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System Dynamics Modeling of Chinese Urban Housing Markets for Pedagogical and Policy Analysis Purposes

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Although numerous academic papers have applied system dynamics (SD) models to real estate markets over the past generation, the technique remains relatively unknown and little used both in the academic economics literature and, more to the point, among practitioners and educators in the real estate community. Yet SD has the potential to address key needs among these constituencies. SD can provide intuitive and transparent models that should be able to improve pedagogy for educating large numbers of potential real estate entrepreneurs particularly in emerging market countries. SD models can more easily accommodate non-market features and unique institutional components of actual real estate markets especially in emerging market countries. And SD models are particularly oriented toward modeling market transitions toward long-run equilibria, facilitating the study of the dynamic path the market follows and which dominates the real history of housing markets in emerging market countries. In the present paper we report on the current state of a project to develop a SD model for urban housing markets in China, aimed at facilitating policy analysis as well as the support of practical educational tools that might reach large masses of potential entrepreneurs in that country. Depreciation is caused almost entirely by decline in current real income, only secondarily by increase in the capitalization rate ("cap rate creep"). Depreciation rates vary considerably across metropolitan areas, with areas characterized by space market supply constraints exhibiting notably less depreciation. This is particularly true when the supply constraints are caused by physical land scarcity (as distinct from regulatory constraints). Commercial real estate asset market pricing, as indicated by transaction cap rates, is strongly related to depreciation differences across metro areas.

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By

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Although numerous academic papers have applied system dynamics (SD) models to real estate markets over the past generation, the technique remains relatively unknown and little used both in the academic economics literature and, more to the point, among practitioners and educators in the real estate community. Yet SD has the potential to address key needs among these constituencies. SD can provide intuitive and transparent models that should be able to improve pedagogy for educating large numbers of potential real estate entrepreneurs particularly in emerging market countries. SD models can more easily accommodate non-market features and unique institutional components of actual real estate markets especially in emerging market countries. And SD models are particularly oriented toward modeling market transitions toward long-run equilibria, facilitating the study of the dynamic path the market follows and which dominates the real history of housing markets in emerging market countries. In the present paper we report on the current state of a project to develop a SD model for urban housing markets in China, aimed at facilitating policy analysis as well as the support of practical educational tools that might reach large masses of potential entrepreneurs in that country.

Introduction: China's Urban Housing Market

The past generation has witnessed in China the greatest urbanization in world history to date. Over 500 million people moved from rural to urban settlement from 1980 to 2015, and this process continues. At least another 250 million inhabitants will move to urban areas in China by the year 2030. Furthermore, real per capita incomes have been doubling roughly every seven years, and will likely continue to grow at very rapid rates, resulting in tremendous increase in demand both in terms of the quality and the quantity of urban housing, including renovation and reconstruction of the existing stock as well as new stock. It is impressive that Chinese cities have for the most part well accommodated this unprecedented demand. This has been done in part by flexibly adapting the policy framework governing the housing industry, including most notably the transition from the old centrally-planned social housing system to a largely market-driven system based on the sale of long-term land leaseholds by local government authorities to private developers who in turn produce housing (largely units for owner-occupancy) and other types of buildings. A constitutional amendment in 1988 permitted the purchase of land use rights for leaseholds of 70 years for residential use, 30 to 50 years for industrial and commercial use, and since 2002 such land sales have been made through a public bidding process.[1]

In recent years the urban housing system in China has begun to face some new challenges. The industry began to weaken at the time of the international Great Financial Crisis in 2009. At that time the Central Government introduced stimulus policies that, while successful in stemming the slowdown in the market, led to a new round of soaring housing prices notably in some of the so-called "first tier" cities (also known as "gateway" cities, including Beijing, Shanghai, Shenzhen, and, depending on the source, also possibly including Tianjin, Guangzhou and/or Chongqing). This price surge has led to concerns about home affordability in some cities, as well as fears that the market might be exhibiting an asset price "bubble" which, if such a bubble exists and should collapse, could wreak havoc in the financial system not only in China but possibly internationally as well. Related to this concern, it is notable that since 2009 local governmental authorities and real estate developers have taken on a striking increase in the amount of debt. There are also concerns that the demand for purchasing housing units in some cities tends to include a large component that is simply using housing units as stores of monetary wealth, not for the purpose of living in the units. Such demand is referred to as the "speculative"

[1] Deng *et al*, 2015.

housing demand, effectively using housing as an investment, in part due to lack of widespread alternative investment opportunities. For various reasons, many of these units are simply held vacant, wasted in terms of actually providing housing to anybody.[2] It also becomes clear that the housing market is linked to the local government public finance system in a manner that is perverse and ultimately unsustainable. Local governments now obtain a crucial proportion of their revenue from the sale of land leaseholds, which are paid for entirely up front at the time of sale (rather than by annual rental payments). Further, the ability of local governments to sell land is effectively used as collateral for debts taken on by the authorities. Yet, both the supply of, and the demand for, land for leaseholds is not infinite, and the revenue such sales produce highly depends on the prices the land leaseholds command in the marketplace. When local governments sell land leaseholds to developers, the land is generally supposed to be developed within two years. The obvious risk is that land development will be driven by local governments' needs for revenue, including possibly to service debts and invest in other infrastructure expenditures, rather than by actual market demand and need for buildings, including especially housing.

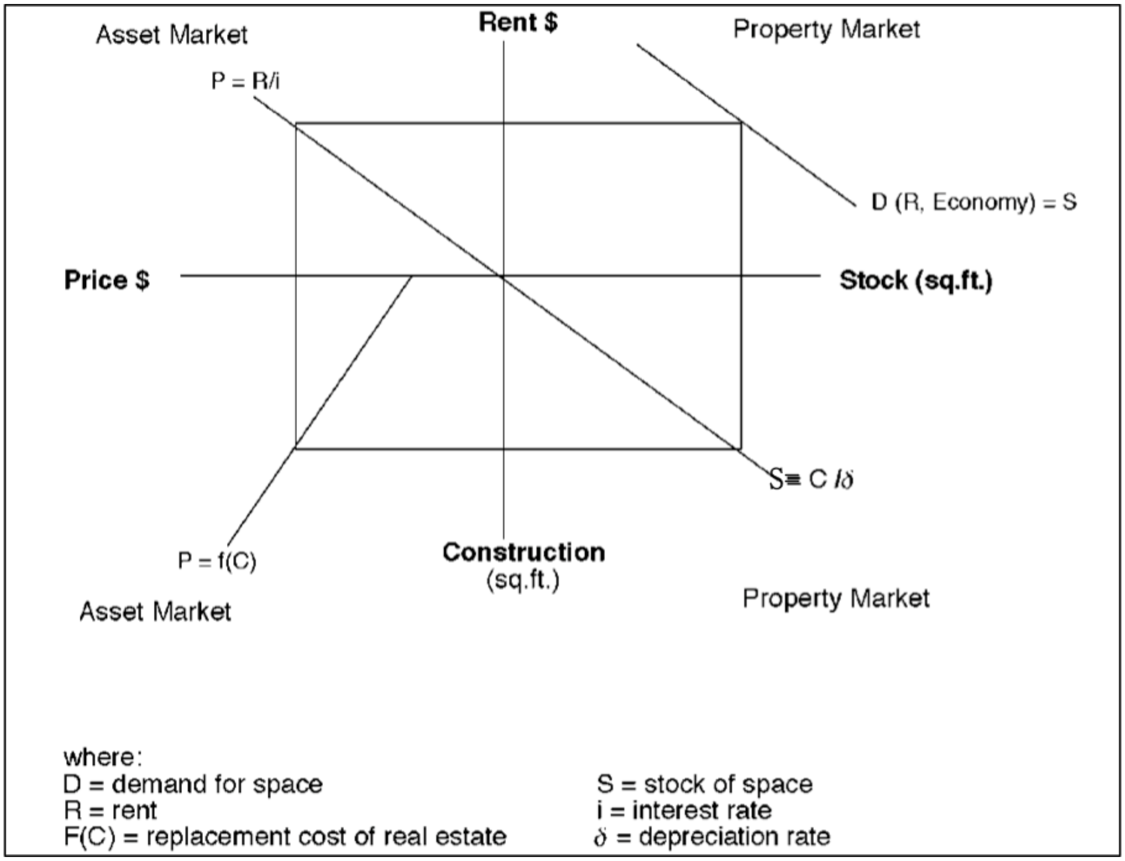
From Urban Economics to System Dynamics Modeling of Real Estate Markets

There is a long and substantial history in the urban economics literature of models of real estate markets. Though the antecedents go back at least to Hendershott & Ling (1984), much of the modern literature has been based on, or effectively reflects, a particularly compelling and

[2] Deng, Gyouko & Wu (2015) report that the Southwestern University of Finance & Economics Household Finance Survey in 2013 found a nationwide average vacancy rate over 22%, based on a survey of 28,000 households.

eloquent depiction of the inter-related markets for space usage and for property asset ownership known as the "four quadrant model" (4QM) proposed by DiPasquale and Wheaton (1992, 1996).

