# The Utilization of System Dynamics for House Pricing Analysis in Malaysia

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**Abstract— An increasing demand for residential housing has been a debate globally due to rapid economic development, particularly in Malaysia. The housing price appreciation showed steep increase both in urban and rural areas. Therefore, most of the people are afraid that they are unable to cope with such a high property prices. Even with the housing prices almost hitting the sky, yet the real factors as well as its causal effects are still open to question. Thus, this paper presents a system dynamics model of housing prices in Malaysia to identify the causality among related factors. The model expects the rising of population and strong growth in inflation in the long run that will affect housing prices significantly. As this dynamic model is expected to portray the main interacting variables, their causal effects can provide guideline for better intervention measures, in particular for the policy improvement in near future.**

***Keywords***— *house affordability, house pricing, system dynamics*

## 1. Introduction

In recent years, rapid economic development has resulted in an increasing demand for residential housing in Malaysia. Such pressure brings together issues in housing sector, namely informal housing or slum settlements [1]-[4], social issues [5]-[6], housing development [7]-[9], and housing affordability [10]-[12], to name only a few. As house is the largest single asset of most households, with its value represents important component of aggregate portfolio of financial intermediaries, understanding the key elements of housing prices able to provide the central banks with better knowledge to the performance of its financial system [13].

Reviewing the housing prices in Malaysia, we can see that the prices have appreciated dramatically whether in major cities as well as in smaller towns and rural areas. To date, Malaysia's average house price was currently at RM 387, 258 in the year of 2016, RM334,000 for terrace house and RM336,000 for high rises house [14]. In addition, referring to Table 1, a house price-to-income ratio of 6.17 times that puts Malaysia on the "severely unaffordable" scale based on median multiple methods [15]. Such condition primarily resulted from a gross mismatch between housing supply and demand from diverging expectations between households and developers [16], [17]. From the perspective of supply side, cyclical factor and structural factor are contributed to the market failure. This situation served an adequate supply of affordable houses in Malaysia [17][18]. On the other hand, on demand side, they claimed that the growth in household income are not kept up with the increase in house price. They also pointed out that from 2016 - Q12017, although 35% Malaysian households can afford houses priced up to RM250,000, only 24% of new launches were in that range, indicating the undersupply of affordable homes.

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**Table 1.** Housing Affordability Rating

| Housing Affordability | Median |
|---|---|
| Severely Unaffordable | 5.1 and over |
| Seriously Unaffordable | 4.1 to 5.0 |
| Moderately | 3.1 to 4.0 |
| Affordable | 3.0 and under |

* Median multiple: Median house price divided by median household income
Source: Demographia International Housing Affordability Survey, 2016

Referring to Table 2, to offer viewpoint, the most expensive housing in Malaysia can be found in Kuala Lumpur, with house prices averaging to RM 747,391 in the third quarter of 2016. Whereas in Perlis, on the other hand, had the meanest housing price with an average price of RM153,472 respectively. This price hike affects the society and standard living among citizen, also provides unhealthy outlook into Malaysian economy. Therefore, most of the people are afraid that they are unable to cope with such a high property prices.

**Table 2.** House price to income ratio in Peninsular Malaysia

| States | House price to income ratio |
|---|---|
| Kuala Lumpur | 6.88 |
| Penang | 6.32 |
| Selangor | 5.10 |
| Terengganu | 4.79 |
| Pahang | 4.67 |
| Johor | 5.51 |
| Kedah | 4.28 |
| Kelantan | 4.26 |
| Negeri Sembilan | 4.09 |
| Perak | 3.99 |
| Perlis | 3.26 |
| Melaka | 2.43 |

Even with the housing prices almost hitting the sky, yet the real factors as well as its causal effects are still open to question. Among contributing factors involved in determining housing price in Malaysia [19] includes population, demand, supply, location, neighbourhood, physical characteristic, accessibility, developer, cost of material and land, and income. Whereas, the perspective are divided into three categories – policy maker, developer and buyer. Thus, this paper presents a system dynamics model of housing prices in Malaysia to identify the causality among related variables. The dynamic model is expected to portray the main interacting variables and their causal effects which the output in turn will provide a guideline for researchers as well as decision makers for policy recommendation.

## 2. Key Factors Related to House Pricing

In this study, we will investigate the key factors that relate to structural diagram of house pricing. The interrelated factors are population, inflation, liquidity and investment. These factors highlight the interconnections and feedback process embedded within the house pricing system that provide as a fundamental insight in understanding its complexity and multiplicity due to the interconnections of several variables.

