On the Dynamic Linkages among Economic Policy Uncertainty, Land Use and Housing Prices: Evidence from Time Series and Panel Data Models

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ABSTRACT

In the first chapter of this thesis, we explore the dynamic relationship between economic policy uncertainty (EPU) and real housing prices in the US, taking into account the potential impact of structural breaks and other covariates on housing prices. The findings suggest the presence of strong time-varying Granger causality from EPU to housing prices with statistically significant tests of various subsamples. A key finding of the study is that strong causality from EPU to housing prices is observed during periods of declining EPU associated with rising housing prices, but not in periods such as the high EPU and declining housing prices. This suggests that lower levels of EPU can help predict real housing prices. This finding is useful for policymakers, real estate agents, and portfolio managers in the housing market who have an interest in predicting the housing market and evaluating its associated risks.

In the second chapter, we investigate the dynamic relationships between housing price return and EPU growth by incorporating economic growth and short-term interest rate as additional variables to circumvent for omitted variable bias. Empirical results show that a positive shock to EPU growth leads to a decrease in the housing price return while the same does not hold for the reverse case. Also, the housing price return is observed to have a very weak effect on explaining the changes in EPU growth. Based on these outcomes, several policy directions are constructed for all stakeholders ranging from real estate agents, portfolio managers, and policymakers in the housing market. These policies could be employed to predict the housing market and evaluating its associated risks.

In the third strata, the study investigates the asymmetric nexus of agricultural land and housing market vis-à-vis house prices using the Non-linear Autoregressive Distributed Lag (NARDL) approach. The finding notes a significant and positive short and long-run relationship between housing prices and agricultural land especially when there is a negative shock on agricultural land. But when there is a negative shock on EPU, the impact on housing prices is significant and negative for both the short-run and long-run. While an asymmetric long-run relationship is significant and positive between EPU and housing prices, such a significant occurrence does not exist for agricultural land. Hence, in meeting housing demand and mitigating an escalated growth in house prices, the implementation of the effective land-use policy is encouraged.

The last strand of this thesis employs the panel cointegration approach to investigate the dynamic relationship between the housing market vis-à-vis housing price (hp) and agricultural land (land) of a panel of fifteen countries over the period 1997 to 2015. Additionally, the Granger Causality approach of Dumitrescu-Hurlin is employed for the investigation. Meanwhile, the impact during the short-run of GEPU is statistically significant and positive on hp whereas it is not significant for land. Interestingly, the investigation reveals Granger causality from agricultural land to the housing price with feedback. The research presents an indication that policymaker(s) and urbanization stakeholders should be more concerned about effective and sustainable long-term policies. Future anomalies of food scarcity and skyrocketing house prices associated with agricultural land-house prices trade-off challenges could potentially be mitigated by such effective policy frameworks.

Keywords: Housing prices, Economic policy uncertainty, Time-varying Granger causality, Panel Vector Autoregression, agricultural land, NARDL model.

ÖZ

Bu tezin ilk bölümü, yapısal kırılmaların ve değişkenlerin konut fiyatları üzerindeki potansiyel etkisini hesaba katarak, ABD'deki ekonomi politikası belirsizliği (EPU) ile reel konut fiyatları arasındaki dinamik ilişkiyi araştırmaktadır. Ampirik sonuçlar, EPU'dan konut fiyatlarına zamanla değişen Granger nedenselliğinin varlığını göstermektedir. Çalışmanın önemli bir bulgusu, EPU'dan konut fiyatlarına güçlü Granger nedenselliğin, artan konut fiyatları ile bağlantılı olarak EPU'nun düştüğü dönemlerde gözlendiği, ancak yüksek EPU ve düşen konut fiyatları gibi dönemlerde gözlenmediğidir. Bu, düşük EPU seviyelerinin reel konut fiyatlarını tahmin etmeye yardımcı olabileceğini göstermektedir. Bu sonuç, konut piyasasını tahmin etmek ve ilgili riskleri değerlendirmekle ilgilenen, konut piyasasındaki politika yapıcılar, emlakçılar ve portföy yöneticileri için yararlıdır.

İkinci bölümde, ihmal edilen değişkenlerin yarattığı olası problemleri aşabilmek için model ek değişkenler olarak ekonomik büyüme ve kısa vadeli faiz oranını dahil ederek konut fiyatı getirisi ve EPU büyümesi arasındaki dinamik ilişkileri araştırıyoruz. Ampirik sonuçlar, EPU büyümesine yönelik pozitif bir şokun konut fiyatı getirisinde bir düşüşe yol açtığını göstermektedir. Ayrıca, konut fiyatı getirisinin de EPU büyümesindeki değişiklikleri açıklamada çok zayıf bir etkiye sahip olduğu görülmektedir. Bu sonuçlara dayanarak, emlakçılardan portföy yöneticilerine ve konut piyasasındaki politika yapıcıları için çeşitli politika önerileri oluşturulmuştur. Bu politikalar, konut piyasasını tahmin etmek ve bunlarla ilişkili riskleri değerlendirmek için kullanılabilir.

Üçüncü çalışma, Doğrusal Olmayan Otoregresif Dağıtılmış Gecikme (ARDL) modelini kullanarak konut fiyatları ile tarım arazisi kullanımı arasındaki asimetrik ilişkiyi araştırmaktadır. Bulgular, özellikle tarım arazileri kullanımı üzerinde negatif bir şok yaşandığında, bu şokun konut fiyatlarını pozitif etkilediğini ortaya koymaktadır. Ancak EPU üzerinde negatif bir şok olduğunda, konut fiyatları üzerindeki etki hem kısa hem de uzun vadede istatiksel olarak anlamlı ve olumsuz bulunmuştur. EPU ile konut fiyatları arasında asimetrik uzun vadeli bir ilişki istatiksel olarak anlamlı ve pozitif bulunmuştur. Bu nedenle, konut talebinin karşılanmasında ve konut fiyatlarındaki artan büyümenin azaltılmasında etkin arazi kullanımı politikasının uygulanması teşvik edilmektedir.

Bu tezin son kısmında, 1997-2015 dönemi için on beş ülkeden oluşan bir panelin konut fiyatı ile tarım arazisi kullanımı arasındaki dinamik ilişkiyi araştırmak üzere panel eşbütünleşme yaklaşımı kullanılmıştır. Ek olarak, Granger nedensellik ilişkisinin yönünü belirleyebilmek için Dumitrescu-Hurlin Granger Nedensellik yaklaşımı kullanılmıştır. Granger nedensellik sonuçlarına göre, tarım arazisi kullanımı ve konut fiyatı arasında geri beslemeli bir Granger nedensellik ilişkisi bulunmuştur. Araştırma, politika yapıcılar ve kentleşme paydaşlarının etkili ve sürdürülebilir uzun vadeli politikalar konusunda daha dikkatli olmaları gerektiğine dair bir gösterge sunmaktadır. Tarımsal arazi kullanımı ve konut fiyatları arasındaki ticaret zorluklarıyla ilişkili gıda kıtlığı ve hızla artan konut fiyatlarının gelecekteki anormallikleri, etkili politikalar ile potansiyel olarak hafifletilebilir.

Anahtar Kelimeler: Konut fiyatları, Ekonomik politika belirsizliği, Zamanla değişen Granger nedenselliği, Panel Vektör Otoregresif Regresyon, tarım arazisi, NARDL modeli.

DEDICATION

To My Family

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criteria
ARDL	Autoregressive Distributed Lag
CO2	Carbon Dioxide
ECB	European Central Bank
EPU	Economic Policy Uncertainty
EU	European Union
FEVD	Forecast Error Variance Decomposition
GC	Granger Causality
GDP	Gross Domestic Product
GNC	Granger non-causality
GFG	Global Financial Crisis
GMM	Generalized Methods of Moment
HQIC	Hannan-Quinn Information Criteria
HP	House Price Index
INF	Inflation
IPI	Industrial Production Index
IRF	Impulse-Response Functions
LAND	Agricultural Land
NARDL	Non-linear Autoregressive Distributed Lag
MS-VAR	Markov switching Vector Autoregression
OECD	Organization for Economic Cooperation and Development
PMG	Pooled Mean Group
POP	Population

RE	Recursive
RER	Recursive Rolling
RO	Rolling
RV	Stock Market Volatility
SB	Structural Break
SIC	Schwarz Information Criteria
TBILL	3-Month Treasury Bill Rate
TVGC	Time - Varying Granger Causality
UNEMP	Unemployment Rate
US	United States
WDI	World Development Indicator

Chapter 1

INTRODUCTION

Following the recent global financial crisis (GFC), an ensuing recession has led to a renewed interest in the possible interdependencies between housing markets and policy uncertainty. This thesis takes into account global, and local economic dimensions of policy uncertainty vis-à-vis uncertainty shocks. Over the years, greater interest in the housing market has been observed given the rising population across the globe. Scholars on the other hand have developed a special interest in examining the role of uncertainty in the housing market. Further, more attention has been given to examining the investigation of economic policy uncertainty (EPU) and macroeconomic variables, with regards to their influence on the behavior housing prices. The most important reason for these interests is the existence of a feedback mechanism between housing and macroeconomic variables. According to the housing price model, there seems to be no direct relationship between uncertainty and housing prices. This is because the housing pricing model is a function of some macroeconomic variables such as interest rate, unemployment, real income, population, etc. Intuitively, it can be deduced that uncertainty exhibit a significant influence on macroeconomic variables which in turn affects the housing price. On this premise, we can strongly suggest that there is an indirect relationship between the EPU and housing prices (HP).

Food, clothing, and shelter remain basic human needs across the globe. The housing sector plays a crucial role in the socio-economic characteristics of inhabitants in the world. Recently, the World Bank (2018) asserted that the housing sector is the largest component of wealth and investment in most developed and developing countries. Therefore, in this study, it is pertinent to examine this dynamic sector and its linkages with other economic aspects.

Accordingly, in the second chapter of this thesis, an investigation into the causal interaction between EPU and HP is considered while controlling for other crucial macroeconomic indicators, such as the 3-month Treasury bill rate, industrial production index, stock market volatility, population, and the US unemployment rate. The reason for incorporating covariates other than the EPU into the model is to avoid possible model misspecification. Previous studies relied on panel causality (Aye, 2018; Christou *et al*., 2017; Chow *et al*., 2017; El-Montasser *et al*., 2016) and the bootstrap rolling (RO) window approaches (Su *et al*., 2016; Emirmahmutoglu *et al*., 2016). As the GFC of 2007-2009 showed, understanding the dynamics of housing prices, most especially in the US is crucial to predict the behaviour of contagious effect as it relates to the global economy.

Unfortunately, the GFC perfectly illustrates the situation of the contagious effect as it relates to the US and the global economy. This crisis was triggered by the subprime residential mortgages that happened between August 2007 and 2008. Thereafter, the bankruptcy of the investment bank Lehman Brothers, collapses on the American International Group and the Reserve Primary Fund money market fund were notable circumstances of the GFC especially between 15 and 16 September 2008. In specific, the effect of the bankruptcy of the Lehman Brothers on other financial institutions and economic sectors was severe considering that Lehman Brothers was the fourth largest investment bank with over $600 billion in assets and 25,000 employees. The consequence of this was the decline in the US economic growth in the third quarter of 2008, thus the event preceding the recession started in December 2007 that later became the worst economic crisis in the US since World War II. Moreover, as the US witnessed a record-high unemployment rate, the world economy declined at an annual rate of –7.3 percent in the first quarter of 2009 (Mishkin, 2011).

As such, the influence of the 2008 subprime mortgage crisis on the US housing sector is not unexpected. Indeed, it devastated the real estate domain and the world economy at large. Little wonder the saying that when America sneezes, the world catches a cold. Economists and other stakeholders have explored the 2008 crisis and its policy framework implications (Crotty, 2009; Shiller, 2012). The US subprime mortgage crisis is considered as the major cause of the GFC of 2007-2009. The contagious effect began with European countries and thereafter spread as far as East Asia. A handful of factors could be responsible for the speed of contagion of this devastating crisis; the financial sector and trade linkages between the US and some of the affected developed and developing countries are worth observing. From this backdrop, the prediction of the HP is important for the US economy, especially while controlling for the macroeconomic variables and considering the influence of EPU.

The third strata of this thesis consider the dynamic and endogenous relations among housing prices, EPU, the short-term interest rate, real gross domestic product for 16 OECD countries.

Thus, it is paramount to emphasize the importance of the dynamics of the housing market as it affects the macroeconomics trends as well as the business cycle. It will be consistent with the theory to argue that the variations in household wealth accumulation, income, and the level of expenditure can be impacted. This impact is often caused by the size of rents, variations in the house prices, and/or interest rate associated with a mortgage, and these exert a huge influence on the price levels and aggregate demand. Besides, economic growth, investment in residential forms of housing, and the living standard are influenced by the changes in housing prices, and it depends on the efficiency of the constructive response.

Chapter four of this thesis considers the asymmetric nexus of HP and agricultural land (LAND) and within the non-linear ARDL (NARDL) model for Sweden.

Besides the fact that housing plays a major socio-economic role by representing the main wealth of the poor in the developing economies, agriculture has consistently remained a source of food and raw materials, especially to the housing market. Agricultural activities can only be carried out on land. Thus, this is expected to exert pressure on the allocation of land and triggering a potential trade-off between housing purposes and agricultural purposes. However, we recall the position of Thomas Malthus who postulated that population was growing at a geometric rate whereas food production (agriculture) was only growing at arithmetic progression, thereby advocating for improvement in food production. Therefore, it is interesting to ask, does the usage of agricultural land affect the housing prices? Expectedly, and in a careful manner, this chapter will explore the relationship between agricultural land and housing prices in proffering answers to this critical question.

In the last chapter of this thesis, the interaction between the HP and LAND while controlling the global economic policy uncertainty for the fifteen OECD countries is investigated. The objectives of this chapter are presented in the following folds: firstly, the potential nexus of LAND, and the HP is established. Secondly, due to policy influence on the HP (Lu *et al*., 2017) and land (Shen *et al*., 2018; Wang *et al*., 2016), the model control for policy effects and other uncertainty factors using the GEPU index. Putting this into perspective, this should provide useful evidence for or against the hypothesis that LAND usage impacts the HP. Additionally, the study further found that policy uncertainty has a stronger impact on the housing market as studied by Wang *et al*. (2016). Moreover, using a dynamic heterogeneous panel approach, the study is poised to present a broader investigation that reflects wider policy implications regarding the subject of discussion.

Chapter 2

THE CAUSAL LINK BETWEEN HOUSING PRICES AND ECONOMIC POLICY UNCERTAINTY IN THE US

2.1 Introduction

Food, clothing, and shelter are basic human needs across the globe. The housing sector plays a crucial role in the socio-economic characteristics of inhabitants in the world. Recently, the World Bank (2018) asserted that the housing sector is the largest component of wealth and investment in most developed and developing countries. Therefore, it is pertinent to examine this dynamic sector and its linkages with other economic aspects.

In the last decade, several studies have been conducted on the relationship between housing prices and some macroeconomic variables (Kishor & Marfatia, 2017; Zhang *et al*., 2016; Leamer 2015; Leung, 2015; Apergis et. al., 2015; Cesa-Bianchi *et al*., 2015; Aye *et al*., 2014; Balcilar *et al*. 2014; Cesa-Bianchi, 2013; Simo-Kengne *et al*., 2013; Canarella *et al*., 2012; Demary, 2010; Gupta *et al*., 2010; Sirmans *et al*., 2005; Goodhart & Hofmann, 2008). Specifically, Goodhart and Hofmann (2008) indicate the multidirectional link between monetary variables, housing prices, and other macroeconomic variables for industrialized countries over the period of 1970-2016. Their study asserts that the impact of shocks on credit and money can be severe under rising house prices. Similarly, Gustafsson *et al*. (2016), Leamer (2015), Aye *et al*. (2014), and Balcilar *et al*. (2014) share the opinion that HP is one of the most significant measures of macroeconomic activity. In their analyses, they argue that HP plays a significant role in curbing the global economic crisis. Thus, we should consider factors that drive housing prices and what constitutes a suitable HP model in the empirical analysis to make a sound and reliable HP prediction. This will, in one way or another, help policymakers, investors, and stakeholders to make sound housing policy and decide the interplay within the real economy.

In the wake of the GFC, HP volatility and economic uncertainty are observed to have increased (Hirata *et al*., 2013). In this regard, the extent growing literature tries to explore the linkage between the housing market and economic uncertainty (Aye, 2018; Ongan and Gocer, 2017; Christou *et al*., 2017; André *et al*., 2017; Antonakakis and Floros, 2016; Burnside *et al*., 2016). Within the framework of economic theory, Burnside *et al*. (2016) and Hirata *et al*. (2013) point out that uncertainty causes a reduction in housing demand. On the other hand, high uncertainty can increase volatility in HP (André *et al*., 2017). In this case, due to the cost of investment reversal, firms reduce residential investment and suspend their projects as they accumulate new information (Hirata *et al*., 2013). Therefore, to understand the linkages between EPU and the HP is highly informative for prospective homeowners, economic planners, financial institutions, policymakers, and property investors. However, most of the studies in the existing literature have been conducted on the relationship between housing returns and the EPU index (Aye, 2018; Christou *et al*., 2017; André *et al*., 2017; Su *et al*., 2016). These studies focus on returns on housing prices and EPU, given that the return is computed from housing prices. In addition, high volatility in housing prices spurs uncertainty; thus, it becomes imperative to investigate holistically the causal effect of HP on EPU.

The impact of the 2008 subprime mortgage crisis on the US housing sector is not unexpected. Indeed, it devastated the real estate domain and the world economy at large. Economists and other stakeholders have researched the 2008 crisis for its policy framework implications (Crotty, 2009; Shiller, 2012). The US subprime mortgage crisis is considered as the major cause of the GFC of 2007-2008. The contagious effect began with European countries and even spread as far as East Asia. A handful of factors could be responsible for the speed of contagion of this devastating crisis; the financial sector and trade linkages between the US and some of the affected developed and developing countries are worth observing.

As the GFC of 2007-2008 showed, understanding the dynamics of housing prices, most especially in the US is crucial to predict the behavior of contagious effect as it relates to the global economy. There is extant literature on the US housing market, which focuses on the predictability of housing prices. Some of the studies examine the possible bubbles in the US real estate sector (Akinsomi *et al.*,2016; Balcilar *et al.*, 2018; Gupta and Wong, 2019), while other studies relate the US housing prices to macroeconomic variables such as income, population, unemployment (Jud and Winkler, 2002; Iacoviello and Neri, 2010; Gupta *et al.*, 2012; Bahmani and Ghodsi, 2016). In the recent times, a strand of literature has emphasized on the relationship between the US housing prices and EPU (André *et al.*, 2017; Christou *et al.*, 2017; El-Montasser *et al.*, 2016; Antonakais *et al.*, 2015). Notably, Bahmani and Ghodsi (2016) show that interest rate and income have short-run and long-run effects on the US housing prices in almost all states of the US. Moreover, Aye et. al., (2019) use a hazard model to examine the spillover effect of EPU on the housing market cycles in 12 OECD countries and show that correlations between housing prices and economic uncertainty tend to increase significantly especially during the US recession, indicating a time-varying correlation.

Against this backdrop, this current study explores the causal interaction between EPU and HP while controlling for other crucial macroeconomic indicators, such as the 3-month Treasury bill rate, industrial production index, stock market volatility, population, and the US unemployment rate. The reason for incorporating covariates other than the EPU into the model is to avoid possible model misspecification. Previous studies relied on panel causality (Aye, 2018; Christou *et al*., 2017; Chow *et al*., 2017, El-Montasser *et al*., 2016) and the bootstrap rolling (RO) window approaches (Su *et al*., 2016). To the best of our knowledge, no study has investigated the Granger-causal relationship between EPU and housing prices using both RO and recursive rolling (RER) bootstrap Granger Causality (GC) tests in a multivariate time-series framework. Hence, the current study seeks to fill this gap in the literature by using the time-varying GC (TVGC) test developed as well as the RER approach proposed by Shi *et al*. (2019, 2018). Thus, this study not only contributes to the growing literature on housing prices and EPU, but it also extends the methodology to a multivariate setting.

The rest of the study will take the sequence, Section 2 discusses the methodology, and Section 3 presents the data and empirical results, while Section 4 concludes.

2.2 Methodology

As highlighted in the extant literature, alternative approaches to testing for GC under the existence of structural breaks (SB). The Markov switching model is one of these approaches that has been extensively used (See Krolzig, 1999; Hamilton, 1989).

Furthermore, older studies apply threshold autoregression (See Teräsvirta, 1998; Granger & Teräsvirta, 1993), while more recent studies, such as Balcilar and Ozdemir (2013b, c) apply two-regime Markov switching VAR (MS-VAR) models for the analysis of causality in the presence of regime-switching. Even though MS-VAR models are useful to test for regime-switching GC, there is a limitation on the number of regime changes, and as such, the models are unable to consider where there are several structural changes coupled with varying lengths of regime periods. To overcome the aforementioned limitation, the recursive (RE) and rolling techniques are used, as advanced by Swanson (1998) and Thoma (1994). In the same vein, the rolling bootstrap (RO) procedure proposed by Balcilar and Ozdemir (2013a), Balcilar *et al.* (2010), and Swanson (1998) come in handy to account for multiple SB. More recently, Shi *et al.* (2019, 2018) extend the literature by proposing the RER approach as an alternative technique to test for TVGC. The crucial merit of the RER and RO is that they both explicitly address the multiple SB with potential shifts in parameters in the individual time-span; however, these approaches have their merits and weaknesses.