Exhibit 1: The DiPasquale-Wheaton 4Q Model (DiPasquale & Wheaton, 1992)



In the 4QM the upper-right quadrant reflects the market for the usage of built space. The horizontal axis is the stock of built space (effectively, the occupied space, as the basic model does not consider vacancy), and the vertical axis is the annual net rental price. The line (function) in the upper-right quadrant, S = D(R, Economy), is the demand function of the space users, reflecting how much space would be occupied as a function of rent, which in turn of course reflects the aggregate marginal benefit of space occupancy to the users. "S" is the quantity of stock demanded (occupied), "R" is the annual rental price, and "Economy" represents the sources of need and preference for space usage. Although the basic 4QM represents rental property, the essence of the model can be applied to owner-occupied property as well if we think of the rent as “imputed rent” or the annual value of the service flow of the built space to its users.

The upper-left quadrant then relates the rental price on the vertical axis (“R”) to the asset price in the property market on the horizontal axis (“P”). (All the axes in the 4QM radiate out from the origin, hence, movement leftward on the left quadrants’ horizontal axis represent larger positive prices for the assets.) The function in the upper-left quadrant represents the rental income yield in the property asset market, that is, the ratio of property asset prices to annual rental income, P = R/i, where “i” is the yield rate per annum.[3]

The lower-left quadrant depicts the real estate development industry. The line in the lower-left quadrant represents the annual rate of new construction of built space in the market, as measured on the vertical axis (with the positive direction being downward on that axis, away from the origin). The construction function, P = f(C) (or its inverse, $C = f^{-1}(P)$), relates the responsiveness of the development industry to pricing in the property asset market. This reflects building “replacement cost” and the price elasticity of supply. In the traditional depiction this function includes a region on the asset price axis below (to the right of) which no development will take place (the asset price presumably being too low to compensate for the cost of land and construction plus necessary developer profit).

Finally, the lower-right quadrant relates the rate of new construction to the effective real depreciation (in effect, the demolition rate) in the existing stock of buildings. The function in the

[3] In the classical 4QM the yield, in effect, the pricing in the asset market, is taken to be entirely exogenous. More sophisticated models, either enhancements to the 4QM or stock-flow models, make the asset market yield a partly endogenous parameter. However, there is strong evidence that in fact asset market yields are largely exogenous to the real estate system, coming substantially from the capital market, at least in terms of short to medium term changes in the yields, and at least in the United States. (See Geltner & Mei 1995, and Plazzi *et al* 2010.)

lower-right quadrant, $S = C/\delta$, divides the annual construction rate by the annual depreciation rate. (For example, if 1M m^2 per year are built, but 5% of existing buildings are demolished each year because they are fully depreciated, then the steady-state stock will be 1M/0.05 = 20M m^2, with the 1M m^2 new construction each year exactly offsetting the 0.05*20M = 1M m^2 of demolitions each year.)

The culminating and key feature of the 4QM is the rectangle whose vertices just touch each of the four function lines in the four quadrants. This rectangle is the long-run equilibrium in the system. The vertical and horizontal sides of this rectangle represent the equilibrium within and between the space and asset markets in the upper two quadrants as mediated to a steady-state result by the development industry in the lower two quadrants (assuming the developers are the ones who demolish old buildings as well as build new ones). The model is simple and eloquent in its evocation of the overall system, the relationship between the two real estate markets and the development industry. It is a great pedagogical device.

But it is crucial to recognize that the DiPasquale-Wheaton 4QM is a steady-state model. It represents a long-run equilibrium. It does not depict dynamics, how the system changes over time from one long-run equilibrium to the next. It is true that the model can be “played with” to gain some insight about dynamics, for example as described in Geltner et al (2014) Chapter 2.[4] But this type of “playing” with the 4QM is informal and vague in its positive implications.

[4] Consider a permanent upward shock in the demand function in the upper-right quadrant. Ceteris paribus, this will lead to an increase in rent and corresponding increase in asset price seen by dropping horizontal and vertical straight lines counterclockwise from upper-right through upper-left. But then when you try to follow this new rectangle continuing counterclockwise through the lower two quadrants you do not “meet up” on the right quadrants’ horizontal axis; the rectangle is not closed, indicating you do not have a long-run equilibrium. The fully closed and complete rectangle anchored on the new (higher) demand function will result in a fallback in the rent and asset prices to levels ultimately above their pre-shock starting values but below the initial myopic values first indicated, suggesting a type of cyclical or cobweb (“tatonnement”) process.

Colwell (2002) describes a series of elaborations of the original DiPasquale-Wheaton 4QM that can account directly and explicitly for the long-run equilibrium and address other simplifications in the simple model. But these enhancements undercut the eloquence and pedagogical value of the original model, and do not provide any explicit dynamics, tending to reinforce the model's focus on long-run equilibrium rather than on transition paths toward such equilibria.

The urban economics literature has addressed this deficiency with a stream of models that are essentially formal elaborations of the 4QM into systems of simultaneous linked equations. They are referred to as "stock-flow models", and do indeed represent the dynamics of the market. These can be calibrated by econometric analysis of empirical data about rents and occupancy and construction observable in actual real estate markets. This stream of literature dates to at least to Rosen (1984). Wheaton, and Wheaton and Torto (1987, 1988, 1997, 1999) did most of the development, and Hendershott and co-authors (1995, 2002a, 2002b, 2010) provided substantial enhancements. Though first developed for office markets, these types of models can in principle be applied to any real estate market sector.[5]

The stock-flow models from urban economics are powerful and practical tools that have been used successfully by sophisticated elements in the real estate investment industry in the U.S. and other mature markets. These economic models are generally taken as a sort of "canonical" starting point for system dynamics models of urban real estate systems. The objective of system dynamics (SD) models is not to negate or supplant the urban economics stock-flow models, but to complement and extend them.

[5] See Ibanez & Pennington-Cross (2013) for a review as well as a survey overview applying the modeling to 34 major metropolitan areas and four space market sectors in the United States. Stock-flow models have also been applied to London and a few other global cities that have substantial data on the space market and construction industry history.

In particular, urban economists have long noted that the stock-flow models of dynamic equilibrium stop short of being complete or ideal for some purposes. It has been noted that the econometric models become too complex or data-hungry if they try to include unique or special features, typically institutional characteristics, of particular markets.[6] The econometric models also are challenged to incorporate certain behavioral characteristics of key system actors. For example, it is difficult for a typical stock-flow model to model the effect of something like the extra speculative demand, or the exogenous land sales/development interventions that are important characteristics of Chinese housing markets. The econometric stock-flow models are generally data intensive, requiring long time series of historical data, which makes them difficult to apply in many emerging market situations where little reliable data is available, let alone for long histories. In general, the econometric models lack richness and flexibility in their ability to explicitly model particular elements and causal flows and actors' behaviors which can be important not only in understanding system behavior but in analyzing policies and decisions. This includes key elements in the system such as explicit consideration of the nature and role of land supply and land price. The elasticities and other sensitivity and adjustment parameters in the econometric models often lack much temporal richness, usually at most only a distinction between "short run" and "long run" elasticities, but without the degree of temporal nuance that would be most useful from a policy and decision perspective.[7] Finally, the econometric models can be difficult for non-specialists to visualize and grasp, making them challenging to

[6] Wheaton (1999), Smith & van Ackere (2002), and Eskinasi (2012).

[7] Use of Error Correction Models (VECs) as in Hendershott *et al* (2002b) do provide interesting empirical calibration of adjustment times. But VEC models are data intensive, and SD models can bring explicit causal modeling with added depth and flexibility to enable representation of unique institutional frameworks in the market, while also still taking into consideration the findings from the stock-flow models.

communicate to decision makers and of limited use for pedagogical purposes to a non-specialized audience.

It is the thesis of the present paper that many of these challenges in the stock-flow models can be addressed by SD modeling, in particular in the case of the Chinese urban housing markets, at least to a degree that will prove useful for purposes of policy research and/or pedagogy for teaching young real estate entrepreneurs in China.

A Basic Canonical SD Model of a Real Estate Market

As noted, system dynamicists often take the 4QM, or its more formal dynamic elaboration in the stock-flow model, as a basic starting-point platform for building a SD model of a real estate market. In the present case we take the 1999 Wheaton model as a highly influential and somewhat canonical representative, and use it as a basic platform for our development of an SD model for Chinese markets.[8] In this section we describe a basic SD model of a real estate market that exactly replicates the 1999 Wheaton stock-flow model. In subsequent sections we describe some initial exploration of modifications and enhancements of this basic model in order to explore the Chinese context.

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[8] One discrepancy should be noted. The stock-flow models generally pertain most directly to markets for rental properties. Yet the Chinese urban housing market, though it includes an important rental segment, is primarily a for-sale housing market. There can be important differences in the functioning of the equilibrium for such markets. Wheaton (1990) elaborated a model of the market for owner-occupied houses that focuses on some unique features of such markets. He notes that, regarding turnover within the existing quantity of houses and households (apart from change in aggregate demand and supply), every buyer is also a seller and each move creates a temporary vacancy. We have not yet brought this consideration into our SD modeling of the Chinese urban housing market. However, SD models of housing systems have been built that explicitly model the vacant stock as a loop in the system (see, e.g., Barlas *et al* 2007, and Mashayekhi *et al* 2009), and could be incorporated into our model for China. But to date the Chinese urban housing market is characterized primarily as an aggregate-growth market for new housing, with turnover of existing stock playing a relatively minor role. Hence, while we explicitly model “special” vacancy in the form of a speculative demand loop, we do not model traditional turnover vacancy.

