System Dynamic Approach for Analyzing Cyclic Mechanism in Land Market and Their Effect on House Market Fluctuations

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Abstract— In this article we have developed a simple dynamic model to portray a cyclic producing mechanism in land market and in the following we have probed the effect of land market oscillation on house market price, which has not been addressed before. In this model, in the beginning two cyclic producing mechanisms (including Speculation Effect and Cumulative Mechanism) in land market are introduced and their effect on house market is elaborated in detail. As we combine the land market model with house market model, to develop an integrated model that offers better understandings of house market trends. The model showed that, in contrast to common perception which presumes house market fluctuations (in demand sector) to be totally intrinsic, they are mainly due to cyclic producing mechanism in land market. Our work uncovers the rich dynamic complexity of the real estate system and can serve as a good example of applying systems thinking principles to complex real world problems. Moreover, we have taken advantage of classic mass-spring systems, to model the house and land market and thus a simple powerful tool is introduced to predict the effect of various mechanisms affecting the house market (e.g. capital market)and it can be a great help to understand the complex house market system, in more depth.

Keywords. House Cost, PortFolio, Investment, Inflation.

I. INTRODUCTION

The housing market intrinsically leads to a cycles (Malpezzi 2004) that can be observed in the economics trend of almost all countries all over the world (harris 2003, Bertrand renaud 1995). These cycles are a major of special interest of investors and researchers, since the cycles affect the business and commercial cycles significantly(Fred E. Foldvary 2003), besides they also influence the return of investment (ROI) as well as economic success and failure (Phyrr 2003). The last but not the least, these cycles have an impact on investment circumstances, banking, government policy and social (conditionsMalpezzi 2004,Weiss 1991). Contemplating all of the aforementioned factors, it is crystal clear that analyzing these cycles is absolutely crucial. Various approaches to housing issue along with different results from recent researches in this field, manfiests the complexity of the topic (Grisson & Delisle 1999). The intricacy stems from housing market structure as well as several factors affecting the market price (yean pin lee, 1996).

One of the influential factors, whose price remarkably affects house price, is construction land (meikle 2001). Moreover

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there is close correlation between land demand and house demand (Yean pin lee ,1996), as a result, a deep accurate insight about land market can be an effective tool for economists and managers to make better decisions in the field of developing and controlling the land market. This knowledge can be a great help in the process of land allocation and increasing the land density in some vicinities (yean pin lee 1996). Therefore land is on of the most essential factors in house market. Dynamic Analysis of land market and house market is really complicated, however the most effective way to analyze a complex system is taking advantage of a dynamic model to simulation the real world and probing the model outcome. This method is effective mainly because the aforementioned systems is described by high order non linear equations and no scholars is able to solve these equations without simulations, the simulation help the scholar the grasp the interrelation between various elements in the systems (forrester, 1991). The main focus of the literature is on dynamic modeling of house market and the process of shaping house market cycles. to name a few, Investigation of speculation intensifying effect on house market cycles (Malpezzi,Wachter, 2003), studying the fluctuating behavior in rent market (wheaton, 1999) and investigation of cycles in house ownership market and their causes, and also the mutual relation between rent market and ownership market and its effect on house price cycles. In this article, first of all we analyzed the dynamics of land market and we will elaborate on its Cyclic Producing Mechanisms (CPMs) . In the following, the effect of these mechanism in land market variables is investigated (no previous article has address this issue). Afterwards, land market along with house market is dynamically analyzed and the land market CPM, which plays a great role in land market cyclic behavior, is closely investigated. At the end, the effect of the land market CPM on house market parameters is studied and the effect of ignoring them in some policies is clarified.

