GOAL PROGRAMMING AND FUZZY APPROACH IN DETERMINING MUTUAL HOUSE PRICE AND AFFORDABILITY: A STUDY IN KEDAH, MALAYSIA

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Abstrak

Pemilikan rumah merupakan satu isu kompleks yang melibatkan banyak faktor. Kemampuan pemilikan dan projek tertangguh merupakan antara faktor yang mendapat perhatian. Secara dasarnya, terdapat tiga pihak terlibat dalam pembangunan perumahan; pemaju swasta, kerajaan, dan pembeli rumah. Pihak kerajaan telah mewujudkan beberapa program seperti 'PR1MA' dan 'Rumah Pertamaku' untuk menangani isu ini. Program ini diuruskan melalui kerjasama awam-swasta (PPP). Pihak pembeli rumah pula, selain daripada harga rumah, terdapat kecenderungan lain yang dipertimbangkan. Interaksi antara tiga pihak ini menjadi kompleks disebabkan perbezaan dalam kecenderungan dan sasaran. Tujuan kajian ini adalah untuk membina model interaksi dalam menentukan harga rumah bersama. Selain itu, tahap kemampuan pemilikan rumah juga diukur. Kecenderungan dan sasaran setiap pihak dikaji, dan kekangan mereka dikenalpasti untuk dimodelkan dengan menggunakan pendekatan Pengaturcaraan Gol. Kekangan itu adalah berdasarkan faktor ekonomi yang mempengaruhi harga rumah. Seterusnya, interaksi antara pihak tersebut disimulasikan untuk mendapatkan harga purata rumah bersama. Terdapat 193 pembeli rumah, dua pemaju swasta, dan kerajaan di Kedah yang terlibat, menghasilkan 386 simulasi. Kemudian, tahap kemampuan pemilikan rumah diukur menggunakan pendekatan Logik Kabur. Dapatan kajian menunjukkan bahawa purata harga rumah yang dicadangkan oleh model ialah RM169, 879.20. Ia juga menunjukkan penduduk Kedah mampu memiliki rumah kos rendah, selaras dengan harga purata bersama yang dicadangkan oleh model interaksi. Harga purata rumah yang dicadangkan boleh dijadikan satu rujukan kepada semua pihak yang terlibat dalam pembangunan perumahan. Pembinaan model menekankan penglibatan interaksi manusia seiring dengan faktor ekonomi.

Kata kunci: Harga rumah, Pengatucaraan gol, Simulasi, Model interaksi, Logik kabur.

Abstract

Home ownership is a complex issue involving many determinants. Affordability is the limelight as well as delayed completion. Basically, there are three parties involved in a housing development; private developer, government, and house buyer. The government has reserved its role by organizing several programs such as 'PR1MA' and 'My First Home' in order to overcome the issue. The programs are managed through public-private partnership (PPP). On side of the house buyer, apart from house price, there are other preferences considered. The interaction between these parties becomes complex due to disparity in preferences and target. The purpose of this study is to develop an interaction model in determining a mutual house price. Besides, the affordability level of home ownership is also measured. The preferences and the target of each party were investigated, and their constraints were established to be modelled by using Goal Programming approach. The constraints are based on the economics factors that influenced house price. Next, the interaction among parties was simulated to get the average mutual house price. There are 193 house buyers, two private developers, and a government in Kedah involved, hence, 386 simulations were performed. Then, the level of affordability of owning a house was measured by using Fuzzy Logic approach. Findings show that the average mutual house price suggested by the model is RM169, 879.20. It is shown that the residents of Kedah afford to own low-cost houses, in accordance to the average mutual house price suggested by the interaction model. The suggested average house price could be a reference to all related parties in housing development. The construction of the model emphasized the inclusion of human interactions along with economic factors.

Keywords: House price, Goal programming, Simulation, Interaction model, Fuzzy logic.

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This thesis is dedicated to them.

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Glossary of Terms

BNM	Bank Negara Malaysia
DM	Decision Maker
FL	Fuzzy Logic
GP	Goal Programming
GDP	Gross Domestic Product
KLSE	Kuala Lumpur Stock Exchange
NAPIC	National Property Information Centre
PPP	Public-private partnership
PR1MA	Perbadanan PR1MA Malaysia
REHDA	Real Estate and Housing Developers' Association Malaysia
RM	Ringgit Malaysia

CHAPTER ONE

INTRODUCTION

1.1 The importance of the housing sector

Housing is a vital sector in determining a country's economic development. Kim (2004) stated that housing sector contributes about 30% of the wealth of the world, which is more than equities (19%). In addition, the World Bank (1993) stated that about 8% of Gross National Product (GNP) per capita is obtained from housing investment, and also contributes more about 10% of GDP from housing service.

Bank Negara Malaysia (BNM) (2012) also stressed that housing market is a vital part of the domestic economy. Macroeconomic variables (i.e., real GDP, inflation, producer price, population, consumer sentiments and ratio of housing transactions over housing stock) seem to be the most influential factors for house price increment.

Housing sector seems to face acute problems such as high price and delayed completion. This issue causes the buyers who are middle or low income earners face additional problem when they plan to buy or own a house. Yet, fluctuation in demand and supply indicates that the buyers pay what they expect for their money.

In addition, several studies in the literature also stressed on the importance of homeownership in creating motivations for homeowner and communities (Glaeser & Sacerdote, 2000; Tan, 2009). Moreover, surprisingly, homeownership is closely related to health (Matthews et al., 2002; Meyers et al., 2005), and children's developmental (Green & White, 1997; Tan, 2009) as well.

Matthews et al. (2002) posited that homeownership is closely related to hypertension. In their 10 year longitudinal study, they found that buyers who have trouble to settle the basic payment for their houses will experience hypertension compared to those who have no such issue.

Other than that, another causal research that studied the impact of housing subsidies on children from low income family showed that housing subsidies increase the availability of nutritious food (Meyers et al., 2005). The finding implies that house subsidies could help to improve a person's socioeconomic condition. This study has confirmed the previous study by Meyers, Rubin, Napoleone, and Nichols (1993) which found that housing subsidies can increase poor children's health.

A study showed that a mobile family that frequently moves from a place to another in searching for a better living shelter, could disrupt children's emotion (Bartlett, 1997). This phenomenon is due to repeated disturbance of their social ties.

Moreover, Green and White (1997) studied the difference of children behaviour development between families who own or rent a house and suggested that it is easier to control the children when we live in decent environment and have good neighbourhood. Aaronson (2000) augmented the study of Green and White (1997) and studied on the impact of homeownership towards children's cognitive ability. Aaronson (2000) suggested that neighbourhood stability influences children's mental development as well, due to the probability of the children to socialize with good people as well as exposure to a more stable school environment.

From the literature, the researcher can conclude that home ownership is a vital issue because it surprisingly affects children's health and social development as well. Thus, it can be concluded that affordable housing is a vital component for a country to enable its citizens to experience good quality of life. Unfortunately, there are many issues that can cause the general public to become unable to buy houses. These issues is presented in the next section.

1.2 House price

The increase in house price has been worrying house buyers in Malaysia. iProperty.com reported that many Malaysian nowadays are becoming not afford to own a house (Sinar Harian, 2013). iProperty.com is a company that is having online property portal website is Asia that focused on developing and operating leading real estate portals and delivering most comprehensive set of related real estate service throughout Asia region. This finding is based on their research towards 13,145 respondents. From the survey, mean (μ) calculated is 7.15 from a maximum of 10 point in Likert scale. In this scale, one represents most purchasable while ten represents most not purchasable (Sinar Harian, 2013). This situation suggests irrelevant house price compared to household income.

According to the Malaysian House Price Index as reported by National Property Information System (NAPIC) (2014), house price in Malaysia has increase. In 2012, house price for all types of house recorded a rise in each quarter. It rises 11.8 percent in the second quarter, followed by more than 11.9 percent increase, and further increase by 8.3 percent in the fourth quarter of the same year (NAPIC, 2014).

A survey reported by Real Estate and Housing Developers' Association Malaysia (REHDA) revealed that 95% of the house buyers are first time buyer (Shalini, 2013).

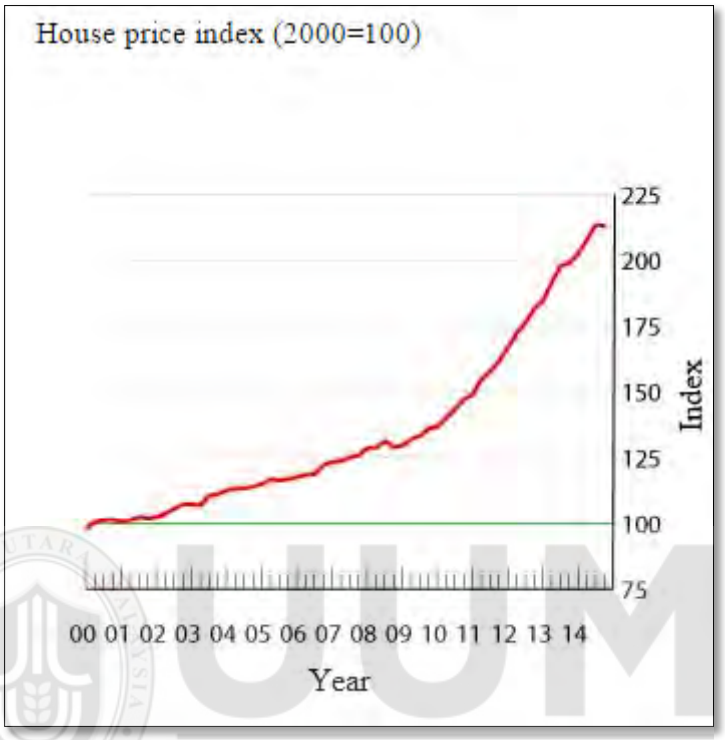


Figure 1.1. *House price index of Malaysia*

Figure 1.1 shows the continuously surging house price in Malaysia from 2001 to 2013 (Global Property Guide, 2015). Aside from Malaysia, Mexico also experiences the same pattern (see Figure 1.2) of yearly increase. This scenario suggests that the house price is a global issue faced by people all over the globe.

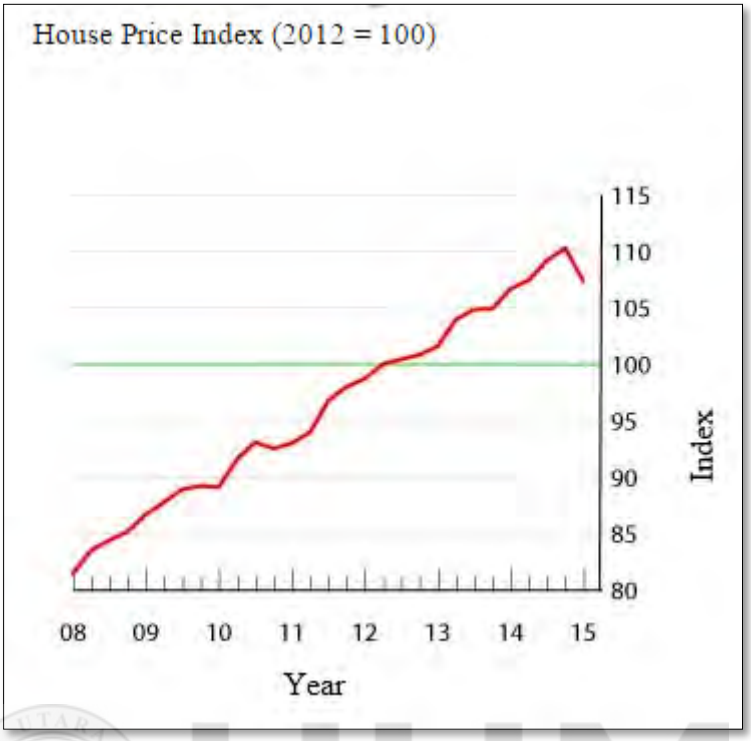


Figure 1.2. House price index of Mexico

1.3 Housing Scenario in Malaysia

There are several types of housing in Malaysia which are terraces, townhouses, semi-detached houses, bungalows, apartments, condominiums, and serviced apartments.

Table 1.1 shows total housing units approved to be constructed by private developers based on house price categories in January until March 2015. The houses are categorized based on price. It can be seen from the table that numerous private developers applied for high cost type of houses. Selangor state reported the highest number of application for high cost houses (6,613 units) followed by Pulau Pinang state (5,543 units). It is apparent from the table that very few private developers applied for the construction of low cost and low medium cost houses. Only Pulau Pinang state

shows interest in building low cost houses (885 units) followed by Perak state (67 units) and Melaka state (40 units). This table also reveals the same pattern for low medium cost houses. The highest to apply for construction is Selangor state at 550 units, followed by Pulau Pinang state (135 units) and Johor (4 units). Developers in other than these states did not even apply to build low medium cost houses.

Table 1.1

Number of House Units Approved for Construction to Private Developers by Category of House Price, January – March 2015

STATE	LC	LMC	MC	HC	TOTAL
Johor	4	4	482	3,891	4,381
Kedah	-	-	-	1,059	1,059
Kelantan	-	-	-	48	48
Melaka	40	-	-	840	880
Negeri Sembilan	-	-	-	369	369
Pahang	-	-	-	1,404	1,404
Perak	67	-	-	2,704	2,771
Perlis	-	-	-	-	-
Pulau Pinang	885	135	478	5,543	7,041
Selangor	30	550	302	6,613	7,495
Terengganu	-	-	-	49	49
W.P. Kuala Lumpur	-	-	-	4,032	4,032
W.P. Putrajaya	-	-	-	2,743	2,743

(Ministry of Urban Wellbeing Housing and Local Government, 2015)

Guide:

LC: *Low Cost (Less than RM42,000)*
LMC: *Low Medium Cost (RM42,001-RM70,000)*
MC: *Medium Cost (RM70,001-RM100,000)*
HC: *High Cost (above RM100,000)*

Meanwhile, Table 1.2 reports abandoned housing projects. This table presents the number of housing projects abandoned until March 2015.

It can be seen from the data in the table that Selangor state experienced biggest number of abandoned housing projects (22 projects) followed by Perak state (8 projects). These

projects affect 4,798 house buyers (and 500 house buyers in Selangor and Perak, respectively. The number of abandoned houses totals up to 7,288 units in Selangor and 958 units in Perak. Terengganu, Melaka and Perlis recorded no abandoned house project. From the table, it is clear that there is the demand in housing projects, for example, in Johor state, the number of house units developed is 2,734 and 2,051 buyers, which means almost all units have been sold.

Table 1.2

Abandoned Housing Projects by State until 31 March 2015

State	**Number of Projects**	**Number of house units**	**Number of buyers**
Johor	8	2,734	2,051
Kedah	2	765	169
Kelantan	1	39	29
Melaka	-	-	-
Negeri Sembilan	4	974	807
Pahang	4	761	589
Perak	9	958	500
Perlis	-	-	-
Pulau Pinang	2	1,550	1,337
Selangor	22	7,288	4,798
Terengganu	-	-	-
W.P. Kuala Lumpur	1	134	23

(Ministry of Urban Wellbeing Housing and Local Government, 2015)

1.4 Housing Scheme in Malaysia

The government has provided several solutions to overcome the problem. For instance, 'Perbadanan PR1MA Malaysia' (PR1MA) program is a housing program for middle household income so that residents can afford to own their house (PR1MA, 2017) and 'My First Home' (My First Home Scheme, 2013) that target buyers who are not

working with the government. PRIMA and My First Home are government housing development projects aimed to encourage home ownership for first time buyer. Table 1.3 summarizes the requirements needed to apply for PRIMA and My First Home.

Table 1.3

Summary of My First Home and PR1MA

My First Home	PR1MA
(1) 100% financing, i.e. no need 10% down payment (2) Residential properties in Malaysia only (3) Malaysian not exceeding 35 years old (4) Single borrower's gross income not exceeding RM5,000 per month and joint borrowers gross income not exceeding RM10,000 per month (based on gross maximum income of RM5,000 per month per borrower) (5) Property value between RM100,000 and RM400,000 (6) Must occupy property upon purchase (7) Financing tenure not exceeding 40 years, or not more than 65 years old (8) Instalment payable via monthly salary deduction (9) Compulsory fire insurance / Takaful (10) Amortising facility only, without redrawable features	(1) Malaysian (2) Average monthly household income of RM2500-RM7500 (3) Applicant must be at least 21 years old (4) Those who currently own no more than one property (5) PR1MA homes are allocated through an open balloting process (6) A 10-year moratorium will be imposed, during which the property cannot be sold or transferred to another party without prior approval from PR1MA (7) Must occupy property upon purchase

From Table 1.3, it is clear that the government is focusing on property value that is between RM100,000 to RM400,000 and the middle-income earner. Middle income that

categorized by the government is citizen with household income in range of RM2,500 and RM10,000. Also, we can see from Table 1.3 that the government restricted the buyer to occupy the property upon purchase. This is to make sure that the buyer does not take advantage of the schemes, for example by renting the house to other people.

Eleventh Malaysia Plan (2016-2020) has stressed about affordable house price, parallel with theme "Anchoring Growth on People" (Prime Minister Speech in House of Representatives 21 May 2015, 2015). The Eleventh Malaysia Plan is the final plan towards realizing Vision 2020. More low and medium costs housing is targeted to be developed in these five years (BERNAMA, 2016; Prime Minister Speech in House of Representatives 21 May 2015, 2015). REHDA (2016) stated that over 10,877 housing units have been launched in first quarter of 2015, but only 4,373 housing units sold. This shows the lower buying power among first time house buyer. The demand in medium cost housing also depends on buying power and house price. This subtopic intends to highlight house price categories in Malaysia in depth.

Penang state Government is rebranding their concept of low- and medium-cost housing into affordable housing program. This housing program is divided into several categories; A, B, C, D, E, and F. Table 1.4 shows Penang housing program respective categories. The price starts from RM42,000 (Housing type A) up to RM400,000 (Housing type F). Price point in Table 1.4 below shows the suggested retail house price that can be altered based on several factors such as competition and demand. This price range is more detail compared to PR1MA program.

Table 1.4

House Price Category based on www.penangpropertytalk.com

Housing Type	**Price Point**
A (Low Cost)	RM42,000
B (Low Medium Cost)	RM75,000
C (Affordable housing)	RM150,000
D (Affordable Housing)	RM200,000
E (Affordable Housing)	RM300,000
F (Affordable Housing)	RM400,000

Source: (Penang Property Talk, 2017)

Meanwhile, Selangor state government advocates affordable housing for residents who have household income of less than RM10,000 (see Table 1.5). Selangor's affordable housing use same concept with Penang's affordable housing but with less detailing in pricing compare to Penang's. However, Selangor affordable housing offer detail in area (per square feet). Earner with income less than RM3,000 monthly are eligible to apply for Rumah Selangorku Type A with the specification of 700 square feet (sf), priced at RM42,000. For person with income more than RM3,000 but not more than RM10,000 monthly, they are eligible to apply for Rumah Selangorku Type B, C, and D. In the case of Rumah Selangorku Type C, there are three varieties available which are the 800 sf, 900 sf, and 1080 sf. While for Rumah Selangorku Type D, there are two varieties which

are the 1,000 sf and 1200 sf. The retail price for Rumah Selangorku Type B, C, and D is in between RM100,000 and RM250,000.

Table 1.5

House price Categories of Rumah Selangorku

Type of House	Immensity (psf)	Retail Price (RM)	Income Eligibility (RM)
Rumah Selangorku Type A	700	42,000.00	≤ 3,000.00
Rumah Selangorku Type B	750 800		
Rumah Selangorku Type C	900 1,080	100,000 – 250,000	≤ 10, 000.00
Rumah Selangorku Type D	1,000 1,200		

Source: Lembaga Perumahan dan Hartanah Selangor (2017)

Kedah does not have specific affordable home besides PR1MA house. The house price for this state is similar to PR1MA which is in range of RM100,000 – RM400,000.

However, to compare house price in different states is not appropriate due to difference in terms of household income and living cost. PR1MA have stated that house prices within the range of RM100,000 – RM400,000 is affordable. Selangor state, however comes out with different perspective which put the range of RM100,000 – RM250,000 as affordable for middle income earners. Meanwhile, another scheme, Rumah Mesra Rakyat 1Malaysia (RMR1M) which is also targeting low income household, listed their house retail price between RM45,000 to RM65,000. However, RMR1M scheme is only

eligible for low income earners with their own lands which means that state government does not need to prepare land for housing.

Based on Statistical Report First Quarter 2016, house prices are divided into several categories. There are four categories which is low cost housing, low-medium cost housing, medium cost housing and high cost housing. The pricing can be referred in Table 1.6.

Table 1.6

Malaysia House Price Categories

Housing categories	**Price (MYR)**
Low cost housing	Below 42, 000
Low-medium cost housing	42, 001 – 70, 000
Medium cost housing	70, 001 – 100, 000
High cost housing	100, 001 and above

Source: Jabatan Perumahan Negara (2016)

It can be seen from the data in Table 1.4, Table 1.5, and Table 1.6 that high cost housing (RM100,001 and above) is considered affordable currently. Pulau Pinang state also categorized house price that is Type C to Type F as affordable (see Table 1.4). The question is how affordable is Malaysian in owning a home?

In spite of government housing program seems fair to residents, the fact is many still cannot afford to own a house (Nor Malina & Azrina, 2012). REHDA reported that the middle income do not afford to buy a house due to major commitment (REHDA, 2016). Despite, research shown low income earner and middle income earner prefer middle cost house on strategic location (REHDA, 2016). This shows that the price is not solely

the factors influence the homeownership but still the main reason. Government's concern also can be seen in effort of build collaboration with the private sector.

1.5 Public Private Partnership

Public-private partnership (PPP) is a collaboration between public sector and private sector with the purpose to develop public infrastructure (UN-HABITAT, 2011). The collaboration between public and private sector is believed to be a good chance in developing properties. However, number of PPP practice seems to be small since PPP is not appealing from both public or private points of view.

Several studies have been done to identify the failure factor of PPP collaboration (Suhaiza, 2013; UN-HABITAT, 2011). PPP has been practiced in developed countries (e.g. Australia, UK, United States, Ireland) and developing country (countries in Asia, Africa and Malaysia) (UN-HABITAT, 2011; Abdul-Aziz & Jahn Kassim, 2011).

PPP has been introduced in Malaysia since 1983 where Kuala Lumpur City Hall as a government agency developed 80,000 units of low cost house (Abdul-Aziz & Jahn Kassim, 2011). In PPP, government collaborates with the private sector in the development of public facilities (Suhaiza, 2013). In Malaysia, one of the closest and recent examples of PPP is PR1MA. PR1MA is a government's initiative to supply affordable houses for low income citizens. This means PPP is a good solution to decrease housing problem. PPP is believed to be a better strategy than traditional where the public goes alone in development which the burden of financial, risk and expertise

is taken alone. Due to this, it is only natural that the public will prefer PPP over conventional housing schemes.

UN-HABITAT (2011) highlighted that PPP has some advantages and disadvantages. The advantages are PPP can save cost, provide risk sharing, on-time delivery, and improve levels of service while its disadvantages are additional cost due to PPP depending on number of project bidders, and also because of long term contract needed outside expert to forecast all possible future contingencies. Suhaiza (2013) stated the private sector is not attracted to participate in PPP. Originally, PPP is the agenda of the government to enhance public service's quality. Therefore, the attractiveness factor of PPP that is to save cost, provides an integrated solution for public infrastructure or service, delivery on time, and accelerate project development is seen as bias from the perspective of the private sector (Suhaiza, 2013; UN-HABITAT, 2011). However, since PPP in Malaysia is focusing on developing low-cost housing which will help the citizens in buying affordable houses, this research aimed to analyze the social interaction between decision makers involved in this process.

1.6 Malaysian Household Income

In 2017, Department of Statistic Malaysia (DOSM) published Malaysian household income and basic amenities 2016 (Department of Statistics Malaysia, 2015). DOSM reported that 11.7% of Malaysian earned less than RM2,000 per month, 42.1% earned less than RM4,000 monthly, and 65.0% earned less than RM6,000 monthly.