The function setup in our SD model is exactly the same as in the Wheaton stock-flow model. We use the same initial values as in the Wheaton 1999 paper in order to confirm the validity of this translation process. In Wheaton's semi-hypothetical U.S. office market there is an initial employment work-force of 10 million (demand, labeled "E" in Exhibit 2, below), occupying 2,500 million square feet of office space (stock). The initial equilibrium rent is $20 per square feet. With a market cap-rate estimated at 5%, the estimated price is $400 per square foot. The construction rate equals the demolition rate and the market is at equilibrium. The elasticities in the basic Wheaton model and in our SD model are -0.4 for demand, and 2.0 for supply. Then an unexpected external shock affects the market: a permanent shift in the demand curve from 10 million to 15 million in the work force.

Exhibit 2: The System Dynamics Model of the Stock Flow Model in Wheaton 1999

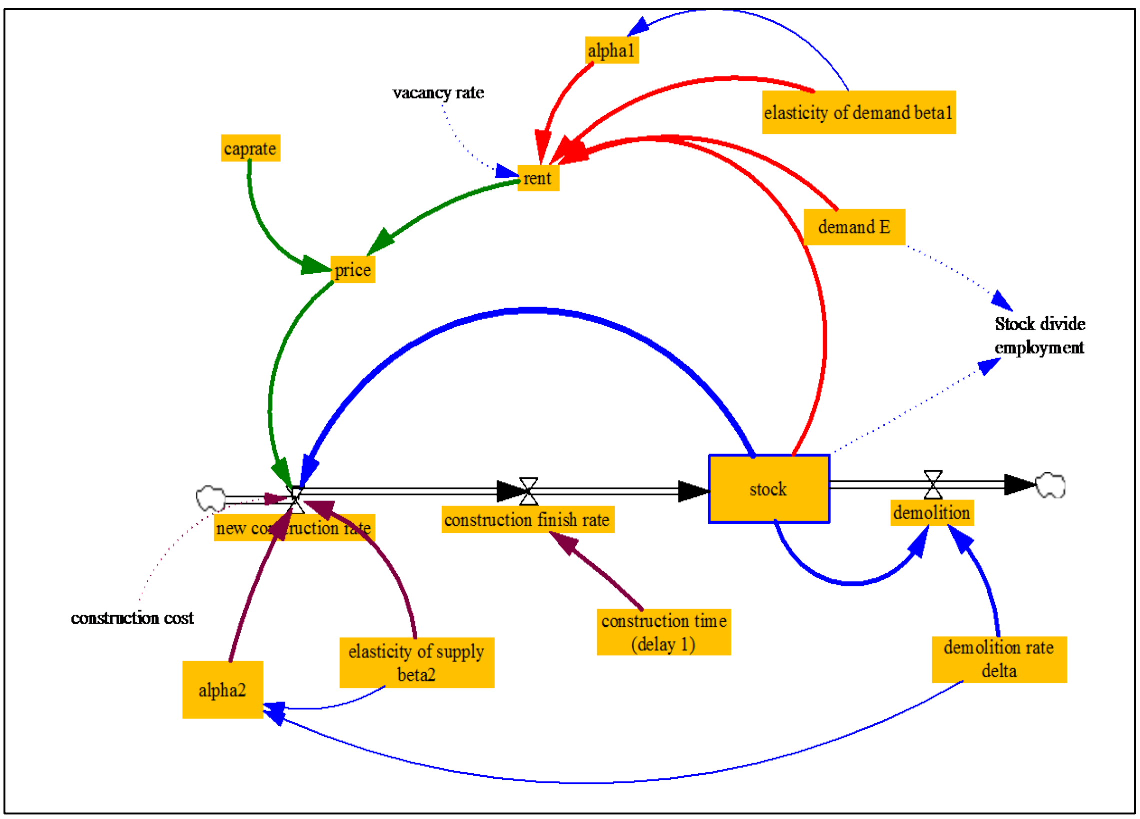
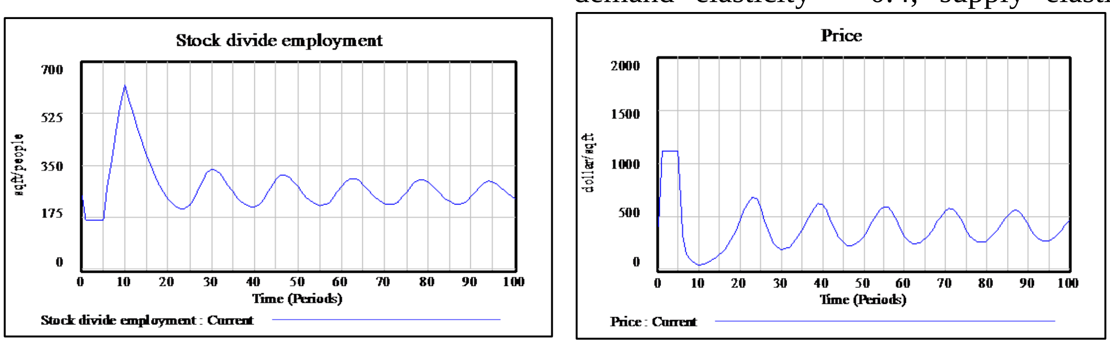


Exhibit 2 presents our SD replication of this Wheaton stock-flow dynamic system. The model includes the key variables in the 4QM. For example, "demand" and "stock" in the space market jointly determines the rent level. (Parameters such as alpha 1 and alpha 2 are dimensionless scaling factors equivalent to constants in the Wheaton model.) Variables such as "vacancy rate" and "construction cost" are linked into the system using dotted-line arrows. We can follow the causal relationships indicated by the arrows to see, for example, how the impact of a sudden increase in demand is perpetuated through the real estate markets. First, because the increase in demand was unexpected, the supply of office space, namely, the current stock, remains unchanged. As a result, as indicated by the red arrows, the rent rises immediately. The cap rate (asset market yield) remains constant, and the asset price of property increases, as shown by the green arrows. A rising property price triggers reaction in the stock-flow part of the SD model, which occurs along the main double-arrow flow from left to right. From the supply side, the developers will increase construction volume in order to meet the demand and price increase. Wheaton assumes a space delivery lag of "n" periods will occur due to site planning and construction. In his stock-flow model, the "n" period construction delay takes on a value of 5 time-periods to represent quick construction, or 8 time-periods to represent long construction time.

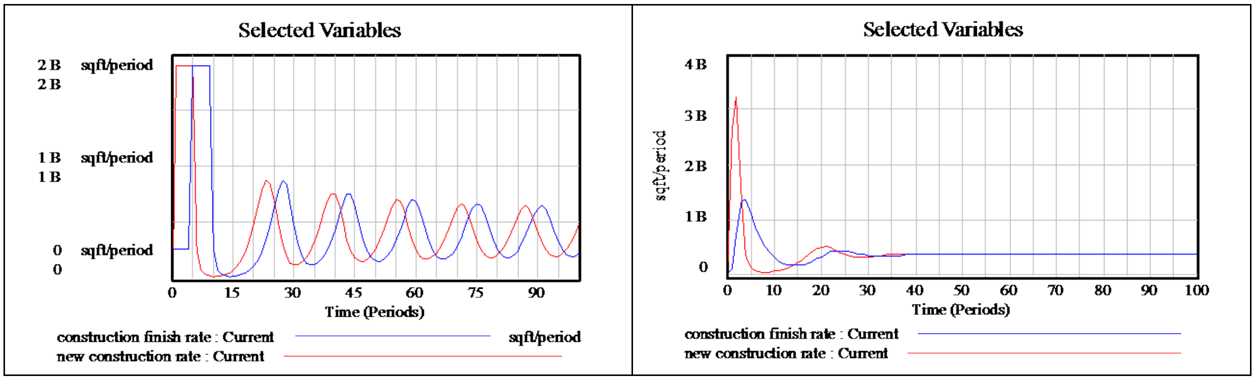
In this model, the rate of construction completions exactly equals the rate of construction starts, that is "n" periods ahead. This represents a traditional pipeline delay structure: meaning that given a fixed delay time, the amount of finished stock from the delay is precisely the same as the order of entry. The mathematical relationship will be that the construction "outflow" at time (t) equals to the construction "inflow" (starts) "n" periods earlier where "n" is the average time required for construction. The newly finished construction adds to the stock. This newly added stock will offset the ongoing demolition, which is proportional to the stock. We can expect the stock to keep rising until it meets the new, increased level of demand, and thereby brings down the rent and thus the property price. When the price starts to drop, the construction will slow down, bringing the stock to a level that will be maintained so that the entire real estate system reaches a new steady-state equilibrium. It should be noted that in both the stock-flow model and the SD model, the initial values of the variables are exogenous and are preset except for two key variables: the rent variable is calculated from the total stock of office, demand, and the rental elasticity of demand; and the rate of construction starts is jointly decided by the stock, the elasticity of supply, and the property price.