II. LAND MODEL

A. Structure

The model of land market is demonstrated in the figure 1. It consists of 3 main sectors including supply, demand and price that will be elaborated in the following Supply Sector, Since required land for construction is majorly formed of time-worn houses, land supply is solely provided by the land of these houses. Demand Sector, it comprises of two main parts
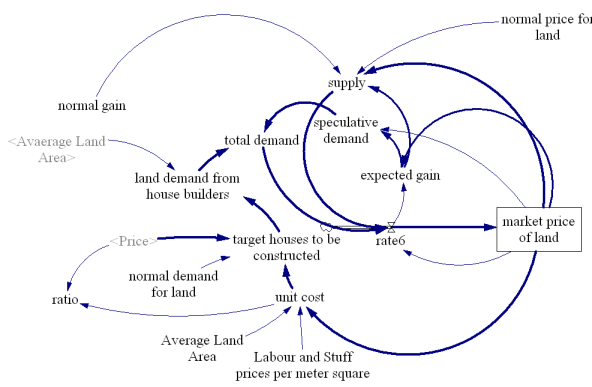
- Construction Demand.

Fig. 2: The effect of speculation on land price fluctuation

Fig. 3: The effect of speculation on land price fluctuation

Fig. 4: The effect of speculation on land price fluctuation

- Speculative Demand.

The price of the house determines the total demand for house. Multiplied by a coefficient, the total demand settles the construction demand. The expected return of keeping the house, determined by land price and its growth trend, decides the speculative demand. Price, the supply-demand mechanism regulates the price. In this model, congestion is defined as the number of built floors and it is assumed to be constant.

B. Outputs and analyzing the model

1) The effect of speculative mechanism on land price fluctuation: In the beginning we will inspect the effect of speculation on land market cycles. In this phase, we assume house price to be constant to eliminate its probable effect on land price. As it is can be observed on Figure 2, the positive loop -which is bold in figure 2- leads to oscillation, in the following we will discuss this loop in more detail:

Suppose that the land supply decreases. Consequently, the price rises and the rate of price increase goes down. As a result, the expected return of maintaining the land rather than selling will also falls. (Expected Return is defined as the ratio of the price growth to the price, the greater the ratio, the greater the desire for speculation.) This decline will decrease the speculative demand and therefore the total demand will drop and thus the land price diminishes. The opposite story happens as the demand rises, in that case the price rises consequently and this cycle begins all over again.

2) The effect of cumulative mechanism on supply and demand: Now, we formulate a hypothesis of 4 phases which explains the cyclical behavior of price `in the absence of supply lag` and on the basis of interaction of theses two mechanisms and dominance shifts between them. As is clear from the following hypothesis, neither accumulation mechanism nor price mechanism is a CPM. But their combination, to which can serve as a CPM.

I) At the outset, demand is equal to supply and the price is high, so it is lucrative for suppliers to supply even more. As the supply increases, the cumulative supply increases and as a result the price decrease, however the price still remains high enough to encourage suppliers to increase the supply and this will continue until sell rate become equal to destruction rate
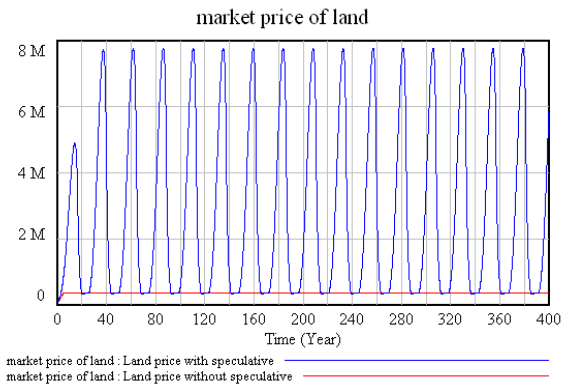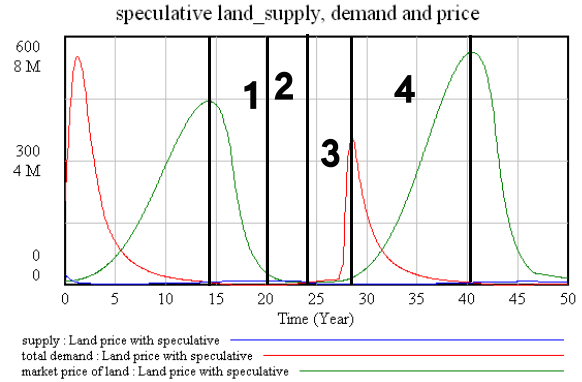
of time-worn houses.

