, because they were all experts in the field. They rated a five-point Likert scale with points ranging from five (very important) to one (not at all important). We chose a five-point scale because we believed the respondents' measurement of the construct might range from high to low. The survey instrument had five different categories with rating factors including infrastructure, financing, land acquisition, input or factor price, price/rent levels and trends. We further broke down each category into subcategories.

The third and final section of the questionnaire asked respondents to provide their views concerning policy interventions required to address the challenges of urban housing development, and also to provide qualitative comments for their ratings in the second section. These comments helped to enrich the quantitative data. The respondents suggested strategies they believed could enhance urban housing development in Ghana.

We pre-tested the questionnaire to ensure that the information was clear to respondents, drawing our sample from the population for which the study was intended. The pre-test answers showed that the survey instrument was appropriate for the study. With graduate students' assistance, we administered the final questionnaires in April and May 2017. The questionnaires were hand-delivered to the offices of respondents and picked up at a later date. This reduced the possibility of unreturned questionnaires, as would be the case with mail questionnaires. Likewise, this greatly helped in attracting respondents' attention and also provided the opportunity to clarify the meaning of the response scales. We trained the graduate students who helped administer the questionnaires on how to respond to clarifying questions from respondents.

The respondents did not receive any monetary compensation for their time; we relied solely on their generosity and interest in the subject matter. All the real estate developers surveyed were members of the GREDA, an organization whose members not only build properties for sale but also offer practical recommendations to the government and other stakeholders on how to improve the real estate market.

Data analysis

We analyzed the responses from the questionnaires using unweighted mean rankings and a dependent *t*-test. We used the dependent *t*-test to determine significant differences in the means between the factor ratings. The test equation takes the following form:

$$t = \frac{\frac{\Sigma d}{N}}{\frac{\Sigma d^2 - \frac{(\Sigma d)^2}{N}}{N(N-1)}} \tag{1}$$

In equation (1) above, d is the difference between matched scores, and N is the number of pairs of scores. We used SAS and Stata codes for all statistical analyses and verbatim quotes from respondents' comments to support the quantitative results and discussion.

Results and discussion

Demographic characteristics of respondents

In Table II, it is clear that the majority of respondents (95 per cent) were real estate developers, with the remaining (5 per cent) employed by the government[3]. The government employees came mainly from the Lands Commission and OASL. The Lands Commission is mainly responsible for managing public lands or lands vested in the state. The OASL facilitates the management and development of stool, or skin, lands, which are held in trust by tribal chiefs[4]. The dominant gender for the sample was male (75 per cent). This is typical of the cultural setting, in which men often have better access to labor market opportunities than women.

All respondents were educated, the main educational level being a bachelor's degree (65 per cent). Managers constituted 56 per cent of the sample with the remainder being chief executive officers (CEOs). This implies that all the respondents were involved in high-level decision-making in their organizations, emphasizing their ability to provide expert opinions on the questionnaire. It is also interesting to note that the average number of years respondents worked in their organizations was seven. This further highlights the fact that respondents were very experienced in their area of work and could adequately comment on real estate development issues. The average age of the sample respondents was 51 years. Furthermore, it took, on average, 10 min for respondents to complete the questionnaire. This is an indication that the questionnaire was clear and easy to interpret.

The relative importance of constraints on housing development

To assess the relative importance of housing development constraints, Table III presents unweighted mean scores, standard deviations and minimum and maximum scale scores for each constraint. It also includes a mean ranking item. Overall, the respondents rated the constraints relating to land acquisition as the top most important factors hindering housing development. Complex tenure arrangements ranked number one both under this category and overall. This is noteworthy because land is the entry ticket to real estate development: there can be no development without a site. Developers are naturally concerned about

Description	Attribute	Frequency	(%)
Respondent category	Government institution	3	5.26
	Real estate developer	54	94.74
Gender	Male	43	75.44
	Female	14	24.56
Education level	PhD/DBA	2	3.50
	Master's	13	22.81
	Bachelor's	37	64.91
	Higher National Diploma	4	7.02
	Lawyer	1	1.75
Position title	CEO	25	43.86
	Manager	32	56.14
Work location	Accra	53	92.98
	Tema	4	7.02
Average years at work	7.39		
Average age (in years)	50.96		
Average duration of interview (in minutes)	9.93		

Notes: The sample has 57 respondents consisting of real estate developers (54) and government officials (3)

Table II. The table presents the demographic information for all respondents in the study

Table III. The table presents the summary statistics for the factor ratings by all respondents

Factor	Obs.	Mean rank	Mean rating	SD	Min rating	Max rating
Infrastructure			*1.81*	*0.48*	*1*	*3*
Electricity	57	14	2.32	0.81	1	4
Roads	57	19	1.65	0.88	1	5
Sewage	57	22	1.40	0.53	1	3
Telecommunications	57	21	1.51	0.50	1	2
Water	57	20	1.60	0.59	1	3
Quality of local schools	56	23	1.38	0.68	1	5
Financing			*3.11*	*0.41*	*2*	*5*
Access to development financing	57	8	3.23	0.76	2	5
High interest rates	57	5	3.58	0.60	3	5
Complex loan provisions	57	10	2.44	0.63	1	4
Lack of tax incentives/breaks	57	12	2.40	0.59	2	4
Land acquisition			*4.04*	*0.42*	*3*	*5*
Complex tenure arrangements	57	1	4.74	0.55	2	5
Difficult land registration process	57	3	4.46	0.68	3	5
Land litigation risk	57	2	4.61	0.49	4	5
Lengthy permit approval	57	4	3.91	0.76	2	5
Approval and registration fees	57	15	2.30	0.82	1	4
Input or factor prices			*2.84*	*0.49*	*2*	*4*
High cost of land	57	5	3.58	0.78	2	5
High cost of labor	57	9	2.63	0.72	1	4
Lack of skilled labor	57	16	2.07	0.80	1	4
High cost of building materials	57	11	2.44	0.82	1	5
Price/rent levels and trends			*2.56*	*0.54*	*2*	*4*
Lack of consumer demand	57	18	1.75	0.85	1	5
Undeveloped mortgage markets	57	7	3.54	0.73	2	5
Taxes on housing transactions	57	17	1.88	0.71	1	3
Housing inflation	57	12	2.40	0.65	1	4

Notes: The factors are put in main categories (in italic) and subcategories. The table includes the number of observations (Obs.), sample mean rating for the various factors, mean ranking, standard deviation (SD), minimum (Min) and maximum (Max) ratings

purchasing land for development if there is uncertainty about the rightful claimant to the title. This is because uncertainty about the rightful owner of the land engenders acquisition and entitlement risks that reduce the value of the investment or expected returns. These risks can be considerable for a developer trying to operate in a complex informal land tenure system.

The second-ranked category is financing. High interest rates increase the cost of borrowing for real estate developers. According to the research group Trading Economics, Ghana has the second-highest interest rates in the world, after Malawi[5].

The Bank of Ghana sets the policy rate at which commercial banks can borrow from the central bank for onward lending to their clients. This implies a higher policy rate, making it extremely costly for real estate developers to borrow from banks. Table IV below provides the average yearly monetary policy rates from 2002 to 2017.

As can be seen in Table IV above, the rates have stayed above 12 per cent for about 16 years. This obviously has had an impact on commercial banks' lending rates, which as of 2017 range between 26 and 32 per cent. Aside from the cost of credit to developers, credit length is also a major issue. Most banks prefer short-term lending, which is not good for real estate, given its illiquid nature. Properties take time to develop and sell, especially in a

Year	Prime/monetary policy rate
2017	23.83
2016	25.92
2015	23.60
2014	19.00
2013	15.80
2012	14.60
2011	12.75
2010	14.30
2009	18.40
2008	15.55
2007	12.75
2006	14.17
2005	16.83
2004	18.88
2003	25.33
2002	25.50

Source: Bank of Ghana

Table IV. The average yearly monetary policy rate

market where mortgages are difficult to obtain. The respondents also gave a high rating to input or factor prices, especially land. Not only do developers have difficulty acquiring litigation-free lands, but the prices charged are also on the high side. A cursory survey of land prices reveals that serviced plots of 100 ft × 70 ft in Accra and Tema sell for a minimum of US$6,000.

Developers view the price/rent levels and trends of an underdeveloped mortgage market as a significant constraint. Buying housing is Ghana is usually self-financed due to the lack of mortgage products; where these products do exist, it is difficult to obtain a mortgage. The main mortgage lenders in Ghana are HFC Bank and Ghana Home Loans. A down payment of 20 per cent on the value of the house is currently required to obtain a loan from these institutions for a 20-year term. Mortgage interest rates quoted by HFC Bank in 2017 were around 29 per cent. Given this high cost of obtaining a mortgage, majority of Ghanaians are priced out of the mortgage market, and this calls for more innovative mortgage products to be introduced into the system.

Table V examines the differences between factor ratings. Because the same respondents rated the various factors, we expected that a relationship would exist between their scores, and we accounted for this relationship in the dependent group *t*-test. In Table V, factors in bold are compared to those not bolded. The table indicates that the respondents considered land acquisition to be more constraining in real estate development than financing, input or factor prices, price/rent levels, trends or infrastructure. In a similar vein, the respondents ranked financing as a more important housing development constraint than input or factor prices, price/rent levels or infrastructure. Overall, the respondents viewed infrastructure as the least important factor hindering housing production in Ghana. The need to provide infrastructure facilities such as water, electricity, roads and sewage can require substantial investment, especially if development is in a remote location, but our respondents considered other elements to be bigger concerns. Aside from electricity, which is highly rated, the rest of the subcategories under infrastructure received low rankings. A possible reason for this low rating of infrastructure could be that most of these

Table V. The table presents a dependent group t-test among the various mean factor ratings

Factor	Mean	Mean differences	*t*-statistic
Land acquisition	*4.04*		
Financing	3.11	0.93	11.8***
Input or factor prices	2.84	1.19	14.1***
Price/rent levels and trends	2.56	1.47	15.2***
Infrastructure	1.81	2.22	24.7***
Financing	*3.11*		
Input or factor prices	2.84	0.26	3.8***
Price/rent levels and trends	2.56	0.54	6.9***
Infrastructure	1.81	1.30	17.3***
Input or factor prices	*2.84*		
Price/rent levels and trends	2.56	0.28	3.1***
Infrastructure	1.81	1.04	12. 5***
Price/rent levels and trends	*2.56*		
Infrastructure	1.81	0.75	8.0***
Number of observations		57	

Notes: Each factor in italic is compared to the other factors beneath it. The accompanying mean differences and *t*-statistics are also presented. ***indicates statistically significant difference in means at the 1% level of confidence

companies develop in areas where infrastructure already exists and do not, therefore, find it to be a hindrance.

The reasoning behind ratings and policy recommendations

The qualitative reasons behind the quantitative judgments and ratings are presented in this section, as well as some policy recommendations. The verbatim views of the respondents are in quotation marks. With supporting statements from previous literature, we also analyze these verbatim views and provide some recommendations. Most respondents indicated that their ratings were based on the negative effects that these constraints had on housing delivery in urban Ghana. Some noted that the customary land holding system needed to be streamlined to ensure transparency in land transfers. They argued that the government should play a major role in facilitating land acquisition in urban centers. One respondent had this to say: "The government should acquire all lands in Accra so that they can be made available to developers". Another respondent stated, "The state should acquire the lands and lease them out to developers". Some of these statements may suggest the creation of land banks by the state so developers will no longer have to deal with a complex customary landholding system. The problem with the state getting involved in such an arrangement, however, is the bureaucracy that may result. In addition, if lands are to be acquired by the state, land owners may not trust the state to compensate them for the fair market value of their acquired lands.

Aryeetey and Udry (2010) developed a theoretical model proposing a decentralized system of land banks in Ghana where traditional authorities like chiefs and local government could rent lands from owners. The banks could build a sufficient inventory of lands that could then be rented to investors like developers and commercial farmers. Aryeetey and Udry (2010) posited that the land banks might initially operate at a loss due to competition for rents from other land owners outside the banks, but that this would change when investors began to realize the security of tenure that land banks provided. Though

their model sounds intuitive, the implementation of such an initiative would be challenging because it requires a strong legal structure to ensure transparency and accountability.

Obeng-Odoom (2014) recommended that, to ensure the security of land tenure, individuals rather than chiefs should be the custodians of their lands. For the author, this will correct an unjust system of chiefs managing lands by putting power directly into the hands of landowners. This is a laudable idea if individual landownership rights are properly registered. Mexico's success in registering traditional land rights (i.e. the certification of the Ejido rights) is a case Ghana can learn from. The registration process in Mexico is participatory; decisions are made with the consent of local authorities.

The respondents also proposed the development of a well-functioning mortgage market. One study participant asked that "effective mortgage systems be implemented". Another noted that "lenders should reduce interest rates for housing loans". The penetration of the mortgage market in Ghana is one of the lowest in Africa. Asabere *et al.* (2016) depicted a positive relationship between mortgage market development and economic growth, measured by gross national income per capita, for some African countries. Although correlation does not necessarily mean causation, a developed mortgage market implies a well-developed financial system that is a remnant of economic growth. Badev *et al.* (2014) reported as much as 80 per cent outstanding mortgage debt to gross domestic product for developed countries, while the percentage is less than 1 per cent for lower-income countries, including Ghana. The Center for Affordable Housing Finance in Africa (2017) estimates that only 2 per cent of urban dwellers in Ghana (Accra) can afford to buy the cheapest house built by a real estate developer, given the current mortgage structure. This surely calls for policies to develop mortgage products that are affordable for the average individual.

Some of these policies will require the development of a stable macroeconomic environment that lowers lending rates and attracts long-term capital from external sources to replenish mortgage funds. Double-digit government lending rates undermine long-term investments in housing finance. Thus, the development of a strong financial system is essential for the creation of a secondary mortgage market. There is also a need for the establishment of a legal framework that recognizes existing property rights and ensures secure titles to property for collateral. The government should consider designing a regulatory framework for the development of innovative mortgage products to capture the informal economy.

Given that internal sources of finance for real estate development are difficult to come by and expensive, companies could form partnerships to obtain loans from multilateral financial institutions like the African Development Bank, Shelter Afrique and the International Finance Corporation (IFC). The IFC invests in various sectors of the economies of developing countries. The organization currently supports the development of green buildings in some developing countries. For an investment proposal to be successful in securing financing, however, it needs to be backed by reasonable assumptions and reliable data. This is what real estate developers in urban Ghana should aim for and team up with the public sector to come up with positive net present value real estate projects.

To reduce the cost of real estate development and make urban housing more affordable, the respondents felt that developers should be more reliant on local building materials and the training of local artisans. One respondent suggested that it was necessary for "the trend of overdependence on foreign building materials to be reversed". Raw materials for producing cement, a major factor input for housing development, are mostly imported. Ghana also produces a lot of timber, but developers are not utilizing the resource efficiently to build cost-effective housing. Policy makers should find ways to stimulate the

manufacturing of cement using local raw materials. This would have the added advantage of creating jobs for people at quarrying sites and other areas on the value chain.

The unavailability and high cost of skilled construction laborers have an impact on urban housing prices as well. A policy to address this shortage by training workers in that area would be beneficial. The government already has a youth and unemployment program that could integrate this training module. Subsidies could also be provided, including removing or reducing the tax rate on imported construction materials. Other respondents also recommended efficiency in the development process. One study participant stated that "minimizing waste on real estate development would significantly reduce prices". One way to do that would be to use cost-effective construction materials and reduce delays in the development stages.

Some of the respondents suggested the formalization of real estate development in urban areas. One stressed that "the informal real estate development market should be controlled or made unattractive". Though the informal sector complicates the ability of public institutions to regulate real estate development and distorts the formal market, it plays an important role in providing housing stock for the majority of urban dwellers. The informal sector thrives on improper regulation, lack of housing finance and institutional failures. An attempt to rectify these will help formalize the real estate market.

The availability of infrastructure is important for the success of large-scale real estate development projects. Sanitation access, roads, bridges, electricity and water provided to certain areas by the government can engender real estate development. If such infrastructure is unavailable, it puts pressure on developers to provide it, which significantly increases the cost of projects. In most cases, the extra cost is passed on to end users, thus making housing out of the financial reach of the majority of the urban population. In a global survey of real estate developers by the Urban Land Institute (2014) to determine the drivers of real estate development, most respondents considered infrastructure to be the number-one driver of real estate investment. The government should pay attention to the provision of infrastructure because it has a multiplier effect on the overall economy, especially affordable housing in urban centers. There could be public–private partnerships in such ventures.

Conclusion

Housing is an important component of a country's economy. The rapid population growth in African cities calls for policies to support the provision of adequate housing to meet demand. However, there is scarcity of research about the housing problem in African cities. This paper aims to address this gap by investigating constraints on housing development in two Ghanaian cities: Accra and Tema. Using a purposive sampling technique, we surveyed managers of private real estate development companies, as well as some public officials, with a Likert scale questionnaire to measure the severity of the factors hindering housing development in these areas. All of the managers and CEOs interviewed work for big real estate development firms that are part of GREDA. The public officials are CEOs of the main land sector agencies in Accra and Tema. The interviewees, thus, had a good understanding of the constraints on housing development.

The results show that the respondents consider the inadequate housing in urban Ghana to be caused by anachronistic institutional arrangements. This is contrary to the view that the housing supply problems in Ghana arise mainly from inadequate funds (Tipple *et al.*, 1998); this study documents that the institutional challenges are more confounding than financial problems, relatively speaking. A large percentage of study participants report that land tenure arrangements, land litigation risk, difficult land registration process, lengthy

procedure for securing building permits and cost of land acquisition are the major factors that significantly affect real estate development. The difficulty in accessing development funds, underdeveloped mortgage market, high interest rates and high cost of labor and construction materials are some of the other constraints for housing development. Policy recommendations are proposed for more effective and market-supporting institutional interventions to improve urban housing supply. Our findings agreed with those of North (1990); efficient institutions enforce property rights and enhance contracts.

Notes

1. Using the Bank of Ghana's Daily Interbank FX Rates, US$1 = GHC4.41 as of January 03, 2018.
2. Apart from private real estate developers and heads of some few government institutions, other stakeholders are excluded due to resource constraints. This is a limitation to the study.
3. The results remain qualitatively similar even if government respondents are excluded from the analysis.
4. The titles "stool" or "skin" lands refer to the chief's symbol of authority; in southern Ghana, it is the stool, while in the northern part, it is the skin.
5. Trading Economics country interest rates (2018), available at https://tradingeconomics.com/country-list/interest-rate?continent=africa (accessed February 02, 2018)

References

Abdulai, R.T. (2010), *Traditional Land Holding Institutions in Sub-Saharan Africa – the Operation of Traditional Landholding Institutions in Sub-Saharan Africa: A Case Study of Ghana*, LAP Lambert Academic Publishing.

Abdulai, R. and Ndekugri, I. (2007), "Customary landholding institutions and housing development in urban centres of Ghana: case studies of Kumasi and WA", *Habitat International*, Vol. 31 No. 2, pp. 257-267.

Ametefe, F., Aboagye, A.Q.Q. and Sarpong-Kumankoma, E. (2011), "Housing and construction finance, deposit mobilization and bank performance in Ghana", *Journal of Property Research*, Vol. 28 No. 2, pp. 151-165.

Arku, G. (2006), "Housing and development strategies in Ghana, 1945-2000", *International Development Planning Review*, Vol. 28 No. 3, pp. 333-358.

Arku, G. (2009), "Housing policy changes in Ghana in the 1990s", *Housing Studies*, Vol. 24 No. 2, pp. 261-272.

Arku, G., Luginaah, I. and Mkandawire, P. (2012), "You either pay more advance rent or you move out: landlords/ladies' and tenants' dilemmas in the low-income housing market in Accra, Ghana", *Urban Studies*, Vol. 49 No. 14, pp. 3177-3193.

Aryeetey, E. and Udry, C. (2010), "Creating property rights: land banks in Ghana", *American Economic Review*, Vol. 100 No. 2, pp. 130-134.

Asabere, P.K., McGowan, C.B., Jr and Lee, S.M. (2016), "A study into the links between mortgage financing and economic development in Africa", *International Journal of Housing Markets and Analysis*, Vol. 9 No. 1, pp. 2-19.

Asare, E.L. and Whitehead, C. (2006), "Formal mortgage markets in Ghana: nature and implications", *RICS Research Paper Series*, Vol. 6 No. 13.

Awanyo, L. (2009), "Meeting housing-space demand through in situ housing adjustments in the Greater Accra metropolitan area, Ghana", *Environment and Planning C: Government and Policy*, Vol. 27 No. 2, pp. 302-318.

Badev, A.I., Beck, T., Vado, L. and Walley, S.C. (2014), "Housing finance across countries: new data and analysis", (Policy Research Working Paper 6756). World Bank, Washington, DC, available at: https://openknowledge.worldbank.org/handle/10986/16821 (accessed 10 December 2017).

Center for Affordable Housing Finance in Africa ((2017), "Housing finance in Africa: a review of some of Africa's is housing finance markets", available at: http://housingfinanceafrica.org/app/uploads/2017_CAHF_YEARBOOK_14.10-copy.compressed.pdf (accessed 8 July 2018).

Daily Graphic Online (2014), "Ghana has 1.7 -million housing unit deficit", available at: http://graphic.com.gh/news/general-news/18541-ghana-has-1-7-million-housing-unit-deficit.html (accessed 20 August 2018).

Gough, K. and Yankson, P.W.K. (2011), "A neglected aspect of the housing market: the caretakers of peri-urban Accra", *Ghana Urban Studies*, Vol. 48 No. 4, pp. 793-810.

Grant, R. (2007), "Geographies of investment: how do the wealthy build new houses in Accra, Ghana?" *Urban Forum*, Vol. 18 No. 1, pp. 31-59.

Grant, R. and Yankson, P.W.K. (2003), "City profile: Accra", *Cities*, Vol. 20 No. 1, pp. 65-74.

Hutchison, N. and Disberry, A. (2015), "Market forces or institutional factors: what hinders housing development on brownfield land?" *Journal of European Real Estate Research*, Vol. 8 No. 3, pp. 285-304.

Karley, N.K. (2002), "Alternative options to mortgages in Ghana", *Housing Finance International*, Vol. 17 No. 2, pp. 26-30.

Kasanga, R.K. (1988), "Land tenure and the development dialogue", "The myth concerning communal landholding in Ghana", Occasional Paper 19. Department of Land Economy, University of Cambridge, Cambridge.

Konadu-Agyemang, K. (2001a), "A survey of housing conditions and characteristics in Accra, an African city", *Habitat International*, Vol. 25 No. 1, pp. 15-34.

Konadu-Agyemang, K. (2001b), "Structural adjustment programs and housing affordability in Accra, Ghana", *The Canadian Geographer/Le Géographe Canadien*, Vol. 45 No. 4, pp. 528-544.

Konadu-Agyemang, K. (1991), "Reflections on the absence of squatter settlements in west African cities: the case of Kumasi, Ghana", *Urban Studies*, Vol. 28 No. 1, pp. 139-151.

Kwofie, T.E., Botchway, E. and Adinyira, E. (2011), "Historical overview of housing provision in pre and post-independence Ghana", Paper presented at the West Africa Built Environment Research Conference, Accra, Ghana.

Luginaah, I., Arku, G. and Baiden, P. (2010), "Housing and health in Ghana: the psychosocial impacts of renting home", *International Journal of Environmental Research and Public Health*, Vol. 7 No. 2, pp. 528-545.

North, D. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge University Press, Cambridge.

Fore, G. (1989), "Housing in Ghana: the case for a Central executing agency", *Habitat International*, Vol. 13 No. 1, pp. 5-17.

Owusu-Ansah, A. (2012), "The dynamics of residential property values in developing markets. The case of Kumasi, Ghana", *Journal of International Real Estate and Construction Studies*, Vol. 2 No. 1/2, pp. 19-35.

Owusu-Ansah, A. (2014), "Modelling the supply of new residential construction in Aberdeen, UK", *International Journal of Housing Markets and Analysis*, Vol. 7 No. 3, pp. 346-362.

Obeng-Odoom, F. (2014), "Urban land policies in Ghana: a case of the emperor's new clothes?" *The Review of Black Political Economy*, Vol. 41 No. 2, pp. 119-143.

Ollennu, N.A. (1962), *Principles of Customary Land Law in Ghana*, Staples Printers, London.

Statistical Service of Ghana (2008), "Ghana living standards survey: report of the fifth round", available at: www.statsghana.gov.gh (accessed 30 June 2013).

Statistical Service of Ghana ((2012),) "Population and housing census, 2010", available at: www.statsghana.gov.gh (accessed 30 June 2013).

Tipple, A.G. and Korboe, D. (1998), "Housing policy in Ghana: towards a supply-oriented future", *Habitat International*, Vol. 22 No. 3, pp. 245-257.

Tipple, A.G., Korboe, D., Willis, K. and Garrod, G. (1998), "Who is building what in urban Ghana? housing supply in three towns ", *Cities*, Vol. 15 No. 6, pp. 399-416.

Urban Land Institute (2014), *Infrastructure 2014: Shaping the Competitive City*, Urban Land Institute, Washington, DC, available at: http://uli.org/wp-content/uploads/ULI-Documents/Infrastructure-2014.pdf (accessed 12 June 2017).

UN-Habitat (2005), "Home ownership through mortgage finance", UN-Habitat Features, available at: www.unhabitat.org (accessed 9 July 2013).

UN-Habitat (2016), *Housing Profile in Ghana*, UN-Habitat, Nairobi, available at: www.unhabitat.org (accessed 11 July 2017).

Further reading

Karley, N.K. (2008), "Ghana residential property delivery constraints and affordability analysis", *Housing Finance International*, Vol. 22 No. 4, pp. 22-28.

Ministry of Works and Housing (1986), *National Housing Policy and Action Plan 1987-1990*, Accra.

Owusu-Ansah, A. and Abdulai, R.T. (2014), "Producing hedonic price indices for developing markets: explicit time variable versus strictly cross-sectional models", *International Journal of Housing Markets and Analysis*, Vol. 7 No. 4, pp. 444-458.

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Epidemiological spreading of mortgage default

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Abstract

Purpose – This paper aims to introduce mathematical models to capture the spreading of epidemics to explain the expansion of mortgage default events in the USA.

Design/methodology/approach – The authors use the state of infectiousness and death to represent the subsequent steps of payment elinquency and default, respectively. As the local economic structure influences regional unemployment, which is a strong driver of mortgage default, the authors model interdependencies of regional mortgage default rates through employment conditions and vicinity.

Findings – Based on a large sample between 2000 and 2014 of loan-level data, the estimation of key parameters of the model is proposed. The model's forecast accuracy shows an above-average performance compared to well-known approaches such as linear regression or logit models.

Originality/value – The key findings may be useful in understanding the dynamics of mortgage defaults and its spatial spreading.

Keyword Big data

Paper type Research paper

1. Introduction

The recent credit crisis of 2007 has resulted in a rapid decline of building prices and consequently of mortgage values due to increased mortgage default risk. The negative impacts not only influenced the US economy but also resulted in a worldwide recession. Therefore, the understanding of how mortgages become infected by each other and consequently delinquent and default consecutively has been neglected so far to the best of our knowledge. Credit risk is highly influenced by the dependence between defaults. Researchers concentrated on the individual default probabilities, but a pool of mortgage loans and derivatives written on those mortgages are riskier if the defaults appear at similar dates. Therefore, default dependence is a main concern to risk management or pricing of mortgaged backed securities. Important research has been conducted on simultaneous default such as, for example, in Duffie *et al.* (2009). However, only a few studies, for example, Cowan and Cowan (2004) and Hillebrand *et al.* (2012), consider dependencies in the mortgage market by serial correlation.

The failure of models to capture the dynamics and interdependencies of mortgage performance reveals the need for new models based on a deeper understanding of mortgage default characteristics. To our knowledge, no model has been suggested, yet, that explicitly explains the spreading of mortgage default. Our approach is to capture the dynamics of mortgage default in terms of a compartment model for epidemic diseases.

There is some evidence that mortgage defaults are influenced by payment difficulties of debtors living in the surrounding area. Like the infection of a disease, Goodstein *et al.* (2011) show that default rates increase after the information that another mortgage within the

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neighbourhood defaulted started to spread. They explain this behaviour through fallen psychological barriers. For example, Chan *et al.* (2013) observe the same effect and can show that an increase of foreclosure nearby result in decreasing house prices and increasing default probabilities. Therefore, the use of compartment models normally capturing the course of a disease seems appropriate to explain mortgage default spreads.

In this paper, we analyse the default dependence between 2000 and 2014 within a large data set of individual US mortgages. The data include both pre-crisis and post-crisis times.

First, we propose a model that compares the states of mortgage contracts during their life cycles to a classical susceptible-infected-recovered model (SIR model) first described by Kermack and McKendrick (1927). The SIR model originally divides the population in different subgroups, called compartments, depending on if they are infected. We assign the basic ideas of the SIR model to capture the dynamics of the local mortgage market inside a US county.

Second, we determine rates that measure the amount of mortgages which change their states of infection through statistical methods for survival analysis. The Cox model is used to describe the time how long mortgage contracts stay in a specific compartment (Cox, 1972). As macroeconomic variables are strong drivers of mortgage defaults, we include unemployment rates, house prices, the mean credit score (FICO) within a county and the spread between the average mortgage rate within the county and the national mean. These variables are well-known factors influencing mortgage payments (Elul *et al.*, 2010; Divino and Rocha, 2013; Danis and Pennington-Cross, 2008).

Third, we model the interdependencies between several local mortgage markets that are far apart through industrial similarities proposed by Feser *et al.* (2005) because there is evidence that regional unemployment rates are influenced by the economic structure inside the area (Weiler, 2001).

The question we address is whether epidemic models are able to determine the dynamics of mortgage markets and to which extent the dependence of mortgage default rates can be measured through the proposed approach of industrial similarities among several counties. In addition, we examine how accurate the model predicts real data and compare the results to earlier research.

The paper is organized as follows. We shortly introduce the classical SIR model in Section 2, its similarity to the possible states of mortgage loans and statistical models for survival analysis. Then we discuss housing prices, unemployment rates, mortgage rates and their influence on the default probability of individual mortgages, as well as the geographic measure of economic structures, in Section 3. After the theoretical setup in Section 4, we present the data used in our work in Section 5. Section 6 presents the empirical results and Section 7 concludes the paper.

2. Epidemic models

Epidemiological investigation has a long history in research dating back many centuries, however, the mathematical models were introduced in a series of seminal papers by Kermack and McKendrick in the 1920s, see for example Matthews and Woolhouse (2005).

Today, models with multiple facets and in a variety of complexities exist. The models may be categorized as deterministic or stochastic depending on their specification. Brauer *et al.* (2008) provide a broad overview on mathematical models for disease analysis. Deterministic, or compartmental models, try to capture the dynamics on a large scale. They are therefore very suitable for investigating the average evolution of a total population, whose individuals are categorized into different subgroups, called compartments, according to their status (Matthews and Woolhouse, 2005).

The basic framework of the majority of the epidemiological models is formed by the deterministic SIR model which assumes that people are homogneous, i.e. each individual has the same likelihood to become infected if exposed and is expected to experience the same severity of infection. Further, the population is assumed to be well-mixed, which yields equal exposure within each subpopulation. These assumptions allow to use the mean-field methods often deployed in physics to derive the results. Mean-field theory assumes strict homogeneity. The following introduction is based on the description in Keeling and Eames (2005) and Britton (2010), but may be found elsewhere in slightly different notation. The name SIR is derived from the possible model states. $\{S(t).\, t \geq 0\}$ denotes the amount of susceptible people at time t, i.e. the number of people that are endangered to become infected. $\{I(t).\, t \geq 0\}$ describes the infectious or infected part of the population, in other words, those that are able to spread the disease, and $\{R(t).\, t \geq 0\}$ denotes the group that has recovered from the disease. As an extension the natural death of a person is usually modelled as a state called $\{D(t).\, t \geq 0\}$ which means that the total population alive at time t. $\{N(t).\, t \geq 0\}$ is estimated through $N(t) = S(t) + I(t) + \mathrm{R}(t).\, \forall t$

Exchanges between the compartments in a deterministic model are driven by transition rates. People are born with a rate of μ and die with a rate of τ per unit of time. A person is able to die no matter in which compartment he is in. All susceptible people are infected with the force of infection β and recover at rate γ. Transition is the only possible way from S to I and from I to R. Let all rates be denominated as number of people per unit of time. If one assumes born children to be healthy. the model dynamics may be represented through a set of differential equations as in Brauer *et al.* (2008):

$$\frac{dS}{dt} = \mu \cdot N(t) - \beta \cdot S(t) \cdot I(t) - \tau \cdot S(t) \tag{1}$$

$$\frac{dI}{dt} = \beta \cdot S(t) \cdot I(t) - \gamma \cdot I(t) - \tau \cdot I(t) \tag{2}$$

$$\frac{dR}{dt} = \gamma \cdot I(t) - \tau \cdot R(t) \tag{3}$$

$$\frac{dD}{dt} = \tau \cdot S(t) + \tau \cdot I(t) + \tau \cdot R(t) \tag{4}$$

In equation (1) the dynamics of the susceptible people is described by a constant birth rate $\mu \cdot N(t)$ that increases the amount of state $S(t)$. With rate $\beta \cdot S(t) \cdot I(t)$ people get infected and die with rate $\tau \cdot S(t)$ that both decrease the amount of susceptibles. Equation (2) describes the amount of the infected population where $\beta \cdot S(t) \cdot I(t)$ newly infected people join this state at every time span. They recover at rate $\gamma \cdot I(t)$ which increases the amount of recovered people in equation (3), then. Infected and recovered people die at rate $\tau \cdot I(t)$ and $\tau \cdot R(t)$. Equation (4) captures all deaths in every period and is the sum of all people dying while being in one of the other states.

Burnside *et al.* (2016) adapt the epidemiological approach to the housing market. They model the dynamics of the fraction of agents with different views about future house prices.

A few agents changing their expectations through random social interactions can result in a housing market boom. Their work is based on Piazzesi and Schneider (2009), who show

that a small amount of investors that are optimistic about future house prices is sufficient to cause a price increase.

Statistical models used for survival analysis were developed to analyse the time-to-occurence of a certain event as well as the circumstances related to that event. Survival analysis approaches are used to study time-to-failure characteristics of machine components, time-to-death in clinical studies or in the estimation of the incubation time of diseases. For a deeper understanding of survival analysis, we refer to Elandt-Johnson and Johnson (1999); Lawless (2011) and Kalbfleisch and Prentice (2011).

As we are interested in modelling how long mortgage contracts stay in a specific state and when they leave to another one according to our model, the transition rates are considered in terms of survival analysis approaches.

The essential term in survival analysis we use is the hazard function, or hazard rate, $h(t)$. In contrast to the unconditional survival function, the hazard function is based on the conditional probability of observing the event of interest in the next small time step $[t.t + \Delta t]$, given that the event has not yet happened by time t. The hazard rate is defined as:

$$h(t) = \lim_{\Delta t \to 0} \frac{1}{\Delta t} \mathbb{P}[t \leq T < t + \Delta t | T \geq t] \tag{5}$$

To capture explanatory variables, Cox (1972) proposed a semi-parametric model for the hazard function, whereas he defines the hazard function as:

$$h(t, x) = h_0(t) \cdot exp\left[x_1 \beta_1 + \cdots + x_p \beta_p\right] = h_0(t) \cdot exp\left[x^T \beta\right] \tag{6}$$

where β is the vector of coefficients and $h_0(t)$ is the baseline hazard, the hazard function with all covariates being equal to zero. As the baseline hazard is not of parametric form, the model is called to be a semi-parametric model. Because of its flexibility to handle time-dependent parameters, as well as frailty terms. the Cox model is the most popular approach for modelling the relation between covariates and censored data.

There are a lot of studies involving Cox models to describe the time till a mortgage defaults (Deng *et al.*, 1996; Quercia and Stegman, 1992). The main focus is to estimate the influence of loan-level characteristics and macroeconomic factors on the time between mortgage origination and termination.

3. Drivers of mortgage default

This section briefly summarizes some of the various drivers of mortgage default used in our model that are investigated in earlier research.

It has already been proved that a reduced unemployment rate is followed by a falling probability of mortgage default. This is due to an increased likelihood that the monthly mortgage payments cannot be served if the borrower gets unemployed. It can even be seen that the default rate increases only if the unemployment rate rises (Elul *et al.*, 2010).