Exhibit 3: Market reaction to a 50% demand shock (lag: n=5; depreciation-growth: $\delta = 0.10$; demand elasticity = 0.4; supply elasticity =2.0)



In simulated solutions, the SD model indicates that the demand jump instigates a dynamic oscillation in the system, with the numerical settings as described in the Exhibit 3 caption. This exactly replicates the results of Wheaton's 1999 paper. Given the current parameter values that are used in the simulation, the price variable has difficulty reaching a steady state, which was what Wheaton's paper focused on. However, the SD model allows us to see that certain combinations of parameters (such as relatively more elastic supply compared to demand) will in fact lead the price back to a steady state after a period of oscillation. This is also as has been discussed in papers on Wheaton's original stock-flow model.

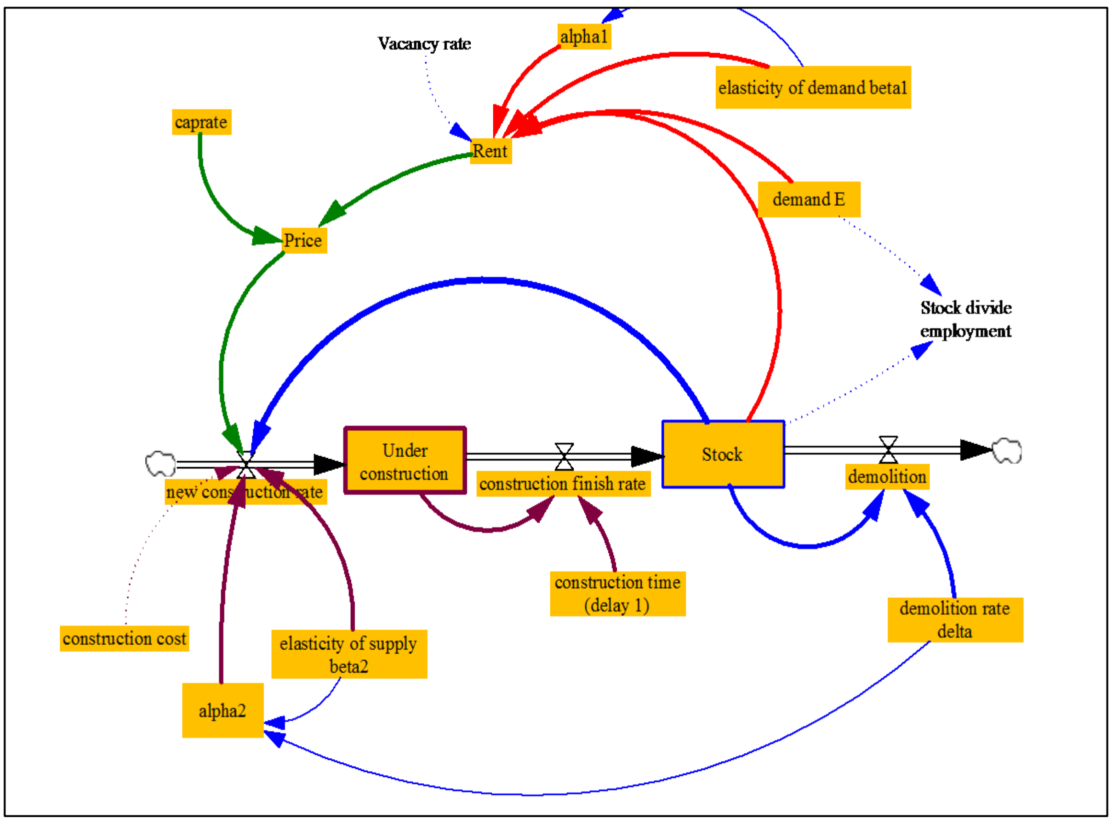
Exhibit 4: Construction starts & completions based on the Pipeline delay structure (left panel) vs the First-order delay structure (right panel)



Even for such a simple model and basic replication of a stock-flow model, we see that the SD model can bring additional insight and discovery. Unlike the stock-flow model, the SD model can more explicitly model the causal flows and processes that govern the system. For example, the SD model enables us to see that the stock-flow model implicitly assumes what in system dynamics is called a "pipeline" delay structure in the completion of construction starts. In the pipeline structure, individual items exit the delay queue in the same order and after exactly the same time. The type of oscillation that Wheaton finds in his stock-flow model can only be replicated in the SD model if we model the delay structure as a pipeline, with an n-period delay. But suppose that in reality the system does not exhibit construction delay as characterized by the "pipeline" type of structure. Suppose that once developers decide to invest, some will start construction fast and finish fast, while others will finish slowly. This could be due to asymmetrical information, or different construction resources, etc., or some projects may simply take longer to complete than others. It may therefore be more realistic to assume that construction follows what in SD terminology is called a "first-order material delay" structure, where the construction completion rate is proportional to the stock of property under construction. Exhibit 4 shows the difference in system dynamic results between a pipeline delay structure and a first-order delay structure.

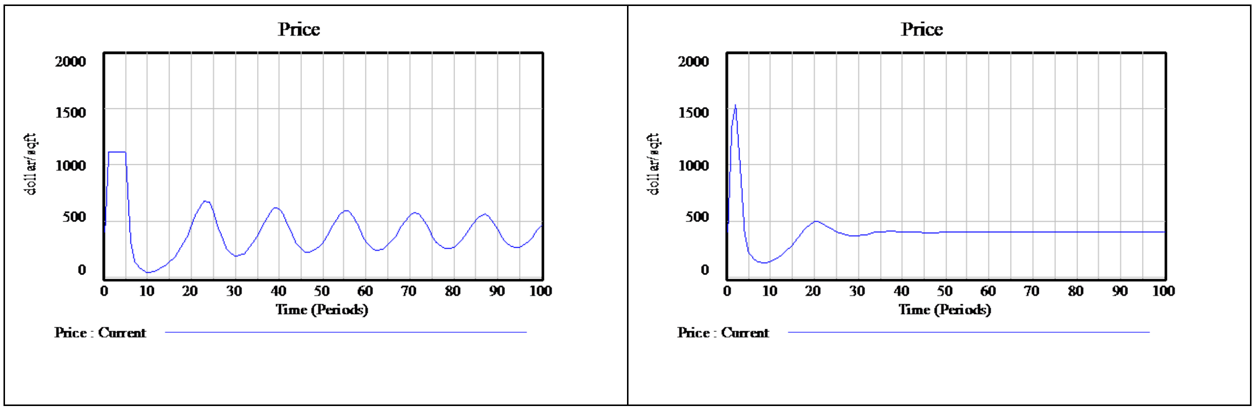
Exhibit 5 shows how the First-order Delay structure is accommodated in the SD model. We add a stock "under construction" variable. The "under construction" variable is used as a stock to count all the buildings that are under construction at each period of time. The exit rate, or construction finish rate, equals the "under construction" stock amount divided by the construction period.

Exhibit 5: The System Dynamics Model of the Stock Flow Model with an "Under Construction" Stock Variable



The result of the simulation is quite different with this change as we saw in Exhibit 4 regarding the dynamics of the construction starts and completions. Exhibit 6 confirms that the different result also is experienced in the price dimension. With the first-order delay structure the first local maximum demonstrates a higher magnitude of price jump, but after that the system reaches a price steady state much quicker and shows less oscillation.

Exhibit 6: Price Oscillation reduced significantly when construction delivery structure is modified



Background on Land Financing System of Local Governments in China

Before we present our next step in the development of a SD model for the China urban housing market, it is worthwhile to delve a little more deeply into the unique system of local government finance that has evolved in recent years in China to provide some background context. A recent report for the IMF spotlighted this issue (Lu & Sun, 2013). That report pointed out that the receipts from the sale of land lease rights are the main source for local governments' debt servicing payments. Such finding is also confirmed by recent work of other researchers (Ding 2003; Ding 2007b; Hsing 2010; Deng, Gyourko and Wu 2012). As a result, a correction in real estate prices that results in lower land prices could hurt the debt servicing ability of local governments and the local government-financing platform (LGFP). This could impair national banks' asset quality (Sheng & Soon, 2015).

In China, developers and investors can lease urban land for terms of 30 years for industrial use, 50 years for commercial use, and 70 years for residential use. The ability to lease land is critical because it directly links land and the capital market thereby allowing local governments to tap into the capital markets, while still allowing the Government to technically maintain the ownership of the land. Income that comes from land leasehold sales transactions has since become an important component in local governments' fiscal revenue structure.

Fiscal reforms in the 1990s enhanced the role that land plays in local government revenues. In 1992, the leadership of Chairman Jiang Ze-min and then vice Prime Minister Zhu Rong-ji initiated a new "tax sharing system," fully implemented in 1994 (Xiang 2008). This is a landmark in China's fiscal reform history in recent decades. It set policy between the Chinese Central Government and local governments regarding the collection, sharing, and spending of various taxes, such as the corporate tax, income tax, land-lease revenue, etc. Numerically speaking, the central government previously had access to only 22% percent of the total tax revenue, but after the 1994 tax reform its share rose to 56%; with the local governments' share falling correspondingly from 78% to 44% (Li 2012). This change is widely considered to be the root of the "Fiscal-Power" conflicts (*qianquan maodun*) between the China Central Government and local governments (Liu 2014). While the reform took tax revenue from the local governments, it did not reduce the actual tasks assigned to the local governments (Zhou 2006). In short, the fact that central government has the dominant financial power while the local government has the actual duty to perform crucial government functions (including the provision of urban infrastructure) has created a mismatch between authority and responsibility (Jiang, Liu and Li 2007).