### 2.1 Population

In general, the relationship between housing and population are inter-related [20]. This means that although the increasing number of population determines the housing demand, the availability of suitable and affordable housing is also key to its demand. Among research works that investigate the relationship between these factors include [21]-[24]. Identifying the local interactions between housing prices and population is complicated as these factors having simultaneous and spatially interdependent relationship. To investigate these factors using standard econometric models are unable to address the multiple identification problems that may arise from the simultaneity, spatial interaction, and unobserved spatial autocorrelation [25], thus motivate our study to utilize system dynamics that is able to extract underlying structural dynamics between the factors.

### 2.2 Inflation

House prices are important in signaling inflation since a large amount of individual wealth is embedded in houses [26]. [27] highlighted inflation, yield curve, bank credit and mortgage markets conditions in particular countries are among dependent variables for house prices. [27] examined the long-run impact of inflation on homeowner equity, specifically the relationship between house price and inflation factor based upon prices of nonhousing goods and services. Some early to recent studies also investigated inflation hedging ability of real estate. Such as [28] that focused on correlations between rates of return on real estate and inflation rates over time, [29] that examined effectiveness of inflation hedging in several scenarios, to recent works by [14][30][31], all focusing specifically on hedging on inflation via house pricing.

### 2.3 Liquidity

The standard financial theory forecasts that the level of liquidity as well as liquidity risk are priced, with support from empirical studies that find the effects of liquidity on asset prices are statistically significant and economically important as it is able to control traditional risk measures and asset characteristic. The effect of liquidity (or illiquidity) risk are able to affect investors' required return, corporations' cost of capital and the allocation of economy's real resources [32]. As there are numerous study on liquidity and asset pricing especially in microstructure and trading, we will only focusing our discussion into liquidity toward specific asset, which is real property. Such literatures include of [33]-[35], to name only a few. Ref. [36] argued that globalization affect such as injection of foreign liquidity to real estate market causes strong implication towards regional housing prices movements, thus they strongly proposed intervention from the policy makers to ease such pressure.

### 2.4 Investment

This key dimension in housing issues is normally associated with house market bubbles, in which hugely affected by the role of real estate investors. The largest scenarios of housing booms and busts, almost half of purchase mortgage originations were associated with investors [37]. A significant drop in house prices will deteriorate the balance sheet of all households in the neighborhood, thus threatens to reduce residential investment and consumer demand towards the property market [38][39]. [40][41] recognized that housing market is the single most critical part, and leads output in U.S. economy, respectively. While [42] agreed that the fast growth in housing prices and residential investment in housing sector are not just a passive reflection of macroeconomic activity, but might be one of the driving forces of business cycles. Such importance role of investment in housing sector signified by the finding of [43] that proposed strong capital formation especially in residential sector directly causes GDP growth, which in turn causes capital formation in other business sector. Such finding is also previously highlighted by [44] that warned policy maker to not funnel capital away from housing into plant and equipment acitivities as it could produce severe short-run dislocations in the U.S. economy.

The next subsection will look closely on the developmental process of system dynamics model for house pricing and identifying key factors that specifically relate to Malaysian landscape. To demonstrate the utility of system dynamics for house pricing analysis, we will constrict the scope of this research work towards two main factors, i.e. population and inflation. These factors are considered as both factors contribute directly to house pricing [45]-[47].

## 3. Methodology

Basically, the idea of the research process was derived from the system dynamics (SD) methodology comprising of problem identification, development of dynamic hypothesis, model formulation, model testing and policy recommendation [48]. Figure 1 shows the overall process followed by the description for each steps.

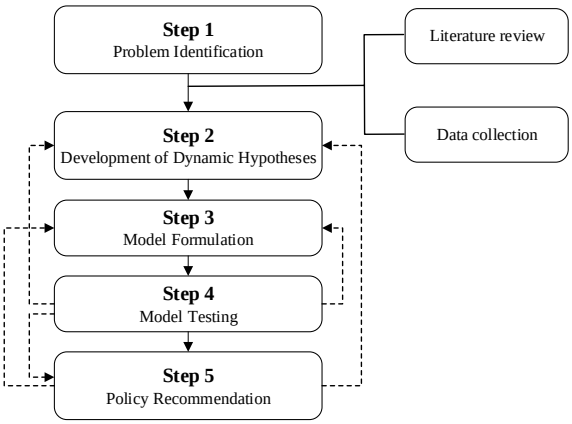


**Figure 1.** Research process

***Step 1: Problem Identification***
In this stage, the focus is to identify the problem of house pricing in Malaysia. We identified several related key variables from the literatures that were i) population, ii) inflation, iii) liquidity, and iv) investment [49]. As previously noted, we will focus our attention towards two main factors – the population and inflation.