More recently, Shi *et al.* (2018) carry out a comparative evaluation of the false detection rate (FDR) and true detection rate (TDR) of the RE, RO, or RER methods by using Monte Carlo simulations. They find that the RO estimation approach proposed by Balcilar *et al.* (2010), Balcilar, and Ozdemir (2013a) provides the most reliable results. The RO method generates higher TDR; on the other hand, the RO approach provides a slightly higher FDR relative to the RER approach for most cases considered in the simulation study. The RE approach provides the worst performance regarding the FDR and TDR, while the RO approach provides the best overall performance for nonstationary time series (Shi *et al.*, 2019). This study prefers the RO and RER methods based on their robustness in terms of false causality detection rate

(FCDR) and true causality detection rate (TCDR). To explain the TVGC for p-th order VAR(p), the model for the n-vector time series is defined as follows:

$$y_t = \Phi_0 + \sum_{k=1}^{p} \Phi_k y_{t-k} + \varepsilon_t, \qquad t = 1,2,\ldots,T \tag{2.1}$$

where p indicates the lag order, $y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})'$, Φ_k are $n \times n$ fixed coefficient matrices, $\Phi_0 = (\phi_{1,0}, \phi_{2,0}, \ldots, \phi_{n,0})'$ is an $n \times 1$ vector of intercept terms, and $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \ldots, \varepsilon_{nt})'$ is an n-vector zero-mean white noise or innovation process with a positive definite covariance matrix $E[\varepsilon_t \varepsilon_t'] = \Sigma$. Also, VAR(p) can be written using the following correlated companion form:

$$y_t = \Pi x_t + \varepsilon_t, \qquad t = 1,2,\ldots,T \tag{2.2}$$

where $x_t = \left(1, y_{t-1}', y_{t-2}', \ldots, y_{-p}'\right)'$ and $\Pi = [\Phi_0, \Phi_1, \ldots, \Phi_p]$ is an $n \times (np+1)$ matrix.

Our focus in this paper is to test for GNC from the EPU to the HP. The GNC indicates that EPU does not have predictive power over the HP. Let y_{jt} denote EPU variable and y_{it} denote HP. GNC from EPU to housing prices ($y_{jt} \nrightarrow y_{it}$) can be tested by imposing the following joint zero restrictions on the parameters of the VAR model in Equation (2.1) or in Equation (2.2):

$$H_0\colon\ y_{jt} \nrightarrow y_{it} \implies \phi_{ij,1} = \phi_{ij,2} = \cdots = \phi_{ij,p} = 0 \tag{2.3}$$

where $\phi_{ij,k}$ are the coefficient in the i-th row and j-the column of the matrix Φ_k, $k = 1,2,..,p$, in Equation (2.1). The null hypothesis of GNC can be tested by imposing the following restrictions on Equation (2.2):

$$H_0\colon\ R\pi = 0 \tag{2.4}$$

where R denotes the selection matrix of dimension $p \times n(np+1)$ and $\pi = \text{vec}(\Pi)$ denotes a vector of dimension $n(np+1) \times 1$ using row vectorization. Assuming the

EPU variable is the second element of y_t (y_{2t}) and the HP variable is the first element (y_{1t}), the selection matrix for the null hypothesis $y_{2t} \nrightarrow y_{1t}$ is given by:

$$R = \begin{pmatrix} 0 & \overbrace{0 \ 1 \ 0 \ \cdots \ 0}^{\text{columns 2 to } n+1} & \overbrace{0 \ 0 \ 0 \ \cdots \ 0}^{\text{columns } n+2 \text{ to } 2n+1} & \cdots & \overbrace{0 \ 0 \ 0 \ 0 \ \cdots \ 0 \ 0}^{\text{columns } n(p-1)+3 \text{ to } n(np+n)} \\ 0 & 0 \ 0 \ 0 \ \cdots \ 0 & 0 \ 1 \ 0 \ \cdots \ 0 & \cdots & 0 \ 0 \ 0 \ 0 \ \cdots \ 0 \ 0 \\ \vdots & \vdots \ \vdots \ \vdots \ \ddots \ \vdots & \vdots \ \vdots \ \vdots \ \ddots \ \vdots & \ddots & \vdots \ \vdots \ \vdots \ \vdots \ \ddots \ \vdots \ \vdots \\ 0 & 0 \ 0 \ 0 \ \cdots \ 0 & 0 \ 0 \ 0 \ \cdots \ 0 & \cdots & 1 \ 0 \ 0 \ 0 \ \cdots \ 0 \ 0 \end{pmatrix} \quad (2.5)$$

In the RER estimation method, the endpoints of the regression are indexed by $\tau_2 = \{\tau_w, \tau_w + 1, \dots, T\}$ analogs to the RO estimation. On the other hand, the starting point τ_1 of the estimation accounts for all possibilities, that is 1 to $\tau_2 - \tau_w + 1$. Unlike the RO method, the starting point in the RER method does not keep a fixed distance with τ_2. The RER method associates the order of endpoints $\tau_2 = \{\tau_w + 1, \dots, T\}$ with the starting points indexed by $\tau_1 = \{1,2, \dots, \tau_2 - \tau_w + 1\}$. Furthermore, the RER Wald statistics are the sup of the probable RO statistics for a specific point and represented as: $\left\{SW_{\tau_{1=\tau_2-\tau_w+1}}^{\tau_2}\right\}_{\tau_2 \in [\tau_w, T]} = \sup_{\tau_2, \tau_1 \in [1, \tau_2 - \tau_w + 1]} [\{W_{\tau_1}^{\tau_2}\}]$.

Implementation of the RO and RER methods requires us to estimate the Wald tests for a subset of a sample with beginning point (τ_1) and endpoint (τ_2). Let the OLS estimates of the VAR(p) model in Equation (2.2) estimated for this subsample be given by $\hat{\Pi}_{\tau_1,\tau_2}$ and its row vectorization form by $\hat{\pi}_{\tau_1,\tau_2} = \text{vec}(\hat{\Pi}_{\tau_1,\tau_2})$. The sequence of Wald statistics is obtained by imposing restrictions in Equation (2.3) on the subperiod estimates, i.e. we examine the null hypothesis with restrictions $H_0 : R\hat{\pi}_{\tau_1,\tau_2} = 0$. The OLS estimates $\hat{\pi}_{\tau_1,\tau_2}$ are obtained for individual equation $i = 1,2, \dots, n$, via $\hat{\pi}_{i,\tau_1,\tau_2} = \left[\sum_{t=\tau_1}^{\tau_2} y_{it}\, x_t'\right]\left[\sum_{t=\tau_1}^{\tau_2} x_t\, x_t'\right]^{-1}$. The errors for individual equations in the subperiod estimate is derived as $\hat{\varepsilon}_t' = [\hat{\varepsilon}_{1t}, \hat{\varepsilon}_{2t}, \dots, \hat{\varepsilon}_{nt}]$ by using $\hat{\varepsilon}_{it} = y_{it} - \hat{\pi}_{i,\tau_1,\tau_2} x_t$. In this study, we obtain the estimate of the error covariance matrix Ω

as $\hat{\Omega}_{\tau_1,\tau_2} = T_w^{-1} \sum_{t=\tau_1}^{\tau_2} \hat{\varepsilon}_t \, \hat{\varepsilon}_t'$, where $T_w = \tau_2 - \tau_1 + 1$. Based on the aforementioned procedure, the Wald statistics for the Granger non-causality (GNC) restrictions given in Equation (2.4) for each subperiod is calculated from the following equation:

$$W_{\tau_1}^{\tau_2} = \left(R\hat{\pi}_{\tau_1,\tau_2}\right)' \left\{ R \left[\hat{\Omega}_{\tau_1,\tau_2} \otimes \left(\sum_{t=\tau_1}^{\tau_2} x_t \, x_t' \right)^{-1} \right] R' \right\}^{-1} \left(R\hat{\pi}_{\tau_1,\tau_2}\right) \qquad (2.6)$$

In Equation (2.6), the Wald test statistic assumes that error variances are homoscedastic. However, the GC test obtained under the homoskedasticity assumption may have invalid empirical levels with the loss of test power in the presence of heteroskedastic errors. In order to circumvent this problem, we employ a modified Wald test (MWALD), which addresses the effect of heteroskedasticity. The MWALD statistic is obtained as:

$$W_{\tau_1}^{*\tau_2} = T_w \left(R\hat{\pi}_{\tau_1,\tau_2}\right)' \left[R \left(\hat{M}_{\tau_1,\tau_2}^{-1} \hat{W}_{\tau_1,\tau_2} \hat{M}_{\tau_1,\tau_2}^{-1} \right) R' \right]^{-1} \left(R\hat{\pi}_{\tau_1,\tau_2}\right) \qquad (2.7)$$

where $\hat{M}_{\tau_1,\tau_2} = I_n \otimes \hat{Q}_{\tau_1,\tau_2}$, $\hat{Q}_{\tau_1,\tau_2} = T_w^{-1} \sum_{t=\tau_1}^{\tau_2} x_t \, x_t'$, and $\hat{W}_{\tau_1,\tau_2} = T_w^{-1} \sum_{t=\tau_1}^{\tau_2} \hat{\psi}_t \, \hat{\psi}_t'$ with $\hat{\psi}_t = \hat{\varepsilon}_t \otimes x_t$.

The RO Wald statistic is asymptotically distributed as Chi-square, while the Wald statistic obtained from the RER method has a nonstandard asymptotic distribution. Shi *et al*. (2018) obtain the limiting distribution of the Wald statistic of the RER method. The studies by Guilkey and Salemi (1982) and Toda and Phillips (1993, 1994) show that the Wald tests, including the GNC test used in this current study, may be subject to severe sample-size distortions. Furthermore, the modified Wald test in Equation (2.7) requires the estimation of the fourth-order moment matrix $\hat{W}_{\tau_1,\tau_2}$. Furthermore, the modified Wald test in Equation (2.7) requires the estimation of the fourth-order moment matrix $\hat{W}_{\tau_1,\tau_2}$. Particularly in small samples, the fourth moment estimator is highly sensitive to extreme variations. Therefore, we employ the bootstrap techniques proposed by Balcilar *et al*. (2010) to estimate the Wald statistics in Equations (2.6) and (2.7).[1] The bootstrap method is applied under the null hypothesis restrictions of $R\hat{\pi}_{\sigma_1,\sigma_2} = 0$, where R is defined in Equation (2.5). In the bootstrap implementation, the full sample VAR under the maintained hypothesis has fixed coefficients $\Pi_{\tau_1,\tau_2} = \Pi$ for all sub-samples $t = \tau_1, \tau_1 + 1, \ldots, \tau_2$. Following the residual-based bootstrap technique in Balcilar *et al*. (2010), under the restrictions of the null hypothesis, the *p*-values (or critical values) of the GC test are calculated with 1,000 replications.

2.3 Data and Empirical Results

The monthly frequency US data used to investigate the causal relationship between the HP (i.e. deflated by CPI) (HP) and EPU while controlling for other crucial macroeconomic indicators, such as 3-month treasury bill rate (TBILL), industrial production index (IPI), stock market volatility (RV), population (POP), inflation (INF) and unemployment rate (UNEMP). Our dataset spans the period 1953:M1 to 2018:M11. The HP series come from Shiller (2015) which is the longest available monthly HP series for the US (André *et al*., 2017). The EPU is developed by Baker *et al.* (2016),[2] who use overlapping sets of newspapers to create this index. The first covers 1900-1985 and encompasses the *Wall Street Journal, Los Angeles Times, New York Times, Washington Post, Boston Globe,* and *Chicago Tribune. The Miami Herald, USA Today, San Francisco Chronicle and Dallas Morning Tribune* are added to the aforementioned newspapers to complete the period from 1985 onwards. To construct the EPU index, the newspapers must simultaneously contain uncertainty, the economy, and policy. Data on other macroeconomic indicators obtained from the

[1] See Balcilar *et al*. (2010) for details of the bootstrap implementation.
[2] Available for download at www.policyuncertainty.com.

Thomson Reuters DataStream. Figure 1 shows the time series plot of the HP, EPU, and the aforementioned macroeconomic covariates.

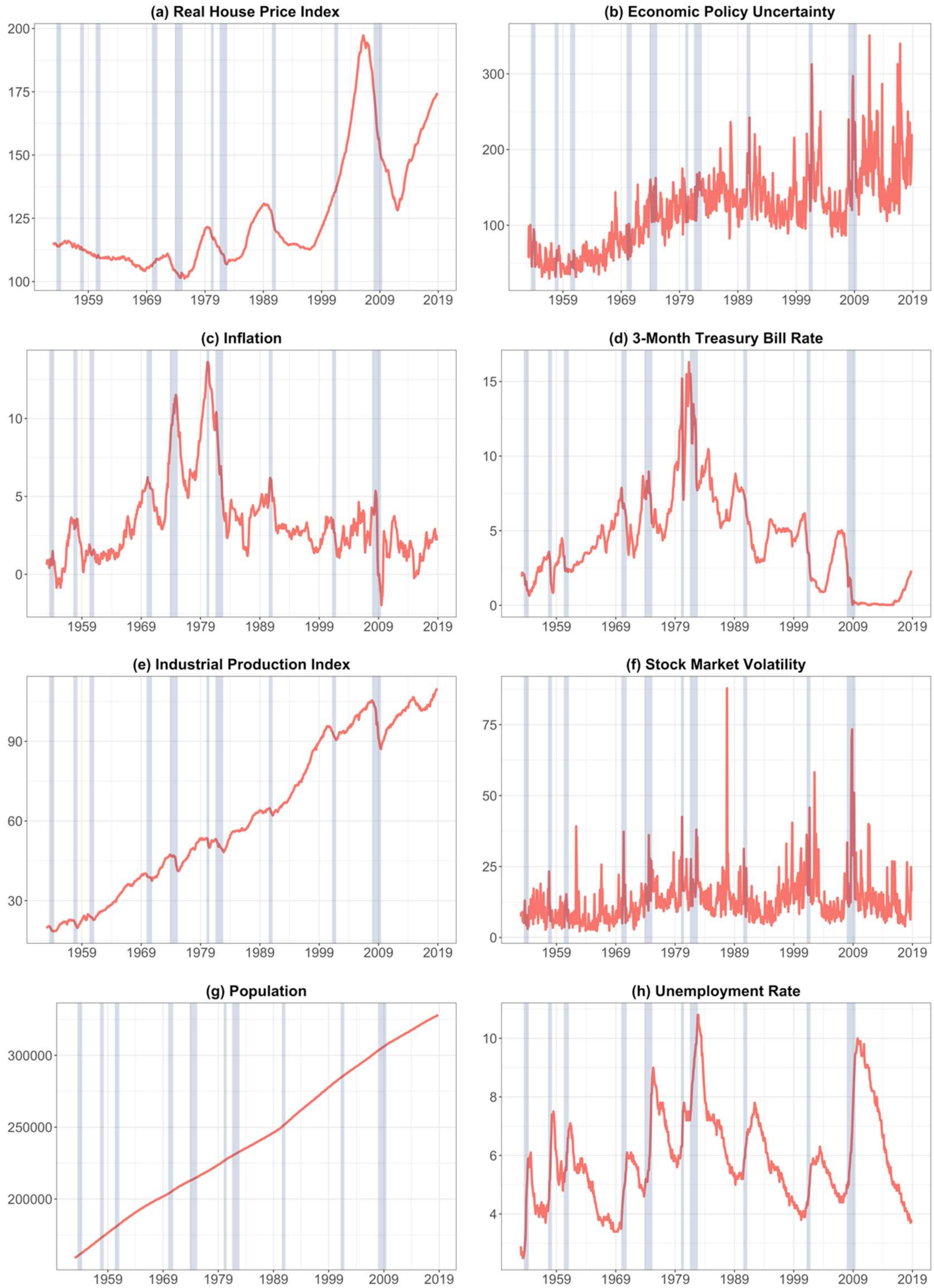

Figure 1: Time Series Plots of the Series

Table 1: Summary Statistics

	HP	EPU	INF	TBILL	IPI	RV	POP	UNEMP
N	791	791	791	791	791	791	791	791
Mean	125.3954	119.6115	3.4052	4.3299	62.1227	12.7399	243753.9000	5.8791
SD	22.8861	51.6066	2.6735	3.0950	28.6017	8.1832	48985.4400	1.6036
Min	101.1890	29.6202	-1.9782	0.0100	18.4432	2.1674	158973.0000	2.5000
Max	197.2549	350.7124	13.6210	16.3000	109.9836	87.8339	328163.8640	10.8000
Skewness	1.4284	0.7035	1.4928	0.8540	0.1290	3.0804	0.0872	0.6746
Kurtosis	4.1409	4.1426	5.4560	4.0786	1.6460	20.5752	1.8118	3.1251
JB	311.8810***	108.5280***	492.5751***	134.4850***	62.6240***	11431.4010***	47.5390***	60.7390***
Q(1)	788.4841***	541.1373***	778.7769***	779.0727***	788.7632***	209.4479***	788.0044***	777.3690***
Q(4)	3118.7229***	1770.5251***	2967.2099***	2986.5413***	3129.0084***	543.8284***	3122.0977***	2965.6173***
ARCH(1)	787.7894***	168.8451***	773.4838***	710.3623***	788.4063***	46.6834***	789.9230***	766.5992***
ARCH(4)	786.2860***	186.1437***	774.0458***	715.0550***	785.6234***	50.9562***	786.9992***	766.6548***

***Note*:** *N* is the number of observations, SD is the standard deviation, JB refers to Jarque-Bera normality test, Q(1) and Q(4) show the Ljung-Box first- and fourth-order autocorrelation tests, ARCH(1) and ARCH(4) denote the first- and fourth-order LM tests for the ARCH. *** denotes statistical significance at the 1% level.

Table 2: Pearson Correlation

	HP	EPU	INF	TBILL	IPI	RV	POP	UNEMP
HP	1.0000							
EPU	0.4182	1.0000						
INF	-0.2423	0.0915	1.0000					
TBILL3M	-0.4083	-0.0741	0.7483	1.0000				
IPI	0.7849	0.7003	-0.1312	-0.2865	1.0000			
RV	0.0951	0.4518	0.1985	0.1285	0.2444	1.0000		
POP	0.7543	0.7334	-0.1338	-0.2954	0.9888	0.2398	1.0000	
UNEMP	-0.1135	0.3371	0.1811	0.0904	0.0972	0.1953	0.1928	1.0000

Note: The table presents the pairwise Pearson correlation coefficients

The summary statistics that comprise measures of central tendency like the mean, standard deviation, maximum and minimum for real housing price, EPU, and other crucial macroeconomic variables in their level forms are reported in Table 1. Also, the table contains the kurtosis, skewness, and the JB normality test that captures distributional characterizes of the series. As reported in the table, EPU is more volatile than HP.

The descriptive statistics in Table 1 show that the variables have positive skewness statistic values, which indicate more than half of the values are less than the mean. The positive kurtosis statistic value of all the series implies fat-tailed behavior. This is evidence by the rejection of the Jarque-Bera (1980) normality test at the 1% significance level for all variables. Furthermore, the Ljung-Box statistics indicate the existence of serial correlation in all series. Additionally, the ARCH-LM statistics show that all series display ARCH. Table 2 reports the pairwise Pearson correlation coefficient. The HP is positively correlated with the EPU, IPI, RV, and POP. However, HP negatively correlates with the INF, TBILL, and UNEMP. A negative correlation coefficient is also found between the EPU and the TBILL. On the other hand, the EPU is positively correlated with the INF, IPI, RV, POP, and UNEMP. In addition, the results of the standard unit root tests confirm that the HP, EPU, and other crucial macroeconomic series are all stationary at first difference. We also investigate the long-run relationship among the series. The Johansen (1988, 1991) cointegration test results reported in Table 3 indicate three cointegrating relationships among the variables at the 5% level of significance. As earlier stated, the bootstrap GC can be applied without considering the integrating and/or cointegrating properties of the series. Thus, we proceed to the causality tests without explicitly modelling the cointegration between the variables.

To explicitly capture the time-varying nature of the causal interaction between EPU and the real housing price, we incorporate other crucial macroeconomic variables for the US. First, we investigate the linear GC using the full sample in the vector autoregressive (VAR) model framework for completeness and comparability. Before proceeding to linear GC tests, we check the lag order for the VAR model as reported in Table 4. Akaike Information Criteria [AIC] (Akaike, 1969), the Schwarz Information Criteria [BIC] (Schwarz, 1978; Rissanen, 1978), and Hannan-Quinn Information Criteria [HQIC] (Hannan and Quinn, 1979) suggest optimal lags of 8, 2 and 3, respectively. For parsimony, we prefer the SIC and HQIC over the AIC and use lag orders of 2 and 3.