As a form of compromise, the central government gave local governments the autonomy to use most land and real estate related tax income. The decentralization of land regulation power, plus the implementation the tax sharing system, gave local governments a channel to achieve their fiscal needs. As a result, local governments focus on creating their private disposable “purses” through land sales, and aim to further develop the local real estate related industry. For example, in 2009, land sales in Hainan province amounted to 10.2 billion RMB, and accounted for about 34% of the province’s total fiscal budget (*caizheng yusuan*) (Ouyang 2012).

These developments gradually evolved into the so-called land based municipal financing mechanism, or in short, “land finance.” It means that local governments rely on income from land related sales to increase the governments’ fiscal budget. There are mainly four channels of land financing (Yue, Teng and Wang 2009):

1. Direct land “sale”;
2. Free industrial land development, with the expectation of collecting tax revenue from the industry later;
3. Tax revenue from real estate development industries; and
4. Use land sales income as collateral to obtain loans from central banks.

Li and Luo (2010) organized these channels into three categories:

1. Land finance I is the narrowest. It includes direct land tax and indirect tax from real estate and construction industries.
2. Land finance II mainly includes the land sales fees (effectively, the up-front price of the leasehold sales, the full present value of the leaseholds).
3. Land finance III consists of loans obtained from the central banks using land as collateral.

However, the process of land finance has its internal flaws: the local government, positioned as a monopoly in land supply, can effectively control the quantity, location, and use of the land in terms of urbanization. The local government officials naturally plan land sales around their own best interests (Tao, Yuan and Cao 2007). Under the pressures of local economic growth and regional competition, and in order to maximize their economic achievement within the assigned five-year tenure for a government official, local government leaders have prioritized non-residential land use and exploited the maximum land-lease sales price from residential land sales (Wang and Tu 2014).

By favoring industrial land use, local governments constrain the supply of land for residential use and push up the land price to maximize the total land sales revenue (Zhang, Wang and Xu 2011; Zheng and Shi 2011). Li and Luo (2010) report that on average at the national level only 15% of the total land goes into residential use. Based on land transaction data between 2003 and 2005, industrial land prices were typically only a third of residential land prices (Tao et al. 2009). Research also indicates that local governments taking advantage of their monopolistic position can morph into speculators. Instead of selling land, they become land hoarders and the size of hoarded land is substantial and startling (Du and Peiser 2014).

The exclusive right to sell the leasehold of land to private developers gave the local governments the incentive to convert agricultural land around the urban fringe and sell as much land as possible in order to obtain the maximum land sale fees.[9] The land "seizure" cost, which refers to the money that the local government pays to obtain land from farmers, is minimal (Jiang, Liu and Li 2007). Based on 30 cities' land reclamation and sales data, the estimated land sale price has been18 times the cost paid to the farmers (Wang 2005).

Facing such profit, local governments have used land finance heavily to fuel urban development and finance infrastructure provision. Based on land transaction data from 1999 to

[9] The term "fees" in this context simply refers to the proceeds the local governments obtain from the sale of the land leaseholds.

2007, analysts have estimated that sales of land count for more than 30% of local government's budget (Liu and Jiang 2005; Li and Luo 2010).

Local governments also use land sales fee revenue as collateral to start a second round of money-raising. While they are not allowed to borrow directly from government-owned central banks, they can set up entities related to the local governments and use land transfer fees (leasehold sales revenue) or potential conversion-in-progress agriculture land stock as collateral to borrow money under the name of such an entity (Liu and Zhang 2010).

Since 2010, local governments have taken on so much debt that they face great difficulty to pay back even the interest portion, thus creating what has been termed a "local government debt crisis".[10] By June 2014, local governments in 84 key cities in China had a total debt of 8,700 billion RMB, equivalent to about 1,500 billion US dollars (Zhang 2014), almost comparable in magnitude to the U.S. municipal bond market as a fraction of GDP. In order to repay the debt, the municipalities are forced to borrow more money, or sell more land that they can have immediate access to, thus potentially getting trapped in a vicious cycle (Yang and Huang 2010).

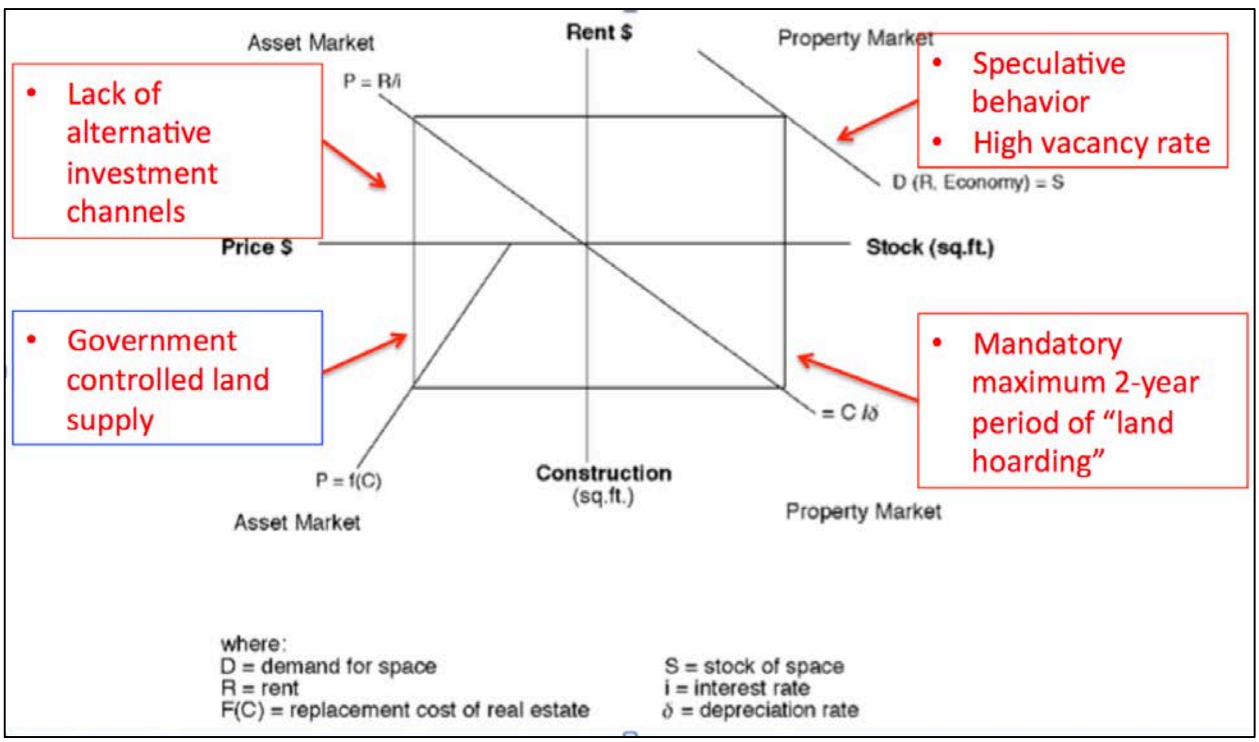
The current urbanization process in China may well be actually financed just through land finance. With the leverage of debt, the effect of the initial large amount of land sales fees has been magnified. Since land is a scarce and fixed resource, such continuous "self-financing" will not last forever.

[10] http://cn.nytimes.com/china/20130624/cc24localdebt/

Exploring the Development of a SD Model for Chinese Urban Housing Markets

In this section we present the preliminary development of a SD model for Chinese urban housing markets. At this stage our model is just a slight elaboration of the previously described basic canonical model (based on the 1999 Wheaton stock-flow model). Nevertheless, it introduces two unique and important "non-market" features of the Chinese system: the land-finance scheme just described, and the prominence of "speculative" demand for ownership of housing units purely as places to "store money", beyond the "real" demand for housing services. We first present the model in its general form, and later calibrate it with the previous Wheaton parameters and test it on two system shocks.

Exhibit 7: A revisit of the D-W model in the context of Chinese urban housing market



As noted, the China SD model is based on the system dynamics version of the 4QM described previously. Its structure and equations are easily modifiable for the purpose of integrating special features of the Chinese system. Certain unique or nonmarket features can be "plugged-in", that is, added onto the basic model as extra elements or modules.

In Wheaton's 1999 stock-flow model paper, he mentions that he adopts the standard view that the flow of capital assets depends upon their price relative to replacement costs, and argues that the model can be easily improved by incorporating the construction cost (K), which also includes land cost. This can be done by replacing Price (P) with (P-K) in the equations. In view of the major role of land cost as suggested in the previous section, our first modification is to include the cost of development land into the model (in effect, the price developers must pay to the local government for purchase of leaseholds).