II) in this phase the price still declines and thus sales take overweighs destruction and therefore supply will decrease until supply becomes equal to demand (The cumulative mechanism rules).

III) in the beginning of this phase demand equals to supply and the price is at the minimum level. Since the destruction rate is still less than sales rate, the supply keeps decreasing and due to low price, the demand will grow and it accumulates. Demand rise will result in rise in price. On the other side, because the ratio of house price to actual cost decrease, consequently the demand for the land decreases, however the former factor which is rise in demand because of low price, is more dominant and thus the price keeps rising.

IV) In this phase the price is growing and this in turn will lead to escalation of supply. As supply increases the ratio of destruction rate to land sales will decrease and therefore the demand will drop. At the end the demand and supply will finally reach each other and the price will reach to its highest level. It is exactly similar to the first phase and this cycle will begin all over again. .

in this phase we can see the same state like first one and it can continuously make cyclic behavior ,that we named them accumulative mechanism in land market, when these behaviors
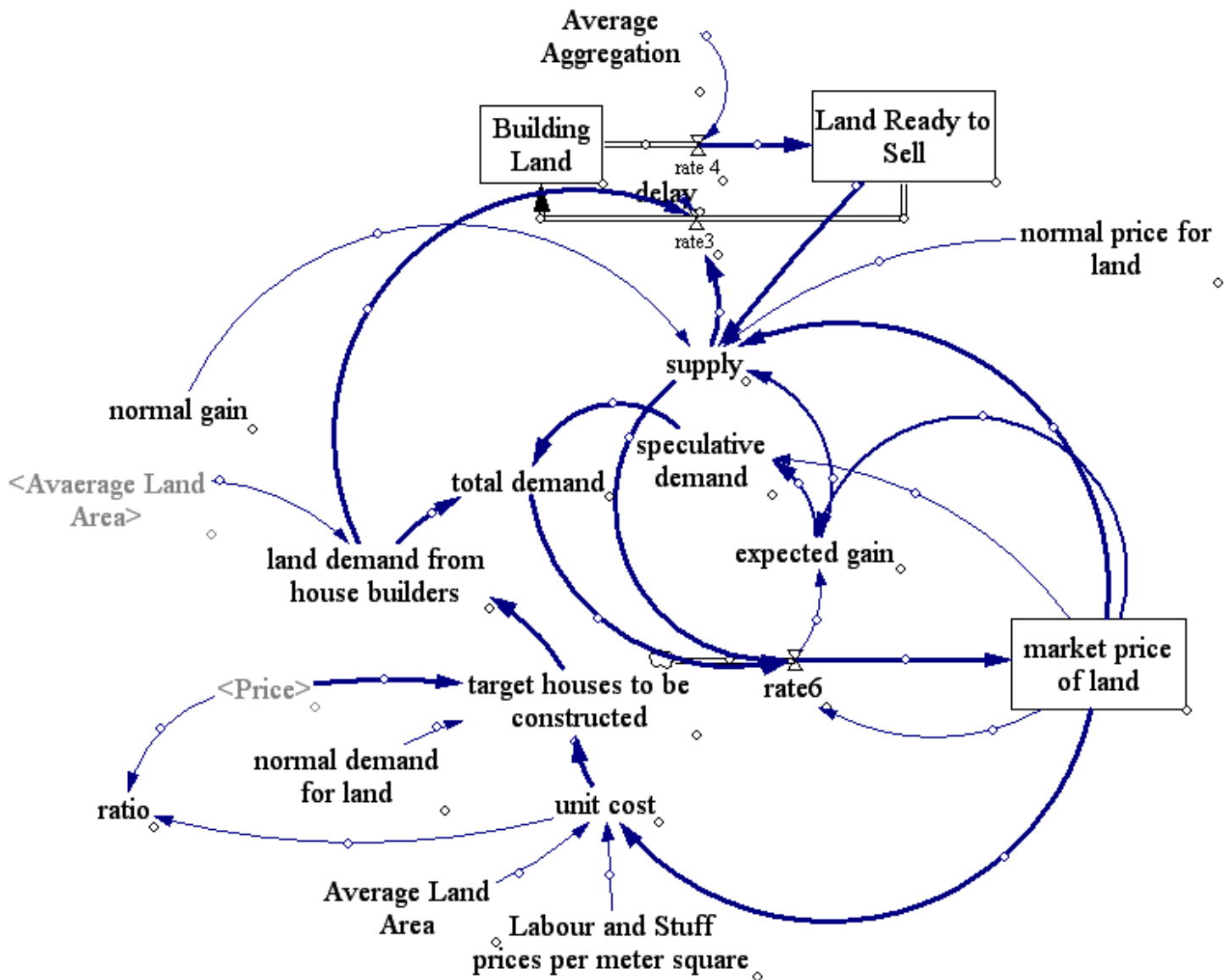
Fig. 1: Structure of Land Market