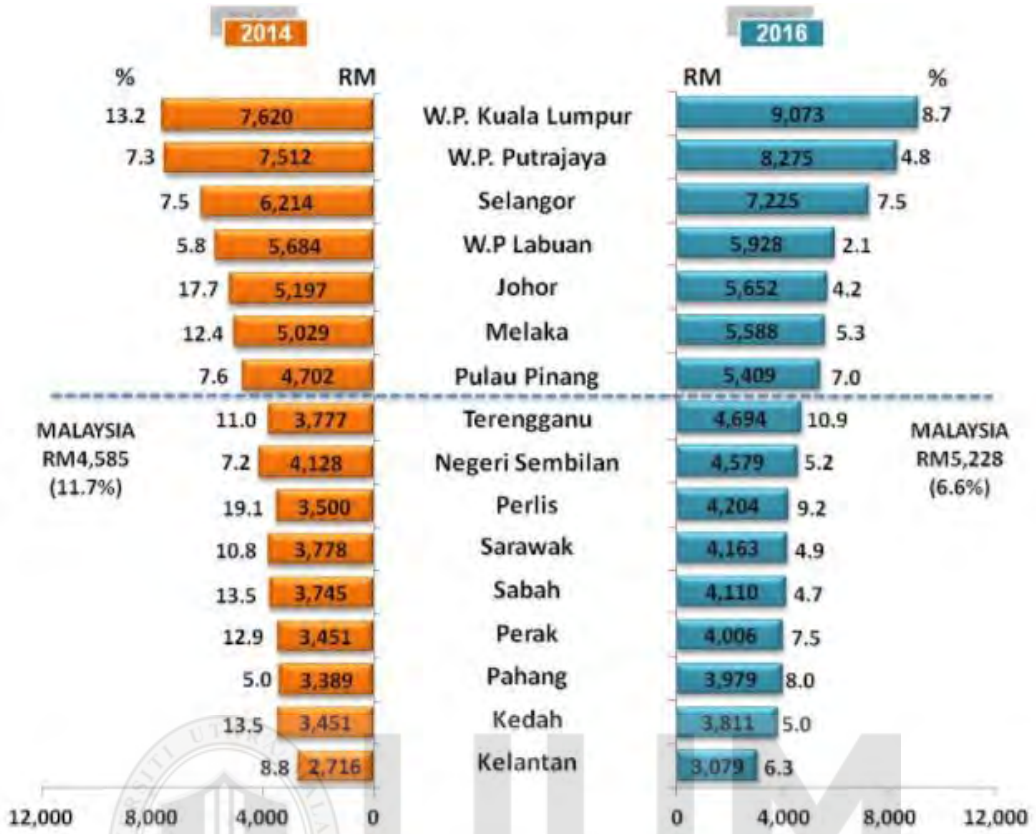


Figure 1.3. Median monthly household income by states, Malaysia, 2014 and 2016

Figure 1.4. Mean monthly household income by states, Malaysia, 2014 and 2016

It can be seen from Figure 1.3 and Figure 1.4 that Kedah state has median household income of RM3,811 and mean household income of RM4,971 in 2016.

Malaysians can be categorized into three income categories which are T20 (i.e. Top 20%), M40 (i.e. Middle 40%), and B40 (i.e. Bottom 40%). DOSM reported that households in the T20 earn at least RM13,148 monthly, M40 earn at least RM6,275 while B40 earn RM3,000.

1.6.1 House price and Affordability

As stated in New Straits Times, according to BNM, if a household can finance a house with less than three times its annual household income, then the house is considered affordable (Hamid, 2016).

Hence, by this definition, we conclude the affordable house price based on Figure 1.4 into Table 1.7 below. For example, for Perlis state, the mean household income is RM4,998. The value (i.e. RM4,998) is then times with 12 months and then times with 3 years which give in result RM179,928. Same method applied to get affordable house price for another states.

Table 1.7

Affordable House price by States in Malaysia

State	Affordable House price (RM)
Perlis	179,928
Johor	249,408
Kedah	124,236
Sabah	192,744
W.P. Kuala Lumpur	420,912
Perak	182,340
Melaka	246,564
Terengganu	207,936
Sarawak	193,932
Kelantan	151,704
Pulau Pinang	243,756
Selangor	340,668
Putrajaya	415,980
Negeri Sembilan	211,932
W.P. Labuan	294,264
Pahang	180,432

1.7 Factors Influencing House price

The house buyer has preferences for owning a house. A study by Tan (2012) reported that house buyers do not only prefer to buy affordable house but they also prefer houses in safe and decent environment.

Middle cost house (assumed affordable) with a price cap of RM220,000 (i.e., My First Home's price cap) can only be built on the outskirt or outside of the city due to fly rocketing land price (Ministry of Finance's Valuation and Property Service Department, 2011). However, the house will be far from facilities (e.g., school, workplace, hypermarket) which is less preferred by first time home buyers (Tan, 2012). As pointed out by Yam and Ismail (2008), buyer preference is more or less the same as Abraham Maslow's motivation theory (i.e., from only physical shelter to a quality living environment). Most studies noticed that house buyer preference is closely related to workplace (Clark, Deurloo, & Dieleman, 2006; Crane, 1996; Kauko, 2007; Levine, 1998; Teck-hong, 2011; Wang & Li, 2006). Besides, many argued that home ownership is also influenced by decent surroundings, like fresh air (i.e., far from factories) (Kiel & Zabel, 2008; Yusuf & Resosudarmo, 2009) and with plenty of trees and water (Lo & Jim, 2010; Luttik, 2000), and some studies posited that safe neighborhood environment (Hafazah, 2008; Teck-hong, 2011) is also a powerful influence.

Although there are many aspects to consider in decision process of buying a house, the price of house is still the main factor due to income limitation and other commitments. Abdul Hamid, Pieng, and Gan (2012) identified that type of property is the most important variable for house buyers' decision-making process, followed by variable of

design of house, price, and location. However, these variables are only applicable for middle-high income earners as studied by Abdul Hamid et al. (2012). The preference might vary due to different samples or respondents.

Table 1.8 summarizes the preferences of the house buyer with respect to the literature. Price, location, distance from workplace, secure environment, and accessibility to amenities are importance factors that contribute to the decision of buying a house.

Table 1.8

House Buyer Preferences

Preferences	**Researcher**
Price	Abdul Hamid et al. (2012)
Location	Abdul Gapor, Malik, & Husin (2011), Abdul Hamid et al. (2012)
Secure environment	Tan (2012)
Accessibility	Kiel & Zabel (2008), Tan (2012), Yusuf & Resosudarmo (2009).
Distance from workplace	Clark et al. (2006), Crane (1996), Kauko (2007), Levine (1998) Teck-hong (2011), Wang & Li (2006)

1.7.1 Interaction between the Government and the Private Developer

A private developer has a clear objective that is to maximize profit (Wilkinson & Reed, 2008). In certain situation, the private developer acts as initiator which they have to go

through all procedure of land acquisition which will cost a lot. In other way, if they acquire land for development from others (i.e. government), they do not need to hire planning consultant, for instance, in the design and costing phase. Thus, from the situation, we can say that the private developer may be able to reduce the problems (i.e., facing local authority's procedure) by collaborating with the public sector.

Profits for medium cost standard housing is 15% higher than low cost standard housing, according to a case study in Malaysia by Bertaud and Malpezzi (2001). Due to this, private developer prefers to build medium or high cost housing.

The project is made in collaboration between public sector and private developer to ease overall process. This is because land matter falls under state government's authority, while the private sector is the expert in building the houses.

However, collaboration between public and private sector is not likely to be successful in many countries, including Malaysia (UN-HABITAT, 2011; Suhaiza, 2013). The private developer is likely to build middle cost housing units or high cost housing units first rather than low cost housing unit, because middle cost housing unit and high cost housing unit give better profit, and due to high price of land price, it is better to build high cost house rather than low cost house. In contrary, it is the government's obligation to fulfil resident's requirement of owning a house. Different objectives between these two parties might result in unsuccessful collaboration.

1.7.2 Interaction between the Government and the House buyer

The house buyers obviously could only depend on the government if they want to minimize their cost of buying a house. This is due to the subsidy that the government provide for the housing programs.

Tan (2012) found that, lately, house buyers prefer eco-friendly housing and start to appreciate "go-green". This implies that house buyers have other reasons aside from price when they decide to buy a house. Consequently, many public housing developments have turned into a slum because they do not follow buyers' preference. The government wants to fulfil residents' need rather than consider their preferences. This might be because of lack of expertise in the public sector, and also lack of financial source.

1.7.3 Interaction between the Private Developer and the House buyer

Private developers are profit maximizers. Numerous private developers tend to build high price housings which could not be afforded by low and middle income earners. This is due to better profit from selling those properties. However, there are many factors involved in determining a house's price. For example, land price and location. Generally, the closer the land to the facilities (e.g. school, city center, hospital, hypermarket), the higher the price. Hence, private developers need to consider these factors in setting the price.

House buyers have their own preferences in buying a house. Their preferences can be fulfilled by the house specifications offered by the private developers except for price. Middle-income earners with gross income between RM2,500 to RM10,000 monthly are forced to buy affordable houses only. Based on BNM, a house buyer could only afford a house that is priced three times their annual gross income. This implies that middle-income earners could only afford a house within the price of RM90,000 to RM360,000.

1.8 Problem Statement

In housing development projects involve three parties (i.e., the government, the developers, and the buyers) can be seen as a social interaction, which, the intention is every party could benefit from the collaboration (i.e., if they are collaborating) and ensure that the collaboration succeeds. For instance, the government could save administrative cost, acquire expertise and overcome cost limitation in construction.

Collaboration between the government and the private sector might result to affordability of buyers to buy their own house. However, concentrating to build low-cost housing units will lessen the private sector's profit. Consequently, the private sector might delay the construction of low cost housing units and concentrates to the high cost housing unit.

In housing development, conflict happens between parties that are known as decision makers (i.e. for this study, the parties are the government, the private developers, and the house buyers) as each of them has different preferences and interests. However,

they need to collaborate in order to ensure the success of the developed project. How they will interact so that the development project will be successful is unknown yet and need detailed investigation.

As far as we know, there is no model developed that can represent such interaction. Most of the time, an economic indicator is used when determining the house price. The idea here is to analyze the strategies and behaviors of the parties involved when confronted with different objectives through the simulation framework. A new house price range might be suggested from the simulation and can be compared to the existing house price range.

1.9 Research questions

This research aims to answer these following questions:

1. What are the buyer's preferences in buying a house and the private developer's preferences and the government's preferences in building a house?

2. How to model each party's housing development preferences?

3. How is each party in a housing development project connected to each other?

4. How to validate and verify the developed model?

5. What are the affordable house prices in Kedah state?

1.10 Objectives of study

The aim of this study is to develop an interaction model between three parties involved in housing development to determine mutual house price by specifically embarking on these specific objectives;

1. To identify the preferences of the house buyers in buying a house and the preferences of the private developer and the government in building a house.

2. To develop goal programming (GP) model of the problem.

3. To develop an interaction simulation model of the three related parties.

4. To verify and validate the interactive simulation model.

5. To measure affordability of house buyers in owning a house using Fuzzy Logic.

1.11 Scope of study

This study focused on Malaysia scenario. The conflicting interaction between house buyers, private developers and the government is covered in this study. The outcome is the better understanding of preferences of each party involved.

In this study, the researcher focus on the middle income buyers, which is households with income between RM2,500 and RM10,000 (PR1MA, 2017). The researcher conclude that these middle income earners are the group who are concerned with the high price of houses based on considerable amount of literature which posited about

trend of the middle income earners in buying a house (Abdul Hamid et al., 2012; Abdul Gapor et al., 2011).

Abdul Gapor et al. (2011) found that high income earners tend to buy high cost house. This is due to cost of living that influences the decision of buying a house. Middle income earners need to struggle with high cost of living and are unable to buy their own house. In contrast, high income earners face no problem in buying a house. A study found that majority of high income earners buy a house within five years after employment, rather than lower income earners which buy a house after 6 year of employment. Abdul Hamid et al. (2012) stated that they choose middle-high income respondents in their study due to behavior of those group that have more aspects to consider rather than needs aspect solely.

This is agreed by REHDA president, deputy president Datuk FD Iskandar in 2012, stating that high income earners have no problem in buying a house, same with low income earner, which they entitle for low cost house (iProperty.com, 2014).

This study only covers the case for northern Malaysia only. The researcher made general observation about the government's preferences. This is due to the believe that the government is non-profitable body that aims to fulfill the residents' needs.

1.12 Significance of study

This research will contribute to the body of knowledge, especially in behavioral economic but in specific, the application of simulation (which is the use of simulation)

is able to study the behavior of related parties. The use of GP to model housing problem in Malaysia is a new method implemented for this kind of study.

Basically, GP is a mathematical concept which formulates the best strategy of parties (i.e., decision makers) to face complex situation. In this study, the parties are the house buyers, the private developers, and the government. GP is a technique that use concept of satisficing which is suitable for situations that confront with multiple objectives or goals (Ignizio & Romero, 2003). Thus, this technique is suitable to be used to formulate housing problem in Malaysia.

Other than that, this study is also significant because it can avoid Malaysians from losing the opportunity to own an affordable house. This study will suggest a new price alternative to overcome the problem. Thus, the researcher believed that this research needs to view in depth of the issues that affect the buyers.

Indirectly, this research proposes to provide more information to private developers in determining house price, to be more suitable with residents' affordability.

1.13 Organization of study

This research is divided into five chapters. Chapter one discusses on the background of this study, problem statement, objectives of the study, research questions and significance of the study.

Chapters two contains a comprehensive review of the literature. The chapter provides a foundation for this research. It starts with the general issues related to housing (e.g., factor of high house price), importance of homeownership from many angles, and several approaches that have been used to suggest the solution of the issue. Due to the scope of this study, which is limited to Malaysia's context, the country's housing planning system will also be reviewed in this chapter.

Chapter three focuses on the methodology and the process of developing mathematical model. Those process is to achieve all objectives of this study.

Chapter four contains data analysis of the mathematical model. The output from the mathematical model is analyzed using several analyses for example descriptive analysis.

Lastly, chapter five elaborates about the results from data analysis done and related discussions. The limitations and recommendations for future studies also discussed in this chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discuss on previous studies and issues regarding housing development in general and comparison of techniques used in the analysis of land and property.

2.2 Economic indicator on house price

In attempt to investigate the factors affecting house price, Keng (2011) found that real per capita income, total loan to housing, KLSE Consumer Index, and unemployment rate have significant relation to house price index.

Another study by using hedonic method to develop house price index model, the study highlighted the importance of location attribute, size and area of building, number of transaction done, and age of building (Afiqah, Lizam, & Jalil, 2012). Hedonic method is a regression technique employed to estimate prices of qualities or models that are not available on the market. Using this technique, those characteristics (e.g. location attribute, size and area of the building, number of transaction done, and age of building) show an impact on house price index.

Other than that, Ong (2013) determined that Growth Domestic Product (GDP) has significant relationship with house price. Surprisingly, this finding is contrary with

Pillaiyan (2015), which found that GDP does not have significant relationship with house price. Meanwhile, other factors that is inflation rate and income increment rate were found to be not significant with house price index. The different findings between these two research might be due to bubbles in housing market that happen currently.

Meanwhile, Osmadi, Kamal, Hassan and Fattah (2015) discussed that the population, housing demand and supply, location, neighborhood, physical characteristics, accessibility, developer, cost of material and land, and income determined the house price and affordability in buying a house.

Table 2.1 summarizes the variables used from previous study to discover the fundamentals behind house price.

Table 2.1

Fundamental Behinds House Price

Research Factors	Keng (2011)	Afiqah et al. (2012)	T. Ong & Chang (2013)	Osmadi et al. (2015)
Per Capita Income	/			
Unemployment Rate	/			
Durable goods inflation rate	/			
Total loans to housing	/			
Average lending rate	/			
KLSE Composite index	/			
Growth Domestic Product (GDP)			/	
Population				/
Location		/		/
Demand and supply				/
Physical Characteristic				/
accessibility				/
developer				/
Cost of material				/
Neighborhood				/
Size		/		
Number of transaction done		/		
Age of building		/		

2.3 Methods Used for Solving Housing and Land Development Study

There are several methodologies can be used to solve housing and land development, such as empirical study using quantitative method, usually descriptive statistics. Besides, simulation technique is a method that can model the whole situation in housing development, so that the interaction between the parties involved can be viewed from the bigger picture. Other than that, qualitative method can also suggest the improvement in housing development, for instance, either from a researcher's point of view or analysis of case study. The methods are reviewed under this sub-section.

2.3.1 Simulation game theory

Game theory is a game that mimics the decision actors' behavior. It is an interdependency decision made by actors involved which means one's decision will impact the other's decision as well (Samsura, van der Krabben, & van Deemen, 2010).

Ma and Mu (2008) presented a simulation model to study about the relationship between land supply and house price based on the theory of disequilibrium and non-linear cobweb. By considering two parameters that are land and housing, and expanding them to land demand, current land price, housing demand, and current house price, the study revealed that Nash Equilibrium exists when both parameters are small. Nash Equilibrium is a concept of an optimal solution in a game theory after considering all possible choice that the other player could make, therefore, the players cannot deviate from the optimal solution (Investopedia, 2018).

Another study established a model to analyze the factors that contribute to high house price in Hong Kong (Yue, Leung, & Fung, 2012). Due to the government of Hong Kong practices land auction to developers in order to increase land value, the study developed two party games between the government and the developer, where the government's strategy is to set a high price of lands or low price of lands, meanwhile the developer also have two strategies that is set high price of houses or low price of houses. From the model, Nash Equilibrium exists when two of them choose to play high-high (i.e., the government sets high price of land and the private developer sets high price of house). This is due to the expectation of the government to avoid

developers from making extra profit by selling high price house although the price of land is low. However, finding shows that after windfall tax was introduced, the developers are more likely to sell house with reasonable price in order to neglect profit losses and also avoid shouldering too many taxes.

These studies (Ma & Mu, 2008; Yue et al., 2012) show the capability of game theory to model a problem and suggest the solution when the researcher plays with the built model. For instance, Yue et al. (2012) added the windfall tax in the model, thus resulting to a simulation process. Thus, the windfall tax can be a suggestion to control the house price in Hong Kong. It is important to note that, the windfall tax is a tax levied by the government on certain industries that experience above-average profit (Investopedia, 2018).

2.3.2 Descriptive statistics

Another approach is using quantitative methodology by listing down all factors that contribute to the increase in house price (Hamzah, Khoiry, Ali, Zaini, & Arshad, 2011; Abdul-Rahman, Wang, Wood, & Low, 2012; Liew & Haron, 2013). Descriptive statistics is an explanation of the data set of a sample to learn about certain population.

Concerned about high house price, Hamzah et al. (2011) found that the factors that influence the increment of house price can be divided into two, which are external factors and internal factors. The external factors are the factors that cannot be controlled by decision makers such as GDP, inflation rate and unemployment rate while the internal factors are the factors that can be controlled by decision makers, i.e. land owner,

land developer and etc. However, external factors monopoly the influence on house price more than internal factors.

Other than that, Abdul-Rahman et al. (2012) added that population growth can be related to general labor, since, in Malaysia, the residents is not attracted to work in the construction sector. This phenomenon leads to the use of foreign workers, thus, increasing the number of population. Furthermore, they require less salary compared to local workers. As a consequence, construction sector will need to hire foreign workers.

Besides, Malaysia's policy that encourages foreign investment in housing sector also contributes to one of the factors (Liew & Haron, 2013). This situation is a catalyst for foreigners to immigrate to Malaysia, especially in developing city such as Klang

Other than that, Liew and Haron (2013) found that fluctuations in the housing market, population growth over housing, and transfer fees and taxation of housing also contribute to high house price. By using statistical analysis, finding suggested the uncontrollable factors influence the increment of the house price the most. These results is in agreement with another study by Ong (2013).

2.3.3 System dynamic approach

System dynamic approach is a well-known technique that provides wide view of a problem. It is a simulation technique used to understand behavior over time of a complex and dynamic system (Sterman, 2000). Behavior over time represents the variations and trends in the variable of interest. In the field of system dynamic, the

problem under study is analyzed dynamically. The issue of real estate have also been modeled in several studies using system dynamic approaches (Chen, 2005; Barlas, Özba, Özgün, Ozbas, & Ozgun, 2007; Ho, Wang, & Liu, 2012).

A study constructed a model to foresee the factors of rapid growth of house price in Shanghai (Chen, 2005). The model emphasizes many speculative behaviors such as consumer, suppliers and also foreign investors. From the model, apparently foreign investors play an important role which they buy properties and then try hard to increase the price. However, the model was lack of government provision of land, and there is a need to further extend the model.

Barlas et al. (2007) modeled the dynamic price of real estate in Istanbul. The model provides an explanation of the oscillation price which is the delays in starting the construction as well as the delays in completing the project when the demand rises causing the price to rise as well. This model explains that the oscillation happened because after the projects are completed, there is surplus demand, which in turn cause the price to decrease.

Based on scenario analysis, logical suggestions can be made. For example, Ho et al. (2012) developed a model to monitor empty houses in Taiwan using an integrated technique of system dynamic and genetic artificial neural network. They explained that artificial neural network is a forecasting tool which fits in a non-linear situation. The non-linear situation, in other words can be described as dynamic, thus the tool fits the housing market situation. In the study, factor analysis was also done to discover the

variables which give the most effects to the system. From the study, the researchers found that a system to view housing market should be done to enable policy makers to view the overall problem and make analysis based on that. This is because compared to advanced countries, the rental housing market in Taiwan gives a low contribution to the country. This is based on system dynamic characteristic which can overview a dynamic problem as a whole over time. Since then, system dynamic is also used as a forecasting tool fix with dynamic situation like the housing market.

2.3.4 Regression analysis

Regression analysis is a statistical tool to investigate the causal effect between variables (Sykes, 1993). For instance, price is influenced by demand. In housing problem, several studies have use this technique (Page, 2008; Ong, 2013).

Page (2008) included microeconomic factors in their model. The factors are land, materials, labor costs, profits and other impact costs. The study that is held in New Zealand used regression to model house price in that region. The study posited that the major factor contributing to price of house is land, about 40% of the whole cost, claiming that location of land impacts the price. For example, a land located in suburb area and near to tourist area is more expensive than a land in rural area. The second factor that contributed highly to house price is material cost, which contributes about 30%. Type of material cost used (e.g. imported material) is also a factor. Besides, finding shows that labor is a factor of high house price as well.

In another study, model of house prices developed to investigate the relationship between macroeconomic factors and house price in Malaysia (Ong, 2013). The study is robust and significant because it employed empirical data from Valuation and Property Services Department of the Ministry of Finance Malaysia 2001-2010. The macroeconomic variables that are included in the model are GDP, population, inflation rate, cost of construction, interest rate and Real Property Gains Tax (RPGT).

However, using regression analysis, the researcher found that there are only three variables correlated with house price that are GDP, population and RPGT. Conversely, house buyers are not affected by GDP (Ma, 2010), instead house demand is highly related to the growth of GDP. In the model of Ong (2013), there are several variables not included such as investment, economy and personal income.

2.3.5 Goal Programming

GP is a technique that uses concept of satisficing, suitable for situation that confronts with multiple objectives or goals (Ignizio & Romero, 2003).

Tan, Shen, Lu, and Shen (2011) modeled competitiveness of private developers with the purpose to assist them in providing an optimal decision making in the process of bidding for contract. Tan et al. (2011) considered five goals that are clearly important from the perspective of client which are construction cost, construction time, quality standard, safety performance, and environment performance. Therefore, the usage of GP helps house buyer to minimize the deviation from the goals, subject to their constraints. This action could maximize their chances of winning the bid.

To the best of our knowledge, GP has not yet been explored as a way of determining house price that is agreed by many parties in Malaysia. Housing development in Malaysia involved many parties that generally comes with different objectives and preferences such as costing and percentage of profit from selling a house.

2.3.6 Fuzzy Logic

Fuzzy logic (FL) can be said as process of numeration of the linguistic. FL has been widely used in numerous area, for instance in predicting housing selling price (Kuşan, Aytekin, & Özdemir, 2010), model academic performance of students (Yadav & Singh, 2011), and real estate investment valuation (Giudice, Paola, & Cantisani, 2017).

Kuşan et al. (2010) used triangular membership function in their study. The finding showed that the FL model can be used in predicting housing selling price in Turkey. Yadav and Singh (2011) seek to answer if there is any difference of using FL application in measuring student's performance compared to classical methodology. The study highlighted the usefullness of FL and its reliability and flexibility. The triangular membership function was used in the study due to its simplicity.

Besides, FL is also used in real estate study (Giudice et al., 2017). In their case study, they concluded that application of FL could reduce uncertainty of operators and investors in real estate sector. This is due to the uncertainty that changed to limited extend.

2.3.7 Summary of techniques have been used

Several studies (Abdul-Rahman et al., 2012; Hamzah et al., 2011; Liew & Haron, 2013) can only suggest the factors, but not suggestion of solutions, compared to what game theory can offer in Ma and Mu (2008) and Yue et al. (2012) as well as system dynamic approaches (Chen, 2005; Barlas et al., 2007; Ho et al., 2012). This is due to technique used in the studies (i.e. Hamzah et al., 2011; Abdul-Rahman et al., 2012; Liew & Haron, 2013) that is limited to factor analysis.