***Step 2: Development of Dynamic Hypothesis***
Once the key variables have been identified, the next step is to develop a dynamic hypothesis of the interactions among these key variables. There are several ways to develop dynamic hypothesis such as causal loop diagram, subsystem diagram and stock and flow diagram. Due to suitability for this research problem, subsystem diagram has been used to map the key variables and its relationship in determining house prices. The subsystem diagram is shown in Figure 2.

As described in Section 2.0, four key variables were considered, namely: i) population, ii) inflation, iii) liquidity, and iv) investment. In general, changes in the number of population carries major impact to housing demand. The changes also involved underlying structural dynamics between inflation,

liquidity and investment. The shaded are showed our considered factors in this research work.

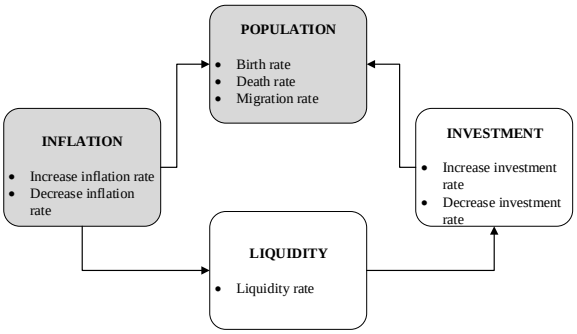


**Figure 2.** Subsystem diagram for house pricing

***Step 3: Model Development***

In this stage, the mental model which was mapped using subsystem diagram was translated into stock and flow model using Vensim software. Basically, the stock and flow model is made by stocks, inflows, outflows, valves and clouds as shown in Table 3. Stock represents as a reservoir to accumulate these elements, while, flows act as channels for transferring flow of things into and out of stocks. Inflow occurs when the flow increases and outflow occurs when the flow decreases. Valves act as the flow regulator [48]. Auxiliary acts as the intermediate between variables.

**Table 3.**
Elements in system dynamics model formulation

| Elements | Diagram notation | Functions |
|---|---|---|
| Stock | | Reservoir |
| Flow (inflow or outflow) | | Channel/connector |
| Valve | | Flow regulator |
| Clouds (source or sink) | | Stocks outside model boundary |

In this research, the identified key variables are assigned as stocks as shown in Figure 3. Stocks are represented by Malaysia population, house price and inflation. These are authors' initial key interest to explore the behaviour and trends of housing prices since these are the basic elements [45]-[47] in demonstrating the dynamic in house pricing, therefore only stock and flow model for population sector is presented in this paper. Housing prices is affected by the number of population, black market emergence, construction expenses as well as housing demand [49].

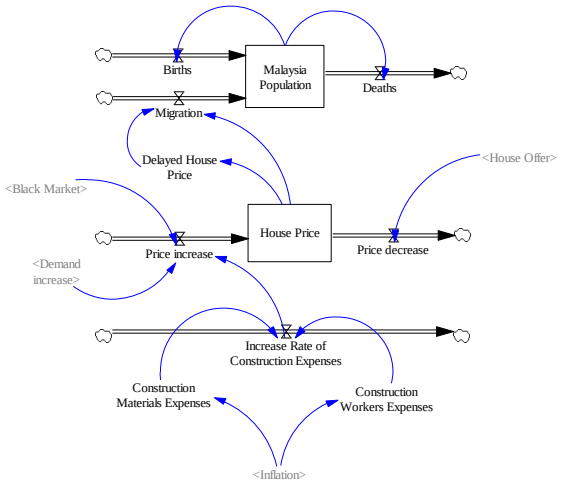


**Figure 3.** Stock and flow model for population sector

In Figure 3, we can see that the population sector consists of population and house price representing stocks of 'Malaysia Population' and 'House Price'. Flows are provided for births, deaths, migration and price changes to show the dynamics in population and house price. This sector calculates house price for each year related to the changes in the number of population. Also, in the figure, we can see that the inflation factor appears as shadow variable in population sector.

***Step 4: Model Testing***

In developing SD model, the model testing process starts in line with SD model development. This procedure is conducted to establish the robustness and stability of the developed model [48][50]-[53]. Its main purpose is to uncover model's flaws and to increase its confidende. The tests are classified into the structural and behavioural validity tests.