A second driver that is considered here is the house price, which is negative correlated to the frequency of defaults (Danis and Pennington-Cross, 2008). If the house price declines over the lifetime of the mortgage contract, the difference between it and the outstanding loan amount gets negative, which is a reason for the borrower to default (Elul *et al.*, 2010).

When a mortgage is originated, the lender offers a mortgage rate to the borrower, which is influenced by the interest rate level of the financial market and the borrower characteristics to capture the borrowers creditworthiness. Divino and Rocha (2013) imply an

increased default probability after the interest rate drops, because the contract can be switched to one with lower interest rate.

The area around the real estate bought by the mortgage borrower also influences the default probability. Chan *et al.* (2013) show a negative influence of foreclosures in the neighbourhood due to dropping house prices. If a mortgage in the neighbourhood defaults the stigma of an own default, it is not seen as tragic as before, which increases the default rate due to a psychological reasons (Goodstein *et al.*, 2011).

The history of loan payments is a strong driver to predict the ability to pay loan payments in the future. In the US the creditworthiness is captured by a single number called FICO-score (Danis and Pennington-Cross, 2008). It has been shown that mortgage contracts whose borrower has got a high score are less likely to default (Bajari *et al.*, 2013).

4. Theoretical setup

To compare the epidemic model to the mortgage market. the life cycle of a mortgage contract needs to be observed.

Initially a mortgage is originated, its payments are assigned through the mortgage contract and payments can be assumed to be on time. The mortgage is seen as susceptible (state S) and called current. If the payments are delinquent so that the payments are at least one month behind schedule, the mortgage is seen as infected (State I). Then there are three possibilities that can happen. First, if the debtor is in delay on multiple monthly payments, the contract is considered defaulted by the lender, and, in terms of an epidemic model, dead due to the infection (State D). Second, the borrower can sell the real estate, pay back the outstanding debt and therefore leave the model in a recovered state (State R). Third, the borrower pays back all outstanding payments so that the mortgage contract returns to State S and is seen as susceptible again the next point of time.

Before the epidemic mortgage market model is introduced, there are some assumptions that are made both to simplify the theoretical structure and to adjust properties of the mortgage market to the epidemiological model.

The mortgage market is modelled as a state space model and the parameters are estimated by an iterated filtering algorithm proposed by Ionides *et al.* (2006). Further details on state space models can be found for example in Robert H. Shumway and Stoffer (2011).

We assume a homogenous credit pool, which means that the amount of outstanding debt, mortgage rate and monthly mortgage payments are assumed to be equal for all mortgages. US counties are the geographical unities as they are "the largest territorial division for local government within a state of the USA' (Merriam-Webster, 2016). A lot of studies use ZIP codes to include spatial effects in its models which is crucial according to Grubesic (2008). To eliminate data issues, only counties are considered where more than 50 mortgages are originated between 2000 and 2014 according to the used data introduced in the next section.

Furthermore, a default of a mortgage is only possible if the loan has been delinquent before and a defaulted mortgage leaves the model and is not considered for the rest of the observed timespan. A mortgage is able to be prepaid, e.g. the outstanding debt is fully paid before termination, both in a delinquent state and in a state where the monthly payments are on schedule.

During the whole life cycle, a mortgage is not considered to be in more than one state. The mortgage's payments are either on schedule or delayed, but not both. The cause of termination is considered to be unique, too. Either the mortgage's outstanding debt is fully repaid or the debtor fails to make payments multiple times so that the contract is considered defaulted by the lender.

The parameter estimation of the state space model requires the definition of five compartments:

- *Compartment B*: Equivalent to the level of infectious bacteria in Bertuzzo *et al.* (2010), this state corresponds to an unobserved system state that tries to include the mortgage dynamics not captured by explanatory variables, i.e. the systematic distress in the given local mortgage market.
- *Compartment S*: This is a pool of performing (current) mortgages whose payments are on schedule.
- *Compartment I*: This is a pool of delinquent mortgages whose payments are at least one month behind schedule.
- *Compartment P*: This is a pool of prepaid mortgages, hence the balance has been prepaid.
- *Compartment D*: This is a pool of defaulted mortgages, that means the mortgagor seized and did not resume servicing until property was repossessed and foreclosed.

The general model for the USA, i.e. several counties, with discrete equidistant time increments is given by the following system of differential equations. To capture the dynamics, we formulate an adapted version of the compartment model for each county i in the form:

$$\frac{\partial B_i(t)}{\partial t} = -\mu_{B_i} \cdot B_i(t) + \lambda_i(t) + \sum_{k=1}^{N} \omega_{i,k} \cdot \delta_{i,k} \cdot \phi_{i,k}\big(B_k(t)\big) \tag{7}$$

$$\frac{\partial S_i(t)}{\partial t} = \mu_i - \beta_i \cdot B_i(t) \cdot S_i(t) + \gamma_i(t) \cdot I_i - \nu_i^S(t) \cdot S_i(t) \tag{8}$$

$$\frac{\partial I_i(t)}{\partial t} = \beta_i \cdot B_i(t) \cdot S_i(t) - \gamma_i(t) \cdot I_i - \nu_i^I(t) \cdot I_i(t) - \alpha_i(t) \cdot I_i(t) \tag{9}$$

$$\frac{\partial P_i(t)}{\partial t} = \nu_i^I(t) \cdot I_i(t) + \nu_i^S(t) \cdot S_i(t) \tag{10}$$

$$\frac{\partial D_i(t)}{\partial t} = \alpha_i(t) \cdot I_i(t) \tag{11}$$

The model of Cox (1972) is used to describe transition rates as follows:

$$\lambda_i(t) = a_{i0} \cdot \left(I_i^{Data} + dD_i^{Data}\right) \cdot e^{a_{i1} \cdot ALQ_i(t) + a_{i2} \cdot HOUSE_i(t) + a_{i3} \cdot SPREAD_i(t) + a_{i4} \cdot FICO_i(t) + \epsilon_{i2}} \tag{12}$$

$$\nu_i^S(t) = b_{i0} \cdot e^{b_{i1} \cdot ALQ_i(t) + b_{i2} \cdot HOUSE_i(t) + b_{i3} \cdot SPREAD_i(t) + b_{i4} \cdot FICO_i(t) + \epsilon_{i1}} \tag{13}$$

$$\nu_i^I(t) = c_{i0} \cdot e^{c_{i1} \cdot ALQ_i(t) + c_{i2} \cdot HOUSE_i(t) + c_{i3} \cdot SPREAD_i(t) + c_{i4} \cdot FICO_i(t) + \epsilon_{i3}} \tag{14}$$

$$\alpha_i(t) = d_{i0} \cdot e^{d_{i1} \cdot ALQ_i(t) + d_{i2} \cdot HOUSE_i(t) + d_{i3} \cdot SPREAD_i(t) + d_{i4} \cdot FICO_i(t) + \epsilon_{i4}} \tag{15}$$

$$\gamma_i(t) = e_{i0} \cdot e^{e_{i1} \cdot ALQ_i(t) + e_{i2} \cdot HOUSE_i(t) + e_{i3} \cdot SPREAD_i(t) + e_{i4} \cdot FICO_i(t) + \epsilon_{i5}} \tag{16}$$

As the above approach is modelled as a state space model, the states need to be linked to the observed data by a measurement model. We assume a normal distribution with the observed amount of mortgages in each states as mean values and standard deviations $\sigma_i^S, \sigma_i^I, \sigma_i^P$ and σ_i^D for each state and county.

$ALQ_i(t)$ describes the unemployment rate and $HOUSE_i(t)$ house prices in county i at time t is the difference between the weighted average mortgage rate in county i at time t and $SPREAD_i(t)$ is the national mean rate of 30 year fixed-rated mortgages at time t. $FICO_i(t)$ is the average FICO-score of all considered mortgages within county i at time t. I_i^{Data} and dD_i^{Data} are normal distributed random variables with the observed amount of delinquent and newly defaulted mortgages in the previous month $t-1$ as mean values and σ_i^S, σ_i^I as standard deviations.

The error terms $\epsilon_{i1} \ldots \epsilon_{i5}$ are assumed as independent and normal distributed with $\tau_{i1} \ldots \tau_{i5}$ as standard deviations. $\phi_{i.k}(x)$ is considered as a function where x is weighted by the inverse of the distance between county i and county j in miles. $\delta_{i.k}$ captures the dependencies between two counties and is described below.

Equation (7) describes the unobserved system state that tries to capture the systematic distress in a given local mortgage market in county i at time t by accounting for contagion effects through linked counties. With a constant rate of $\mu_{B_i} \cdot B_i(t)$, the bacteria state decreases and is inspired by the cholera epidemic model in Bertuzzo *et al.* (2010). Infected and previously defaulted mortgages in the neighbourhood contribute to the concentration of state $B_i(t)$ by influencing $\lambda_i(t)$ through equation (12), $\sum_{k=1}^{N} \omega_{i,k} \cdot \delta_{i,k} \cdot \phi_{i,k}(B_k(t))$ connects the bacteria state of county i to bacteria states of linked counties by applying the approach described below.

The dynamics of susceptible mortgages whose payments are on schedule is described by equation (8). In every period, newly originated mortgages that are assumed to be healthy and enter the state with rate μ_i. Mortgages that become delinquent with rate $\beta_i \cdot B_i(t) \cdot S_i(t)$ decreases state S in equation (8) and increase State I that is described through equation (9). As it can be seen, the rate at which mortgages become delinquent is highly influenced by the bacteria State B.

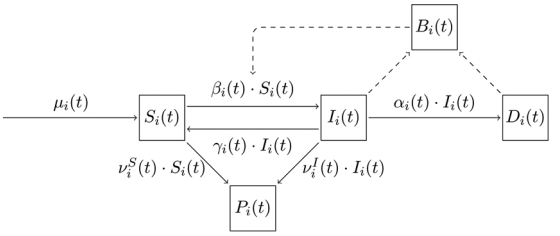
On the opposite, with rate $\gamma_i(t) \cdot I_i$ delayed mortgage payments are repaid so that the payments are on schedule again. This decreases State I and increases State S. $\gamma_i(t)$ is defined in equation (16).

The amount of mortgages that outstanding debt is fully paid back before termination is estimated by $\nu_i^S(t) \cdot S_i(t)$, which decreases the amount of current mortgages and increases the amount of prepaid mortgages captured by State R in equation (10). $\nu_i^S(t)$ is modelled by a Cox model and can be seen in equation (13).

All mortgages that are infected and their payments are behind schedule are prepaid with rate $\nu_i^I(t) \cdot I_i(t)$, which is captured by equation (14), which decreases State I and increases State R.

Rate $\alpha_i(t) \cdot I_i(t)$ describes the amount of delinquent mortgages that are considered as defaulted. $\alpha_i(t)$ is defined by equation (15) and increases chronological sequence of defaulted mortgages in equation (11)

Figure 1. shows a flowchart that illustrates the model.



Notes: Description of the local mortgage market through a flowchart. μ_i is the rate of newly originated mortgages that increase the amount of susceptible loans S_i (t) between [t-1; t). β_i (t) shows the amount of newly delinquent loans and α_i (t) describes the rate of delinquent loans I_i (t) that default, and therefore stay in state D_i (t) for the rest of the observation period. γ_i (t) shows the extent to which loans get back to their scheduled payments and v_i^S (t),v_i^I (t) are rates at which mortgages are prepaid and increase P_i (t) depending from which state (S_i (t) or I_i (t)) they come from. B_i (t) is the unobserved system state that represents systematic distress

Figure 1. Flowchart of local mortgage market

The question that remains is how to link two counties so that their dependencies can be included in state B or alternatively: How should $\delta_{i,k}$ be estimated?

Industry sectors are not evenly distributed throughout the US landscape. They are settled in regions, e.g. automotive sector in Michigan.

Ellison *et al.* (2007) summarize as a main factor that industry sector are settled in agglomerations through its falling transport costs. Delgado *et al.* (2016) develop an algorithm that combines all sectors of the six-digit North American Industry Classification System (NAICS) in 51 traded industries whose occurrence are agglomerated and 16 local industries that are spatial dispersed. As we are interested in industries that can be mainly found in specific regions, local industries are left out in our study. Their basic idea is to search for co-location patterns, input-output links and similarities in labour occupations to define value chains that are similar in their demands, offers, knowledge and technology. The definition of the value chains and its corresponding six-digit NAICS code is available upon request.

The question where these agglomerations are found is estimated by the work of Feser *et al.* (2005), who define a measure to address the geographic occurrence of industrial sectors.

The G-statistic measures the deviation in standard deviations from the mean. For a given value chain u, the G-value for county i:

$$G^*_{u,i} = \frac{\sum_j \omega_{ij} \varepsilon_j - W_i \overline{\epsilon}}{s\sqrt{\frac{nS_{1i} - W_i^2}{n-1}}} \tag{17}$$

given value chain u. ω_{ij} is the spatial weight, which defines the neighbouring counties j to i (i.e. either binary adjacency matrix or centroid distance-based approach which decrease as

the distance between the centres or two regions increases). Further, let $W_i = \sum_j \omega_{ij}$ and $\overline{\epsilon} = \sum_j \frac{\epsilon_j}{n-1}$, $S_{1i} = \sum_j \omega_{ij}^2$ and $s^2 = \left(\frac{\sum_j \epsilon_j^2}{n-1}\right) - (\overline{\epsilon})^2$.

There are multiple possibilities to determine both independent variables of G_i^* and the spatial weight matrix ω_{ij}. Feser *et al.* (2005) propose the use of the residuals after they regressed the value chain employment $\hat{y}$ on total (export oriented) employment (x) with coefficient (β) derived from national averages (i.e. $\hat{y} = \beta \cdot x + \varepsilon$) for each county. Therefore, ε_j is the residual of county j for a given value chain and

$$\omega_{ij} = \begin{cases} \frac{\varepsilon_i \varepsilon_j}{\sum_j \varepsilon_i \varepsilon_j}, & \textit{county i and county j share a border or } i = j \\ 0, & \textit{else} \end{cases} \tag{18}$$

given the values for the G-statistic are available for all counties N and for all value chains P under considerations. The following methodology may be used to derive the function $\delta_{i,k}$. If the G-value of county n for value chain i is greater than a cutoff value c for any chain i, then the two vertices will be connected. The connection is recorded in a matrix E. For any two counties $k, l \in 1, , N$ edges are governed by:

$$\delta_{ij} = \begin{cases} \frac{\sum_u 1_{G_{u,i}^* > c \cdot G_{u,k}^* > c}}{P}, & \textit{if } \sum_u 1_{G_{u,i}^* > c \cdot G_{u,k}^* > c} \geq 1, \; i \neq k \\ 0, & \textit{else} \end{cases} \tag{19}$$

The matrix E may be updated on a regular basis to consider changes in the underlying industrial structure. The updating frequency is to be determined, as the process is deemed to be computationally costly. Therefore, the G-statistics is computed once for annual means between 2000 and 2014.

The boundary value for the G-statistic was set to $\Phi\left(1 - \frac{\alpha}{2}\right)$, in which α was set to 0,005 and Φ denotes the cumulative Gaussian normal distribution. As the G-statistic describes specialized counties, a smaller value α would result in a tighter definition of specialization. Hence, a higher deviation from the national average would be required to denote a county as 'specialized'. The G-statistic for every county and all value chains are computed and the results are available upon request.

As previously noted, Elul *et al.* (2010) have studied the effect of local unemployment rates on default. The study found that unemployment is a significant, systematic measure for defaults. Therefore, the test for the direct default channel was reduced to test for co-movement of unemployment rates within the counties identified through the value chains.

5. Data

The loan-level data have been obtained from three different sources. All contracts that have its maturity date after January 2000 are included.

First, Bloomberg L.P. (2015) was used to collect a sample from securitized mortgage loans in a series of mortgage backed securities. The data was downloaded in July 2015. A list of the firms and their products is available upon request. The data consist of 2,433,501 mortgage contracts that have originated prior to 2014.

Second, the loan performance data provided by Fannie Mae (2015) and available online have been another source. The data obtained in July 2015 consist of 7,963,189 individual loans. The performance files report the monthly payments of fixed-rated mortgages that are bought by Fannie Mae between January 2000 and March 2012. The duration is between 25 and 35 years and all documents are available at origination date.

Third, loan performance files consisting of 4,205,383 individual loans provided by Freddie Mac (2015) has been sampled online in December 2015. The duration of the fixed-rated mortgages is 30 years and all documents are available at origination date, too.

As previously mentioned, only counties with more than 50 mortgage contracts originated between 2000 and 2014 are considered which covers 1490 counties or over 90 per cent of the US population according to USA Census Bureau (2010). The observation of every county starts, if more than ten mortgages are originated to avoid data issues. A list of all considered counties is available upon request.

The unemployment rate has been provided by the US, Bureau of Labor Statistics (2015)[1].

Zillow Home Value Index was used to get a proxy of house price data on county level. Unfortunately, not all counties considered are covered by the index. Therefore, average values of neighbouring counties are used to get monthly house price values in case of missing information.

The mortgage rates of the financial market is provided by Freddie Mac (2016). To get the spread between the national mean and the regional interest rate level the following difference is estimated. In every county, we compute the weighted average coupon rate if more than 100 mortgages are active at the time. If that is not the case we use spatial Kriging to get an approximation and to avoid data issues. The national mean of 30-year fixed-rated mortgages minus the weighted average regional coupon rate yields the spread mentioned earlier.

The FICO-score is a well-known index to capture the creditworthiness of a borrower. We use the average FICO within a county from the loan-level data to obtain a proxy of the ability to pay for the whole county. Like before, to avoid data issues, we only consider the mean value if more than 100 mortgages are active during the specific month. Otherwise, we use spatial Kriging to approximate the average FICO-score within the county.

In both approximations a Gaussian semivariogram model is assumed to get monthly parameter for spatial Kriging. Then spatial mean values are computed for each county to get FICO and spread values at each considered county and date. Information about spatial Kriging can be found for example in Cressie (1992).

In Table I, descriptive statistics of the mortgage data used in our work are presented. As it can be seen most of the defaulted mortgages were originated between 2006 and 2009.

6. Empirical analysis

First, the iterated filtering algorithm, proposed by Ionides *et al.* (2006). Is performed for each county without contagion effects to or from other counties. Therefore, equation (7) is modified with $\omega_{i,k} = 0, \forall i, k$. The iterated filtering algorithm is performed 60 times with different starting points to estimate all parameters used in the model. While the first observation of every state in a county is used as the state's starting point, parameters are chosen uniformly distributed between $[-1; 1]$. We assume the parameters a_{i0}, b_{i0}, c_{i0}, d_{i0}, $\tau_{i1} \ldots \tau_{i5}$, $\sigma_i^S, \sigma_i^I, \sigma_i^P$ and σ_i^D for all I to be positive, which means both they start uniformly distributed between [0; 1] and transition rates are positive, too. Then the sum of all absolute deviations between the mean of simulated data and real observations for all dates and different compartments is estimated. The parameter vector

Table I. Descriptive statistics of the used data: the amount of observed mortgages, the share of defaulted and prepaid mortgages per origination year till the end of 2014

Origination year	Amount	Share of prepaid mortgages in %	Share of defaulted mortgages in %
1995	2	0	100
1996	8	0	75
1997	40	0	82.5
1998	432	0	79.4
1999	198,576	95.19	2.05
2000	531,500	96.11	2.32
2001	1,161,116	95.55	1.85
2002	1,249,121	92.67	2.01
2003	895,079	86.28	2.51
2004	705,582	79.51	4.25
2005	794,234	72.97	7.31
2006	1,241,833	61.35	16.29
2007	987,064	55.35	21.06
2008	1,195,790	60.85	16.72
2009	1,712,289	54.22	10.73
2010	711,539	55.6	0.84
2011	622,896	45.16	0.5
2012	972,210	18.15	0.2
2013	999,383	7.13	0.17
2014	623,379	3.38	0.03
Total	14,602,073	58.9	6.68

that minimizes the sum of each compartment's absolute values is accepted as optimal. Due to the amount of parameters estimated, only the distribution of each parameter from all local mortgages market is presented in Table II. Furthermore, for every parameter that is not assumed to be positive, distribution tests are performed if the estimation's mean are equal to zero.

Although parameter estimations are widely distributed including both positive and negative values, several insights can be deduced. Besides of c_3, the parameter distribution for all parameters from equations (13) and (14) that are not assumed to be positive have got significantly negative means. This is in line with studies from Section 3. If a county's unemployment rate or spread increase or if house prices or the county's average FICO-score decrease, $\alpha_i(t)$ from equation (15) rises and $\gamma_i(t)$ from equation (16) increases if house prices and the interest rate spread rise, as well as if county's unemployment rates and the average FICO-score decrease. The bacteria concentration is highly influenced by $\lambda_i(t)$ from equation (12) that is positively affected by county's house prices. It decreases if unemployment rates, spread or the average FICO-score rise.

Although the convergence of iterated filtering algorithms is presented in Ionides *et al.* (2011), we check how the parameter estimation is influenced by the starting vectors. Therefore, we simulate the time series 100 times based on our parameter vector that we assumed as optimal and estimate parameter vectors with the same settings described earlier based on the simulated time series. Then, a confidence interval at the 95 per cent level is estimated through the 100 newly estimated parameter vectors; 21 out of the 37 entries are located inside the confidence level.

As we are interested how mortgage defaults are influenced by other local mortgage markets, we then estimate $\omega_{i,k}$, $\forall i, k$. Therefore, the optimal parameter vector described above along with $\omega_{i,k} = 0$, $\forall i, k$ is used as a starting point to estimate dependencies between different regions. The Iterated Filtering algorithm is performed 100 times. As there

Parameter	Starting values	Min	Max	Mean	Std.	Median	25%-Quantile	75%-Quantile
μ_B	U(0; 0.01)	−0.048	0.4845	0.1436***	0.1073	0.138	0.0467	0.2175
a_0	U(0; 1)	0	5701.1179	11.9757***	162.2451	0.0656	0.0035	0.7225
a_1	U(−1; 1)	−21.8823	19.0543	−0.4804***	4.9222	−0.3089	−3.5627	2.6522
a_2	U(−1; 1)	−17.6773	16.4966	0.0688***	5.2092	0.0786	−3.2539	3.5217
a_3	U(−1; 1)	−16.7574	16.2802	−1.3328***	5.1004	−1.407	−4.8581	1.9386
a_4	U(−1; 1)	−18.4288	14.2373	−1.6141***	4.832	−1.7233	−4.7448	1.6113
b_0	U(0; 1)	0	1244.0863	3.6140***	45.538	0.0028	0.0001	0.0544
b_1	U(−1; 1)	−19.8978	17.9656	−1.6851***	5.3843	−1.4422	−5.1567	1.8142
b_2	U(−1; 1)	−18.9368	16.3412	−1.2240***	5.3914	−1.2228	−4.6627	2.4684
b_3	U(−1; 1)	−15.7788	14.0072	−0.4213***	4.8996	−0.3786	−3.7302	2.9093
b_4	U(−1; 1)	−20.4202	14.2985	−2.3290***	4.994	−2.4471	−5.6623	0.9278
c_0	U(0; 1)	0	256.604	0.8503***	9.3001	0.056	0.0011	0.4933
c_1	U(−1; 1)	−20.613	15.4185	−0.9446***	5.209	−0.9756	−4.2658	2.5447
c_2	U(−1; 1)	−21.0172	17.549	−1.3304***	5.155	−1.2898	−4.5564	2.1796
c_3	U(−1; 1)	−19.4739	17.5729	−0.0340***	4.9214	−0.1081	−3.2959	3.1625
c_4	U(−1; 1)	−21.9419	10.1632	−4.9443***	4.753	−4.9097	−7.8229	−2.0036
d_0	U(0; 1)	0	1229.8495	4.6200***	56.1177	0.1765	0.0181	0.6369
d_1	U(−1; 1)	−18.6083	26.2288	1.1069***	5.8314	0.9133	−2.8203	4.7567
d_2	U(−1; 1)	−18.3982	18.305	−0.652***	5.2332	−0.5952	−4.1475	2.7115
d_3	U(−1; 1)	−19.2549	22.7965	0.4222***	5.1507	0.3634	−2.8417	3.6781
d_4	U(−1; 1)	−18.8977	11.6279	−4.0278***	4.2121	−4.3557	−6.7781	−1.4783
e_0	U(0; 1)	0	3673.3285	9.8503***	113.7003	0.3061	0.0312	0.7815
e_1	U(−1; 1)	−18.0942	16.0386	−1.6741***	4.8261	−1.8034	−4.8131	1.5316
e_2	U(−1; 1)	−18.0664	19.5672	0.2969***	5.1675	0.362	−3.1509	3.6631
e_3	U(−1; 1)	−15.2089	17.7133	1.092***	4.8661	1.1946	−2.0059	4.2625
e_4	U(−1; 1)	−18.1969	14.7393	−1.309***	4.3014	−1.0416	−3.795	1.1859
τ_1	U(0; 0.1)	0	0.1269	0.0488***	0.0292	0.0476	0.0238	0.0731
τ_2	U(0; 0.1)	0	0.117	0.0488***	0.0288	0.0476	0.0236	0.0722
τ_3	U(0; 0.1)	0.0001	0.1239	0.0494***	0.03	0.0475	0.0237	0.0744
τ_4	U(0; 0.1)	0.0001	0.1182	0.0506***	0.0296	0.0502	0.0248	0.0755
τ_5	U(0; 0.1)	0	0.1206	0.0503***	0.0295	0.0491	0.0255	0.0749
μ	U(0; 1)	0	0.0109	0.0043***	0.0016	0.004	0.0033	0.0054
β	U(0; 1)	−0.2252	1.2045	0.5523***	0.3039	0.5706	0.2906	0.8119
ρ^S	U(0; 1)	0.0016	0.8521	0.1900***	0.1093	0.1829	0.1047	0.2601
ρ^I	U(0; 1)	0.0006	0.6281	0.1146***	0.0805	0.096	0.0517	0.1637
ρ^P	U(0; 1)	0.0157	0.7959	0.2055***	0.097	0.2004	0.1399	0.2612
ρ^D	U(0; 1)	0.0003	0.6017	0.1025***	0.0742	0.0876	0.0446	0.1455
Likelihood		−1538.2513	1769.6048	611.9083***	321.3004	516.8854	387.4436	773.8229
Residuals		6.135	63.0931	21.5549***	8.7291	19.6861	14.377	27.7738

Notes: Descriptive statistics of the parameter estimation without any contagion to or from other counties. The distribution of absolute residuals and log−likelihoods for each county are presented, too. The distribution of starting values for the Iterated Filtering algorithm are given, as well as the minimum, maximum, mean, standard deviation, median and the lower and upper quartile of the estimated parameters. $\mathcal{U}(0;1)$ describes a uniform distribution between 0 and 1. All parameters are described between equation (7) and equation (16). $p^* < 0.05$, $p^{**} < 0.01$ and $p^{***} < 0.001$ shows the significance level if the hypothesis that the mean of the parameter is equal to zero can be rejected

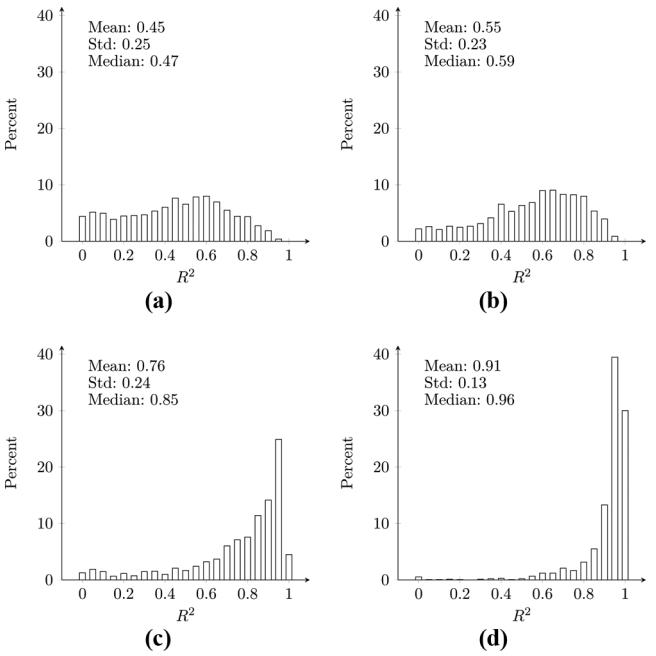
Table II. Descriptive statistics of parameter estimation

are 104,550 parameter values of $\omega_{i,k}$, $\forall i, k$ that are estimated, only some descriptive statistics are presented here. $\omega_{i,k}$ is distributed between $-3.2 \cdot 10^{-4}$ and $-3.2 \cdot 10^{-4}$ with a mean value of $1.43 \cdot 10^{-5}$, a standard deviation of $4.59 \cdot 10^{-3}$ and a median of $-9.14 \cdot 10^{-8}$. A complete list of all values is available upon request.

After the performance of the iterated filtering algorithm, the complete model is simulated 500 times with the optimal parameter vector and mean values per compartment, county and date are computed to get four time series per county; one for each compartment.

For every county and compartment, R^2values between simulated values and real data are computed to show the share of variability of each compartment explained by the proposed model. Figure 2 shows the histograms of all R^2values for each compartment and each county that consists of more than 50 mortgages due to our data. As we are interested in modelling the whole mortgage market and the influence both between the defined compartments within a county and the dependencies from other regions, we show the explained variability not only of defaulted mortgages. Fluctuations of mortgages that are paid on schedule and explained by the model can be seen in Figure 2(a) with a median value of 47 per cent. Our model explains more than 59 per cent of the variability of the share of delayed mortgages for 50 per cent of all observed counties as it is shown in Figure 2(b). The share of prepaid and defaulted mortgages is explained through R^2values with a median of 85 and 96 per cent, respectively. This can be seen in Figure 2(c)-(d).

We used four different approaches from previous studies that capture mortgage defaults to compare to the performance of the presented epidemiological model. For this purpose, we



Note: (a) Current mortgages; (b) delayed mortgages; (c) prepaid mortgages; (d) defaulted mortgages The figure shows the R^2 distribution of each county in the specific compartment. (a) the var paid on schedule explained by the proposed model; (b) the R^2 distribution of all delayed mortgages; and (c) and (d) explained variability of prepaid and defaulted mortgages, respectively

Figure 2.
Histogram of R^2 values

estimate all parameters for our model by use of the data till December 2012. Then we predict the behaviours of each county's four compartments and compare them to the real dynamics via R^2 and absolute residuals. The four concepts that we want to compare to our approach are as follows:

(1) Linear regression is used, for example, in Agarwal *et al.* (2009) and Beem (2014): we describe each of the four compartments through an equation with all variables defined in Section 4. Parameters are estimated due to the data until December 2012, and the compartments are predicted till December 2014 for each county individually.

(2) Linear regression of log-odds is used in Coleman *et al.* (2005), Misina *et al.* (2006) among others: we describe the log-odds for the default and prepaid compartment through an equation with all variables defined in Section 4. Parameters are estimated due to the data until December 2012 and the log-odds are predicted till December 2014 for each county.

(3) Multinomial logit model that is used in the study of Elul *et al.* (2010), Floros and White (2016): we describe the probability that a mortgage is prepaid, defaulted or right censored through a multinomial logit model with both all variables defined in Section 4 and individual loan characteristics such as the coupon rate, individual FICO-score, loan-to-value ratio and the unpaid balance at origination. Parameters are estimated due to all loans that are originated until December 2012 and a forecast is made for all loans originated after January 2013.

(4) Multinomial probit model that is used in Rebelo and Caldas (2010) and Rajan *et al.* (2015): we describe the probability that a mortgage is prepaid, defaulted or right censored through a multinomial probit model with both all variables defined in Section 4 and individual loan characteristics like the coupon rate, individual FICO-score, loan-to-value ratio and the unpaid balance at origination. Parameters are estimated due to all loans that are originated until December 2012 and a forecast is made for all loans originated after January 2013.

We define two prediction periods. The first period is 2013 and the second is both 2013 and 2014 to consider short-term and long-term forecast performance. We estimate the difference between R^2 values and absolute residuals of each compartment and each county of the four well-known models and our approach. Then, we test if the mean of the distribution is equal to zero.

First, we compare our model to a linear regression and show the results in Table III. When predicting the four compartments both one year and two years ahead the state of current and delayed mortgages are determined more precisely on average through a linear regression than the epidemiological approach. The linear regression shows averagely higher R^2 values and lower absolute residuals. Both the compartments of prepaid and defaulted mortgages and the forecast of all four compartments combined are predicted in greater detail through the epidemiological approach. The R^2 values are significantly higher and the differences between the absolute residuals are significantly lower compared to the linear regression model. These effects can be seen on short- and long-term forecasts.

Second, we compare our model to the linear regression of log Odds-ratio. Again, we predict the odds ratio one year and two years ahead and show the results in Table IV. Here, we do not compare the four compartments, but the amount of defaulted or prepaid mortgages in a specific period compared to the amount of active mortgages, called default-rate or prepaid-rate. As it can be seen, the epidemiological approach predicts the default-rate

Table III. Performance of epidemiological approach compared to linear regression

Compartment	Period	Difference	Mean	Median
Current	2013	R^2	−0.0136***	0.0044
Default	2013	R^2	0.3784***	0.3539
Delayed	2013	R^2	−0.0156***	0.0032
Prepaid	2013	R^2	0.3548***	0.3079
Current	2013 \ 2014	R^2	−0.1504***	−0.0898
Default	2013 \ 2014	R^2	0.4111***	0.3842
Delayed	2013 \ 2014	R^2	−0.1921***	−0.1217
Prepaid	2013 \ 2014	R^2	0.3772***	0.3327
Default	2013	Residuals	−0.5994***	−0.5096
Delayed	2013	Residuals	0.2067***	0.1464
Prepaid	2013	Residuals	−0.9196***	−0.8099
All	2013	Residuals	−1.0871***	−0.9638
Default	2013 \ 2014	Residuals	−1.5703***	−13.677
Delayed	2013 \ 2014	Residuals	0.3983***	0.3733
Prepaid	2013 \ 2014	Residuals	−2.2909***	−20.625
All	2013 \ 2014	Residuals	−3.0133***	−26.652

Notes: The distribution of the difference between $R^2$of predicted compartments between the epidemiological approach and the linear regression is estimated. Furthermore, the absolute residuals of the predicted compartments between the epidemiological approach and the linear regression is estimated, too. $p^* < 0.05$, $p^{**} < 0.01$ and $p^{***} < 0.001$ shows the significance level if the hypothesis that the mean of the difference is equal to zero can be rejected

Table IV. Performance of epidemiological approach compared to linear regression of log odds

Compartment	Period	Difference	Mean	Median
default-rate	2013	R^2	0.0166***	0.0011
prepaid-rate	2013	R^2	−0.0022***	0
default-rate	2013	Residuals	−0.2725***	−0.0039
prepaid-rate	2013	Residuals	−0.3873***	−0.0174
default-rate	2013 \ 2014	R^2	−0.0021***	0
prepaid-rate	2013 \ 2014	R^2	−0.0121***	−0.0009
default-rate	2013 \ 2014	Residuals	−0.6637***	−0.0126
prepaid-rate	2013 \ 2014	Residuals	−0.929***	−0.0504

Notes: The distribution of the difference between R^2 of predicted default-rates and prepaid-rates between the epidemiological approach and the linear regression of log odds is estimated. Furthermore the absolute residuals of the predicted default-rates and prepaid-rates between the epidemiological approach and the linear regression of log odds is estimated, too $p^* < 0.05$, $p^{**} < 0.01$ and $p^{***} < 0.001$ shows the significance level if the hypothesis that the mean of the difference is equal to zero can be rejected

and the prepaid-rate more precisely than the linear regression of log odds both at the one-year forecast and the two-year forecast. The absolute residuals from our approach are on average highly significant lower in both periods. If we compare the differences between the R^2 values of both models we can just show significantly higher values of the default-rates at the one-year forecast.