act with the same mechanism on house market(mashayekhi 2009) ,we encounter very complex system .

3) the effect of variables on system behavior: :

1) The first variable is **Average Area** which used for each house:

This variable has 2 major effects on land price:

- **Decreasing the average price**: In the model, given the congestion to be constant, decreasing the average area simply leads to increase in the ratio of land supply to land demand. Therefore the average price will decline. However, if we define congestion as the number of floors (This definition is currently used in Iran) as it can be elicited from Figure 5, the average price will increase.
- **Damping the Oscillations altitude**: Increasing the average price, which was explained in previous section,

causes the expected return to decline and consequently it discourages the speculation. Thus the cumulative oscillator mechanism diminishes and the altitude of oscillation will drop.

2) the second variable is **The ratio of land's vacant time to the house durability**:

This variable shows how long it takes for a vacant land to be utilized in construction cycle again. In other words, it reflects the land turnover in the market. In contrast to the hypothesis put forth in (Mashayekhi-Ghili 2009) that claims house durability has an inverse relation with oscillation altitude, as it can be elicited from Figure 7, if we let house lifetime be constant and increase the vacant time of the lands, the altitude of oscillation will reduce. Thus, in the house market it is important to notice that destructing time-worn houses by itself is not an effective policy and decreasing the speculation in land market should also be taken into consideration.
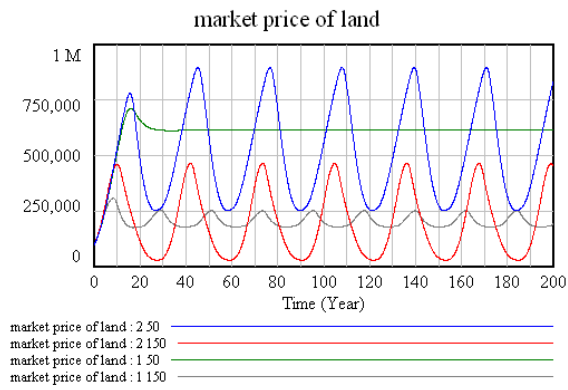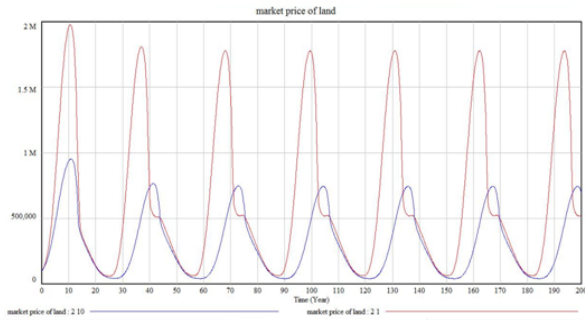
Fig. 5: Market Prices of Land Versus Time