Table 3: The Johansen Cointegration Test

Eigenvalues	$H_0(\lambda_{\max})$	$\lambda_{\max}$	$\lambda_{\max}(0.05$	$H_0(\lambda_{\text{trace}})$	λ_{trace}	$\lambda_{\text{trace}}(0.05)$
0.1943	$r = 0$	170.2151**	52.3626	$r = 0$	405.5054**	159.5297
0.1499	$r = 1$	127.9686**	46.2314	$r \leq 1$	235.2903**	125.6154
0.0601	$r = 2$	48.80199**	40.0776	$r \leq 2$	107.3217**	95.7537
0.0364	$r = 3$	29.24389	33.8769	$r \leq 3$	58.5197	69.8189
0.0185	$r = 4$	14.70931	27.8543	$r \leq 4$	29.2758	47.8561
0.0097	$r = 5$	7.711022	21.1316	$r \leq 5$	14.5665	29.7971
0.0077	$r = 6$	6.082843	14.2646	$r \leq 6$	6.8555	15.4947
0.0010	$r = 7$	0.772627	3.8415	$r \leq 7$	0.7726	3.8415

***Note*:** $\lambda_{\max}$ is the maximal eigenvalue and λ_{trace} is the trace cointegration test. $\lambda_{\max}(0.05)$ and $\lambda_{\text{trace}}(0.05)$ denote the 5% critical values of the $\lambda_{\max}$ and λ_{trace} test, respectively, which are taken from Mackinnon *et al.* (1999). The lag order (p) is selected using the Schwarz information criterion and is equal to 2. ** indicates the rejection of the null hypothesis at the 5% significance.

Table 4: Lag-length Selection Tests

Lag	Log *L*	LR	FPE	AIC	SIC	HQIC
0	-26098.5	NA	1.26E+19	66.68329	66.73093	66.70161
1	-11832.1	28204.86	2215.781	30.40637	30.83516	30.57126
2	-10723.5	2168.981	153.7476	27.738 27	28.54822*	28.04973
3	-10595.4	248.1671	130.5175	27.57435	28.76544	28.03238*
4	-10515.1	153.7098	125.2436	27.53288	29.10512	28.13747
5	-10449.2	124.9917	124.6674	27.5279	29.48129	28.27907

6	-10391.9	107.468	126.8814	27.54496	29.8795	28.44269
7	-10295.2	179.1995	116.8217	27.4616	30.1773	28.50591
8	-10222.6	133.1603*	114.3956*	27.43962*	30.53646	28.63049

Note: Log *L* is the log-likelihood, LR is the likelihood ratio test and FPE is the final prediction error.* denotes the lag order selected by the criterion.

Table 5 presents the linear GC test results. This outcome reveals that EPU does not GC on the HP at the five percent significance level. Subsequently, we conducted a lag sensitivity check for the robustness of the linear GC test with lag order of 3, which is determined by the HQIC. The results of the linear GC test with the lag order of 3 are presented in Table 6. According to Table 6, the H_0 is that EPU does not GC HP also fails to reject at the five percent level of significance. Therefore, we can conclude that there is no evidence of predictability from EPU to HP with different lags from the full sample VAR model. The results presented in Tables 5 and 6 are based on the non-causality restrictions imposed on the linear VAR model estimated using the full sample data. The important assumption of the full sample VAR model is the non-existence of SB in the sample. However, SB may alter the parameter values, and the direction of the causal relationship may be time-varying. This means that structural changes may possibly affect temporal (Granger) causality relationships because it is sensitive to the selected sample period. In such a situation, several tests can be used to examine the stability of the VAR models (Andrews and Ploberger, 1994). It has been argued in the literature that when the estimated parameter belongs to an unstable relationship, such parameters are erroneous. This position is further supported by Hansen (1992), whose study indicates that the parameters from an unstable relationship have implications on forecasts. Zelileis *et al*. (2005) add that such results are spurious and inferences drawn from such unstable parameters are inconsistent and not reliable for policy framework. In order to ascertain the stability of the parameters of the VAR model, we perform stability tests to explore the temporal stability of the coefficients of the VAR model, using the *Max-F, Exp-F* and *Ave-F* statistics of Andrews and Ploberger (1994), and Andrews (1993). These tests have distortions in the beginning and end of the sample, thus necessitate trimming from the ends of the sample. We use 15% trimming from each end of the samples to carry out the test. Table 7 reports the results of *Max-F, Exp-F,* and *Ave-F* test statistics. These three tests of parameter stability have the same null hypothesis of "stable parameter", however, in the case of the alternative hypothesis, the choice varies. The battery of test statistics indicates that the parameters are unstable at a 5% significance level for all equations of the VAR model with the exception of the *Ave-F* test for the POP equations. Considering the evidence from the parameter instability tests, it may be concluded that the GC test built on the VAR model for variables under consideration are not reliable and can lead to misleading inferences because the parameters in the VAR model are unstable within the study period. Taking into account the evidence of parameter instability, we proceed to the TVGC approach. The time-varying Wald test result for GC from EPU to HP and are given in Figures 2(a) and 3(a) for the RO and RER tests, respectively, whereas Figures 2(b) and 3(b) displays the heteroskedasticity-consistent time-varying Wald tests. Figures 2(a) and 3(a) report the *p*-values of the RO and RER Wald statistics, respectively, which are obtained from a VAR model with a fixed lag order and a window size of 60 months.[3] The study uses 1,000 bootstrap replications to obtain the *p*-values. Figures 2(a) and 3(a) presents the Wald tests under the assumption of homoscedastic residuals. On the other hand, in Figures 2(b) and 3(b), we report the *p*-values under heteroskedastic residuals assumption calculated using the MWALD test statistic given in Equation (7). Thus, given that the estimated VAR model shows heteroskedasticity, as seen in Table

[3] We set the subsample lag orders at the full sample lag order selected by the SIC. The results are, however, not sensitive to subsample specific lag selection. The results with subsample specific lag order are available upon request from the authors.

1, this might translate into a disparity in the conventional standard Wald tests in figures 2(a) and 3(a) and heteroskedasticity consistent Wald tests in Figure 2(b) and 3(b).

Table 3: Granger Causality Tests with Lag Order Chosen by HQIC

Equation	Causing variable								
	HP	EPU	INF	TBILL3M	IPI	RV	POP	UNEMP	ALL
HP	---	2.7235	23.0041***	4.4837	13.7300***	3.9482	1.6059	2.2541	58.0390***
EPU	6.8638*	---	7.3293*	0.4754	6.8232*	9.4825**	12.7451**	1.0409	110.6575***
INF	1.5101	1.9801	---	13.2608***	18.0698***	5.3250	1.7346	5.1620	63.0824***
TBILL	1.2431	4.5496	21.0465***	---	9.4700**	1.4473	1.3843	15.0558***	75.1368***
IPI	20.0741***	3.9016	4.8714	10.7379**	---	25.7248***	3.1866	19.6465***	114.6205***
RV	8.3021**	2.4885	1.6848	3.8985	26.7471***	---	7.1862**	6.2824*	66.5323***
POP	5.5569	10.5947**	4.9924	0.6731	6.1826	4.2613	---	3.7536	39.4813**
UNEMP	7.6071*	1.4303	6.8949*	5.7796	34.6765***	13.5504***	3.1089	---	111.0256***

Note: The order ($p = 3$) of the VAR is determined by the HQIC. ***, **, and * denote the rejection of the null of no GC at 0.01, 0.05, and 0.10 level of significance, respectively.

Table 4: Granger Causality Tests with Lag Order Chosen by SIC

Equation	Causing variable								
	HP	EPU	INF	TBILL	IPI	RV	POP	UNEMP	ALL
HP	---	1.3853	18.4233***	5.2143*	2.1444	4.0124	1.0427	0.5521	43.2966***
EPU	4.2772	---	3.9621	0.1013	3.6798	7.0301**	12.2413***	0.2982	108.5930***
INF	1.9684	1.3046	---	13.2692***	0.7324	2.0420	2.1169	1.3450	32.6857**
TBILL	0.8152	0.7899	15.4745***	---	2.9648	1.3371	0.0791	17.9558***	47.5026***
IPI	14.8895***	5.7129	9.4593**	11.7914**	---	26.5384***	0.6758	25.4484***	126.2955***
RV	8.0319**	1.0095	2.8671	2.1816	14.5152***	---	6.0821**	4.9866*	51.4920***
POP	4.5445	10.4723**	2.2196	0.0770	7.3038**	2.4597	---	1.3632	31.1866**
UNEMP	11.2834***	0.5694	13.9315***	3.6997	44.2762***	14.9192***	4.4274	---	137.2226***

Note: The order ($p = 2$) of the VAR is determined by the SIC. ***, **, and * denote the rejection of the null of no GC at 0.01, 0.05, and 0.10 level of significance, respectively.

Table 5: Parameter Stability Tests

Equations	*Max-F* statistics		*Exp-F* statistics		*Ave-F* statistics	
	Value	*p*-value	Value	*p*-value	Value	*p*-value
RHPI	120.0794***	0.0000	56.1744***	0.0000	70.0978***	0.0000
EPU	64.3984***	0.0000	25.8925***	0.0000	21.2731**	0.0097
INF	58.3204***	0.0000	23.9874***	0.0000	31.0812***	0.0000
TBILL	52.2656***	0.0000	20.9553***	0.0001	19.2415**	0.0268
IPI	49.7520***	0.0001	20.2585***	0.0001	23.4125**	0.0031
RV	48.9838***	0.0001	18.2442***	0.0004	18.2975**	0.0418
POP	52.7447***	0.0000	21.1455***	0.0000	12.6270	0.3760
UNEMP	66.7454***	0.0000	66.7454***	0.0000	43.1833***	0.0000

Notes: The distribution of the parameter stability tests in non-standard asymptotic distributions. Hence, p-values for the non-standard asymptotic distribution of all three tests are calculated by using Hansen's (1997) technique. *** and ** indicate significance at 1% and 5% level, respectively.

This study explores the non-causality tests between the HP and EPU while accounting for other key macroeconomic variables that may affect the housing market dynamics. The non-causality test, following the common practice, is performed at the 5% statistical significance level; nevertheless, a 10% statistical significance level is also considered to accommodate low test power due to small sample size and short time span. The results in Figures 2 and 3 show the p-values of the Wald tests vary noticeably over the sample period alternating between significant and insignificant test results. This result indicates the existence of an influential SBs. Figure 2(a) reveals that the H_0 in which EPU does not have predictive power over HP fails to reject at the 10% level of significance for the majority of the sample when the RO method is employed. However, there are subperiods in which the p-values of the RO tests are less than the 5% significance level and more frequently below the 10% significance level. The periods where the p-values indicate significant causality at the 10% level from EPU to HP are 1964, 1973-1974, 1981-1983, 1984, 1987-1992, 2001, 2003-2005, and 2007 subperiods. In Figure 3(a), the p-values of the RER test results show that the H_0 in which EPU does not GC HP can be rejected for 1964, 1973, 1981-1983, 1987-1991, 2003-2004, and 2009 subperiods at the 10% level. As clearly seen from the comparison of Figure 2(a) and 3(a), the RO Wald test statistics show more Granger causal links compared to the RER Wald statistic. Generally, the RO method has a superior ability to detect true structural break than the RER method (see Shi et al. (2019, 2018)). Comparing Figures 2(a) and 3(a), we observe that the RO method indicates more SB relative to the RER method.

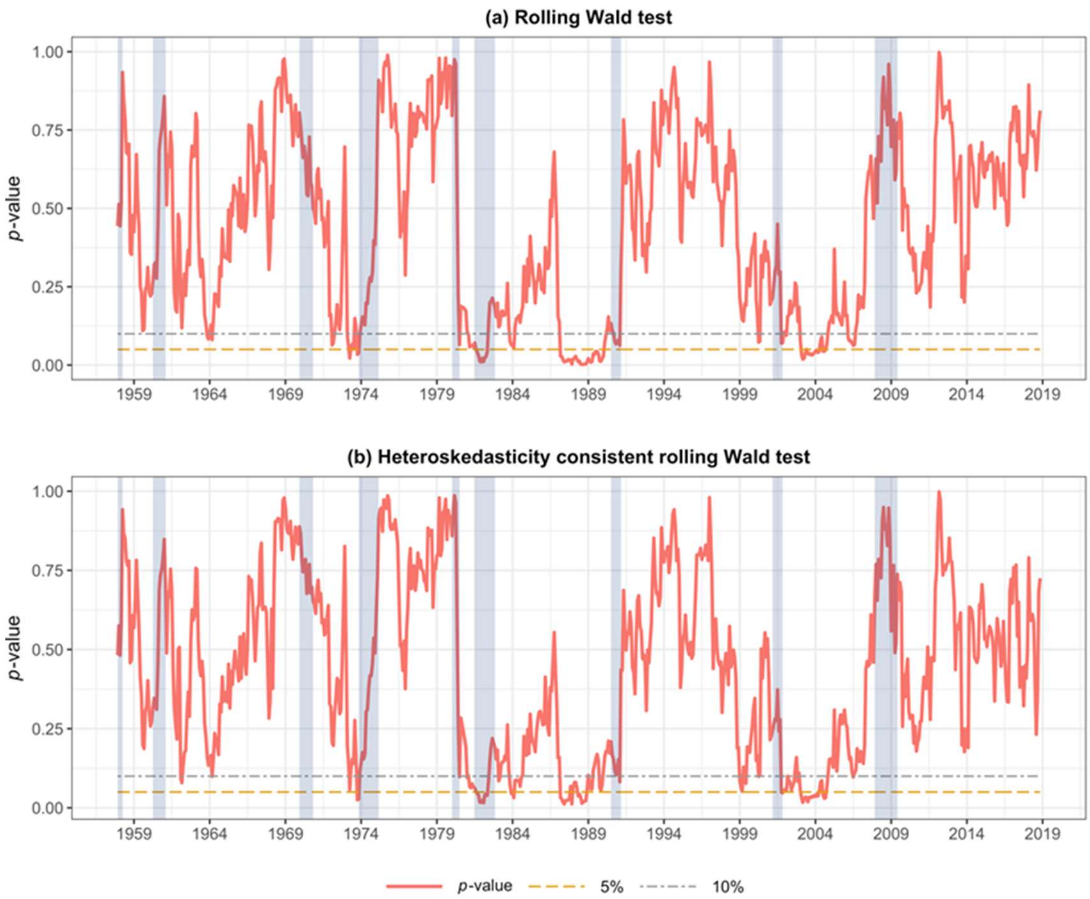

Figure 2: Rolling Causality Tests from EPU to HP

Parallel to the evidence given in Figure 2(a) and 3(a), the heteroskedasticity consistent versions of the RO and RER tests results presented in Figures 2(b) and 3(b), respectively. In Figure 2(b), the null hypothesis that EPU does not GC HP fails to reject at the 10% level of significance for the majority of the sample. However, similar to the homoscedastic Wald tests, heteroskedastic Wald tests show a Granger causal link from EPU to HP at the 10% significance level for the 1962, 1964, 1973-1974, 1981-1982, 1983-1985, 1987-1991, 1999, 2002-2005, and 2007 subperiods. Moreover, in Figure 3(b), the bootstrap *p*-values of the RER GC heteroskedasticity-consistent Wald test results are below the 10% significance level for 1973-1974, 1983, 1984, 1987-1989, 1991-1993, 2003-2005, and 2009 subperiods. The heteroskedastic versions of the RO and RER Wald test should be preferred to their homoscedastic counterparts in terms of their rejection periods of the non-causality hypotheses because they account for the possible heteroskedasticity in the residuals and, thus, more reliable. Based on the results in Figures 2 and 3, we also conclude that the RER method is more responsive to heteroskedasticity, especially in the case of its lower success rate in identifying causality relationships.

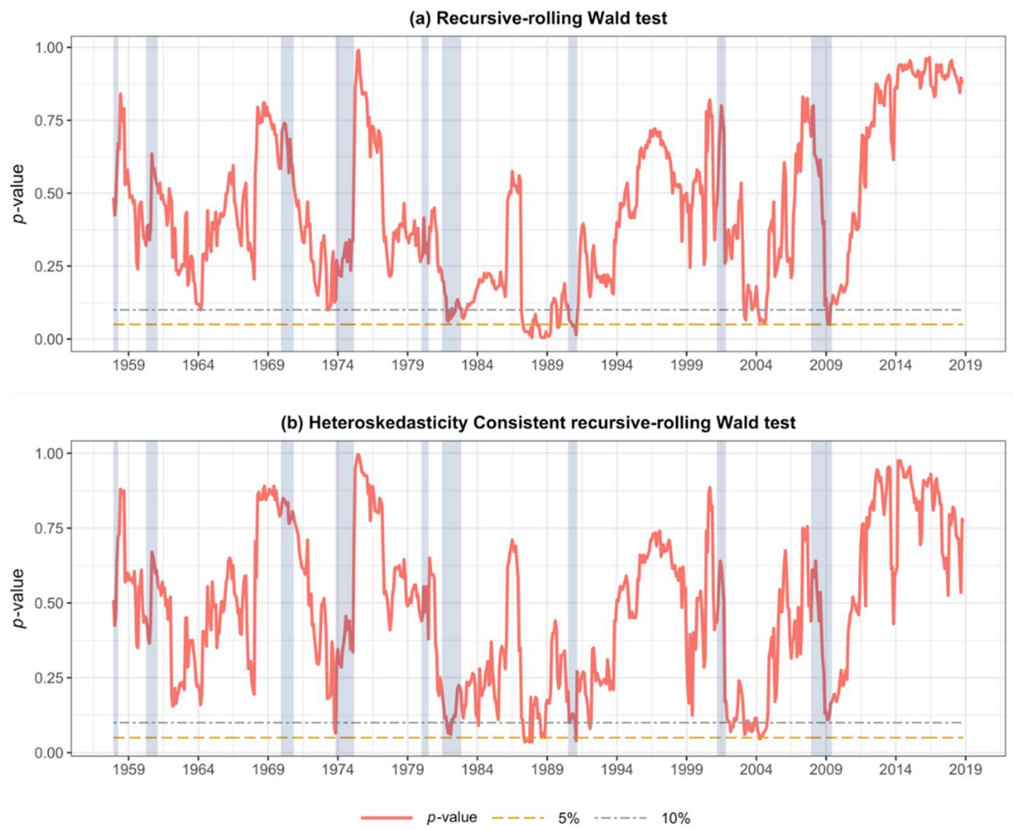

Figure 3: Recursive-rolling Causality Tests from EPU to HP

The bootstrap *p*-values in Figures 2 and 3 show that the heteroskedasticity-consistent version of the RER test generally detects the same causal relationship detected by the RO test, but the RER test shows considerable sensitivity to heteroskedasticity. The reason is that our time series data indeed indicate significant conditional heteroskedasticity leading to significant performance differences in detecting causal links, particularly in the case of the RER method. Hence, it is more plausible to consider the combination of RO and the heteroskedasticity consistent RO tests to date-stamp the periods of a dynamic causal relationship. Figure 4 date-stamps the periods where a significant causality from the EPU to HP is indicated either by the RO test or the heteroscedasticity consistent RO test. Both tests identify the Granger causal relationship running from EPU to HP in 1962, 1964, 1973-1974, 1981-1985, 1987-1991, 1999-2005, and 2007 subperiods. A plausible explanation for the identification of 1962 is the Cuban Missile Crisis between the US and the then Soviet Union. This increased EPU and consequently affected HP negatively in the US. The Granger causal link found in 1964 could be explained by the "War and Poverty" policy introduced by US President Lyndon Baines Johnson to eliminate the paradox of poverty among the citizens. The US government had to apparently increase public spending by 13% and reduce the tax rate from 52% to 47%, among other policies. These policies imply that investors regained confidence as a result of improvement in EPU. In 1973-1974, there was a crash in the stock market, which suddenly led to stagflation in the US. Similarly, the 1973 oil crisis and unabated upheavals in the international oil prices by OPEC influenced the increase in EPU, which consequently affected HP.

More so, the causality found between 1981 and 1985 could be attributed to the Iranian Revolution, which dramatically increased oil prices across the globe. This resulted in the 1979 energy crisis. In addition, the contractionary monetary policy aimed to control inflation in this period rather led to an economic recession. All these led to a rise in EPU and a decrease in HP. The 1980s was the Great Moderation period in the US and other advanced economies (Summers, 2005). The Great Moderation reduced macroeconomic volatility and lowered inflation volatility, which improved market functioning for households and firms. After this peacetime expansion, inflation, however, started to increase, and the Fed reacted by increasing the interest rate between 1987 and 1989. This response by the FED could not reduce the growth of inflation but rather worsened the situation with the subsequent effect of oil price shock in 1990, coupled with an accumulated debt of the 1980s. These factors all contributed to a short-lived recession. Furthermore, the demise of the speculative bubble, decreasing in investments during the September 11 attacks in the US is attributed to the causal relationship from EPU to HP in 1999-2005. Another crucial causal link from EPU to HP found in 2007 is due to the subprime mortgage crisis. This crisis led to the crash of housing bubble in the US, which apperantly shut down the operations of many financial institutions.