The multinomial logit and probit model both estimate the probability that a mortgage is prepaid, defaulted or is paid on schedule over the whole duration. To compare our approach to both models, we predict the probability of each individual mortgage in 2013 and 2014 and compare the average probability in each county with the quotient between the average

amount of defaulted or prepaid mortgages and the amount of active mortgages in the specific county. The results of the prediction accuracy between the logit, probit and the epidemiological approach is presented in Table V. As the logit and probit model do not do any statement when a mortgage defaults or is prepaid, we only compare our model to them over the long-term period of two years. The results show that both the default-rate and the prepaid-rate is described on average more precisely through our approach. R^2 values over all counties for default rates are 11.88 per cent estimated through the logit model and 21.92 per cent through the probit approach. Our model shows a R^2 of 35.97 per cent. Prepaid-rates show R^2 values of 0.13 and 0.18 for logit and probit models, respectively, compared to 0.05 per cent through our approach.

In Figures 3 and 4, the evolution of predicted and real values of delayed and defaulted mortgages are visualized. The two sample counties of Boulder County in Colorado and San Diego County in California are picked because both they predict defaulted mortgages above average if compared to other counties and sufficient mortgages were taken up within those counties according to our data. The real data from December 2012 are used as a starting point for the long-term prediction of two years.

In summary, it can be said, therefore, that our model explains an above average proportion of the variance of mortgage defaults than previous studies.

7. Conclusion

With our approach, we can, for the first time, model the spatial contagion effect of mortgage defaults using an epidemiological approach. We introduced the connection between compartments of disease models and the corresponding states in the mortgage market. With the concept of G-statistic as a measure of geographic occurrence of industrial sectors we introduce an approach to capture the dependencies of other local mortgage markets that are far away but economically similar.

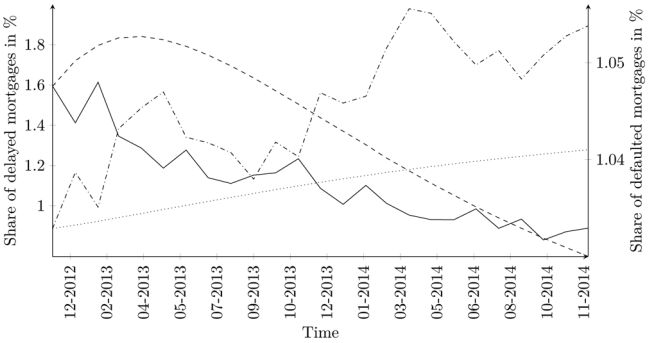
After origination, a mortgage contract is assumed to be paid on schedule and is therefore seen as healthy or susceptible. During its lifetime the payments can get delinquent due to macroeconomic conditions which is comparable to an infected person and, at worst, defaults (this means the infected person dies). Another opportunity for borrower is to prepay the mortgage either in a healthy or infected state. These loans leave the model like recovered people in an epidemic approach.

Furthermore, we estimate the parameter vector with a big dataset of more that 14 million loans originated between 2000 and 2014 using the iterated filtering algorithm and describe the performance of the simulated compartments. We showed that our approach predicts future default and prepayment rates more precisely than previous concepts such as linear regression, logit and probit models or linear regression of log odds.

Model	Compartment	Period	Difference	Mean	Median
logit	default-Rate	2013 \ 2014	Residuals	−0.1460***	−0.0121
probit	default-Rate	2013 \ 2014	Residuals	−0.0887***	−0.0551
logit	prepaid-Rate	2013 \ 2014	Residuals	−0.1734***	−0.0904
probit	prepaid-Rate	2013 \ 2014	Residuals	−0.2033***	−0.1131

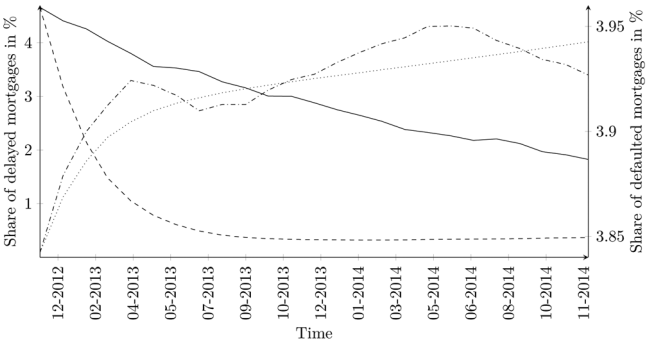
Notes: The distribution of the difference between the absolute residuals of the predicted default-rates and prepaid-rates between the epidemiological approach and the logit and probit model is estimated. $p^* < 0.05$, $p^{**} < 0.01$ and $p^{***} < 0.001$ shows the significance level if the hypothesis that the mean of the difference is equal to zero can be rejected

Table V. Performance of epidemiological approach compared to multinomial logit and probit model



Notes: The figure shows the predicted and real values of both delayed and defaulted share of mortgages in Boulder County (Colorado) between January 2013 and December 2014. Delayed mortgages are shown on the left y-axis while defaulted mortgages are shown on the right *y*-axis. The solid line describes the evolution of the real share of delayed mortgages and the dashed line shows the predicted values. The dash-dotted line displays the share of defaulted mortgages according to the data and the dotted line describes the predicted values

Figure 3.
Performance of predicted evolution in Boulder County (Colorado)



Notes: The Figure shows the predicted and real values of both delayed and defaulted share of mortgages in San Diego County (California) between January 2013 and December 2014. Delayed mortgages are shown on the left y-axis while defaulted mortgages are shown on the right *y*-axis. The solid line describes the evolution of the real share of delayed mortgages and the dashed line shows the predicted values. The dash-dotted line displays the share of defaulted mortgages according to the data and the dotted line describes the predicted values

Figure 4.
Performance of predicted evolution in San Diego County (California)

In summary, our new approach to estimate the dynamics of mortgage default rates and its spatial contagion effect even between local markets that are far apart is a new strategy that shows an above-average performance and support the idea of using more flexible concepts in the mortgage market.

Note

1. The data has been available online on the website of Federal Reserve Bank of St. Louis.

References

Agarwal, S., Amromin, G., Ben-david, I., Chomsisengphet, S. and Evanoff, D.D. (2009), "Do financial counseling mandates improve mortgage choice and performance? Evidence from a legislative experiment", Federal Reserve Bank of Chicago. Working Paper, available at: www.chicagofed.org/digital_assets/publicati. . .s/2009/wp2009_07.pdf.

Bajari, P., Chu, C., Nekipelov, D. and Park, M. (2013), "A dynamic model of subprime mortgage default: estimation and policy implications", Working Paper, National Bureau of Economic Research.

Beem, R.H. Jr (2014), "Residential mortgage delinquency rates: the determinants of default", *Issues in Political Economy*, Vol. 23, pp. 59-75.

Bertuzzo, E., Casagrandi, R., Gatto, M., Rodriguez-Iturbe, I. and Rinaldo, A. (2010), "On spatially explicit models of cholera epidemics", *Journal of the Royal Society Interface/the Royal Society*, Vol. 7 No. 43, pp. 321-333.

Bloomberg, L.P. (2015), "Mortgage loan level data", *Bloomberg Database*, Karlsruher Institut für Technologie (KIT) – Lehrstuhl für Financial Engineering und Derivate.

Brauer, F.P., Driessche, V.D. and Wu, J. (2008), "Mathematical epidemiology", *Vol. 1945 of Lecture Notes in Mathematics*, Heidelberg: Springer Berlin Heidelberg, Berlin.

Britton, T. (2010), "Stochastic epidemic models: a survey", *Mathematical Biosciences*, Vol. 225 No. 1, pp. 24-35.

Burnside, C., Eichenbaum, M. and Rebelo, S. (2016), "Understanding booms and busts in housing markets", *Journal of Political Economy*, Vol. 124.

Chan, S., Gedal, M., Been, V. and Haughwout, A. (2013), "The role of neighborhood characteristics in mortgage default risk: evidence from New York city", *Journal of Housing Economics*, Vol. 22 No. 2, pp. 100-118.

Coleman, A., Esho, N., Sellathurai, I. and Thavabalan, I. (2005), "Stress testing housing loan portfolios: a regulatory case study", Australian Prudential Regulation Authority Working Paper.

Cowan, A.M. and Cowan, C.D. (2004), "Default correlation: an empirical investigation of a subprime lender", *Journal of Banking and Finance*, Vol. 28 No. 4, pp. 753-771.

Cox, D. (1972), "Regression models and life-tables", *Journal of the Royal Statistical Society. Series B*, Vol. 3, pp. 187-220.

Cressie, N. (1992), "Statistics for spatial data", *Terra Nova*, Vol. 4 No. 5, pp. 613-617.

Danis, M.a. and Pennington-Cross, A. (2008), "The delinquency of subprime mortgages", *Journal of Economics and Business*, Vol. 60 Nos 1/2, pp. 67-90.

Delgado, M.M., Porter, E. and Stern, S. (2016), "Defining clusters of related industries", *Journal of Economic Geography*, Vol. 16 No. 1, pp. 1-38.

Deng, Y., Quigley, J.M., Van Order, R. and Mac, F. (1996), "Mortgage default and low downpayment loans: the costs of public subsidy", *Regional Science and Urban Economics*, Vol. 26 Nos 3/4, pp. 263-285.

Divino, J.A. and Rocha, L.C.S. (2013), "Probability of default in collateralized credit operations", *The North American Journal of Economics and Finance*, Vol. 25, pp. 276-292.

Duffie, D., Eckner, A., Horel, G. and Saita, L. (2009), "Frailty correlated default", *The Journal of Finance*, Vol. 64 No. 5, pp. 2089-2123.

Elandt-Johnson, R.C. and Johnson, N.L. (1999), *Survival Models and Data Analysis*, John Wiley and Sons, Hoboken, New Jersey.

Ellison, G.E., Glaeser, L. and Kerr, W. (2007), "What causes industry agglomeration? Evidence from coagglomeration patterns", Working Paper, National Bureau of Economic Research.

Elul, R., Souleles, N. and Chomsisengphet, S. (2010), "What triggers mortgage default?", *American Economic Review*, p. 100.

Fannie, M. (2015), "Loan performance data", available at: https://loanperformancedata.fanniemae.com/lppub/index.html

Feser, E., Sweeney, S. and Renski, H. (2005), "A descriptive analysis of discrete US Industrial complexes*", *Journal of Regional Science*, Vol. 45 No. 2, pp. 395-419.

Floros, I. and White, J.T. (2016), "Qualified residential mortgages and default risk", *Journal of Banking and Finance*, Vol. 70, pp. 86-104.

Freddie, M. (2015), "Loan-Level dataset", available at: https://freddiemac.embs.com/FLoan/Data/download.php

Freddie, M. (2016), "Mortgage rates survey archive", available at: www.freddiemac.com/pmms/pmms_archives.html

Goodstein, R.P., Hanouna, E.C., Ramirez, D. and Stahel, C.W. (2011), "Are foreclosures contagious?", *SSRN Electronic Journal*.

Grubesic, T.H. (2008), "Zip codes and spatial analysis: problems and prospects", *Socio-Economic Planning Sciences*, Vol. 42 No. 2, pp. 129-149.

Hillebrand, E.A., Sengupta, N. and Xu, J. (2012), "Temporal correlation of defaults in subprime securitization", *Communications on Stochastic Analysis*, Vol. 6, pp. 487-511.

Ionides, E., Bretó, C. and King, A. (2006), ""Inference for nonlinear dynamical systems", *Proceedings of The National Academy of Sciences of the USA*, Vol. 103, pp. 18438-18443.

Ionides, E.L., Bhadra, A., Atchadé, Y. and King, A. (2011), "Iterated filtering", *The Annals of Statistics*, Vol. 39 No. 3, pp. 1776-1802.

Kalbfleisch, J.D. and Prentice, R.L. (2011), *The Statistical Analysis of Failure Time Data*, John Wiley and Sons, Hoboken, New Jersey.

Keeling, M.J. and Eames, K.T.D. (2005), "Networks and epidemic models", *Journal of the Royal Society, Interface*, Vol. 2 No. 4, pp. 295-307.

Kermack, W.O. and McKendrick, A.G. (1927), "A contribution to the mathematical theory of epidemics", *Proceedings of the Royal Society A: Mathematical. Physical and Engineering Sciences*, Vol. 115 No. 772, pp. 700-721.

Lawless, J. (2011), *Statistical Models and Methods for Lifetime Data*, 2nd ed., John Wiley and Sons, Hoboken. NJ..

Matthews, L. and Woolhouse, M. (2005), "New approaches to quantifying the spread of infection", *Nature Reviews. Microbiology*, Vol. 3 No. 7, pp. 529-536.

Merriam-Webster (2016), "County", available at: www.merriam-webster.com/dictionary/counties.

Misina, M., Tessier, D. and Dey, S. (2006), "Stress testing the corporate loans portfolio of the canadian banking sector", Bank of Canada, Working Paper, pp. 2006-2047.

Piazzesi, M. and Schneider, M. (2009), "Momentum traders in the housing market: survey evidence and a search model", *American Economic Review P&P*, Vol. 99 No. 2, pp. 406-411.

Quercia, R.G. and Stegman, M.A. (1992), "Residential mortgage default: a review of the literature *", *Journal of Housing Research*, Vol. 3, pp. 341-380.

Rajan, U., Seru, A. and Vig, V. (2015), "The failure of models that predict failure: distance. incentives. and defaults", *Journal of Financial Economics*, Vol. 115 No. 2, pp. 237-260.

Rebelo, J. and Caldas, J.V. (2010), "Default mortgage profile: a micro analysis of the portuguese case", *Portugese Journal of Management Studies. XV*, Vol. 109 No. 126.

Shumway, R.H. and Stoffer, D.S. (2011), *Time Series Analysis and Its Applications with R Examples*, 3rd ed., Springer-Verlag, New York, NY.

US. Bureau of Labor Statistics (2015), "Unemployment in states and local areas (all other areas)", available at: https://fred.stlouisfed.org/tags/series?ob=pv&od=desc&t=county%3Bmonthly%3Bunemployment

U.S. Census Bureau (2010), "County adjacency file", available at: www.census.gov/geo/reference/county-adjacency.html

Weiler, S. (2001), "Unemployment in regional labor markets: using structural theories to understand local jobless rates in West Virginia", *Industrial and Labor Relations Review*, Vol. 54 No. 3, pp. 573-592.

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Externalities of home-ownership on entrepreneurship: empirical evidence

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Abstract

Purpose – This study aims to examine the externalities from regional home-ownership to individual-level entrepreneurship.

Design/methodology/approach – The paper links individual-level data from the Finnish Income Distribution Statistics for years 1990-1992 to regional home-ownership proportions. Probit models of entrepreneurship with regional home-ownership and appropriate control variables as regressors are estimated. A rental housing market deregulation experiment which caused exogenous variation in regions' home-ownership is exploited to identify the causal effects on entrepreneurship.

Findings – Results show that higher home-ownership in a region leads to greater entrepreneurship. Further analyses together with the fact that homeownership tends to have detrimental labour market effects suggest that homeownership encourages entrepreneurship by leading to less paid work opportunities. These results are in line with those of earlier literature that self-employment and entrepreneurship, especially during bad economic times, are partly motivated by bad employment opportunities.

Originality/value – This study presents novel results on the externalities that home-ownership has on entrepreneurship. These externalities are shown to be important enough that they need to be considered when assessing the economic effects of various policies that affect the prevalence of owner-occupied housing. The instrumental variables' estimates are the first causal estimates in the literature and the bias resulting from assuming exogeneity is shown to be nonnegligible.

Keywords Self-employment, Externalities, Entrepreneurship, Home-ownership, Housing system reforms, Instrumental variables estimation

Paper type Research paper

1. Introduction

Home-ownership is associated with greater self-employment and entrepreneurship[1]. This positive relationship has been found at the individual and regional levels. The most common explanation for the positive relationship between home-ownership and entrepreneurship is that home equity serves as collateral and, therefore, facilitates owners' business activities. Indeed, the results from some studies point to the role of financing possibilities to home-owners created by the amount of home equity and house price increases.

Although home equity may be behind both the individual and regional relationship, another regional-level transmission mechanism is suggested by the empirical results on the labour market effects of home-ownership. Namely, starting from the contribution by Oswald (1996), higher regional home-ownership has been shown to be associated with, and actually

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cause, worse labour market conditions. Recently, it has been argued that home-owners themselves are not necessarily the most important group the labour market possibilities of which are worsened by the higher regional home-ownership. Instead, the effects of home-ownership may work through externalities on the regional labour market. Such adverse externalities may affect entrepreneurship and unemployment. The sign of this effect is of interest because earlier studies have produced mixed results on how labour market conditions interact with entrepreneurship. The recent study of Svaleryd (2015) includes a review of results on the literature and a discussion of how the push effect of adverse labour market conditions encourages necessity entrepreneurship and how, in turn, the pull effect discourages opportunity entrepreneurship. The sign of the net effect of local labour market conditions, of course, depends on which of the two effects dominates. The effect of regional home-ownership on entrepreneurship through the labour market externalities likewise depends on the magnitude of the two effects that the externalities create.

This study examines the effects of home-ownership on self-employment and entrepreneurship. The focus is on the externalities of home-ownership, or the effects on others than the home-owners themselves. Finnish rental market deregulation reform in the early 1990s created exogenous variation in home-ownership rates between regions so that region-level externalities can be reliably estimated. As a by-product, estimates of the direct effects of personal home-ownership on home-owners themselves are produced. Moreover, the individual-level data used include information indicating whether the individuals have mortgage loans. Estimates on the relationship between a mortgage and entrepreneurship are also produced.

The results are in line with what is expected based on hypotheses and earlier empirical results. In a nutshell, home-owners are more likely to experience periods of self-employment and entrepreneurship, on top of which others' home-ownership further increases self-employment and entrepreneurship. However, having a mortgage is associated with less entrepreneurship. Because both the individual-level effect and the externality are positive, earlier studies have unsurprisingly found a positive relationship between home-ownership and self-employment and entrepreneurship regardless of whether the analysis is conducted at the regional or individual level. The externalities can be argued to be caused by the negative labour market effects of regional home-ownership; as a result, given scarce paid work opportunities, people rely on self-employment and entrepreneurship. This argument is corroborated by the results from additional analyses showing that regional home-ownership increases the probability of experiencing entrepreneurship associated with relatively low income levels. However, it should be noted that home-ownership-induced entrepreneurship may yield higher returns in longer run and when compared to the generally relatively low incomes of entrepreneurs.

The rest of the paper is organised as follows. Section 2 presents the relevant background literature and theoretical ides. The data are introduced and the empirical strategy is explained in Section 3. The main results and the results on which types of entrepreneurship are affected are presented in Section 4 and the robustness of the results is assessed. Finally, Section 5 concludes.

2. Background and literature

Most individual-level studies regressing entrepreneurship on a set of personal characteristics that include a home-ownership variable report a positive association between home-ownership and entrepreneurship. Examples of such analyses include those of Bernhardt (1994) for Canada, Johansson (2000a) and Tervo (2006) for Finland, Brown *et al.* (2006) for the UK, Skriabikova *et al.* (2014) for Ukraine and East Germany and Fairlie (2013) and Harding and Rosenthal (2017) for the US. Regional-level association has been studied and found to be

positive by, for example, Fotopoulos (2013) for the UK and Lisi (2017) for Italy. Blanchflower and Oswald (2013), in turn, report that less business formation occurs in US states with higher home-ownership rates.

The positive association has been argued to be due to the fact that home-owners are able to use their homes as collateral to get funds for business activities. Indeed, Fairlie (2013) shows that, in the USA, home values are positively associated with entrepreneurship. Harding and Rosenthal (2017) look at the effects of housing capital gains on self-employment and find them to be positive. Having a mortgage loan probably decreases the possibilities to use home as collateral. Bracke *et al.* (2018) examine the effect of mortgage debt on entrepreneurship and find that the effect is negative. It is to be noted, however, that there are reverse-causality reasons for why the statistical association between mortgage debt and entrepreneurship is negative. First, entrepreneurs, like the rich, tend to save more and accrue more wealth than others, one reason being that they often need to self-finance their businesses (Carroll, 2000; Carroll, 2002; Quadrini, 1999; Quadrini, 2000). Second, and relatedly, entrepreneurs may find it hard to obtain credit due to their volatile incomes. For these reasons, entrepreneurs are less likely than others to have mortgage loans[2].

The literature on the labour market effects of home-ownership starting from Oswald's (1996) contribution offers another potential explanation for the relationship between home-ownership and entrepreneurship. It has been found that unemployment is higher in the regions with higher home-ownership. The most recent papers on such effects are those by Blanchflower and Oswald (2013) for the USA, Isebaert *et al.* (2015) for Belgium, Wolf and Caruana-Galizia (2015) for Germany and Laamanen (2017) for Finland. Various studies examining the relationship between individual-level home-ownership and unemployment have found that home-owners are more successful than others in avoiding unemployment (Flatau *et al.*, 2003; Munch *et al.*, 2006; Van Leuvensteijn and Koning, 2004; Munch *et al.*, 2008; Coulson and Fisher, 2009). It has been speculated that home-owners are relatively active in (local) job search and have low reservation wages because they are reluctant to move to other regions and because they need to meet mortgage payments (Flatau *et al.*, 2003; Munch *et al.*, 2006; Laamanen, 2017). Because the positive regional-level association between home-ownership and unemployment cannot be explained by the individual-level result, some of the recent studies argue that home-ownership affects labour markets through externalities (Isebaert *et al.*, 2015) and others present evidence for these externalities (Blanchflower and Oswald, 2013; Laamanen, 2017). The transmission mechanisms behind the labour market effects of home-ownership beyond the direct effects on owners themselves are not very well known. Oswald (1996) and Blanchflower and Oswald (2013) present the well-known hypothesis about lesser labour mobility but also disuss other possible transmission mechanisms: NIMBYism and changes in risk preferences associated with home-buying. Laamanen (2017) argues that mortgage loan payments encourage labour supply and discourage consumption at the individual level, and that these changes lead to displacement effects and less demand for labour at the regional level. He also presents evidence supporting these claims.

It is unlikely that entrepreneurship is unaffected by the abovementioned impacts of home-ownership on labour market behaviour and outcomes. Indeed, some recent studies have focussed on the effects of negative labour market changes and found that entrepreneurship is positively associated with increases in unemployment at the regional level (Fairlie, 2013) and recent job loss at the individual level (von Greiff, 2009; Røed and Skogstrøm, 2014). Focussing on spin-off entrepreneurship, Eriksson and Kuhn (2006) find that "push spin-offs", businesses created by employees of a workplace which ceases operation, is a counter-cyclical phenomenon.

Interestingly, Berglann *et al.* (2011) find that entering entrepreneurship depends positively on personal unemployment but negatively on the local unemployment rate.

By bringing together the above ideas and empirical results, hypotheses on the individual-level and regional-level home-ownership–entrepreneurship associations can be formulated. At the level of individuals and households, the association is predicted to be unambiguously positive. A home serves as collateral for business loans and home-owners, unwilling to move to other regions, resort to entrepreneurship when faced with bad job opportunities. Having a mortgage likely limits the use of collateral but amplifies the positive job search/labour supply effect. Because of these two reasons, and because entrepreneurs are less likely to take up mortgages, the statistical association between a mortgage and entrepreneurship is ambiguous. The regional-level relationship between home-ownership and entrepreneurship includes the abovementioned individual-level relationship and the externalities. Based on earlier research, it is clear that home-ownerships' externalities on regional labour markets are negative. How the negative labour market externalities affect entrepreneurship is not self-evident although most of the results listed above suggest that worse labour market conditions encourage entrepreneurship. Thus, it is important to empirically examine the individual-level associations and related causal effects, and the externalities. This study specifically focuses on the externalities because an identification strategy for estimating causal external effects is available.

3. Data and empirical strategy

The individual-level data on self-employment, entrepreneurship and the background controls come from the service files of the annual Income Distribution Statistics (IDS) for years 1990-1992. The IDS includes a large set of variables based on information from different registers, including tax records, and survey answers. Importantly, the IDS includes two alternative sources of information on whether an individual is self-employed or an entrepreneur. First, one survey question asked about self-employment/entrepreneurship experience during the year. Second, register-based socio-economic status information is available. Both of these variables are used in the analyses to demonstrate the robustness of the results and to estimate the effects separately on small and large businesses.

The microdata are linked to county-level home-ownership proportions calculated from population registers using information on county of residence included in the IDS. Estimate both the direct effect of an individual's housing tenure and the indirect externality from regional home-ownership is therefore possible. Information on the county of residence is also crucial because the rental housing market deregulation experiment was implemented in selected counties only, as described below in more detail.

All models to be estimated are probit models of the following type:

$$E^*_{ijt} = \alpha hor_{jt} + \beta' X_{ijt} + \gamma_j + \delta_t + \epsilon_{ijt}, \tag{1}$$

and

$$E_{ijt} = \begin{cases} 1, & if\, E^*_{ijt} > 0. \\ 0, & otherwise. \end{cases},$$

where E_{ijt} is an indicator variable for whether individual i residing in county j was self-employed or an entrepreneur during year t. Variable hor_{jt} is the proportion of home-ownership in county j in year t. Vector X is the vector of individual-level control variables. The control

variables are mortgage dummy, home-ownership dummy, real wealth (in 1992 FIM), real wealth squared, real wealth cubed, gender, age (years plus months/12), age squared, age cubed, marital status (six categories), household size, number of children, education (seven categories) and the type of the municipality of residence (four categories). The home-owners who claim the mortgage interest deduction in year t are inferred to have a mortgage loan in that year because information on mortgages is not, as such, included in the data. γ_j and δ_t are the county and year fixed-effects, respectively. Finally, the individual-level error term is ϵ_{ijt}.

We estimate model (1) by using the sample of non-institutionalised individuals aged 15-69. The age 15 is chosen because it is the minimum legal working age in Finland. The age 69 is the upper limit of the age range because although the retirement age is lower than this, some individuals in the data are either in paid work or are self-employed or entrepreneurs in later ages. Moreover, Zissimopoulos and Karoly (2007) argue that older individuals are an important group both being in and entering self-employment. The descriptive statistics on the variables used in the estimations for the sample are presented in Table I.

The main parameter of interest, α, may be biased because of endogeneity or omitted variable problems. These problems are caused because the changes in regions' self-employment and entrepreneurship may affect the prevalence of home-ownership, or some factors which cannot be controlled for may affect both self-employment/entrepreneurship and home-ownership. A Finnish policy experiment in the early 1990s is used to construct instrumental variables for identifying the causal effect of regional home-ownership. The experiment used is the first, regional phase of the Finnish rental housing market deregulation. The experiment was the first phase of the process in which the rental market in the entire country was deregulated by the mid-1990s. The new rental market legislation removed rent ceilings and exact limits on rent increases. Evictions without landlords specifying their grounds were made easier as well. The opposition had worries that the new law would have an increasing effect on rents. As a result, the government decided to deregulate the markets in parts of the country where, as phrased in the associated committee report, "demand and supply of rental housing are in approximate balance" first. On the basis of the presumption that the markets were closer to balance in the northern and central parts of the country, counties excluding the south were chosen as the experiment region. More specifically, the markets in the seven northernmost and central counties were deregulated, with the exception of the university cities, and the six southern counties were not. About one-third of all homes in the country were situated in the experiment regions. The experiment started in the beginning of 1991, when new (completed) apartments and houses were made free from the regulations. In the second phase, effective 1 February 1992 in the entire country, all new contracts for private rental dwellings were deregulated. Because the first phase of the deregulation treated different regions differently during the 13-month period between 1 January 1991 and 1 February 1992, identifying variation in home-ownership between regions was created. The mechanism through which the experiment affected home-ownership rates is the change in landlords' behaviour as their activities became more profitable in the experiment counties. Rents could now be increased and non-profitable contracts could be terminated. As will be seen from the first-stage results of the instrumental variables analyses, the experiment indeed led to decreases in home-ownership in the experiment counties compared with the excluded counties. More information on the effects of the reform on home-ownership rates and a more detailed description of the experiment can be found in Laamanen (2017).

Four instrumental variables are constructed using the experiment. First, note that the experiment had potentially different effects on home-ownership in 1991 and 1992. This is

Variable	Mean	St. dev.	Min	Max
Dependent variables				
Entrepreneur (self-reported)	0.164	0.370	0	1
in the 1st income quarter of the population	0.040	0.196	0	1
in the 2nd income quarter of the population	0.043	0.203	0	1
in the 3rd income quarter of the population	0.031	0.172	0	1
in the 4th income quarter of the population	0.050	0.218	0	1
in the 1st income quarter of those with employment experience	0.064	0.245	0	1
in the 2nd income quarter of those with employment experience	0.033	0.177	0	1
in the 3rd income quarter of those with employment experience	0.025	0.156	0	1
in the 4th income quarter of those with employment experience	0.042	0.201	0	1
Entrepreneur (socio-economic classification)	0.145	0.352	0	1
no employees	0.109	0.311	0	1
employees	0.036	0.186	0	1
in the 1st income quarter of the population	0.041	0.197	0	1
in the 2nd income quarter of the population	0.041	0.197	0	1
in the 3rd income quarter of the population	0.026	0.158	0	1
in the 4th income quarter of the population	0.038	0.191	0	1
in the 1st income quarter of those with employment experience	0.064	0.244	0	1
in the 2nd income quarter of those with employment experience	0.029	0.168	0	1
in the 3rd income quarter of those with employment experience	0.020	0.140	0	1
in the 4th income quarter of those with employment experience	0.032	0.176	0	1
Explanatory variables				
County home-ownership rate	0.668	0.035	0.603	0.718
Owner with mortgage	0.212	0.409	0	1
Owner	0.806	0.395	0	1
Real (1992 FIM) wealth in 100,000	1.202	2.367	0	90.390
Male	0.506	0.500	0	1
Age (year-end)	40.925	14.61	16	69.917
Marital status				
Single	0.295	0.456	0	1
Married	0.592	0.491	0	1
Separated	0.003	0.052	0	1
Widow	0.040	0.196	0	1
Divorced	0.028	0.166	0	1
Unknown	0.042	0.200	0	1
Household size	3.208	1.434	1	16
Number of children	0.861	1.179	0	13
Education				
Basic or no degree	0.435	0.496	0	1
Lower secondary	0.253	0.435	0	1
Higher secondary	0.189	0.391	0	1
Vocational college	0.045	0.208	0	1
Lower university	0.024	0.153	0	1
Higher University	0.048	0.213	0	1
Graduate school	0.006	0.077	0	1
Type of municipality				
Capital region	0.140	0.347	0	1
Urban	0.378	0.485	0	1
Semi-urban	0.166	0.372	0	1
Rural	0.316	0.465	0	1

Table I. Descriptive statistics

because of the different legislation in the experiment counties and in the excluded counties for the entire 1991, but in 1992, the two groups of counties had a different legislation for one month only. Because of this, and because the legislation might have taken some time to take effect, differential effects in the two years are allowed for. Another source of effect heterogeneity is that the experiment treated the six counties with universities differently than the one county without. Therefore, differential effects in these two types of counties are allowed for. Let us first construct four dummies to allow for the two dimensions described above:

(1) Dummy $a = 1$ in 1991 for the county fully exposed (and 0 otherwise)
(2) Dummy $b = 1$ in 1992 for the county fully exposed (and 0 otherwise)
(3) Dummy $c = 1$ in 1991 for the counties partly exposed (and 0 otherwise)
(4) Dummy $d = 1$ in 1992 for the counties partly exposed (and 0 otherwise)

It would be possible to use these dummies as the excluded instruments, in which case the first-stage would be a difference-in-differences model with two treatment groups and differential effects in the two different years. But only new housing units were deregulated in the experiment, so the strength of the instruments can be increased by interacting each dummy a, b, c, and d with the share of deregulated multifamily dwellings in the county in question. This is done, and the resulting instrumental variables used in the analyses are denoted by A, B, C and D. Multifamily houses instead of all dwellings are used to further increase the strength of the instruments. This is done because single-family houses are almost always owner-occupied and, therefore, irrelevant from the point of view of the experiment and its effects. The measure of the home-ownership proportion is the average of the previous year-end value and the coming year-end value. Thus, an approximation of the number of dwellings completed by the midyear of 1991 is preferable. We use half the number of dwellings completed in 1991 and dwellings completed in January 1992 for the instruments of 1991 and 1992, respectively[3].

4. Results

4.1 Home-ownership and entrepreneurship

The results from estimating model (1) by using the two alternative dependent variables are presented in Table II. In the two leftmost columns, the exogeneity of regional home-ownership is assumed. In the two other columns, the instrumental variables are used to deal with endogeneity. The first thing that can be observed is that the results from the four models are very similar, especially when it comes to the individual-level variables. The estimated effect of regional home-ownership is positive and significant in all models. The coefficient of the county-level home-ownership proportion is higher when the exogeneity assumption is abandoned. This difference suggests that assuming exogeneity leads to downward-biased effect estimates. The results of the Wald tests of exogeneity not presented here suggest that the biases are not negligible. A potential explanation for the direction of the bias is based on how labour market conditions, home-ownership and self-employment/entrepreneurship interact: self-employment and entrepre-neurship are higher when the labour market conditions are worse. In such a situation, the ability of individuals and households to buy homes (and maintain ownership) is decreased because incomes are low. Therefore, changes in labour market conditions other than those caused by home-ownership itself drive self-employment and entrepreneurship up and home-ownership down. Such relationships contaminate the parameter estimates of the two leftmost columns of Table II. The first-stage results show that the signs of the coefficients of the excluded instruments are negative, as expected based on the discussion in the previous section. Furthermore, the instrument set works well in the sense that comparing the F-statistic on the

Entrepreneurship variable Method	Self-reported Probit	Socio-economic Probit	Self-reported IV Probit	Socio-economic IV Probit
Regional home-ownership				
County home-ownership	2.51** (1.10)	2.75*** (0.83)	6.37** (2.48)	5.50*** (1.92)
Personal characteristics				
Mortgage	−0.057*** (0.004)	−0.060***(0.004)	−0.057*** (0.004)	−0.060*** (0.004)
Owner	0.024*** (0.006)	0.027*** (0.006)	0.024*** (0.006)	0.027*** (0.007)
Real wealth	0.044*** (0.002)	0.034*** (0.001)	0.044*** (0.002)	0.034*** (0.001)
Real wealth^2	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)
Real wealth^3	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Male	0.039*** (0.004)	0.029*** (0.003)	0.039*** (0.004)	0.029*** (0.003)
Age	0.045*** (0.003)	0.035*** (0.002)	0.045*** (0.003)	0.035*** (0.003)
Age^2	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)	−0.001*** (0.000)
Age^3	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Marital status				
Single	−0.013 (0.012)	−0.010 (0.011)	−0.012 (0.012)	−0.009 (0.011)
Married	−0.007 (0.007)	−0.002 (0.007)	−0.007 (0.007)	−0.002 (0.007)
Separated	−0.004 (0.006)	−0.002 (0.007)	−0.003 (0.006)	−0.002 (0.007)
Divorced	0.015 (0.026)	−0.011 (0.029)	0.015 (0.026)	−0.011 (0.029)
Unknown	−0.010 (0.014)	−0.003 (0.010)	−0.009 (0.014)	−0.003 (0.010)
Household size	0.015*** (0.002)	0.017*** (0.002)	0.015*** (0.002)	0.017*** (0.002)
Number of children	−0.014*** (0.002)	−0.015*** (0.002)	−0.014*** (0.002)	−0.015*** (0.002)
Education				
Lower secondary	−0.006* (0.003)	−0.008** (0.003)	−0.006* (0.003)	−0.008** (0.003)
Higher secondary	−0.030*** (0.004)	−0.034*** (0.004)	−0.030*** (0.004)	−0.034*** (0.004)
Vocational college	−0.034*** (0.008)	−0.043*** (0.007)	−0.034*** (0.008)	−0.043*** (0.007)
Lower university	−0.064*** (0.012)	−0.056*** (0.010)	−0.065*** (0.012)	−0.056*** (0.010)
Higher university	−0.024** (0.009)	−0.057*** (0.011)	−0.024** (0.009)	−0.057*** (0.011)
Graduate school	0.020 (0.018)	−0.049** (0.019)	0.019 (0.018)	−0.050** (0.019)
Type of municipality				
Capital region	−0.068*** (0.004)	−0.049*** (0.004)	−0.068*** (0.004)	−0.049*** (0.004)
Urban	−0.070*** (0.004)	−0.059*** (0.003)	−0.070*** (0.004)	−0.059*** (0.003)
Semi-urban	−0.038*** (0.007)	−0.032*** (0.005)	−0.038*** (0.007)	−0.032*** (0.005)
First-stage results: Excluded instruments				
Instrument *A*			−0.157*** (0.002)	−0.157*** (0.002)
Instrument *B*			−0.542*** (0.008)	−0.542*** (0.008)
Instrument *C*			−0.177*** (0.001)	−0.177*** (0.001)
Instrument *D*			−0.463*** (0.005)	−0.463*** (0.005)
F-statistic			26.38***	26.38***

Notes: Marginal effects calculated at sample means from population-weighted regressions including county dummies and year dummies. N = 32,110. Robust clustered (county-year) standard errors in parentheses. *, ** and *** denote significance at 10, 5 and 1 per cent levels, respectively. The omitted category is widowed females with a basic or no degree residing in a rural region

Table II. Models of entrepreneurship

excluded instruments with the critical values in Stock and Yogo (2002) suggests small second-stage bias and test size distortion.