***Step 5: Policy Recommendation***

Policy design and evaluation is conducted in attempt to improve the model after its robustness is validated [48]. Generally, model improvement can be categorized into sensitivity test and policy optimization. In the sensitivity test, changes are made in parameter values, taken into account both worst-case and best-case scenarios; while policy optimization is the process to improve model's results, either in terms of its performance or by calibrating it to suit into reported time series data.

# 4. Results and Discussion

## 4.1 Data Collection and Analysis

In this research, data collection is obtained from Department of Statistics and several respected agencies website. In general, the numerical data includes the total number of the whole population in Malaysia, births and deaths rates, house price and inflation rate.

## 4.2 Simulation Study

In this paper, we present results demonstrating the utility of system dynamics modelling for house pricing in Malaysia. Initially, by using the current values for all variables, the simulation results are displayed as shown in Figure 4.

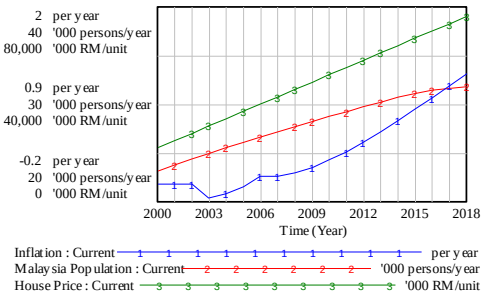


**Figure 4.** Initial simulation results

We present the initial base case results from the year 2000 to 2018. The results show that the number of population and house price increase steadily over the years. The steady increased in the number of population reflects that the number of population in Malaysia is only affected by births and deaths and is not affected by the migration. However, inflation is flattening from the year 2000 until 2002 and fluctuated until 2006 before gradually rise until 2018, consistent with the employment of pegged exchange rate from 1998 that provides stability and facilitates trade and investment, thus showed low and stable inflation rate [54]. Inflation shows upward trend from 2003 towards 2005 which responding to the abandonment of the pegged currency that ended in July 2005.

Validation tests were carried out to establish the robustness of the model. Structure and parameter verification were based on existing housing literature while behavior verification was carried out by comparison with real data as shown in Figure 5 and Figure 6. As for the population, the model is precise as shown in Figure 5. However, in Figure 6, the pattern for the base case run and the reference mode is similar with slight deviation. The slight deviation might be due to the exogenous related factors such as liquidity and investment that are not captured in the model and this leaves room for improvement.

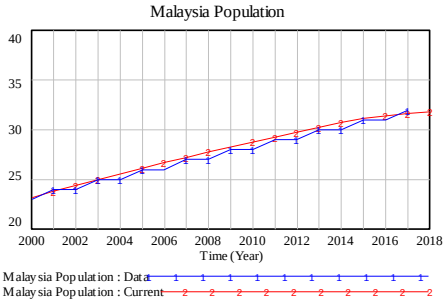


**Figure 5.** Behaviour verification for population

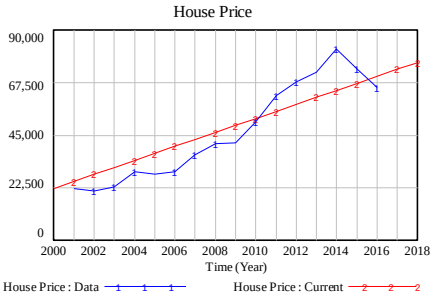


**Figure 6.** Behaviour verification for house price

From this initial results, we observed that inflation is the leverage points in the current developed system since the changes in inflation rate will lead to significant changes in house price. This leverage point can be further tested by tracking the extraneous factors related to inflation that influenced the house price in Malaysia. There are several factors related to inflation in which intervention can be made such as liquidity and investment. Small shift in the inflation relate factors is expected to produce significant changes in the house price. This situation indicates that if no interventions were made (such as in improved policies), as the number of population increases, house price is also expected to rise, resulting to added pressure for Malaysians in effort to own a house. Significant increase in inflation over the years can also be expected. Thus, we propose aggressive intervention approach should be carried out in order to curb such indefinite changes.

# 5. CONCLUSION

In this paper, we developed a simulation model for house pricing in Malaysia. There are four identified factors related to house pricing which are population, inflation, liquidity and investment. However, in this paper we only discussed two factors and the results are preliminary only as they are based on the SD model developed for illustrating the usefulness of SD model in providing visualization of house pricing and its interrelationship with its key factors in Malaysia. As such, we consider two main factors, i.e. population and inflation to illustrate this model. In addition, the utility of SD model is able to assist

decision maker to identify the dominant factors that would be useful for policy intervention. It is expected that the output of the model will portray the main interacting variables and their causal effects which the output in turn will provide a guideline for researchers as well as decision makers for policy recommendation.

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