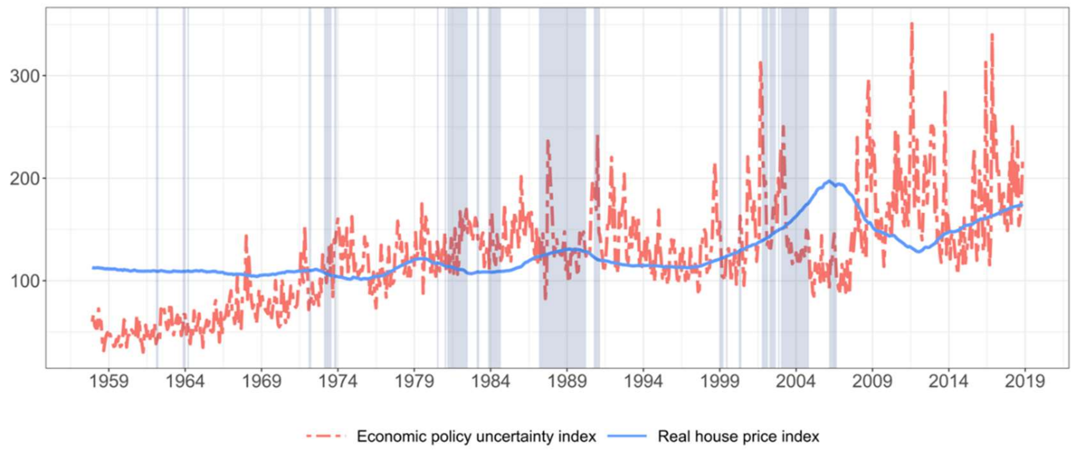

Figure 4: Causality periods, EPU and HP

2.4 Conclusion

Since the crash of the subprime crisis of 2007, much attention has been drawn to the housing market across the globe. The US housing market plays a pivotal role in the global housing market dynamics. This is true given that the subprime crisis stems from the US. In addition, external shocks to the housing market play a crucial role in affecting HP. EPU in recent times stands out among all uncertainties to which the market can be prone. Thus, it is on this premise that we investigate the causal linkage between HP and EPU while accounting for other crucial macroeconomic indicators, such as IPI, RV, TBILL, POP, INF, and UNEMP, which could mainly affect the housing market dynamics. This study contributes to the housing/real estate literature by applying the RO and RER GC tests in multivariate time series framework, which offers a more robust and consistent outcome that previous studies have failed to address. The techniques are also novel and aid in modeling parameters in a time-varying structure in the absence of any assumptions of the change mechanism. This study was built on a VAR model for monthly frequency data from 1953M01 to 2018M11. The summary statistics indicate an ARCH effect across all variables under consideration. This outcome necessitates the need to control for heteroscedasticity, which is adequately addressed in the course of this study. Empirical results show that all the variables of interest nonstationary at level form, i.e. I(1). Therefore, we investigate the long-run association among the variables via the Johansen multivariate cointegration test technique. The study finds the variables are cointegrated over the full sample period. Subsequently, we examine the causal effect from EPU to HP using lag orders selected by the SIC and HQIC. This is necessary to explore the true nature of causality. At both lags, the study finds no GC from EPU to HP at the 5% significance level based on the full sample VAR. This outcome is valid under the assumption of parameter stability. However, in cases of parameter instability, the results and inferences from such estimations might be spurious. Thus, this study circumvents these issues by conducting the parameter stability test as reported earlier in the study. The parameter stability test reveals that the parameters are not stable. Hence, the need to employ the time-varying RO and RER GC test is more appropriate. Further empirical findings are insightful. We observe a common pattern of Granger causal relationship from EPU to HP for several subperiods. For instance, in 1962, 1964, 1973-1974, 1981-1985, 1987-1991, 1999-2005, and 2007 subperiods, Granger causal relationships are found. The major finding of the study is that a strong causality from EPU to housing prices is observed during periods of declining EPU associated with rising housing prices, but not in periods such as the high EPU and declining housing prices. Information of this sort is insightful for policymakers, portfolio managers in the housing market and real estate agents to predict the future returns in the housing sector and assess its associated risks.

Chapter 3

HOUSING SECTOR AND ECONOMIC POLICY UNCERTAINTY: A GMM PANEL VAR APPROACH

3.1 Introduction

Housing has a crucial role in the social and well-being framework across the globe. It forms one of the three basic needs of man that translate into better welfare for families, the community and the large world, especially when it is accessible (Cournède *et. al*., 2019).

Besides, it is paramount to emphasize the importance of the dynamics of the housing market as it affects the macroeconomics trends as well as the business cycle. It is consistent with the theory to argue that variations in household wealth accumulation, income, and the level of expenditure can be impacted. This impact is often caused by the size of rents, variations in the house prices, and/or interest rate associated with a mortgage, and these exert a huge influence on the price levels and aggregate demand. In addition, economic growth, investment in residential forms of housing, and the living standard are influenced by the changes in housing prices, and it depends on the efficiency of the constructive response.

Consequently, nations that experienced a swift decrease in investment in residential housing, most especially after the world economic and financial turbulence required additional time to come out of the shocks. More importantly, it takes time for such an economy to bounce back to the real per capita income that is being experienced before the crisis. This is not to forget that the global economic downturn started with a subprime mortgage crisis in 2007. Although the US economy is at the epicenter of the worst GFC, the unexpected downturn has heightened the uncertainty in both developed and developing countries (Hirata *et al.*, 2013). This reason accounts for why the housing sector has attracted attention from the policymakers, real estate agents, and portfolio managers.

Until now, several studies examined the relationship between the housing market and business cycle (Fehrle,2019; Kydland *et al.*, 2016; Leamer 2015; Lee and Song, 2015; Nyakabawo *et al.*, 2015; Balcilar *et al.*, 2014; Aye *et al.*, 2014; Iacoville and Neri, 2010; Ghent and Owyang, 2010; Leamer, 2007; Case *et al.* 2005; Green, 1997) while others explore the nexus between HP and macroeconomic variables (Mohan *et al.*, 2019; Gupta *et al.*, 2019; Kishor and Marfatia, 2017; Gustafsson *et al.*, 2016; Panagiotidis & Printzis,2016; Cesa-Bianchi, 2015; Gupta and Hartley, 2013; Simo-Kengne *et al.*, 2013; Demary, 2010; Goodhart & Hofmann, 2008). Concerning the relationship between HP and the real gross domestic product (RGDP), most studies confirmed the existence of a correlation between HP and RGDP. Specifically, as shown by Kydland *et al.*, 2016 and Leamer (2007, 2015), fluctuations in the housing market have a leading effect on the fluctuations in the business cycle. More so, Aye *et.al*., (2014) used bootstrapped rolling GC to investigate the relationship between the housing and output growth considering the time variation in the causal link for South Africa. The result shows that there is a uni-directional causality from real HP to output growth. In the case of the nexus between the HP and macroeconomic variables, the existing literature reveals that the housing market variables are interrelated with macroeconomic variables.

Regarding the housing-macroeconomic variables nexus, Kishor and Marfatia (2017) noted that housing prices are driven by income and interest rate in 15 OECD countries. However, in the case of South Africa, Gupta and Hartley (2013) highlighted that HP can be used to forecast real GDP growth and inflation. On the other hand, the study hints that HP has a leading indicator role in the South African economy. Also, Bernanke (2008) opined that "*…housing and housing finance played a central role in precipitating the current crises*." Thereafter, Iacovillo (2010) confirm that during the Great Recession fluctuations in the housing market reflected both in the business cycle and macroeconomic fundamentals. Thus, it is important to consider factors that derive housing prices as well as what constitutes an appropriate HP model to make reliable HP predictions.

In the aftermath of the GFC in 2007-2008, the volatility in both HP and EPU significantly increased (Hirata *et al*., 2013). Similarly, the spillover of GFC also toll on the stock market and EPU as documented in the studies of Balcilar *et al.* (2019), Li *et al*. (2016), and Balcilar *et al.* (2015). Furthermore, given the importance of the relationship between the housing market and macroeconomic variables, there is a burgeoning literature showing the importance of the association between EPU and the housing market (Aye *et. al*., 2019; Christou and Fountas, 2018; Aye, 2018; Huang *et al*., 2018; André *et al*., 2017; Anoruo & Nwoye, 2017; Chow *et al*., 2017; Christou *et al*., 2017; El-Montasser *et al*., 2016; Antonakakis *et al*., 2016; André *et al.,* 2015). For instance, Christou and Fountas (2018) showed that EPU tends to raise growth in housing investment and decrease HP inflation in most of the US states. More so, Aye (2018) employed cross-sample validation (CSV) GC technique to analyze whether EPU causes real housing returns. The result indicates that EPU causes real housing returns in Chile and China among 8 emerging economies. Additionally, Chow *et al*.

(2017) applied both panel linear and nonlinear GC tests to examine the growth in EPU and the real housing return in China and India. Both test results showed that there is only linear and nonlinear unidirectional GC running from growth in EPU and real housing returns. However, econometric models of housing prices should include macroeconomic activity such as a measure of income, real interest rate, etc. (Muellbauer and Murphy, 2008; Meen, 2002). With this aim, Antonakakis *et al*. (2016) investigated the dynamic spillover among the housing market, EPU, and the stock market in the US based on the time series model. The finding suggests that EPU can predict the housing returns for the US. Furthermore, the empirical study of André *et al.* (2015) shows that EPU affects real housing returns for the US while accounting for key macroeconomic and financial determinants of housing prices.

Given the above-highlighted literature trajectory, even though the literature on the housing market and EPU is quite large, most of the extant studies focused only on the relationship between the housing market variables such as the real housing returns or housing price and EPU without considering the other important determinants of housing price model for blocs. To this end, the present study complements/extends the frontiers of knowledge on housing literature by first, accounting for other key macroeconomic determinants that have been ignored in the literature. For instance, the study of Christou *et al*. (2017) investigated the relationship between EPU and real HP returns for selected 10 OECD countries without accounting for key macroeconomic variables (interest rate, RGDP, etc.). Similarly, El Montasser *et al*. (2016) also explored the theme under consideration without accounting key macroeconomic variables) for seven advanced economies. Hence, the present study seeks to bridge the above-highlighted vacuum in the literature by modelling the dynamic and endogenous relations among HP, EPU indices, the short-term interest rate (INTRATE), RGDP.

This is to avoid the potential drawback associated with model misspecifications, useful covariates are incorporated into the specified model. To the best of authors' knowledge, this is the first study to examine the dynamic and endogenous relations among the aforementioned variables for the selected 16 countries. The second distinction of the study is the adoption of the Panel vector autoregressive (PVAR) model. The important feature of the PVAR model is that it allows the consideration of the endogeneity problem while also overcoming the small sample size limitations. Finally, outcomes from the study will serve as a policy blueprint for all agents in the housing sector and policymakers, especially in an era where the housing sector is plagued with high externalities effect (uncertainty).

The rest of this current study is structured as follows. Section 2 provides data and methodology. Section 3 presents the empirical results while Section 4 concludes the paper with adequate policy prescriptions.

3.2 Data and Methodology

3.2.1 Data

The empirical model for this study has five variables, namely; HP, EPU indices, the INTRATE, RGDP, and POP for Australia, Canada, Greece, Germany, Hong-Kong, Ireland, Italy, Japan, Netherlands, Russia, Singapore, Spain, Sweden, UK, and the US. The study uses quarterly data over the period 2004Q2 and 2018Q4. The choice of the period and countries is not only based on the availability of the data on HP and EPU but also that these countries have embarked on series of housing policies which led to high fluctuations in the housing prices. The data for HP is obtained from the OECD[4]

[4] The countries include Australia, Canada, Germany, Greece, Ireland, Italy, Japan, Netherlands, Russia, Spain, Sweden, UK and US member of OECD.

and Bank of International Settlement (BIS) databases[5]. The data for annual RGDP in constant 2010 dollar and population are retrieved from the WDI database and then converted to quarterly frequency data by using quadratic interpolation to be consistent with the quarterly HP data. The INTRATE data is sourced from DataStream while the EPU data is obtained from www.policyuncertainty.com. Baker *et al.* (2015) performed EPU indices by searching the lead newspaper of each country to find at least one term from three-term sets. Under the first one, the newspaper contains uncertain, uncertainty, or uncertainties. The second set includes the economy or economics. The third set comprises policy-related terms such as “monetary policy”, “central bank”, “legislation” and “deficit”. Notably, the EPU data originally has a monthly frequency. Since the HP is quarter frequency data, also the EPU data is converted to its quarter frequency value by taking an average of three months.

By definition, any return or growth in a series can be calculated by taking the first difference of the natural logarithm of itself. As a preliminary analysis, Levin, Lin, and Chu (2002), and Breitung (2000) panel unit root tests are applied to determine the integrated order of the selected variables. The results as reported in Appendix A reveal that with the exception of EPU and INTRATE all other variables became stationary after taking their first differences. Hence, we used year-on-year percentage changes for each quarter in HP, RGDP, POP, and EPU[6] to obtain growth rates of HP ($\widehat{HP}$), RGDP ($\widehat{RGDP}$), POP ($\widehat{POP}$) and EPU ($\widehat{EPU}$).

[5] Following Goodhart and Hofmann (2008) the housing prices are proxied by the residential property prices while the real residential property prices are obtained for Hong-Kong and Singapore from the BIS database.

[6] Note that, the post-estimation results did not confirm the stability with the level form of EPU for PVAR model. Therefore, we used EPU growth in the analysis to obtain more robust and reliable results.

3.2.2 Methodology

This study investigates the dynamic and endogenous relations among HP, RGDP, EPU, and INTRATE in selected countries over the period 2004Q2-2018Q4 by using the PVAR model in the Generalized Method of Moments (GMM) framework. Sims (1980) proposed time series VAR models as an alternative to multivariate simultaneous equation models built on macro-econometrics literature while panel version of the VAR model is proposed by Hoaltz-Eakin *et al.* (1988) for multiple analysis techniques across fields. PVAR model is structured in an endogenous system, where all variables in the system are treated in an unrestricted manner. This is applicable where the outlined variables are strongly correlated with each other. Subsequently, relative to conventional time series modeling, the PVAR model accommodates for cross-sectional dynamics heterogeneity, which provides more information about the sources of heterogeneity in the system. This kind of modelling technique helps to identify the dynamic heterogeneity among the blocs of countries investigated. Finally, with the PVAR approach, it becomes easy to capture all time variations as regards the coefficients as well as the variance of the shocks. Given these features, it is imperative that the PVAR modelling is more suitable for our investigation.

Therefore, this study follows Abrigo and Love (2015) who combined the conventional VAR models with panel data. Initially, k-variables are homogenous PVAR order of p with panel-specific effects defined in the following system of the linear equation:

$$HP_{it} = HP_{it-}\ A_1 + HP_{it-2}A_2 + \cdots + HP_{it-p}A_p + X_{it}B + u_i + \varepsilon_{it} \quad (3.1)$$

$$i \epsilon \{1, 2, . . .,16\} \text{ and } t \epsilon \{2004, . . .,2018\}$$

where HP_{it} is a (1 x m) vector of the dependent variables, X_{it} is a (1 x n) vector of independent variables covariates including EPU, INTRATE, and RGDP. The estimated parameters are A_1, . . ., A_p (m x m) matrices and B (n x m) matrices. u_i captures country-specific fixed effect while ε_{it} denotes idiosyncratic errors with the following assumptions: $E(\varepsilon_{it}) = 0, E(\varepsilon'_{it}\varepsilon_{it}) = \sum$ and $E(\varepsilon'_{it}\varepsilon_{is}) = 0$.

Abrigo and Love (2015) also confirmed that the PVAR model based on equation (3.1) has cross-sectional heterogeneity and dynamic interdependency problems since u_i variables are related to the independent variables. Hence, the Ordinary Least Square (OLS) technique cannot be appropriate due to biased coefficients (Nickell, 1981). To overcome this problem, the GMM technique can be applied to estimate the PVAR model (Arrelano and Bond, 1991; Arrelano and Bover, 1995; Blundell and Bond, 1998). Hoaltz-Eakin *et al.* (1998) confirm that the equation by equation method is a consistent estimation of the PVAR model. They also demonstrate that to estimate the model as a system of equations might lead to efficiency gains. Abrigo and Love (2015) assume that Z_{it} row vector includes the common set L $\geq$ kp + p instruments where $X_{it} \in Z_{it}$ and superscript numbers refer to the number of equations in the system. Based on the equation (3.1), Abriago and Love (2015) proposed the following transformed model:

$$HP^*_{it} = \overline{HP^*_{it}}A + \varepsilon^*_{it} \tag{3.2}$$

$$HP^*_{it} = \begin{bmatrix} hp^{1*}_{it} & hp^{2*}_{it} \ldots & hp^{k-1*}_{it} & hp^{k*}_{it} \end{bmatrix}$$

$$\overline{HP^*_{it}} = \begin{bmatrix} HP^*_{it-1} & HP^*_{it-2} \ldots & HP^*_{it-p+} & HP^*_{it-p} & X^*_{it} \end{bmatrix}$$

$$\varepsilon^*_{it} = \begin{bmatrix} \varepsilon^{1*}_{it} & \varepsilon^{2*}_{it} & \ldots & \varepsilon^{k-1*}_{it} & \varepsilon^{k*}_{it} \end{bmatrix}$$

$$A' = \begin{bmatrix} A'_1 & A'_2 & \ldots & A'_{p-1} & A'_p & B' \end{bmatrix}$$

Abriago and Love (2015) support that the PVAR model is invertible and has an infinite-order moving average (VMA) representation under the stability condition of the PVAR model. This characteristic of stability helps us to interpret the estimated impulse-response functions (IRF) and forecast error variance decompositions. The IRF (Φ_i) can be calculated by using infinite order VMA:

$$\Phi_i = \left\{ \begin{array}{ll} I_k & , \quad i = 0 \\ \sum_{j=1}^{i} \Phi_{t-j} A_j & , \quad i = 1,2 \end{array} \right\} \tag{3.3}$$

where Φ_i represents the VMA parameters.

Also, h-step forecast error variance decomposition (FEVD) can be computed as:

$$HP_{it+h} + E[HP_{it+h}] = \sum_{i=0}^{h-1} \varepsilon_{i(t+h-i)} \Phi_i \tag{3.4}$$

where HP_{it+h} represents the observed vector at period t+h while $E[HP_{it+h}]$ represents the h-step ahead estimated vector at period t. Abriago and Love (2015) orthogonalize the innovations by using P matrix which is $P'P = \sum$ for IRF and FEVD techniques.

This current study uses the STATA statistical software programs advanced by Abriago and Love (2015) to run the PVAR fitted model. Abriago and Love (2015) advance the Helmert transformation to overcome the orthogonality problem.

3.3 Empirical Results

Table 8a presents the key statistics for the overall sample under consideration. As can be seen from Table 8a, the mean value of population growth is the lowest while the EPU growth is the highest per quarter. Specifically, the end of 2009 witnessed the least growth in EPU for Australia. The highest EPU growth is witnessed in Canada at the beginning of 2008. For housing prices, the lowest growth occurred in the first quarter of 2011 and the highest growth occurred in the last quarter of 2011 in Russia. Expectedly, EPU growth is more volatile and population growth is less volatile than the other selected variables. Under the normal distribution, skewness value should be around zero and kurtosis value should be around three. Hence, the distribution of all series is positively skewed with excess kurtosis (i.e. leptokurtic).

Table 8b displays the correlation coefficient estimation for the selected variables. The estimate is negative between HP growth and EPU growth. However, other selected variables are positively correlated with HP growth which concurs with the theoretical expectation.

Table 8: Descriptive statistics and Correlation Analysis

a) Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
$\widehat{HP}$	2.0286	8.1061	-28.7906	55.5858	0.7098	8.2450
$\widehat{RGDP}$	2.0663	3.4338	-9.6220	27.6151	1.1073	12.9432
$\widehat{EPU}$	11.4988	45.8125	-62.0387	312.6817	1.7015	8.4777
$\widehat{POP}$	0.6798	0.7949	-1.9700	5.6683	1.7112	10.2985
INTRATE	2.4715	2.7361	-0.7767	21.1433	1.6205	8.1590

b) Correlation Analysis

	$\widehat{HP}$	$\widehat{RGDP}$	$\widehat{EPU}$	$\widehat{POP}$	INTRATE
$\widehat{HP}$	1.0000				
$\widehat{RGDP}$	0.5879*	1.0000			
$\widehat{EPU}$	-0.0373	0.0272	1.0000		
$\widehat{POP}$	0.2668*	0.9362*	0.0850*	1.0000	
INTRATE	0.0972*	-0.1854*	0.1167*	0.1934*	1.0000

Note: ** denotes the significance at 0.01 level.*

Table 9: Lag Order Selection Criteria

Lag	CD	J	J-pvalue	MBIC	MAIC	MQIC
1	0.9982	169.4603	1.78E-11	-257.0619*	41.4603	-73.3277
2	0.9986	82.9052	0.0013	-236.9864	-13.0948	-99.1858*
3	0.9964	43.8611	0.0789	-169.4000	-20.1389*	-77.5329
4	0.9992	12.7088	0.6939	-93.9218	-19.2912	-47.9822

Note: *The asterisk * denotes the selected optimum lag order.*

The lag order selection is crucial to proceed with the PVAR model. Hence, Table 9 provides that the overall coefficient determination, Hansen J-statistic of over-identifying restrictions, and three information criteria, namely the AIC, the BIC, and HQIC. From Table 9, the null hypothesis of over-identified restriction is valid and failed to reject at a 5% level of significance for the third order. Also, MAIC has the smallest value in the third order. Hence, the preferred model is determined as a third-order PVAR model for impulse-response functions (IRFs) and forecast error variance decomposition (FEVD).