Let us turn next to the results on the direct effects of individual-level home-ownership on self-employment and entrepreneurship. One should bear in mind that these results are associations and do not necessarily reflect causal effects. In line with most results in the

earlier literature, home-owners are more likely to be self-employed and entrepreneurs. This result is also in line with the discussion in Section 2 according to which home-owners more often have the needed collateral and resort to entrepreneurship to avoid following jobs to other regions. The positive association between home-ownership and entrepreneurship is more than offset by having a mortgage loan. Notice, however, that this is conditional on total wealth. Therefore, the correct interpretation of the results is that, first, individuals who own their homes are more likely to be entrepreneurs than individuals who do not own their home but, instead, have a corresponding amount of non-housing wealth. Second, home-owners with mortgage are less likely to be entrepreneurs than both outright owners and non-owners who have a corresponding amount of non-housing wealth. A possible interpretation of these results is that home equity serves as an important source of financing for those engaging in business activities. Having a mortgage means that the home-owner has less net wealth to base financing on. The positive association between having a mortgage and entrepreneurship can be partly because of reverse causality, that is, entrepreneurs have more savings and a more limited access to credit and are, therefore, less likely to take up a mortgage (Section 2). Harding and Rosenthal (2017) also find that there is a negative association between having a mortgage and being self-employed in the USA. They argue that this association should be positive if mortgages were used extensively to finance self-employment. However, they find such a positive relationship between entrepreneurship and a specific type of mortgage loan which allows for easy access to home equity. The results presented in Table II of this study suggest that research on the effect of home-ownership should try to control for other wealth as well as having a mortgage rather than just the housing tenure status. When it comes to the effect of wealth itself, the marginal effect is positive but declining for almost all sample individuals.

The results on the other control variables are mostly in line with what has been found in earlier studies. Males are more likely to be entrepreneurs than females. The entrepreneurship probability increases rather rapidly with age until about age 40, after which it starts to decline. The decline is not as fast as the increase so that the oldest individuals in our sample are as likely to engage in entrepreneurship as the 20-year olds. No statistically significant differences exist between different marital statuses. Family size has a positive association and the number of children a negative association with the probability of entrepreneurship. Most Finnish families are nuclear families, so this result comes mostly from having a spouse having a positive association and children having a negative association with entrepreneurship. Education has a negative association with entrepreneurship but, interestingly, those having a higher university degree or a graduate school degree report experiencing entrepreneurship more than some of the less-educated groups; however, most of this is not reflected in their socio-economic classification. The final result is that those living in urban areas are significantly less engaged in entrepreneurial activities than those living in rural areas. Such urban-rural difference in the prevalence of self-employment and entrepreneurship in Finland has been noticed by earlier studies, e.g. Haapanen and Tervo (2009). The estimates of the year fixed effects (not presented here) show a significant increase in entrepreneurship over time, especially from the year 1991 to the year 1992, conditional on the covariates.

4.2 Different types of entrepreneurship

It needs to be acknowledged that large-scale entrepreneurial activities may differ markedly from self-employment and entrepreneurship without employees. The motives behind activities of different scale can be different and, therefore, the impacts of home-ownership may also differ. In the IDS, those whose socio-economic classification is entrepreneurs are

further classified as entrepreneurs with and without employees. The results from estimating model (1) with entrepreneurship without employees and entrepreneurship with employees as the dependent variables are presented in the first and second columns of Table III, respectively. The results presented in Table II for the entrepreneurship-encouraging effect of home-ownership mostly come from the effect on entrepreneurship without employees. In additional analyses not presented here, it was noticed that the effect on entrepreneurs who

Entrepreneurship variable Method	Socio-economic, no employees IV Probit	Socio-economic, employees IV Probit
Regional home-ownership		
County home-ownership	3.72*** (1.32)	0.90 (0.61)
Personal characteristics		
Mortgage	−0.050*** (0.003)	−0.004*** (0.001)
Owner	0.023*** (0.005)	0.002 (0.001)
Real wealth	0.020*** (0.001)	0.008*** (0.000)
Real wealth^2	−0.001*** (0.000)	−0.000*** (0.000)
Real wealth^3	0.000*** (0.000)	0.000*** (0.000)
Male	0.018*** (0.002)	0.008*** (0.001)
Age	0.024*** (0.002)	0.007*** (0.001)
Age^2	−0.001*** (0.000)	−0.000*** (0.000)
Age^3	0.000*** (0.000)	0.000** (0.000)
Marital status		
Single	−0.004 (0.008)	−0.002 (0.004)
Married	0.004 (0.005)	−0.006 (0.003)
Separated	−0.002 (0.005)	0.002 (0.003)
Divorced	−0.025 (0.026)	0.009 (0.008)
Unknown	0.005 (0.008)	−0.008** (0.003)
Household size	0.014*** (0.001)	0.000 (0.000)
Number of children	−0.013*** (0.001)	0.000 (0.000)
Education		
Lower secondary	−0.003 (0.002)	−0.002* (0.001)
Higher secondary	−0.028*** (0.004)	−0.003 (0.001)
Vocational college	−0.025*** (0.005)	−0.010*** (0.002)
Lower university	−0.032*** (0.008)	−0.013*** (0.003)
Higher university	−0.035*** (0.010)	−0.012*** (0.002)
Graduate school	−0.015 (0.016)	−0.021** (0.008)
Type of municipality		
Capital region	−0.042*** (0.005)	−0.000 (0.003)
Urban	−0.053*** (0.003)	−0.000 (0.001)
Semi-urban	−0.027*** (0.004)	0.001 (0.001)
First-stage results: Excluded instruments		
Instrument *A*	−0.157*** (0.002)	−0.157*** (0.002)
Instrument *B*	−0.542*** (0.008)	−0.542*** (0.008)
Instrument *C*	−0.177*** (0.001)	−0.177*** (0.001)
Instrument *D*	−0.463*** (0.005)	−0.463*** (0.005)
F-statistic	26.38***	26.38***

Notes: Marginal effects calculated at sample means from population-weighted regressions including county dummies and year dummies. N = 32,110. Robust clustered (county-year) standard errors in parentheses. *, ** and *** denote significance at 10, 5 and 1 per cent levels, respectively. The omitted category is widowed females with a basic or no degree residing in a rural region

Table III. Models of entrepreneurship without and with employees

employ more than four people is even smaller in magnitude than the effect on employers presented in the second column of Table III. This result means that the positive effect of regional home-ownership on entrepreneurship works through encouraging small-scale entrepreneurship. This is natural because building a large-scale business takes time. However, one should notice that the results partly reflect the effects on business closures. Therefore, home-ownership seemingly neither encourages the quick establishment of larger-scale businesses nor discourages the closure of such businesses. Instead, there are significant effects on small-scale entrepreneurship only.

The results for entrepreneurship without employees and entrepreneurship with employees have interesting differences when it comes to the individual-level control variables. First, the relationship between individual home-ownership and entrepreneurship is statistically significant only for entrepreneurship without employees. The coefficient estimate for having a mortgage is statistically significant in both columns of Table III but it is markedly smaller in the case of entrepreneurship with employees. Second, small-scale entrepreneurship increases in real wealth much faster than large-scale entrepreneurship does. Similarly, small-scale entrepreneurship varies much more with age than large-scale entrepreneurship does. Finally, another interesting finding is that the probability of being an entrepreneur with employees does not vary significantly between rural and more urban regions whereas the probability of entrepreneurship without employees is more common in rural than in urban areas.

The hypothesis that home-ownership has externalities on entrepreneurship is based on the idea that the negative labour market effects of home-ownership affect entrepreneurship. The results thus far point to positive effects of home-ownership on entrepreneurship that can be explained by the lack of paid-work opportunities. If this were indeed the case, the resulting entrepreneurial activity would be inferior to its alternatives in terms of pay and perhaps other attributes. The data include individuals' tax-record information, so whether the data support this idea can be examined. On the basis of their real (in 1992 FIM) total taxable income (including business income, wages, benefits, capital income etc.), the entrepreneurs are classified into four groups. The real income categories are based on the 25th, the 50th and the 75th percentiles in the 15- to 69-year-old non-institutionalised population calculated from the sample. Table IV presents the results from estimating model

Table IV. The effects of regional home-ownership on entrepreneurship at different income levels

Entrepreneurship variable Method	Self-reported IV Probit	Socio-economic IV Probit	
Population income quarters			
1st quarter	2.02** (1.02)	1.86** (0.86)	N = 31,918
2nd quarter	2.21** (1.05)	2.03** (0.92)	N = 31,918
3rd quarter	0.74 (0.60)	0.77 (0.50)	N = 32,110
4th quarter	0.58 (0.57)	0.18 (0.41)	N = 32,110
Income quarters of those who experienced any employment			
1st quarter	4.17** (1.81)	3.95** (1.65)	N = 31,918
2nd quarter	0.90 (0.64)	0.56 (0.51)	N = 31,918
3rd quarter	0.15 (0.48)	0.51 (0.32)	N = 32,110
4th quarter	0.51 (0.53)	−0.05 (0.38)	N = 32,110

Notes: Marginal effects calculated at sample means from population-weighted regressions including the control variables as inTables II and III. Robust clustered (county-year) standard errors in parentheses. *, ** and *** denote significance at 10, 5 and 1 per cent levels, respectively. The omitted category is widowed females with a basic or no degree residing in a rural region

(1) by instrumental variables and using entrepreneurship with different levels of income as the dependent variables. The sample sizes are a little smaller in the analyses of entrepreneurship with below-median income. Such is the case because there are no entrepreneurs with below-median income who have completed graduate school. Therefore, those 192 individuals are dropped from the sample because of perfect prediction.

Regional home-ownership has a positive effect on entrepreneurship with income in each of the four income categories. The effect pattern is very similar when the self-reported entrepreneurship variable or the variable based on socio-economic classification is used. Home-ownership only has a statistically significant effect on entrepreneurship with below-median incomes. The effect is slightly larger on entrepreneurship with income between the 25th and the 50th percentile than on entrepreneurship with income below the 25th percentile. This exercise demonstrates that, indeed, home-ownership encourages entrepreneurship which does not help the entrepreneurs to earn high incomes. On the contrary, it seems that, at least when it comes to pay, the entrepreneurship resulting from a higher regional home-ownership seems to be, in terms of income, an inferior alternative to the activities of about half of the population. The percentiles are also calculated excluding the unemployed, students, retired and other individuals who did not report any employment during the year to assess how entrepreneurship encouraged by regional home-ownership pays off compared to the activities of the part of population which experienced any type of employment. Naturally, the incomes of those who experienced any employment are higher than those of the entire population. The results in Table IV show that only entrepreneurship with income in the lowest quarter is statistically significantly affected by home-ownership. This result further supports the idea that home-ownership has negative effects on the local labour market and this is partly reflected as greater low-income entrepreneurship. However, two caveats are of order. First, although the home-ownership-induced entrepreneurship does not pay very well off in the short run (as shown by the results), the long-run pay-offs may be even much better. Second, entrepreneurs have been shown to earn less and to benefit less from wage work experience in terms of earnings than dependent workers. Much-cited works on the topic include Evans and Leighton (1989) and Hamilton (2000), and Johansson (2000b) presents Finnish evidence. This means that entrepreneurs with incomes low when compared to the general population or labour force may still be relatively high-ability among the labour force and successful among the group of entrepreneurs.

4.3 Robustness

A potential threat to the identification of causal effects using the deregulation experiment is that entrepreneurship developed differently in the experiment and the non-experiment counties for reasons other than the experiment itself. In such a case, it is possible that the estimates presented above capture also the underlying trends in entrepreneurship instead of just the causal effects of home-ownership. Pre-experiment changes in entrepreneurship can, however, be estimated using the IDS data from the years 1989 and 1990. The estimation was conducted and the statistical significance of the "difference-in-differences" was tested. It appeared that none of the dependent variables of this study changed statistically significantly differently in the experiment region when compared to the non-experiment region.

Including an explanatory variable together with a variable which can be thought of as an instrumented version of it in the same regression may lead to misleading results (Angrist, 2014). In the case of this study, individual-level home-ownership dummy is a measure of home-ownership and the (instrumented or not) regional home-ownership variable can be thought of as an instrumented version of it. The potential problem is caused by the endogeneity of the non-instrumented variable. It can be argued that individual home-ownership is, indeed, endogenous. Therefore, robustness checks are needed to see whether the results are biased. Appropriate robustness checks can be conducted by re-estimating the models without the (endogenous) individual-level home-ownership dummy. The mortgage loan dummy is also left out because it measures housing tenure, especially in the absence of the home-ownership dummy. It is clear that the coefficient estimate of the (instrumented) regional home-ownership proportion now captures the effect of a change in regional home-ownership, including the direct effect which operates through individual home-ownership and having a mortgage loan. Therefore, the coefficient measures the total effect (the direct effect and the externality) of a change in regional home-ownership. All the estimations in this study were conducted without the two endogenous variables and the results remained qualitatively similar.

Yet another potential source of bias is ignoring the effect of regional unemployment on entrepreneurship. The combination of regional unemployment having an effect on entrepreneurship and being correlated with the instrumental variables would result in biases in the IV estimations. Such bias can be avoided by controlling for regional unemployment. However, the literature suggests that regional unemployment is an outcome affected by home-ownership and is, therefore, a "bad control" (Angrist and Pischke, 2009). Bearing this qualification in mind, all the four models in this paper were re-run with county unemployment rate as an additional regressor to check robustness. When it comes to the estimated effects of regional home-ownership, there were no significant differences between the results of these checks and the results presented in this paper. Therefore, it is safe to conclude that regional home-ownership has a positive causal effect on entrepreneurship and that this effect is at least partly an externality[4].

5. Conclusions

This study examines the effects of home-ownership on entrepreneurship. The focus is on the indirect effects beyond the effects on home-owners of their own housing tenure. The hypothesis is that, because home-ownership has been found to have negative externalities on local labour markets, higher regional home-ownership rates lead to changes in incentives for entrepreneurship. The results show that regional home-ownership has a positive effect on entrepreneurship, conditional on individuals' own home-ownership status, having (or not) a mortgage loan and other personal control variables. This result is robust to using alternative measures of entrepreneurship.

The additional analyses presented in this study suggest that small-scale entrepreneurship and entrepreneurship leading to a low level of income is encouraged by higher regional entrepreneurship. The result on the income level suggests that the negative effects of home-ownership on the local labour markets make paid work scarce which works as a push factor that pushes individuals to entrepreneurship. This idea is in line with the results in earlier literature that a significant part of entrepreneurial activities is because of necessity rather than opportunity. However, the results of this study concern the short run and the pay-offs from entrepreneurship induced by regional home-ownership may be better in longer run and especially when compared to the group of entrepreneurs instead of the population or the labour force.

Earlier literature has demonstrated that home-ownership has detrimental effects on the labour market. Currently, these effects are understood to operate through externalities. This study shows that the externalities are not limited to higher unemployment and less employment. Instead, greater home-ownership, and, therefore, policies that favour home-ownership, push individuals into entrepreneurship as paid employment opportunities become scarcer. To better understand the transmission mechanisms behind the results, research directly studying these mechanisms is needed.

Notes

1. In this study, the term entrepreneurship is used to cover self-employment, as well. The variables in the data also cover both self-employment and entrepreneurship.
2. We would like to thank an anonymous referee for pointing out the reasons for which not only having a mortgage affects entrepreneurship but also *vice versa*.
3. The dwelling data are annual, but the data on buildings by building type are quarterly. The way to obtain a measure of the number of dwellings completed in January 1992 is to multiply one-third of the share of buildings completed in the first quarter by the number of dwellings completed during the entire year.
4. The results from all robustness checks are available from the author upon request.

References

Angrist, J. (2014), "The perils of peer effects", *Labour Economics*, Vol. 30, pp. 98-108.

Angrist, J.D. and Pischke, J.-S. (2009), *Mostly Harmless Econometrics: An Empiricists Companion*, Princeton University Press, Princeton, NJ.

Berglann, H., Moen, E.R., Røed, K. and Skogstrøm, J.F. (2011), "Entrepreneurship: origins and returns", *Labour Economics*, Vol. 18 No. 2, pp. 180-193.

Bernhardt, I. (1994), "Comparative advantage in self-employment and paid work", *Canadian Journal of Economics*, Vol. 27 No. 2, pp. 273-289.

Blanchflower, D.G. and Oswald, A.J. (2013), "Does high home-ownership impair the labor market?", working paper No. 19079, National Bureau of Economic Research, Cambridge (MA), May.

Bracke, P., Hilber, C.A. and Silva, O. (2018), "Mortgage debt and entrepreneurship", *Journal of Urban Economics*, Vol. 103, pp. 52-66.

Brown, S., Farrel, L. and Sessions, J.G. (2006), "Self-employment matching: an analysis of dual earner couples and working households", *Small Business Economics*, Vol. 26 No. 2, pp. 155-172.

Carroll, C.D. (2000), "Why do the rich save so much?", in Slemrod, J. (Ed.), *Does Atlas Shrug? The Economic Consequences of Taxing the Rich*, Harvard University Press, Cambridge, pp. 463-485.

Carroll, C.D. (2002), "Portfolios of the rich", in Guiso, L., Haliassos, M. and Jappeli, T. (Eds), *Household Portfolios*, MIT Press, Cambridge, pp. 389-429.

Coulson, N.E. and Fisher, L.M. (2009), "Housing tenure and labor market impacts: the search goes on", *Journal of Urban Economics*, Vol. 65 No. 3, pp. 252-264.

Eriksson, T. and Kuhn, J.M. (2006), "Firm spin-offs in Denmark 1981-2000—patterns of entry and exit", *International Journal of Industrial Organization*, Vol. 24 No. 5, pp. 1021-1040.

Evans, D. and Leighton, L. (1989), "Some empirical aspects of entrepreneurship", *American Economic Review*, Vol. 79 No. 3, pp. 519-535.

Fairlie, R.W. (2013), "Entrepreneurship, economic conditions, and the great recession", *Journal of Economics and Management Strategy*, Vol. 22 No. 2, pp. 207-231.

Flatau, P., Forbes, M. and Hendershott, P.H. (2003), "Homeownership and unemployment: the roles of leverage and public housing", working paper No. 10021, National Bureau of Economic Research, Cambridge (MA), October.

Fotopoulos, G. (2013), "On the spatial stickiness of UK new firm formation rates", *Journal of Economic Geography*, Vol. 14 No. 3, pp. 651-679.

Haapanen, M. and Tervo, H. (2009), "Self-employment duration in urban and rural locations", *Applied Economics*, Vol. 41 No. 19, pp. 2449-2461.

Hamilton, B. (2000), "Does entrepreneurship pay? An empirical analysis of the returns to self-employment", *Journal of Political Economy*, Vol. 108 No. 3, pp. 604631.

Harding, J.P. and Rosenthal, S.S. (2017), "Homeownership, housing capital gains and self-employment", *Journal of Urban Economics*, Vol. 99, pp. 120-135.

Isebaert, D., Heylen, F. and Smolders, C. (2015), "Houses and/or jobs: ownership and the labour market in Belgian districts", *Regional Studies*, Vol. 49 No. 8, pp. 1387-1406.

Johansson, E. (2000a), "Self-employment and liquidity constraints: evidence from Finland", *Scandinavian Journal of Economics*, Vol. 102 No. 1, pp. 123-134.

Johansson, E. (2000b), "Self-employment and the predicted earnings differential – evidence from Finland", *Finnish Economic Papers*, Vol. 13 No. 1, pp. 45-55.

Laamanen, J.-P. (2017), "Home-ownership and the labour market: evidence from rental housing market deregulation", *Labour Economics*, Vol. 48, pp. 157-167.

Lisi, G. (2017), "Homeownership and new entrepreneurs: first empirical evidence of a bidirectional interaction", *Applied Economics*, Vol. 49 No. 60, pp. 5983-5991.

Munch, J.R., Rosholm, M. and Svarer, M. (2006), "Are homeowners really more unemployed?", *The Economic Journal*, Vol. 116 No. 514, pp. 991-1013.

Munch, J.R., Rosholm, M. and Svarer, M. (2008), "Homeownership, job duration, and wages", *Journal of Urban Economics*, Vol. 63 No. 1, pp. 130-145.

Oswald, A.J. (1996), "A conjecture on the explanation for high unemployment in the industrialized nations: part I", Working Paper No. 475, Department of Economics, University of Warwick, Coventry, December.

Quadrini, V. (1999), "The importance of entrepreneurship for wealth concentration and mobility", *Review of Income and Wealth*, Vol. 45 No. 1, pp. 1-19.

Quadrini, V. (2000), "Entrepreneurship, saving, and social mobility", *Review of Economic Dynamics*, Vol. 3 No. 1, pp. 1-40.

Røed, K. and Skogstrøm, J.F. (2014), "Job loss and entrepreneurship", *Oxford Bulletin of Economics and Statistics*, Vol. 76 No. 5, pp. 727-744.

Skriabikova, O.J., Dohmen, T. and Kriechel, B. (2014), "New evidence on the relationship between risk attitudes and self-employment", *Labour Economics*, Vol. 30, pp. 176-184.

Stock, J.H. and Yogo, M. (2002), "Testing for weak instruments in linear IV regression", Technical working paper No. 284, National Bureau of Economic Research, Cambridge (MA), November.

Svaleryd, H. (2015), "Self-employment and the local business cycle", *Small Business Economics*, Vol. 44 No. 1, pp. 55-70.

Tervo, H. (2006), "Regional unemployment, self-employment and family background", *Applied Economics*, Vol. 38 No. 9, pp. 1055-1062.

Van Leuvensteijn, M. and Koning, P. (2004), "The effects of home-ownership on labour mobility in The Netherlands", *Journal of Urban Economics*, Vol. 55 No. 3, pp. 580-596.

von Greiff, J. (2009), "Displacement and self-employment entry", *Labour Economics*, Vol. 16 No. 5, pp. 556-565.

Wolf, N. and Caruana-Galizia, P. (2015), "Bombs, homes, and jobs: revisiting the Oswald hypothesis for Germany", *Economics Letters*, Vol. 135, pp. 65-68.

Zissimopoulos, J.M. and Karoly, L.A. (2007), "Transitions to self-employment at older ages: the role of wealth, health, health insurance and other factors", *Labour Economics*, Vol. 14 No. 2, pp. 269-295.

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Household mortgage demand: a study of the UK, Australia and Japan

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Abstract

Purpose – Homeownership has been the main focus of housing policies in most countries. Typical means that households use to achieve homeownership is to take out a loan and supplement this with accumulated wealth for a downpayment. This paper aims to analyze the mortgage demand behavior of households in the UK, Australia and Japan.

Design/methodology/approach – Using three panel data sets, HILDA for Australia, KHPS for Japan and USS for the UK, the paper estimates three equations using ordinary least squares: mortgage demand function, housing demand function and initial loan to value ratio function.

Findings – Though homeownership is a preferred tenure and the mortgages are "recourse" loans, housing markets in these three countries operate in different mortgage market institutional structures. Results indicate that income elasticity of mortgage demand differ despite income elasticity of housing demand being similar. Different mortgage institutions in countries that pose constraints for borrowers also determine mortgage demand. Other factors such as demography and economic conditions have also played an important role in determining mortgage and housing demand.

Originality/value – The paper is first, to the authors' knowledge, that explores the role of institutions in mortgage demand in a comparative framework for the UK, Japan and Australia.

Keywords Australia, UK, Mortgages, Japan, Institutions, Panel data

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1. Introduction

Benefits from homeownership cannot be understated in any society. Almost two-third of households in the UK, Australia and Japan live in ownership houses. The percentage homeownership rate has however declined recently from 70.6 per cent in 2000 to 65.2 per cent in 2012 in the UK and from 69.5 per cent in 2001 to 68.7 per cent in 2012 in Australia. In Japan, the homeownership rate has marginally increased from 61.1 per cent in 2007 to 61.9 per cent in 2013 (source: https://tradingeconomics.com/japan/home-ownership-rate). Mortgage has played a crucial role in enabling households to buy homes in 2012, nearly half of the homes were purchased using mortgage in the UK. However, this share of homes bought on mortgages has declined from 61.4 per cent in 2000. In Australia, home purchasers with mortgage are more than 50 per cent in 2011, and this has increased compared to 41 per cent in 2001. These statistics indicate that though the homeownership rates in these countries are similar, the role that mortgages have played is somewhat varied.

The objective of this paper is to understand the causes for differences in household mortgage demand in the UK, Australia and Japan. This is important for the stability of overall economy as well, as the mortgage market plays a very important role in the transmission of monetary policy, which has a profound impact on the macro economy. The mortgage market and monetary market are intertwined and due to the linkages between the monetary market and the macro economy, changes in the mortgage market get transmitted to the macro economy. The proportion of fixed and variable rate mortgages (VRMs) is of great importance for the national economy as the interest rate shocks affect fixed and VRMs differently (Koblyakova *et al.*, 2014). The adjustable rate mortgages (ARMs), which are linked to short-term interest rate face far greater monetary policy risk than the fixed rate mortgages (FRMs). An economy, such as the UK, where the level of debt as a proportion of GDP is high and a large proportion of this debt is linked to ARMs, the risk of transmission of policy changes remain high. This, in times of crisis, poses challenges for effectiveness of monetary policy instruments to achieve financial stability.

In recent times, the Global Financial Crisis (GFC) is an example where the mortgage market caused the instability in the financial systems of various countries to various degrees. The financial and capital markets in the UK were strongly impacted due to the tight liquidity conditions that followed the GFC and this has affected the macro economy. Post GFC, the real GDP growth rate in the UK dropped to −4.3 per cent in 2009 and the economy did not regain its pre-crisis level of growth until 2014. The Australian financial and capital markets (monetary market) were not as badly influenced as the UK, and liquidity in the market was not so tight. One of the reasons could have been that Australia did not hold much of the asset-backed securities (mortgage backed securities and its derivatives) linked to the sub-prime crisis, which contained the impact of GFC in the country. The real GDP growth, though slowed, never became negative during the GFC. Similar to Australia, Japan also did not witness tight liquidity conditions post GFC. The real GDP growth rate in Japan has been low witnessing negative values frequently after the bubble burst in late 1990s during the so-called "lost decade(s)". The real GDP growth in Japan during the GFC was also negative with growth rates of −3.7 and −2.0 per cent in 2008 and 2009, respectively. The strength of the linkage between the mortgage market and macro economy differs among countries depending on the characteristic of the mortgage market, its institutions and structure of mortgage debt. This paper investigates the demand side of the mortgage market.

Specifically, the paper aims to understand the drivers of mortgage market and their impact. To accomplish this objective, it is critical to analyze household behavior over mortgage choice and its demand. In particular, what determines household mortgage

demand? Furthermore, what is the relation between mortgage demand and a particular mortgage instrument? Literature suggests that the mortgage demand by a household is derived from their housing demand or said alternatively, housing and mortgage demand are jointly determined (Leece, 2006; Koblyakova *et al.*, 2014). Therefore, this paper analyses mortgage choice as simultaneously determined with mortgage demand and also with housing demand.

The three countries, the UK, Australia and Japan, included in this paper provide a context of very similar policy objective and consumer preferences with regard to homeownership but they offer diversity in mortgage market institutions and available instruments despite the fact that mortgages are recourse type of loans in these three countries. The institutions differ in terms of availability of mortgage contract types, implementation of foreclosure and personal bankruptcy laws. As has been observed earlier that the homeownership rates in three countries are similar, however, to achieve these very similar homeownership rates, the extent of mortgage debt that households have accessed and the type of mortgage instrument that they have chosen is different across these countries. Households in the UK and Australia have predominantly chosen ARM (also called VRMs), while in Japan the choice has been quite varied from VRMs to short-term and to long-term housing loan instruments. The difference in the extent of mortgage penetration in these countries is reflected in the level of outstanding mortgage debt as a proportion of GDP. In the UK, the ratio of outstanding mortgage debt to GDP is 70 per cent, in Australia it is 80 per cent and in Japan it is less than 30 per cent. Besides the type of mortgage instrument (ARM or FRM), length of fixed period of FRM, conditions imposed by lenders regarding prepayment, tax treatment, lenders' constraints (mortgage payment to income ratio, downpayment to house value ratio), foreclosure and bankruptcy laws and practices also differ among these three countries.

Despite the differences in practices used in mortgage markets in the UK, Australia and Japan, a large proportion of households have fulfilled their homeownership dreams by accessing mortgage finance. Their decisions have involved the level of debt and the type of mortgage instrument (FRM or ARM).

With this background, this paper analyses the determinants of mortgage demand and housing demand of households in the UK, Australia and Japan. This is achieved by basing the analysis within the theoretical framework of mortgage demand (Leece, 2004; Chapter 2). These models are highly suggestive of empirical specifications for econometric estimation of mortgage demand. The empirical estimation takes the form of econometric estimates of mortgage demand, housing demand and initial loan to value ratio as separate equations. Cross-sectional estimations utilize data extracted from Understanding Society Survey (USS) for the UK, from The Household, Income and Labour Dynamics in Australia (HILDA) for Australia and from Keio Household Panel Survey (KHPS) for Japan.

The paper is structured as follows. Section 2 analyses the relevant literature, while Section 3 details econometric methodology applied in the paper. Section 4 discusses the data. Section 5 presents the findings and interpretation of the results, and Section 6 forms the conclusion.

2. Literature review

Several factors influence the demand for mortgage debt within the mortgage market. Besides demand for housing (Follain, 1990; Jones, 1993), these incorporate efficiency of the mortgage system, lending conditions, availability of mortgage types, regulatory constraints and economic environment (Lea, 2011; Miles, 2012). In a perfectly efficient mortgage market, under the Modigliani and Miller's theoretical propositions, borrowers should be indifferent

to the size, mortgage type and gearing features of the mortgage contract (Leece, 2004). However, the institutional features of a mortgage market imply varying degree of mortgage constraints, which affect mortgage debt and mortgage instrument choices (Diamond and Lea, 1992; Campbell and Cocco, 2003).

Factors that affect house price movements and changes in mortgage flows include changes in household demographic situations, personal disposable income and changes in interest and tax rates. Among empirical studies, Follain and Dunsky (1997) and Ling and McGill (1998) used US household-level data in econometric estimates of mortgage demand. The results for household mortgage demand highlight the importance of demographic and economic factors such as age and personal income and highlight that tax savings, associated with interest deductions, significantly affect the size of mortgage debt. Leece (2004, 2006), using the UK data, suggests that borrowers' choices about mortgage debt and type of mortgage contract depend on opportunities to acquire the housing debt. Using nominal interest rates and regional house price inflation as proxies for the user cost of owner-occupation, their research recognizes the importance of differentials in regional house prices in the decisions on mortgage size. At the macroeconomic level, the stability of the mortgage finance system in a country also depends on the level of household indebtedness and the distribution of variable or fixed rate contracts (Duca *et al.*, 2010). The structural variations in housing finance systems impose various degrees of sensitivity to changes in policy rates, depending on household's leverage, size and type of mortgage debt (McLennan *et al.*, 2000; Campbell, 2012).Papers that have also explored the within country regional variations in the mortgage markets, have suggested that the level of mortgage debt is the key factor for the differentials in the impact of monetary policy within the UK (Evans and McCormick, 1994; Leece, 2004) and the USA (Campbell, 2012). Results also suggest that liquidity constraints and higher mortgage interest burdens have effectively restricted the demand for mortgage debt.

Extending the discussion on mortgage demand to cross-country comparisons, the cross-country variations in economic conditions, housing and mortgage market institutions adds another nuance to the discussion. Given that the tax regime and monetary policy structure differs in different countries impacting their house prices differently, it is expected that cross-country variations in house prices substantially influence the starting point of households in entering owner-occupation (Lea, 2010). House price variations also lead to variable expectations about capital gains, facilitating an increase/decrease in housing and mortgage demands depending on the direction of expectations and accordingly reinforcing house price positively/negatively (Taltavull de La Paz and White, 2012). Thus, the differing economic conditions in various countries may result in different effect of monetary policy on mortgage market operation; however, academic research in this area has been hampered by paucity of cross-country data availability (Bell and Lowe, 2000).

Among the few studies that explore mortgage choice decisions from the cross-national perspective, Badarinza *et al.* (2017) suggest that the mortgage markets are highly heterogeneous across countries, demonstrating varying effects over the space and time. Exploring whether households choose a mortgage contract responding to current interest rate regime or based on expected future changes in mortgage prices, Badarinza *et al.* (2017) show that the structure of mortgage rates are strong predictors of mortgage choice decisions. Their findings suggest that in a tight lending markets, liquidity-constrained households will choose the cheapest available options, with the aim to balance their current level of consumption and maximum level of the mortgage debt.

In their cross-country study, Dow and Montagoni (2007) consider the possibility of impact of differences in the cost for mortgage loans and availability of mortgage debt

arising due to differences in mortgage policies on mortgage demand. Their research identifies differences in cross-country variations in the housing finance costs. They also found that national financial institutions respond differently to changes in monetary policy reflecting cross-country variations in credit conditions. Thus, depending on the state of local industry and on the asset values of collateral, credit attributes may differ in different countries and regions. Further, considering the differences in the lending and borrowing channels, Dow and Montagoni (2007) provide empirical evidence of the cross-country differences of the various groupings of financial markets and intermediaries. Notably, cross-country differences in the cost of credit is explained by the disproportional creation of critical mass of financial activity and intensity of mortgage intermediaries in certain countries.

Further, cross-country difference in demographic trends and its influence on the housing market has been explored by Levin *et al.* (2009). Highlighting the importance of demographic factors on size of mortgage debt, findings suggest that differences in the rate of growth of age groups relevant to first-time buyers are particularly important. They suggest that a decline in real house prices and mortgage borrowing levels are more likely to occur in the countries where younger population is expected to decline in size.

Cross-country disparities in the distribution of income may also cause various responses from housing and mortgage markets across the countries. Besley *et al.* (2010) suggest that countries characterized by higher incomes and higher house prices provide better lending conditions for mortgage contracts.

Investigating cross-country variations in mortgage debt decisions, Campbell (2012) examines the potential impact of national economic features on the mortgage market structure, which influences households' behavior toward debt. Household's demand for debt is governed by the choice of house location, the decision to become a homeowner and the choice of mortgage rate. The choice of mortgage rate relates to the risk of changes occurring in the macroeconomic environment that affects a household's circumstances. Results suggest that a mortgagee, who is constrained, faces significant risk from uncertainty and timing, as is implied by the variable mortgage rate option that she chooses. Given a cross-country perspective, this may suggest that countries with the prevalent variable mortgage debt have inherently higher interest rate risks and are less financially stable.

Analyzing the role of differences in economic conditions at the regional level, Cho *et al.* (2012) suggest that mortgage risks differ due to differing underlying risks across regions which impart heterogeneity in mortgage loans. Analyzing the period 1993-2007, they indicate that a long-term equilibrium relationships exist between the mortgage default rates and regionally differentiated economic and social variables associated with mortgage affordability and liquidity constraints such as incomes and unemployment rates, which impact a household's ability to afford mortgage repayments. It may be hypothesized that a similar outcome could be expected in at cross-country level because the economic and mortgage market condition would differ.