We then need to add new variables to the model to reflect the behavior when local governments sell land to meet their budget goals. In Exhibits 8 and 9, our SD model suggests that the local government's behavior can strongly determine whether land prices drive housing prices into an unstable spiral or not, depending on whether the local government land sale behavior is aimed at "maximizing revenue" or aimed at a "fixed revenue" target. As before, the arrows show the flow of causality among the key parameters or elements in the system. A positive relationship means that the subsequent (downstream) element changes over time in the same manner or direction as the prior (causal) element, and a negative relationship indicates the opposite.

Exhibit 8: China Housing Market Systems Dynamics with Local Government Revenue-Maximizing Behavior.

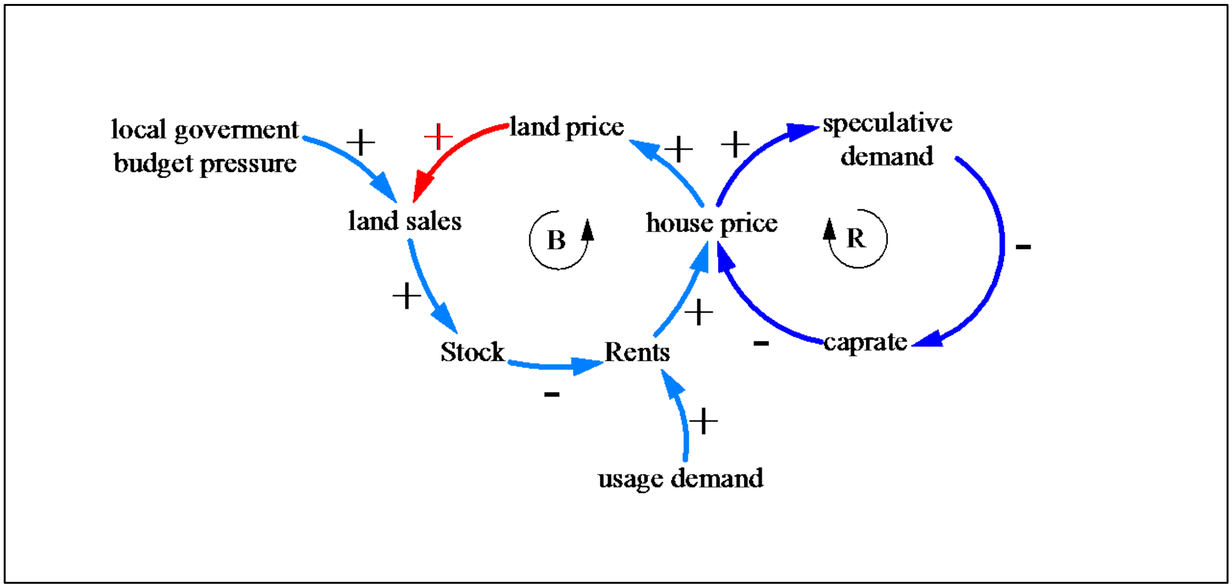
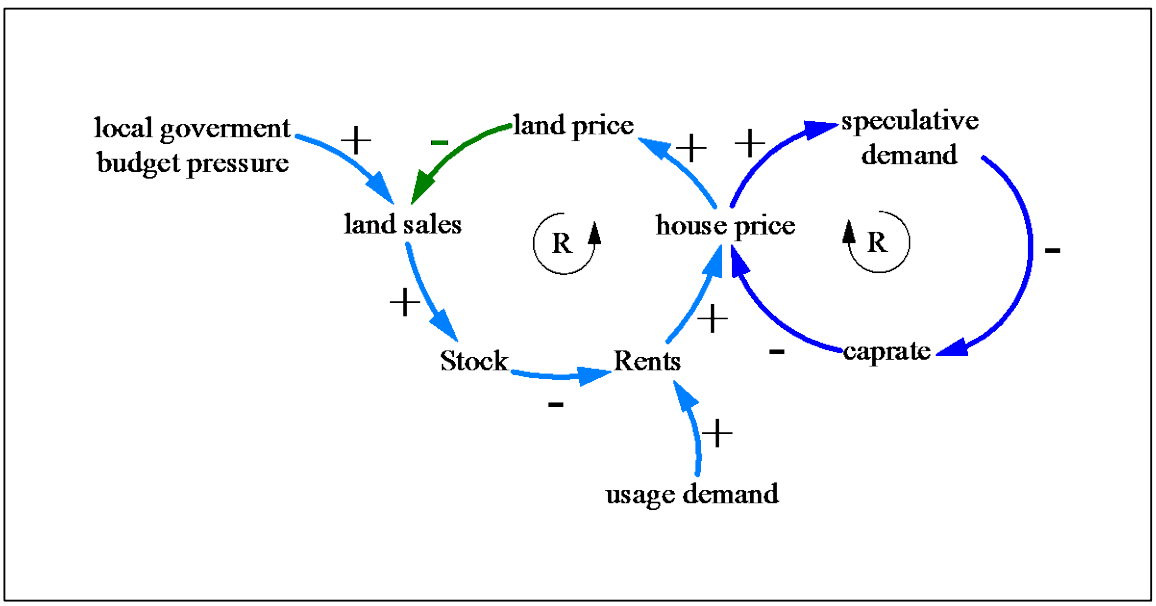


Exhibit 9: China Housing Market Systems Dynamics with Local Government Fixed Revenue Target Type Behavior.



As the Exhibits show, the system is described largely by two loops. The main loop is on the left, representing the fundamental housing market. It relates land prices to local government land sales authority behavior, which in turn affects the stock of housing in the market, which in turn affects rents and house prices, and then, via the Residual Theory, land prices are affected once again.[11] The secondary loop on the right reflects another nonmarket feature in the Chinese housing market, the speculative demand for housing, not as a consumption good for its use in providing housing services, but merely as a store of money (an "investment" asset). Assuming myopic behavior, this loop tends to reinforce whatever is happening in the main fundamental housing market loop, and thereby can cause the results to be exaggerated or magnified. The model shows how the system can be sensitive to local government land sales authority behavior.

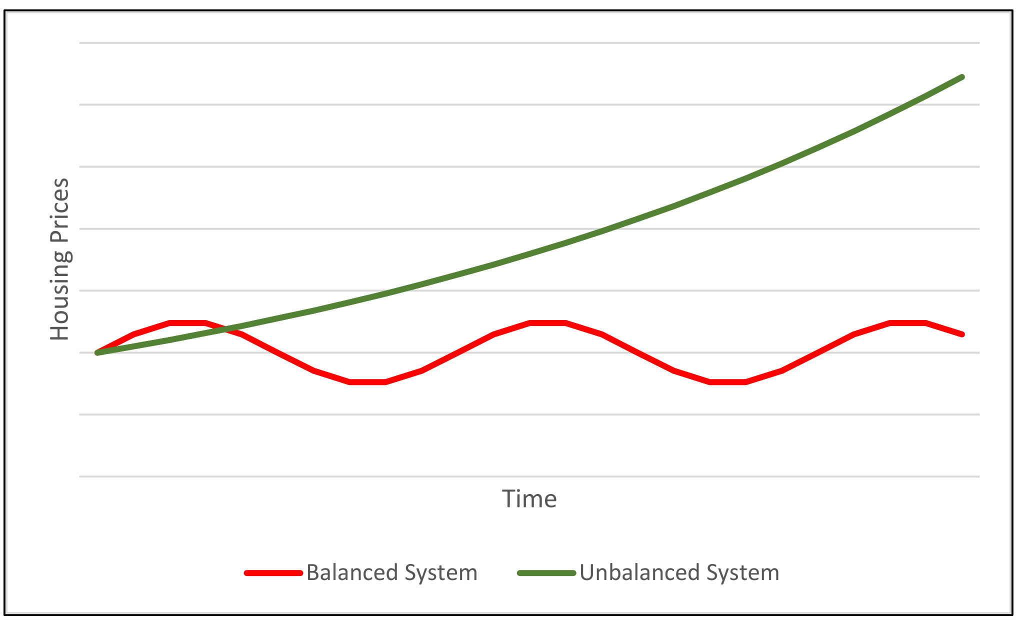
As Exhibit 8 shows, when the local government is revenue maximizing, the system does not tend overly toward house price bubbles. The housing market loop on the left acts as a balancing loop, which means that it tends to keep the system in balance, not spiraling out of control. The key point is that rising land price leads the revenue-maximizing local government land sales authority to sell more land acreage. This leads to an increase in the supply of housing, which puts downward pressure on rents and/or house prices, which in turn closes the loop in a dampening manner by putting downward pressure on land prices, thereby counteracting or dampening the initial trigger which was rising land prices.[12]

[11] The "Residual Theory" refers to the residual theory of land value, a basic concept in urban economics. The Residual Theory says that land value is a derivative, and it goes back to Ricardo, "The Principles of Political Economy and Taxation," 1817. A now classical elaboration of Ricardo's principle is in E. S. Mills, "Urban Economics," 1972, page 40: "…land rent is a residual, equal to the excess of revenues from the sale of goods produced on the land over remunerations to non-land factors used in production."