Before estimating IRFs and FEVD, the stability condition of the estimated PVAR model has been checked. The stability condition requires that all roots of the companion matrix must lie inside the unit circle. Figure 5 shows the stability condition of the third-order PVAR model of $\widehat{RGDP}$, INTRATE, $\widehat{HP}$, and $\widehat{EPU}$. It further confirms that the estimated PVAR model is stable since all the roots lie inside the unit circle.

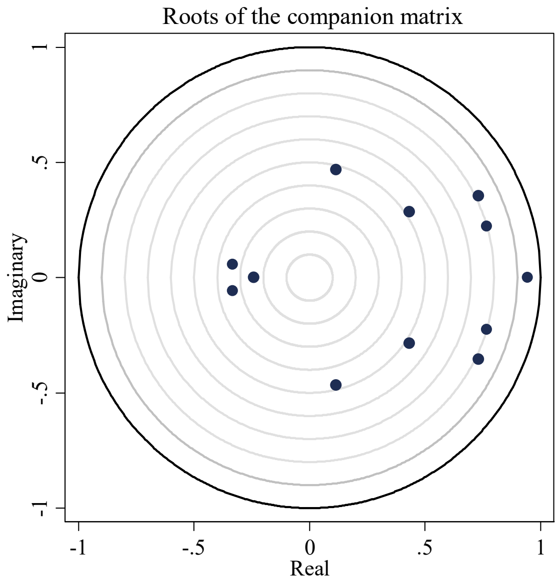

Figure 5: Eigenvalue Stability Condition

IRFs are used to examine the dynamic interrelationship between the selected variables in a PVAR model. Figure 6 provides the IRF plots with the 95% confidence bands, which are estimated by using Monte Carlo simulations with 200 repetitions. From Figure 6, expectedly the impact of $\widehat{EPU}$on $\widehat{HP}$ is significantly negative between the second and eighth horizons after which it turns insignificant relation. It means that a positive shock to $\widehat{EPU}$ leads to a decrease in the HP return. This can be explained by both the demand and supply sides. According to the demand side, the household might delay home-buying decisions due to the increased uncertainty about their future income. Further, uncertainty about the demand for housing can cause investors and firms to postpone their investment as a result of the increased cost of finance and the risk of default, and thereby reducing supply. The combination of both side effects leads to a decrease in housing returns due to the nature of irreversible investment in housing. This aligns with the findings of Su et. al. (2019), Aye (2018), Burnside *et al*. (2016), Hirata *et al*. (2013), Givanzi and Mochan (2012), Cunningham (2006) and Berkovec (1989). With respect to the IRF of $\widehat{EPU}$on INTRATE show that the positive shock to

$\widehat{EPU}$ leads to a decrease in INTRATE just on the fifth horizon. The impact of this shock turns into insignificant for the other horizons. The consequence of this insignificant impact might be explained by the action of the Central Bank (CB). The plausible explanation is attributed to the CB's ability to adjust the short-term interest rate through open-market operations to a predetermined level regarding their policy objectives. Moreover, the Central Bank implements the interest rates of wholesale short-term securities across the banking sector, thus affecting the market interest rates in the short-term (Moore 1988). Also, the results of the IRF show that $\widehat{RGDP}$reacts negatively to a shock to $\widehat{EPU}$. This relation is consistent with the theoretical expectation of Bloom (2009), Dixit *et al*. (1994), and Bernanke (1983). It has been argued that EPU may influence the decision-making process of managers in terms of investing and hiring of an organization. It is paramount for an organization to pass through higher levels of EPU to forecast future sales which will dictate whether to improve or slow down production activities to maximize business objectives. This process leads to a decrease in economic activity (Balcilar *et al.,* 2016; Jones and Olson, 2013).

The IRF plots in Figure 6, also reveal that the dynamic impact of $\widehat{HP}$ on $\widehat{EPU}$. is statistically insignificant over the sample period. The result is in line with the findings of Chow *et al.* (2018), who report that there is no panel nonlinear and linear GC running from real housing returns to growth in EPU for the case of China and India. However, the result is in contrast with the findings of El-Montasser *et al.* (2016) and Su *et al*. (2016) for the US and UK countries. This conflict perhaps depends on the specific panel countries. Also, the INTRATE responses are insignificant to the shock of $\widehat{HP}$. This finding might be linked with the interest rate policy rule function which is also known as a Taylor rule. According to this rule, there is no direct feedback effect from asset prices to the policy interest rate. Asset prices may only indirectly impact interest rate through its effects on output and inflation and for this to occur, wealth and income effects of asset price variations must be significant. This confirms the conclusion reached by Singh and Pattanaik, (2002). Lastly, the IRF of $\widehat{HP}$ on $\widehat{RGDP}$indicates that $\widehat{RGDP}$responses positively to the one-standard exogenous shock of ΔHP. In other words, a $\widehat{HP}$ shock triggers an increase in economic growth. This perhaps due to collateral and wealth effects of HP changes on consumption (Miller *et. al*., 2011). If household(s) consider their property as wealth and adjust their spending decisions according to net wealth, changes in housing prices may affect their consumption. More so, based on the permanent income hypothesis unexpected increases in housing prices lead to increasing homeowners' expected life wealth and they will tend to increase their consumption. Thereby housing equity may trigger the wealth effect. The results align with the extant literature such as Antonakasis and Floros (2016), Nyakabawo (2015), Aye *et al*. (2014), Demary (2010).

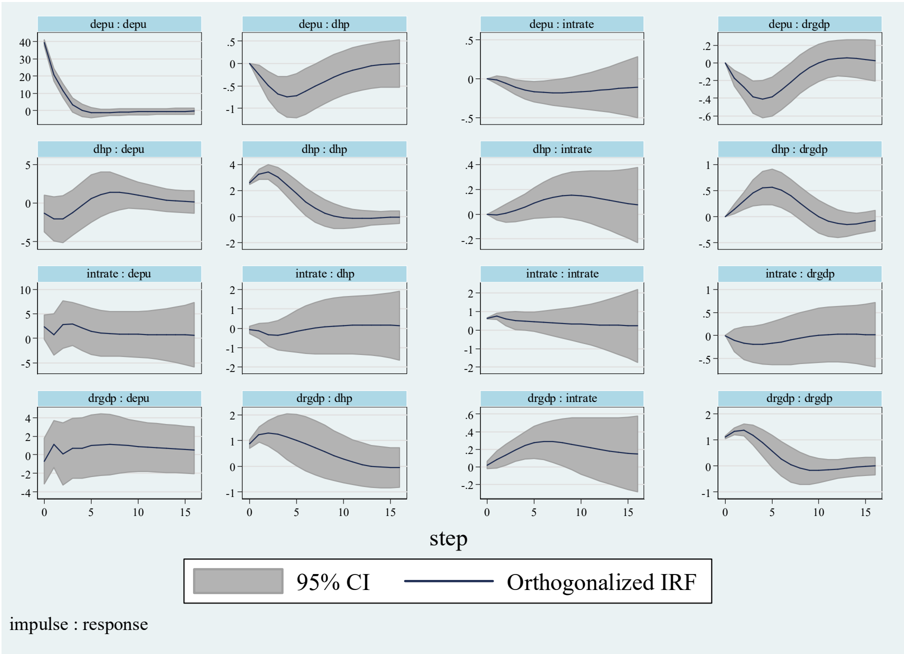

Figure 6: Impulse-Response for 3 lags PVAR ($\widehat{RGDP}$, INTRATE, $\widehat{HP}$, $\widehat{EPU}$)

Table 10: Variance Decomposition of PVAR model

	s	$\widehat{HP}$	$\widehat{RGDP}$	$\widehat{EPU}$	INTRATE
	4	0.8540	0.1234	0.0170	0.0056
$\widehat{HP}$	8	0.8030	0.1504	0.0407	0.0059
	12	0.7905	0.1576	0.0451	0.0068
	16	0.7891	0.1572	0.0452	0.0084
	4	0.0055	0.0010	0.9830	0.0104
$\widehat{EPU}$	8	0.0071	0.0027	0.9758	0.0143
	12	0.0094	0.0044	0.9707	0.0155
	16	0.0097	0.0052	0.9686	0.0165
	4	0.0454	0.9801	0.0367	0.0107
$\widehat{RGDP}$	8	0.1380	0.7720	0.0730	0.0170
	12	0.1441	0.7652	0.0737	0.0170
	16	0.1500	0.7590	0.0739	0.0172
	4	0.0005	0.0390	0.0097	0.9507
INTRATE	8	0.0155	0.1311	0.8074	0.0461
	12	0.0351	0.1680	0.0675	0.7295
	16	0.0414	0.1771	0.0766	0.0766

It is worthy of mentioning here that in order to explain the exogenous shock the outlined variables by the aid of FEVD of the fitted model over the specified horizon. By doing so, the FEVD helps us to determine the relative importance of each exogenous shock on the variables in the PVAR model. For this reason, Table 10 provides the FEVD estimation results. As can be seen from Table 9, 16 percent of the variation in $\widehat{HP}$ is explained by $\widehat{RGDP}$ and 5 percent can be explained by $\widehat{EPU}$ in the 16th forecast period (i.e. 4 years). However, the contribution of INTRATE to the shock of $\widehat{HP}$ is small and almost constant over time. This result shows that $\widehat{RGDP}$ has a relatively greater influence to explain the changes in $\widehat{HP}$ shocks both in the short and long term. Alternatively, the FEVD of $\widehat{EPU}$ shows that INTRATE, $\widehat{HP}$, and $\widehat{RGDP}$ can explain the total variation in $\widehat{EPU}$ by 1.65, 0.97 and 0.52 percent, respectively in the 16th quarter. As $\widehat{EPU}$ accounts for about 97 percent of the variation in itself. This shows the high level of uncertainty in $\widehat{EPU}$.

3.4 Robustness Check

As a robustness check of our findings, this study conducts two more different models. In the first model, the $\widehat{INTRATE}$ is considered as its own growth rate to be consistent with other aforementioned variables while the order of the variables remained the same as the original PVAR model at lag order 3. Following the study of Jäger and Schmidt (2017), Chow *et al*. (2016), and Bian and Gete (2015), $\widehat{POP}$ is added to the second model. Since the population is more exogenous than the other variables, $\widehat{POP}$ takes the first place in the ordering of the variables. Lag order 3 is selected by using AIC for the second model. Before comparing the results of IRF estimations, the stability of the two models needs to be tested. Hence, Figure 7 presents the stability graphs of the two models. As shown in Figure 7, all the roots of the companion matrix are within the unit circle, which refers to the stability of the two estimated models. More so, the IRF estimation results of the two models as reported in Figure 8 and Figure 9 reveal that the dynamic relationship between $\widehat{EPU}$ and $\widehat{HP}$ are the same. In another way, the earlier result is consistent and robust.

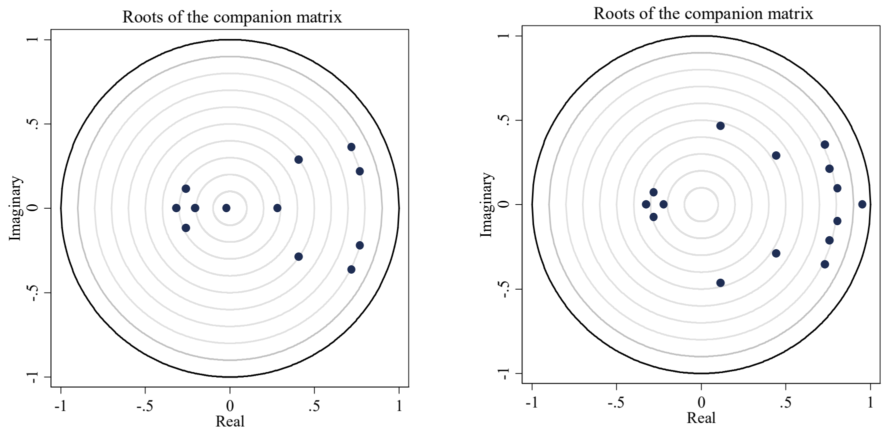

Figure 7: Eigenvalue stability condition graphs[7]

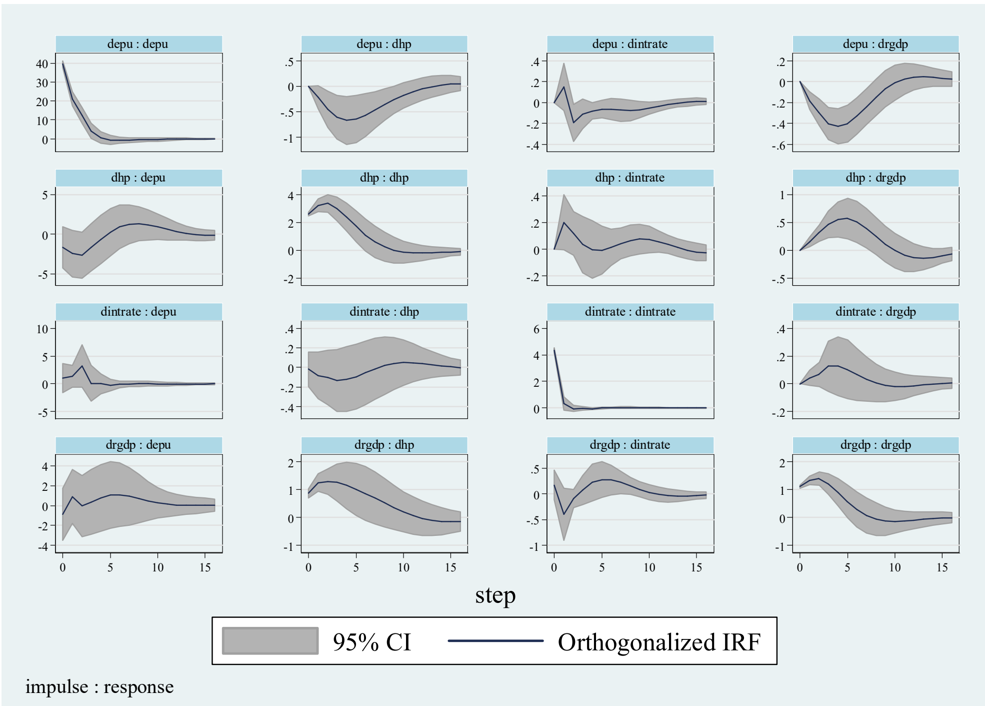

Figure 8: Impulse-Response for 3 lags PVAR (($\widehat{RGDP}$), ($\widehat{INTRATE}$), ($\widehat{HP}$), ($\widehat{EPU}$))

[7] The left one refers to PVAR model with $\widehat{INTRATE}$ and the right one refers to PVAR model with $\widehat{POP}$ variable.

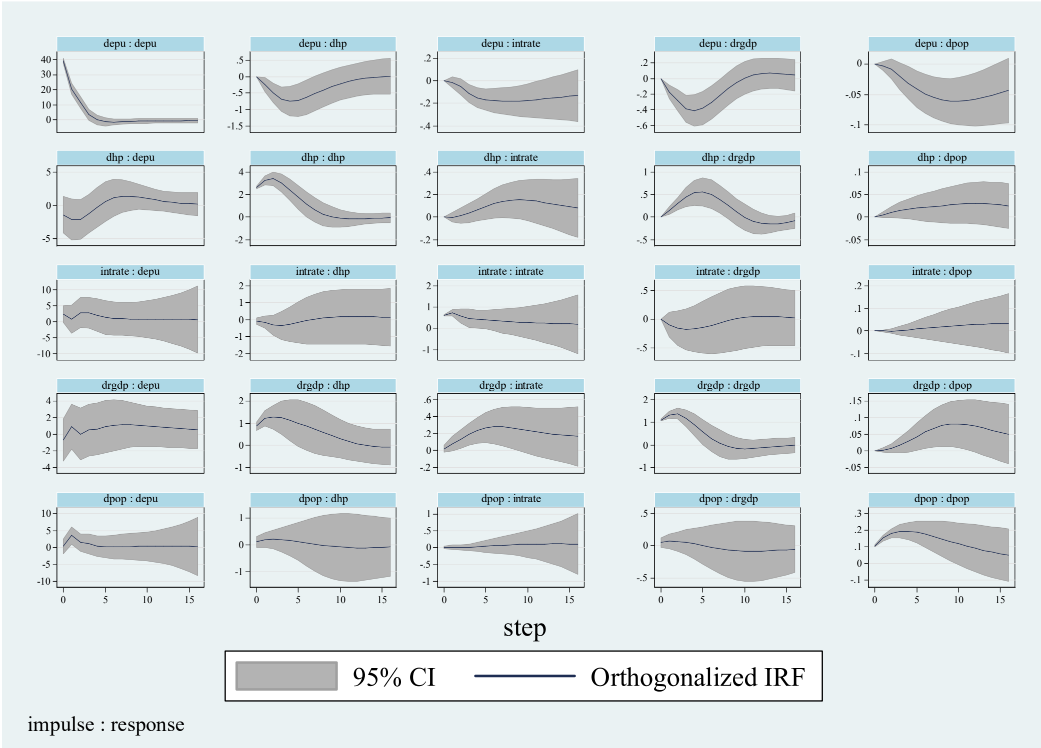

Figure 9: Impulse-Response for 3 lags PVAR (($\widehat{POP}$) , ($\widehat{RGDP}$) , INTRATE, ($\widehat{HP}$), ($\widehat{EPU}$))

3.5 Conclusion

In 2007, the GFC that was triggered by a subprime mortgage crisis had not happened without leaving some adverse traces. This sudden slump or depression has exacerbated uncertainties in the world. Thereafter, the relationship between the housing sector and EPU have attracted a lot of attention in the existing housing market literature since the last GFC. However, the literature is plagued with focus only on the interaction between the housing market variables and EPU without considering other crucial determinants of the housing market. By addressing the gap in the literature, the present study offers new insight into the dynamic relationships between HP return and the EPU growth. In doing this, the economic growth and the short-term interest rate were incorporated in the model both as additional variables to circumvent for omitted variable bias approach. To achieve this aim, the study conducted a PVAR technique that allows the consideration of the endogeneity problem while also overcoming the small sample size limitations.

The empirical results of IRF show that the positive shock to EPU growth leads to a decrease in the HP return. From the investors' point of view, heightened uncertainty regarding policy guide translates into weak investment in the housing sector. Consequently, the weak housing investment is observed to cause an adverse effect on economic growth since the housing sector (a leading sector for economic growth) reportedly shown strong resilience. Similarly, evidence from the FEVD results indicates that HP return has a relatively greater possibility to explain the changes in economic growth shocks in both the short and long run. However; the dynamic impact of HP return on EPU growth is statistically insignificant over the sample period. Moreover, this is also confirmed by the FEVD results which shows that the HP return has a very weak effect in explaining the changes in EPU growth. Regarding the policy framework, this finding reveals that EPU has more power to explain the changes in itself. Hence, policymakers, real estate agents, and portfolio managers in the housing market should consciously seek strategies to reduce uncertainty in the economy.

Chapter 4

THE ASYMMETRIC RELATIONSHIP BETWEEN AGRICULTURAL LAND AND THE HOUSING MARKET

4.1 Introduction

The World Bank Housing Finance states that "*Housing plays a key socio-economic role and represents the main wealth of the poor in most developing countries*" (World Bank, 2018). This is an indication of the importance of housing, an age-long, and one of the most important human needs across the globe. In a similar report, the United Nations (UN report, June 2017) also expressed that the population is a vital indicator of the housing market. The oversight report carefully cautioned that the impact of the increasing world population could be explosive. This concern has motivated the curiosity of researchers to further extend contextual studies on housing and in a way try to establish linkages. Since the global economic and financial crisis of the 1930s, the worst crisis of such was globally experienced in 2007. It was worst, causing the housing market meltdown, but was importantly known to be caused by the subprime mortgage crisis (Crotty, 2009; Shiller, 2012; André *et al*., 2017).

Extant literature has vindicated the versatility of housing market and its supposed relationship with handful of macroeconomics (Kishor & Marfatia, 2017; Nyakabawo *et al*. 2015; Cesa-Bianchi, 2013; Canarella *et al*., 2012; Sirmans *et al*., 2005) financial

(Case *et al*. 2005; Aoki *et al*., 2004; Estrella & Mishkin, 1998), and socio-economic (Cho *et al*, 2006, Bengtsson; 2001; Case & Shiller, 1988) variables. For instance, the study of Cho *et al*. (2006) examined how the inclusion of certain social-amenities in a housing structure could add-up to the price of the house. Also, recent extant literature has shown linkages in the volatility of housing market dynamics and uncertainty indices (André *et al*., 2017; Christou *et al*., 2017; Ongan & Gocer, 2017; Burnside *et al*., 2016). Specifically, Burnside *et al*. (2016) relate uncertainty with the demand for housing and found that uncertainty affects housing returns. Also, André *et al*. (2017) expressed that high uncertainty tends to cause a volatility increase in HP as well as the risk-return properties of property investment. The study of the impact of uncertainty on housing market vis-à-vis housing prices is highly informative to prospective homeowners, financial institutions, economic planners, policymakers, and real estate, and property developers. Hence, effective modelling of the housing market (using precisely the market indicators) and the market determinants is fundamental to the dynamics of the sectors of the economy. In that respect, a handful of econometric tools, geographical tools (an example is a geographically weighted regression, GWR), mathematical statistics (like neural networks and fuzzy logic), and among others are continued to be employed to study the housing market dynamics.