However, to compare the study of Ma and Mu (2008) and Yue et al. (2012) with the study of Hamzah et al. (2011), Abdul-Rahman et al. (2012), and Liew and Haron (2013) the studies have their own advantages, as the descriptive statistic employs real data, that collected from a population, while, in the game theory, the data are more to assumption to represent real life situations. The same goes to system dynamic. But, in order to model a decision making process, game theory might be more realistic due to its usefulness in analyzing decision maker's decision when facing certain situations.

System dynamic represents the situation as a whole, thus, the researcher can analyze the overall situation, that is, which entity gives the most impact to the system, vice versa. From that analysis, the researcher can give suggestion in order to reduce the problem. However, system dynamic is limited to modelling a system, but not to model the strategies of entities. While, game theory emphasizes strategies of each entity so that each entity in a system knows how to control the situation, whether they choose to have win-win situation or win-lose situation.

Aside from that, regression analysis provides a cause-effect between variables, where the technique can suggest the most influential variable and instead. However, the method does not fit the problem posed by the researcher, as the researcher's objective is to construct an interaction model between the decision makers. GP provides the decision maker a satisficing decision when confronted with multiples objectives. This should be fix with problems in any area, where, generally people will always have conflicting objectives.

On the other hand, from the literature, scarce land is suggested as a tough factor that contributes to high house price. Hence, very detail strategies are needed by developers to maximize the use of this resource. Practically, to avoid the problem, social interaction with land and property development is investigated. Different researchers have measured the social interaction in different ways (Glumac, Blokhuis, Han, & Smeets, Schaefer, 2010; Samsura et al., 2010; Yue et al., 2012) and each has its advantages and drawbacks. The summary of techniques has been compressed in Table 2.2.

Table 2.2

Summary of Techniques Used in Housing Study

Method	Explanation	Place of study	Authors
Simulation Game Theory (GT)	Studied the relationship between land supply & house price using non-cooperative GT	Hong Kong	Ma & Mu, (2008)
	Studied the factors contribute to high house prices using non-cooperative GT	Hong Kong	Yue et al., (2012)

Descriptive statistic	Studied the factors contribute to high house prices	Malaysia	Hamzah et al., (2011);Abdul-Rahman et al., (2012); Liew & Haron (2013)
System dynamic (SD)	Studied the oscillation of house prices	Istanbul	Barlas et al., (2007)
	Developed a model to monitor the empty house in Taiwan	Taiwan	Ho et al., (2012)
	Studied the behaviour of house prices speculator	Shanghai	Chen (2005)
Regression analysis	Studied the relationship between factors of macroeconomics and house prices	Malaysia	Ong (2013)
	Relationship between factors of microeconomics and house prices	New Zealand	Page (2008)
GP	Modelled the competitiveness of private developer	Hong Kong	Tan et al., (2011)
FL	Predicting House Selling Price in Turkey	Turkey	Kusan et al., (2010)
	Real estate investment valuation	Italy	Giudice et al. (2017)

2.4 Concluding Remarks

This chapter covers previous studies that focus on housing. Through this chapter, it is found that there are fundamental factors behind house price such as economic factors,

size, location, and design. However, there is a limited study that focuses on social factors such as preferences of house buyers.

Other than that, this chapter also reviewed on techniques that have been used in housing study such as GT, FL, GP, regression, and system dynamic.

GP is a methodology for modelling a problem with conflicting goals and objectives (Ignizio & Romero, 2003). This method has been widely applied in several fields such as transportation problem (Aruna, 1994; Verma, Biswal, & Biswas, 1997), equipment purchasing problem (Y. Chen, Chen, & Huang, 2009), solid waste management (Chang & Wang, 1996; Chang & Wang, 1997) and real estate problem (Teck Hong Tan, 2009).

GP is different from other optimization techniques such as heuristic technique or linear objective technique because GP's objective is not to find the optimal solution. Instead, GP uses the concept of satisficing and measures the degree of non-achievement of the problem goal and making its main purpose is to minimize the deviation of the goal.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the process of data collection, process to attain the objectives of this study, employment of GP in mathematical model development, use of simulation in solving house price problem, and employment of FL in defining house buyer affordability.

3.2 Research process

Research process explains in detail on how this study achieves each objective. The process is divided into several phases. The overall research process is illustrated in Figure 3.1.

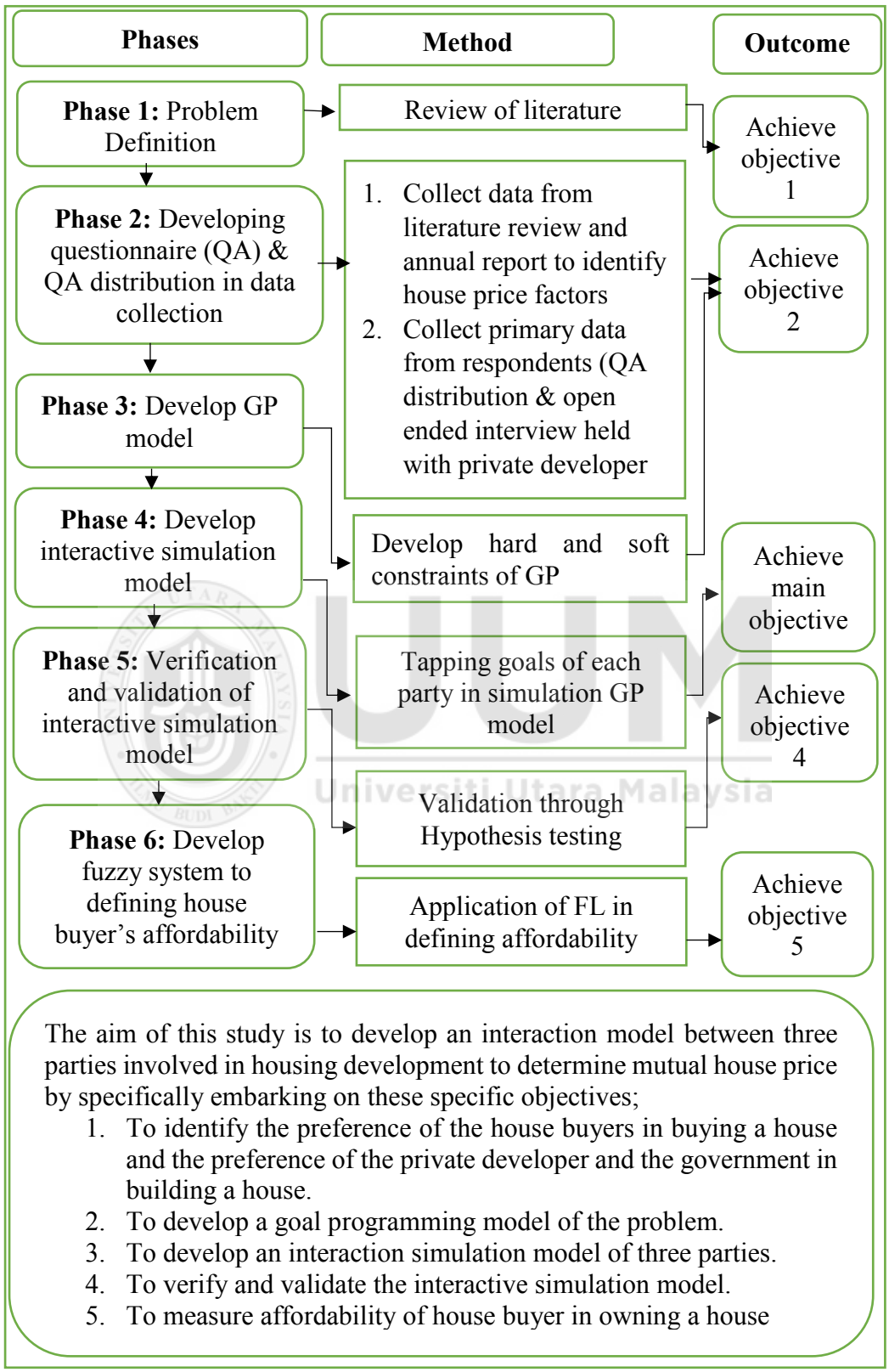


Figure 3.1. Structure of research activities

3.3 Data Collection

This research collected two types of data which are primary and secondary data. Purpose of data collection is to find the factors related to this study such as cost and preferences of the parties involved.

Primary data was obtained from semi-structured interview conducted with private developers and also survey questionnaire with house buyers. House buyers was randomly selected throughout each district of Kedah. This research is only interested to study on middle income earners. The private developers are also chosen from Kedah due to the scope of this study. Since the focus is on PPP projects, thus private developers were chosen based on their experience in PPP project.

Secondary data source is from NAPIC and DOSM. Factors related to the parties' preferences were explored through literature review analysis and used for the model development. Besides, general observation of the government were made through extensive literature review. We stick with the general information which is the government is non-profit party that only encourages what is the best for the residents (i.e. house buyers).

Beforehand, letter of permission to undergo survey with private developers and house buyers was approved by Awang Had Salleh Graduate School, Universiti Utara Malaysia. The survey was proceed once approved.

3.3.1 Primary Data

There are two ways of gaining primary data in this study which are through semi-structured interview and survey questionnaire. These two methods have their own richness in acquiring data and were chosen due on their suitability. These methods are explained in the following subsection.

a) Semi structured interview

Semi-structured interview enables the researcher to gain information through a combination of specific and open ended questions (Hove & Anda, 2005; Yin, 2003) since semi-structured interview offers two-way communication between interviewer and interviewee, it allows new ideas to be brought up during the interview. House price problem was discussed during the interview session to validate the variables that the researcher considers in the model construction.

The semi-structured interview done with private developers is to ascertain whether the information that the researcher acquired from literature is usable. Objectively, the process is to validate the robustness of variables used in model building.

Semi-structured interview was held with two private developers: 'Developer A' and 'Developer B'. The questions that the researcher asked were:

1) Can you briefly tell me about your company?
2) What is the new housing project of your company?
3) Which districts in Kedah have your company built housing projects?

4) What type of housing did your company built?
5) How about the current market price of housing?
6) How does your company determine the house price? What factors do you consider?
7) Based on question 6, with such house price, is there any objective the company must obey, such as profit from sale must be approximately 30% of the house price or for instance, land cost must not exceed RM7,000?

This survey questions were carefully built based on the first objective which concerns about the preference of private developers in building a house. Two private developers have been interviewed for this purpose.

b) Survey questionnaire

In this study, online survey questionnaire is the most suitable way to collect primary data from house buyers. The questionnaire for this study was generated using Google Doc. The underlying reason of using this method is due to increase of internet usage nowadays, meaning that this method could easily reach numerous respondents of this study.

Online survey is an easy and cost efficient way and also relatively quick in collecting data. The questionnaire was distributed using email and social media such as Twitter and Facebook.

Besides, hardcopy of the questionnaire was also given to related respondents. This technique is efficient to collect data from a group of people within short period of time. About 100 sets of questionnaires have been distributed to Universiti Utara Malaysia's

staff. This questionnaire was developed to ascertain the preferences of house buyers as stated in objective one of this study, other than information from literature review. There are 193 respondents (house buyers) acquired for study. The questionnaire set is given in Appendix A.

3.3.2 Secondary data

The variables required for model development are acquired from literature review. Variables that influence house price are compiled in the Table 3.1 below. The variables include the preferences of house buyers as well as private developers:

Table 3.1

List of Variables

Constraint	Author(s)
Land price	Ma & Mu, (2008), Page (2008), Ministry of Finance's Valuation and Property Service Department (2011), Yue et al. (2012)
Construction cost	Page (2008)
Location from retailing outlet	Abdul Gapor et al. (2011), Abdul Hamid et al. (2012)
Distance from workplace	Yam & Ismail (2008), Abdul Gapor et al. (2011), Tan (2012)
Distance from school	Tan (2012)

From Table 3.1, location and land price can be seen as the most discussed factor for house price. Generally, the more strategic the location of a house, the higher is the price. The location of a house might satisfy house buyer, for instance near to workplace and retailing outlets. How much will the house buyer pay for the house with the specifications that they want will be computed in the mathematical model.

Land price and construction cost are the main considerations in deciding house price. Private developers must not incur loss from setting house price that are too low (price did not cover land and construction costs). The private developers' preferences were attained through semi-structural interview with them.

NAPIC, DOSM, Penang Property Talk, and Jabatan Perumahan Negara also provided secondary data for this study. Recent price of house, transaction number, and type of houses are collected from NAPIC website; https://napic.jpph.gov.my/, meanwhile, income of Kedah residents was acquired from DOSM; https://www.dosm.gov.my/v1/. Types of house and price ranges were acquired from Jabatan Perumahan Negara; www.ehome.kpkt.gov.my/ and Penang Property Talk; www.penangpropertytalk.com/.

3.4 Developing GP model

In GP, there are five main components which are decision makers, decision variable, objective (maximize or minimize a goal), goal, criterion and constraint (hard and soft constraints).

The decision makers refer to persons, stakeholders, or organizations to whom the decision problem belongs (Jones & Tamiz, 2010). The decision makers in this study are the parties involved that are private developers, house buyers, and government.

Decision variable is the factor that the decision makers has control in, which in this study is house price (Jones & Tamiz, 2010). Decision variable can be more than one, which is making the purpose of GP could be classify as search of decision variables set that can satisfy decision makers' goals and constraints.

Criterion is a single measure by which the goodness of any solution to a decision problem can be measured (Jones & Tamiz, 2010). There are numerous criteria from different fields, however the most common criteria are cost, profit, time, distance, and personal preferences of decision makers. A study involving more than one criterion is referred to as multi-criteria decision making (MCDM). This study is considered as MCDM due to many criteria considered while finding the most satisficing value of decision variable.

Objective in this study referred to additional direction (maximize or minimize) that the parties prefer on the criteria scale (Jones & Tamiz, 2010). For instance, minimize house price. Each party could have their own criteria, e.g. house buyers want to minimize house price, private developers want to maximize house price which can yields more profit, while government will try to minimize house price so that house buyers could afford to buy their dream home. In practice, a decision problem with a set of maximized

and minimized activities will be conflicting, as they cannot reach optimal solution simultaneously.

Goal is known as a target level, which the parties desire to achieve on that criterion (Jones & Tamiz, 2010). The parties in this study have desire to achieve house price at exact price, for example a house buyer target to buy a house at RM150,000.

Deviational variable measures the difference between target level and achievable value for a criterion (Jones & Tamiz, 2010). If the value is above the target level, then it is positive deviational variable, otherwise, it is negative deviational variable. The essence of GP is the minimization of unwanted deviational variables, based on the objective of the parties. For house buyers that wanted to obtain house price as low as possible, the objective must be to minimize positive deviational variable. Instead, private developers want the house price to be high, thus their objective should be minimizing negative deviational variable, while the government wants to minimize positive deviational variable.

Constraint is a restriction upon the decision variable that must be satisfied so that the solution could be implementable in practice (Jones & Tamiz, 2010). This is represented by the following equation with F is the feasible region that satisfy all the constraints and sign restrictions.

$$x_n \in F$$

There are two types of constraints which are soft constraints and hard constraints.

A general form of GP is as follows; goals are allowed until I number of goals, $i = 1, \dots, I$. n is defined as decision variables that the parties have control on, with term $x_n = x_1, x_2, \dots, x_n$. Each goal has an achievable value, $f_i(x_n)$, on its underlying criterion. The parties set a numeric target for each goal denoted as g_i. This then leads to the general formulation of ith goal:

$$f_i(x) + d_i^- - d_i^+ = g_i$$

d_i^+, d_i^- are positive deviational and negative deviational of the ith goal. For example, if $g_i = 150{,}000$ and $f_i(x) = 130{,}000$ then $d_i^- = 20{,}000$. This represents underachievement of the target level by 20,000. The two deviational variables are constraints that take non-negative and non-zero value simultaneously.

$$d_i^-, d_i^+ \geq 0$$

The parties have to decide which deviational variables are unwanted. In this study, the parties would minimize any negative and positive deviation from the target level. This kind of goal or target are termed as soft constraints which the parties desire to meet but if the goals cannot be met then it does not imply that the solution is not feasible, but satisfying. The linkage between satisfying and GP is clear as GP model contain a set of goals to be reached, thus meeting as many of these goals as possible is the main objective of GP.

Finally, the unwanted deviational variables need to be minimized, in the form of an achievement function, and thus to ensure the solution to be as close as possible to the set of desired goals.

$$Min\ Z = \sum_{i}^{I} d_i^+ + d_i^-$$

In this study, hard constraints are considered. Hard constrains must be fulfilled first so that the goals could be achieved. In contrary with soft constraints, hard constraints should not have deviational variables as follows;

$$f_i(x) \leq g_i$$

This hence leads to the general algebraic form of GP:

$$Min\ Z = \sum_i^I d_i^+ + d_i^- \tag{3.1}$$

Subject to

$$f_i(x_n) + d_i^- - d_i^+ = g_i \tag{3.2}$$

$$f_i(x_n) \leq g_i \tag{3.3}$$

$$x_n \in F \tag{3.4}$$

$$d_i^-, d_i^+ \geq 0 \tag{3.5}$$

$i = 1, \ldots, I$

$x_n = x_1, x_2, \ldots, x_n$

3.4.1 Formulating Goals and Setting Target Levels

Goals and hard constraints need to be distinguished at this stage. Hard constraints are variables that must be satisfied in order for a solution to be implemented, if it does not fulfilled this criteria, it should be regarded as a goal.

In this study, X denotes mutual house price, g is the desired house price of each party, i, where $i = 1,2,3$ with 1 is for the private developer, 2 is for the house buyer and 3 is for the government. There are six factors involved in house price determination which are land transfer, C_1, land price, C_2, total cost, C_3, construction cost, C_4, location, L, and house type, H.

Further item under location and house type factors are the preferences from house buyer, j. The preferences for factor location and house type are in Table 3.2.

Table 3.2

Preferences j

j	**Preferences**	**Factor**
1	Workplace	Location
2	School	
3	Retailing outlet	
4	Rural	
5	Suburban	
6	Urban	
7	Apartment	House type
8	One-storey terrace	
9	Two-storey terrace	

In this study, each party aimed to achieve their desired house price, g. Private developers, house buyers, and government have their very own target of the level of the house price. If the target cannot be met, it does not imply that they do not agree. The unmet target is still acceptable. d_i^- and d_i^+ are the deviational from the desired house price.

This then leads to following functions;

$$X + d_1^- - d_1^+ = g_1$$

$$X + d_2^- - d_2^+ = g_2$$

$$X + d_3^- - d_3^+ = g_3$$

Generally, the private developer's objective is to reduce costs as low as possible, so that the profit will be higher. They will set high house price so that they could yield more

profit. In this case, private developer will minimize their underachievement or negative deviational variable. This is coherent with the rationality of parties (i.e. to maximize their own profit). This is totally the opposite of what house buyer and government desired; which are lower house price that can be afforded by homebuyers. The government also desired a good reputation for serving residents in housing purchases. Consequently, the goal of each soft constraint for house buyer and government is to minimize the overachievement from the goal (or d_i^+). Thus, the objective function will be in the following algebraic format:

$$Min\ (d_1^- + d_2^+ + d_3^+)$$

However, based on literature review, house price is influenced by several elements factor and preferences. The factors and preferences are commonly fixed and need to be satisfied in which will affect the house price. Hence, the factors and preferences are treated as hard constraints.

The costs include land cost and construction cost shouldered by the private developer. For the private developer, these costs are a requirement, therefore it is treated as the hard constraint. Land cost, C_2 is related to the total cost of a house, C_3 . The percentage of contribution from total cost, P_1 are included in the constraint;

$$C_2 \leq P_1 * C_3$$

Construction cost, C_4 is also correlated with total cost of housing development, C_3, while P_2 is percentage of contribution from construction cost.

$$C_4 \leq P_2 * C_3$$

The preferences refer to the preferences of the parties. Private developer shall have their own preferences in setting their profit. The profit that the private developer made must follow the rule of sale price, X, minus total cost, C_3. However, the private developer still have to pay taxes to the government, P_3, and pay for land transfer cost, C_1. The transfer fee of land is based on land price, C_2.

$$X > X - C_3 - C_1 - (P_3 * X)$$

$$C_1 = P_1 * C_2$$

Besides, house buyer also have preferences in buying their house. From literature review, location and house type are the most common house buyer preferences. Location is divided into two; nearer to workplace, L_1, school, L_2, and retailing outlet, L_3; and type of location of house either it was built in: rural area, L_4, suburban area, L_5, or urban area, L_6. The weightage, w_j is used to differentiate the level of preferences.

$$(X * w_1 * L_1) + (X * w_2 * L_2) + (X * w_3 * L_3) < X$$

Location for area of house built represented by algebraic formulation as follows;

$$(X * w_4 * L_4) + (X * w_5 * L_5) + (X * w_6 * L_6) < X$$

The house could be near to all three preferences (i.e. workplace, school, and retailing outlet) and the house could not be in all locations (i.e. rural area, suburban, and urban). Hence, we develop the conditional as follows;

$$L_j = \begin{cases} 1 \; if \; house \; buyer \; prefer \; to \\ 0 \; otherwise \end{cases}$$

Where $j = 1,2, \ldots ,6$.

Based on data from NAPIC (2015), we found that house price also could differ based on type of house. There are numerous types of house in Malaysia, however, we only consider a few. This is subject to the probability that the government is not planning to build some types of house which is low cost flat, cluster house, town house, and low cost house due to its cost (PR1MA, 2017).

We use weightage, w_j to represent weightage for apartment, H_7, 2 for one-storey terrace, H_8, 3 for two-storey terrace, H_9.

$$X > (w_7 * H_7 * X) + (w_8 * H_8 * X) + (w_9 * H_9 * X)$$

A house buyer will not buy many houses at any one time. Hence;

$$H_j = \begin{cases} 1, if \; house \; buyer \; prefer \; to \\ 0, \quad otherwise \end{cases}$$

Where $j = 7,8,9$.

There is a constraint that must be obeyed by all parties which is economic constraints. The economic constraints have factors that cannot be controlled or known as macroeconomic factors. The house price may be influenced by macroeconomic factors such as unemployment rate, GDP, population and inflation rate. Many studies have tried to prove the relationship between those variables and house price (Afiqah et al., 2012; Keng, 2011; Ong & Chang, 2013; Osmadi et al., 2015). Hence, the researcher decided that those economic variables cannot be left out. These elements fundamental to the house price index have been studied in Malaysia using multiple regression (Keng, 2011).

We adopt Keng (2011) finding (i.e. mathematical model of house price index) in our study due to its nature that includes all elements of macroeconomic that influence house price index.

Keng (2011) includes factors of per capita income, E_1, unemployment rate, E_2, total loan to housing, E_3, and KLSE composite index, E_4. Let I be house price index, and p be coefficient of intercept of the model. Each factor has its own parameter represented as $q_b, b = 1,2,3,4$.

$$I = -8.423 + 0.0127E_1 + 3.579E_2 + 0.00088E_3 + 0.00372E_4$$

However, in order to compare house prices, the index, I need to be transformed into the same unit, which is RM. In the formula price index, I below, P_1 is price in current price, P_o is time based price.

$$I = \frac{P_1}{P_0} \times 100$$

The formula transformed into this form;

$$X = \frac{I}{100} \times P_0$$

Where, price in current price, P_1, substituted by mutual house price, X. By doing so, we can now compare the mutual house price, X with the price from index price after taking consideration of economic factors.

The above consideration leads to general form of GP for this study;

$$Min\ (d_1^- + d_2^+ + d_3^+) \quad (3.6)$$

$$X + d_1^- - d_1^+ = g_1 \quad (3.7)$$

$$X + d_2^- - d_2^+ = g_2 \quad (3.8)$$

$$X + d_3^- - d_3^+ = g_3 \quad (3.9)$$

$$C_2 \leq P_1 * C_3 \quad (3.10)$$

$$C_4 \leq P_2 * C_3 \quad (3.11)$$

$$X > X - C_3 - C_1 - (P_3 * X) \quad (3.12)$$

$$C_1 = P_1 * C_2 \quad (3.13)$$

$$(X * w_1 * L_1) + (X * w_2 * L_2) + (X * w_3 * L_3) < X \quad (3.14)$$

$$(X * w_4 * L_4) + (X * w_5 * L_5) + (X * w_6 * L_6) < X \quad (3.15)$$

$$X > (w_7 * H_7 * X) + (w_8 * H_8 * X) + (w_8 * H_9 * X) \quad (3.16)$$

$$I = -8.423 + 0.0127E_1 + 3.579E_2 + 0.00088E_3 + 0.00372E_4 \quad (3.17)$$

$$X = \frac{I}{100} \times P_0 \quad (3.18)$$

3.4.2 Developing Interaction Model

From the GP model developed, the parties will focus on achieving their goals. Each preference must be taken into consideration so that the house price can be carefully determined. The purpose of this subsection is to explain how each party interact with each other in order to get a price that successfully fulfill all requirements (i.e. preferences and constraints).