[12] We have not yet incorporated, but can easily do so and will do, the effect of local government artificially constraining the proportion of residential land sales in favor of industrial land. This could be reflected in another decision node in the system in which the local government decides on the proportion of land sales that is to be residential.

On the other hand, when the local government land sales authority is aiming at a "fixed revenue" type of target, the relationship between the "land price" and "land sales" variables is a negative relationship. This changes the main housing market loop on the left from "balancing" to "reinforcing" in SD terminology. An increase in land price now leads the local government land sales authority to reduce the amount of land sales (in acreage), as selling less acreage of land will suffice to meet the fixed revenue budget target due to the higher land price per acre. Thus, higher land prices lead to less land sales which results in less stock of housing in the market than would otherwise occur, in spite of rapidly growing housing demand (reinforced by speculation in the right-hand loop). The reduced (or less rapidly growing) housing supply drives up rents and prices, leading to higher land prices (again via the Residual Theory), and the loop continues in an upward spiral.

Exhibit 10: Two Different Price Dynamics Tendencies Resulting from Two Alternative Land Sales Governance Behaviors.



As Exhibit 10 shows, the different nature of the local government land sales authority behavior leads to dramatically different housing price dynamics, in theory. Revenue maximization behavior in which higher land prices lead to more sales of land area to developers results in a system that is fundamentally balanced dynamically, even if it may experience cycles that tend to revert to the mean over time. (And those cycles could be rather exaggerated, especially due to the reinforcing speculative demand loop.) Fixed revenue targeting behavior in which higher land prices lead to less sales of land acreage into the development process results in the system tending to spiral out of control, with ever higher housing prices. (Once the bubble bursts, the same system dynamics would lead prices to collapse rapidly in a self-reinforcing manner, if the land sales governor remains the same.)

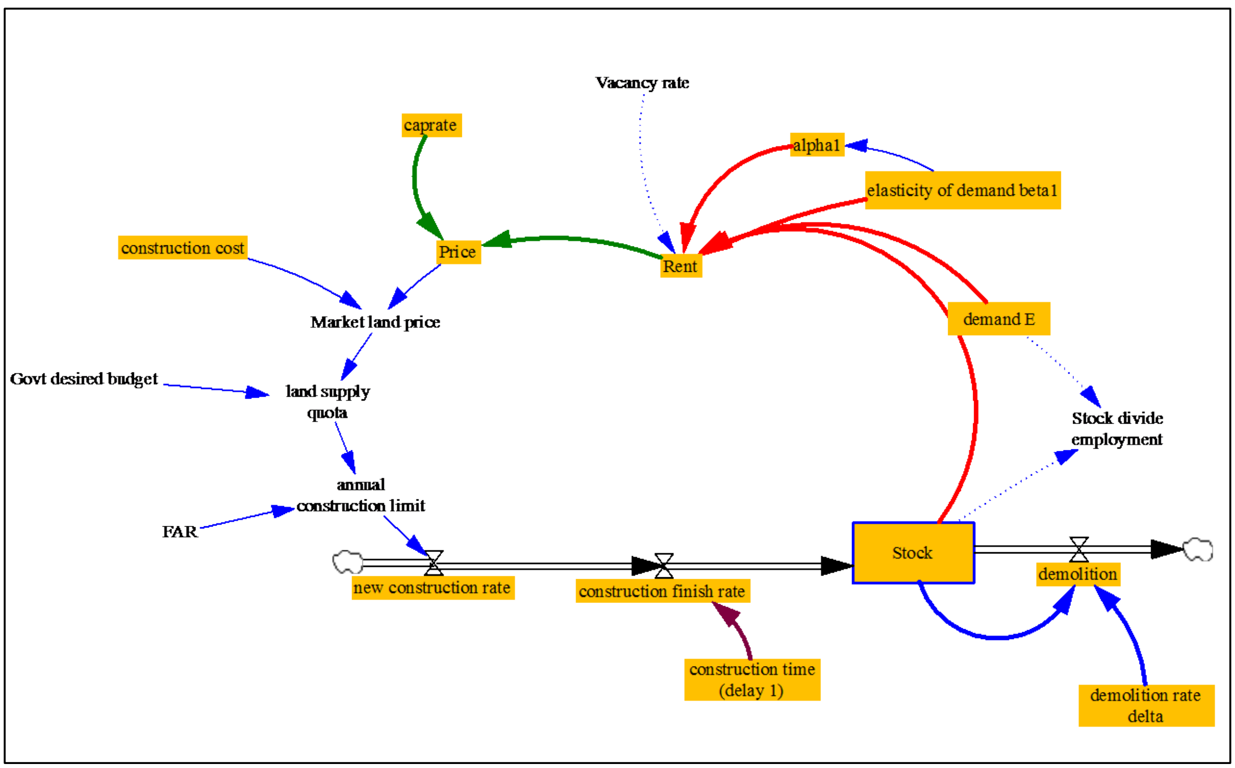
The modification of the land financing scheme is added to the structure of the system that can alter the system behavior. In the following section, we will explore the above-described SD model calibrated with the original 1999 Wheaton model parameter values. The goal is to compare the simulation results with and without the land finance scheme component. While this data is hypothetical, it has some pedigree in the literature, and can provide interesting results for gaining insight into the system behavior .

An Initial Example Experiment

The plan of the simulation is as follows: start with the model as we discussed previously (the original 1999 Wheaton model with the pipeline delay structure). At the outset the system is in steady-state with the property asset price at the equilibrium level of 400$ per sqft. Then we introduce the 50% demand jump due to an increase of the work force from 10M to 15M.

An important modification is that the new construction rate is not calculated based on original Wheaton model, which is a straightforward econometric type supply elasticity function (with the threshold step representing minimum replacement cost). Instead, the SD model assumes that the local government needs to meet certain budget goal every year. When they sell the land, no matter what the quantity is, it is assumed that local developers must absorb the entire supply at the system-implied price (which of course, reflects the rents, which in turn reflect the supply and demand balance). And the model assumes that the developers will start the development of the land almost instantly instead of hoarding it (although a certain construction delay may apply, that is, a specified time of construction). This new structure is shown in Exhibit 11. While this may represent a simplified and somewhat extreme or archetypical case, it will be instructive of analytical purposes.

Exhibit 11: Modified System Dynamics model including land finance component



With this modification, we run the Exhibit 11 SD model under two possible scenarios, to test the behavior of the system:

1. Scenario 1 has two phases, first is the jump in the demand, then after some time the extra demand goes away, for example perhaps due to government restrictions on home purchases.
2. Scenario 2: The budget goal of the local government changes. For example, this could be caused by a change revenue needs reflecting a change in expenses that must be covered due to necessary local government expenditures or debt service requirements.

As usual, we first need to establish the model running in its initial steady-state as a starting point. Then, by adding the demand jump as an external shock, we can observe the system dynamics reflecting now the altered model structure that includes the land finance component. Calibrating based on our prior results with the canonical model, we start with a local government budget target of $37.5B, which is consistent with the starting point steady-state price of 400$/sqft.[13]

In the first phase of Scenario 1, we add the 50% demand jump, from 10M to 15M work-force. As we can see in Exhibit 12, the price no longer demonstrates the cyclical behavior anymore as it did in the initial Wheaton model that we saw previously; instead it spirals upward. This is because the new land component serves as a valve that altered the initial equilibrium-seeking behavior of model. When the demand increases there is a surge in the property price. Since construction cost remains constant by assumption, there is a jump in land price (due to the Residual Theory). If the total budget of the local government remains constant, the land supply

[13] Just to reiterate, the Wheaton quasi-hypothetical market figures are based on the U.S. aggregate office market in the 1990s. Obviously, our ultimate objective is to calibrate for Chinese urban housing markets.

will drop as the government does not need to sell as much land acreage to meet the budget. This means that the new housing supply will have more trouble meeting the new demand.[14] As a result, the housing price will further increase. The entire model becomes a reinforcing loop model, a quantitatively calibrated version of the previous generic Exhibit 9 model. The result is that the housing price demonstrates the exponential (explosive) behavior seen in the right-hand panel of Exhibit 12.