Fig. 7: Market Price Of Land

3) the third variable is **the effect of price elasticity of supply on land market oscillations** :

In land market, as the price elasticity of supply increases, the difference between supply and demand level increase and it intensifies the fluctuation. It is worth mentioning that just like in house market, In land market, the cumulative mechanism leads to unpredictable reaction of market to the elasticity, however, because the speculation CPM effect is dominant, the cumulative CPM effect is not noticeable. we can see this effect on Figure 8,9.

III. HOUSE AND LAND MARKET

A. House Market Structure

We have utilized the model of ghili and Mashayekhi for the House market model and it is connected to land market model. The structure of this model is similar to the Wheaton's rental model but there exist certain differences between them. Some are simple and small. For instance delay in construction is modeled as a first-order delay rather than a fixed delay. In addition, in this model, the price adjustment process has been modeled completely in a different way and price is not adjusted by supply and demand immediately. Rather, the price is modeled as a stock variable whose flow is determined by demand-supply ratio. If supply and demand are equal, the flow is zero and if demand-supply ratio rises, the flow increases (Mashayekhi, 2006; Sterman, 2000).

But the main difference between the two models is concerned with the stock-flow structures. This difference arises from particular characteristics of owner-occupied market, as a durable

goods market, which are absent in rental market. Goods traded in owner-occupied market are basically different from those of rental market. Goods traded in rental real estate markets are not real estate but the use of real estate for a certain period of time. Seeking simplicity we can say one year use of real estate. This is not durable goods, because it endures less than one year. The very houses are supplied and traded.

Consequently, in such a market, real estate is transferred from sellers to households. On the basis of this transfer, there is a stock variable named "Occupied Houses" whose flow, "sales rate", transfers houses from "Vacant Houses" into this stock. "sales rate" is equal to demand divided by transaction time when there is not supply shortage in the market. When supply (i.e."Vacant stock") is less than demand, sales rate is equal to supply divided by transaction time. One can formulate this logic using a fuzzy minimum. This is the difference between stock-flow structures of owner-occupied and rental markets. Here, supply and demand are stocks in nature. Supply is equivalent to vacant houses stock, whose flows are "construction completion rate" and "sales rate". Demand is a function of "homeless families", which is determined by subtracting a constant (i.e. all families) from a stock (i.e. occupied houses). Therefore, "depreciation rate of houses" and "sales rate" are flows which change the number of homeless families. Such a stock-like nature can result in the accumulation of supply or demand over a period of time. If construction completion rate is greater than sales rate, "Vacant Houses" (i.e. supply) is accumulated. On the other hand, if sales rate is less than depreciation rate of houses, homeless families are accumulated. In this model, for the purpose of simplification, it is supposed that there is no speculative demand in the market, and like the rental market model (Wheaton, 1999), sellers supply all of the houses regardless of price. In addition, population is supposed to be constant, but including depreciation in the model is equivalent to incorporating population growth or some trend in demand (Wheaton, 1999).
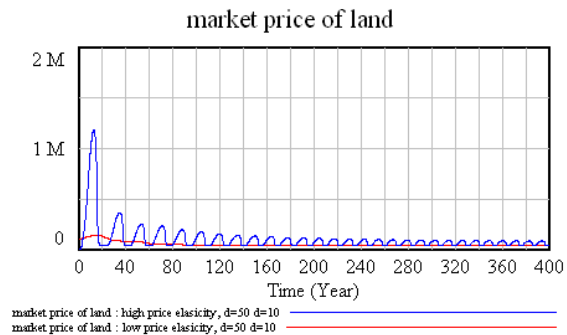