The peculiarity of Sweden, a case study of the European housing market is indicative. The average growth rate of HP between 2007 and 2017 in Sweden is the highest among the 28 European Union countries (see Appendix for Table A). Also, considering that the GFC period (2007-2011) is covered by the duration estimate for the average growth rate, the observed Table A and the visual representation in Figure 10 show the trend of the average house prices for the EU. Also, by area, the largest country in the EU is in the order of France, Spain, and Sweden, with Sweden typically having the highest average growth rate among the three. Notwithstanding, the HP in the country has consistently increased in the past two decades without any sign of decline even during the GFC (Andreas Claussen, 2013). In Sweden, the housing policy, support for the construction of the housing structure, and the planning system are the main indicators that differentiate the Swedish housing market from other neighboring markets. With a population of about 10.2 million people, the country has a low population density of 22 inhabitants per square kilometer (57/sq mi). Interestingly, the highest concentration of people is in the southern half of the country and the country's forest area is the second largest among the EU countries.

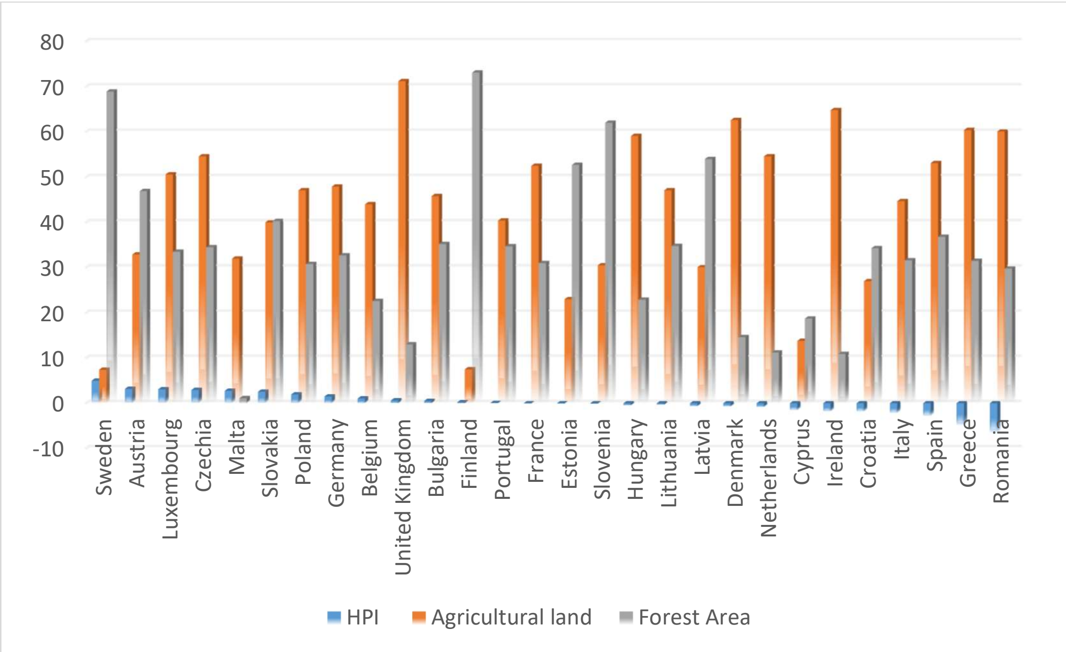

Figure 10: Representation of the average growth in house price, the proportion of Agricultural land and Forest area in 28 EU countries

Against the backdrop of the above motivation and coupled with the limitation of land resources as an essential determinant vis-à-vis component of a housing structure (Zhang *et al*. 2011) we examine the trade-off relationship between the housing market and land supply. The study is designed to advance the work of Shen *et al*. (2018)[8] which noted the existence of a significant impact of urban land use restriction on real estate destocking at different periods across cities. In enumerating the novelty of this study, firstly the short-run and long-run relationship, specifically between the agricultural land supply (usage) and the real house price for the case of Sweden is investigated. Secondly, due to policy influence on the housing market (Lu *et al*., 2017), employed model control for policy effects and other uncertainty factors using the EPU index. And lastly, non-linear ARDL (NARDL) is employed to capture the asymmetric of the relationship (Katrakilidis & Trachanas, 2012). The rest of the study is structured as follows. Section 2 highlights the dynamics of the housing market in the European Union as well as the interaction between agricultural land and house prices in Sweden. Section 3 covers the data description and empirical methodologies. The empirical findings and discussion are reported in Section 4. Concluding remarks and policy implications of the study are provided in Section 5.

4.2 The Housing-Agricultural Land Dynamics: A Compendium Trend in Sweden

Generally, land resources and natural habitat are an important component of the housing market. This main component of production, one of human's natural resources has over time remained a contentious subject to individuals, corporate, and government. As such, across the globe, the land-use policies have continued to be a relevant tool in the allocation of land for housing development (Bao & Peng, 2016; Barry & Roux, 2016). In advanced countries like China where there is a huge housing shortage, built-up land efficiency is employed (Chen, Chen, Xu & Tian, 2016).

[8] The detail analysis of demand and supply of land regarding house prices can be followed-up from Shen, Huang, Li, H, Li, Y and Zhao (2018).

Furthermore, Zhong, Chen, and Huang (2016) examined the impact of land revenue on urban land growth such that a decreasing population density (also known as space effect) is ensured. This is because of the importance and association between the population and the housing market (Hiller & Lerbs, 2016). However, agricultural activities (for instance, food and cash crops cultivation, fishery and animal husbandry, e.t.c) are much important for humans as housing. But, by and large, the land resource remains a common factor of the two human activities. Practically, the more availability of this common factor (land resource) for one activity, the less of an area is available for the other. Notably, the motivation to study this interplay with Sweden as a case study of the EU is because of the country's sharp decline in the availability of agricultural land (see Table A). In other cases, agriculture and energy (precisely renewable energy source) production, land are optimized using modern techniques like the Ecosystems Services Value (ESV) (Chuai *et al*., 2016). And, in recent times, Photovoltaic (PV) systems are installed on farmland where crops are concurrently grown to optimize agricultural land usage (Alola & Alola, 2018). Specifically for the case of Swedeen, vast agricultural land and natural habitat have consistently being cultivated for grains, root crops, vegetables, fruits, and livestock causing a higher production projection for the year 2017.

4.3 Data and Methodology

4.3.1 Data

The analysis consists of three variables namely; the HP, the EPU, and agricultural land (sq. km) [LAND] for Sweden using annual data over the period of 1976 – 2015. The start and end year being purely driven by data availability of the EPU and agricultural land variables. The HP[9] is seasonally adjusted, and it implies the ratio of nominal price to the private consumption expenditure deflator. The HP index data is obtained from the OECD housing database. LAND[10] is an explanatory variable, which is expressed as the share of land area (sq. km) meant for agricultural as either arable, under permanent crops, or under pastures. The datasets were sourced from the World Bank Development Indicator Database. The EPU indices developed by Baker *et al*. (2015) that is based on a leading newspaper in each country. The authors opined that such examined articles for indexing should essentially and simultaneously contain the economic, policy, and uncertainty. The original data on EPU are monthly frequency but were converted into annual values by taking averages. The EPU[11] is employed in the study to control for other variables. All variables are transformed into their natural logarithmic form to correct for potential heteroscedasticity of each series. Considering the housing market extant literature (Zhang *et al*., 2011; Burnside *et al*.; 2016; André *et al*, 2017) our model is derived such that *hp = f (epu, land)*. Following Pesaran and Shin (1998), Peseran *et al*. (2001), and Shin *et al*. (2014), nonlinear asymmetric cointegrating regression form as follows:

$$\ln hp_t = \alpha + \beta_1^{+} \ln epu^{+} + \beta_2^{-} \ln epu^{-} + \beta_3^{+} \ln land^{+} + \beta_4^{-} \ln land^{-} + \varepsilon_t \quad (4.1)$$

where ln is the natural logarithm of the values, α is the intercept of the estimation, β respective long-run coefficients of the explanatory variables, and ε_t is the estimated error for all the values of t = 1, 2, …, n (n = 40). The explanatory series are decomposed into their negative and positive partial sums as follows:

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[9] Detail information about the real house price index can be obtained from the OECD. http://www.oecd.org/.

[10] World Bank Development Indicator is the sources of agricultural land information. https://data.worldbank.org/.

[11] More can read on EPU index. http://www.policyuncertainty.com/.

$$x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max(\Delta x_i, 0),\ x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(\Delta x_i, 0) \quad (4.2)$$

where x_t representing epu_t and $land_t$.

4.3.2 Empirical Methodology

Evidence from recent literature has significantly established SB and nonlinearity relationship between the EPU and real housing returns (André *et al*, 2017). Following such empirical studies, the current study considered Zhang, Wu, Y, and Shen (2011) by incorporating agriculture land as obtained in equation 1 to capture the asymmetric impact of agriculture land on real housing prices by using NARDL approach.

Modifying the usual ARDL, we estimate the model (1) above using the NARDL model of Shin *et al* (2014). The asymmetric error correction model is as follows:

$$\Delta hp_t = \alpha_0 + \varphi hp_{t-1} + \delta_1^+ epu_{t-1} + \delta_2^- epu_{t-1} + \delta_3^+ land_{t-1} + \delta_4^- land_{t-1} + \sum_{i=1}^{p} \beta_1 \Delta hp_{t-i}$$
$$+ \sum_{i=0}^{q} \beta_2 \Delta epu_{t-i}^+ + \sum_{i=0}^{q} \beta_3 \Delta epu_{t-i}^- + \sum_{i=0}^{q} \beta_4 \Delta land_{t-i}^+ + \sum_{i=0}^{q} \beta_5 \Delta land_{t-i}^- + \varepsilon_t \quad (4.3)$$

In implementing the model representation in equation 4.3, firstly, the standard Ordinary Least Square (OLS) is estimated. Secondly, an asymmetric long-run relationship or cointegration between the level form of variables, hp, epu^+, epu^-, $land^+$, $land^-$, is tested which entails two proposed procedures of Shin *et al* (2014). The H_0 of a modified F-test is no-cointegration $(\varphi = \delta^+ = \delta^- = 0)$ is tested against the alternative of cointegration by using the bound-testing method proposed by Shin *et al*. (2011) and Pesaran *et al*. (2001) for the eq. (3). Also, Shin *et al* (2013) imitate Banerjee *et al*. (1998) and proposed the t-statistic that tests the $H_0 : \delta = 0$ against the

$H_1 : \delta < 0$. Thirdly, using the standard Wald test, to examine the short-run symmetry ($\beta = \beta^{+} = \beta^{-}$) and long-run symmetry $(\delta = \delta^{+} = \delta^{-})$ for all variables. Finally, the asymmetric ARDL model (3) is employed to estimate the asymmetric cumulative dynamic multiplier effects, the following equation is used:

$$m_h^{+} = \sum_{j=0}^{h} \frac{\partial hp_{t+j}}{\partial epu_t^{+}}, m_h^{-} = \sum_{j=0}^{h} \frac{\partial hp_{t+j}}{\partial epu_t^{-}}, m_h^{+} = \sum_{j=0}^{h} \frac{\partial hp_{t+j}}{\partial land_t^{+}}, m_h^{-} = \sum_{j=0}^{h} \frac{\partial hp_{t+j}}{\partial land_t^{-}},$$

for h=0,1,2 … (4.4)

where, if $h \to \infty$, then $m_h^{+} \to \beta^{+}$, and $m_h^{-} \to \beta^{-}$ where β^{+} and β^{-} are the long-term asymmetric coefficients estimated as $\beta^{+} = -\delta^{+} / \varphi$ and $\beta^{-} = -\delta^{-} / \varphi$ respectively.

4.4 Empirical Results

According to Table 11, the HP index is more volatile than the EPU index. Agricultural land has the lowest volatility, which supports that the agricultural land has been much more stable from 1976 to 2015. The trends of *hp, epu*, and *land* series in the study are visually indicated in Figures 11, 12, and 13 above. The figures consciously reveal economic episodes and political regimes in the country for the period under consideration. Specifically, our emphasis is on the characterization of agricultural land during the estimated period. In Sweden, as observed in the visual plot (see Figure 13), the decline in the availability of agricultural land is drastic and the reverse is the case for the availability of forest land as compared to the first ten EU countries with the highest house price growth rate (see Table 11).

Subsequently, this study proceeds to investigate the stationary properties of the series under consideration.

Table 11: Descriptive Statistics and Pair-Wise Correlation

	HPI	EPU	LAND
Mean	4.13	4.64	10.41
Median	4.07	4.67	10.40
Maximum	4.86	4.85	10.53
Minimum	3.73	4.18	10.32
Std. Dev.	0.33	0.18	0.07
Skewness	0.59	-0.84	0.38
Kurtosis	2.18	2.70	1.83
Jarque-Bera	3.40	4.87**	3.21
Probability	0.18	0.09	0.20
HP	1.00		
EPU	-0.59*	1.00	
LAND	-0.60*	0.67*	1.00

Note: HP denotes the real house price index, EPU denotes EPU index, and LAND denotes agricultural land. * and ** indicate significance at 1and 5 percent level, respectively.

Figure 11: The upward-trend of the real house price index

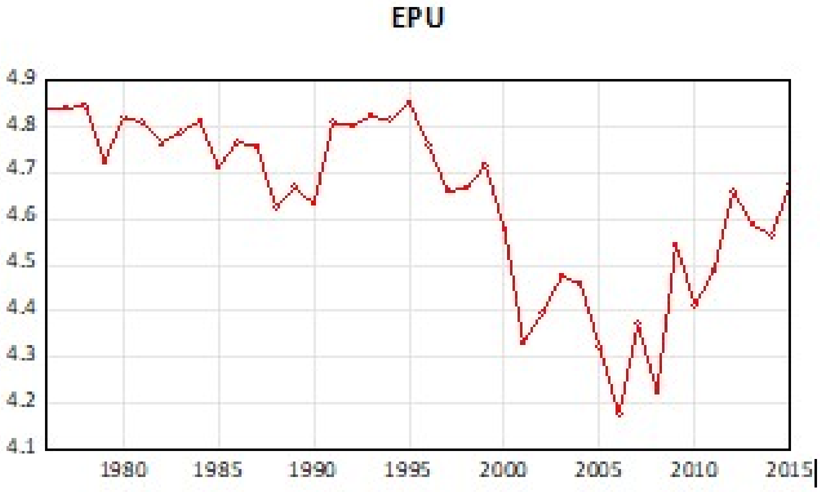

Figure 12: The EPU is characteristically shown at level.

Figure 13: The downward trend of the agricultural land area

Table 12: Ng-Perron Unit Root Test Results

	MZa		MZt		MSB		MPT	
Variables	**MZa^{I}**	**MZa^{B}**	**MZt^{I}**	**MZt^{B}**	**MSB^{I}**	**MSB^{B}**	**MPT^{I}**	**MPT^{B}**
HP	-6.30	-11.88	-1.49	-2.34	0.23	0.2	4.74	8.19
ΔHP	-9.06**	-10.89	-2.06	-2.3	0.22	0.2	2.97	8.51
EPU	-3.21	-10.49	-1.26	-2.16	0.39	0.2	7.61	9.26
ΔEPU	-17.14*	-17.02***	-2.88	-2.89	0.17	0.1	1.57	5.50
LAND	1.09	-6.09	1.33	-1.62	1.22	0.2	102.55	14.84
ΔLAND	-18.92*	-18.78**	-3.05	-3.04	0.16	0.1	1.37	4.94

Note: ***, **, and * indicate significance at the 0.1, 0.5 and 0.10 level respectively. $^{I, B}$ denote the intercept and intercept with the trend.

Table 13: ZA (1992) Tests for Unit Root Under a Single Structural Break

	Level			First Difference		
	ZA_I	**ZA_T**	**ZA_B**	**ZA_I**	**ZA_T**	**ZA_B**
HP	-3.79	-4.34	-4.27	-4.86*	-4.36*	-4.79
Time Break	2003	1999	2003	1998	2005	1998
Lag Length	1	1	0	3	3	3
EPU	-3.69	-3.41	-4.72	-9.35*	-8.70*	-9.21*
Time Break	2000	2009	2001	2007	2002	2007
Lag Length	0	0	0	0	0	0
LAND	-4.17	-3.48	-4.03	-6.93*	-7.02*	-7.50*
Time Break	1985	1996	1985	2001	1986	1987
Lag Length	0	0	0	0	0	0

Note: * represent significance at the 0.1.

The investigation would not proceed without first testing for the stationarity of the variables (the motivation is to make sure no *I* (2) variable is used for the investigation) and to check for any evidence of structural beak. This is necessary to avoid spurious analysis as the NARDL model is most appropriate when all series are either I (0) or I (1) not I (2) (Ouattara, 2004; Shahbaz, 2017)**.** For this purpose, Ng-Perron (2001) unit root test is used to examine unit root properties of each series which is appropriate for small sample size and the Zivot-Andrews (ZA) (1992) unit root test to take into account SB for each series to avoid spurious analysis and by extension misleading policy implication. The results of the unit root test with Ng-Perron for the series are presented in Table 12. This empirical exercise shows that all series are non-stationary at the level while they become stationary at their first difference i.e. I (1). Similarly, Table 13 indicates the ZA unit root test with the H_0 of non-stationary under a single SB failed to reject at the level form for the series under consideration. However, HP, EPU index, and LAND are I (1). Since unit root test results prove that none of the variables is I (2), then the study proceeds by testing for symmetric asymmetric cointegration relationships among the variables.

Table 14: Bound tests (linear and the nonlinear ARDL)

Dependent Variable ΔHP	F-statistic	90% lower bound	90% upper bound	Result
Linear ARDL (2,0,0) model	$F_{PSS,linear}$: 2.23	4.19	5.06	No long-run relationship exists
Non-linear ARDL	$F_{PSS,nonlinear}$: 5.38*	3.17	4.14	Long-run relationship exist

Note: * indicates significance at the 10 percent level. Asymptotic critical value bounds are obtained from Pesaran *et. al* (2001) critical values case III and select k=2.

Firstly, the linear long-run relationship among the variables is estimated by using the ARDL approach. The optimal lag-lengths is selected based on AIC (1981). The findings, presented in Table 14, the H_0 of no long-run relationship exist cannot be rejected at a 10 percent significance level (F-value=2.23). However, the F-value of asymmetric ARDL model is greater than the upper threshold at the 10 percent level of significance, which supports the presence of long-run relationships among real HP, EPU, and LAND for the period of 1976-2015. This result indicates the necessity of considering asymmetric relation among the variables.

Table 15: Dynamic asymmetric ARDL

Dependent variable: ΔHP			
Variable	Coefficient	Standard error	T-ratio [Prob]
Constant	1.78	0.46	3.80 [0.00]***
HP (-1)	-0.44	0.12	-3.79[0.00]***
EPU^{+}(-1)	0.01	0.12	0.03 [0.97]
EPU^{-}(-1)	-0.38	0.20	-1.89 [0.07]*
$LAND^{+}$(-1)	4.30	3.52	1.22 [0.24]
$LAND^{-}$(-1)	1.83	0.80	2.27 [0.03]**
ΔHP (-1)	0.85	0.17	4.78 [0.00]***
ΔEPU^{+}(-2)	-0.34	0.50	-2.22 [0.04]**
ΔEPU^{-}(-2)	0.37	0.19	1.91 [0.07]*
$\Delta LAND^{-}$	4.59	1.35	3.41[0.00]***
L^{+}_{EPU}	0.01 [0.98]	L^{-}_{EPU}	0.86 [0.04]**
L^{+}_{LAND}	9.79 [0.23]	L^{-}_{LAND}	-4.16 [0.00]***

R^2	0.84	R-bar^2	0.68
X^2_{NORM}	1.65 [0.44]	X^2_{HET}	1.40 [0.24]
F_{FF}	0.08 [0.97]	X^2_{AC}	13.11 [0.66]
$W_{LR, EPU}$	6.03 [0.02]***	$W_{SR, EPU}$	1.01 [0.33]
$W_{LR, LAND}$	0.41 [0.53]	$W_{SR, LAND}$	1.86 [0.189]

Note: X^2_{NORM}, X^2_{HET}, and X^2_{AC} represent LM tests for normality, heteroscedasticity, and serial correlation, respectively while F_{FF} represents the F test for functional form. ***, **, and * indicate significance at the 1, 5, and 10 percent level respectively. The insignificant short-run coefficient of variables is dropped.

The empirical results of the dynamic asymmetric ARDL model are reported in Table 15. This finding reveals that the EPU index and agricultural land together explain 84% variation of the HP index. The Wald test is applied to affirm the existence of an asymmetric relationship among the variables. The results show that the only positive component of the EPU index is 6.03 [p-value=0.02] is statistically significant at a 5 percent significance level. Therefore, to avoid spurious policy implication, NARDL is employed for Sweden.

In the long term; a negative shock in the EPU index has a negative effect on the HP index. This outcome indicates that any negative shock to EPU decreases the HP. On the other hand, a negative shock in agricultural land is positively linked with HP, (statistically significant coefficient of 1.83). A positive shock in EPU is related to HP (statistically significant coefficient of -0.34 at lag 2) in the short run. This positive shock to the EPU index collapses the HP index. A negative shock in EPU in the previous period (lag 2) is positively related to the HP index (a statistically significant coefficient of 0.37). For agricultural land, the negative shock has a positive impact on the HP index in the very short-run (but with a higher statistically significant coefficient of 4.59 at lag 0).