There is paucity of academic literature in understanding the impact of mortgage market institutions on mortgage debt. Mortgages in the UK, Australia and Japan are recourse loans implying that a lender may seek financial damages beyond the mortgages housing asset if the borrower fails to pay the liability and if the value of the underlying asset is not enough to cover it. Theory would suggest that recourse should deter default on home loans and have implications for mortgage demand. However, the extent to which these recourses can be manifested differ across different countries and hence the effect on mortgage demand could differ. In the USA, recourse/non-resource nature of housing loan is a state law generating different outcomes across states. In Australia, personal bankruptcies are low due to severe

consequences of bankruptcy under Australian Law and difficulty that one faces in accessing finance after bankruptcy (Kitson *et al.*, 2015). There is no specific protection afforded to bankrupts and if the "bankrupt is sole owner, and no other person has an interest (legal or equitable) in the property, neither the bankrupt nor the bankrupt's family has any right to remain in the possession of the home" (Mason and O'Mahony, 2014). If loan falls in arrears, the realization of the security property through sale can take 8-12 months on average (Kitson *et al.*, 2015). The process of foreclosure is also simple and requires an order from Registrar – General on satisfying the conditions of default. In Japan, almost all mortgages are recourse with very tiny fraction being non-recourse (Asset Enhancement Securities Limited, 2005). The "Civil Execution Act: Minji Shikkoo Hoo: Code No. 4 – 1980, Article 22" defines the court orders and processes required for foreclosure. However, the Japanese court procedure in mortgage foreclosure is slow and could take as much as 24 months (ibid). In the case of the UK, as discussed by Aron and Muellbauer (2016), the default rates during the Global Financial Crisis were low due to government's generous support for borrowers with payment problems and increased forbearance (by lowering the rate of repossessions and increasing the rate of arrears) by banks, lending to the view that foreclosure is not as ruthless as the definition of "recourse" would imply. Their estimates further highlighted that forbearance changed with economic conditions.

Summarizing the findings, previous research has used utility maximization theory from a life cycle perspective as a theoretical basis for analyzing mortgage demand, while recognizing mortgage market constraints related to liquidity and affordability. Previous studies inform the econometric specification and suggest several explanatory variables for inclusion in empirical model of mortgage demand. In an international context, it appears that the cross-country differences in interest rate regime, lending conditions, liquidity constraints, pricing of risks, demographic trends and macroeconomic fundamentals play a deterministic role in mortgage debt and mortgage choice decisions. However, the role of mortgage institutions in a cross-country analysis has been less investigated, which becomes a gap for further investigation. While present paper highlights the role of mortgage institutions, it leaves detailed investigation into the regulations and practices that impact mortgage demand for future research.

3. The three-country context and the data

Table I presents the key demographic, economic, housing and mortgage market characteristics in Australia, Japan and the UK. While the homeownership rates and household preference toward homeownership are similar in these countries, the socio-economic and housing market environment is different. This makes these three countries interesting cases for understanding the drivers of mortgage demand.

Demographically too, the size of population is quite different between Australia, the UK and Japan. Population of Japan is the largest, while other two countries have almost half the population of Japan. Although the population of Japan is large, it is declining in absolute numbers, while the population in other two countries is growing owing to international immigration. These countries are facing an increase in the number of one-person household partly due to the delay in age of marriage (and due to non-marriage) and partly due to population ageing. Rising life expectancy is further increasing the number of aged population. The life expectancy of Japan is the highest in the world and the rate of ageing is also the highest. Regarding fertility rate, there is a notable difference between three countries. Japan has been suffering from a low fertility for a long time; however, Australia and the UK are not. The household size has become smaller in all three countries therefore

the number of households is increasing in the UK and Australia but is decreasing in Japan because the total population decline.

Demographic differences impact housing market significantly. The number of houses exceeds that of households in Japan, and the vacancy rate has been rising amounting to more than 13.5 per cent (Moriizumi, 2015). On the other hand, there is a shortage of housing in the UK and Australia due to a strong pressure of demand for housing caused by increasing population. The vacancy rate in the UK has decreased from17 per cent in 2009 to 12 per cent in 2014, while in Australia, it is about 10.7 per cent in 2011 (ibid). It is interesting that even though Australia faces population increasing, its vacancy rate keeps constantly low. Owing to shortage of housing in Australia and the UK, there is excess demand in these countries causing high volatility in house prices in these countries. On the other hand, housing prices, have been declining for a long time in Japan and volatility in house prices is not so large in Japan due to excess supply.

The homeownership rates in these three countries have been declining despite low mortgage rates, favorable tax treatment and several financial assistance by government, especially for first time buyers (Moriizumi, 2015). The homeownership rate among young households has been continuously declining, whereas the ownership rate for the elderly has been above the average rate of homeownership in these three countries. Moriizumi (2015), in case of Japan, proposes that the reasons for declining homeownership among young households are factors such as late marriage or non-marriage and economic and financial downturn. While declining fertility rate may increase expectations about bequest, delay in receiving bequest due to rising life expectancy is also causing delays in homeownership of young households (ibid). The fertility rate in Australia and the UK is not declining, but the homeownership rate among young households in these countries is low. Late marriage or non-marriage leading to late formation of household is a common influence causing delays in homeownership across all countries.

Housing markets and mortgage markets operate within the broader economy. The impact of GFC on economy, financial markets and hence housing has been different among countries. The financial and capital markets in the UK were strongly impacted resulting in tightening of liquidity and slowdown in the economy. The real GDP growth rate of the UK dropped to −4.3 per cent in 2009. Australian financial and capital markets (monetary market) were not so badly affected as the UK, and liquidity was not so tight. One of the reasons probably was that Australia did not hold asset-backed securities that were linked to sub-prime loans. The real GDP growth rate, though declined, never became negative during

	Australia		Japan		UK	
	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
Fixed = 1	0.0741	(0.2620)	0.4126	(0.4923)	0.3687	(0.4825)
Age	42.5755	(9.8679)	47.4451	(10.3126)	39.3932	(8.3038)
Household size	3.4638	(1.2110)	3.8573	(1.2832)	3.0541	(1.2571)
Number of children	1.1734	(1.1418)	0.9440	(1.0567)	1.0322	(1.0395)
Log(gross household income)	11.3989	(0.5827)	6.5658	(0.4644)	8.2963	(0.4940)
Payment-to-Income ratio	0.2394	(0.3743)	0.2208	(0.3133)	0.1723	(0.0760)
N	3,588		5,747		2,978	

Notes: Gross household income is measured in each country's currency unit. However, in the estimation, this doesn't cause any problems as we take a log for both dependent and independent (income) variables, allowing us to interpret estimated coefficients as income elasticity (which are unit-free)

Table I.
Descriptive statistics

GFC. Similar to Australia, Japan was not strongly impacted by GFC with respect to liquidity tightness. The real GDP growth rate in Japan has been low having negative values often after the bubble burst in late 1991s, during the so-called "lost decade(s)". The real GDP growth rate during GFC was also negative with −3.7 and −2.0 per cent in 2008 and 2009, respectively. After GFC, it recovered to the level of almost 2 per cent.

The unemployment rate rose with the GFC in all three countries but has dropped in the UK and Japan. The unemployment rate in Australia has not yet fallen to the pre-GFC levels and the labor market is yet to recover. The inflation rate is decreasing in all three countries and Japan has been suffering from deflation for a long period since 2000s. These differences in the macro economy are reflected in household economic conditions, which significantly influence household behavior toward borrowing and buying a house, especially the behavior of young household and first-time buyers.

Economic and financial factors, such as unemployment rate, house price and mortgage rates, are closely related to each other. Rising house prices and house price volatility as in the UK and Australia certainly depresses the ownership rate, while low mortgage rates promote home purchases. Tight credit constraints, especially during and after the GFC has likely depressed home buying activity among young home buyers. As for Japan, although house (land and real estate) prices and mortgage rates have been declining at the same time, homeownership rates has also fallen for decades. From the economic standpoint, income volatility and unemployment rate are related, which have been high in Japan due to the sluggish economic conditions that have prevailed since late 1991s. Besides the negative and positive impacts of demographics mentioned above, these economic and financial factors have significantly influenced the behavior of young home buyers in Japan.

The three countries included in this paper present quite different systems of mortgage structure. Australia and the UK are dominated by VRMs with short-term initial fixed rate, while there is a wide range of interest rate structures in Japan, from VRM to FRM with short-term, medium-term (3-15 years) and long-term (20-35 years) FRMs. Convertible loan is also prevalent in Japan. Initial fixed-rate discounts are common in all three countries.

In a perfect market, as per Modigliani Miller hypothesis, these structures should not affect households' mortgage decisions. However, with asymmetric information and other inefficiencies, these differences may influence the behavior of mortgage borrower's mortgage choice.

As discussed in Moriizumi (2015), the spread between FRM and ARM has always been positive, as expected in the finance theory. In the UK during GFC, and in Australia in most years since 1990s, ARM and FRM rates were very close and the relationship had reversed very often even before the GFC. In Japan, Government Housing Loan Corporation (GHLC), before its abolition, directly provided a long-term mortgage to borrowers at low interest rates by policy. The rate on ARM did not often change and it was fixed to be higher than FRM (GHLC mortgage). Consequently, the share of FRM has been larger than that of ARM for a long time. However, after the abolition of GHLC the mortgage rate for ARM is lower than FRM and the spread between FRM and ARM has been within a very narrow range. Recently the share of ARM has been rising (Moriizumi, 2015).

Features of mortgage instruments across countries impact prospect borrowers in each country. The size of mortgage market and the share of ARM to FRM depends on which mortgage instrument borrowers select and to what extent they demand for. The share of ARM in the mortgage market is the largest in Australia. ARM's share is increasing in Japan amounting to more than 40 per cent.

Moriizumi (2015) notes that housing loan to income ratio during 2006-2010 is the highest in the UK, followed by Australia, and is the lowest in Japan. The ratio has decreased in the

UK and Japan after GFC, while in Australia, it has stayed at high level. It is interesting issue, therefore, whether households take out a loan to buy homes and to what proportion of house value do they finance using mortgage.

The paper uses three datasets. For Australia, HILDA panel survey data for years 2002 (Wave 2), 2006 (Wave 6) and 2010 (Wave 10) have been used. In HILDA data set, these are the years where question on original mortgage amount was asked. For Japan, KHPS data for years 2004-2011 (all available waves) have been used. In case of KHPS, all existing waves of survey have asked the question regarding initial mortgage amount. Hence all the waves have been included in the research. For the UK, the paper uses USS for years 2009 and 2012. They are also years where original mortgage amount is available from the survey question.

The difference in the periods across three data sets does not pose problem as dummy for time in the estimation control for differences in period. This paper has taken advantage of the full data range that is available.

The descriptive statistics is presented in Table I.

Table I indicates that in the Australian data, 7.4 per cent of households have taken an FRM. The proportion of FRMs in Japan is about 41.3 per cent and for the UK is 39.4 per cent, substantially higher than Australia. This clearly indicates the differences in preference and/or availability of different mortgage instruments. The average age of borrowers in Australian data is 42.3 years, while in Japan, the average age is 47.4 years and the UK is 39.4 years. This possibly indicates that households in the UK or Australia may be better positioned in terms of affordability and face less liquidity constraints than Japanese households. The mortgage payment to income ratio in Australia and Japan are very similar at around 23 and 22 per cent, respectively. In the UK, the mortgage payment to income ratio is about 17 per cent.

4. Econometric methodology

The modeling approach involves estimation of three equations using ordinary least squares: mortgage demand function, housing demand function and initial loan to value ratio function. Equations (1)-(3) represent formal structure of these equations. Equation (1) models mortgage demand as a function of independent variables – household income, household characteristics such as the age of borrower, household size, income and mortgage payment structure. Dummies for rural and urban locations and regions have also been included. To capture the differences in mortgage origination, dummies for mortgage originations have been included. The second equation models housing demand as a function of independent variables that relate to household characteristics and income. To capture the mortgage market characteristics, variables for mortgage instrument choice and payment to income ratio have also been included. The three equations to be estimated are as follows:

(1) Mortgage demand function:

$$Log(M_{it}) = \alpha_0 + \alpha_1 X_{it} + \alpha_2 Log(Y_{it}) + \varepsilon_{it}$$

(2) Housing demand function:

$$Log(V_{it}) = \beta_0 + \beta_1 X_{it} + \beta_2 Log(Y_{it}) + \nu_{it}$$

(3) Initial loan to value ratio function:

$$Log(M_{it}/V_{it}) = \Upsilon_0 + \Upsilon_1 X_{it} + \Upsilon_2 Log(Y_{it}) + \eta_{it}$$

The description of variables is as follows:

Mortgage value at origination (M_{it}): This is the amount of initial loan that households took out at the time of purchase of their house. As mortgage amount is

measured in local currency unit (i.e. AUD for Australia, Yen for Japan and GBP for the UK), we take the natural logarithm of this variable. This allows us to interpret estimated coefficients as (semi-) elasticity (which does not depend on the unit of measurement).

Purchase price of house (V_{it}): This is the price paid for house at the time of purchase.

Initial loan to value ratio (M_{it}/V_{it}): This reflects the loan as a percentage of value of house.

Mortgage instrument choice (I_{it}): 1 if fixed interest rate mortgage, 0 otherwise. FRMs are defined as mortgages that remained fixed for at least three consecutive years since origination. In case of Japan, KHPS asks a direct question whether the mortgage is fixed rate. We simply use the answer to this question, which includes, in principle, any FRM. For Australia and the UK, HILDA and BHPS do not have survey questions that directly ask mortgage contract type. We therefore impute the type of contract by looking at respondent's repayment history. If the repayment for a mortgage is constant across three consecutive years, we assume that the mortgage is fixed rate contract. This approach of identifying FRM in the case of the UK is same as Koblyakova *et al.* (2014).

Age: Age is the age of household head in the sample at period *t*.

Household Size: Represents the size of household in period *t*.

Number of children: Represents number of children in the household in period *t*.

Gross household income (Y_{it}): Annual gross income of household in local currency in period *t*.

Payment to income ratio: This variable represents mortgage payment to income ratio in period *t*.

Urban-rural dummies: 1 if the property is located in urban areas; 0 otherwise.

Regional dummies: These are dummies for different regions in a country.

Dummies for mortgage origination years: These are dummies for years of origination of mortgage.

The purpose of equation (3) above is to explore an important relation between mortgage demand and housing demand. By definition, income elasticity for initial LTV is the difference between income elasticity for purchase price of home and mortgage amount. Taking the difference between equations (1) and (2) yields:

$$Log(M_{it}) - Log(V_{it}) = Log(M_{it}/V_{it}) = \Upsilon_0 + \Upsilon_1 X_{it} + \Upsilon_2 Log(Y_{it}) + \eta_{it},$$

which implies that $\Upsilon_0 \equiv \alpha_0 - \beta_0$; $\Upsilon_1 \equiv \alpha_1 - \beta_1$; $\Upsilon_2 \equiv \alpha_2 - \beta_2$.

Estimation of equation (3) allows us to capture the difference in coefficients of independent variables in mortgage demand and purchase price of house equations. This is particularly important for the variable, "gross household income." The coefficient of gross household income in mortgage demand function is the income elasticity of mortgage and the coefficient of gross household income in housing demand function is the income elasticity of purchase price of house. The difference between the two elasticity estimates (as measured by the coefficient of income in initial loan to value function) allows us to understand the role of the mortgage market institution in determining deviation in demand for mortgages in response to changes in income from demand for housing in response to changes in income. We utilize this feature to understand how these deviations move over time.

The paper estimates the three functions described above for the UK, Australia and Japan. To ascertain the equality of coefficients of various variables across these countries, a test for coefficient equality has been conducted (Chow, 1960).

5. Results

The estimates of the three functions are presented in Tables II, III and IV. The choice of FRMs negatively influenced the demand for mortgage in all three countries. The FRMs lead to smaller size debt for liquidity-constrained households. The price effect and large positive premium associated with FRMs lead to lower mortgage debt. The coefficient is much higher for Australia than for the UK and Japan. This may be due to the prevalence for VRMs to a greater extent in Australia and a likely selling of these mortgage contracts to households by financial advisers. The spread that lenders have charged for FRM over ARM is low in Australia compared to the UK. The low interest environment has continued in Australia even after GFC.

Looking at the life cycle factors, the coefficient of age has a positive sign for the UK while negative for Australia and Japan. In the UK, households tend to acquire larger properties in later stage of life (Koblyakova *et al.*, 2014) and that explains the positive sign. This is confirmed by the housing demand function (presented in Table III). The effect of age on size of property, however, is at decreasing marginal rate as indicated by small size coefficient of squared term of age variable. In case of Australia, however, while households buy larger properties as they age (as seen from positive sign of coefficient for age in housing demand function, Table III), the tendency to take out larger mortgage debt with age declines. It is likely that the risk of taking out larger loans due to the recourse nature of debt in Australia deters households from increasing their debt. While the mortgages are recourse loans in the UK and Japan as well, Australian foreclosure and bankruptcy laws operate quite expediently in case of a mortgage default compared to other two countries. Households increase their proportion of equity contribution as they buy larger houses. In Japan, the size of debt declined with age and so did housing demand. The sign of the coefficient of household size in mortgage demand function is negative for Australia and Japan while positive for the UK. In case of Australia, it could be possible that larger household size is crowding out demand for mortgage debt (Table II) and housing (Table III), but reliability on this explanation is weak as the coefficients are insignificant. The reliability on the sign of coefficients of household size in the UK and Japan is also weak due to insignificance of the estimates.

With higher number of children, households in the UK, Australia and Japan desire bigger homes and they take out bigger debts to fulfill their requirements. The positive coefficient of mortgage payment to income ratio reflects the borrowing constraints and lending market conditions. What is interesting is the relatively high payment to income ratio elasticity for mortgage demand in the UK than in Australia or Japan. This reflects that relatively the UK mortgage market is less constrained than Australia and Japan. The payment to income elasticity for housing demand (Table III) is very similar across three countries. This is important as it indicates that households do not increase their housing demand due to increase in payment to income ratio but rather increase their component of debt to finance the purchase in the UK. Given that the policies of government and lenders' attitude toward households who face income stress is accommodative and supportive in the UK (Aron and Mauellbauer 2017), despite mortgages being recourse, explains household behavior. In Japan and Australia, the recourse nature of mortgages poses restrictive conditions for households.

The most important result of the analysis is the difference in income elasticity for mortgage demand among three countries with the UK being the highest (Table II). The income elasticity of housing demand (Table III) is also higher for the UK than Australia and Japan but the difference is not as big as in the case of income elasticity of mortgage demand. One possible argument for small income elasticity of mortgage demand for Japan could be due to the narrower range of housing options or greater willingness of households to pay for

Table II. Mortgage demand function

Dependent var.: log (mortgage amount)	Regression results: Australia Coef. (S.E.)	Japan Coef. (S.E.)	UK Coef. (S.E.)	Test for coefficient equality: All F value (*p*-value)	AUS vs JPN F value (*p*-value)	AUS vs UK F value (*p*-value)
FRM = 1	−0.0630** (0.0250)	−0.0294** (0.0128)	−0.0184** (0.0083)	1.5331 (0.2159)	1.4287 (0.2320)	2.8726* (0.0901)
Age	−0.0038 (0.0056)	−0.0108** (0.0048)	0.0109** (0.0046)	5.4948*** (0.0041)	0.9026 (0.3421)	4.1055** (0.0428)
$(\text{Age}/100)^2$	0.0029 (0.0065)	0.0131*** (0.0050)	−0.0216 ***(0.0058)	10.5210*** (0.0000)	1.5640 (0.2111)	7.9908*** (0.0047)
Household size	−0.0155 (0.0125)	−0.0062(0.0062)	0.0044 (0.0074)	1.1209(0.3260)	0.4419(0.5062)	1.8692(0.1716)
Number of children	0.0321**(0.0129)	0.0313*** (0.0080)	0.0140(0.0086)	1.2807 (0.2779)	0.0025(0.9598)	1.3600(0.2436)
Log(gross household income)	0.5274*** (0.0208)	0.3356*** (0.0191)	0.8888*** (0.0119)	340.6352*** (0.0000)	46.2451*** (0.0000)	227.6039*** (0.0000)
Log(payment-to-income ratio)	0.3576*** (0.0286)	0.2807*** (0.0141)	0.8208*** (0.0134)	409.9167*** (0.0000)	5.8268** (0.0158)	215.3948*** (0.0000)
Adjusted R^2	0.6832	0.2825	0.8169			
N	3,588	5,747	2,978			

Table III. Housing demand function

Dependent var.: log (purchase price of home)	Regression results Australia Coef. (S.E.)	Japan Coef. (S.E.)	UK Coef. (S.E.)	Test for coefficient equality All F value (p-value)	AUS vs JPN F value (p-value)	AUS vs UK F value (p-value)
Age	0.0224*** (0.0058)	−0.0201*** (0.0034)	0.0172*** (0.0060)	27.4778*** (0.0000)	39.5351*** (0.0000)	0.3718 (0.5420)
$(\text{Age}/100)^2$	−0.0135** (0.0066)	0.0267*** (0.0035)	−0.0075 (0.0069)	19.9880*** (0.0000)	28.8777*** (0.0000)	0.3972 (0.5285)
Household size	−0.0087 (0.0121)	0.0139*** (0.0051)	−0.0168 (0.0106)	4.2578** (0.0142)	2.9599* (0.0854)	0.2528 (0.6151)
Number of children	0.0447*** (0.0128)	0.0027 (0.0063)	0.0525*** (0.0119)	9.3407*** (0.0001)	8.7550*** (0.0031)	0.1978 (0.6565)
Log(gross household income)	0.4059*** (0.0183)	0.3742*** (0.0152)	0.4956*** (0.0162)	15.6439*** (0.0000)	1.7821 (0.1819)	13.5332 (0.0002)
Log(payment-to-income ratio)	0.1744*** (0.0166)	0.1929*** (0.0110)	0.2055*** (0.0192)	0.7989 (0.4499)	0.8641 (0.3526)	1.4989 (0.2209)
Adjusted R^2	0.6683	0.3285	0.6763			
N	3,579	5,747	5,458			

other consumption/investment items. To see if these alternative explanations are indeed true, we look at the estimation results for (log of) purchase price of housing and the initial loan-to-value ratio functions. If mortgage demand in Japan is income inelastic due to smaller housing options or greater demand for other consumption/investment items, then income elasticity for purchase price of housing would also be small as well. The results (Table III) shows that income elasticity for purchase price of housing in Japan are similar (though statistically different in some cases) to the UK and Australia. This suggests that relatively small income elasticity for mortgage demand in Japan is a result of different lending practice (i.e. mortgage lenders in Japan tend to respond less to the rise in household income levels) and lenders' forbearance during defaults. The results are similar for Australia and Japan.

Regression results for initial LTVs are shown in Table IV. While estimated income elasticity of LTV is comparable between Australia and UK, it is strikingly different for Japan. The negative coefficient for Japan can be a result of different income responses to housing demand and mortgage lending. If richer households tend to purchase more expensive homes, whereas mortgage amount does not rise sufficiently, income elasticity for initial LTV can be negative (i.e., richer households tend to have lower LTVs). To examine this further, we separate the sample based on the purchase year of housing (prior to 1990, 1991-1995, 1996-2000, 2001-2005 and after 2006) and estimate the same regression models for LTVs. The results are shown in Table V, which shows that the negative coefficient of household income is observed only for mortgages originated between 1991 and 2000, which may be due to reluctance on the part of mortgage lenders to extend new loans. Again, this is the reflection of the mortgage market conditions, which are far easier in the UK. Aron and Muellbauer (2016) argued that in the UK, generous government policies lowered the foreclosure by 21 per cent and lenders' forbearance reduced foreclosure by an additional 13 per cent. In the UK, lenders can access other assets and other incomes of borrowers for up to seven years to settle the debt. In practice, the foreclosure happens after all other supportive policies of government and lenders fail to cure the situation, which is not frequent occurrence. In Japan in case of default the underlying lien (mortgage) is transferred from a bank to a credit guarantee company who then subrogates the debt, usually by auction. If after the auction, the company cannot recover the debt, it accesses other assets of the borrower, as the loan is recourse loan. Sometimes, short sale of underlying property is also a way that is used to recover unpaid debt. When the default is caused by a borrower's death, the outstanding debt is completely covered by private insurance company. A borrower is required by the bank to take out the life insurance. On the other hand, if default is caused by illness of a borrower and the borrower does not have insurance that covers illness, the property is foreclosed. For a brief period of December 4, 2009, until March 31, 2013, "Moratorium law" was enacted which allowed borrowers to ask lenders to change (relax) the terms of contract; amount of payment or amortization term when borrowers were facing payment stress and lenders were required to approve such requests as far as possible. However, this law has expired now. During extreme natural and economic events such as "bubble" burst in Japan, the government implicitly supported non-bank financial institutions to prevent bankruptcies due to rising defaults and allowed borrowers to negotiate their payments to reduce the burden. Generally speaking, the recourse loan is restrictive for a borrower in Japan except in cases of extreme events. Australia mortgage market is restrictive in events of default. The loans are foreclosed and disposed off in the event of default in fairly short period without much opportunity for borrower to renegotiate. Being recourse loan, lenders also have claim to other assets of borrowers to cover their loans.

Table IV. Initial loan to value ratio function

	Regression results			Test for coefficient equality		
Dependent var.: log(initial LTV)	Australia Coef. (S.E.)	Japan Coef. (S.E.)	UK Coef. (S.E.)	All F value (p-value)	AUS vs JPN F value (p-value)	AUS vs UK F value (p-value)
FRM = 1	−0.0108 (0.0229)	−0.0407*** (0.0109)	−0.0159 (0.0119)	1.4672 (0.2306)	1.3873 (0.2389)	0.0389 (0.8436)
Age	−0.0258*** (0.0055)	0.0091** (0.0042)	−0.0142** (0.0062)	13.9448*** (0.0000)	25.6830*** (0.0000)	1.9663 (0.1609)
$(\text{Age}/100)^2$	0.0160** (0.0063)	−0.0133*** (0.0043)	−0.0007 (0.0077)	7.4366*** (0.0006)	14.7073*** (0.0001)	2.8097* (0.0937)
Household size	−0.0083 (0.0133)	−0.0202*** (0.0055)	−0.0007 (0.0108)	1.4437 (0.2361)	0.6784 (0.4102)	0.1998 (0.6549)
Number of children	−0.0113 (0.0139)	0.0287*** (0.0070)	−0.0202* (0.0120)	7.8673*** (0.0004)	6.6381*** (0.0100)	0.2364 (0.6269)
Log(gross household income)	0.1257*** (0.0189)	−0.0383** (0.0151)	0.1046*** (0.0188)	29.2475*** (0.0000)	45.9413*** (0.0000)	0.6280 (0.4281)
Log(payment-to-income ratio)	0.1915*** (0.0217)	0.0878*** (0.0098)	0.3104*** (0.0235)	42.5435*** (0.0000)	19.0255*** (0.0000)	13.8019*** (0.0002)
Adjusted R^2	0.1369	0.0921	0.2431			
N	3,579	5,747	2,978			

Table V. Estimates of function incorporating time period as independent variables

Dependent var.	Log(mortgage amount) Australia Coef. (S.E.)	Japan Coef. (S.E.)	UK Coef. (S.E.)	Log(purchase price of home) Australia Coef. (S.E.)	Japan Coef. (S.E.)
Age	−0.0060 (0.0058)	−0.0108** (0.0049)	−0.0013 (0.0076)	0.0205*** (0.0056)	−0.0200*** (0.0034)
$(\text{Age}/100)^2$	0.0053 (0.0067)	0.0123** (0.0051)	−0.0071 (0.0092)	−0.0114* (0.0064)	0.0262*** (0.0036)
Household size	−0.0074 (0.0125)	−0.0056 (0.0061)	0.0122 (0.0139)	−0.0011 (0.0121)	0.0141*** (0.0051)
Number of children	0.0269** (0.0129)	0.0316*** (0.0080)	0.0097 (0.0161)	0.0395*** (0.0126)	0.0028 (0.0063)
Log(gross household income)					
Purchase year prior to 1990	0.3041*** (0.0410)	0.2419*** (0.0390)	0.5506*** (0.0557)	0.2045*** (0.0334)	0.2919*** (0.0310)
Between 1991 and 1995	0.4528*** (0.0397)	0.2429*** (0.0369)	0.6806*** (0.0488)	0.3356*** (0.0379)	0.3589*** (0.0268)
Between 1996 and 2000	0.5354*** (0.0285)	0.3587*** (0.0261)	0.712*** (0.0460)	0.3995*** (0.0252)	0.3754*** (0.0222)
Between 2001 and 2005	0.6029*** (0.0330)	0.4329*** (0.0330)	0.8008*** (0.0201)	0.5446*** (0.0323)	0.438*** (0.0265)
After 2006	0.6194*** (0.0359)	0.5107*** (0.0609)	0.792*** (0.0187)	0.3774*** (0.0498)	0.4819*** (0.0647)
Log(payment-to-income ratio)	0.3560*** (0.0285)	0.2765*** (0.0141)	0.6382*** (0.0252)	0.1738*** (0.0163)	0.1908*** (0.0111)
Adjusted R^2	0.6879	0.2865	0.5515	0.6741	0.3309
N	3,588	5,747	5,227	3,579	5,747

Notes: ***, **and *indicate that the estimated coefficient is significant at 1%, 5% and 10%, respectively. Robust standard errors are given in parentheses. Fixed effects for urban/rural area, regions and year of mortgage origination are controlled in all estimation but omitted from the results

(*continued*)

Table V.

Dependent var.	Log(purchase price of home) UK Coef. (S.E.)	Australia Coef. (S.E.)	Log(initial LTV) Japan Coef. (S.E.)	UK Coef. (S.E.)
Age	0.0175*** (0.0061)	−0.0262*** (0.0055)	0.0093** (0.0042)	−0.0152 (0.0094)
$(Age/100)^2$	−0.0088 (0.0069)	0.0164*** (0.0063)	−0.0139*** (0.0043)	−0.0023 (0.0111)
Household size	−0.0110 (0.0105)	−0.0072 (0.0134)	−0.0197*** (0.0055)	0.0289* (0.0166)
Number of children	0.0442*** (0.0118)	−0.0120 (0.0139)	0.0288*** (0.0070)	−0.0424** (0.0184)
Log(gross household income)				
Purchase year prior to 1990	0.3763*** (0.0339)	0.1007*** (0.0326)	−0.0500* (0.0260)	0.1752*** (0.0603)
Between 1991 and 1995	0.3973*** (0.0320)	0.1213*** (0.0341)	−0.1159*** (0.0349)	0.274*** (0.0512)
Between 1996 and 2000	0.4515*** (0.0422)	0.1392*** (0.0276)	−0.0167(0.0231)	0.2619*** (0.0596)
Between 2001 and 2005	0.6475*** (0.0215)	0.0621* (0.0321)	−0.0051(0.0273)	0.1512*** (0.0243)
After 2006	0.596*** (0.0194)	0.246*** (0.0467)	0.0287(0.0576)	0.1946*** (0.0239)
Log(payment-to-income ratio)	0.1962*** (0.0188)	0.1913*** (0.0216)	0.0857*** (0.0099)	0.4479*** (0.0307)
Adjusted R^2	0.6813	0.1413	0.0916	0.1816
N	5,458	3,579	5,747	5,227

The discussion above indicates that the mortgage market regulatory framework and institutional culture plays an important role in determining mortgage demand. This is an important area for future research.

6. Conclusion

This paper analyses the mortgage demand and housing demand in the UK, Australia and Japan. There are large differences in mortgage systems among these three countries, for instance, type of mortgage instrument (ARM vs FRM), length of fixed period of FRM, conditions of prepayment, tax treatment, lenders' constraints (mortgage payment to income ratio, downpayment to house value ratio) etc., which impact borrowers' choice of mortgage and its demand. The comparative analysis, however, brings out interesting results related to mortgage and housing demand, the most important being the mortgage institutional structure particularly related to foreclosure. For the markets where the mortgages are recourse loans, borrowers may borrow less compared to markets that have non-recourse loans because in the case of default, recourse loans allow lenders to foreclose any asset in addition to the mortgaged property to recover outstanding loans. This is particularly true during declining house price conditions. While the mortgage in the UK is a recourse loan like Australia and Japan, lenders foreclose properties only in extreme situations where government support or lenders renegotiations do not alleviate borrowers' payment stress. This is not the case in Japan and Australia. This has resulted in higher income elasticity of mortgage demand in the UK than the other two markets.

An interesting finding from the study is that though there are large differences in the mortgage system (market) among three countries, borrowers when they choose an FRM their mortgage amounts are less than otherwise. Further to the conclusions of Naoi, Moriizumi and Yukutake (2013) and Koblyakova *et al.* (2014), where they show that a risky borrower chooses ARM as mortgage instrument, this paper shows that, in addition, an FRM borrower borrows less than an ARM borrower. This reinforces further that FRM borrowers are less risky than ARM borrowers. The FRM borrower is not a short-sighted decision maker and makes its plan including repayment of loan on a long-term basis despite of length of the fixed term that is available in the market. Therefore, the choice of mortgage instrument is a good screening device for distinguishing between a safe borrower and a risky borrower.

Housing market conditions have also played an important role in determining mortgage demand. During the period of analysis in this paper, while Australia experienced secular rise in house prices, Japan suffered from constant decline. The UK also witnessed upward trend in house prices from 1990 onwards except after the GFC when the prices fell. If we look at the function with initial LTV as a dependent variable, the income coefficient for Japan turned out to be negative for mortgages originated between 1991 and 1995, the period in which Japan's house price dropped significantly after the bubble burst, the so-called "lost decade(s)".

As is often said that the Japanese are in general risk-averse, households do not like to borrow much, even though they are in the highest income class. High-income households save more for the downpayment, which implies that the mortgage penetration at the economy level is very low. In fact, from the micro data, it is evident that a household does not borrow much, which implies low income elasticity of mortgage demand. In other words, attitudes toward risk are different among the three countries and this is reflected in the income elasticity of mortgage demand. Risk also arises from the way foreclosure laws are implemented. In Japan and Australia, the laws are implemented expediently in comparison to the UK. This leads to lower elasticity of mortgage demand in Australia and Japan than

the UK. The income elasticity for the UK is the largest among the three countries. This implies that the impact of change in mortgage market such as the rise and fall of mortgage rate, increase in number of default, arrears or delinquency etc., on monetary market in the UK is the strongest in the three countries. This is consistent with the fact that during the GFC the UK was affected most significantly among the three countries.

Demographic factors also explain the differences in mortgage demand between three countries. The population is growing in the UK and in Australia, while it is declining in Japan. Japan has been suffering from fertility decline for a long period. Even though fertility is declining in Australia and the UK, population is increasing owing to migration. These demographic factors impact income elasticity of housing demand because households demand less house space due to the decline in the number of children. Declining fertility can prompt inter-vivos transfer or increase its amount, while it reduces the mortgage demand.

Increasing population in Australia and the UK has a strong pressure for housing demand, causing mortgage demand to rise. On the contrary there is an excess supply in housing market in Japan, which may imply that the mortgage market in Japan may not be as active as in Australia and the UK. Further investigation indicates that as age of household advances a household borrows more until certain age in Australia and the UK, however, the impact of age on mortgage borrowing is opposite in Japan. Households borrow more during young age in Australia and the UK. In Japan, however, due to excess supply in the housing market, low fertility and high ageing rates, borrowers borrow less. This suggests that the linkage between mortgage and monetary markets will be weak in the future in Japan, while those of Australia and the UK will be stronger for a long time.

References

Aron, J. and Mauellbauer, J. (2017), "Modelling and forecasting mortgage delinquency and foreclosure in the UK", *Journal of Urban Economics*, Vol. 94, pp. 32-53.

Badarinza, C., Campbell, J. and Ramadorai, T. (2017), What Calls to ARMs? International Evidence on Interest Rates and the Choice of Adjustable Rate Mortgages. *Management Science*, Vol. 64 No. 5, pp. 2275-2288.

Bell, M. and Lowe, R. (2000), "Building Regulation and Sustainable Housing. Part 1. A Critique of Part L of the Building Regulations 1995 for England and Wales", *Structural Survey*, Vol. 18 No. 1, pp. 28-37.

Besley, T., Meads, N. and Surico, P. (2010), "Risk Heterogeneity and Credit Supply: evidence from the mortgage market", Bank of England Discussion Paper 29.

Campbell, J. (2012), "Mortgage Market Design", *Review of Finance*, Vol. 17 No. 1, pp. 1-33.

Campbell, J. and Cocco, J. (2003), "Household risk management and optimal mortgage choice", *Quarterly Journal of Economics* November, pp. 1449-1494.