Fig. 8: Tension Versus Price with assumption that ratio of substance to steady time is big

B. House and Land Market Structure

Linking the two models for house and land market (which were introduced in previous parts) together, we will reach to an aggregated model that has 3 main sectors. These 3 sectors are as follow:

market price of land

market price of land : low price elasicity, d=50 d=1 ——
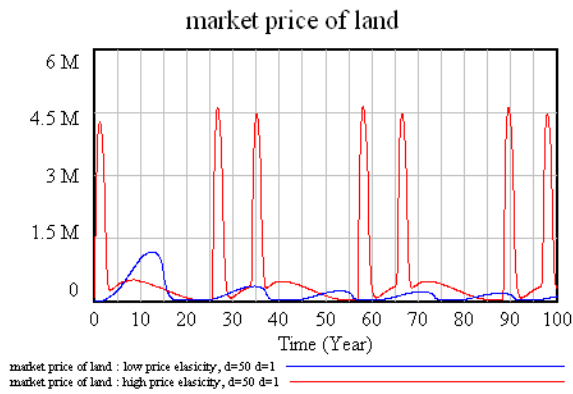market price of land : high price elasicity, d=50 d=1 ——

Fig. 9: Tension Versus Price with assumption that ratio of substance to steady time is small

- The rate of time-worn house depreciation divided by congestion coefficient will determine the inflow of ready to be sold lands. The congestion is assumed to be constant in this model to understand the internal oscillator mechanisms in the market. In prospect studies, one might consider population growth in the model to make it more accurate.
- Built lands multiplied by congestion coefficient will determine the construction start rate.
- The ratio of house price to actual unit cost (actual unit cost is calculated by multiplying the average area of lands by sum of 1 square meter land price and cost of labor and equipment is an influential actor in land demand.

C. Analyzing Model output

1) the effect of land speculative cpm on house market:
In this part in order to fully understand the effect of land market oscillation on house market, we have decreased the house lifetime to lessen the impact of cumulative loop, which was discussed in Ghili's paper. As it is illustrated in Figures 10,11 although we have eliminated the house market oscillator elements in the model, house market prices still fluctuates. In the following we will elaborate more on the causes of this behavior. The positive and negative loops that cause the oscillations are depicted in Figure13 with different thickness.

2) the effect of land market on influential factors is house market: **effect of the 3rd effective house market CPM on supply price elasticity**:
One of the interesting functionality of the 3rd CPM in house model is reducing the sensitivity of the house model to price elasticity of demand. To state the matter in a different way, in low price elasticity range, the model does not show oscillation and changes in model fluctuation due to changes is price elasticity only occurs in high value of price elasticity. This clearly shows that the 3rd CPM in house market, which is formed by adding the land market model, is far more influential than the mechanisms ruling in land market alone. As a result, if we neglect the land market effect in developing the policies for rent market or house market (which are said to be interelated [Ghili's Paper]) we may make a huge mistake
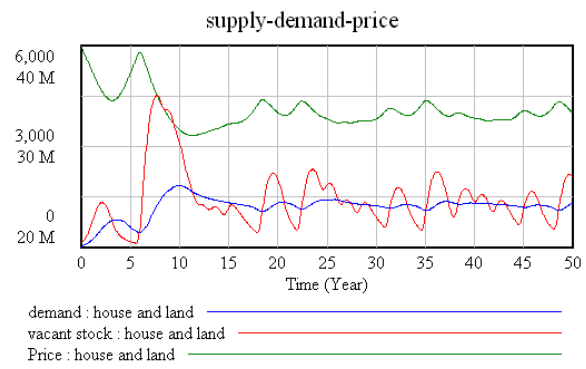
supply-demand-price

demand : house and land ——
vacant stock : house and land ——
Price : house and land ——