4.4.1 Diagnostic test

Considering the diagnostic investigation, the empirical evidence for diagnostic tests confirms that there is no problem of serial correlation (X^2_{AC}), Breusch/Pagan heteroscedasticity and non-normality of the residual term as presented in Table 10. The empirical model has a well-designed functional form as confirmed by Ramsey reset test (F_{FF}) and that suggests the consistency and reliability of the estimations. Also, visual observation and evidence from Figure 14 confirms only the existence of an overall asymmetry between EPU and real house price. The role of a negative shock in EPU dominates its positive shock. This result supports the previous findings (see Table A), where a positive shock in EPU has an insignificant effect on real house prices. However, a significant asymmetric response to shock in agricultural land is observed at the beginning of the period, in which a positive shock in agricultural land dominates a negative shock in agricultural land.

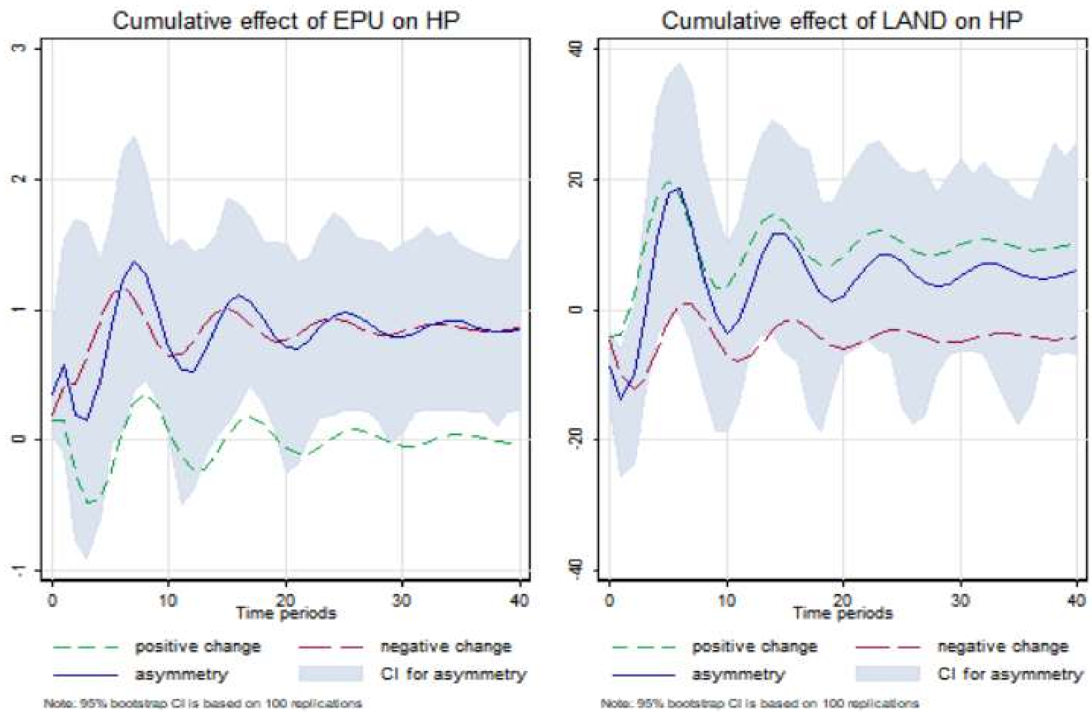

Figure 14: Dynamic cumulative effect of EPU (left) and LAND (right) variables on the real housing price index

4.5 Conclusion and Policy Implication

In this study, the relationship between agricultural land and the HP is investigated for the case of Sweden. And, significant observations regarding the asymmetric properties were established. Preliminary observation revealed that among the first eleven EU countries with recent significant growth in house prices, Sweden has a unique and interesting distribution or share of agricultural and forestry areas (see Appendix for Table A). Regarding the country, this sharp decline (the depletion) of the agricultural land suggests variation in land availability (evidence of land-use change). The empirical results show that there is no evidence of symmetric cointegration relation between house prices and agricultural land. Hence, using a NARDL approach, there is significant evidence of both the short and long-run relationships between the aforesaid variables. Although the result contradicts the lack of causal relationship in Tse (1998), the result is consistent with the evidence of long-run relation observed by

Du *et al*. (2011) and Kok *et al*. (2014) Also, the results show that there is no evidence of a short-run asymmetric relationship between EPU and real house price while evidence of long-run asymmetric relationship is statistically significant. The long-run asymmetric relationship affirms similar evidence that EPU affects both real housing returns and subsequently their volatility (Aye, 2018; André *et al*., 2017; Su *et al*., 2016). It implies that the association between agricultural land and house prices is such that percentage change in house prices with respect to the percentage change in agricultural land differs over time. Although the short-run asymmetric relationship between house prices and agricultural land is statistically significant. Also, no evidence of a long-run asymmetric relationship between the two variables.

4.5.1 Policy Implication

In recent time, the dynamics of the housing market has been linked to many factors; urbanization, population, demography, and macroeconomic variables (interest rate, inflation, exchange rate, etc.) as widely discussed in extant literature (Cesa-Bianchi *et al*., 2015; Goodhart *et al*., 2008; Case & Shiller, 1988). More importantly, the land is a major determinant of construction vis-à-vis housing cost since it is often used for building, agriculture, and forestry purposes. Hence, policymakers are more concerned about the trade-off of natural habitat or land use for aforesaid purposes (building, agriculture, and forestry). In this study, the asymmetric long-run relationship between LAND, EPU, and HP is examined.

Our result indicates that a negative shock on the previous value of EPU negatively impacts on HP in the long-run. As opined by Bernanke (1983), investment deferment is the result of an increase in uncertainty, thereby creating a short-term and sharp depression in the economy. In our case, the implication is that the confidence of investors (such as investment in housing or real estate) increases in response to a reduction in uncertainty in the long-run. Hence, the policy is geared toward reducing uncertainty as a measure of encouraging investment in the real estate and housing market and subsequently leading to the growth of the Swedish economy. The short-run implication from our result for both negative and positive shocks in EPU is statistically significant in the last two years on real housing prices. This is evidently because investors are posed to be more optimistic in the last two years as compared to the last year (it translates that the impact of uncertainty becomes lesser as the year passes).

Also, the study reveals that negative shock in agricultural land is positively related to real housing prices in both the short and long-run. Hence, according to conventional logic and economic reasoning, the conversion of agricultural land should be into housing and other non-agricultural use. However, in Sweden, specifically forestry (as observed in Table A) appears to gain more area of converted agricultural land which shows that the supply of housing is hampered due to the unexpected conversion. This leads to a housing supply deficit which causes an increase in HP according to the law of supply. In policy-wise, the effective appropriation of the country's land-use policy especially in response to both housing demand, agricultural production, and forestry dictates the key decision of the stakeholders.

Despite the contributory significance and the suggestive policy implementations of this investigation, the study could be extended to possibly cover the entire European Union countries or by applying regional comparison. Lastly, based on the observation from the information of agricultural and forestry land as indicated in Table A, forestry land or another related variable could be incorporated or investigated in a replication study.

Chapter 5

THE DYNAMICS BETWEEN HOUSING PRICE AND AGRICULTURAL LAND: APPRAISING WITH EPU INDEX

5.1 Introduction

The World Bank Housing Finance state that "*Housing plays a key socio-economic role and represents the main wealth of the poor in most developing countries*". Similarly, the United Nations (UN report, June 2017) also noted that the population is an important determinant of the housing market. This contextual and further study on housing is an obvious motivation that has triggered the curiosity of researchers in a way try to establish linkages. Beginning from the time of the global economic meltdown of the 1930s until now, again another worst economic crisis was globally experienced in 2007. This is so because the crisis is largely responsible for the housing market meltdown and was importantly known to be caused by the subprime mortgage crisis (André *et al*., 2017; Shiller, 2012; Crotty, 2009). Again, preceding the event to the GFC, Mankiw, and Weil (1989) had earlier studied the housing market and noted the relationship between house market and several factors; an example is demographic like aging.

In the current study, prior knowledge of the land resources limitation (Jackson, 2018; Eriksen, 2017; Hawley *et al*., 2017), the trade-off nexus of the housing market and land supply is further explored. On that note, the study of Davis *et al*. (2017) and Wang *et al*. (2016) were carefully noted for further insights. Importantly from Davis *et al*., (2017)[12], useful information on the linkage between land prices and house prices was presented specifically on the dynamics of house prices across Washington Areas from 2000 to 2013. Regarding this, the current study investigates the nexus of the housing market and agricultural land among fifteen countries (Australia, Canada, France, Germany, Hong Kong, Japan, Ireland, Italy, Spain, Netherland, Singapore, South Korea, Sweden, United Kingdom, and the United States,) from the four (4) continents of the world. The investigation was conducted for the aforesaid countries of the Global EPU (henceforth referred to as GEPU) over an annual frequency period 1995-2015. The objectives of this study are presented in the following folds: firstly, the potential nexus of the LAND and the HP is established. It should provide useful evidence for or against the hypothesis that LAND usage impacts HP. Secondly, due to policy influence on the housing market (Lu *et al*. 2017) and land (Shen *et al*. 2018; Wang *et al*., 2016), our model control for policy effects and other uncertainty factors using the EPU index. We further examined that EPU has a stronger impact on the housing market. And lastly, using a dynamic heterogeneous panel approach, our research is poised to present a broad investigation that reflects wider policy implications regarding the subject of discussion. Considering the aforesaid aims of the current study, it is billed to add quality perspectives within the context of existing knowledge of literature because:

- The concept of the housing market and agricultural activity (two active sectors of most major economies) is related in a conceptualized study for the first time;

[12] The detail analysis of land and house prices linkage can be followed-up from Davis, Oliner, Pinto and Bokka, (2017).

- It presents for the first time an investigation that employs GEPU instead of the national EPU;
- And, studying fifteen (15) countries in a panel data presents a wider representation of the contextual study from four continents of the world.

The remaining structure of the study is carefully planned and presented in the following order. Section 2 contains a brief literature extract and the dynamics of the dynamic of land used for agricultural practice in the countries under investigation (countries spreading over four continents). Section 3 covers data description and empirical methodologies while results and discussion of the estimates are presented in Section 4. Lastly, the concluding remarks, implications for policy, and recommendations for further study are provided in Section 5.

5.2 Overview of Previous Studies

The shred of literature has proven the versatility of housing market and the perceived relationship with a handful of macroeconomics (Kishor & Marfatia, 2017; Zhang *et al*., 2016; Cesa-Bianchi *et al*, 2015; Nyakabawo *et al*.,2015; Aye *et al*., 2014; Cesa-Bianchi, 2013; Canarella *et al*., 2012; Sirmans *et al*., 2005). Also, the housing market and the financial factors' relationship has been observed over time (Cesa-Bianchi *et al*., 2015; Case *et al*. 2005; Aoki *et al*., 2004). Moreover, the study of the interaction between socio-economic factors and the housing market has provided useful insight (Davis, Oliner, Pinto & Bokka, 2017; Cho, Bowker & Park, 2006; Bengtsson; 2001) variables. Illustratively, Cho *et al*., (2006) examined how the availability of social-amenities in a housing structure could affect the price of a house. In studying Washington DC (District of Colombia) Metro area, Davis *et al*., (2017), observed significant variance in values of residential land and house prices. Importantly, the study significantly revealed that the year 2000 witnessed a higher volatility of residential land values more than any of the observed years. Again, a shred of literature has shown linkages in the volatility of housing market dynamics and uncertainty indices (Gupta & Hassapis, 2017; Christou, Ongan & Gocer, 2017; Burnside, Eichenbaum & Rebelo, 2016; André *et al.,* 2015). Importantly, Burnside *et al.*, (2016) relate uncertainty with demand for housing and found that uncertainty affects housing returns. Hence, information from the study of the impact of uncertainty on the housing market is very useful to prospective homeowners, financial institutions, economic planners, policymakers, and real estate, and property developers. Regarding research modelling of the concept of housing, a handful of econometric tools, geographical tools like the geographically weighted regression, GWR (Manganelli *et al*.,2014), mathematical and computing tools like neural networks and fuzzy logic (Selim, 2009; Kuşan, Aytekin & Özdemir, 2010), and others have consistently been employed to study the dynamics in the housing market.

5.3 Agricultural Land Availability: Cross-continental Brief Review

A major component of the housing market that has an age-long multi-linkage with other sectors of the economy and the state's natural resource is the land resources. In the worst scenario, human activities (on the land) that are responsible for the conversion and degradation of habitats have continued to cause global biodiversity declines and land-use trade-offs (Newbold *et al*., 2015; Lambin, *et al,* 2001; Foley *et al*., 2005). As such, the allocation of land resources has continued to be a political, economic, and financial instrument being used by different classes of society for different purposes. Depending on the part of the world; in some society land resources is a major source of wealth, with some land resources is more or less a 'curse' (source of dispute, civil unrest, killing, etc.) while some count on the natural soil for their agricultural activities. That is why the land-use policies have continued to be a relevant global tool in the allocation of land for housing development (Cai *et al*., 2018; Bao & Peng, 2016; Barry & Roux, 2016). For example, in countries like China where there is a huge housing shortage, built-up land efficiency is employed (Chen *et al*., 2016). In reality, the importance of agriculture to the economy has been mentioned in numbers of literature (Matsuyama, 1992). The relevance of agriculture and the use of land resources for agricultural purposes largely depends on the availability and component of the land resources. As such, each country and region of the world is potentially known for specific agricultural practice and the use of the available land resources for agricultural practice. Because of the basis to work, culture and socio-economic forces have been largely associated with the agricultural practice over hundreds of years ago.

5.3.1 Oceania

In Oceania, the smallest continent in terms of total land availability has a vast body of water which is believed to be larger than the landmass of the entire world combined. Australia being the largest of the countries in the continent have the most diverse climate. Dairy, beef production, wheat, and cereals, oilseeds are among the main agricultural production. Also, Forestry and commercial fishing are important economic activities among Oceania's continental islands with Australia and Papua New Guinea leading the pack. The environmental outlook of the region makes research on land use and agricultural-related theme a strong note of interest (Hamblin, 2009; Ridoutt *et al*., 2014). Specifically, for Australia, Hamblin (2009) noted that the country's export value from agriculture amounts to about 20%. It maintained that, in producing food for an estimated 55 million people, Australia's agricultural sector consumes more than 70% and 60% of the water and land resources of the continent respectively. As such, the country was required to redefine its agricultural sector policies and reappraisal of its property rights among other things especially that effectively address farmland use and housing policy trade-offs.

5.3.2 Northern America

In the North Americas, the United States (US) and Canada had utilized different land-use policy instruments that have a greater impact the sectors of the economy (Mu, *et al*., 2017; Brown, Johnson, Loveland & Theobald, 2005; Muller & Middleton, 1994; Delafons, 1969). Earlier, Delafons (1969) observed that the private use of land in the US in the 1960s was absolutely under public control. In such a time, compared to the United Kingdom (UK) there was no significant concern for shielding agricultural land from urban development like the rural and urban housing development. In identifying the dynamics of land-use changes and its geographical distribution especially in North America, Brown *et al*. (2005) investigated the impact of spatial and temporal dynamics in population, agriculture, and the use of urban land. The study maintained that the patterns of land development are greatly impacted by the increasing attractiveness of nonmetropolitan areas between 1970 and 2000, a decline in the size of households, and the decrease in density settlement. The study further indicates a stable and partial cropland area in the region of Corn Belt and the West respectively during the period 1950 to 2000. The result is a 22% decrease in the cropland area of the east of the Mississippi River. In addition, it reveals the encompassing implication of the redistribution and neglect of agricultural lands relative to the land areas of the United States. Also, in the case of Canada, Muller and Middleton (1994) observed the dynamics of land-use change in the Niagara Region of Canada. In the investigation, the urbanization of agricultural land use in the Niagara Region is the common type of land-use change. It maintained that wooded and agricultural land-use is the main continued ‘exchange’ of land area in the region.

5.3.3 Asia

The continent of Asia is of great research interest especially in the field of agriculture. More importantly, effective land-use transition over recent decades has shown to significantly increase forest cover and agricultural production. In recent times, some of the Asia countries Hong Kong, Japan, South Korea, and Singapore have continued to find a balance between urbanization and agricultural production. Zhao, Peng, Jiang, Tian, Lei, and Zhou (2006) noted the unique land transformations in Asia. The study examined the consequences of land use transformation and noted that land used for agriculture in Asia is about 50% of the total Asian land area. It further maintained that there is a predominantly high level of degradation of the large rivers and lakes of the globe in Asia with the heaviest deforestation rate of the region occurring in Southeast Asia. Notably, in addition to significant negative ecological consequences, pollution of the air and water, and regional climatic alteration, the inadequate land use for housing development has continued to be a challenge.

5.3.4 Europe

Studies have shown that land use in Europe has continued to attract several environmental policy instruments (Alola, A. & Alola, U., 2018; Bański, 2017; Van Meijl *et al*., 2006; Rabbinge & Van Diepen, 2000). Bański (2017) carefully studied the use of land for agricultural purposes within the region of Central Europe with the concept of agrarian structure and the land market. In the study, farmland restitution and change of ownership are few observed factors responsible for the re-modelling of modern land use in the region. Moreover, in the Eastern region, the main directions in the context of land-use change are noted to be the influence of the process of privatization which in turn affects the agricultural sector. The study further highlighted that the use of land for agricultural purposes is not expected to significantly decrease for the European Union-25(EU 25) over 30 years from the time of the study. Expectedly, there is a small change in the European pattern of land use for the agricultural activity that is associated with the negative effect of openness of agricultural policies in comparison to the case of Africa.

5.4 Dataset and Empirical Methodology

5.4.1 Dataset

Our analysis comprises of three variables namely; the HP index, the GEPU and LAND (sq. km) for a panel of 15 countries namely Australia, Canada, France, Germany, Hong Kong, Ireland, Italy, Japan, South Korea, Netherlands, Singapore, Spain, Sweden, UK, and USA over the period of 1997 – 2015 (i.e., T=19 and N=15). The HP index is expressed as the ratio of nominal price to the private consumption expenditure deflator and it is seasonally adjusted. All the data for the countries are generated from the OECD housing database except South Korea and Singapore datasets, which are sourced from the DataStream database. LAND[13] is defined as the share of land area (sq. km) meant for agricultural as either arable, under permanent crops, or pastures. The datasets were obtained from the WDI database. This study follows an empirical study of Baker *et al*. (2016) where they adopted EPU Index data. The GEPU[14] Index is generated as a Gross Domestic Product - weighted average of national *epu* indices for 19 countries[15]. Hence, this informed of the rationale for the selection of the 15 (epu) countries under current investigation. The original dataset of GEPU are monthly frequency but are converted into annual frequency by taking averages to be consistent with the frequency of HP index and agricultural land. The GEPU index is employed

[13] World Bank Development Indicator is the sources of agricultural land information. https://data.worldbank.org/.
[14] For interested readers see, http://www.policyuncertainty.com/
[15]However; Chile, China, Mexico, Russia, Brazil and India were excluded from the sample due to none availability of real house price index data. While Colombia and Greece were new entrants' countries in the EPU index (as at July, 2018).

in the study to control for other variables. This choice is justified to account for global factors (unobserved variables) compare to individual countries EPU and because of data availability and suitability of the econometric model relative to EPU. Also, the employed GEPU entails cross-section dependency in the panel countries since they were not likely to share similar dynamic feature(s). The descriptive statistics with the correlation matrix of the variables are presented in Tables 16 and 17 before being transformed into their natural logarithmic form to correct for potential heteroskedasticity of each series.

Table 16: Descriptive Statistics

	HP	*GEPU*	*LAND*
Observations	285	285	285
Mean	4.51	4.55	10.85
Median	4.57	4.65	11.88
Maximum	5.62	5.08	15.35
Minimum	3.78	3.51	1.89
Std. Dev.	0.27	0.29	3.46
Skewness	-0.06	-0.38	-1.28
Kurtosis	4.57	2.78	4.07
Jarque-Bera	22.31*	7.55*	87.54*
Probability	0.00	0.02	0.00
Sum	1286.52	1297.53	3092.90
Sum Sq. Dev.	22.06	24.66	3390.811

Note: HP, GEPU, and LAND represent real house price index, EPU index, and agricultural land, respectively. *, ** indicate that series are not normally distributed at 1, 5 percent respectively.