Cho, Y., Hwang, S. and Satchell, S. (2012), "The optimal mortgage loan portfolio in UK regional residential real estate", *The Journal of Real Estate Finance and Economics*, Vol. 45 No. 3, pp. 645-77.

Chow G. (1960), "Test of Equality Between Sets of Coefficients in Two Linear Regressions", *Econometrica*, pp. 28-3.

Dow, S. and Montagoni, A. (2007), "The regional transmission of UK monetary policy", *Regional Studies*, Vol. 41 No. 6, pp. 797-808.

Duca, J., Muellbauer, J. and Murphy, A. (2010), Housing Markets and the Financial Crisis of 2007-2009: Lessons for the Future. *Journal of Financial Stability*, Vol. 6 No. 4, pp. 203-217.

Evans P. and Mccormick B. (1994), "The new pattern of regional unemployment: causes and policy significance", *Economic Journal*, Vol. 104, pp. 633-647.

Follain J. (1990), "Mortgage choice", *AREUEA Journal*, Vol. 18 No. 2, pp. 125-144.

Follain J. and Dunsky R. (1997), "The demand for mortgage debt and the income tax", *Journal of Housing Research*, Vol. 8(2), pp. 155-200.

Jones L. (1993),"The demand for home mortgage debt", *Journal of Urban Economics*, Vol. 33, pp. 10-28.

Koblyakova, A. Hutchison, N. and Tiwari, P. (2014),"Regional Differences in Mortgage Demand and Mortgage Instrument Choice in the UK", *Regional Studies*, Vol. 48 No. 9, pp. 1499-1513.

Lea, M. (2010), "Sources of funds for mortgage finance". *Journal of Housing Research*, Vol. 1 No. 1, pp. 87-98.

Leece, D. (2004), "*Economics of the Mortgage Market: Perspectives on Household Decision Making*", Blackwell, London.

Leece, D. (2006), "Testing a theoretical model of mortgage demand on UK data", *Applied Economics*, Vol. 38, pp. 2037-2051.

Levin, E., Montagnoli, A. and Wright, R. (2009), "Demographic change and the housing market: evidence from a comparison of Scotland and England", *Urban Studies*, Vol. 46 No. 1, pp. 27-43.

Ling D. and Mcgill G. (1998), "Evidence on the demand for mortgage debt by owner-occupiers", *Journal of Urban Economics*, Vol. 44, pp. 391-414.

Moriizumi, Y. (2015), "*International Comparison of Housing and Mortgage Markets: Australia, Japan and the United Kingdom*", mimeo, New York.

Naoi, M., Moriizumi, Y. and Yukutake, N. (2013), "Income Risk and Mortgage Choice among Japanese Households", February, available: at SSRN

Taltavull De La Paz, P. and White, M. (2012), "Fundamental drivers of house price change: the role of money, mortgages, and migration in Spain and the United Kingdom", *Journal of Property Research*, 29 No. 4, pp. 341-367.

Further Reading

Alm, J. and Follain, J. (1987), "*Consumer demand for adjustable rate mortgages*", Housing Finance Review 6, pp. 11-17.

Brueckner, J. (1986), "The pricing of interest rate caps and consumer choice in the market for adjustable-rate mortgages", *Housing Finance Review*, Vol. 5, pp. 119-136.

Brueckner, J. (1994), "The demand for mortgage debt: some basic results", *Journal of Housing Economics*, Vol. 3 No. 4, pp. 1-21.

Brueckner, J. and Follain, J. (1988), "The rise and fall of the ARM: an econometric analysis of mortgage choice", *Review of Economics and Statistics*, Vol. 10, pp. 93-102.

Campbell, J. and Cocco, J. (2007), "How do house prices affect consumption? Evidence from micro data", *Journal of Monetary Economics*, Vol. 54, pp. 591-621.

Leece, D. (2000), "Household choice between fixed and floating rate debt: a binomial probit model with correction for classification error", *Oxford Bulletin of Economics and Statistics*, Vol. 62, pp. 61-82.

Leece, D. (2001), "Regressive interest rates expectations and mortgage instrument choice in the United Kingdom housing market", *Real Estate Economics*, Vol. 29, pp. 589-614.

Meador, M. (1992), "The effect of mortgage laws on home mortgage rates", *Journal of Economics and Business*, 34(2), pp. 143-148.

Miles, D. (2003), "The UK Mortgage Market: Taking a Longer-Term View – Interim Report", HM Treasury, London.

Miles, D. (2004), "The UK Mortgage Market: Taking a Longer-Term View – Final Report", HM Treasury, London.

Ostas, J. (1977), "Regional differences in mortgage financing costs: a re-examination", *Journal of Finance*, Vol. 32 No. 5, pp. 1774-1778.

Schaaf, A.H. (1966), "Regional differences in mortgage financing costs", *Journal of Finance*, Vol. 21, pp. 85-94.

Tsatsaronis, K. and Zhu, H. (2004), "What drives housing price dynamics: cross-country evidence", BIS Quarterly Review, Vickery, J. (2006), "Interest Rates and Consumer Choice in the Residential Mortgage Market", Federal Reserve Bank of New York Working Paper, pp. 65-78.

Dungey, M., Tchatoka, F., Wells, G. and Yanotti, M. (2015), "Mortgage choice determinants: the role of risk and bank regulation", *Economic Record*, Vol. 91 No. 295, pp. 417-437.

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Prescience evidence of the housing market and production sector performance nexus

Insights from Malta

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Abstract

Purpose – Observation of misalignment of the house prices with fundamentals in Malta was recently investigated (Vakili-Zad and Hoekstra, 2011; Micallef, 2018). As such, this study aims to investigate nexus evidence of the housing market and production sector performance in Malta by using quarterly data spanning from 2005Q1 to 2016Q4.

Design/methodology/approach – Industrial expansion and development indicator-producer price index (ppi) and unemployment (uem) are used along with volatility index (vix) and fertility rate (frate) as control variables in a multivariate autoregressive distributed lag approach.

Findings – Precisely, the investigation reveals that any disequilibrium in the long-run equilibrium among these variables is subsequently corrected by the movement in the housing market vis-à-vis real residential property price. As the system is observed to adjust with a speed of 39.7 per cent in a situation of economic disequilibrium, the long-run impacts on the housing market are positive for ppi and vix but negative for frate and eum. The observed direction of the impacts in the short-run are the same as in the long-run for all variables. A reported sensitivity test indicates a very minimal differential impact for each variable in the long-run but with a significantly different adjustment parameter of 81.9 per cent. Also, the estimated system posits a very stable model that is void of serial correlation and heteroskedasticity.

Research limitations/implications – In view of the vibrant nature of the real estate and the housing sector of the country, consideration of the effective policy instruments provided by this study is strongly encouraged. On a wider note, these practicable tools could further be recommended to other regional countries.

Originality/value – The research presents a novel perspective of the real estate and housing sector of Malta, specifically in the light of economic diversification. The country's housing sector is studied in relation with the performance of other sectors for the first time.

Keywords Unemployment, Housing market, ARDL-bound testing, Dynamic relationship, Producer price index, Republic of Malta

Paper type Research paper

1. Introduction

Humans' basic concerns are not far from challenges associated with lacks or inadequacies of food, health, and shelter. Availability of shelter especially with the modern housing features has continued to share prior stone-age intentions for housing; the original purposes of protection and sense of personal independence among other reasons. World Bank housing

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finance statement key message which states "Housing plays a key socio-economic role and represents the main wealth of the poor in most developing countries" (World Bank, 2017) speaks more of the importance of housing. Importantly, most analysts and researchers attributed the last financial crisis that plagued the USA economy into recession (global recession) to housing prices simply because of its impact on human basic needs. Preceding the event to the global financial crisis, quality studies have revealed the impact and relationship between house price and handful of macroeconomics (Kishor and Marfatia, 2017), financial (Estrella and Mishkin, 1998 and Aoki, Proudman and Vlieghe, 2004), and socio-economic variables (Luttik, 2000). Factors like the population, dependency ratio, unemployment, income/wage pressure or rate, interest rate, mortgage rate, construction cost, marriage or marital status, migration patterns, and among other perceived variables have been linked with house price. For instance, population was reported by the United Nations (UN, 2017) to be a vital indicator of housing prices. The report observed that about 83 million people is currently being added to global population annually as the trend projects the increase of the world population from 7.6 billion people in 2017 to 8.6 billion, 9.8 billion and 11.2 billion in 2030, 2050 and 2100 respectively. The report also maintained that 962 million people are currently over 60 years of age in 2017, but predicted to move up to 2.1 billion and 3.1 billion in 2050 and 2100 respectively. This information, in addition to other challenges like rapid urbanisation and ageing were reported to exhibit certain characteristics with housing delivery systems across the globe.

Here, adopting a simplified methodology, Reichert (1990) previously detailed the microeconomic aspects of demand and supply parameters of the housing effect. The demand induced factors as studied by Pitkin and Myers (1994) and Flavin and Yamashita (2002) in addition to the supply-related effects examined by Painter and Redfearn (2002) and Ball *et al.* (2010) forms the literature guides in the studying housing price the dynamics. Also, non-economic and finance-related variables have been empirically observed to have significant impact on house prices. Governmental and institutional policies such as the land-use policy and tax reform among others (Bajic, 1983; Campbell and Cocco, 2007; Ihlanfeldt, 2007; Katz and Rosen, 1987; Pollakowski and Wachter, 1990) have also been studied within the framework of house prices. Conversely, the impact of house prices on some of the aforementioned variables has been widely studied (Johnes and Hyclak, 1999; Meen, 2003; Hämäläinen and Böckerman, 2004). An error correction model was adopted by Johnes and Hyclak (1999) which gave significant evidence that unemployment and labour force affect house prices and conversely that house prices is a determinant of the size of labour force. Evidences of volatility in housing price dynamics (Case and Shiller, 2003; Case *et al.*, 2005) which was discovered to be similar to that of stock market (Ding, Granger and Engle, 1993) continued to be source of interest to researchers. These were consistent with the observations of Luo *et al.* (2007) which noted that the dynamics of housing prices were evidently regarded as unstable in nature.

The motivation for this study is built on the evidence of Malta's geographical and strategic location. Malta is a crossing-bridge at central Mediterranean region that inter-locks countries and continents. This is in addition to the fact that the subject of housing market has not been painstakingly and quantitatively studied using the country as a case study at least to the best of authors' knowledge. In spite of the size of the country and the perceived unavailability of larger sample size as noted in previous study, the current industrial and economic expansion makes the study of the Malta's housing market an interesting research subject. An earlier study by Abelson *et al.* (2005) investigated house prices in the context of consumer price index (CPI) indicator. The novelty of this study is that the nexus of housing market *vis-à-vis* real residential property price and the performance or expansion of the country's manufacturing/production industry is investigated. As the country manufacturing

industry is reported to be one of the most active sector, the study appropriately captures the sector's activities with the producer price index and unemployment rate. Accordingly, the study is aimed at establishing a dynamic nexus of the housing market and the sector performance *vis-à-vis* producer price index (Figure 1 presents a perceived relation or co-movement). Also, in this autoregressive distributed lag (ARDL) approach and incorporating fertility rate and a control variable (volatility index), the dynamic impacts of these variables are observed. Hence, this study adds to the existing literature by providing empirical evidence of cointegration of the real residential property price with unemployment rate and producer price index by using a quarterly dataset spanning 2005Q1 to 2016Q4.

The other sections of this paper are arranged as follow. Section 2 highlights the pattern and development of production and manufacturing sector of Malta in conjunction with the country's housing market. Data description and the empirical techniques used form the content of Section 3, and results interpretations are summarised in Section 4. A concluding remark with policy implication insight is detailed in Section 5.

2. The housing market studies: review of extant literature

Consistent studies continue to reveal intriguing and more interesting behavioural pattern associated with house price or housing indices. Notable of these is the work of Mankiw and Weil (1989) which investigates the relationship between house prices and ageing. The study by Hiller and Lerbs (2016) recently investigate the relationship between housing price and population. The study technically simplified population effect to three distinct perspective; the investment demand effect, the age effect and the size effect (size of the population). The work pointed that total population is less important compared to household size. It was argued that if household sized, i.e. number of people in a family decreases dues to family members' independence, divorce, etc., housing price would expectedly increase because the number of people in need of housing will increase. Hiller and Lerbs (2016) further investigates the relationship between changes to age distribution and housing price using 87 German cities with strong cross-sectional dependence from 1995 to 2014. In the study, a mixed-regression spatial panel model with an underlying multivariate framework was used. A minimal increase in the real urban housing price across cities with more aged people and heterogeneous effects caused by populations aging across housing segments was the result

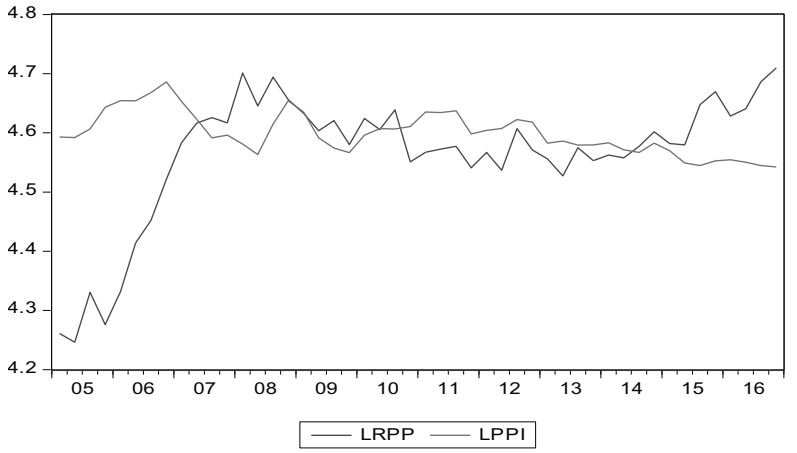

Figure 1. Graphical evidence of a co-movement of ln*rpp* and ln*ppi*

of the study. Park *et al.* (2017) advanced the study using panel regression which evidently showed significant evidence of inverse correlation between housing prices and dependency ratio in overall regional market. But the study further reveals a positive correlation between housing prices and real gross domestic product (GDP) per capita in each region.

Besides, Sirmans *et al.* (2005) used hedonic regression analysis to estimate the marginal contribution of each of the eight enumerated characteristics of macroeconomics to house prices. Sirmans *et al.* (2005) characterised the macroeconomics variables affecting house prices as construction and structure variables, external house features, environmental neighbourhood and location factors, internal house features, natural and environmental characteristics, marketing, occupancy and selling factors, public service amenities, and financial issues. The notable study of Tu (2000, 2004) identified the importance of real GDP per capita, total housing stock, inflationary effects affordability, housing finance and supply, and demographic variables on house prices. The dynamics of house prices as caused by its determinants paved way to the study by Berry and Dalton (2004) in grouping these housing price determinants as institutional, short-run and long-run factors. The institutional factors are the government taxes and levies and the short-run factors include investment demands and interest rate. The long-run factors are wealth level, economic growth and demographics. Similarly, the work of Canarella *et al.* (2012) empirically noted the dynamics of housing price as caused by effect of shocks to the capital gain series which could either be permanent or transitory depending on the test assumptions as the result indicates evidence of lack of uniformity. The aforementioned finding corroborates the investigation of housing supply elasticity (Harter-Dreiman, 2004), an investigation that relates the housing price movement with income shocks. Investigating house prices in Australia, both Abelson and Chung (2005) and Abelson *et al.* (2005) reported the unavailability or lack of reliable published data for housing prices in the country which led to estimation of authoritative account of apartment and house prices across Australia. Explaining the pattern of house prices in the same country, Abelson *et al.* (2005) noted long-run equilibrium and short-run asymmetric error correction of housing price dynamics. It revealed empirically that both real disposable income and consumer price index significantly and positively determines house prices. Additionally, the study reveals that real mortgage rates, unemployment rate, housing stock and equity prices have negatively significant effect on Australia's house prices.

2.1 The housing market dynamics and industrial expansion in Malta

The island of the Republic of Malta, located in southern European and central Mediterranean is one the third smallest and most densely populated European country with a total population of less than half a million people and its capital, Valletta ranked as the smallest by area among European Union (EU) capitals. The country's financial and economic landscape is known to have changed over time, this include its accession to EU membership in 2004 in addition to the official adoption of the euro as the national currency in 2008 (Central Bank of Malta, 2017). Although, the country's small land size seems to be rapidly used, the geographical location as shown in Figure 2 continue to be a major benefit in that it serves as connecting bridge between countries. Maltese island's resilient economy with a buoyant GDP of €9.9bn by 2016 was noted as the second fasted growing economy among the EU countries.

Malta competitive advantage is its lower industrial cost base, as the island country is reported to have a considerably lower cost than continental Europe that has enhanced the country's regional and continental business penetrations (Malta Profile, 2017). This industrial sector, the fastest growing sector due to the government's diversification policy accounts for about US$4.938 billion in export and making it the second to services the highest contributor to GDP with a value of about 13 per cent. The diversification policy of

Source: © Google Maps

Figure 2. The map of Republic of Malta

the government has seen the sector innovatively sub-divided into automotive components, medical devices, pharmaceuticals, electronic components, precision engineering and injection moulding. This diversification strategy has increased flexibility and resilience of the economy and such ensuring the country's resistance to economic and industry-specific disturbance and external disturbances like political unrest within the region (this include Arab spring and Syria unrest among others).

Tourist arrivals and significant earnings from the tourism sector has consistently positioned Malta as tourists and investors' hub (Boissevain, 1977; Katircioglu, 2009; Oglethorpe, 1985). Strategically at the heart of the Mediterranean, tourist destination and connecting hub of regional and Coastline Mediterranean Country (Alola and Alola, 2018), the country is diversifying its economy. This has recently informed government's aim at replicating the progressive success recorded in the country's tourism development in the manufacturing and production sector of the economy. Intuitively, with Malta been regarded as one of the world's most densely populated country and given the favourable economic outlook, significant economic expansion relative to its housing sector is unavoidable. The works of Bianco (2006), Vakili-Zad (2006); Darmanin (2008), Camilleri (2011); Vakili-Zad and Hoekstra (2011), Falzon and Bezzina (2013); Falzon and Lanzon (2013) and Micallef (2018) are among the existing studies on the real estate and housing market in Malta. Interestingly, Bianco (2006) examined the housing and real estate market of Malta as the country gained European Union (EU) accession. Using an experimental year of 1980 to 2005 (far below the span year of the current study, 2005Q1-2016Q4), Bianco (2006) expressed the importance of environmental planning awareness, residential typologies, and the built and new aesthetic to the housing and real estate market. Also, in their study of the Malta's housing dynamics, Vakili-Zad and Hoekstra (2011) empirically observed the age-long and unusual tandem of vacancy rate of dwellings and housing prices. The study maintained that the housing market in Malta is such that exhibits some contradictory forces which obviously defy the law of demand and supply. However, their comprehensive study further investigated and carefully detailed the factors possibly responsible for such unusual anomaly in the country's

housing market. These factors were considered to include; the influence of the church, the Maltese family tradition, clientelist state and political parties, rent control and policies, inadequate of alternative investment mechanism, economy and employment, and the ripple effect associated with the trajectory increase in housing prices. On a different note, the concern of the misalignment of the housing dynamics with its fundamentals is expressed and further examined recently by Micallef (2018). In the study, the CBM property price index (based on advertised prices from newspapers) and the NSO index (based on contracted prices from Inland Revenue Department) were constructed and chain-linked. It further noted a differential price recoveries such that the advertised house prices were observed to be slightly overvalued as against the contract prices in 2017. As a major producer of machinery and mechanical appliances, mineral fuels, pharmaceutical products, aircraft and parts, games and sports equipment, and among other industrial activities, the observed dynamics in the housing market amidst the industrial and economic revolution observed in Malta is of importance.

3. Data and empirical specifications

3.1 Data

This study uses a balanced quarterly data that spans from 2005Q1 to 2016Q4 for the multivariate time series investigation. The housing market data for Malta used in this study is the Real Residential Property Prices for Malta (henceforth denoted as *rpp*, a not seasonally adjusted index 2010 = 100) which was obtained from the online database of ST. Louis FED (FRED, 2018). Also, the International financial statistics database of the International Monetary Fund (International financial statistics, 2017) is the source of the producer price index (*ppi*), fertility rate (*frate*), and the unemployment rate (*uem*) of the population that were employed for the investigation. While *frate* (a proxy for population growth) could account for the unobserved "local or domestic" determinants of the housing market, we equally use Chicago Board Options Exchange (CBOE) volatility index (*vix*) to accounts for global factors (factors like the crude oil price). The Real Residential Property Prices (*rpp*) index is the dependent variable while the other variables are the explanatory variables. From extant literature, studies have shown considerable relationship between most of the aforementioned variables and the housing market. The link between unemployment and the housing market was presented by Abelson *et al.* (2005) and Johnes and Hyclak (1999), population-housing dynamics contained in Hiller and Lerbs (2016). Moreover, the suitability of variables for this investigation is further confirmed by the correlation estimates presented in the Table I. Also, the Table I presents the descriptive statistics of the dataset.

3.1.1 Model specification. Reichert (1990) in his study approached changes in real housing prices using a reduced form equilibrium model. The model was developed for an eight-factor model which was modification that reflects the equilibrium of supply and demand housing services.

Given that housing prices (HP) is represented as a function of quantity demand (Q^d_t) and quantity supplied (Q^s_t) of housing during a period *t* as:

$$rpp_t = f\left(Q^d{}_t, Q^s{}_t\right) \tag{1}$$

The study by Kishor and Marfatia (2017) also recently investigated the relationship between house prices, personal disposable income and interest rates as components of demand and supply in housing market. Park *et al.* (2017) adopted a similar approach used for the housing demand and supply components by Kishor and Marfatia (2017). In the new approach, Park *et al.* (2017) also considered the equilibrium of housing demand and supply by incorporating

Var.	Mean	Median	Max./Min.	Skewness	Kurtosis	Jarque-Bera
log*rpp*	4.5630	4.5710	4.710/4.246	−1.5413	4.8696	25.9959*
log*frate*	0.3409	0.3507	0.372/0.300	−0.2699	1.4957	5.1087
log*ppi*	4.5992	4.5946	4.686/4.543	0.3864	2.4468	1.8063
log*uem*	1.8255	1.8516	1.988/1.442	−1.0370	4.0426	10.7757*
log*vix*	2.8941	2.8129	4.071/2.401	1.1788	4.3825	14.9398*

Number of observations for each estimate is 48

Correlation

	log*rpp*	log*vix*	log*uem*	log*frate*	log*ppi*
log*rpp*	1.00				
	–				
log*vix*	0.4572*	1.00			
	(0.0011)	–			
log*uem*	−0.5513*	0.0720	1.00		
	(0.0000)	(0.6266)	–		
log*frate*	0.4134*	0.2713	−0.6075*	1.00	
	(0.0035)	(0.0622)	(0.0000)	–	
log*ppi*	−0.3711*	0.0665	0.6118*	−0.4555*	1.00
	(0.0094)	(0.6533)	(0.0000)	(0.0011)	–

Notes: Var. is the variable name and *rejects null hypothesis for normal distribution at 1% significance level. Max./Min. implies maximum/minimum. Also, the information from the correlation estimates indicate a statistically significant (at 1%) correlation between the dependent variable log*rpp* and the regressors

Table I. Descriptive statistics and the correlation estimates of the variables

the fluctuation rate of per capita real Gross Domestic Product (*gdp*), fluctuation rate of population and dependency ratio.

Within similar context, the housing demand and housing supply equilibrium model for the island of Malta as presented in equation (1) above *vis-à-vis rpp = f (ppi, frate, uem, vix)* is given as:

$$rpp_t = \alpha_i + \beta_1 ppi_t + \beta_2 frate_t + \beta_3 uem_t + \beta_4 vix_t + \varepsilon_t \tag{2}$$

presents the hedonic housing model with demand and supply components such that the periods $t = 1, 2, \ldots$ 2016Q4. Additionally, using the natural logarithm of the above expression which indirectly solve the hetereoscadacity issue by enhance uniformity of data presents:

$$\log rpp_t = \alpha_i + \beta_1 \log ppit + \beta_2 \log frate_t + \beta_3 \log uem_t + \beta_4 \log vix_t + \varepsilon_{tt} + \varepsilon_t \tag{3}$$

3.2 Empirical specifications

Before investigating the aforementioned relationship between fluctuation in housing prices and producer price index movement using the desired models, it is interesting to ascertain the stationarity of the variables. In investigating the order of integration, i.e. $I(0)$ or $I(1)$, the Augmented Dickey-Fuller (ADF), Phillips Perron (PP) and KPSS[1] are adopted for this purpose.

3.2.1 Unit root and structural break tests. It is econometrically essential to investigate statistical properties of a series over a period of time in a stationary level, i.e. whenever a series is constant over time. Using the Augmented Dickey-Fuller (ADF) test approach by

Said and Dickey (1984) and assuming dynamic data ARMA (*p, q*) structure, the null hypothesis that a time series y_t is non-stationary against the alternative that it is stationary used. The ADF test is implied below:

$$y_t = \beta' \mathbf{D}_t + \phi y_{t-1} + \sum_{j=1}^{p} \psi j \Delta y_{t-j} + \varepsilon_t \tag{4}$$

where the p is the lag difference terms which is set such that the error term ε_t is serially uncorrelated and homoscedastic. The $\mathbf{D_t}$ is a vector of deterministic terms which are constant, time trend, e.t.c. And the null hypothesis (*H0*) of y_t is non-stationary, i.e. *I*(1) given $\phi = 1$ as against the alternative hypothesis (*H1*). The series ln*hp,* ln*rgdpi* and ln*ppi* in this case are independently assumed the value of y_t of the equation (4) and the estimations expressed in Table II. Additionally, a non-stationarity or unit root test by Phillips and Perron (1988, p. 480) which was commonly used in financial time series became advantageous in that it preferably deals with issues of serial correlation and Heteroscedasticity in the errors than the ADF and does not have to specify lag length. The representation for the Phillips Perron (PP) unit root test is given as:

$$\Delta y_t =_{=} \beta' \mathbf{D}_t + \pi y_{t-1} + \mu_t \tag{5}$$

although the error term μ_t which is expectedly stationary *I*(0) may be also be heteroskedastic, such anomaly together with serial correction is corrected by the PP test while producing a modified test statistics Z_t and Z_π from the normal statistics $t_{\pi=0}$ and $T\hat{\pi}$. Phillips and Perron (1988, p. 480) gives a detail expression of the modified statistics which possess similar asymptotic distributions as the ADF t-statistics and normalised bias statistics such that the null hypothesis is given that $\pi = 0$ while the alternative $\pi \neq 0$. The vectors of deterministic $\mathbf{D}_t$ of constant, time trend, etc. for each series ln*hp,* ln*rgdpi* and ln*ppi* estimated from the equation (5) is represented in Table II. Furthermore, the bottom part of Table II indicates Zivot-Andrews (ZA) (2002) unit root test result. With the ZA test by Zivot and Andrews (2002), the null hypothesis that there is a unit root under a single structural break cannot be entirely rejected at the level forms for all log*frate*, log*uem* and log*vix* series. But, partial evidence of stationarity was observed for log*rpp* and log*ppi* series. However, upon the first difference transformation, the series were all stationary.

3.2.2 Autoregressive distributed lag-bounds test approach. Our study used the uniqueness of the Autoregressive distributed lag (ARDL)-bound testing model as presented by Pesaran *et al.* (2001). The model specification is used because it is acknowledged to be insensitivity to sample size as well capable to model datasets with mixed order of integration, i.e. *I*(0) or *I*(1) except for *I*(2). Here the output statistics (Wald statistics or joint F-statistics) is compared with the set of critical values variables; the lower bound critical values are estimated with assumption that variables are *I*(0) and the upper bound critical values are estimated with assumption that the variables are *I*(1). As such, the evidence of long-run cointegration in the system is established when the F-statistic is greater (>) than the upper bound critical value, the case when the null hypothesis of no cointegration is rejected. Alternatively, we fail to reject the null hypothesis of no cointegration when the F-statistics is less than (<) the lower bound critical value. The result could be inconclusive when the estimated F-statistics is shown to be between the two values. As the test is sensitive to lag selection, the lag selection information criteria mostly by Akaike (AIC) and Schwarz (SIC) are used before performing the bound test. Also, the suitability of the expected model is tested for serial correlation, heteroscedasticity and stability tests. This

Table II. The Unit root and structural break tests

Variables	ADF Test I	ADF Test I + T	Phillips Perron Test I	Phillips Perron Test I + T	Stationarity Statement	
log*rpp*	−3.2597**	−2.8035	−2.6197	−2.3437		
Δlog*rpp*	−8.5924*	−8.8297*	−8.3458*	−8.5805*	log*rpp* is I (1), partially mixed	
log*ppi*	−2.4289	−4.5226*	−1.7133	−2.8158		
Δlog*Ppi*	−5.608675*	−5.6094*	−5.8715*	−6.6652*	log*ppi* is I (1), partially mixed	
log*frate*	−1.3281	−2.2668	−2.2185	−3.1031		
Δlog*frate*	−6.5151*	−6.3989*	−6.6621*	−6.5904*	ln*frate* is I (1)	
log*uem*	−0.2157	−1.6416	0.5466	−1.2807		
Δlog*uem*	−8.9408*	−9.0920*	−9.0066*	−9.2681*	log*uem* is I(1)	
log*vix*	−2.437875	−2.454375	−2.350500	−2.292759		
Δlog*vix*	−7.291678*	−7.276170*	−8.022198*	−9.132084*	log*vix* is I (1)	
ZA	ZA_I	ZA_T	ZA_B	ΔZA_I	ΔZA_T	ΔZA_B
log*rpp*	−3.1694	−5.2482*	−3.1694	−4.1675	−5.2053*	−5.0994*
Time Break	2010Q4	2014Q2	2010Q4	2008Q2	2009Q3	2009Q1
log*ppi*	−5.6775*	−4.7872**	−5.6592*	−5.3857*	−5.7734*	−6.8661*
Time Break	2010Q4	2012Q4	2010Q4	2008Q3	2011Q2	2008Q2
log*frate*	−3.2888	−4.16388	−3.96587	−7.5494*	−6.8584*	−7.4142*
Time Break	2014Q1	2012Q2	2012Q1	2008Q4	2009Q2	2008Q4
log*uem*	−2.9261	−2.8839	−2.9597	−10.0606*	−9.6089*	−9.9165*
Time Break	2009Q1	2013Q4	2013Q2	2008Q4	2009Q3	2008Q4
log*vix*	−4.44975	−4.13472	−4.43979	−7.95028*	−7.26296*	−8.2875*
Time Break	2007Q3	2009Q1	2007Q3	2009Q2	2007Q4	2009Q1

Notes: *and ** respectively, indicate 1% and 5% statistical significances. I, T, Δ and *ln* are respectively intercept, trend, first difference and log value of variable. Automatic maximum lag selection 9 with SIC. Bartlett kernel and automatic selection of Newey-West Bandwidth are used for the ADF and Phillips–Perron unit root tests. Also, ZA tests for unit root under single structural break tests are reported for I, T and Δ

ARDL-bound test specification adopts a more general expression of conditional error correction model (ECM) in addition to the option of imposing restriction on intercept, trend, and or both. Hence, we use it to the general model of equation (3) as presented in the following expression:

$$\Delta \log rpp = \alpha_0 + \sum\nolimits_{j=1}^{n} \text{bj}\, \Delta \log rpp_{\text{t}-j} + \sum\nolimits_{j=0}^{n} \text{cj}\, \Delta \text{lo}ppi_{\text{t}-j} + \sum\nolimits_{j=0}^{n} \text{dj}\, \Delta \log frate_{\text{t}-j} + \sum\nolimits_{j=0}^{n} \text{ej}\, \Delta \log vix_{\text{t}-j} + \sum\nolimits_{j=0}^{n} \text{fj}\, \Delta \log uem_{\text{t}-j} \partial_1 \log rpp_{\text{t}=1} + \partial_2 \log ppi_{\text{t}=1} + \partial_3 \log frate_{\text{t}=1} + \partial_4 \log vix_{\text{t}=1} + \partial_5 \log uem_{\text{t}=1} + \varepsilon_{1\text{t}} \quad (6)$$

where the underlying ARDL model presents the parameters b_j, c_j, d_j, e_j, and f_j as the short-run dynamic coefficients and the ∂_1, ∂_2, ∂_3, ∂_4, and ∂_5 presents the corresponding long-run multipliers. The error term ε_t is the (iid) serially independent random "disturbance" term. Also, the above specified model presents the null hypothesis of no cointegration as, i.e. *H0*: $\partial_1 = \partial_2 = \partial_3 = \partial_4 = 0$ against the alternative by comparing the estimated F-statistics with the critical lower and upper bound values detailed above. Hence, the result of the estimate as presented in Table III shows evidence of significant long-run relationship in the model and the statistical significance of the error correction model.

3.2.3 Sensitivity and diagnostic tests. To ascertain the reliability of the model used for this investigation, a sensitivity test of the equation (6) is performed. The test is expected to validate the robustness of the investigation. In doing so, the model (of equation (6)) is repeatedly estimated but without one of the main explanatory variable, log*ppi*. The same procedure as above is repeated for this purpose and the resulting model, a long-run ARDL (5, 4, 1, 7) with the output is presented in Table III above. While the result showed significant

Test statistic *F-statistic*	K	Significance (%)	Critical value bounds I(0)	I(1)
5.099326	4	1	3.74	5.06
		2.5	3.25	4.49
		5	2.86	4.01
		10	2.45	3.52

Long-run estimates with log rpp as dependent variables

	log*uem*	log*vix*	log*ppi*	log*frate*	ECM(-1)
ARDL (2, 0, 5, 0, 0)	−0.6149*	0.0327	0.3333	−1.7850*	−0.3970*
ARDL (5, 4, 1, 7)	−0.6419*	0.1314*		−2.7082*	−0.8199*

Short-run with log rpp as dependent variables

	log*uem*	Log*vix*	Log*ppi*	log*frate*
ARDL (2, 0, 5, 0, 0)	−0.2441*	0.0282	0.1323	−0.7086*

Notes: *Indicates statistical values at 1% significance level. The information criteria, AIC selects lag length 6. The F-statistic (5.099326) rejects the null hypothesis of no long-run relationship, we then conclude that there is significant evidence of long-run relationship in the examined model. The ECM (Error Correction Model) is the adjustment parameter of the model which indicates the speed of adjusting from short-run to long-run equilibrium. The coefficient of the ECM is negative and statistically significant. The ARDL (2, 0, 5, 0, 0) and ARDL (5, 4, 1, 7) models are used where the latter is performs a further robustness check

Table III. ARDL-bound test

similarity with the main model ARDL (2, 0, 5, 0, 0), there is significant divergent in the speed of adjustments.

Residual diagnostics tests were performed for both serial correlation and heteroscedasticity that further hesitate on the robustness the strength of the estimated system of equation (6). This confirms that the general model of equation (3) is subjected to serial correlation and heteroscedasticity tests using the Breusch-Godfrey serial correlation LM (Lagrange Multiplier) test and Breusch-Pagan-Godfrey tests respectively. The report of the test as shown in Table IV implies failure to reject the null hypotheses for 'no serial correlation' and 'homoscedasticity'. Additionally, the stability diagnostic by CUSUM test and the CUSUM of square test (as shown in Figure 3 and 4 below) for the model error term suggests that the estimated system is reliable.