Fig. 10: Supply demand Price

housing & land price

Price : house and land ——
market price of land : house and land ——
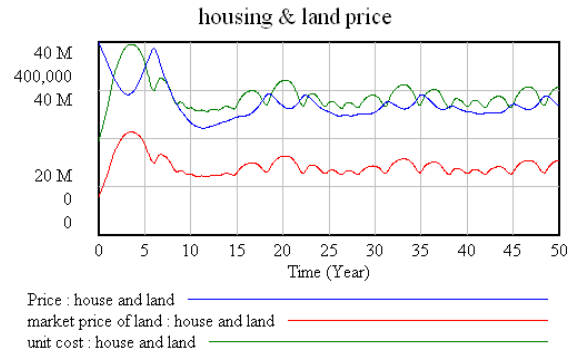unit cost : house and land ——

Fig. 11: Housing and Land Price

and by changing a parameter such as construction rate (which reflects the price elasticity of demand) we may not reach our desired goal.

IV. CONCLUSION AND PROSPECT STUDIES

To give a better understanding of the insights of this model, let's start with the classic dynamic system, spring-mass system. If a mass is attached to some parallel springs, it will oscillate less than it would in the case that the mass was attached to each of the springs. On the other hand, if the springs are placed in series the system will oscillate more intensely comparing to the case that the mass was connected to each of the spring.

As it can be seen in parallel and series spring-mass systems, when the oscillator elements (the springs in our example) are directly connected to the oscillating factor (the mass in our example), the altitude of oscillation will decrease, while in the case of indirect connection (as in series connection) the altitude of oscillation will rise. Now let's get back to the house market problem. Using the same rule, if we analyze each cyclic producing mechanism individually and its connection to house market (i.e. Direct or Indirect) we can predict the combined effect of all CPMs together. For example, two CPMs (Supply Lag and durability mechanism) which are inside house market, are both connected directly to the house market. On the other hand, land market oscillation is serried with one of the house
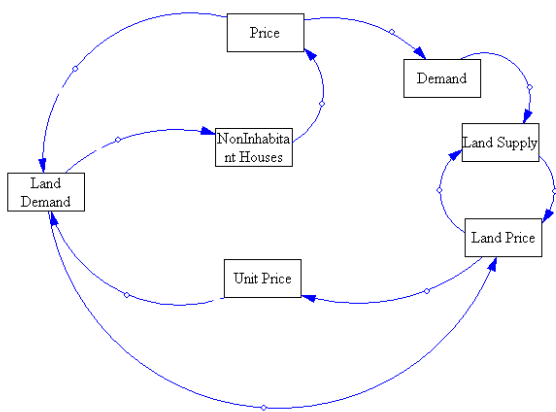
Fig. 12: The Structure That Generate Our Third CPM

market CPMs (Supply Lag). Given the spring-mass metaphor, if we deactivate the two house market CPMs, the land market CPM will be connected directly to the house market and still there will be oscillation in house market, and it is verified by the model results. This finding introduce a new CPM for house market, that was neglected in previous researches.

In land market just like in house market, cumulative mechanism along with speculation effect leads to oscillation in the market. These mechanisms in the land market, may affect other variables in this market and misapprehending of these variables may lead to mistakes in establishing policies. Furthermore, land market oscillation has nonlinear effect on house market fluctuation and thus it may mislead us in recognizing the sources of these oscillations. Hence, it is inevitable to analyze house market along with land market and taking land market into consideration in developing policies for rent market as well as house market is absolutely vital.

Finally, the last but not least, Analyzing house market is really complicated and there are several effective factors in this market. Analyzing all of these factors is absolutely sophisticated and arduous. In addition to all mechanisms and factors that were discussed in this article, there are many other factors and markets such as Investment market that affect house market, and they all dynamically changes and these changes may affect the house market as well.