Table 17: The Correlation matrix

	HP	*GEPU*	*LAND*
HP	1.00		
T- stat.	-----		
P- val.	-----		
GEPU	0.19	1.00	
T- stat.	3.35	-----	
P- val.	0.00*	-----	
LAND	-0.28	0.16	1.00
T- stat.	-4.96	2.74	-----
P- val.	0.00*	0.01*	-----

***Note*:** Correlation is significant at * 1 percent and ** 5 percent, respectively.

5.4.2 Empirical Methodology

Following the housing market extant literature (Peng & Wheaton, 1994; Zhang, Wu, Y & Shen, 2011; Burnside, Eichenbaum & Rebelo; 2016; André *et al*, 2017), we specify the housing market model as follow;

$$HP_{i,t} = f(GEPU_{i,t}, LAND_{i,t}) \quad (5.1)$$

Equation (5.1) is further specified in the natural logarithmic format of housing price as *HP*, global economic policy uncertainty as *GEPU*, agricultural land as a *LAND*, and expressed as follow:

$$\ln HP_{i,t} = \alpha_0 + \alpha_1 \ln GEPU_{i,t} + \alpha_2 \ln LAND_{i,t} + \varepsilon_{i,t} \quad (5.2)$$

The priority of the current investigation is to examine the impact of GEPU and LAND on HP using typical ARDL model proposed by Pesaran *et al*. (1999), which is specified as follow:

$$\ln HP_{i,t} = \beta_i + \sum_{j=1}^{p} \delta_{i,j} \ln HP_{i,t-j} + \sum_{j=0}^{q} \gamma_{i,j} X_{i,t-j} + \varepsilon_{i,t}, \quad (5.3)$$

where $X_{i,t}$= ($\ln GEPU_{i,t}$, $\ln LAND_{i,t}$); *i* is the number of cross-sections (i.e. *i* = 1,2,3,…, *N*); *t* is also the number of periods (i.e. *t* = 1,2,3,…, *T*), β_i=country - level fixed effect,

$\delta_{i,j}$ is the coefficient of the lags of the dependent variable, $\gamma_{i,j}$ = coefficient of lagged independent variables.

ARDL cointegration method presents the short- and long-run estimates by considering the endogeneity problem. This method can be applied regardless of the integrating order of the variables, i.e. I (0) or I (1).

Equation (5.3) is again specified in the form of an ECM as shown below:

$$\Delta \ln HP_{i,t} = \phi_i (\ln HP_{i,t-1} - \theta_i X_{i,t}) + \sum_{j=1}^{p-1} \delta^{*}_{i,j} \Delta \ln HP_{i,t-j} + \sum_{j=0}^{q-1} \gamma'^{*}_{i,j} \Delta X_{i,t-j} + \varepsilon_{i,t} \qquad (5.4)$$

in which;

$\phi_i = -\left(1 - \sum_{j=1}^{p} \delta_{i,j}\right)$ is the speed of adjustment, if the coefficient (ϕ_i) is statistically insignificant it means that there is no evidence for a long-run relationship.

$$\theta_i = \frac{\sum_{j=0}^{q} \gamma_{i,j}}{\left(1 - \sum_{j=1}^{p} \delta_{i,j}\right)}, \quad \delta^{*}_{i,j} = -\sum_{k=j+1}^{p} \delta_{i,k} \text{ and } \gamma'^{*}_{i,j} = -\sum_{k=j+1}^{q} \gamma_{i,k}.$$

In equation (4), $\phi_i (\ln HP_{i,t-1} - \theta_i X_{i,t})$ measures the speed adjustment in case(s) of deviation of the independent variables from the short-run disequilibrium. The short-run dynamics of the housing market model is captured by the terms $\sum_{j=1}^{p-1} \delta^{*}_{i,j} \Delta \ln HP_{i,t-j}$ and $\sum_{j=0}^{q-1} \gamma'^{*}_{i,j} \Delta X_{i,t-j}$.

In addition to the Pooled Mean Group (PMG) estimation method of Pesaran *et al.*, (1999), the estimations methods of the Mean Group (MG) by Pesaran and Smith (1995) and the Dynamic Fixed Effect (DFE) are employed to investigate the error correction model (ECM). While the MG estimator is robust to heterogeneity in the long-run and short-run coefficients, a restriction is imposed on the coefficients of the long-run and short-run as well as the adjustment speed in order to ensure equality across cross-sections under the DFE estimator. The PMG estimator is only robust to heterogeneity in the short-run slope coefficients, while assumes that the slope coefficients in the long-run are homogenous.

5.4.2.1 Panel Granger Causality Test Technique

The test of the GC approach of Dumitrescu-Hurlin (2012) is used to identify the causal relationship between the variables in a selected panel country. This test is flexible under the case when the number of cross-sections is greater than the number of periods, or vise-a-vise, for heterogeneous and unbalanced panels. Moreover, another utility of this test is that it can be applied when cross-sectional dependency evidence exists. The linear panel regression model is given in Equation (5.5) as follows:

$$z_{i,t} = \varphi_i + \sum_{m=1}^{M} \lambda_i^m z_{i,t-m} + \sum_{m=1}^{M} \phi_i^m X_{i,t-m} + \varepsilon_{i,t} \qquad (5.5)$$

where z is real HP index and X is the vector of the independent variables (i.e. GEPU LAND). The H_0 and H_1 hypotheses for the homogenous GC test are defined as below:

H_0: $\phi_i = 0$ $\forall_i$=1,2,…,M

H_1: $\phi_i = 0$ $\forall_i$=1,2,…,M_1

$\phi_i \neq 0$ $\forall_i$=M_1+1, M_1+2, …., M

where M_1 is an unknown parameter under the case 0≤ M1/M <1. The null hypothesis assumes there is no GC relationship within the cross-sections (i.e. M_1=M) whereas the alternative hypothesis points out GC relationship within in the panel (i.e. M_1=0).

5.5 Empirical Results

The descriptive statistics estimation of the panel-based series is reported in Table 16. We find that LAND is more volatile than the HP and the GEPU. The volatility is in HP is lower than the other variables. The correlation analysis is indicated in Table 17 which reveals a negative correlation between LAND and HP and a positive correlation between GEPU and HP. The LAND is positively correlated with GEPU. It is imperative to note that the pair-wise correlation test is not substantiated as further estimation will be carried out on the investigated variables over the period considered. This is necessary to avoid spurious analysis and by extension misleading policy implication(s). Again, the Levin *et al*. (2002) (LLC), Im *et al*. (2003) (IPS), Fisher-ADF and Fisher-PP type of the unit root test approaches were employed to investigate the integrated levels of the variables and the results reported in Table 18. Based on our empirical results, we find a uniform conclusion that the H_0 of non-stationarity can be strongly rejected at a 1 percent significance level after taking the first difference of the variables. Therefore, we can conclude that the integrated order is one for all variables, i.e. I (1). This statement implies that there can be long-run cointegration relations among the housing price, the GEPU, and the agricultural land. Hence, the panel Fisher-type cointegration test developed by Johansen (1991) for the H_0 (of no-cointegration) against the H_1 in the panel is employed. The result is presented in Table B of the appendix which also furnishes a sensitivity check of the cointegration method. Results in Table B show that the statistical evidence of long-run relationships among the HP, GEPU, and LAND for each lag.

The information in Table 19 reports the results of the estimations for PMG, MG, and DFE specifications for HP, GEPU, and LAND. Comparing the estimation techniques

PMG, MG, and DFE, our results match PMG with MG, and MG with DFE before using Hausman specification test statistics to select the appropriate technique. Significant evidence shows that DFE is preferred to PMG since speed-of adjustment coefficient is negative and statistically significant at 1 percent significance level. This indicates the existence of a long-run equilibrium relationship between housing prices, GEPU, and agricultural land over the investigated period. This outcome is in line with the result of the Fisher-Johansen panel cointegration test (used in the study as a robustness check). Based on the more suitable DFE estimation technique results in Table 18 (a significantly more consistent and efficient estimator), the speed of adjustment in case(s) of any form of disequilibrium is corrected by 11 percent annually for the estimated panel countries. Furthermore, GEPU has a negative impact on HP in the long run while in the short-run the impact is positive. This indicates that a 1 percent increase in GEPU decreases HP by 0.67 percent in the long run and increases by 0.04 percent in the short run. In addition, the land has a negative and statistically significant effect on the HP in the long run while the short-run impact is strongly insignificant. Thus, a 1 percent increase in the agricultural land area decreases HP by 3.97 percent in the long run for the selected panel countries.

Table 18: Panel Unit Root Tests

	Variables					
	HP		GEPU		LAND	
	Level	First Difference	Level	First Difference	Level	First Difference
Levin, Lin and Chu	-3.83*	-3.58*	-6.18*	-13.00*	-0.40	-10.84*
Im, Pesaran and Shin	0.17	-2.91*	-1.53***	-8.20*	-0.31	-8.78*
Fisher-ADF	41.51***	53.15*	35.90	109.94*	31.60	120.53*
Fisher-PP	41.84***	56.81*	52.25*	132.40*	32.63	144.85*

Note: *, **, *** denotes significance at the 1,5 and 10 percent levels, respectively. Newey-West bandwidth selection with Bartlett kernel for all unit root tests. The Schwarz Information Criterion is used to determine the optimal lag lengths.

Table 19: The estimate result of the PMG, MG and DFE of the ARDL (1, 1) model

Explanatory variables	PMG	MG	DFE
Adjustment Coefficients	-0.04	-0.19*	-0.11*
Long-run Coefficients			
GEPU	1.04*	-0.21	-0.67*
LAND	-0.66*	-3.57	-3.97*
Short-run Coefficients			
Intercept	0.09	4.57	5.62*
ΔGEPU	-0.01	0.04***	0.04*
ΔLAND	-1.07	0.07	0.14
No. of Grp.	15	15	15
No. of Obs.	270	270	270
Hausman Test	MG vs PMG		MG vs DFE
Chi2(2)	3.80		0.00
Prob. > χ^2	0.15		1.00

Note: There is a decrease in the number of observations from 304 to 288 since the first order lag of the real house price index is included as an independent variable in the right side of the model. *, **, *** denotes significance at the 1,5 and 10 per cent levels, respectively.

Table 20: Dumitrescu and Hurlin (2012) dynamic causality test

H_0	W-bar	Z-bar	P-value	Decision
HP ≠> GEPU	1.54	1.50	0.14	Fail to Reject
GEPU ≠> HP	4.31*	9.05	0.00	Reject
GEPU ≠> LAND	1.18	0.51	0.61	Fail to Reject
LAND ≠> GEPU	3.76*	7.58	0.00	Reject
LAND ≠> HP	8.36*	20.16	0.00	Reject
HP ≠> LAND	1.84**	2.31	0.02	Reject

Note: The symbol ‘’ ≠> ‘’ indicates that one variable does not Granger cause the other. *, **, *** are the significance levels at 1, 5, and 10 percent respectively.

Also, the Dumitrescu-Hurlin GC test results are presented in Table 20 above. Unidirectional causality is revealed from LAND to GEPU, and from GEPU to HP at a 1 percent significance level. This specifically implies that the previous value of the agricultural land has predictive power over the future values of the GEPU index. In like manner, the past values of the GEPU have predictive power to forecast the future values of the housing price. Moreover, the result also provides significant evidence of the presence of feedback effect between the HP and the LAND.

5.6 Concluding remarks, Policy Implication, and Recommendation

This empirical work presents an investigation of the dynamics between the housing prices and agricultural land for 15 OECD countries. The panel of 15 countries covered in this investigation is spread over four (4) continents (Oceania, North America, South American, and Europe). The GEPU index was used to control other unobserved factors for this study. Hence, in the panel of countries under investigation and over the experimented period of 1997 to 2015, we observed a significant inference between the real house prices and agricultural land. This outcome is consistent with the study of Uzuner and Alola (*2019*). Our empirical model (Dynamic Fixed effect) significantly corrects the short-run disequilibrium with an adjustment speed of 11% annually; it subsequently shows that there is evidence of a long-run relationship between the variables. This reveals that a 1 percent increase in the land available for agricultural activities in the panel of countries will cause a decline of 3.97 percent in the house prices in the long-run. Although, this relationship is shown to be insignificant in the short-run. Moreover, the feedback effect observed between the variables i.e. LAND and HP further establishes the link between land use and the housing prices in extant literature (Wang *et al*., 2018; Wang *et al*., 2016; Peng & Wheaton, 1994). However, the relationship is observed to be significant both in the long-run and short-run for HP and GEPU. While the effect of *gepu* on *hp* is significantly positive and lowers in the short-run, the elasticity is -0.67. Similarly, the unidirectional GC nexus of the variables i.e. GEPU and HP are significant as reported in the study of Chow *et al*. (2017).

In considering effective policy instruments for implementation, the focus should be on the factors that dictate the dynamics of the housing market; urbanization, population, demography, and macroeconomic variables as noted in extant literature (Hiller & Lerbs, 2016; Case *et al*., 2005). Because of the necessity of land vis-à-vis for building, agriculture, and forestry purposes, and in the case of our study, it uses for agricultural activities, and housing development is expected to be effectively balanced by government and policymakers. As implied in our study, especially from the long-run result, policymaker(s) should be more concerned about the trade-off of natural habitat or land use for aforesaid purposes (building/housing construction agriculture). Since our result implies a trade-off between agricultural land and the real house prices in the long-run, policy that is sustainable for the future period should be encouraged. Such policies like land reclamation, cultivation of genetically-modified crops, etc. that do not hamper the development of agriculture (noting that agriculture constitutes a significant component of the global economy) are encouraged. Regarding the implication of the result between *gepu* and *hp* in our study, an increase in *gepu* which will translate to low investor confidence and resulting to hike in the house prices in the short-run. The assertion as opined by Bernanke (1983) noted that there is a possible deferment in investment by a potential investor in response to a relative increase in uncertainty, especially for short-term shocks. This is expected because investors are discouraged to invest in housing and real estate when there is economic uncertainty. As such, they would rather alternatively invest in another business, thus driving the prices of houses higher as observed in the short-run. But in the long-run, the observed decline in the house prices could be due to the provision of adequate housing policy like the mortgage system or the consistent use of the alternative form of housing. Hence, the factor that determines economic policy like the political dynamics, news dissemination according to Baker *et al*. (2016) could be adequately tailored toward averting such a ripple effect on the housing market. The consistency in the optimistic mood of investors toward the housing sector is important, hence effective and sustainable policy would potentially be adequate.

This study can be advanced in future research such as the spatial examination that considers an exclusively in-depth country-by-country and or continental analysis within this framework. Also, considering the use of national EPU index i.e. each country's EPU could produce an interesting study of significant contribution to the extant literature. Lastly, most parts of the continent of Africa have a long-standing challenge of land tenure, land ownership, land acquisition issues. This age-long land problem that has continued to plague the continent is not unconnected with the history of agricultural activities. For instance, Zimbabwe has witnessed decades of aggravated land reallocation system which largely responsible for the country's systemic economic downturn. Hence, a reflection of the current study could be extended to countries like Zimbabwe, South Africa (known for low-income housing problem), and other countries which have similar challenges.

Chapter 6

CONCLUSION

The main objective of this thesis is to explore the relationship between housing prices and its interaction with EPU and agricultural land for the US, Sweden, and some other OECD countries.

In the second chapter of this thesis, the causal interaction between EPU and HP was investigated while accounting for other crucial macroeconomic indicators, such as TBILL, IPI, RV, POP, INF, and UNEMP, which has been seen to mainly influence housing market dynamics for the US economy. This study contributes to the housing/real estate literature by applying the RO and RER GC tests in multivariate time series framework, which offers a more robust and consistent outcome that previous studies failed to address. The major finding of the study is that strong causality from EPU to HP is observed during periods of declining EPU associated with rising housing prices, but not in periods such as the high EPU and declining housing prices. This suggests that lower levels of EPU can help predict HP. Information of this sort is insightful for policymakers, real estate agents, and portfolio managers in the housing market to predict the future returns in the housing sector and assess its associated risks.

In chapter three, we focused on the dynamic relationships between HP return and the EPU growth for sixteen OECD countries. In doing this, the economic growth and the short-term interest rate were incorporated in the model both as additional variables to circumvent for omitted variable bias approach. To achieve this aim, the study conducted a PVAR technique which allows the consideration of the endogeneity problem while also overcoming the small sample size limitations. The empirical results of IRF showed that the positive shock to EPU growth leads to a decrease in the HP return. From the investors' point of view, heightened uncertainty regarding policy guide translates into weak investment in the housing sector. Consequently, the weak housing investment is observed to cause an adverse effect on economic growth since the housing sector (a leading sector for economic growth) reportedly shown strong resilience. Similarly, evidence from the FEVD results indicated that HP return has a relatively greater possibility to explain the changes in economic growth shocks in both the short run and long run. However, the dynamic impact of HP return on EPU growth is statistically insignificant over the sample period. Regarding the policy framework, this finding revealed that EPU has more power to explain the changes in itself. Hence, policymakers, real estate agents, and portfolio managers in the housing market should consciously seek strategies to reduce uncertainty in the economy.

In the preceding chapter, the relationship between agricultural land and the HPis investigated while controlling the EPU for the case of Sweden using the NARDL estimation techniques. The results showed that there is no evidence of a short-run asymmetric relationship between EPU and real housing prices while evidence of long-run asymmetric relationship is statistically significant. The long-run asymmetric relationship established in this study affirms similar evidence that EPU affects both real housing returns and subsequently their volatility (Su *et al.*, 2016; André *et al.*, 2017; Aye, 2018). It implies that the association between agricultural land and house prices is such that percentage change in house prices with respect to the percentage change in agricultural land differs over time. Although the short-run asymmetric relationship between house prices and agricultural land is statistically significant. Also, there is no evidence of a long-run asymmetric relationship between the two variables. Furthermore, the study reveals that negative shock in agricultural land is positively related to real housing prices in both the long-run and short-run. Hence, according to conventional logic and economic reasoning, the conversion of agricultural land should be into housing and other non-agricultural use. However, in Sweden, specifically forestry (as displayed in Table 1) appears to gain more area of converted agricultural land which shows that the supply of housing is hampered due to the unexpected conversion. This obviously leads to a housing supply deficit which causes an increase in HPaccording to the economic theory of supply. From the perspective of policy, the effective appropriation of the country's land-use policy especially in response to both housing demand, agricultural production, and forestry dictates the key decision of the stakeholders.

Finally, the last chapter presented the investigation of the dynamics between the housing prices and agricultural land while controlling the GEPU for fifteen OECD countries. The findings revealed that the strong evidence of the bidirectional relationship between the variables i.e. land and hp further established the link between land use and the housing prices in extant literature (Wang *et al.*,2018; Wang *et al.*,2016; Peng & Wheaton, 1994;). However, the relationship is observed to be significant both in the long-run and short-run for hp and gepu. While the impact of gepu on hp is significantly positive and low in the short-run, the elasticity is -0.67. Similarly, the unidirectional GC nexus of the variables i.e. gepu and hp is significant as reported in the study of Chow, Cunado, Gupta, and Wong (2017). As implied in our study, especially from the long-run result, policymaker(s) should be more concerned about the trade-off of natural habitat or land use for aforesaid purposes (building/housing construction agriculture). Since our result implies a trade-off between agricultural land and the real house prices in the long-run, government policy that is sustainable for the future period should be encouraged to strike a balance between the agricultural land use and housing prices, such that either sector of the economy is not worse-off. Such policies like land reclamation, cultivation of genetically-modified crops, etc. that do not hamper the development of agriculture (noting that agriculture constitutes a significant component of the global economy) are encouraged.

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APPENDIX

Table A: Trend of house prices index and agricultural land availability in selected EU countries

Country	HPI (% avg. annual growth)	Agricultural /Forest land (% availability)
Sweden	4.99091	7.40 / 68.9
Austria	3.18182	32.9 / 46.9
Luxembourg	3.06364	50.6 / 33.5
Czechia	2.91818	54.6 / 34.5
Malta	2.73636	32.0 / 1.1
Slovakia	2.52727	40.0 / 40.3
Poland	1.92727	47.1 / 30.8
Germany	1.48182	47.9 / 32.7
Belgium	1.04545	44.0 / 22.6
United Kingdom	0.60909	71.2 / 13
Bulgaria	0.49091	45.8 / 35.2
Finland	0.22727	7.5 / 73.1
Portugal	0.1000	40.4 / 34.7
France	-0.0636	52.5 / 31
Estonia	-0.0818	23.0 / 52.7
Slovenia	-0.1182	30.5 / 62
Hungary	-0.49000	59.1 / 22.9
Lithuania	-0.3364	47.1 / 34.8
Latvia	-0.6909	30.1 / 54
Denmark	-0.7455	62.6 / 14.6
Netherlands	-0.8636	54.6 / 11.2
Cyprus	-1.5727	13.8 / 18.7
Ireland	-1.8455	64.8 / 10.9
Croatia	-1.8636	27.0 / 34.3
Italy	-2.1909	44.7 / 31.6
Spain	-2.8636	53.1 / 36.8
Greece	-4.9091	60.4 / 31.5
Romania	-6.6	60.1 / 29.8

Note: House prices index information is from Eurostat (2018). It was calculated with consideration of the global economic recession beginning 2007 until 2017 by taking average of one year % change of house price. Agricultural land and forest area information for the year 2014 were retrieved from the World Bank.database. *Computations were made by the authors.

Table B: Fisher-type Johansen panel cointegration test

H_0	Fisher Stat. *(from trace test)	Prob.	Fisher Stat. *(from max-eigen test)	Prob.
Lag length =1				
r=0	123.70*	0.00	105.90*	0.00
r≤1	50.43**	0.01	40.94***	0.09
r≤2	48.77**	0.02	48.77**	0.02
Lag length =2				
r=0	210.90*	0.00	150.50*	0.00
r≤1	109.00*	0.00	80.14*	0.00
r≤2	80.10*	0.00	80.10*	0.00
Lag length =3				
r=0	123.00*	0.00	123.00*	0.00
r ≤1	327.10*	0.00	332.10*	0.00
r ≤2	142.60*	0.00	142.60*	0.00