4. Empirical results and discussion

The descriptive statistics indicated in Table I present the normality for only the log*frate* and log*ppi* series as well the validity of the skewness (<0) and kurtosis (>3) of all the series

Serial Correlation-Breusch-Godfrey LM Test		Heteroskedasticity-Breusch-Pagan-Godfrey	
F-statistics	p-value (χ^2)	F-statistics	p-value (χ^2)
ARDL (2, 0, 5, 0, 0)			
1.1246	(0.1659)	0.5346	0.8106
(0.3768)		(0.8645)	
ARDL (5, 4, 1, 7)			
0.5333	(0.2423)	1.1987	0.3217
(0.7947)		(0.3446)	

Notes: The p-values and F-statistics values indicate failure to reject both null hypotheses of no serial correlation and homoscedastic in the model. Both tests fail to reject null hypotheses of *no serial correlation* and *homoscedasticity* in the two ARDL models. Also, LM means Langrage multiplier

Table IV. Residual tests

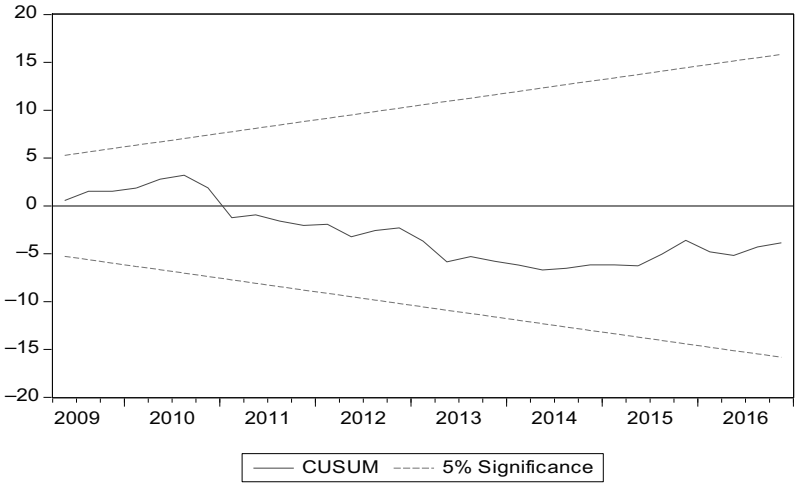

Figure 3. The stability diagnostic by CUSUM test indicates significant stability of the model

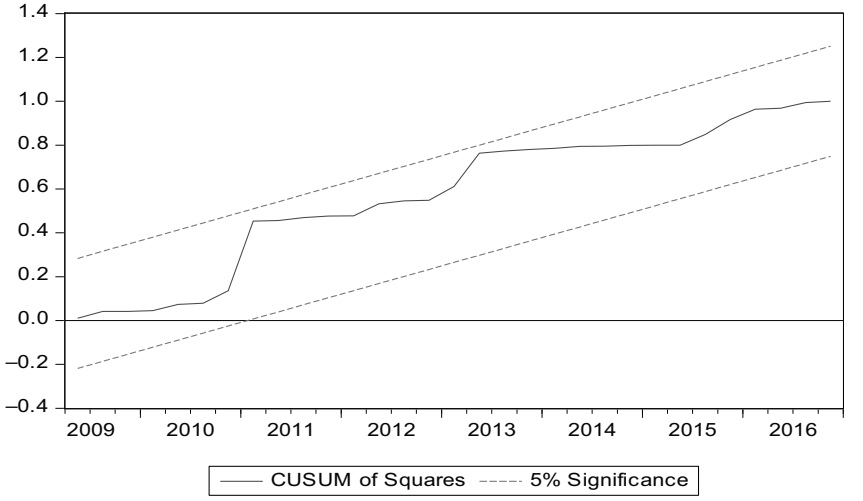

Figure 4.
The CUSUM of squares test further confirms the significant stability of the model

except for the log*frate* and log*ppi* series. Also, the result of the correlation estimates (see Table I) is desirable. It gives a statistically significant preliminary report on the relationship between the dependent and explanatory variables. Regarding the stationarity of the variables, the unit root tests by ADF and PP indicates partial stationarity for two of the variables at level. A superior stationarity test by KPSS (see EndNote) which is known for its power advantage shows conformity with the reported unit root tests. Although the variables are all stationary at first difference, i.e. I (1), the conclusion is that there is evidence of mixed order of integration in the entire dataset. Because of the weakness of the unit root tests (the ADF and Phillips Perron) to detected possible breaks which might be caused by unforeseen shock, the Zivot-Andrew (2002) unit root test under single structural break is further used. Similar to the earlier unit root tests obtained, all the series except for log*rpp* and log*ppi* were not stationary at level. However, after first difference, all the series were observed to be significantly stationary, i.e. I (1). But, additional information, regarding the time breaks of the series is also presented in Table II. Although there were observed breaks in the years 2011, 2013 and 2014 of the variable except for log*vix*, the years 2008 (2008Q4), 2009 (2009Q1) and 2010 (2010Q4) presents most common breaks in all the series. A shock on the economy of the country during this period is possibly associated with the ripple effect caused by the country's adoption of the euro currency on 1 January 2008 and the reported recession of the country's economy in 2009. This observation of the structural unit root and the time breaks information provided have subsequently prevented spurious regression that could lead to erroneous analysis.

And, regarding the long-run relationship (cointegration) in the selected model ARDL (2, 0, 5, 0, 0), the result observed in Table III (upper part of the Table) confirms significant evidence of long-run equilibrium. The F-statistics of the ARDL-bound test is greater than the upper bound of the critical value (i.e. $5.099326 > 5.06$). Empirically, this shows that the null hypothesis of 'no long-run relationship' is rejected at least at 1 per cent significant level. Consequently, as of shown in Table III, the long-run equilibrium model is seen to adjust at a speed (adjustment parameter) of 0.3970 (at 39.7 per cent annual speed). It translates that the model ARDL (2, 0, 5, 0, 0) posits the long-run positive impacts of log*ppi* (elasticity of 0.3333) and log*vix* (elasticity of 0.0327) while the impacts of log*frate* (elasticity of −1.7850) and

log*uem* (elasticity of −0.6149) are positive. In economic term, a 1 per cent increase in *ppi*, *vix*, *frate* and *uem* will expectedly cause 0.33 per cent increase, 0.033 per cent increase, 1.79 per cent decline, and 0.61 per cent decline in the real residential property price (*rpp*) of the housing market of Malta. With the adjustment parameter of −0.8199 (long-run adjustment speed of 81.9 per cent), the result of the sensitivity test with the model ARDL (5, 4, 1, 7) similarly reveals a negative impact of log*frate* and log*uem* on log*rpp* while a positive impact is maintained by log*vix*. Furthermore, the short-run observations associated with the model ARDL (2, 0, 5, 0, 0) similarly posit negative impacts of log*frate* and log*uem* on log*rpp*. This short-run impacts are significantly larger than the long-run for log*uem* (i.e $-0.2441 > -0.6149$)and log*frate* (i.e $-0.7086 > -1.79$). On the other hand, the short-run impact for log*ppi* and log*vix* on log*rpp* are lesser. Finally, indication from the serial correlation (Breusch-Godfrey LM) test and the heteroskedasticity (Breusch-Pagan-Godfrey) test (see Table IV) fails to reject the null hypotheses for 'no serial correlation' and 'homoscedasticity'. The desirability of the aforesaid residual test (significant evidence of no serial correlation and homoscedasticity) in addition to the valid result (visual observation) of the stability diagnostic by CUSUM test (see Figure 3 and 4) further affirms the suitability of the system under current investigation.

5. Concluding remarks and policy implication

The housing market of the island of Malta, a Mediterranean country at the axis and inter-locking Africa, Europe and part of Arabian the countries is empirically in a multivariate time series approach. Our study used quarterly data spanning 2005Q1 to 2016Q4 by incorporating the real residential property price (*rpp*), producer price index (*ppi*), country fertility rate (*frate*), and the Chicago Board Options Exchange (CBOE) volatility index (*vix*) in a hedonic price model using an Autoregressive Distributed Lag (ARDL) estimation approach. As reported above from our investigation, unemployment (*uem*) impacts the housing market *vis-à-vis* log*rpp* negatively in both long-run and short-run. Hence, our assertion further corroborates the findings of Abelson *et al.* (2005) by studying unemployment and house prices relationship in Australia between 1970 and 2003. The study of unemployment, labour force changes and house prices relationship in Johnes and Hyclak (1999) also presents similar result with our investigation. Also, Abelson *et al.* (2005) reported a significantly positive long-run relationship between the house prices and consumer price index (*cpi*). Their result on *cpi* gives insight on the outcome of the observed relationships between *ppi* and the housing market of Malta in our result. Moreover, in the recent study of Hiller and Lerbs (2016), total population was observed to be less important compare to household size in determining the housing dynamics. The fascinating study argued that if household of family size (household/family size could be the fertility rate in our study) decreases dues to family members' independence, divorce, etc., housing price would expectedly increase because the number of people in need of housing will increase. The same significantly negative observation between the fertility rate (*frate*) and the real residential property price in our novel investigation, and especially in both the long-run and short-run instances. Interestingly, further adding evidence to fertility-housing market dynamics in the island of Malta, Vakili-Zad and Hoekstra (2011) noted the importance of 'the church' (the religion perspective) and 'family factor' (Maltese family traditions) to the housing market.

On the policy pathway, in the case of Malta, implementation of effective policy instruments directed at the country's housing and real estate market is important to the economic development of the small island. As the production and manufacturing sector of Malta is very active, and almost the most contributor to the country's economic development, this call for active involvement and participation of the stakeholders. Indicatively, from our result, a low unemployment rate is expected to trigger high house or property prices. As low

unemployment is mostly desirable by nations of world including Malta, effective use of fiscal policies that targets the country's unemployment rate should be cautiously administered. In this case, effective implementation of policies that also target the country's inflation rate (insight from the Phillips curve hypothesis) could be useful. The sensitivity of the country's economy to the effect of the adoption of the euro currency in 2008 (evidence from our structural break points Table II) could be advantageous, but for the rigidity of the euro exchange rate policy. This is because the Central Bank of Malta is expected to have limited influence on the euro exchange rate policy given that the currency is a regionally owned. Again, the average household size in Malta is reportedly larger than most in most European countries (Vakili-Zad and Hoekstra, 2011). In spite of this submission, considering the country's small population size (less than 500,000 people as at 2018) and our result (negative impact of *uem* on *rpp*), adoption of policy that encourages fertility is consequentially encouraged. In doing these, and adopting other workable housing policy in the country, quality and affordable housing would possibly be at the reach of the people.

However, other salient observations, such as the migration factor, is a good perspective that is subject to further study on the housing market particularly in the case of Malta, being a crossing point or border between countries and continents. Also, larger sample size could be adopted possibly with other methodologies like the use of panel data within the same geographical location as Malta, *vis-à-vis* Mediterranean or East European countries.

Note

1. The KPSS stationarity test by Kwiatkowski *et al.* (1992) tests the null hypothesis for stationarity $I(0)$ against an alternative non-stationarity $I(0)$ using a starting model of the form: $y_t = \boldsymbol{\beta}' \mathbf{D}_t + \mu_t + v_t$such that $\mu_t = \mu_{t-1} + \varepsilon_t$, where $\varepsilon_t \sim W\ N(0, \sigma^2_c)$, $\mathbf{D}_t$ contains constant, time trend e.t.c components, μ_t is pure random walk with variance σ^2_c and v_t is $I(0)$ is stationary which could be heteroskedastic but subsequently addressed. The estimated KPSS test statistic is a Lagrange multiplier (LM) for testing the null hypothesis, *H0*: $\sigma^2_c = 0$ against the alternative, *H1*: $\sigma^2_c > 0$. The stationary test results for the series ln*hp,* ln*rgdpi* and ln*ppi* is in agreement with the unit root test estimates in the text.

References

Abelson, P. and Chung, D. (2005), "The real story of housing prices in Australia from 1970 to 2003", *The Australian Economic Review*, Vol. 38 No. 3, pp. 265-281.

Abelson, P., Joyeux, R., Milunovich, G. and Chung, D. (2005), "Explaining house prices in Australia: 1970-2003", *Economic Record*, Vol. 81 No. s1.

Alola, A.A. and Alola, U.V. (2018), "Agricultural land usage and tourism impact on renewable energy consumption among coastline mediterranean countries", *Energy and Environment*, 0958305X18779577.

Aoki, K., Proudman, J. and Vlieghe, G. (2004), "House prices, consumption, and monetary policy: a financial accelerator approach", *Journal of Financial Intermediation*, Vol. 13 No. 4, pp. 414-435.

Bajic, V. (1983), "The effects of a new subway line on housing prices in metropolitan toronto", *Urban Studies*, Vol. 20 No. 2, pp. 147-158.

Ball, M., Meen, G. and Nygaard, C. (2010), "Housing supply price elasticities revisited: evidence from international, national, local and company data", *Journal of Housing Economics*, Vol. 19 No. 4, pp. 255-268.

Berry, M. and Dalton, T. (2004), "Housing prices and policy dilemmas: a peculiarly australian problem?", *Urban Policy and Research*, Vol. 22 No. 1, pp. 69-91.

Bianco, L. (2006), "Malta: housing and real estate, 1980-2005", *Architectural Design*, Vol. 76 No. 3, pp. 76-81.

Boissevain, J. (1977), "Tourism and development in Malta", *Development and Change*, Vol. 8 No. 4, pp. 523-538.

Camilleri, D. (2011), "A long-term analysis of housing affordability in Malta", *International Journal of Housing Markets and Analysis*, Vol. 4 No. 1, pp. 31-57.

Campbell, J.Y. and Cocco, J.F. (2007), "How do house prices affect consumption? Evidence from micro data", *Journal of Monetary Economics*, Vol. 54 No. 3, pp. 591-621.

Canarella, G., Miller, S. and Pollard, S. (2012), "Unit roots and structural change: an application to US house price indices", *Urban Studies*, Vol. 49 No. 4, pp. 757-776.

Case, K.E. and Shiller, R.J. (2003), "Is there a bubble in the housing market?", *Brookings Papers on Economic Activity*, Vol. 2003 No. 2, pp. 299-342.

Case, K.E., Quigley, J.M. and Shiller, R.J. (2005), "Comparing wealth effects: the stock market versus the housing market", *Advances in Macroeconomics*, Vol. 5 No. 1.

Central Bank of Malta (2017), available at: www.centralbankmalta.org/

Darmanin, J. (2008), "The computation of a housing affordability index for Malta", *Bank of Vallette Review*, Vol. 37, pp. 25-34.

Ding, Z., Granger, C.W. and Engle, R.F. (1993), "A long memory property of stock market returns and a new model", *Journal of Empirical Finance*, Vol. 1 No. 1, pp. 83-106.

Estrella, A. and Mishkin, F.S. (1998), "Predicting US recessions: financial variables as leading indicators", *The Review of Economics and Statistics*, Vol. 80 No. 1, pp. 45-61.

European Commission, (Eurostat) (2017), available at: http://ec.europa.eu/eurostat/data/browse-statistics-by-theme

Falzon, J. and Bezzina, F. (2013), "demand attributes for social housing: evidence from housing policy schemes in malta", *European Scientific Journal, ESJ*, Vol. 9 No. 4

Falzon, J. and Lanzon, D. (2013), "Comparing alternative house price indices: evidence from asking prices in Malta", *International Journal of Housing Markets and Analysis*, Vol. 6 No. 1, pp. 98-135.

Federal Reserve Bank of St. Louis (FRED) (2018), available at: https://fred.stlouisfed.org/

Flavin, M. and Yamashita, T. (2002), "Owner-occupied housing and the composition of the household portfolio", *The American Economic Review*, Vol. 92 No. 1, pp. 345-362.

Hämäläinen, K. and Böckerman, P. (2004), "Regional labor market dynamics, housing, and migration", *Journal of Regional Science*, Vol. 44 No. 3, pp. 543-568.

Harter-Dreiman, M. (2004), "Drawing inferences about housing supply elasticity from house price responses to income shocks", *Journal of Urban Economics*, Vol. 55 No. 2, pp. 316-337.

Hiller, N. and Lerbs, O.W. (2016), "Aging and urban house prices", *Regional Science and Urban Economics*, Vol. 60, pp. 276-291.

Ihlanfeldt, K.R. (2007), "The effect of land use regulation on housing and land prices", *Journal of Urban Economics*, Vol. 61 No. 3, pp. 420-435.

International Financial Statistics (IFS) (2017), International Monetary Fund, available at: www.imf.org/en/Data

Johnes, G. and Hyclak, T. (1999), "House prices and regional labor markets", *The Annals of Regional Science*, Vol. 33 No. 1, pp. 33-49.

Katircioglu, S. (2009), "Testing the tourism-led growth hypothesis: the case of Malta", *Acta Oeconomica*, Vol. 59 No. 3, pp. 331-343.

Katz, L. and Rosen, K.T. (1987), "The interjurisdictional effects of growth controls on housing prices", *The Journal of Law and Economics*, Vol. 30 No. 1, pp. 149-160.

Kishor, N.K. and Marfatia, H.A. (2017), "The dynamic relationship between housing prices and the macroeconomy: evidence from OECD countries", *The Journal of Real Estate Finance and Economics*, Vol. 54 No. 2, pp. 237-268.

Kwiatkowski, D., Phillips, P.C., Schmidt, P. and Shin, Y. (1992), "Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit root?", *Journal of Econometrics*, Vol. 54 Nos 1/3, pp. 159-178.

Luo, Z., Liu, C. and Picken, D. (2007), "Granger causality among house price and macroeconomic variables in Victoria", *Pacific Rim Property Research Journal*, Vol. 13 No. 2, pp. 234-256.

Luttik, J. (2000), "The value of trees, water and open space as reflected by house prices in The Netherlands", *Landscape and Urban Planning*, Vol. 48 Nos 3/4, pp. 161-167.

Malta profile (2017), available at: www.maltaprofile.info/

Mankiw, N.G. and Weil, D.N. (1989), "The baby boom, the baby bust, and the housing market", *Regional Science and Urban Economics*, Vol. 19 No. 2, pp. 235-258.

Meen, G. (2003), "Housing, random walks, complexity and the macroeconomy", *Housing Economics and Public Policy*, pp. 90-109.

Micallef, B. (2018), "Constructing an index to examine house price misalignment with fundamentals in Malta", *International Journal of Housing Markets and Analysis*, Vol. 11 No. 2, pp. 315-334.

Oglethorpe, M. (1985), "Tourism in a small island economy: the case of Malta", *Tourism Management*, Vol. 6 No. 1, pp. 23-31.

Painter, G. and Redfearn, C.L. (2002), "The role of interest rates in influencing long-run homeownership rates", *The Journal of Real Estate Finance and Economics*, Vol. 25 Nos 2/3, pp. 243-267.

Park, S., Park, S.W., Kim, H. and Lee, S. (2017), "The dynamic effect of population ageing on house prices: evidence from korea", *Pacific Rim Property Research Journal*, pp. 1-18.

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001), "Bounds testing approaches to the analysis of level relationships", *Journal of Applied Econometrics*, Vol. 16 No. 3, pp. 289-326.

Phillips, P.C. and Perron, P. (1988), "Testing for a unit root in time series regression", *Biometrika*, Vol. 75 No. 2, pp. 335-346.

Pitkin, J.R. and Myers, D. (1994), "The specification of demographic effects on housing demand: avoiding the age-cohort fallacy", *Journal of Housing Economics*, Vol. 3 No. 3, pp. 240-250.

Pollakowski, H.O. and Wachter, S.M. (1990), "The effects of land-use constraints on housing prices", *Land Economics*, Vol. 66 No. 3, pp. 315-324.

Reichert, A.K. (1990), "The impact of interest rates, income, and employment upon regional housing prices", *The Journal of Real Estate Finance and Economics*, Vol. 3 No. 4, pp. 373-391.

Said, S.E. and Dickey, D.A. (1984), "Testing for unit roots in autoregressive-moving average models of unknown order", *Biometrika*, Vol. 71 No. 3, pp. 599-607.

Sirmans, S., Macpherson, D. and Zietz, E. (2005), "The composition of hedonic pricing models", *Journal of Real Estate Literature*, Vol. 13 No. 1, pp. 1-44.

Tu, Y. (2000), "Segmentation of australian housing markets: 1989-98", *Journal of Property Research*, Vol. 17 No. 4, pp. 311-327.

United Nations, Department of Economic and Social Affairs (2017), "World population prospects: the 2017 revision", available at: www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html

Vakili-Zad, C. (2006), "Counting the homeless in Malta", *Journal of Housing and the Built Environment*, Vol. 21 No. 2, pp. 141-157.

Vakili-Zad, C. and Hoekstra, J. (2011), "High dwelling vacancy rate and high prices of housing in Malta a mediterranean phenomenon", *Journal of Housing and the Built Environment*, Vol. 26 No. 4, pp. 441-455.

World Bank (2017), World Development Indicator (WDI), available at: http://databank.worldbank.org/data/reports.aspx?source=World-Development-Indicators

Zivot, E. and Andrews, D.W.K. (2002), "Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis", *Journal of Business and Economic Statistics*, Vol. 20 No. 1, pp. 25-44.

Further reading

Crane currency report (2018), available at: www.cranecurrency.com/slide/malta-printing-facility

Dickey, D.A. and Fuller, W.A. (1979), "Distribution of the estimators for autoregressive time series with a unit root", *Journal of the American Statistical Association*, Vol. 74 No. 366a, pp. 427-431.

Dickey, D.A. and Fuller, W.A. (1981), "Likelihood ratio statistics for autoregressive time series with a unit root", *Econometrica: Journal of the Econometric Society*, Vol. 49 No. 4, pp. 1057-1072.

Ding, H. and Kim, J. (2017), "Inflation-targeting and real interest rate parity: a bias correction approach", *Economic Modelling*, Vol. 60, pp. 132-137.

Engle, R.F. and Granger, C.W. (1987), "Co-integration and error correction: representation, estimation, and testing", *Econometrica: Journal of the Econometric Society*, Vol. 55 No. 2, pp. 251-276.

International Monetary Fund (2017), available at: http://data.imf.org/?sk=388DFA60-1D26-4ADE-B505-A05A558D9A42

Johansen, S. (1988), "Statistical analysis of cointegration vectors", *Journal of Economic Dynamics and Control*, Vol. 12 Nos 2/3, pp. 231-254.

Johansen, S. and Juselius, K. (1990), "Maximum likelihood estimation and inference on cointegration – with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, Vol. 52 No. 2, pp. 169-210.

Levin, A., Lin, C.F. and Chu, C.S.J. (2002), "Unit root tests in panel data: asymptotic and finite-sample properties", *Journal of Econometrics*, Vol. 108 No. 1, pp. 1-24.

MacKinnon, J.G. (1996), "Numerical distribution functions for unit root and cointegration tests", *Journal of Applied Econometrics*, Vol. 11 No. 6, pp. 601-618.

Pesaran, M.H. and Shin, Y. (1998a), "An autoregressive distributed-lag modelling approach to cointegration analysis", *Econometric Society Monographs*, Vol. 31, pp. 371-413.

Pesaran, H.H. and Shin, Y. (1998b), "Generalized impulse response analysis in linear multivariate models", *Economics Letters*, Vol. 58 No. 1, pp. 17-29.

Portnov, B.A., Kim, D.C. and Ishikawa, Y. (2001), "Investigating the effects of employment-housing change on migration: evidence from Japan", *International Journal of Population Geography*, Vol. 7 No. 3, pp. 189-212.

Sharpley, R. (2000), "The influence of the accommodation sector on tourism development: lessons from Cyprus", *International Journal of Hospitality Management*, Vol. 19 No. 3, pp. 275-293.

Sharpley, R. (2001), "Tourism in Cyprus: challenges and opportunities", *Tourism Geographies*, Vol. 3 No. 1, pp. 64-86.

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House prices and unemployment: an empirical analysis of causality

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Abstract

Purpose – This paper aims to examine whether there exists a long-run causal relationship between house prices and unemployment rates for eight major European countries.

Design/methodology/approach – The bootstrap panel Granger causality approach that accounts for cross-sectional dependence, slope heterogeneity and structural breaks is used to detect the direction of causality.

Findings – The empirical findings for the overall panel support the presence of unidirectional causality running from house prices to unemployment.

Practical implications – The findings are not only important for households but also for policymakers concerned with economic and financial stability.

Originality/value – There are only a limited number of studies that have investigated the direct link between house prices and employment or unemployment. Given the increased importance of labor market variables, particularly the choice of the unemployment rate as a key indicator in designing forward guidance and the increased financial stability concerns regarding house price dynamics, it is important to better understand the causal linkages between house prices and unemployment rates. To the best of the author's knowledge, this paper is the first to apply the bootstrap panel Granger causality approach to examine the relationship between house prices and unemployment rates.

Keywords House prices, Households, Financial stability, Home ownership, Panel causality, Unemployment rates

Paper type Research paper

1. Introduction

The recent financial crisis has drawn increasing attention to the relationship between house prices and labor markets. The present paper aims to provide the dynamic link between house prices and labor markets for eight major European countries. Given the increased importance of labor market variables, particularly the choice of the unemployment rate as a key indicator in designing forward guidance and the increased financial stability concerns regarding house price dynamics, it is vital to better understand the causal linkages between house prices and unemployment rates.

The neo-classical framework indicates that house prices are determined by the law of demand for and supply of housing. Therefore, any factor that influences the demand and supply will affect house prices. While on the demand side of the market one could mention factors such as mortgage rates/interest rates, household income, and demographic factors, on the supply side of the market, cost of land, construction costs and availability of credit to finance such costs are important determinants. The neo-classical model of equilibrium

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unemployment does not capture frictions that affect labor markets, including imperfect competition, costly search, matching frictions, financial frictions and borrowing constraints that provide powerful linkages between key markets of the macroeconomy, namely housing, goods, and labor markets.

Branch *et al.* (2014) assume a fixed supply of houses and assert that if housing assets are scarce or lending standards are sufficiently tight, then house prices show a liquidity premium, i.e. houses are priced above the discounted sum of their future rents. There are conditions on fundamentals under which the economy has multiple steady-state equilibria across which unemployment and house prices are negatively correlated. Then, firms' decision to open job vacancies in the retail sector is dependent positively on households' borrowing capacity and hence home equity. But households' demand for homes as collateral is also dependent positively on the aggregate activity in the retail sector, thereby creating strategic complementarities between households' and firms' decisions. Any regulation that raises the eligibility of homes as collateral increases the housing liquidity premium and reduces unemployment.

According to Branch *et al.* (2014) if the construction sector is re-opened, so that the supply of homes is endogenous, then two cases will appear. These two cases allow us to identify the conditions under which the unemployment rate is affected by aggregate demand in the goods market:

(1) a "competitive" case where firms have no market power in the retail market; and

(2) a "monopoly" case where firms have all the market power.

In the competitive case, house prices, which are determined by the relative productivities in the two sectors, are not affected by financial innovations. Relaxing lending standards does not influence unemployment but it creates a reallocation of workers toward the construction sector. In the monopoly case, housing assets are priced at their "fundamental" value (the discounted sum of the rental rates). An increase in the eligibility of homes as collateral decreases aggregate unemployment, increases house prices, and drives workers away from the construction sector.

Thus, the dynamic link is the one related to the collateral channel: adverse movements in real estate prices reduce the borrowing capacity of firms resulting in an increase in job destruction and a decrease in job creation, creating higher levels of unemployment rates and to potential shifts in the Beveridge curve. Conversely, an increase in house prices raise the market value of collateralizable assets that firms own, thereby increasing their borrowing capacity, leading to an expansion of corporate credit, business investment and a reduction in job separation rates. The strong negative relationship between house prices and the unemployment rate is a feature not only of the recent crisis, but characterizes historical business cycles as well (Pinter, 2018).

Fluctuations in house prices themselves could also be a major factor in affecting the housing market and other sectors of the economy. For example, the Great Recession of 2007-2008 in Spain revealed the burst of housing market bubble. The unemployment rate increased from 8.3 to 26 per cent at the end of 2012. Unemployment had previously decreased from 24 to 8.3 per cent during the housing boom period (1995-2007). The negative relationship between house prices and unemployment can, however, be interpreted rather differently.

On the one hand, house prices comove positively and unemployment negatively with the business cycle, so whatever drives the cycle could explain their co-movement. On the other hand, house prices could decline when unemployment goes up in the case of reduced consumption on all goods, and on housing services in particular. However, decline in construction industry that contributed to an increase in unemployment was extended to

other sectors of the Spanish economy via multiplier effects, causing unemployment rate to rise further. In turn, unemployed people who were unable to pay their mortgages had to sell or adhere to foreclosures, which in turn, intensified the decline in house prices. Consequently, it appears that these two macro variables can cause each other.

There are only a few studies that have investigated the potential link between house prices and employment or unemployment. This paper examines causality between house prices and unemployment rates for eight major European countries by applying the bootstrap panel Granger causality approach that accounts for cross-sectional dependence, slope heterogeneity, and structural breaks across countries. To the best of the author's knowledge, this paper is the first to apply the bootstrap panel Granger causality approach to examine the relationship between house prices and unemployment.

This study differs from the existing literature in several ways. First, the bootstrap panel Granger analysis devotes full attention to dynamic co-movement and causalities between housing and labor markets. Second, interest rates are used as control variables to incorporate the effects of monetary policy. Third, most of the previous studies do not consider the presence of structural breaks and this makes the result of causality tests between the variables invalid and biased. Fourth, most of the previous studies assume unemployment as exogenous variable rather than endogenous one as discussed above. Fifth, most of the previous studies that detected causality between housing and unemployment concentrated on the US.

The structure of the paper is as follows. Section 2 outlines previous studies, Section 3 describes the methodology and the data. Section 4 presents the empirical results and some discussions. Section 5 discusses the policy implications and concludes.

2. Previous studies

Pinter (2018) reports that the cyclical components of real house prices and separation rates have about −80 per cent correlation in the UK between 1985 and 2013. He also reveals that unanticipated shocks to house prices explain about 10-20 per cent of output fluctuations and about 20-30 per cent of fluctuations in unemployment and job separation rates. The co-movement between house prices and unemployment may question the suitability of theoretical models (Blanchard and Gali, 2010; Liu *et al.*, 2016). They assume that constant separation rates and focus on fluctuations in job finding rates can explain unemployment dynamics.

However, the theoretical assumption of constant separation rates is in stark contrast with the large empirical contribution of the unemployment inflow rate to the dynamics of the UK and the US unemployment rate (Kiyotaki and Moore, 1997; Petrongolo and Pissarides, 2008; Fujita and Ramey, 2009; Smith, 2011; Liu *et al.*, 2016; Pinter, 2018). Furthermore, most of the previous studies on the macroeconomic effects of uncertainty shocks on labor markets do account for exogenous job separation (Liu *et al.*, 2016; Liu and Leduc, 2015). As they assume exogenous job separation, they focus on responses of equilibrium vacancy and unemployment generated by a movement along the downward-sloping Beveridge curve. Thus, a more realistic model should incorporate endogenous job separation which is likely to further strengthen the aggregate demand effects of uncertainty shocks (Ramey *et al.*, 2000; Walsh, 2005; Krause and Lubik, 2007; Trigari, 2009; Christiano *et al.*, 2011; Pinter, 2018).

Geerolf and Grjebine (2014) examine the causal effect of house price movements on unemployment dynamics. Using a dataset of 34 countries over the past 40 years, they find a large and significant impact of house prices on unemployment fluctuations using property taxes as an instrument for house prices. A 10 per cent appreciation in house prices leads to a 3.4 per cent decrease in the unemployment rate. If house prices directly affect employment in

construction, job volatility in this sector leads to large employment fluctuations. They also influence total employment through their effects on non-residential investment and consumption, two determinants of labor demand. Housing booms have a specific effect on employment in the tradable sector as they result in real exchange rate appreciations that affect manufacturing activity.

Dröes and van de Minne (2016) investigate the determinants of house prices, using almost 200 years of data from the Amsterdam housing market, by applying co-integration and error correction mechanism (ECM). They show that during the 19th century, population, unemployment, housing supply, and construction costs are the main drivers of house price dynamics. At the start of the twentieth century, income started to play a role, and after the Second World War, there are a few decades in which housing supply and especially population growth determined house prices. They also conclude that, from the 1970s onwards, income and interest rates start to have a large impact on house prices, most likely due to financial innovation and liberalization, and financing a house through mortgage debt has become more popular.

Almost all studies related to housing market have focused on household income and interest rates as two main determinants of house prices and have investigated short-run causality or long-run relationship between house prices and income or some variables other than unemployment rate in different countries (Case and Shiller, 2003; Gallin, 2006; McQuinn and O'Reilly, 2008; Holly *et al.*, 2011; Katrakilidis and Trachanas, 2012).

Peek and Wilcox (1991) reports that the unemployment rate is one of many determinants of house prices. Their estimates show that the recovery of house prices in the late 1980 could be attributed to lower unemployment and lower interest rates. Apergis (2003) and Apergis and Rezitis (2003) using data from Greece and conclude that interest rates, inflation, and employment are main determinants of house prices in Greece. Abelson *et al.* (2005) confirm a long-run elasticity of -0.2 between real house prices and unemployment rate in Australia. Kim and Bhattacharya (2009), and Bahmani-Oskooee and Ghodsi (2017) use data from the USA and its regions and find strong evidence of Granger causality from house prices to employment.

Thus, there are only a few studies that have examined the potential link between house prices and employment or unemployment[1].

3. Data and methodology

The real house price index (*HPI*) and the unemployment rate (*UR*) as a percentage of total labor force are downloaded from the OECD database and World Bank database, respectively. The yearly percentage long-run interest rates (*IR*) are taken from the OECD and used as control variables. Appendix I illustrates real house price index and unemployment rate for the countries under review. It also shows descriptive statistics for the variables.

Given the data availability (1991-2016), the following economies are used: Germany, France, Italy, the UK, Switzerland, Sweden, Spain and The Netherlands. These countries are chosen because of the fact that they are biggest economy in the Western Europe in 2017 and had relatively similar housing and labor markets (except Spain with regard to unemployment rate which is highest among the countries under review)[2]. Inflation also seems to have the same long-term levels in all the countries studied. Roughly speaking, financial net wealth growth, population growth, and disposable income growth also have the similar pattern. Residential investment as a percentage of GDP has developed differently during the sample period in the countries but in average it is around 5 per cent of GDP. The selection of time period is dictated by the availability of data.

The estimation follows the bootstrap panel Granger causality proposed by Kónya (2006). This approach has two important advantages. First, it is not required to test the unit root and cointegration (i.e. the variables are used in their levels, without any stationarity

conditions). Second, additional panel information can also be obtained given the contemporaneous correlations across countries (i.e. the equations denote a Seemingly Unrelated Regressions system – SUR system).

Two steps should be followed before applying the bootstrap panel Granger causality: testing the panel for cross-sectional dependence and testing for cross-country heterogeneity. The first issue implies the transmission of shocks from one variable to others. In other words, all countries in the sample are influenced by globalization and have common economic characteristics. The second issue indicates that a significant economic connection in one country is not necessarily replicated by the others.

A set of three tests is constructed to check the cross-sectional dependence assumption: the Breusch and Pagan (1980) cross-sectional dependence (CD_{BP}) test, the Pesaran (2004) cross-sectional dependence (CD_P) test, and the Pesaran *et al.* (2008) bias-adjusted LM test (LM_{adj}). Regarding the country-specific heterogeneity assumption, the slope homogeneity tests ($\tilde{\Delta}$ and $\bar{\Delta}_{adj}$) of Pesaran and Yamagata (2008) are used (Appendix 2 provides more information about these tests). The Kónya's (2006) approach considers both issues, based on SUR systems estimation and identification of Wald tests with country-specific bootstrap critical values. This procedure allows us to consider all variables in their levels and perform causality output for each country:

$$\begin{aligned}
HPI_{1,t} &= \alpha_{1,1} + \sum_{i=1}^{lm1}\beta_{1,1,i}HPI_{1,t-i} + \sum_{i=1}^{\ln1}\delta_{1,1,i}UR_{1,t-i} + \sum_{i=1}^{lk1}\gamma_{1,1,i}IR_{1,t-i} + \varepsilon_{1,1,t} \\
HPI_{2,t} &= \alpha_{1,2} + \sum_{i=1}^{lm1}\beta_{1,2,i}HPI_{2,t-i} + \sum_{i=1}^{\ln1}\delta_{1,2,i}UR_{2,t-i} + \sum_{i=1}^{lk1}\gamma_{1,2,i}IR_{2,t-i} + \varepsilon_{1,2,t} \\
&\vdots \\
HPI_{N,t} &= \alpha_{1,N} + \sum_{i=1}^{lm1}\beta_{1,N,i}HPI_{N,t-i} + \sum_{i=1}^{\ln1}\delta_{1,N,i}UR_{N,t-i} + \sum_{i=1}^{lk1}\gamma_{1,N,i}IR_{N.t-i} + \varepsilon_{1,N,t}
\end{aligned} \tag{1}$$

and

$$\begin{aligned}
UR_{1,t} &= \alpha_{2,1} + \sum_{i=1}^{lm2}\beta_{2,1,i}HPI_{1,t-i} + \sum_{i=1}^{\ln2}\delta_{2,1,i}UR_{1,t-i} + \sum_{i=1}^{lk2}\gamma_{2,1,i}IR_{1,t-i} + \varepsilon_{2,1,t}, \\
UR_{2,t} &= \alpha_{2,2} + \sum_{i=1}^{lm2}\beta_{2,2,i}HPI_{2,t-i} + \sum_{i=1}^{\ln2}\delta_{2,2,i}UR_{2,t-i} + \sum_{i=1}^{lk2}\gamma_{2,1,i}IR_{2,t-i} + \varepsilon_{2,2,t}, \\
&\vdots \\
UR_{N,t} &= \alpha_{2,N} + \sum_{i=1}^{lm2}\beta_{2,N,i}HPI_{N,t-i} + \sum_{i=1}^{\ln2}\delta_{2,N,i}UR_{N,t-i} + \sum_{i=1}^{lk2}\gamma_{2,N,i}IR_{N,t-i} + \varepsilon_{2,N,t}
\end{aligned} \tag{2}$$

In equation systems (1) and (2), *HPI* shows the real house price index, *UR* denotes unemployment rate, *IR* indicates interest rates as control variables, *N* is the number of panel

members, t is the time period (t = 1,. . .,T), and i is the lag length selected in the system. The common coefficient is α, the slopes are β, δ, and γ, while ε is the error term.