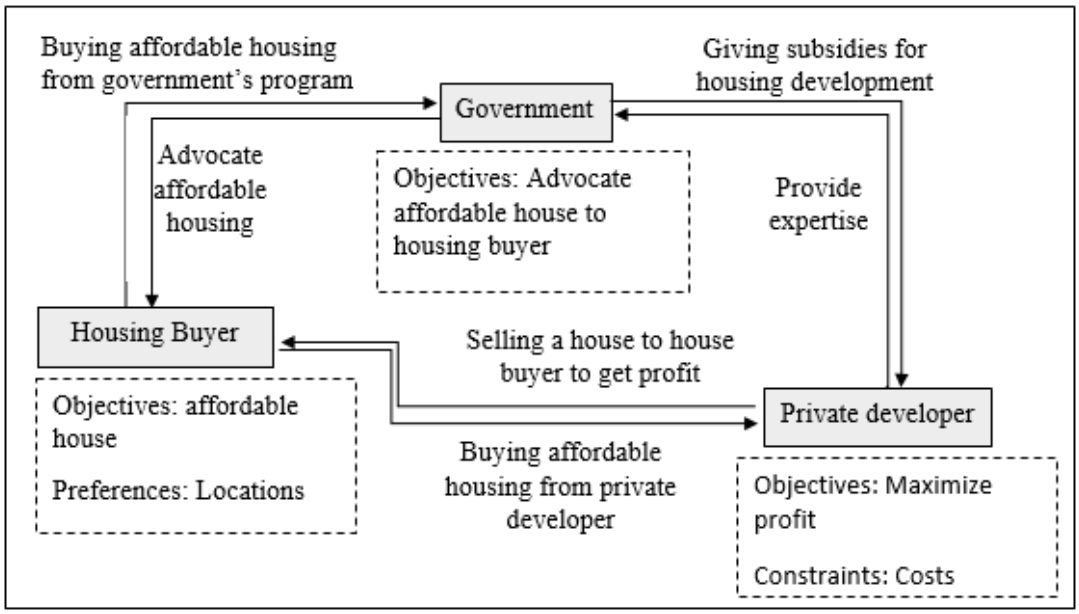


Figure 3.2. Interaction between parties

In Figure 3.2, the parties are interacting with each other by knowing what price is the other parties are targeting, and what preferences and constraints that all of them have. Private developer, house buyer, and government are aware of each party's house price goal. They are also conscious that to achieve the desired target, all constraints need to be satisfied.

Interaction between the parties will eventually suggest a decision variable, which is house price. This price is actually agreed by all parties after all of them consider the preferences and constraints burdened by each of them. The parties will try to lower their expectation at each stage of decision making. The parties simply ask if the solution attained is satisfactory, and if not, how much is the related parties willing to lower their target or goal so that the satisfactory decision (i.e. house price) can be made.

At the stage of lowering the expectation, or target level, each party will add the value of deviational variable, d_i^+ or d_i^- that they are trying to minimize in their objective. This cooperation of interaction will eventually happen so that a satisfactory decision can be made and the decision should be not far from their goals.

However, the parties must also obey the house buyers' affordability constraints and the price could be rejected if it does not comply with the constraints. According to Bank Negara Malaysia, if a household can finance a house with less than three times its annual household income, then the house is considered affordable (Hamid, 2016). Based on this statement, the mutual house price, X that is agreed by the three parties will be accepted by the house buyer if and only if the price is lower than the three times house buyer's annual household income, B. Thus, we compute the statement by below conditional:

$if\ X\ is\ greater\ than\ annual\ salary * 3, then\ reject\ X, otherwise, accept.$

The parties should interact by adding value to their underachievement or overachievement of their target so that more accepted house price could be resulted.

3.4.3 Simulation of GP Interaction Model

The GP model constructed is complex with many variables and interacting components, thus, a simulation is essential. Simulation replicates actual system which refers to house price problem in this study.

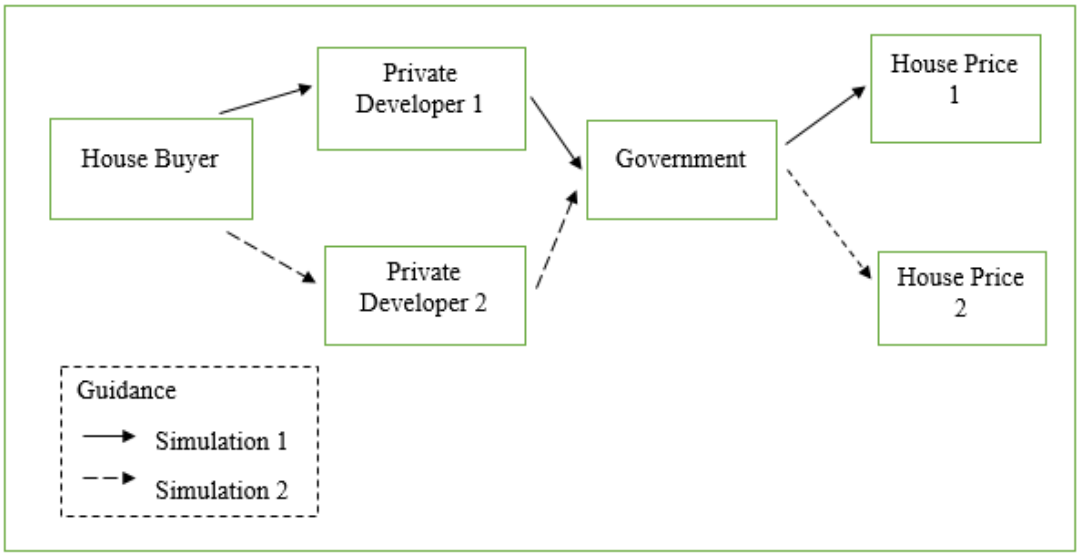


Figure 3.3. *Simulation of GP*

Simulation is iteration of GP interaction model with different goals value from each party. Figure 3.3 illustrates how simulation work in GP model of this study. The house buyer will interact with private developer 1 and the government with respect to preferences and constraints, resulting to house price 1. Again, the same steps were repeated but with private developer 2 thus resulting to house price 2. Note that in this study, there are 193 house buyers, 2 private developers and 1 government involved. This situation will eventually result in 386 house price, where the 193 house buyers will firstly interact with first private developer and government, thus resulting to 193 house prices. The iteration happens again with second private developer and thus resulting to another 193 house prices. Hence, the total of house prices produced are 386. It is important to note that, the target house price from the government is randomly generated by excel function within the range of RM100,000 to RM400,000, all based on PR1MA housing price.

The constructive model was run using Lingo 10.0 programming tool. Lingo 10.0 allows simulation that fix the needs in our study. Relevant data including target house price for each party and salary of house buyers are stored in Microsoft Excel 2010 file which can be automatically linked to Lingo. The Lingo model and the data can be referred to in Appendix C and Appendix D.

3.5 Developing House Price Range from Simulation Result

From 386 house prices produced, only a few was accepted, and the rest will be rejected due to constraints of affordability (refer equations 3.22 and 3.23). The accepted mutual house prices resulting from simulation GP model is then used to find mean, median, mode, and also used for creating price range which are divided into three; low price, medium price, and high price. Formula of the range used is as follows;

$$Range = maximum\ value - minimum\ value$$

To create the three price ranges mentioned before, value of range need to be divided by three.

Affordability of house buyer is then determined by comparing the price range with the sum of 3 years' annual salary of house buyer, by considering definition of affordability provided by BNM. According to BNM, if a household can finance a house with less than three times its annual household income, then the house is considered affordable (Hamid, 2016). Based on this statement, the mutual house price that is agreed by the

three parties will be accepted by the house buyer if and only if the price is lower than three times the house buyer's annual household income.

However, this judgement has fuzzy element that can be clearly defined using FL. Therefore, FL is used to determine the affordability of house buyer. The usage of FL is explained in the following section.

3.6 Model Validation and Verification

Robinson (1997) pointed that verification is building the model right while validation is building the right model. The act of validation is to ensure that the model is sufficiently accurate.

There are various forms of validation such as black box validation, data validation, and white box validation as defined below;

i. Black box validation: defining the accuracy of the overall model using macro check. Its intention is to answer the question if the model can represent the real world.

ii. White box validation: defining the accuracy of the model by part using micro check with the intention to answer the question if the model can represent the real world.

iii. Data validation: defining the accuracy of data for model building and simulation.

For acts of validation and verification, black box validation technique is used. This validation used existing data of residential property transaction by price (2016-2017) from NAPIC. Black box validation is illustrated in Figure 3.6.

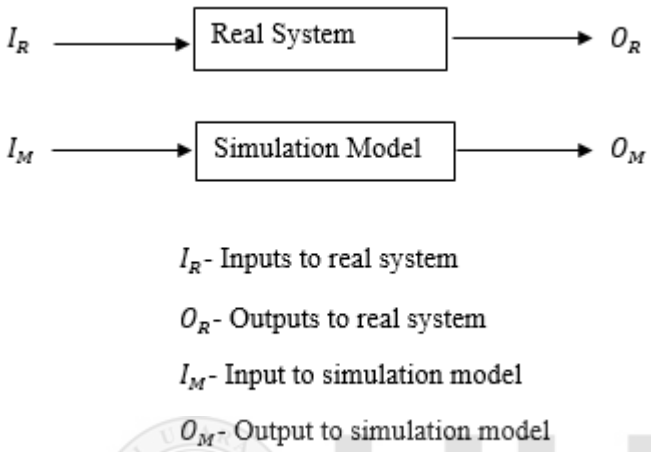


Figure 3.6. Black Box Validation

Next, hypothesis testing (p −value approach) was done. *P*-value approach was done to determine whether it is "likely" or "unlikely" that we would observe the alternative hypothesis. Statistical analysis is used to support subjective finding so that objective decision can be made.

In any hypothesis testing, these steps are applied;

1. Specify null hypothesis, H_0 and alternative hypothesis, H_1.
2. Use sample statistics and assume null hypothesis is true.
3. Use the known distribution of the test statistics, find p −value.

4. Set significant level, α, the probability of making Type I error to be small – 0.01, 0.05, or 0.10. Compare p value to α. If $p > \alpha$, reject H_0 in favor of H_1.

Type I error happens when the researcher rejects null hypothesis when null hypothesis is true. While Type II error is the phenomenon where the researcher fails to reject null hypothesis when null hypothesis should be rejected. Selection of α will determine the level of risk the researcher is willing take in making a decision. For example, if α is 0.01, it indicates the probability of doing Type I error is 0.01. However, by setting α value too low will result less likely detection of difference if one really exists.

Hence, this study choose α = 0.05.

3.7 Defining Affordability Using FL

FL has been widely used in many areas such as in determining housing selling price (Kuşan et al., 2010) and model academic performance of students (Yadav & Singh, 2011). In this study, FL was employed to define affordability of house buyer. Fuzzy is defined as uncertainty. In daily basis, people talk to each other using linguistic term, for instance "the price is too high", or "the water is cold", however those linguistic term is actually being a kind of uncertainty and can be categorized using FL. This method is used in this study to analyse and position the affordability of house buyers.

The term FL was first asserted by Zadeh (1965). FL is rule based ones established from human knowledge using IF-THEN rules. The common type of FL is Mamdani type (Mamdani, 1977). There are three steps involve in FLwhich are Fuzzification, Inference, and Defuzzification.

3.7.1 Fuzzification

Fuzzification is the step where crisp input variables are converted into fuzzy set variables. In this step, the linguistic variables, linguistic terms and linguistic values are identified. House price is linguistic variable because its value is linguistic rather than numeric, which is low price, high price, and low-medium price. Linguistic value is the process of putting low price, high price, and low medium price into numerical extend. FLcan be said as process of numeration of the linguistic. In this study, FL is used to determine the affordability of house buyer. This step is applied to define the limitation of house buyer affordability.

The linguistic variable of two fuzzy inputs in this study are house price and household income. The household income variable is not highlighted using GP technique. This variable is taken into account by using FL application.

House price used in this study are as in Table 3.3.

Table 3.3

House Price

House price	**Range**
Low cost	Below RM42,000
Low-medium cost	RM42,001-RM70,000
Medium cost	RM70,001-RM100,000
Affordable 1	RM100,001-RM150,000
Affordable 2	RM150,001-RM200,000
Affordable 3	RM200,001-RM300,000
Affordable 4	RM300,001-RM400,000
Affordable 5	Above RM400,001

From Table 3.3, the range of house price was taken and combined from Jabatan Perumahan Negara (2016) and Penang Property Talk (2017). Jabatan Perumahan Negara (2016) categorized house price of RM100,001 and above as high cost (see Table 2.5), meanwhile, Penang State Government categorized house price in more detail, which categorizes house prices as affordable type C, affordable type D, affordable type E, and affordable type F for house prices above RM100,000 (see Table 2.3) (Penang Property Talk, 2017). This study added Affordable 5 (i.e. range: RM400,001 and above) to increase the variety.

Household income preference follows PR1MA meaning that middle income earners monthly salary is between RM2,500 to RM10,000. In defining affordability, household income was divided into six categories in the stated range. The income classes are presented as in Table 3.4 follows:

Table 3.4

Income Class

Income class	**Range**
Income Class 1	RM2,500-RM3,000
Income Class 2	RM3,001-RM3,500
Income Class 3	RM3,500-RM4,000
Income Class 4	RM4,001-RM5,000
Income Class 5	RM5,001-RM5,500
Income Class 6	Above RM5,501

The income classes are deliberately divided into six categories based on Report of Household Income and Basic Amenities Survey 2016 which highlighted the median income and mean income of Kedah is RM3,811 and RM4,971 respectively (Department of Statistics Malaysia, 2015). Thus, the ranges have covered the income of Kedah's residents as the respondents of this study. DOSM classified Malaysians into three categories; B40, M40, and T20 (Department of Statistics Malaysia, 2015). However, the range are too big and are not focused on middle income earner as stated in PR1MA

(i.e. RM2,500-RM10,000). This explains the reasons of household income fraction in Table 3.4.

3.7.2 Inference

Secondly, the rule-based part. Mamdani fuzzy inference is applied in the second step of FL. Mamdani fuzzy inference is commonly seen as fuzzy method that was introduced by Ebrahim Mamdani in 1975 (Mamdani & Assilan, 1975). Mamdani's work was based on Lotfi Zadeh study on fuzzy algorithm for complex system and decision process (Zadeh, 1973). The inference process described in the following conditions;

IF X is A, THEN Y is B

Where X and Y are linguistic variables, A and B are linguistic values determined by fuzzy sets. A is premise, while B is consequence of A.

In this study, there are two linguistic variables; house price and household income. Consequently the X in this case should be X_1 and X_2 which represent house price and household income respectively, while Y is linguistic variable for affordability. X_1 and X_2 will be linked by AND operator as follows;

IF X_1 is A_{11}, AND X_2 is A_{21}, THEN Y is B

Note that the linguistic term for the variables were mapped to another linguistic term from other variables.

This study contains six linguistic terms from input variable household income; Income Class 1, Income Class 2, …, Income Class 6, and contains eight linguistic terms from input variable house price; Low Cost House, Low Medium Cost, …, Affordable 5.

Thus, we have 48 rules (i.e. 6 $linguistic\ terms$ $\times$ 8 $linguistic\ terms$).

Two linguistic output terms were considered in this study which is "low price" and "high price". The determination of interval is based on definition of affordability by BNM as mentioned in Section 2.5.1. When a house buyer cannot afford to buy a house, they consider the house to have "high price", and vice versa. In Table 3.5, we use imaginary value to represent "low price" and "high price" which is to put the fuzziness of house price into certain extent. Therefore, we use 1-3 value for low price and 3-5 value for high price.

Table 3.5

Output Class Interval

Low price	**High price**
[1-3]	[3-5]

In this research, triangular membership function was used for all input and output variables. This type of membership function is favored compared to others due to its simplicity in fuzzified and defuzzified calculation. A triangular membership function is specified by three parameters {a, b, c} as in (Yadav & Singh, 2011):

$$\text{Triangle (x: a, b, c)} = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & c \leq x \end{cases}$$

Figure 3.4 illustrates triangular membership function using parameters {a, b, c}.

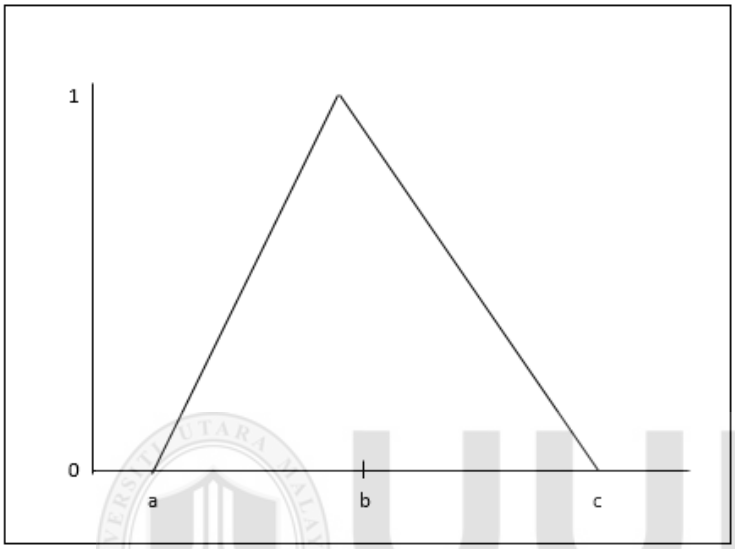


Figure 3.4. Triangular Membership Function

3.7.3 Defuzzification

The last part is defuzzification. Defuzzification step is done by performing this fuzzy to non-fuzzy mapping. The goal of this part is to get back the crisp output from the given set of fuzzy output.

Center of Area (COA) technique is used in defuzzification stage. This technique is chosen because it is widely used in actual applications (Bai & Wang, 2006). This technique works by calculating the weighted average of a fuzzy set. Since this study uses discrete value, the COA defuzzification formula can be expressed in the form as follows:

$$\text{COA} = \frac{\sum_{i=1}^{n} \mu_{A(y_i)} \times y_i}{\sum_{i=1}^{n} \mu_{A(y_i)}}$$

where $\mu_A(y_i)$ are the i =1, 2, …, n sample values of the aggregated output membership function and y_i is the mid value of the output.

Figure 3.5 illustrates general architecture of how FLcould decide affordability of house buyer in buying a house. Finally, the system will tell either the house buyer can afford a specific house.

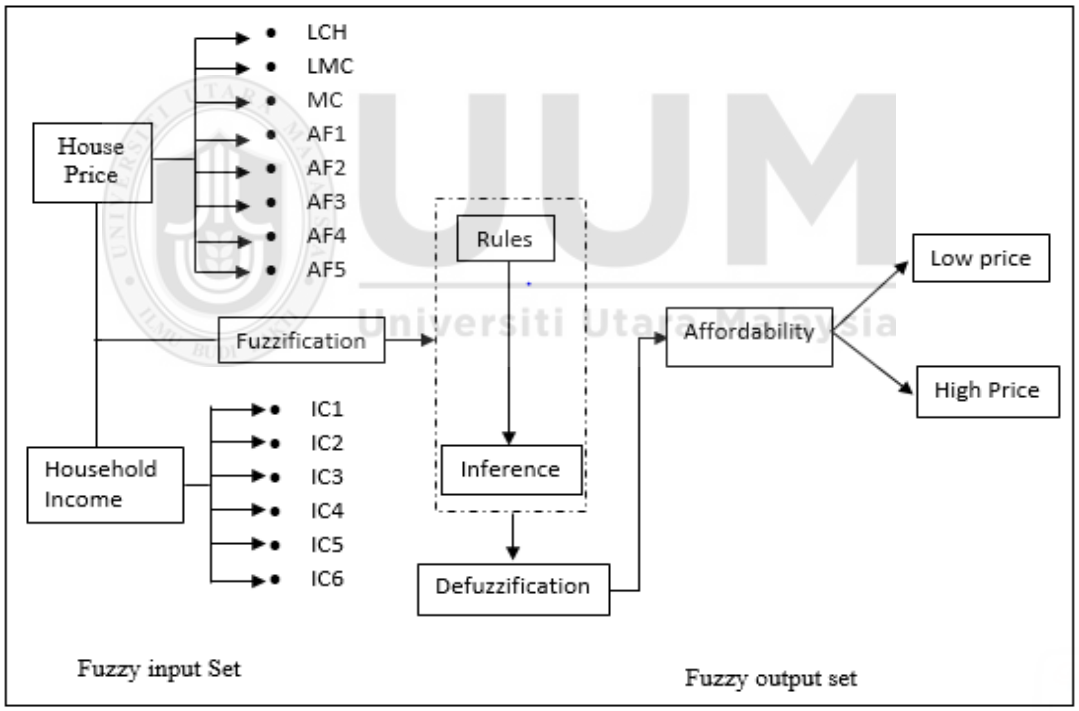


Figure 3.5. General Architecture of the System

The process of defining affordability of house buyer using FL was repeated with house price ranges developed from simulation results. Mean of house price and household

income was also adopted from simulation results. This action is to compare the consistency of results between NAPIC and simulation performed.

3.8 Concluding Remarks

In this chapter, GP framework was established in which to confront the various objectives required by the parties. GP framework with simulation is a technique that fits the social interaction of related parties. We realize that each party has respective goals to achieve, thus to model the problem, firstly we need a mathematical method that can fix the criterion. Because GP is able to handle multiple and conflicting objectives, we decided to use it in this study.

GP is a multiple criteria decision making technique that is widely used to tackle multiple objectives. Our mathematical model was designed based on GP general model.

The application of FL is to enlighten the part of affordability of house buyer, with the assumption that the house buyer does not have any other commitment than paying for housing instalment.

CHAPTER FOUR

DATA ANALYSIS

4.1 Introduction

In this chapter, the results and findings are discussed. The decision model for the parties is based on preferences that have been identified in Chapter Three which is the preferences in buying and selling houses. The decision model of parties in this study is to suggest house price that is agreed by all parties based on their own objectives and preferences.

Parties are said to be cooperative if the suggested house price is agreed, even though it is higher than the expected price. This is called mutual agreement; which the parties would like to compromise in either win-lose situation or win-win situation.

However, this is limited to the existing hard and soft constraints which all of them represent the parties' preferences. Due to this, the decision model is able to produce the mutual house price. Statistical analysis is conducted to support the findings. In addition, types of decision either they are accepting or rejecting the suggested house price are analyzed and examined.

Extended analysis from FL is discussing the affordability of house buyer in this study, thus could make some suggestion on real practice nowadays.

4.2 Demographic Analysis

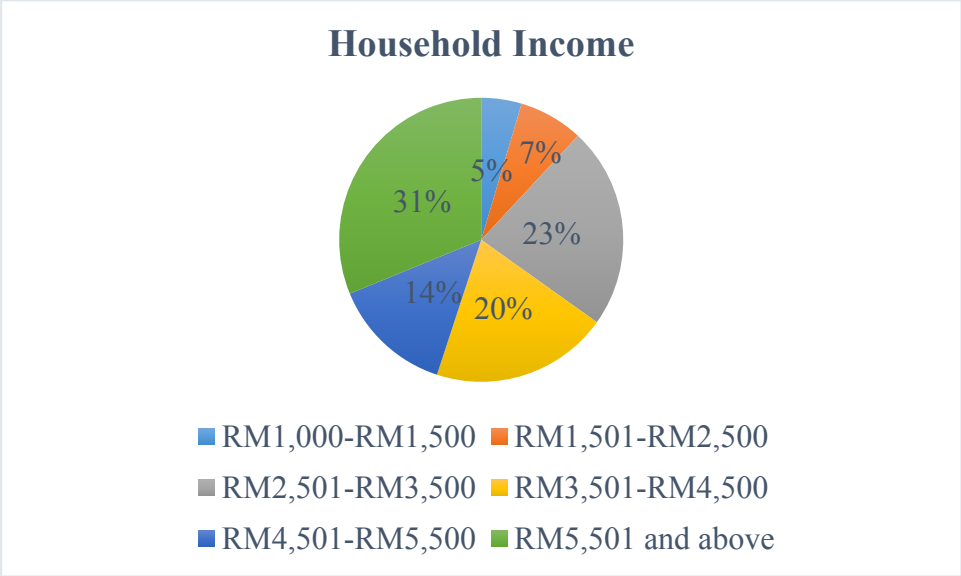


Figure 4.1. Distribution of Household Income

Figure 4.1 shows the distribution of respondents' household income. Majority of the respondents have household income of RM 5,501 and above, followed by RM 3,501 to RM 4,500. The smallest portion of the distribution of respondents' household income is RM 1,000-RM 1,500. This implies the quality of life for citizens in Kedah state. We can infer from this data that both husband and wife are working.