Exhibit 12: Price Oscillation changed to exponential behavior after introducing land finance component

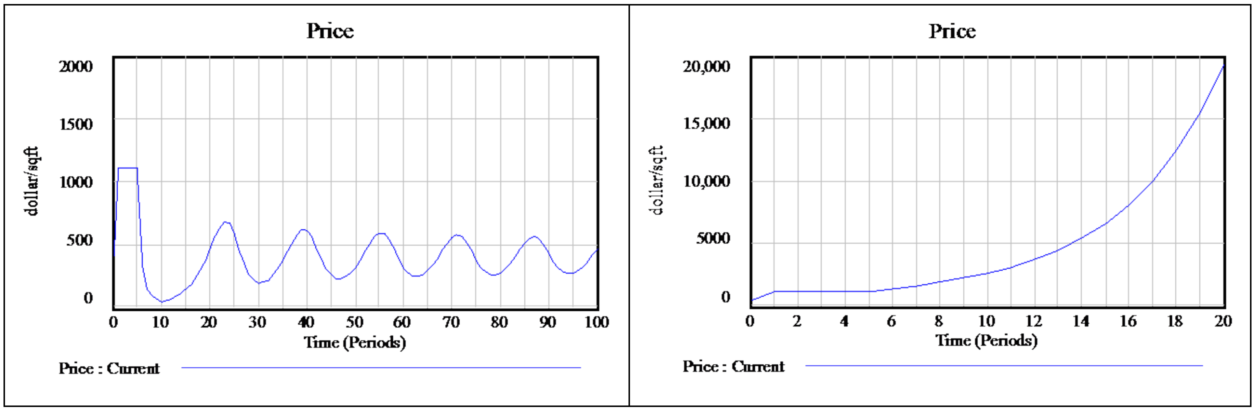
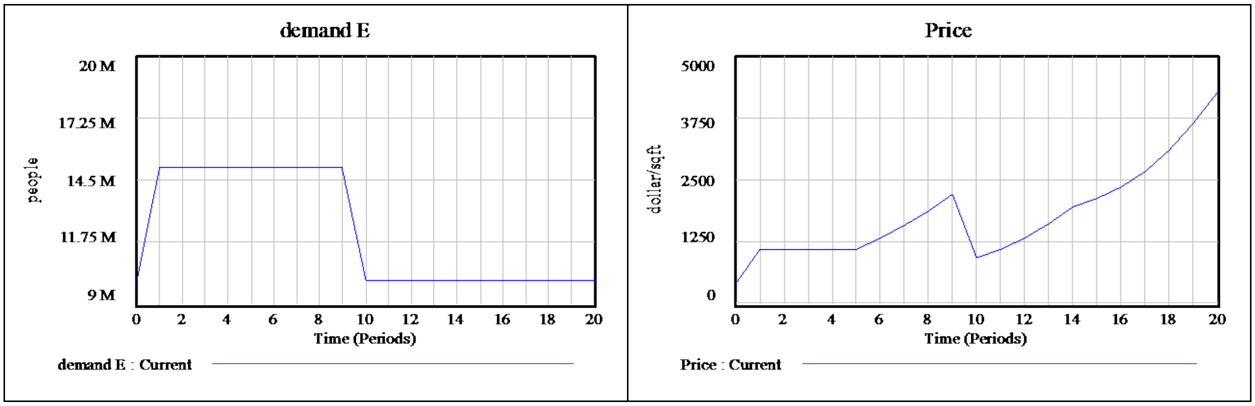


Exhibit 13: Demand jump and suppression (to the left) and the price reaction while having land finance model built in (to the right).



[14] Of course, this could be offset by an increase in density, which would be an additional decision module that could be inserted in the SD model, with possibly interesting implications for the space demand function and the form of urban design implied for the urban development (including related infrastructure needs).

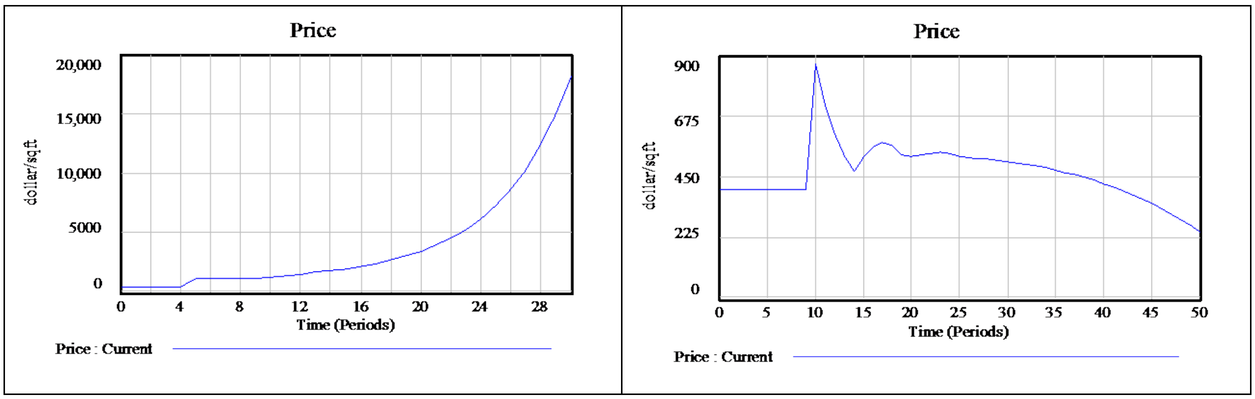
In the second phase of Scenario 1, we reduce the demand by 33% at time 10, that is, back to its original level of 10 million that it had at time zero. This could represent the case where the government sees that the housing price is exponentially increasing, and uses policy controls such as a "home purchase restriction rule" to suppress the demand in order to induce the price to drop. As Exhibit 13 shows, the price does initially drop, but then it resumes its exponential increase as long as the land finance behavior remains governed by the fixed revenue target. That implies that the policy of demand control may be effective in reducing the price in the short term but not the long term. (This agrees with findings in Sun *et al* 2015, and Deng *et al* 2015.)

Exhibit 14: Varying government budget with an upward jump by ~20% at time 5.

Government desired budget=3.75e+10*(1+STEP(1,5))

Now consider Scenario 2. What if the government's budget target changes, for example, it increases? As noted, this could reflect circumstances such as that the government needs more money for infrastructure development, or it faces an immediate burden to service loans. The result is that the housing price starts to plunge as in Exhibit 14. This is because the need for increased revenue forces the government to supply more land acreage into the system, then if the developers are forced to absorb the land supply and start development (at the "normal" density, which reflects the previous land price), there will be an over-supply of property space in the market. Property price thus starts to drop (per square foot), causing land prices to drop, causing the government to have to sell yet more land, and so forth. The model thus demonstrates a downward plunge.

Exhibit 15: When budget jump by 20% @ time stamp 5, the result of price trend with a demand jump @ time stamp 5 (to the left) and @ time stamp 10 (to the right).



Could an increase in demand help? The answer is a definite yes. However, the shape of the results depends on the magnitude and timing of the demand jump. The effect of changes in the budget and the demand will interact with each other and could lead to quite different outcomes in the market price of property. The left figure in Exhibit 15 shows the effect of a budget jump of +20% at time stamp 5 and a demand jump of 50% at the same time. As we can see, the effect of the demand jump dominates that of the budget jump. Compared to the simulation result in the right-hand figure in Exhibit 12, we can see that the price increases at a slower speed, reaching 5000 dollar per sq foot around time period 23 instead of time period 13. Again, we note that the specific numbers in this example are quasi-hypothetical. We are, at this stage, still trying to observe the general system behavior pattern rather than mimic the real world in in specific market. In the right-hand figure in Exhibit 15 we have introduced the demand jump at a later stage at time stamp 10. As we can see, the cumulative effect of the budget jump between time stamp 5 and 10 overtakes the effect of the demand jump, resulting ultimately in a downward price trend.

Conclusion:

This paper presents a new line of analysis for real estate development that builds on the dominant econometric methodology. Starting from well-established theory and methods, the approach here follows in the footsteps of previous system dynamics applications to urban systems, to propose a useful way to examine the dynamics of real estate markets, particularly in contexts where these are subject to a range of controls different from those existing in Western market economies. Our initial focus is on China, but we believe it would be reasonable to apply this approach to other rapidly urbanizing regions, such as South East Asia, India, and elsewhere.

The stock-flow model of real estate markets provides the core conceptual framework for the analysis. In its emblematic representation, the DiPasquale-Wheaton 4 quadrant model (4QM), it focuses primarily on a static equilibrium analysis. But the stock-flow model elaborates some key features of real estate market dynamics, as seen in a number of previous studies done in mature markets where historical data is plentiful. The stock-flow model begs to be made more general and flexible, with greater richness of system elements and causal flow representation and more ability to accommodate non-market and unique institutional features in data-scarce environments typical of emerging market urbanization. A convenient and established way to do this is by using the tools of systems dynamics. These have the advantage, compared to econometric systems of equations with lagged variables, of providing reasonably comprehensive images and explanations of the dynamic effects that balance and dampen the dynamics of a market, or reinforce them in explosive bubbles or collapses.

Our approach is to build on a canonical system dynamics representation of the stock-flow model to explore the possible implications of specific features or restrictions on real estate markets. Procedurally, we embed representations of these features into the basic canonical model and explore their possible effects. Our immediate focus is on combinations of effects that might promote bubbles – and lead to undesirable collapse – and those that might mitigate or prevent such unsustainable results. We also have an interest in an easy to visualize the system that can lend itself to widespread pedagogical use.

So far, our analysis is in the process of exploring the possible implications of the "land financing system" that has developed in China. As we currently understand it, this process puts local governments in charge of assembling and releasing land for development, and has allowed them to use this process as a "cash cow" to generate needed municipal revenues. Preliminary simulations of this process suggest a some ways in which the current arrangements could be unsustainable and perhaps even economically dangerous.

At this point, this line of investigation appears to offer the possibility of some interesting insights, and may also provide an effective pedagogical device. We are thus committed to pursuing this approach to see how far it may take us. We intend to explore the possibilities in detail by calibrating the model to specific situations in China. We welcome suggestions in this regard, and will be happy recruit prospective collaborators!

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