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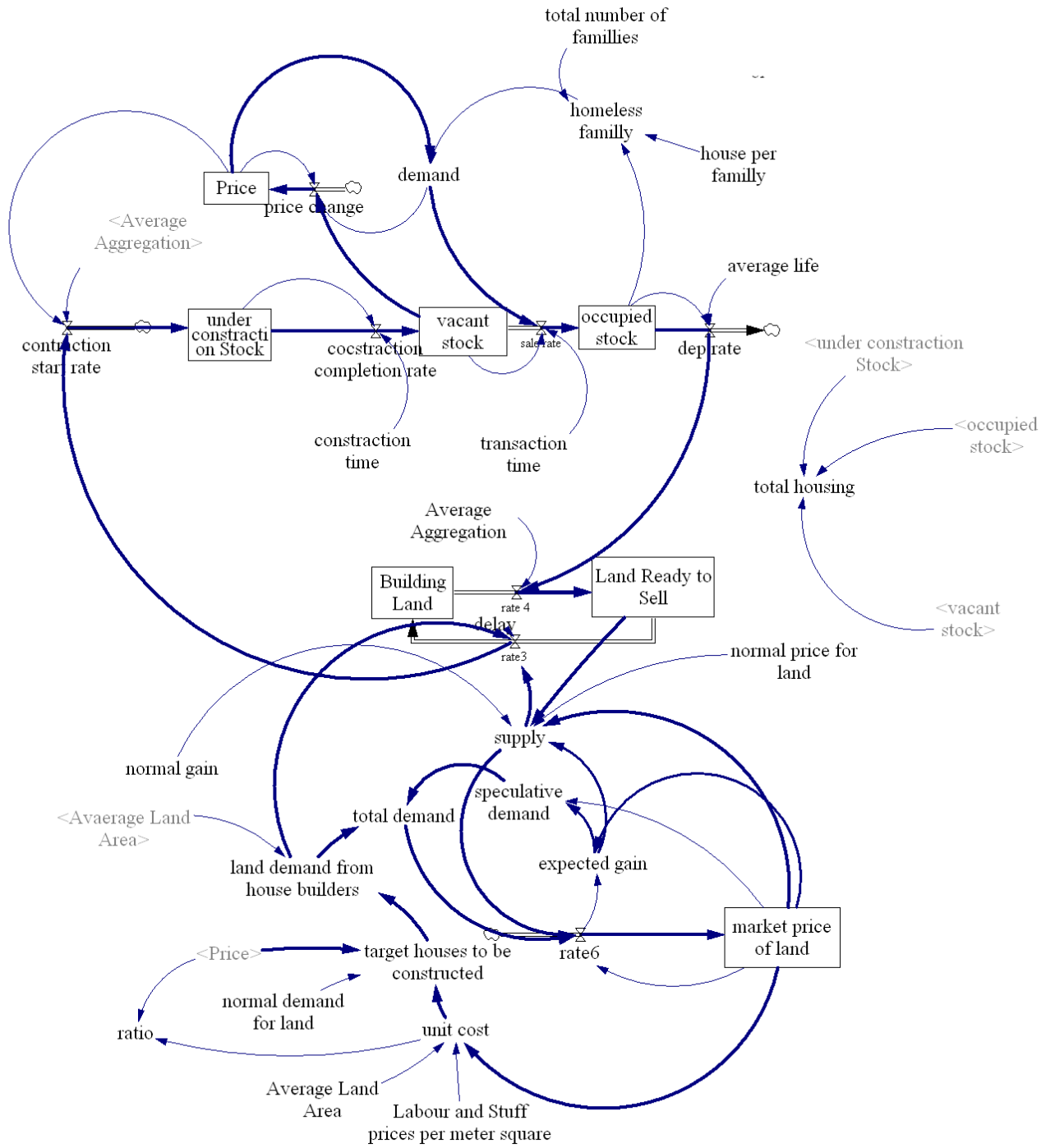[13] Jay W.Forrester, System Dynamics and the Lessons of 35 Years, MIT Working Paper, 1991.

Fig. 6: Land and House Market Structure