4.3 Completing Goals and Targets Level

General model of GP in determining mutual house price was formulated in Section 3.4.1. This section explains the parameter value for each constraint and preference used. Recall that from Section 3.4.1, the objective of the interaction model is:

$Min\ (d_1^- + d_2^+ + d_3^+)$

Subject to:

$X + d_1^- = g_1$

$X + d_2^+ = g_2$

$X + d_3^+ = g_3$

The set of hard constraints developed in Section 3.4.1 is done in this section to complete the formulation of GP interaction model.

An interviewee posited that in housing development, the land cost, C_2 contributes about 2.77% of total development cost of a house, C_3 for land that is located near to facilities. The land price is much cheaper rather than the market price due to the involvement of the government in land acquisition matter, which in PPP the land acquisition matter is allocated to government (Abdul Rahman, Mohd Zulkiffli, & Memon, 2014).

$$C_2 \leq 0.0277 * C_3$$

According to an interviewee, 77% of total cost is coming from construction cost, C_4.

$$C_4 \leq 0.77 * C_3$$

For private developer preferences, in setting their profit, the rule is sale price, X, minus total cost, C_3 followed by paying taxes to the government, 20% of sale, and paying for land transfer cost, C_1 while for residential projects, the developer needs to pay 15% of the land price to the state authority (Leng, 2016).

$$X > X - C_3 - C_1 - (0.2 * X)$$

$$C_1 = 0.15 * C_2$$

House buyers' preferences in this study is house location. The weightage for each location should be different. The following part explains the finding of weightage of house buyer's preferences.

In a study, Tan (2011) found that house buyers are willing to pay 15.50% higher if the house is located near to workplace, L_1, 29.03% higher if their house is located near to school, , L_2, and 31.42% higher if the house is near to retailing outlet (city center), L_3. The weight value is using this study finding but for normalization purpose, $\sum_1^3 w = 1$, which the total of weight value is equal to one.

Ratio formula was used to find the weightage for this study. As for normalization purpose, the total weight value must equal to one, considering these following steps;

i. The house buyer is willing to pay 15.50% higher if the house is nearer to workplace.
ii. The house buyer is willing to pay 29.03% higher if the house is nearer to school.
iii. The house buyer is willing to pay 31.42% higher if the house is nearer to retailing outlet.

Table 4.1

Steps of Finding Weightage

Preferences	**Workplace**	**School**	**Retailing outlet**	**Total**
Percentage of preferences	15.50	29.03	31.42	75.95
Weightage of preferences	$\frac{15.50}{75.95} = 0.20$	$\frac{29.03}{75.95} = 0.38$	$\frac{31.42}{75.95} = 0.42$	1

Table 4.1 explains how weightage was acquired in this study. In column of percentage of preferences, the percentage was added, totaling to 75.95. The percentage for each preference was then divided by the grand total of percentage (i.e. 75.95) and resulted to the weightage of each preference (see column weightage of preference in Table 4.1). The weightage for each preference is said to fulfill normalization when the grand total of all weightage is equal to 1.

As a result, $w_1 = 0.20, w_2 = 0.38, w_3 = 0.42$. Thus;

$$(X * 0.20 * L_1) + (X * 0.38 * L_2) + (X * 0.42 * L_3) < X$$

Another "location" that influences house price is the place that the house is constructed, namely rural, suburban and urban. For simplicity, we compile it in index form as in Figure 4.2. We use 100=RM969,655.40 as price base, which giving meaning that for suburban, the price increase 575.63% from RM969,655.40.

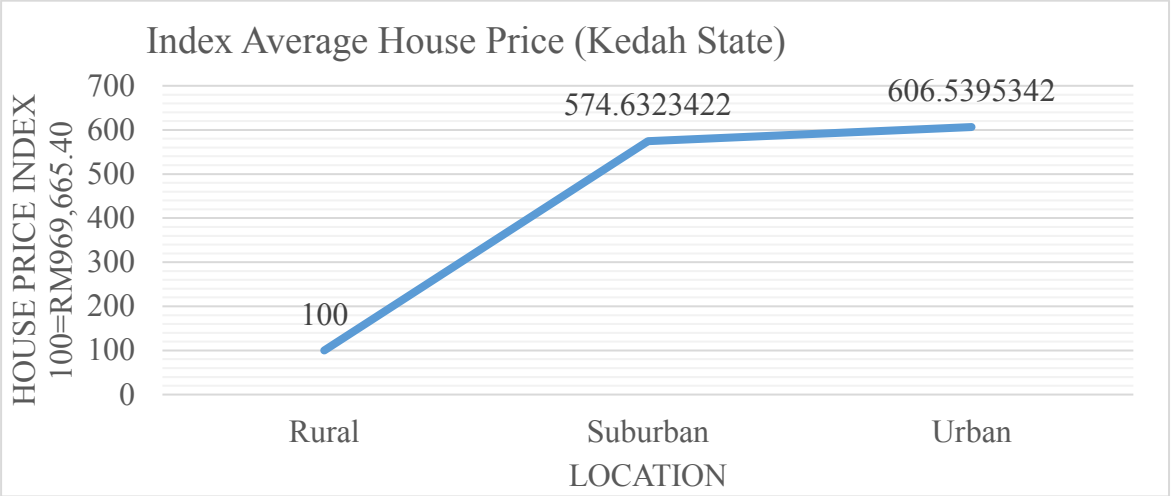


Figure 4.2. Index Average House Price in Kedah State

Price index in Figure 4.2 clearly explains house price in rural, $L_4 <$ suburban, $L_5 <$ urban, L_6. Again, the weight value, w_4, w_5, w_6 is add up to 1 for normalization purpose. The ratio of the index is firstly defined.

Rural: Suburban: Urban = 1: 5.74: 6.06, which gives the summation of 12.8. Thus, using formula percent to fraction, each weight value will change to $w_4 = 0.08, w_5 = 0.45, w_6 = 0.47$.

Therefore, it completes the equation below;

$$(X * 0.08 * L_4) + (X * 0.45 * L_5) + (X * 0.47 * L_6) < X$$

With restriction that the house could not be in all locations;

$$L_j = \begin{cases} 1 \; if \; house \; buyer \; prefer \; to \\ 0 \; otherwise \end{cases}$$

Where $j = 1,2, \ldots ,6$.

Figure 4.3 explains summary of house price based on housing type in Kedah state in index form. We use base price 100 = RM769,438.80. This figure shows that 1-1 $\frac{1}{2}$ storey terrace is 231% increase from apartment price, while $2 - 2\frac{1}{2}$ storey terrace is 292% increase from apartment price.

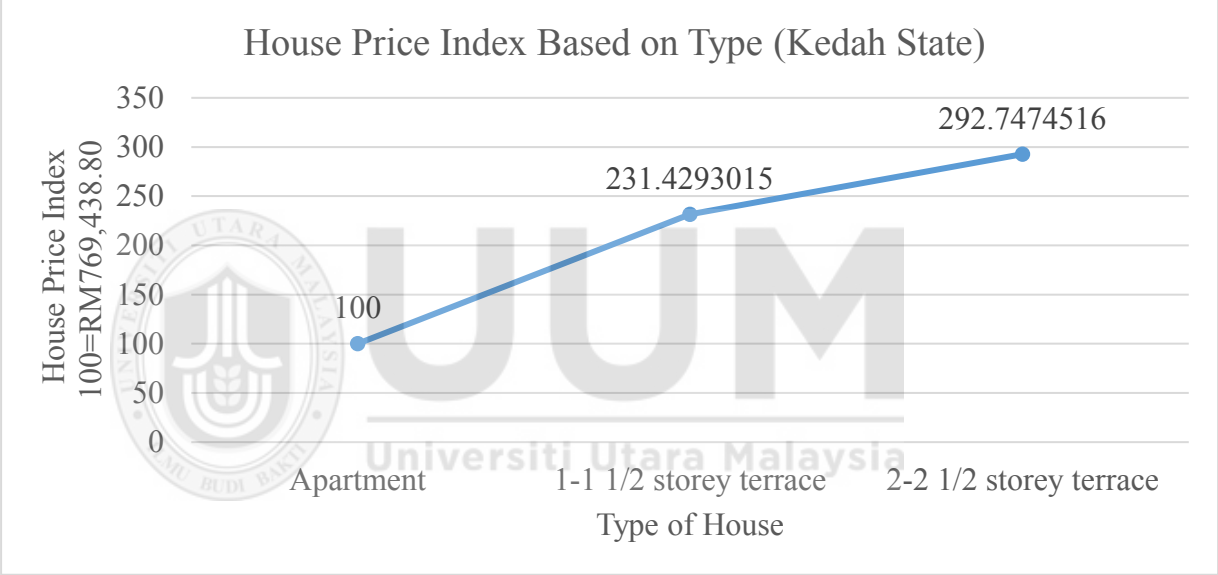


Figure 4.3. House Price Index Based on Type (Kedah State)

Using the same method, the weight value for structural constraint were determined as $w_7 = 0.16, w_8 = 0.37, w_9 = 0.47$. Thus, we use weightage, w_j to represent weightage for apartment, H_7, 2 for one-storey terrace, H_8, and 3 for two-storey terrace, H_9.

$$X > (0.16 * H_7 * X) + (0.37 * H_8 * X) + (0.47 * H_9 * X)$$

Because house buyer will not buy many houses at a time;

$$H_j = \begin{cases} 1, if\ house\ buyer\ prefer\ to \\ 0, \quad otherwise \end{cases}$$

Where $j = 7,8,9$.

Besides from costs and preferences, economic constraint is an obvious limitation that cannot be left out in the GP model of this study. House price is influenced by economic variables. Section 3.4.1 already mentioned that we adopted Keng (2011) findings to our mathematical model. The equation that we adopt is as follows;

$$I = -8.423 + 0.0127E_1 + 3.579E_2 + 0.00088E_3 + 0.00372E_4$$

Per capita income, E_1, unemployment rate, E_2, total loan to housing, E_3, and KLSE composite index, E_4 are fundamental macroeconomic factors that influence house price. Per capita income is the average income earned per person in a given area. Total housing loan influences buyer affordability thus influence fluctuation in house price. Meanwhile, KLSE composite index (stock price) explains wealth effect where if stock price arises, housing demand will increase.

Equation below is suggested to compare the price index with suggested house price obtained by our model.

$$X = \frac{I}{100} \times P_0$$

Above consideration has been completing weightage of preferences and another parameter that involved in GP model of this study. Thus, the complete GP model is as follows;

$$Min\ (d_1^- + d_2^+ + d_3^+) \quad (4.1)$$

Subject to:

$$X + d_1^- = g_1 \quad (4.2)$$

$$X + d_2^+ = g_2 \quad (4.3)$$

$$X + d_3^+ = g_3 \quad (4.4)$$

$$C_2 \leq 0.0277 * C_3 \quad (4.5)$$

$$C_4 \leq 0.77 * C_3 \quad (4.6)$$

$$X > X - C_3 - C_1 - (0.2 * X) \quad (4.7)$$

$$C_1 = 0.15 * C_2 \quad (4.8)$$

$$(X * 0.20 * L_1) + (X * 0.38 * L_2) + (X * 0.42 * L_3) < X \quad (4.9)$$

$$(X * 0.08 * L_4) + (X * 0.45 * L_5) + (X * 0.47 * L_6) < X \quad (4.10)$$

$$X > (0.16 * H_7 * X) + (0.37 * H_8 * X) + (0.47 * H_9 * X) \quad (4.11)$$

$$I = -8.423 + 0.0127E_1 + 3.579E_2 + 0.00088E_3 + 0.00372E_4 \quad (4.12)$$

$$X = \frac{I}{100} \times P_0 \qquad (4.13)$$

4.4 Interaction Model

From above complete GP model, the interaction between parties can be seen. The interaction is illustrated in Figure 4.4.

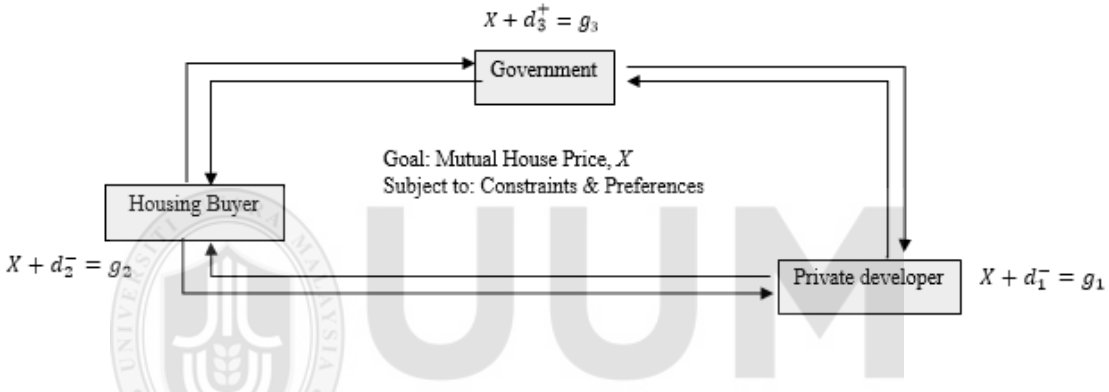


Figure 4.4. Framework of Parties' Interaction

The interaction shows interdependency between parties to get mutual price agreed by all. The parties must have mutual agreement to achieve their objectives. Each interaction is a two-way communication. The private developer, a known profit maximizer could offer higher price to house buyers, however they still need to consider house buyers' preferences so that the houses can be sold. The government can improve their reputation if the collaboration is successful. The government and the private developer depend on each other in term of housing project advocating and expert provider.

Figure 4.5 is the full GP mathematical model showing interaction between parties to achieve a mutual house price. When they are interacting, they are faced with conflicting goals as they are likely to maximizing their own utility or payoff.

In fact, each party realizes the importance of the cooperation in achieving mutual house price, X, so that they can eventually get to attain their desire. In Figure 4.5, every party i will try to minimize their underachievement, d_i^- or overachievement, d_i^+ to express their concern towards the cooperation in getting mutual house price. However, in fact, to ensure the success of this cooperation, the hard constraints need to be met first.

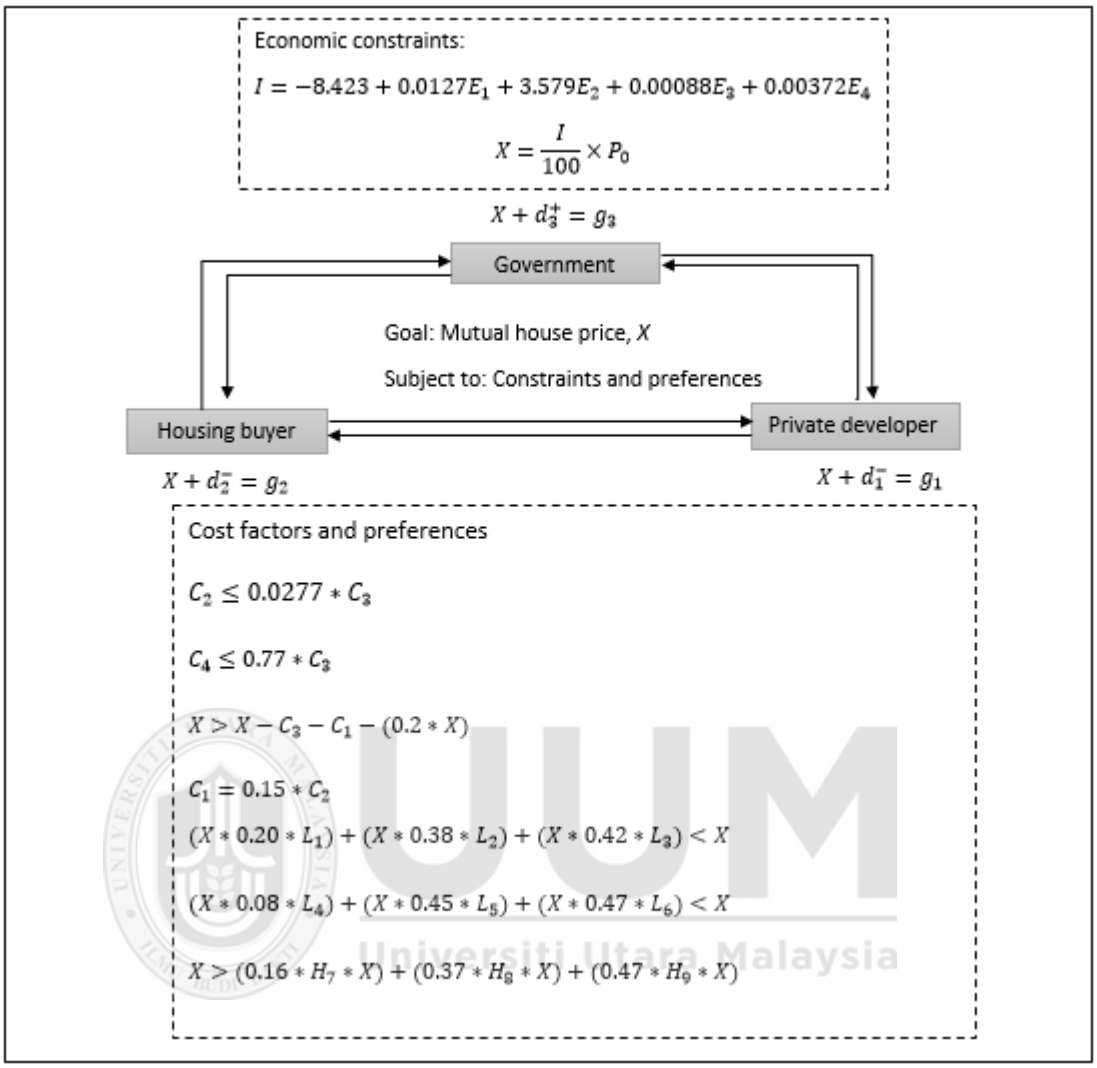


Figure 4.5. Full Interaction Model

From the simulation, mean, median, and mode for the house price were obtained. The results are as in Table 4.2:

Table 4.2

Mean, Median, Mode (RM) of Mutual Price

Statistic	**Value (RM)**
Mean (RM)	169,878.20
Median (RM)	150,001.23
Mode (RM)	101,001.20
Minimum (RM)	85,000.00
Maximum (RM)	350,000.00

Table 4.2 provides mean, median, mode, and standard deviation value of the mutual house price value. The mode of mutual house price shows that the parties tend to agree on value RM 101,001.20. Meanwhile, the mean represents the norm house price that the three parties tend to agree, averagely. The mean value, RM 169,878.20 shows that the value is skewed by two large number, identically are RM85,000.00 and RM350,000.00.

4.5 House Price Range from Simulation Model

The difference between maximum and minimum value of house price is RM265,000. This value was divided by three in order to produce range of house price, which is low price, medium price and high price.

$$Range = Maximum - minimum \quad (4.14)$$

$$350{,}000.00 - 85{,}000.00 = 265{,}000 \quad (4.15)$$

$$\frac{Range}{3} = 88{,}333.33 \quad (4.16)$$

Table 4.3 below is constructed based on the value from equation 4.16:

Table 4.3

House Price Range

Range	**Minimum**	**Maximum**
Low Price (RM)	85,000.00	173,333.33
Medium Price (RM)	173,333.34	261,666.67
High Price (RM)	261,666.68	350,000.01

Table 4.3 constructed in order to cumulate the house price from the simulation as illustrated in Figure 4.6;

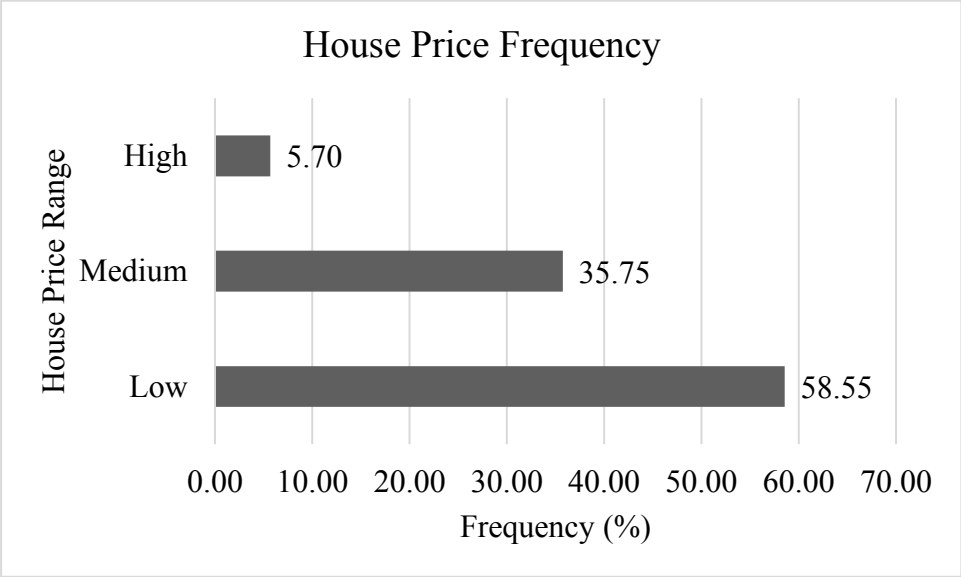


Figure 4.6. Cumulative Frequency of House Price Range

From the data in Figure 4.6, it is apparent that parties tend to agree for lower price, rather than the other two price ranges.

This variance shows that parties are interacting to agree at some price, with regard to respective preferences. Majority of house buyers that are involved in this interaction expected higher price and so, private developers would get a higher payoff based on that. However, in this two-way interaction, the government is present as a moderator between the two said parties. As a result, there is an agreement on a certain price which is suitable with the respective preferences.

Table 4.5

Rejection of Agreement

Simulation	Buyer Annual Salary (3 Years)	Buyer	Private Developer	Government	Mutual Price
s3	209,736.00	101,000.00	250,000.00	139,453.00	101,001.23
s124	319,680.00	120,000.00	250,000.00	124,247.00	120,001.23
s126	240,084.00	250,000.00	250,000.00	183,604.00	250,000.00
s129	284,868.00	150,000.00	250,000.00	299,138.00	150,001.23
s132	280,476.00	250,000.00	250,000.00	257,033.00	205,436.23
s154	207,864.00	250,000.00	250,000.00	159,128.00	123,862.00
s220	144,576.00	101,000.00	350,000.00	300,115.00	101,001.23
s251	216,036.00	200,000.00	350,000.00	203,660.00	189,657.23
s253	99,396.00	200,000.00	350,000.00	127,306.00	157,889.23
s262	203,472.00	85,001.00	350,000.00	397,711.00	85,002.23
s280	118,980.00	250,000.00	350,000.00	282,242.00	184,796.23
s287	263,952.00	250,000.00	350,000.00	172,055.00	250,001.23
s305	235,800.00	250,000.00	350,000.00	212,906.00	250,001.23
s335	159,696.00	500,000.00	350,000.00	305,343.00	350,000.00
s349	163,764.00	150,000.00	350,000.00	189,871.00	150,001.23
s371	263,592.00	150,000.00	350,000.00	153,395.00	150,001.23

From Table 4.5, we can see the difference between the house prices from the buyer, private developer, and government. The mutual price in Table 4.5 cannot be accepted by the house buyer. This situation happens when house price, X is compared based on three years' annual salary of house buyer, B, and in turn out the buyer is not able to afford to buy a house even though based on price agreed by all parties. This refer to the equation below:

$$if\ X\ is\ greater\ than\ annual\ salary * 3, then\ reject\ X, otherwise, accept.$$

House buyer loss his/her buying power and the collaboration is unsuccessful due to low income of house buyer. A successful collaboration will happen if and only if the private developer and the government agreed with the price that the house buyer can afford.

The parties have to interact more on buyers' affordability. Section 3.4.1 already considered house buyer affordability by comparing house price with buyer's three times annual salary which could affect their result of accepted and rejected mutual house price. The collaboration between parties could not be successful if the house price is not affordable.

Result from comparison of house price to three times annual salary is given in Figure 4.7. House buyer could not accept any price that exceeds his/her affordability even though the price is agreed by all parties. The acceptance rate is high (95.85%), proving that the house price is still in range of affordable. Table 4.3 discloses the simulations that result in unaffordability.