To test for Granger causality in this system, alternative causal relations for each country are likely to be found:

- there is one-way Granger causality from X to Y if not all $\delta_{1,i}$ are zero, but all $\beta_{2,i}$ are zero;
- there is one-way Granger causality from Y to X if all $\delta_{1,i}$ are zero, but not all $\beta_{2,i}$ are zero;
- there is two-way Granger causality between X and Y if neither $\delta_{1,I}$ nor $\beta_{2,i}$ are zero; and
- there is no Granger causality between X and Y if all $\delta_{1,i}$ and $\beta_{2,i}$ are zero.

It is also allowed the maximal lags to differ across variables, but the same across equations. In this study, the system is estimated by each possible pair of l_{m1}, l_{n1}, l_{m2}, l_{n2}, l_{k1}, and l_{k2}, and it is assumed that 1 to 4 lags exist. Then the combinations that minimize the Schwarz Bayesian Criterion are chosen.

By inspecting the data, we find that most break dates correspond to major events such as the financial crisis of 1997-1998 and 2007-2008 and the economic downturn of 2001-2002. Due to the existence of these structural breaks, we should incorporate these breaks into our testing model; otherwise, the results will be biased. As Kónya (2006) cannot allow different break dates into the testing model, we follow the procedure adopted by Tsong and Lee (2011) and Bahmani-Oskooee *et al.* (2014) to adjust the data as follows:

$$\hat{y}_t = y_t - \hat{\alpha} - \sum_{l=1}^{m+1} \hat{\theta}_l DU_{l,t} - \sum_{i=1}^{m+1} \hat{\rho}_i DT_{i,t} - \varepsilon_t, \tag{3}$$

where, $\hat{y}_t$ (either *HPI* or *UR*) is adjusted by the effect of possible structural breaks, y_t is *HPI* or *UR*, DU_t and DT_t are defined as the following:

$$DU_{k,t} = \begin{cases} 1 & if\ TB_{k-1} \prec t \prec TB_k \\ 0 & otherwise \end{cases} \tag{4}$$

$$DT_{k,t} = \begin{cases} t - TB_{k-1} & if\ TB_{k-1} \prec t \prec TB_k \\ 0 & otherwise \end{cases} \tag{5}$$

4. Estimation results and discussion

Tables I reports the results of cross-sectional dependence tests (CD_{BP}, CD_p, and LM_{adj}) and slope homogeneity tests ($\overline{\Delta}$ and $\overline{\Delta}_{adj}$). The first set of tests, for cross-sectional dependence, clearly reveals that the null hypothesis of no cross-sectional dependence is rejected for all significance levels. More precisely, this implies that there is a cross-sectional dependence in the case of our sample countries. Any shock in one country is transmitted to others, the SUR system estimator being more appropriate than country-by-country pooled OLS estimator. The second part of the Table shows that the null hypothesis of slope homogeneity is rejected for both tests and for all significance levels. In this case, the economic relationship in one

country is not replicated by the others. As there are both cross-sectional dependence and slope heterogeneity, the bootstrap panel Granger causality approach can be applied.

The results of the bootstrap panel Granger causality test are shown in Tables II. The findings indicate that there is a unidirectional causality running from house prices to unemployment in Italy, The Netherlands, Sweden, and Spain. A bidirectional causality or feedback effect is detected for Germany and Switzerland. The statistically significant negative coefficients indicate that if house price increases this will lead to a decrease in unemployment. The empirical evidence does not reveal any causality between the variables in the UK and France. This stems from the fact that there are two types of determinants regarding unemployment, namely structural and non-structural. Structural determinants are labor market characteristics that have a bearing on its functioning. The non-structural determinants include changes in the real interest rate, variations in the level of technological progress and housing boom-bust effects. Thus, in the case of the UK and France, unemployment is likely affected by structural determinants rather than non-structural ones.

The lack of unidirectional causality running from unemployment to house price in the UK, Italy, France, Sweden, The Netherlands, and Spain may result from some other factors which are driving both house prices and unemployment. Theoretically, unemployment stems from workers setting their wages above the perfectly competitive levels under

Table I. Cross-sectional dependence and slope homogeneity tests

Method	Test statistics	*p*-value
Cross-sectional dependence test		
CD_{BP}	57.325***	0.0000
CD_P	13.166***	0.0000
LM_{adj}	17.634***	0.0000
Slope homogeneity test		
$\overline{\Delta}$ test	9.678***	0.0000
$\overline{\Delta}_{adj}$ test	5.237***	0.0000

Notes: ***indicate significance for 0.01 levels; CD_{BP} test, CD_P test, and LM_{adj} test show the cross-sectional dependence tests of Breusch and Pagan (1980), Pesaran (2004), and Pesaran *et al.* (2008), respectively; $\overline{\Delta}$ test and $\overline{\Delta}_{adj}$ test show the slope homogeneity tests proposed by Pesaran and Yamagata (2008)

Table II. The bootstrap panel granger causality results

	H0: *HPI* does not Granger cause *UR*					H0: *UR* does not Granger cause *HPI*				
			Bootstrap critical value					Bootstrap critical value		
Country	Estimated coefficient	Wald test	1%	5%	10%	Estimated coefficient	Wald test	1%	5%	10%
Germany	−0.453	17.426**	29.267	15.265	10.173	−0.355	20.617*	43.786	24.179	16.665
France	−0.255	8.237	23.985	13.156	9.348	1.014	9.324	31.327	16.275	11.505
Italy	−0.561	14.742**	18.956	10.363	6.516	−0.181	11.371	45.482	23.19	15.427
Netherlands	−0.314	28.527**	36.898	20.124	14.261	−0.163	14.385	54.212	27.834	19.371
UK	−0.19	7.012	21.882	12.227	7.519	0.108	6.742	27.126	14.278	9.415
Sweden	−0.517	26.455**	39.016	21.483	15.492	−0.51	12.382	38.117	20.235	14.169
Switzerland	−0.646	32.398**	47.261	25.169	18.121	−0.629	25.123**	37.16	19.105	13.252
Spain	−0.435	23.264***	20.803	11.325	7.663	−0.45	16.269	46.357	24.263	17.398

Notes: *; ** and ***indicate significance at the 0.10, 0.05 and 0.01 levels, respectively; bootstrap critical values are obtained from 10,000 replications

monopolistic competition. Workers who forecast unemployment can prevent unemployment by relocating to new areas where they have job offers but relocating requires indebted workers to refinance their mortgage loans. In the presence of unemployment which may lead to house price reductions, indebted workers become technically insolvent, and credit tightening raises loan-to-value limits. Such adverse housing market movements therefore cause indebted workers (who forecast unemployment) less willing to accept long-distance job offers, as they require that the workers decrease consumption to pay back their excess debt (Sterk, 2015; Ingholt, 2017). Indebted homeowners are forced to refinance their mortgage loans when relocating, which affects their willingness to do so.

This lock-in effect of technical insolvency is also supported by Stein (1995); Henley (1998); Chan (2001); Ferreira *et al.* (2010); Goetz (2013), and Brown and Matsa (2016). The lack of geographical relocation and low labor mobility makes the effect of unemployment on house prices insignificant. This is why most countries in the sample does not show unidirectional causality running from unemployment to house prices. In the case of Germany and Switzerland, bidirectional causality may result from the fact that homeownership in these countries ranks among the lowest in the developed world, as discussed earlier. Furthermore, Germany and Switzerland rank among the top three with respect to high degree of labor mobility, as discussed earlier[3].

5. Summary and conclusion

Given the increased importance of labor market variables in policy debates across the countries, particularly the choice of the unemployment rate as a key indicator in designing forward guidance and the increased financial stability concerns regarding house price dynamics, it is vital to better understand the causal linkages between house prices and labor markets. This paper examines the causal linkages between real house prices and unemployment rates using data from eight major European countries over the period of 1991-2016.

The paper employs the bootstrap panel Granger causality approach that accounts for cross-sectional dependence, slope heterogeneity, and structural breaks. Interest rates have been included into the model as control variables. The findings show that there is a unidirectional causality running from house prices to unemployment in Italy, The Netherlands, Spain and Sweden. The evidence also shows a bidirectional causality (feedback effect) between house prices and unemployment rates in Germany and Switzerland. The empirical evidence does not show any causality between the variables in the UK and France. This implies that two types of determinants regarding unemployment can be distinguished, namely structural and non-structural. Structural determinants are features of the labor market that have a bearing on its functioning. The non-structural determinants include changes in the real interest rate, variations in the level of technological progress and housing boom-bust effects. Thus, in the case of the UK and France, unemployment is likely affected by structural determinants.

The lack of geographical relocation and low labor mobility make the effect of unemployment on house prices insignificant. This is why most countries in the sample does not show unidirectional causality running from unemployment to house prices. This also implies that, in the case of Germany and Switzerland, bidirectional causality may result from low homeownership and high labor mobility in these countries. A major policy implication of our results is that stabilizing the housing market and house prices do contribute to economic and financial stability led by stable unemployment rate. However, further studies should explore the linkage between unemployment rates and house prices through broader macro models.

Notes

1. Recent studies have been concentrated on spatial models. For example, Guerrieri *et al.* (2013) present a model which links house price movements across neighborhoods within a city and the gentrification of those neighborhoods in response to a city-wide housing demand shock. Jeanty *et al.* (2010) identify the local interactions between housing prices and population migration. Finally, Saks (2008) provides evidence on housing supply regulations and examine their effect on metropolitan area housing and labor market dynamics.
2. In Switzerland, real estate prices have grown rapidly in recent years, especially in certain hotspots. The residential mortgage debt-to-GDP ratio of 120 per cent is the highest in the OECD, and banks are exposed to the real estate sector. High house prices are being supported by very low interest rates, population growth. Restrictive planning regulations have limited the increase in supply (OECD, 2015). A peculiarity of the German housing market is the relatively low homeownership rate. In international comparison the homeownership rate in Germany and Switzerland ranks among the lowest in the developed world though housing costs are moderate in Germany. As far as Germany is concerned, several historic factors might explain this, notably the massive construction of social dwellings in the 1950s and 1960s in West Germany to give accommodation to its citizens and the displaced people from the Eastern parts of the former German Empire (1871-1918) and the large absence of owner-occupied housing in the former German Democratic Republic. By 2014, only around 52 per cent of German households owned the dwelling they inhabited, compared with 67 per cent in the euro area (Dahl and Góralczyk, 2017). Germany and Switzerland are among the top 3 with respect to high degree of labor mobility (European Commission, 2017).
3. To check the robustness of our findings, income was used as a control variable instead of interest rate. The results corroborate the findings from the specifications with interest rates.

References

Abelson, P., Joyeux, R., Milunovich, G. and Chung, D. (2005), "Explaining house prices in Australia: 1970-2003", *The Economic Record*, Vol. 81, pp. S96-S103.

Apergis, N. (2003), "Housing prices and macroeconomic factors: prospects within the European monetary union", *International Real Estate Review*, Vol. 6, pp. 63-74.

Apergis, N. and Rezitis, A. (2003), "Housing prices and macroeconomic factors in Greece: Prospects within the EMU", *Applied Economic Letters*, Vol. 10, pp. 799-804.

Bahmani-Oskooee, M. and Ghodsi, S.H. (2017), "Asymmetric causality between unemployment rate and house prices in each state of the USA", *International Real Estate Review*, Vol. 1.

Bahmani-Oskooee, M., Chang, T. and Wu, T. (2014), "Revisiting purchasing power parity in African countries: panel stationary test with sharp and smooth breaks", *Applied Financial Economics*, Vol. 24, pp. 1429-1438.

Blanchard, O. and Gali, J. (2010), "Labor markets and monetary policy: a new Keynesian model with unemployment", *American Economic Journal: Macroeconomics*, Vol. 2 No. 2, pp. 1-30.

Branch, W.A., Petrosky-Nadeau, N. and Rocheteau, G. (2014), "Financial frictions, the housing market, and unemployment", Working Paper November, Federal Reserve Bank of San Francisco.

Breusch, T.S. and Pagan, A.R. (1980), "The lagrange multiplier test and its applications to model specification in econometrics", *Review of Economic Studies*, Vol. 47 No. 1, pp. 239-253.

Brown, J. and and Matsa, D.A. (2016), "Locked in by leverage: job search during the housing crisis", NBER Working Papers 22929, National Bureau of Economic Research.

Case, K.E. and Shiller, R.J. (2003), "Is there a bubble in the housing market?", *Brookings Papers on Economic Activity*, Vol. 2, pp. 299-342.

Chan, S. (2001), "Spatial lock-in: do falling house prices constrain residential mobility?", *Journal of Urban Economics*, Vol. 49 No. 3, pp. 567-586.

Christiano, L.J., Trabandt, M. and Walentin, K. (2011), "Introducing financial frictions and unemployment into a small open economy model", *Journal of Economic Dynamics and Control*, Vol. 35 No. 12, pp. 1999-2041.

Dahl, J. and Góralczyk, M. (2017), *Recent Supply and Demand Developments in the German Housing Market*, European Commission Directorate-General for Economic and Financial Affairs, May, 025.

Dröes, M.I. and van de Minne, A. (2016), "Do the determinants of house prices change over time? Evidence from 200 years of transactions data", European Real Estate Society (ERES), no. 227.

European Commission (2017), "2016 Annual report on intra-EU labour mobility", Brussels.

Ferreira, F., Gyourko, J. and Tracy, J. (2010), "Housing busts and household mobility", *Journal of Urban Economics*, Vol. 68 No. 1, pp. 34-45.

Fujita, S. and Ramey, G. (2009), "The cyclicality of separation and job finding rates", *International Economic Review*, Vol. 50 No. 2, pp. 415-430.

Gallin, J. (2006), "The long-run relationship between house prices and income: evidence from local housing markets", *Real Estate Economics*, Vol. 34, pp. 417-438.

Geerolf, F. and and Grjebine, T. (2014), "Assessing house price effects on unemployment dynamics", CEPII working paper no. 25, Paris.

Goetz, C.F. (2013), "Falling house prices and labor mobility: evidence from matched employer-employee data", Working Papers, Center for Economic Studies, US Census Bureau, pp. 13-43.

Guerrieri, V., Hartley, D. and Hurst, E. (2013), "Endogenous gentrification and housing price dynamics", *Journal of Public Economics*, Vol. 100, pp. 45-60.

Henley, A. (1998), "Residential mobility, housing equity and the labour market", *The Economic Journal*, Vol. 108 No. 447, pp. 414-427.

Holly, S., Pesaran, M.H. and Yamagata, T. (2011), "The spatial and temporal diffusion of house prices in the UK", *Journal of Urban Economics*, Vol. 69, pp. 2-23.

Ingholt, M.M. (2017), "House prices, geographical mobility, and unemployment" Department of economics, Working Paper 17-06, University of Copenhagen.

Jeanty, P.W., Partridge, M. and Irwin, E. (2010), "Estimation of a spatial simultaneous equation model of population migration and housing price dynamics", *Regional Science and Urban Economics*, Vol. 40 No. 5, pp. 343-352.

Katrakilidis, C. and Trachanas, E. (2012), "What drives housing price dynamics in Greece: new evidence from asymmetric ARDL cointegration", *Economic Modelling*, Vol. 29, pp. 1064-1069.

Kim, S. and Bhattacharya, R. (2009), "Regional housing prices in the USA: an empirical investigation of nonlinearity", *The Journal of Real Estate Finance and Economics*, Vol. 38, pp. 443-460.

Kiyotaki, N. and Moore, J. (1997), "Credit cycles", *Journal of Political Economy*, Vol. 105 No. 2, pp. 211-248.

Kónya, L. (2006), "Exports and growth: Granger causality analysis on OECD countries with a panel data approach", *Economic Modelling*, Vol. 23, pp. 978-992.

Krause, M.U. and Lubik, T.A. (2007), "The (ir)relevance of real wage rigidity in the new Keynesian model with search frictions", *Journal of Monetary Economics*, Vol. 54 No. 3, pp. 706-727.

Liu, Z. and Leduc, S. (2015), "Uncertainty shocks are aggregate demand shocks", Federal Reserve Bank of San Francisco Working Paper 2012-10.

Liu, Z., Miao, J. and Zha, T. (2016), "Land prices and unemployment", *Journal of Monetary Economics*, Vol. 80, pp. 86-105.

McQuinn, K. and O'Reilly, G. (2008), "Assessing the role of income and interest rates in determining house prices", *Economic Modeling*, Vol. 25, pp. 377-390.

OECD (2015), *Economic Surveys*, OECD, Paris.

Peek, J. and Wilcox, J.A. (1991), "The measurement and determinants of single – family house prices", *Real Estates Economics*, Vol. 19 No. 3, pp. 353-382.

Pesaran, M.H. (2004), "General diagnostic tests for cross section dependence in panels", Cambridge Working Papers in Economics No. 0435. Faculty of Economics, University of Cambridge.

Pesaran, M.H. and Yamagata, T. (2008), "Testing slope homogeneity in large panels", *Journal of Econometrics*, Vol. 142, pp. 50-93.

Pesaran, M.H., Ullah, A. and Yamagata, T. (2008), "A bias-adjusted LM test of error cross- section independence", *The Econometrics Journal*, Vol. 11 No. 1, pp. 105-127.

Petrongolo, B. and Pissarides, C.A. (2008), "The ins and outs of European unemployment", *American Economic Review*, Vol. 98 No. 2, pp. 256-262.

Pinter, G. (2018), "House prices and job losses", *The Economic Journal*, Forthcoming, available at: https://doi.org/10.1111/ecoj.12613

Ramey, G., den Haan, W.J. and Watson, J. (2000), "Job destruction and propagation of shocks", *American Economic Review*, Vol. 90 No. 3, pp. 482-498.

Saks, R.E. (2008), "Job creation and housing construction: constraints on metropolitan area employment growth", *Journal of Urban Economics*, Vol. 64 No. 1, pp. 178-195.

Smith, J.C. (2011), "The ins and outs of UK unemployment", *The Economic Journal*, Vol. 121 No. 552, pp. 402-444.

Stein, J.C. (1995), "Prices and trading volume in the housing market: a model with down-payment effects", *The Quarterly Journal of Economics*, Vol. 110 No. 2, pp. 379-406.

Sterk, V. (2015), "Home equity, mobility, and macroeconomic fluctuations", *Journal of Monetary Economics*, Vol. 74, pp. 16-32.

Swamy, P.A.V.B. (1970), "Efficient inference in a random coefficient regression model", *Econometrica*, Vol. 38 No. 2, pp. 311-323.

Trigari, A. (2009), "Equilibrium unemployment, job flows, and inflation dynamics", *Journal of Money, Credit and Banking*, Vol. 41 No. 1, pp. 1-33.

Tsong, C.C. and Lee, C.F. (2011), "Asymmetric inflation dynamics evidence from quantile regression analysis", *Journal of Macroeconomics*, Vol. 33 No. 4, pp. 668-680.

Walsh, C.E. (2005), "Labor market search, sticky prices, and interest rate policies", *Review of Economic Dynamics*, Vol. 8 No. 4, pp. 829-849.

Further reading

Meltzer, B.T. (2011), "The real costs of credit access: evidence from the payday lending market", *The Quarterly Journal of Economics*, Vol. 126 No. 1, pp. 517-555.

Appendix 1

Figures A1-A8, Time plot of the real house price index and unemployment rates (1991-2016).

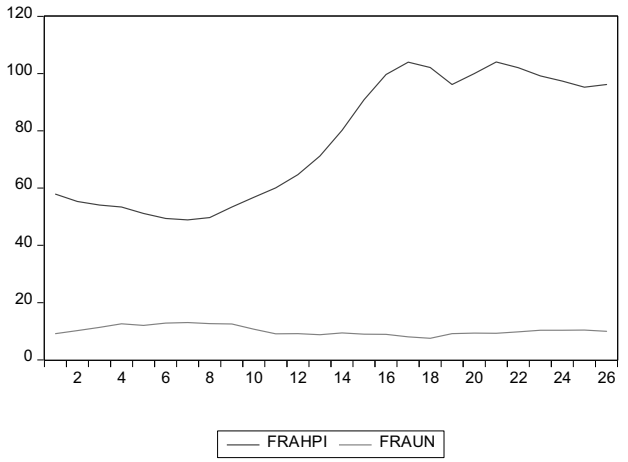

Figure A1. Real house price index and unemployment rate in France (1991-2016)

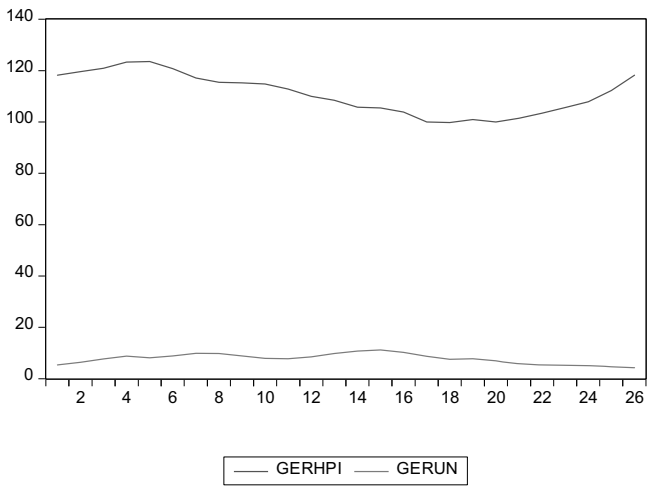

Figure A2. Real house price index and unemployment rate in Germany (1991-2016)

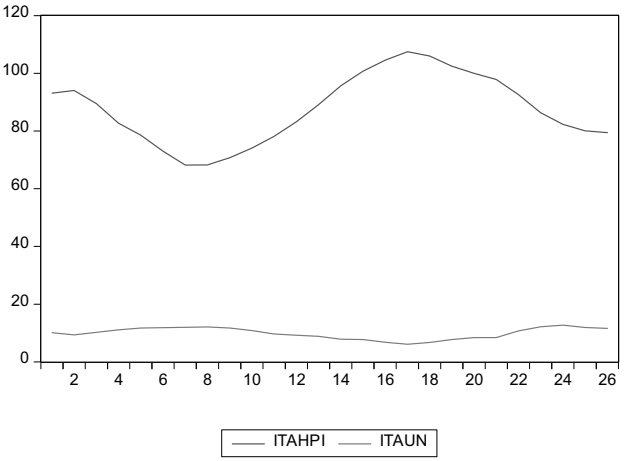

Figure A3.
Real house price index and unemployment rate in Italy (1991-2016)

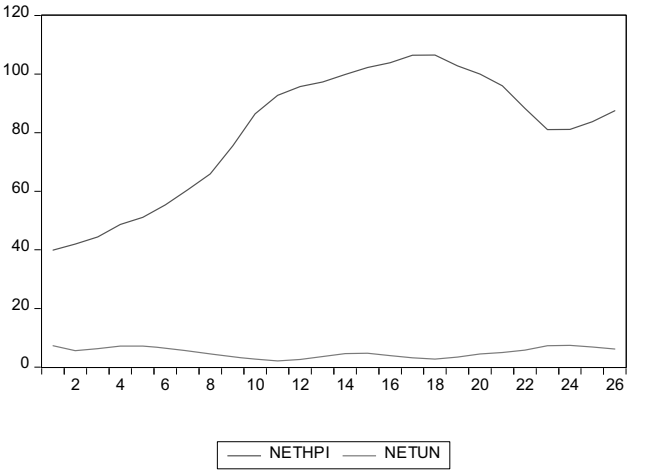

Figure A4.
Real house price index and unemployment rate in The Netherlands (1991-2016)

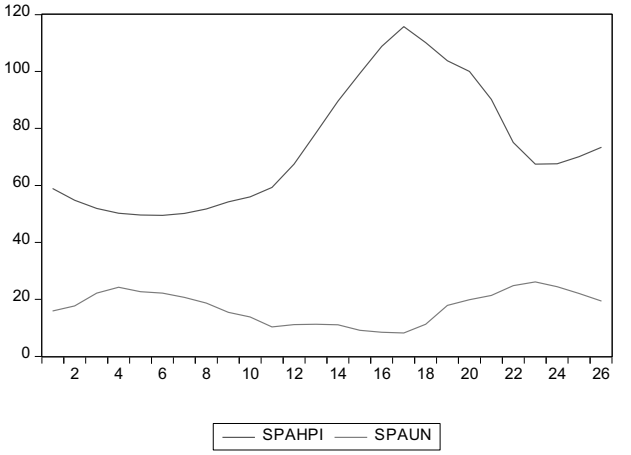

Figure A5. Real house price index and unemployment rate in Spain (1991-2016)

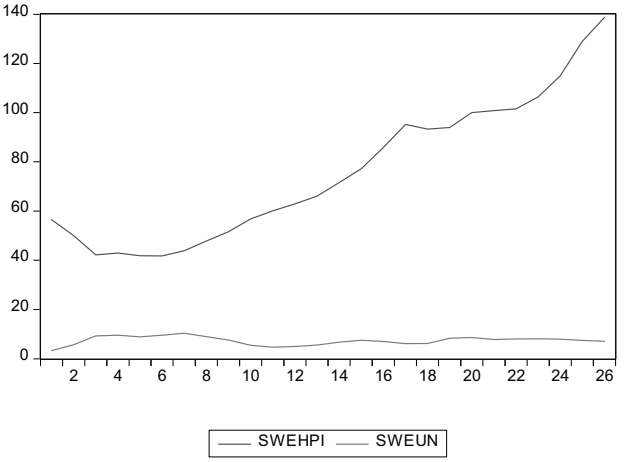

Figure A6. Real house price index and unemployment rate in Sweden (1991-2016)

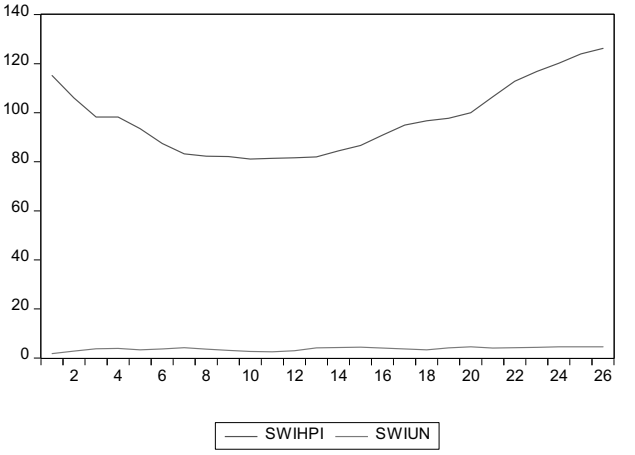

Figure A7.
Real house price index and unemployment rate in Switzerland (1991-2016)

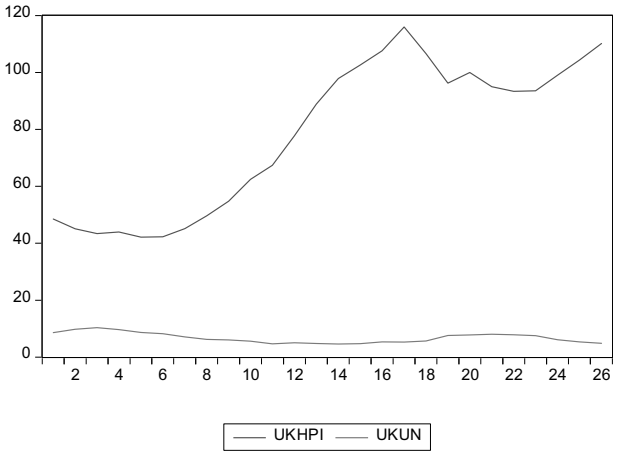

Figure A8.
Real house price index and unemployment rate in the UK (1991-2016)

Table AI.
Descriptive statistics for interest rates (n = 208)

Statistics/variables	FRAIR	GERIR	ITAIR	NETIR	SPAIR	SWEIR	SWIIR	UKIR
Mean	4.510187	4.198910	6.042616	4.349564	5.762323	4.961507	2.831265	5.078712
Median	4.268757	4.143750	4.805000	4.257459	4.780119	4.531667	2.911792	4.888200
Maximum	9.038341	8.458333	13.26575	8.739166	12.36055	10.69083	6.398413	10.10500
Minimum	0.467880	0.090000	1.486433	0.291083	1.393302	0.519167	−0.362000	1.305200
SD	2.168701	2.190968	3.385881	2.118975	3.031692	2.957959	1.719529	2.321768
Skewness	0.249387	−0.020572	1.029968	0.055814	0.918500	0.540657	0.152906	0.404472
Kurtosis	2.704126	2.403803	2.886830	2.637461	2.782387	2.324294	2.734650	2.426586
Jarque-Bera	0.364342	0.386906	4.610825	0.155887	3.707082	1.761304	0.177592	1.065126
Probability	0.833459	0.824109	0.099718	0.925017	0.156681	0.414513	0.915032	0.587098

Table AII. Descriptive statistics for house price indexes (n = 208)

Statistics/ variables	FRAHPI	GERHPI	ITAHPI	NETHPI	SPAHPI	SWEHPI	SWIHPI	UKHPI
Mean	76.65942	110.9310	87.63073	80.57635	73.20577	75.86935	97.30435	78.22915
Median	75.68200	111.1010	87.72400	86.94350	67.53950	68.80550	95.82550	91.11650
Maximum	104.0900	123.5440	107.4900	106.4800	115.7300	138.7300	126.2430	116.0100
Minimum	48.85900	99.70180	68.15300	39.89800	49.45000	41.77400	81.14700	42.18200
SD	22.15551	7.873604	12.07556	22.14508	21.87386	29.03968	14.51951	26.58431
Skewness	−0.006666	0.043499	0.011428	−0.600913	0.595957	0.485506	0.577089	−0.223750
Kurtosis	1.203538	1.646670	1.842634	1.942362	1.959339	2.122556	2.097390	1.383561
Jarque-Bera	3.496409	1.992328	1.451686	2.776568	2.712270	1.855504	2.325733	3.047559
Probability	0.174086	0.369293	0.483917	0.249503	0.257655	0.395442	0.312589	0.217887

Table AIII. Descriptive statistics for unemployment rates (n = 208)

Statistics/ variables	FRAUN	GERUN	ITAUN	NETUN	SPAUN	SWEUN	SWIUN	UKUN
Mean	10.20985	7.725692	9.891962	4.997731	17.32058	7.340538	3.732808	6.739923
Median	9.890000	7.845000	10.17150	4.850500	18.26550	7.546500	3.939500	6.157000
Maximum	13.05600	11.16700	12.68300	7.416000	26.09400	10.35900	4.583000	10.34800
Minimum	7.484000	4.311000	6.075000	2.119000	8.232000	3.243000	1.777000	4.594000
SD	1.565052	1.979552	1.967068	1.690932	5.708191	1.719405	0.736467	1.770200
Skewness	0.472022	−0.140233	−0.355008	−0.059352	−0.199118	−0.405634	−0.904350	0.471022
Kurtosis	2.175992	1.975497	1.870099	1.705197	1.661056	2.653008	3.131168	1.986553
Jarque-Bera	1.701061	1.222289	1.929199	1.831490	2.113976	0.843440	3.562649	2.074064
Probability	0.427188	0.542729	0.381136	0.400218	0.347501	0.655918	0.168415	0.354505

Appendix 2. Cross-sectional dependence tests

Breusch and Pagan (1980) LM test has been used in many empirical studies to test cross-sectional dependency. LM statistics can be calculated using the following panel model:

$$y_{it} = \alpha_i + \beta_{it}^{\circ} x_{it} + \mu_{it} \quad i = 1, 2, \ldots, N \quad t = 1, 2, \ldots, T \tag{1A}$$

where i is the cross-section dimension, t is the time dimension, x_{it} is $k \times 1$ vector of explanatory variables while α_i and β_i are the individual intercepts and slope coefficients that are allowed to differ across states. In the LM test, the null hypothesis of no cross-sectional dependence H_0: $Cov(\mu_{it}, \mu_{jt}) = 0$ for all t and $i \neq j$ is tested against the alternative hypothesis of cross-sectional dependence H_1: $Cov(\mu_{it}, \mu_{jt}) \neq 0$ for at least one pair of $i \neq j$. For testing the null hypothesis, Breusch and Pagan (1980) developed the following test:

$$\mathrm{CD_{BP}} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^{2} \tag{2A}$$

where $\rho_{ij}^{\wedge 2}$ is the estimated correlation coefficient among the residuals obtained from individual OLS estimation of Equation (1A). Under the null hypothesis, the LM statistic has an asymptotic chi-square distribution with $N(N-1)/2$ degrees of freedom. Pesaran (2004) proposes that the LM test is only valid when N is relatively small and T is sufficiently large. To overcoming this problem, Pesaran (2004) introduces the following LM statistic for the cross-section dependency test:

$$CD_p = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left(T\hat{\rho}_{ij}^{2} - 1\right) \tag{3A}$$

However, Pesaran *et al.* (2008) state that while the population average pair-wise correlations are zero, the CD test will have less power. Therefore, they proposed a bias-adjusted test that is a modified version of the LM test by using the exact mean and variance of the LM statistic. The bias-adjusted LM statistic is calculated as follows:

$$LM_{adj} = \sqrt{\frac{2T}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{2}\frac{(T-k)\hat{\rho}_{ij}^{2} - u_{Tij}}{\sqrt{v_{Tij}^{2}}} \tag{4A}$$

where u_{Tij} and v_{Tij}^{2} are the exact mean and variance of $(T-k)\rho_{ij}^{\wedge 2}$, which are provided in Pesaran *et al.* (2008). Under the null hypothesis of no cross-sectional dependence with $T \to \infty$ first followed by $N \to \infty$, the results of this test follow an asymptotic standard normal distribution.

Slope homogeneity tests

To relax the assumption of homoscedasticity in the F-test, Swamy (1970) developed the slope homogeneity test that examines the dispersion of individual slope estimates from a suitable pooled estimator. Pesaran and Yamagata (2008) state that both the F-test and Swamy's test require panel data models where N is relatively small compared to T. To overcome this problem, they proposed a standardized version of Swamy's test (the so-called $\tilde{\Delta}$ test) for testing slope homogeneity in large panels. The $\tilde{\Delta}$ test is valid when *(N, T)* $\to \infty$ without any restrictions on the relative expansion rates of N and T when the error terms are normally distributed. Pesaran and Yamagata (2008) then develop the following standardized dispersion statistic:

$$\bar{\Delta} = \sqrt{N}\left(\frac{N^{-1}S^{\approx} - k}{\sqrt{2k}}\right) \tag{5A}$$

where $S^{\approx}$ is Swamy's statistic. Under the null hypothesis with the condition of *(N, T)* $\to \infty$ and when the error terms are normally distributed, the $\tilde{\Delta}$ test has an asymptotic standard normal distribution. The small sample properties of the $\tilde{\Delta}$ test can be improved when there are normally distributed errors by using the following mean and variance bias-adjusted version:

$$\bar{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}S^{\approx} - E\left(z_{it}^{\approx}\right)}{\sqrt{\mathrm{var}\left(z_{it}^{\approx}\right)}}\right) \tag{6A}$$

where $E\left(z_{it}^{\approx}\right) = k, \mathrm{var}\left(z_{it}^{\approx}\right) = 2k(T-k-1))/(T+1)$.

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