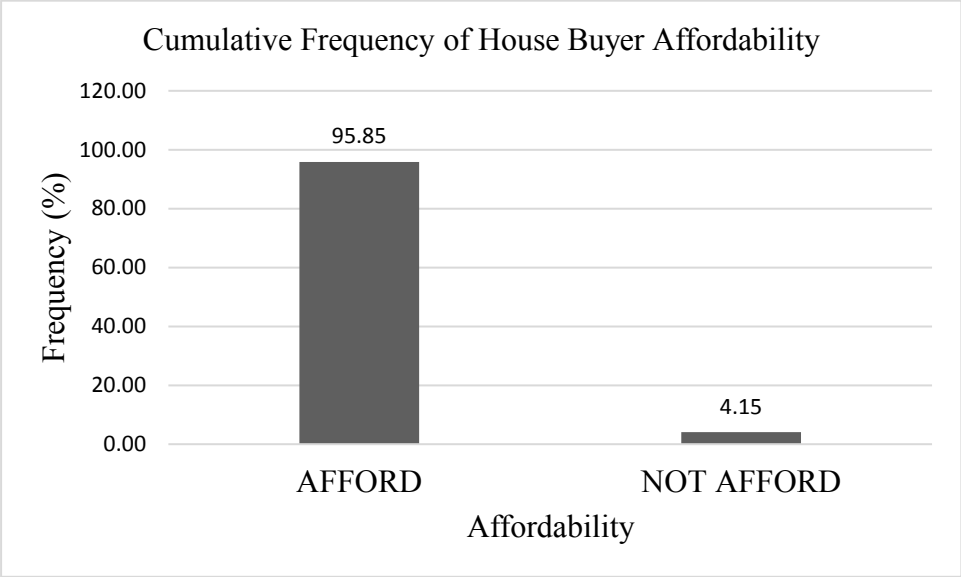


Figure 4.7. Affordability Rate

4.6 Affordability of House Buyer Through FL Methodology

FL prepares a platform for researcher to measure affordability in an objective way. In this section, the researcher measured the affordability of house buyer in owning a house using this method due to its capability to put uncertainty about the extension of the affordability into limited extend.

The measurement using FL was established based on Phase Six in Section 3.2.6. In designing this measurement model, MATLAB's FLToolbox was used. Figure 4.8 is overall fuzzy input and fuzzy output.

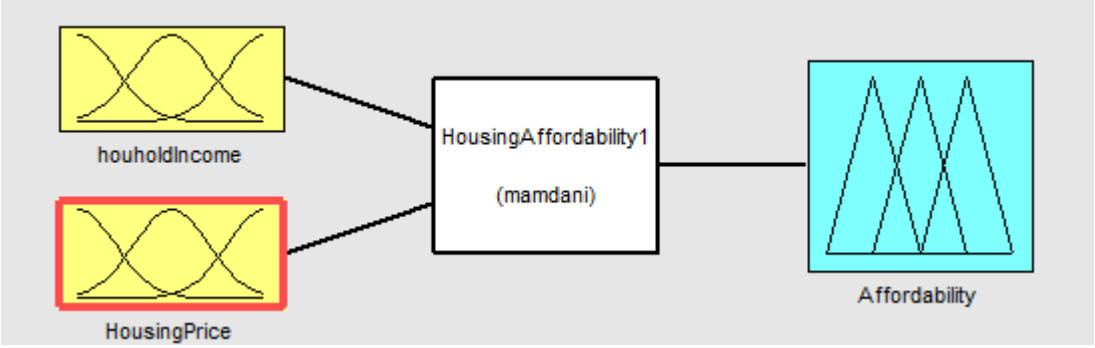


Figure 4.8. Fuzzy Input and Output

Results of the general architecture of the fuzzy system are as presented in Figure 4.8. The fuzzy input which is household income and house price are used to define affordability of the house buyer.

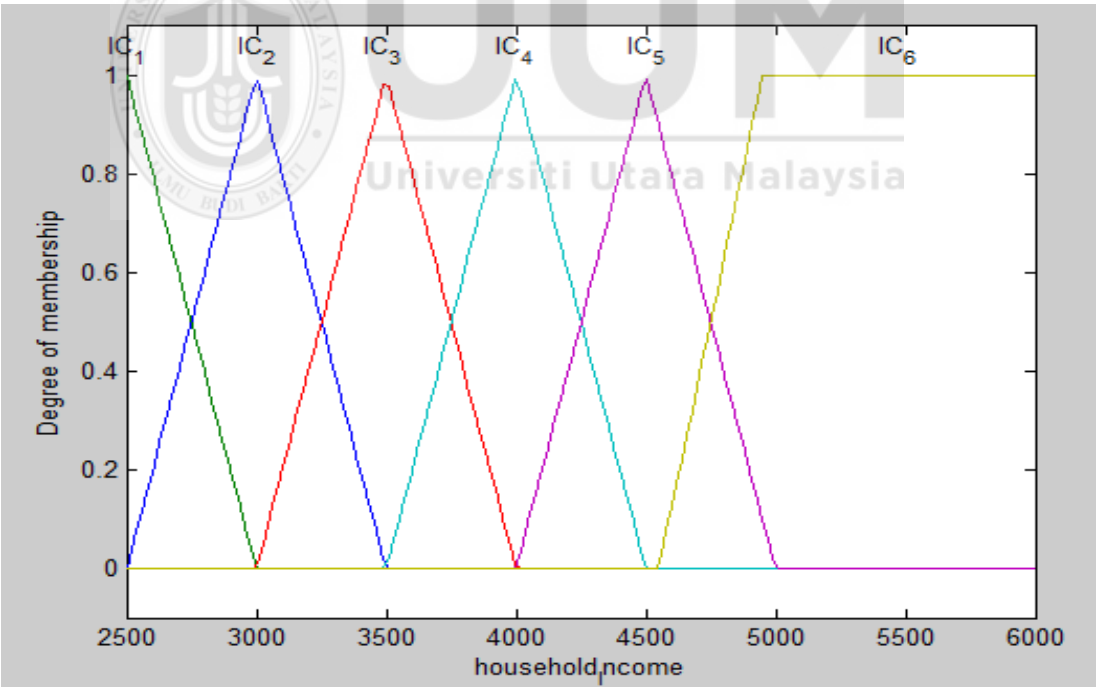


Figure 4.9. Membership Function of Household Income

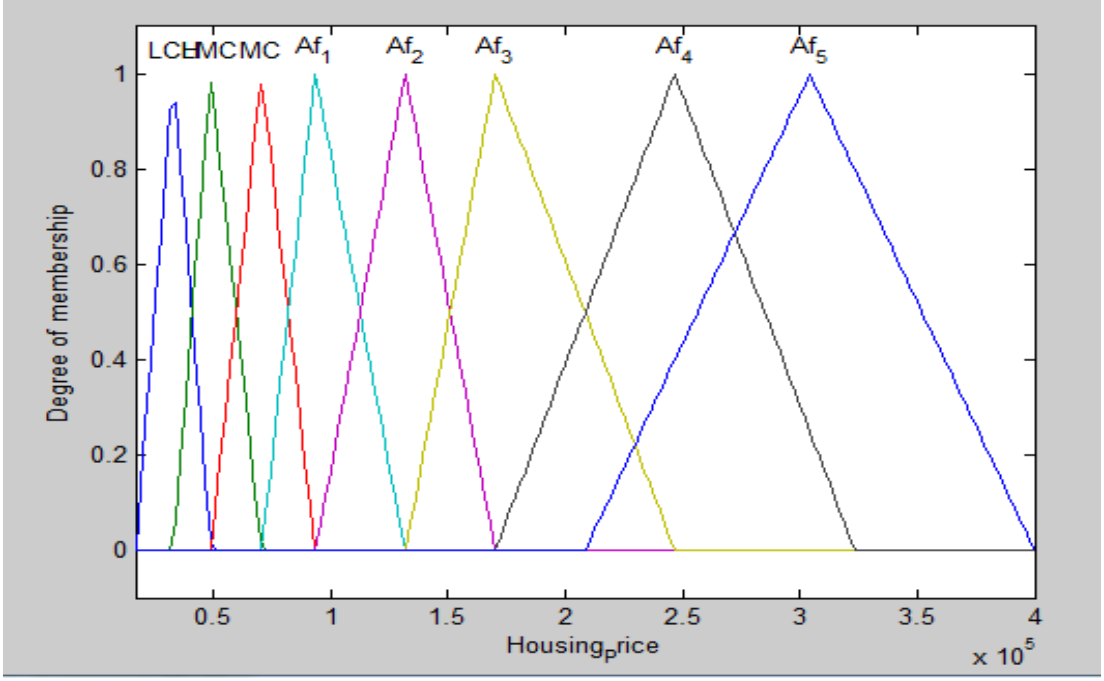


Figure 4.10. Membership Function of House Price

Guide:

Abbreviation	***Meaning***
LCH	*Low Cost House*
LMC	*Low Medium Cost*
MC	*Medium Cost*
AF1	*Affordable 1*
AF2	*Affordable 2*
AF3	*Affordable 3*
AF4	*Affordable 4*
AF5	*Affordable 5*

Figure 4.9 and Figure 4.10 show membership function of household income and membership function of house price respectively. IC in Figure 4.9 represents income class that is classified into six categories. Whereas, in Figure 4.10, the house price is divided into eight categories which are the combined from house price categories employed by Jabatan Perumahan Negara and Penang State Government.

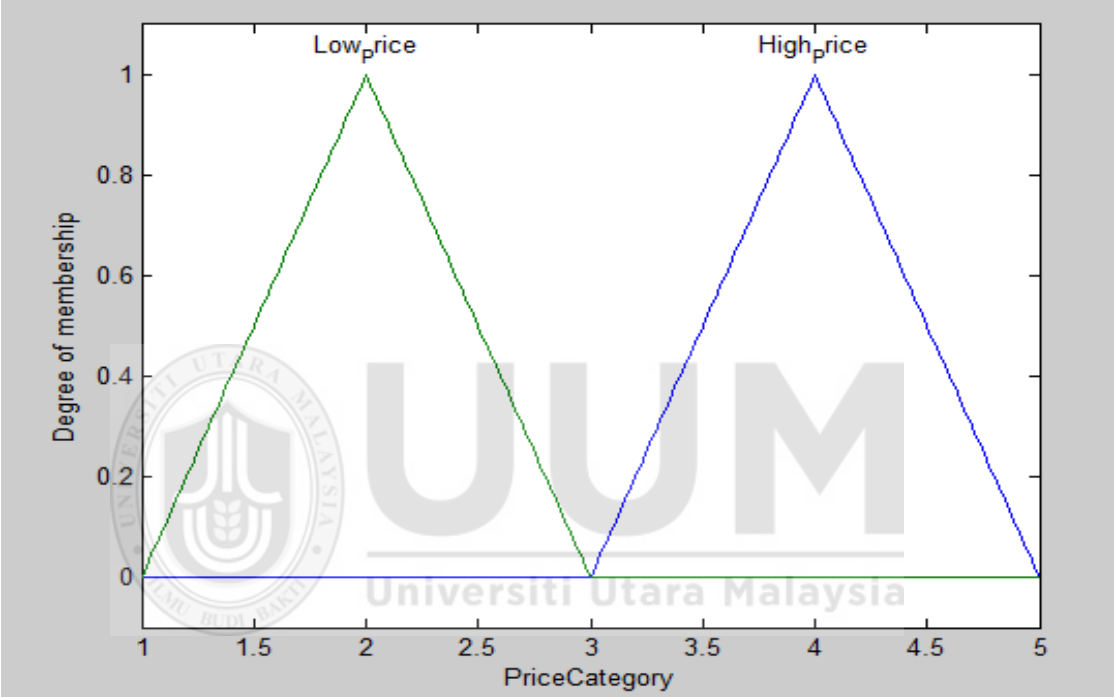


Figure 4.11. Membership Function of Price Category

Figure 4.11 illustrates membership function of output price category. The prices are categorized into two categories which is low price and high price. Low price and high price is the common understanding used by house buyer. However, limits should be set on the extents of "low" and "high". The limitations are explained in Section 3.2.6 previously.

4.6.1 Inference Engine Fuzzy Rule

The inference engine part is where the process of mapping between fuzzy input and fuzzy output is done based on the rules. The rules generated for this FL system is illustrated in Table 4.6.

Table 4.6

Rules Generated

No.	Household Income	House price	Affordability
1	IC_1	LCH	Low price
2	IC_1	LMC	Low price
3	IC_1	MC	Low price
4	IC_1	Af_1	High price
5	IC_1	Af_2	High price
6	IC_1	Af_3	High price
7	IC_1	Af_4	High price
8	IC_1	Af_5	High price
9	IC_2	LCH	Low price
10	IC_2	LMC	Low price
11	IC_2	MC	Low price
12	IC_2	Af_1	Low price
13	IC_2	Af_2	High price
14	IC_2	Af_3	High price

Table 4.6 continue

15	IC_2	Af_4	High price
16	IC_2	Af_5	High price
17	IC_3	LCH	Low price
18	IC_3	LMC	Low price
19	IC_3	MC	Low price
20	IC_3	Af_1	Low price
21	IC_3	Af_2	High price
22	IC_3	Af_3	High price
23	IC_3	Af_4	High price
24	IC_3	Af_5	High price
25	IC_4	LCH	Low price
26	IC_4	LMC	Low price
27	IC_4	MC	Low price
28	IC_4	Af_1	Low price
29	IC_4	Af_2	Low price
30	IC_4	Af_3	High price
31	IC_4	Af_4	High price
32	IC_4	Af_5	High price
33	IC_5	LCH	Low price
34	IC_5	LMC	Low price
35	IC_5	MC	Low price
36	IC_5	Af_1	Low price

Table 4.6 continue

37	IC_5	Af_2	Low price
38	IC_5	Af_3	High price
39	IC_5	Af_4	High price
40	IC_5	Af_5	High price
41	IC_6	LCH	Low price
42	IC_6	LMC	Low price
43	IC_6	MC	Low price
44	IC_6	Af_1	Low price
45	IC_6	Af_2	Low price
46	IC_6	Af_3	Low price
47	IC_6	Af_4	Low price
48	IC_6	Af_5	High price

IC in Table 4.6 is income class referred from Department of Statistics Malaysia (2015), while Af is affordable home. The rules are constructed as the income classes and house prices were compared and lastly mapped to price category as in Table 4.7.

Table 4.7

Assignment of the Inputs to Their Linguistic Output

No	Household Income	House price	Affordability by BNM definition	House price interval (from Section 2.4)	Price Category
1	IC_1	LCH	108,000	Below 42,000	Low price
2	IC_1	LMC	108,000	42,000 – 70,000	Low price
3	IC_1	MC	108,000	Low price	Low price
4	IC_1	Af_1	108,000	100,000 – 150,000	High price
5	IC_1	Af_2	108,000	150,000 – 200,000	High price
6	IC_1	Af_3	108,000	200,000 – 300,000	High price
7	IC_1	Af_4	108,000	300,000 – 400,000	High price
8	IC_1	Af_5	108,000	400,000 and above	High price
9	IC_2	LCH	126,000	Below 42,000	Low price
10	IC_2	LMC	126,000	42,000 – 70,000	Low price
11	IC_2	MC	126,000	70,000 – 100,000	Low price
12	IC_2	Af_1	126,000	100,000 – 150,000	Low price
13	IC_2	Af_2	126,000	150,000 – 200,000	High price
14	IC_2	Af_3	126,000	200,000 – 300,000	High price
15	IC_2	Af_4	126,000	300,000 – 400,000	High price
16	IC_2	Af_5	126,000	400,000 and above	High price
17	IC_3	LCH	144,000	Below 42,000	Low price
18	IC_3	LMC	144,000	42,000 – 70,000	Low price

Table 4.7 continue

19	IC_3	MC	144,000	70,000 – 100,000	Low price
20	IC_3	Af_1	144,000	100,000 – 150,000	Low price
21	IC_3	Af_2	144,000	150,000 – 200,000	High price
22	IC_3	Af_3	144,000	200,000 – 300,000	High price
23	IC_3	Af_4	144,000	300,000 – 400,000	High price
24	IC_3	Af_5	144,000	400,000 and above	High price
25	IC_4	LCH	162,000	Below 42,000	Low price
26	IC_4	LMC	162,000	42,000 – 70,000	Low price
27	IC_4	MC	162,000	70,000 – 100,000	Low price
28	IC_4	Af_1	162,000	100,000 – 150,000	Low price
29	IC_4	Af_2	162,000	150,000 – 200,000	Low price
30	IC_4	Af_3	162,000	200,000 – 300,000	High price
31	IC_4	Af_4	162,000	300,000 – 400,000	High price
32	IC_4	Af_5	162,000	400,000 and above	High price
33	IC_5	LCH	180,000	Below 42,000	Low price
34	IC_5	LMC	180,000	42,000 – 70,000	Low price
35	IC_5	MC	180,000	70,000 – 100,000	Low price
36	IC_5	Af_1	180,000	100,000 – 150,000	Low price
37	IC_5	Af_2	180,000	150,000 – 200,000	Low price
38	IC_5	Af_3	180,000	200,000 – 300,000	High price
39	IC_5	Af_4	180,000	300,000 – 400,000	Not Afford
40	IC_5	Af_5	180,000	400,000 and above	High price

Table 4.7 continue

41	IC_6	LCH	360,000	Below 42,000	Low price
42	IC_6	LMC	360,000	42,000 – 70,000	Low price
43	IC_6	MC	360,000	70,000 – 100,000	Low price
44	IC_6	Af_1	360,000	100,000 – 150,000	Low price
45	IC_6	Af_2	360,000	150,000 – 200,000	Low price
46	IC_6	Af_3	360,000	200,000 – 300,000	Low price
47	IC_6	Af_4	360,000	300,000 – 400,000	Low price
48	IC_6	Af_5	360,000	400,000 and above	High price

4.6.2 Defuzzification from Crisp Output

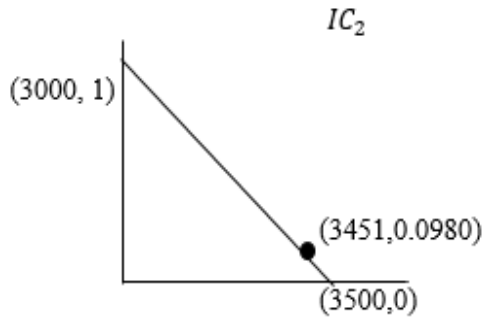
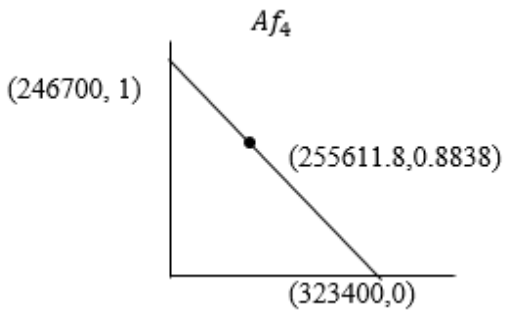
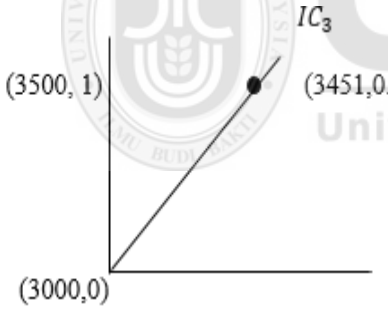
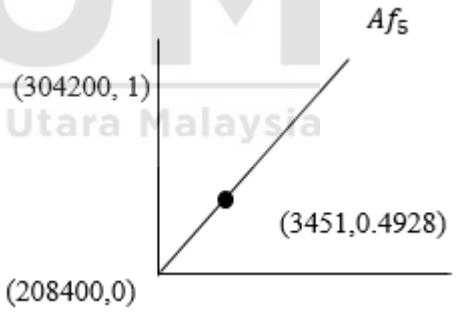
Graph point of interest was constructed and computed in Table 4.8. We can see that for household income = 3,451, IC_2 and IC_3 coincide as in Figure 4.9. While for house price = 255,611.8, Af_4 and Af_5 coincide by referring to Figure 4.10.

The ● sign is the point of interest, which the y value is the value that is calculated based on equation 4.17 below. The y value is actually the value of the aggregated output membership function ($\mu_A(y_i)$).

$$\frac{x-x_1}{x_2-x_1} = \frac{y-y_1}{y_2-y_1} \qquad (4.17)$$

Table 4.8

Graph Point of Interest

Household income = 3,451	House price = 255,611.80
	
	

The fuzzy output for the fuzzy rules are the AND result between household income and house price. The AND operators represent the intersection of the fuzzy sets and it means selecting the minimum value of the membership function between fuzzy inputs.

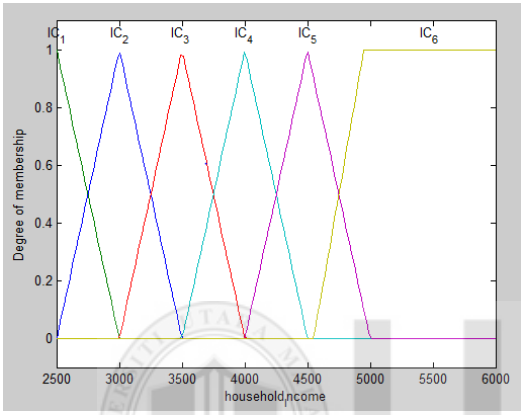
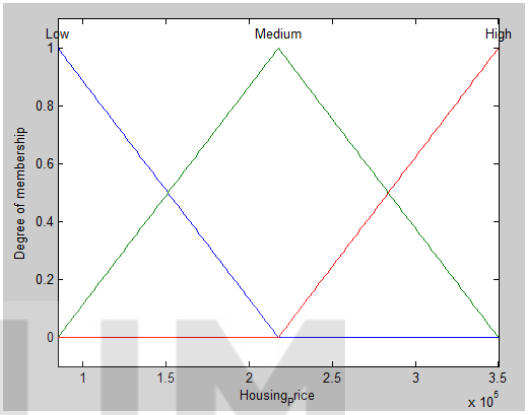
Using MATLAB's FL Toolbox, we find the level of affordability output is = 2 which means low price in linguistic term. This finding shows the affordability of Kedah residents is still on low price, averagely. Another FL system was analyzed using results from our simulation model to check for result consistency.

4.7 Affordability of House Buyer from Simulation Using FL

Using same FL steps in previous sections which is fuzzification, designing fuzzy rules, and defuzzification from crisp output, this section solely used house price ranges developed from simulation result (see Section 4.5). Table 4.9 displays input used in FL. Household income of house buyer is similar as previous section, meanwhile house price range are adopted from ranges formed from simulation results.

Table 4.9

FL Input

Household Income	House Price
	

Output membership function to determine the affordability of house buyer was also used as in previous section;

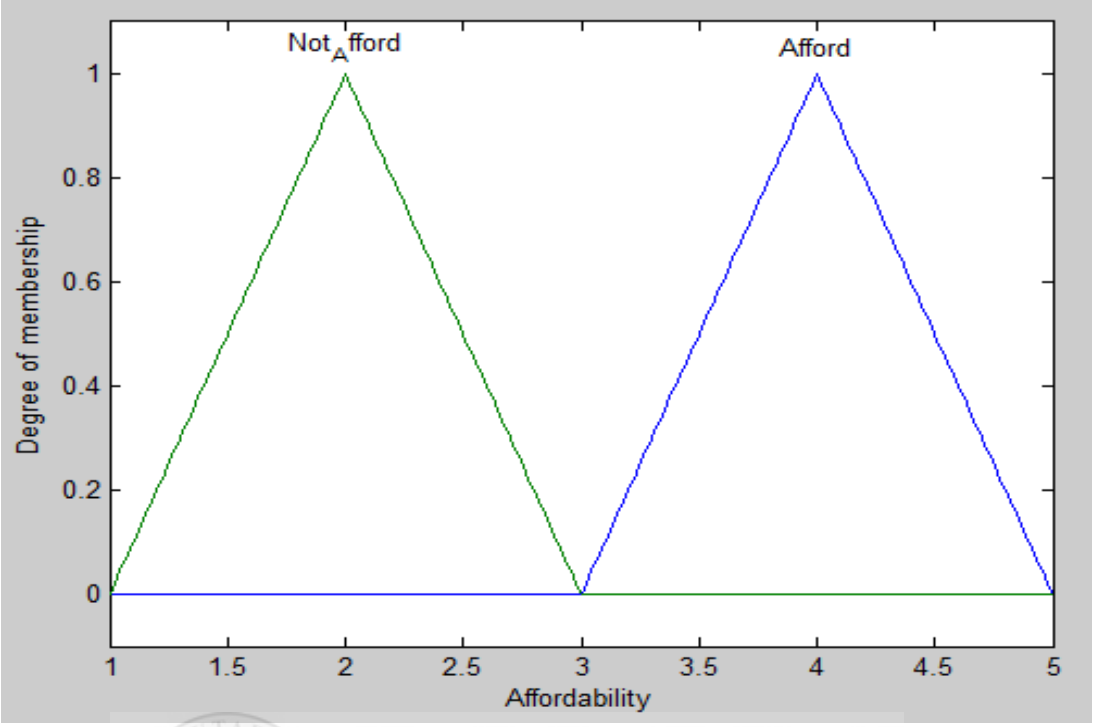


Figure 4.12. Membership Function of FL

Fuzzy rules were generated using same rules which is to compare the household income with house price using BNM statement, as performed in previous section. Rules for this FL system are attached in Appendix G.

Mean of house buyer's income (RM6,390.25) and mean of agreed house price of this study (RM169,878.20) are used in the FL system. The result shows output affordability = 4 which is affordable on high price of house. This finding is contrary with previous sections where it was found that house buyers are able to afford a house using simulation result's mean of house price and house buyer income. Meanwhile, using mean and ranges from NAPIC and house price ranges created from secondary data, the results found that the house buyer cannot afford the given price.

This finding explains inconsistency between the results when using varies mean of house price and household income in FL system. Higher means of sample (from simulation) resulting in higher chance of affordability, which explains why high income earners could afford any house price. However, this finding should can hint private developer to build more affordable houses depending on average household income in specific area or location.

4.8 Model Verification and Validation

Verification and validation of model was done using black box validation technique, which is using comparison with real system. Simulation results were compared to real data of transaction house in Kedah categorized by price from NAPIC.

Firstly, simulation results of house price were grouped by price range similar to actual data from NAPIC. The range are as in Table 4.10 below;

Table 4.10

House Price Range from NAPIC

Price Range (RM)
50,001-100,000
100,001-150,000
150,001-200,000
200,000-250,000
250,001-300,000
300,001-400,000

Figure 4.13 provides total transaction of house in Kedah by price category. In the third quarter 2017, buyers preferred houses in price range of RM100,001-RM150,000 and do not favor for houses priced RM200,001-RM250,000, followed by RM250,001-300,000. This data from NAPIC are consistent with finding of this study which suggest that purchase happens when house buyers expect low price which fit with their household income and affordability. Our study suggests RM100,001-RM150,000 as house price favored by house buyers, however, and least favor for prices to be RM50,001-RM100,000 and RM300,001-RM400,000. This consistency and inconsistency might be due to difference in samples used. Our samples are only focusing on middle income earners while data from NAPIC sampled the whole population.

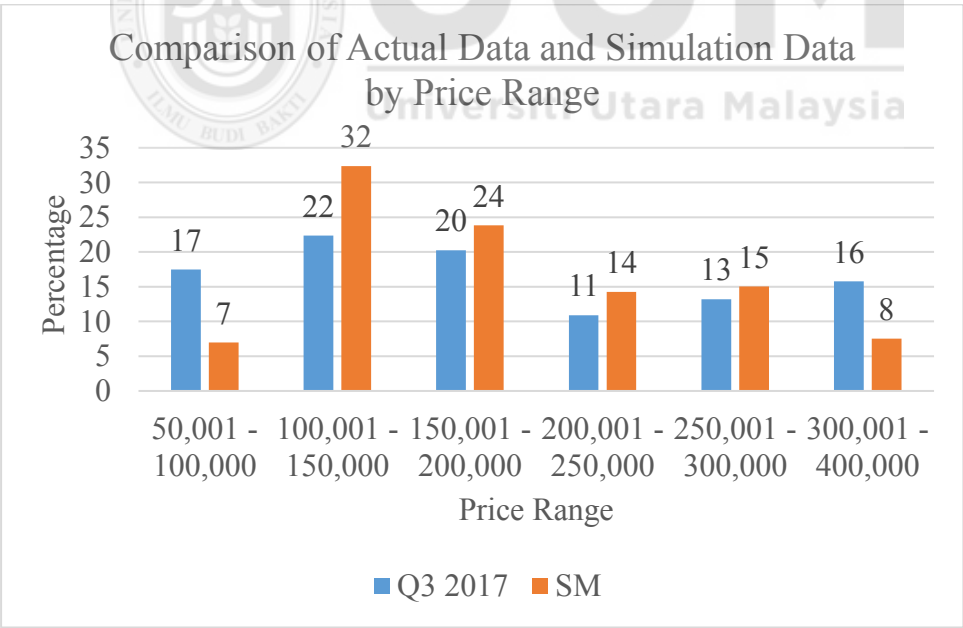


Figure 4.13. Comparison of Actual Data and Simulation Data by Price Range

Wan Abd Aziz, Wan Nor Azriyati; Hanif, Noor Rosly and Singaravello (n.d.) in their study exposed that majority of Kedah residents can afford to buy house in between range of RM80,000-RM100,000. This result is parallel with our finding in Section 4.6 where the house buyer can afford to buy low price house.

4.8.1 Hypothesis Testing for Two Mean

Statistical test was used to compare the percentage between two groups, $p_1$and p_2. This statistical analysis is used to support subjective results in Figure 4.13 so that an objective decision can be made.

Objective of the test is to determine whether the distribution of two groups, which is real data and simulation data is different. Hence, the hypothesis is set as follows;

$$H_0: \mu_{real\ data} = \mu_{simulation\ data}.$$

$$H_1: \mu_{real\ data} \neq \mu_{simulation\ data}$$

Test statistic (z- Test) was run to find p value.

Table 4.11

Z-test: Two Sample for Means

z-Test: Two Sample for Means		**Real Data**	**Simulation Data**
		17.49201278	*6.994819*
Mean		16.50159744	18.60104
Known Variance		18.37486	96.85271
Observations		5	5
Hypothesized Difference	Mean	0	
z		-0.43733076	
P(Z<=z) one-tail		0.330935745	
z Critical one-tail		1.644853627	
P(Z<=z) two-tail		0.66187149	
z Critical two-tail		1.959963985	

Table 4.11 shows results of statistical z-test for two sample means (i.e. real data and simulation data).In order to determine p value, firstly we find variance of data. From Table 4.11, p value = 0.330935745 >0.05. Thus, this test is fail to reject H_0. Hence, at 0.05 significant level (α), the test is fail to reject H_0, which means there is no significance difference between mean of real data distribution and mean of simulation data distribution. This finding indicates that the sample data used in this study may represent population in Kedah state.

4.9 Summary

This chapter focused on results and discussions obtained by this study. Initially, overview of this chapter was briefly discussed followed with demographic analysis of the respondents.

The simulation results from GP model were presented in form of tables on house prices agreed by all parties. From those results, FL was used to find affordability. The result shows that the respondents cannot afford to buy high price house. Model is verified and validated using black box validation by comparing simulation results with real data from NAPIC.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Introduction

This research explored the issue of house price and studied on ways to suggest house price that could be afforded by house buyers. This chapter concludes the study by discussing on these issues; summary of research, limitations of study, and suggestions for future works.

5.2 Summary of Research

Chapter One compiled the issue of high house price and the question of affordability to own a house, including dilemma of middle income earners which is the motivation of this study. It is believed that lack of consideration about house buyers (from middle income earners) preference could be one of the factor of house buyer do not afford to own a house. Definitely, house buyers and the government should suggest appropriate house prices as well as their objectives. This study aimed to find a house price that is mutually agreed by house buyer, private developer, and government in order to resolve the issues.

Chapter Two discussed about the factors that lead to house price determination, such as microeconomic and macroeconomic factors. However, while reviewing the literature, the researcher discovered numerous techniques employed to model the problem in housing development such as simulation techniques (e.g. system dynamic, game theory,

GP) and regression that have been widely used to deal with the issue. However, this study decided to employ GP approach in order to achieve the purpose of the study. This is due to capability of the technique to model the issue as a whole and achieve many objectives at a time with regard to different constraints while tackling the main objective which is to find the mutual agreement on house price. However, it is not a claims that GP is a technique that can accurately represent the decision model, but it is some offer to model a decision in quantitative way.

Numerous research have been done to find equilibrium price for affordable housing and this issue becomes more complex due to macroeconomic and microeconomic changes (Keng, 2011; NAPIC, 2015; Osmadi et al., 2015). This study aimed to find the house price range that is agreed between all parties to fill the gap in the literature. The purposed methodology was able to establish agreement that may be used as an alternative to come up with a rational house price.

Chapter Three presented on how the researcher obtained all objectives of study. Each step done to achieve the objectives is clearly explained in this chapter. This includes how to develop the GP model, how the parties could interact with each other, and how the simulation could provide some suggestions on reasonable new house price range.

For the purpose of GP model construction, the preferences of the parties which is the hard constraints of the model were obtained from extensive search of literature. The preferences of house price were obtained from house buyers in Kedah state, narrowed into middle income earners. For private developer; semi-structured interviews were

conducted in order to obtain their preferences. The objectives are to obtain the parties' preferences on house prices and also to ensure that the preferences obtained from literature review is usable. For government preferences, we refer the preferences made by PR1MA (2017) which is a Malaysia public-private partnership organization.

The developed GP model is then explained on how the simulation works and why simulation is essential in this study. From the simulation, the analysis that can be done also discussed, such as creating a new house price range that more reasonable to house buyer which could give suggestion to private developer and government on distribute the proportion in building more affordable housing to house buyer so that they could afford to own it.

For objective five, FL is a reasonable method to measure the affordability of house buyer to own a house. It is important to view this issue using objective method because the meaning of affordable housing and high house price is too broad or fuzzy. Application of FL is to put this linguistic term into numerical extent so that it can be measured.

Meanwhile, Chapter Four discussed the results from running all processes planned in Chapter Three. In this chapter, new house price ranges have been developed which are low price, medium price, and high price. Analysis showed that all parties are tend to agree on low house price compared to high house price. This implies that private developers could not deny that house buyers need more low priced house. The ranges of house price developed in Chapter Four could be a benchmark to private developers

in setting house price, and setting the proportion of types of house to be developed, such as 50% low price house and 10% high price house.

Affordability of house buyers measured using Fuzzy Logic. From FL system, the house buyers from this study shows high level of affordability while by using data from NAPIC, the result shows the affordability is on low price of house. This inconsistency does not suggest that private developers should develop more high-end type of houses, but they should produce more affordable houses based on analysis on real data from NAPIC. The consideration from private developer could rise in quality of life of house buyer, which at the same time could profit the private developer itself when the housing development does not turn into slump.

5.3 Limitations and Suggestions for Future Works

The study has numerous limitations. For example, substantial parties should be involved in house price determination rather than only three parties; government, buyer, and developer. This study only provides an initial study that could be extended in other studies.

Besides, creating constraints that represent a party's behavior and run a series of computer experiments produced distribution of accepted and rejected price that show what kind of party he is in term of behavior. By understanding their behavior, a question of how a good cooperation formed in deciding price could be answered and lead to better decision making.

It is hoped that this dissertation offers a help towards a broader, more valuable understanding of house price setting process. The constructive house price determination model stressed the importance of organizations or human behavior which always come with many goals and objectives. Each element cannot be left out in decision making so that it can represent real situation.

This study do not claim that GP approach presented an accurate modelling of real decision process in house pricing. It is just compromise modest method to model the decision processes that counts to some degree some important concepts from real world such as economic factors that could lead to price determination. GP offers flexibility towards modelling decision problems, thus a very simple form of it was used in order to serve as a starting point for further refinements.

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Appendix A

House Buyer Questionnaire

Objektif: Soal selidik ini hanya bertujuan untuk mendapatkan maklumat mengenai keutamaan pembeli dalam membeli rumah. Soal selidik ini akan mengambil masa dalam lingkungan 15-20minit.

Sulit dan rahsia: segala maklumat peribadi responder akan dirahsiakan, maklumat yang didapati hanya akan digunakan untuk tujuan kajian.

Arahan: Sila tick √ pada kotak yang disediakan.

1. Umur:_____
2. Status: Bujang ☐ Berkahwin ☐ Bercerai ☐
3. Warganegara: Malaysia ☐ Bukan Malaysia ☐
4. Gender: Lelaki ☐ Perempuan ☐
5. Pekerjaan:_____
6. Pendapatan isi rumah

	Kurang daripada RM2,500
	RM2,500- RM3,999
	RM4,000-RM5,499
	RM5,500-RM6,999
	RM7,000-RM8,499
	RM8500-RM9,999
	Lebih daripada RM10,000

7. Adakah anda telah memiliki kediaman sendiri?
   *kediaman sendiri bermaksud kediaman yang dibeli, tidak termasuk disewa dari pihak lain

	Ya
	Tidak

8. Jika Ya, berapa bijikah kediaman yang dimiliki oleh anda?

	1
	Lebih dari 1

9. Adakah pasangan anda (bagi yang sudah berkahwin sahaja) memiliki kediaman sendiri?
   *kediaman sendiri bermaksud kediaman yang dibeli, tidak termasuk disewa dari pihak lain

	Ya

	Tidak

10. Jika Ya, berapa bijikah kediaman yang dimiliki oleh pasangan anda?

	1
	Lebih dari 1

11. Berapakah harga rumah yang dirasakan mampu milik?

	Kurang daripada RM100,000
	RM101,000-RM199,000
	RM200,000-RM299,000
	RM300,000-RM399,000
	Lebih daripada RM400,000

12. Jenis kediaman apakah yang menjadi kecenderungan tuan/puan beli?

	Teres berangkai
	Semi-D
	Banglo
	Apartment
	Teres berangkai dua tingkat

13. Dengan harga rumah yang dirasakan mampu milik (seperti di soalan 1), apakah nilai-nilai dibawah dirasakan perlu diambil kira?

	Jarak dari rumah ke kilang (mengambil kira pencemaran bunyi dan bau)
	Jarak dari rumah ke taman rekreasi
	Jarak dari rumah ke tempat kerja
	Jarak dari rumah ke sekolah
	Jumlah bilik tidur

14. Jika jarak dari rumah ke kilang diambil kira, berapakah jarak minimum yang diingini?

	Kurang dari 10KM
	10.1KM-20KM
	20.1KM-30KM
	30.1KM-40KM
	Lebih daripada 40

	Kurang dari 10KM

15. Jika jarak dari rumah ke taman rekreasi diambil kira, berapakah jarak yang diingin untuk sampai ke taman rekseasi itu?

	Kurang dari 10KM
	10.1KM-20KM
	20.1KM-30KM
	30.1KM-40KM
	Lebih daripada 40

16. Berapakah jarak yang diingini dari rumah ke sekolah dengan harga rumah yang dibayar?

	Kurang dari 10KM
	10.1KM-20KM
	20.1KM-30KM
	30.1KM-40KM
	Lebih daripada 40

17. Berapakah jarak yang diingini dari rumah ke tempat kerja dengan harga rumah yang mampu dibayar?

	Kurang dari 10KM
	10.1KM-20KM
	20.1KM-30KM
	30.1KM-40KM
	Lebih daripada 40
	Kurang dari 10KM

18. Berapakah jumlah bilik tidur yang diingini, dengan mengambil kira harga rumah yang mampu dibayar?

	2
	3
	4
	Lebih daripada 4

19. Adakah reputasi pemaju memainkan peranan penting dalam rancangan anda untuk membeli rumah?

	Ya
	Tidak

20. Jika ya, reputasi pemaju yang menyediakan rumah yang bagaimanakah yang menjadi keutamaan anda?

	Pemaju yang tersenarai dalam 10 pemaju terbaik di Malaysia
	Pemaju yang tidak tersenarai dalam 10 pemaju terbaik di Malaysia
	Pemaju yang mempunyai koloborasi dengan kerajaan
	Tidak berkaitan

Appendix B

Interview Transcribe

Semi structured interview was held with the private developers that in this written thesis we represent it with 'Developer A' and 'Developer B'. The questions the researcher asked were:

1) Can you briefly tell me about your company?
2) What is the new housing project of your company?
3) Where do your company cover the housing development? Which region?
4) What type of housing did your company build?
5) How about the current market price of housing?
6) How is your company determining the house price? Which factors you are consider?
7) Based on question 6, with such house price, is there any objective the company must obey, such as profit from sale must be approximately 30% of the house price or for instance, land cost must not exceed RM7000?

Transcribe interview with Developer A

Q: can you briefly tell me about your company?

A: Our Company have three offices, they are placed at Kuala Ketil, Sungai Petani and here (Jitra). Our township at Kuala Ketil will develops project at the area of Kuala Ketil, and it same goes to Sungai Petani and here (Jitra), which develops

project according to corresponding place. Here, our new housing project is at Jitra Lake.

Q: Is type of housing is built according to place? Or it is accordance to target customer?

A: Usually semi-D type of house is built for middle income (earner), double storey terrace is also for middle income, but we have double storey terrace at lake home which cost RM700,000 and above. This kind of house will have high income target customer. We also built for low income earner, but the project is by next year.

Q: What is the new housing project of your company?

A: Until now, the ongoing project is lake home project, which I mention earlier. One unit of house is cost RM700,000 and above. For medium (middle income earner), we will run the project next year, if follows the plan, the project will launch in March. Here, we only cover housing project in Jitra, while our townships will cover their place.

Q: Is there any customer complaint about house price?

A: Until now, the house that we sell is on affordable price. For example, double storey terrace is cost RM280,000. We can't get this price at other company. The price that we offer now is the price that other company offer for the last two years. So the house price we offer now is quite cheap than other developer.

Q: How about the current market of house?

A: At first, we will get information about market price that offered by other developers, so that we can set the suitable price. We don't want to set it too low or too high.

Q: How is your company determine the house price?

A: We will do a discussion. We have QS (quantity surveyor), who will study from all aspects. We don't blindly set the price. QS will counts from aspect of construction, contractor, and so on. We will determine the price from it. There are certain things that we consider, that are land cost, built up cost, architect design, and competitor analysis. The construction cost is plus with GST (good and services tax) that is for goods like brick and so on.

Q: So, there are several factors that your company take into consideration in order to get house price. Can you explain in specific about it? For example for a house price to be at RM190,000, what do your company needs to fulfil? The land cost must not exceed about how much? And maybe there are objective like profit that company must achieve?

A: That's all is under QS authority. I will answer it based on data that I get. For a house to be at RM280,000, land cost is at most 6,000, construction cost is RM120,000 and professional fees is RM45,900. The profit we get only when the sales hit the ROI (return of investment).

Q: So there is no such percent of profit that the company set up?

A: Yes. There is no such thing. It is because we (the company) fall under Perbadanan Kemajuan Negeri Kedah authority, so we can't sell too expensive. But for the RM280,000 house that I just mention, we get profit about 14% of total development cost, which about RM2M.

Q: Is there any collaboration between your company and government in housing development? Such as getting project from PR1MA?

A: Here, no. But we have one at our township at Kuala Ketil. But it is still in consideration.

Q: So, if there are collaboration with the government, how private developer makes profit? And how much the government get?

A: Sorry. We don't have the information.

Q: Ok madam, thank you for your cooperation. Your information is very helpful and I'm highly appreciated it. Thank you very much.

Developer B

Q: Good evening sir. Firstly I would like to thank you for your willing to be interviewed. I will start the interview session. Can you briefly tell about your company?

A: Good morning and welcome. Our company is a 100% local company that run housing project in Kota Setar. Our company acts as developer and contractor. We haven't have sub to other company. So, our company will built and sell by ourselves.

Q: What is the new housing project of your company?

A: Now, we have project in Taman Kenyalang in Alor Malai. Before this, we built house in Taman Seri Astana Fasa 1 and Fasa 2, in front of Hospital Sultanah Bahiyah. And also, we have project in Taman Taqwa in Sungai Mati. Currently, we concentrate in Kota Setar. In future, we intent to jump into Selangor's market, which is now is in process of land acquirement. We also will join industry of hotel in Langkawi.

Q: What type of housing did your company built?

A: Until now, we built landed house. We haven't built apartment. That (type) may be in future. We built double storey terrace hyperlink, single storey semi-D, double storey semi-D, and detached house.

Q: How about the current market price of housing?

A: The house that we built is in range of RM300,000-RM400,000. Our target customer, averagely from public sector worker. Public sector has qualification to make loan at bank within range of RM280,000-RM350,000. That is the reason. Private sector worker have trouble in housing loan, unless they are businessman or professional line like an architect.

Q: So you are saying the current price is for middle income earner and high income earner?

A: Yes. 3 over 4 of the sales is coming from public sector worker like school teacher and lecturer. Otherwise, the bank officer, businessman, and so on. But mostly they buy for assets.

Q: How is your company determine the house price? Which factors you are consider?

A: Regarding the price, we have several factors we have consider. The most important factor is land. It is because the increment of land price is quite fast. It applied to land in Kota Setar. The other factor is raw material. Raw material is like metal and brick. The third factor is labor cost. We have use Indonesian worker because of the expertise that they have in building construction. So, that are three factors that directly to house price determination.

Q: That three factors are the major factor?

A: Yes. Other factor can be policy from government. For example, the land premium. If we want to convert the land from agricultural type to building type, the premium that involve need to pay to authority such as city council and land office. Overall, before we start a project, that mean, we start piling, we must ready for budget about RM1M+. The payment for authority, consultant, lawyer, and so on is fall under the budget. Land matter also fall under the budget. That budget is exclude the case if we make loan from bank to buy the land. We have to pay for the interest also. So, those are factors that we consider. One more thing, when we are local company, we have many robust competitor. So we have to build quality house with reasonable price.

Q: For instance for the house with price of RM300,000-RM350,000 that you mention earlier, with such house price, how much profit that your company must have?

A: It depends on the company. Usually government will take profit about 20-30% of total development cost. That is the case if we sub to other contractor. Because we have to pay high to contractor, considering the contractor also profitable party.

Q: How about the land? How much it cost for RM300,000-RM350,000 house per unit?

A: For one hollow land (2877.64m^2) we can build about 6 units house, approximately. So we estimate it about RM100,000 for 6 units of house, including raw material. So, the company might will have RM100,000 profit at most. But usually, it is less than that.

Q: Is your company have collaboration with the government?

A: Until now, no. We just have to get certificate from the government once we complete the project. For example, Alor Setar council city will gives us certificate to validate that the project has finish. That is all.

Q: Do you have information regarding collaboration between private developer and government?

A: Currently, the government trail the private developer to build 70% affordable house of a housing project. For example, if we build 100 units of house, 70 of it must be affordable house, which is RM200,000 and below, per unit. We cannot get profit if this is happen. Only Kedah subsidiary can implement this. If the government command to implement this, we only can get profit on high end house, which is will cover the loss from sale of affordable house. But the policy has not been necessitate.

Q: So how the government will make profit from PR1MA? How much will they get, and how much will the private developer get?

A: We (private developer) get no profit, unless we build less quality house.

Q: So, the government do not give hand in the development? For instance, in stage of land acquirement?

A: No

Q: Is the government only advocate the project, and the private developer will gain profit from sales?

A: Yes. The private developer will gain profit from the sale, and the government will only get the brand. It is because the government is non-profitable party. But, the government will gain from land premium, just in case the land was originally for agricultural, and need to be converted to building development type.

Q: How spacious is required for a land to build a unit of house?

A: For semi detach home, less or more is about 2800 feet^2. It is the standard rate, and it is about to same with any other company.

Q: Ok sir. Thank you for your valuable time. Your cooperation is most appreciate.

A: You are welcome.

Appendix C

Lingo Model

```
MODEL:

SETS:

GAME/G1..G386/:X,ACCEPTBUY,SALARY;
W/1 2 3/:;
PLAYER/BY PD G/:;
FACTOR/SCHOOL WORK RETAIL/:;
GAME_PLAYER(GAME, PLAYER):HOUSEPRICE,N,P;


VARIABLE/TC LANDPRICE CONSTRUCTION TLANDDEVELOPERPAY LANDTRANSFER
TPDPAY UNEMPLOYMENTRATE PERCAPITAINCOME TOTALLOANSTOHOUSING
KLSECOMPOSITEINDEX HPI HPBASE URBAN SUBURBAN RURAL LOWCOSTFLAT
CLUSTERHOUSE TOWNHOUSE CONDO LOWCOSTHOUSE OST TST TSSD OSSD  D
ACCEPTED NOTACCEPTED/:;

ENDSETS


DATA:

!IMPORT DATA FROM EXCEL;
HOUSEPRICE,SALARY=
@OLE('C:\Users\USER\Documents\syuhada\nov2017\11march2018.xlsx','HOU
SEPRICE','SALARY');

TLANDDEVELOPERPAY=0.2;
TPDPAY=0.2;
TC=70000;
PERCAPITAINCOME=0.008408;
KLSECOMPOSITEINDEX=1715.61;
TOTALLOANTOHOUSING=955.5556;
HPBASE=300000;

W2=0.20; !WORK;
W3=0.42; !RO;!
W1=0.38; !SCHOOL;!

!EXPORT DATA TO EXCEL;
@OLE('C:\Users\USER\Documents\syuhada\nov2017\11march2018.xlsx','PRI
CE1','ACCEPTANCE')=X,ACCEPTBUY;


ENDDATA

MIN=@SUM(GAME_PLAYER(I,J):N(I,2)+P(I,1)+P(I,3))/3;

@FOR (GAME(I):
```

```
@FOR (GAME_PLAYER(I,J):
X(I)+ N(I,J)-P(I,J)= HOUSEPRICE(I,J)));


!DEVELOPER'S PREFERENCE;

!PROFIT DEVELOPER;
!LANDTRANSFER=15% OF CURRENT MARKET VALUE OF LAND;

@FOR(GAME(I):
X>=X-(TC-LANDTRANSFER-TPDPAY*X));

LANDTRANSFER=0.15*LANDPRICE;


!LAND COST;

LANDPRICE<=0.0277*TC;

CONSTRUCTION <= 0.77*TC;

!BUYER PREFERENCE;
@FOR(GAME(I):X(I)>W1*HOUSEPRICE(
I,1)*SCHOOL+W2*HOUSEPRICE(I,1)*WORK+W3*HOUSEPRICE(I,1)*RETAIL);
@FOR(GAME(I):X(I)<1.3*@SMAX(HOUSEPRICE(I,1),HOUSEPRICE(I,2),HOUSEPRI
CE(I,3)));

HPI=-
8.423+0.0127*PERCAPITAINCOME+3.579*UNEMPLOYMENTRATE+0.00088*TOTALLOA
NSTOHOUSING+0.00372*KLSECOMPOSITEINDEX+E;

@FOR(GAME(I):X(I)>HPI/100*HPBASE);

!LOCATION CONSTRAINT;

@FOR(GAME(I):
@FOR(GAME_PLAYER(I,J):
X(I)>0.08*X(I)*RURAL+0.45*SUBURBAN*X(I)+0.47*X(I)*URBAN));
RURAL+SUBURBAN+URBAN=1;



!HOUSE TYPE CONSTRAINT;

@FOR(GAME(I):@FOR(PLAYER(I):
X>0.16*X(I)*CONDO+0.37*X(I)*OST+0.47*X(I)*TST));


CONDO+OST+TST=1;

!conditional;

@FOR(GAME(I):
@FOR(GAME_PLAYER(I,J):
@BIN(ACCEPTBUY);
```

```
ACCEPTBUY(I)=@IF(X#GT#SALARY(I),0,1)); !BUYER CONDITIONAL,
1=ACCEPT, 0=NOT ACCEPT;



END
```

Appendix D

Excel Data

SIMULATION	SALARY	SALARY X 3	BUYER	DEVELOPER	GOV
S1	4559	164124	101000	250000	129181
S2	5174	186264	101000	250000	171944
S3	4042	145512	101000	250000	212319
S4	7086	255096	300000	250000	331062
S5	3243	116748	200000	250000	314555
S6	5783	208188	101000	250000	268991
S7	4076	146736	300000	250000	136859
S8	9897	356292	200000	250000	130159
S9	4091	147276	200000	250000	361043
S10	8601	309636	101000	250000	353973
S11	3881	139716	101000	250000	232705
S12	7342	264312	200000	250000	347832
S13	4869	175284	101000	250000	196197
S14	4496	161856	101000	250000	121860
S15	5152	185472	101000	250000	377360
S16	5145	185220	101000	250000	134906
S17	9951	358236	101000	250000	225404
S18	8023	288828	200000	250000	314125
S19	9304	334944	101000	250000	186922
S20	9264	333504	101000	250000	332345
S21	8389	302004	101000	250000	356924
S22	4021	144756	101000	250000	305110
S23	4735	170460	101000	250000	354469
S24	9717	349812	101000	250000	175680
S25	9820	353520	200000	250000	333483
S26	7588	273168	101000	250000	327417
S27	4087	147132	101000	250000	384699
S28	2931	105516	101000	250000	198602
S29	6546	235656	101000	250000	216214
S30	7485	269460	101000	250000	236434
S31	4644	167184	101000	250000	276559
S32	5361	192996	101000	250000	151468
S33	6150	221400	101000	250000	226434
S34	3253	117108	101000	250000	199718
S35	9534	343224	200000	250000	209662

S36	7508	270288	200000	250000	187968
S37	8148	293328	300000	250000	365090
S38	5298	190728	101000	250000	362581
S39	6473	233028	101000	250000	255402
S40	8193	294948	101000	250000	249089
S41	7121	256356	200000	250000	309599
S42	7290	262440	300000	250000	262871
S43	8000	288000	300000	250000	171281
S44	7606	273816	101000	250000	210299
S45	5221	187956	200000	250000	205634
S46	9836	354096	200000	250000	240954
S47	3040	109440	200000	250000	158086
S48	4455	160380	200000	250000	264098
S49	8843	318348	101000	250000	398578
S50	2948	106128	101000	250000	337336
S51	3376	121536	101000	250000	367259
S52	4061	146196	101000	250000	154307
S53	6111	219996	101000	250000	168940
S54	6741	242676	101000	250000	383483
S55	3165	113940	300000	250000	340324
S56	6917	249012	101000	250000	244056
S57	3231	116316	200000	250000	381625
S58	8125	292500	200000	250000	171734
S59	8370	301320	200000	250000	212836
S60	9378	337608	200000	250000	123100
S61	2514	90504	120001	250000	203091
S62	8613	310068	350000	250000	235955
S63	6400	230400	250000	250000	121805
S64	9754	351144	250000	250000	298639
S65	8079	290844	120001	250000	223531
S66	6494	233784	150000	250000	348488
S67	3063	110268	150000	250000	318421
S68	4307	155052	120001	250000	353971
S69	6349	228564	85001	250000	246706
S70	7707	277452	250000	250000	263902
S71	6495	233820	250000	250000	385956
S72	9489	341604	250000	250000	173648
S73	9953	358308	250000	250000	173533
S74	5595	201420	250000	250000	247689
S75	3836	138096	500000	250000	370716
S76	5724	206064	85001	250000	235376
S77	4466	160776	350000	250000	197020

S78	7476	269136	350000	250000	145820
S79	9370	337320	250000	250000	322775
S80	4818	173448	250000	250000	310131
S81	9086	327096	250000	250000	380706
S82	6487	233532	350000	250000	228647
S83	7226	260136	350000	250000	216741
S84	9948	358128	250000	250000	343498
S85	5828	209808	250000	250000	164057
S86	7851	282636	350000	250000	336164
S87	3912	140832	250000	250000	160276
S88	4856	174816	350000	250000	235843
S89	7738	278568	150000	250000	210251
S90	5375	193500	350000	250000	394129
S91	8769	315684	250000	250000	160762
S92	9142	329112	250000	250000	391628
S93	6892	248112	350000	250000	296100
S94	2728	98208	250000	250000	269049
S95	8358	300888	120000	250000	351318
S96	6570	236520	120001	250000	200728
S97	5109	183924	120001	250000	151601
S98	7355	264780	120001	250000	358475
S99	7933	285588	85001	250000	245322
S100	6500	234000	150000	250000	196691
S101	6405	230580	250000	250000	320364
S102	7657	275652	350000	250000	250853
S103	8901	320436	120001	250000	325288
S104	4521	162756	250000	250000	180089
S105	8778	316008	350000	250000	332318
S106	7610	273960	250000	250000	340639
S107	3698	133128	350000	250000	131751
S108	4934	177624	120000	250000	174905
S109	3581	128916	350000	250000	225213
S110	6431	231516	350000	250000	200513
S111	8854	318744	250000	250000	235633
S112	7488	269568	250000	250000	358778
S113	7286	262296	85001	250000	387261
S114	5316	191376	120000	250000	226095
S115	7974	287064	85000	250000	339148
S116	7430	267480	120001	250000	180506
S117	8394	302184	120001	250000	214018
S118	9442	339912	250000	250000	273734
S119	9417	339012	350000	250000	157083

S120	8999	323964	250000	250000	209039
S121	9293	334548	350000	250000	372816
S122	6223	224028	250000	250000	246307
S123	5807	209052	350000	250000	133878
S124	9345	336420	120000	250000	146199
S125	3832	137952	85001	250000	202694
S126	2803	100908	250000	250000	297226
S127	6569	236484	85001	250000	303063
S128	8631	310716	350000	250000	190603
S129	6936	249696	150000	250000	358955
S130	7596	273456	150000	250000	289643
S131	8096	291456	150000	250000	169794
S132	2615	94140	250000	250000	163249
S133	6111	219996	120000	250000	214908
S134	6745	242820	150000	250000	216602
S135	2891	104076	120001	250000	228069
S136	8427	303372	120001	250000	177325
S137	4644	167184	250000	250000	134433
S138	7666	275976	500000	250000	355728
S139	4681	168516	250000	250000	317906
S140	7610	273960	500000	250000	145514
S141	4003	144108	500000	250000	182337
S142	6605	237780	500000	250000	303814
S143	8164	293904	500000	250000	360581
S144	8685	312660	500000	250000	126379
S145	6355	228780	500000	250000	278579
S146	6066	218376	500000	250000	142888
S147	4231	152316	500000	250000	194516
S148	6567	236412	500000	250000	175865
S149	8237	296532	500000	250000	301714
S150	2804	100944	500000	250000	372823
S151	7326	263736	500000	250000	347107
S152	2617	94212	350000	250000	216463
S153	3106	111816	250000	250000	134095
S154	8976	323136	250000	250000	155688
S155	9216	331776	150000	250000	364079
S156	6595	237420	150000	250000	372503
S157	4477	161172	85001	250000	383998
S158	9242	332712	85001	250000	151846
S159	7218	259848	150001	250000	129925
S160	7599	273564	350000	250000	331256
S161	5099	183564	250000	250000	361808

S162	3969	142884	250000	250000	151183
S163	8879	319644	250000	250000	268147
S164	7689	276804	250000	250000	233833
S165	6293	226548	150000	250000	159054
S166	5959	214524	120001	250000	164438
S167	4645	167220	250000	250000	378644
S168	6138	220968	250000	250000	250608
S169	9496	341856	120001	250000	336176
S170	7865	283140	85001	250000	140999
S171	8482	305352	85001	250000	151959
S172	8635	310860	150000	250000	177705
S173	9771	351756	150000	250000	369699
S174	6761	243396	150000	250000	314967
S175	2553	91908	85000	250000	146158
S176	9303	334908	350000	250000	270997
S177	9877	355572	150000	250000	279926
S178	4230	152280	150000	250000	149625
S179	9428	339408	120000	250000	267864
S180	5326	191736	150000	250000	246295
S181	4082	146952	150000	250000	269871
S182	3337	120132	120001	250000	230482
S183	5719	205884	250000	250000	254980
S184	7074	254664	500000	250000	286051
S185	6972	250992	350000	250000	346011
S186	4909	176724	120001	250000	370687
S187	7359	264924	350000	250000	257127
S188	3788	136368	250000	250000	386069
S189	9848	354528	250000	250000	349988
S190	7001	252036	120001	250000	246872
S191	7180	258480	150000	250000	393455
S192	8310	299160	150000	250000	150945
S193	7335	264060	120001	250000	241325
S194	3690	132840	101000	350000	155892
S195	7161	257796	101000	350000	173815
S196	2982	107352	101000	350000	269647
S197	7990	287640	300000	350000	243143
S198	7736	278496	200000	350000	285180
S199	5434	195624	101000	350000	157026
S200	4027	144972	300000	350000	292307
S201	8845	318420	200000	350000	390942
S202	3573	128628	200000	350000	346534
S203	2731	98316	101000	350000	345265

S204	4158	149688	101000	350000	316256
S205	2693	96948	200000	350000	358986
S206	4143	149148	101000	350000	235953
S207	5594	201384	101000	350000	241470
S208	6507	234252	101000	350000	121431
S209	2938	105768	101000	350000	220046
S210	6110	219960	101000	350000	181359
S211	7395	266220	200000	350000	215427
S212	3547	127692	101000	350000	232084
S213	9220	331920	101000	350000	397104
S214	6815	245340	101000	350000	145027
S215	9586	345096	101000	350000	275874
S216	3279	118044	101000	350000	152800
S217	3193	114948	101000	350000	333543
S218	6188	222768	200000	350000	236511
S219	4641	167076	101000	350000	303168
S220	9181	330516	101000	350000	253756
S221	8721	313956	101000	350000	216027
S222	8045	289620	101000	350000	257365
S223	4722	169992	101000	350000	302531
S224	5555	199980	101000	350000	278234
S225	4036	145296	101000	350000	278072
S226	9421	339156	101000	350000	361727
S227	7491	269676	101000	350000	213145
S228	6996	251856	200000	350000	218139
S229	4610	165960	200000	350000	237533
S230	3655	131580	300000	350000	130437
S231	9746	350856	101000	350000	394252
S232	5256	189216	101000	350000	345161
S233	9698	349128	101000	350000	266081
S234	8920	321120	200000	350000	208429
S235	5550	199800	300000	350000	191591
S236	4068	146448	300000	350000	348792
S237	9241	332676	101000	350000	283733
S238	2695	97020	200000	350000	167416
S239	8151	293436	200000	350000	277809
S240	9823	353628	200000	350000	329818
S241	9436	339696	200000	350000	140467
S242	4496	161856	101000	350000	181806
S243	3816	137376	101000	350000	166257
S244	6177	222372	101000	350000	302944
S245	6320	227520	101000	350000	389237

S246	4226	152136	101000	350000	246212
S247	8583	308988	101000	350000	148635
S248	4796	172656	300000	350000	337437
S249	2592	93312	101000	350000	309109
S250	5675	204300	200000	350000	349216
S251	4570	164520	200000	350000	391877
S252	6400	230400	200000	350000	151837
S253	6865	247140	200000	350000	199129
S254	5871	211356	120001	350000	340638
S255	2523	90828	350000	350000	158062
S256	6706	241416	250000	350000	263719
S257	7174	258264	250000	350000	372063
S258	9251	333036	120001	350000	306976
S259	5763	207468	150000	350000	121288
S260	8354	300744	150000	350000	286876
S261	7752	279072	120001	350000	265783
S262	2561	92196	85001	350000	297500
S263	7170	258120	250000	350000	340001
S264	8184	294624	250000	350000	215223
S265	2769	99684	250000	350000	339071
S266	4137	148932	250000	350000	366234
S267	9170	330120	250000	350000	159653
S268	7683	276588	500000	350000	342324
S269	7110	255960	85001	350000	147798
S270	5006	180216	350000	350000	153845
S271	7960	286560	350000	350000	291408
S272	5612	202032	250000	350000	130619
S273	6241	224676	250000	350000	222359
S274	8338	300168	250000	350000	136822
S275	3375	121500	350000	350000	399366
S276	6504	234144	350000	350000	319630
S277	6082	218952	250000	350000	132470
S278	7971	286956	250000	350000	280995
S279	9667	348012	350000	350000	256792
S280	4145	149220	250000	350000	373907
S281	2562	92232	350000	350000	398785
S282	7692	276912	150000	350000	256197
S283	6248	224928	350000	350000	212285
S284	3740	134640	250000	350000	223045
S285	8476	305136	250000	350000	166466
S286	8317	299412	350000	350000	261038
S287	4653	167508	250000	350000	385872

S288	6453	232308	120000	350000	345612
S289	4639	167004	120001	350000	206500
S290	4693	168948	120001	350000	255581
S291	7552	271872	120001	350000	150250
S292	6322	227592	85001	350000	177744
S293	6229	224244	150000	350000	130638
S294	8454	304344	250000	350000	347834
S295	5959	214524	350000	350000	335114
S296	3556	128016	120001	350000	192152
S297	8152	293472	250000	350000	206181
S298	5983	215388	350000	350000	252974
S299	8585	309060	250000	350000	249231
S300	5394	194184	350000	350000	344923
S301	9338	336168	120000	350000	154948
S302	7306	263016	350000	350000	216877
S303	3836	138096	350000	350000	139808
S304	8137	292932	250000	350000	263491
S305	6247	224892	250000	350000	142879
S306	9131	328716	85001	350000	271928
S307	3437	123732	120000	350000	152186
S308	6370	229320	85000	350000	172549
S309	5284	190224	120001	350000	217590
S310	2742	98712	120001	350000	284278
S311	4223	152028	250000	350000	224557
S312	7375	265500	350000	350000	274010
S313	4089	147204	250000	350000	165945
S314	9213	331668	350000	350000	343231
S315	3345	120420	250000	350000	350707
S316	9935	357660	350000	350000	317951
S317	8303	298908	120000	350000	209949
S318	3198	115128	85001	350000	304784
S319	6881	247716	250000	350000	323212
S320	4333	155988	85001	350000	311041
S321	8902	320472	350000	350000	187920
S322	6220	223920	150000	350000	140499
S323	7258	261288	150000	350000	228733
S324	3200	115200	150000	350000	348299
S325	5105	183780	250000	350000	171615
S326	3619	130284	120000	350000	129388
S327	8849	318564	150000	350000	363230
S328	8517	306612	120001	350000	157295
S329	3507	126252	120001	350000	377598

S330	5506	198216	250000	350000	221969
S331	2849	102564	500000	350000	278996
S332	8713	313668	250000	350000	154630
S333	2784	100224	500000	350000	188517
S334	3263	117468	500000	350000	281700
S335	3119	112284	500000	350000	349701
S336	3058	110088	500000	350000	227207
S337	4658	167688	500000	350000	365795
S338	6179	222444	500000	350000	392601
S339	5377	193572	500000	350000	335119
S340	9058	326088	500000	350000	253074
S341	3465	124740	500000	350000	288142
S342	3871	139356	500000	350000	248921
S343	9484	341424	500000	350000	391112
S344	3458	124488	500000	350000	374206
S345	3713	133668	350000	350000	204816
S346	5449	196164	250000	350000	226527
S347	4917	177012	250000	350000	384671
S348	5985	215460	150000	350000	299593
S349	4605	165780	150000	350000	200108
S350	7834	282024	85001	350000	254426
S351	3717	133812	85001	350000	321665
S352	3387	121932	150001	350000	218175
S353	6005	216180	350000	350000	354177
S354	7616	274176	250000	350000	292181
S355	3150	113400	250000	350000	193096
S356	9783	352188	250000	350000	349738
S357	2713	97668	250000	350000	335219
S358	5185	186660	150000	350000	185315
S359	8289	298404	120001	350000	381992
S360	3155	113580	250000	350000	335397
S361	9080	326880	250000	350000	280368
S362	8102	291672	120001	350000	197827
S363	4987	179532	85001	350000	269674
S364	4846	174456	85001	350000	394418
S365	7519	270684	150000	350000	370946
S366	3425	123300	150000	350000	267876
S367	6694	240984	150000	350000	221227
S368	9748	350928	85000	350000	347360
S369	2978	107208	350000	350000	315779
S370	7623	274428	150000	350000	203534
S371	8536	307296	150000	350000	339277

S372	7854	282744	120000	350000	376610
S373	7901	284436	150000	350000	152396
S374	5952	214272	150000	350000	167627
S375	7815	281340	120001	350000	214317
S376	7935	285660	250000	350000	144400
S377	3659	131724	500000	350000	329026
S378	7439	267804	350000	350000	212067
S379	6009	216324	120001	350000	229169
S380	5976	215136	350000	350000	298015
S381	4839	174204	250000	350000	335227
S382	6645	239220	250000	350000	249870
S383	5998	215928	120001	350000	136091
S384	2995	107820	150000	350000	260093
S385	3186	114696	150000	350000	232503
S386	3972	142992	120001	350000	181960

Appendix E

Agreed House price

SIMULATION	SALARY	SALARY X 3	BUYER	DEVELOPER	GOV	AGREED PRICE
S1	4559	164124	101000	250000	129181	101001.2
S2	5174	186264	101000	250000	171944	101001.2
S3	4042	145512	101000	250000	212319	101001.2
S4	7086	255096	300000	250000	331062	250001.2
S5	3243	116748	200000	250000	314555	200001.2
S6	5783	208188	101000	250000	268991	101001.2
S7	4076	146736	300000	250000	136859	205691.2
S8	9897	356292	200000	250000	130159	159948.2
S9	4091	147276	200000	250000	361043	196368.2
S10	8601	309636	101000	250000	353973	101001.2
S11	3881	139716	101000	250000	232705	101001.2
S12	7342	264312	200000	250000	347832	200001.2
S13	4869	175284	101000	250000	196197	101001.2
S14	4496	161856	101000	250000	121860	101001.2
S15	5152	185472	101000	250000	377360	101001.2
S16	5145	185220	101000	250000	134906	101001.2
S17	9951	358236	101000	250000	225404	101001.2
S18	8023	288828	200000	250000	314125	146616.2
S19	9304	334944	101000	250000	186922	101001.2
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S21	8389	302004	101000	250000	356924	101001.2
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S26	7588	273168	101000	250000	327417	101001.2
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S28	2931	105516	101000	250000	198602	101001.2
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S39	6473	233028	101000	250000	255402	101001.2
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S41	7121	256356	200000	250000	309599	200001.2
S42	7290	262440	300000	250000	262871	250001.2
S43	8000	288000	300000	250000	171281	250001.2
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S75	3836	138096	500000	250000	370716	121396.2
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S165	6293	226548	150000	250000	159054	150000
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S345	3713	133668	350000	350000	204816	350000
S346	5449	196164	250000	350000	226527	250001.2
S347	4917	177012	250000	350000	384671	169333.2
S348	5985	215460	150000	350000	299593	129049.2
S349	4605	165780	150000	350000	200108	150001.2
S350	7834	282024	85001	350000	254426	85002.23
S351	3717	133812	85001	350000	321665	85002.23
S352	3387	121932	150001	350000	218175	150002.2
S353	6005	216180	350000	350000	354177	350000
S354	7616	274176	250000	350000	292181	250001.2
S355	3150	113400	250000	350000	193096	127358.2
S356	9783	352188	250000	350000	349738	250001.2
S357	2713	97668	250000	350000	335219	250001.2
S358	5185	186660	150000	350000	185315	150001.2
S359	8289	298404	120001	350000	381992	120002.2
S360	3155	113580	250000	350000	335397	250001.2
S361	9080	326880	250000	350000	280368	250001.2
S362	8102	291672	120001	350000	197827	120002.2
S363	4987	179532	85001	350000	269674	85002.23
S364	4846	174456	85001	350000	394418	85002.23
S365	7519	270684	150000	350000	370946	150001.2
S366	3425	123300	150000	350000	267876	150001.2
S367	6694	240984	150000	350000	221227	150001.2
S368	9748	350928	85000	350000	347360	85001.23
S369	2978	107208	350000	350000	315779	124777.2
S370	7623	274428	150000	350000	203534	150001.2
S371	8536	307296	150000	350000	339277	150001.2

S372	7854	282744	120000	350000	376610	120001.2
S373	7901	284436	150000	350000	152396	150001.2
S374	5952	214272	150000	350000	167627	150001.2
S375	7815	281340	120001	350000	214317	120002.2
S376	7935	285660	250000	350000	144400	250001.2
S377	3659	131724	500000	350000	329026	341040.2
S378	7439	267804	350000	350000	212067	127017.2
S379	6009	216324	120001	350000	229169	120002.2
S380	5976	215136	350000	350000	298015	350000
S381	4839	174204	250000	350000	335227	250001.2
S382	6645	239220	250000	350000	249870	250001.2
S383	5998	215928	120001	350000	136091	120002.2
S384	2995	107820	150000	350000	260093	150001.2
S385	3186	114696	150000	350000	232503	150001.2
S386	3972	142992	120001	350000	181960	120002.2

Appendix F

Letter of Permission

To whom it may concern,

Dear Sir/Madam,
I am a lecture and a researcher at the Faculty of Quantitative Science, Universiti Utara Malaysia (UUM).

My research aims to develop a model of house price determination using integrated technique of goal programming and game theory. Generally, model of house price determination is using regression analysis. Unfortunately, the regression model cannot take into account all decision makers' objective simultaneously. Therefore, in order to pursue the limitation of the model, I intend to use new model. The model expected to suggest price band of house that will be satisfied by three parties that is private developer, government and house buyer.

In order to have some information regarding the issue, your relevant experience and expertise in the housing development is required. The opinion and data collected will be confidential without mentioning to a specific person/party.

Should you have any question regarding this research, you may contact me or my co, Dr Intan Saniah binti Sulaiman at norintan@uum.edu.my.

Your cooperation and contribution of this research is mostly appreciated

Yours Sincerely,

Dr. Nerda Zura binti Zaibidi,
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Endorsed By,

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Appendix G

Fuzzy Rule

No.	Household Income	House price	Affordability
1	IC_1	Low	Low price
2	IC_1	Medium	High price
3	IC_1	High	High price
4	IC_2	Low	Low price
5	IC_2	Medium	High price
6	IC_2	High	High price
7	IC_3	Low	Low price
8	IC_3	Medium	High price
9	IC_3	High	High price
10	IC_4	Low	Low price
11	IC_4	Medium	High price
12	IC_4	High	High price
13	IC_5	Low	Low price
14	IC_5	Medium	Low price
15	IC_5	High	High price
16	IC_6	Low	Low price
17	IC_6	Medium	Low price
18	IC_6	High	Low price