From Tulip Bulbs to Sub-Prime Mortgages Examining the Sub-Prime Crisis: The Case for a Systemic Approach

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INTRODUCTION

In "The Logic of Failure" (Dorner 1996), the author stated "It is hard to say whether more damage has been done by evil people acting intentionally or good people acting in ignorance." This statement is particularly appropriate when addressing the collapse of the U.S. economy that was precipitated by the crisis in the sub-prime mortgage market. Specifically, a popular explanation for the crisis revolves around greed and a lack of ethical decision making amongst some members of the financial community. While such an explanation may have some merit, actions taken by people acting in good faith also played a role, as did the failure of others to act, either because they could not or did not.

This paper illustrates how the lack of a systemic perspective among some of the key actors in the crisis may have contributed to their failure to anticipate the unintended consequences of well-intended actions. Moreover, it highlights the fact that the same circumstances that created the current crisis have occurred multiple times throughout history, and provided cues that signaled the likelihood of an oncoming disaster (Malkiel, 2007, Kindleberger, 1996, Mackay, 1974). This paper applies a methodology that can help decision-makers

visualize how actions and events are interrelated, and thereby better understand both the long and short term consequences of their decisions. The approach taken is not intended to be 'the answer', but offers a starting point for developing a more systemic approach to recognizing and addressing the booms and resulting busts caused by speculative investing.

The statement "The theory and practice that embodies 'learning organizations' can be applied to developing and implementing effective natural policy and management" (Saveland, 1998) can be equally applied to securities policy and management. A learning organization is a group of people who are continually enhancing their capacity to create the results they want. (Senge 1990a, Senge 1990b, Zulauf 2007). At the heart of learning organizations is an understanding of the underlying dynamics of a system. The representation that we develop applies the language of systems thinking to the most recent financial crisis. A mental model of this system and the corresponding systems structure can be used to not only understand what happened, but inform decision-makers when similar speculative behavior occurs in the future. This can in turn help them to understand the potential implications of different courses of action. It goes without saying that the financial system being explored is complex and that a large number of variables will influence its behavior. However, if even basic relationships between key variables are not understood, the potential for poor outcomes will exist.

The remainder of the paper is organized as follows. First we review the origins of the financial crisis and highlight the need for a systemic approach to examining it. We then describe the concept of systems thinking, discuss its importance in understanding complex issues, and highlight a key systems thinking tool, the causal loop diagram (CLD). Third, we show how CLDs can be used to visualize behavior in complex systems. Finally, we use the CLD to show how the underlying structure of speculative growth and collapse is consistent both over time and across a wide variety of situations (i.e. from tulip bulbs to subprime mortgages).

GOOD INTENTIONS GONE BAD

A challenge faced by organizations when existing markets are saturated and growth opportunities are limited is how to sustain growth. Two common approaches to achieving this are to add products to the portfolio offered to existing customers, or to expand the base of customers served. While both approaches can be used effectively, they are not without pitfalls. An excellent, but unfortunate example of the dangers of using these approaches without understanding their underlying dynamics played out in the mortgage banking industry and is a primary factor in the collapse of the U.S. economy. As we will discuss, similar phenomena have played out multiple times throughout history. One dimension of the dynamic behavior we are referring to is loss of focus. Pressure to expand the market base and/or product portfolio can cause a firm to lose focus. This occurs if the firm drifts toward serving customer segments that are not part of their strategic plans, or if they expand their product portfolio in ways inconsistent with strategic objectives or process capabilities. While in the short term the adverse effects of such moves might not be apparent and may be viewed as being consistent with broader strategic objectives, over time, the cumulative effect of such moves can be devastating (Kaboub, Todorova, and Fernandez, 2010).

Given limited opportunities to expand into overseas markets due to the regulatory environment in those markets as well as the lack of infrastructure, banks and other financial institutions sought to increase profits by developing new customers in existing markets. These were customers that the institutions would not ordinarily have sought due to their profile; low/relatively insecure income levels, few assets against which to secure financial obligations, and consequently, high risk of default. Demyanyk and Von Hemert (2011) showed that significant appreciation in housing prices also masked the risks of loaning money to high risk

customers. This led lending institutions to rationalize that increases in real estate equity would enable high risk borrowers to either adjust their borrowing needs or sell short. From the lenders' perspective, the new customer base represented a new source of income, but with little significant risk. As Lewis (2010) demonstrates, most participants were wrong in their assessment of this risk.

A casual reading of the evolution and scope of the subsequent economic crisis in the popular press will cause even the most financially literate reader to recognize the complexity of the problem. Such complexity calls for the need to view the crisis from a systemic perspective rather than a traditional analytical perspective. Richmond (2003) observed that one reason we make so little progress in addressing recurrent problems is that we continue to apply analytical problem solving skills to systemic problems. However, through the application of systemic thinking tools, we can evolve our thinking to better address large complex issues. These tools make it possible to combine the many singular explanations for the crisis to develop a model that can serve as a ***starting*** point for managers and policy makers to assess whether their mental models of the crisis are complete AND correct. The crisis is the result of many factors coming together, yet to understand the dynamics involved, we need to visualize how the variables fit together. Moreover, once we have a sound understanding of the underlying dynamics, we can seek leverage points that allow us to understand the consequences of changes to the model.

WHY SYSTEMS THINKING IS NECESSARY

Taken in isolation, none of the events that led to the sub-prime crisis and subsequent economic meltdown were new. Various financial markets have experienced boom/bust cycles dating back to the 1600's and the tulip bulb crisis involving speculation in the tulip bulb market

in the Netherlands (Sterman 2000; Malkiel 2007). So why were there such severe consequences on a global scale this time? To answer that question, it is important to understand that in the early stages of the evolution of a complex system, the system is composed of several subsystems that have little interaction or impact on each other. As a result, these subsystems can (and generally do) behave as if they are independent, changing in ways that do not substantively impact other subsystems. However, as the subsystems grow and evolve they become more interdependent, eventually reaching a point where changes in one subsystem have a ripple effect on others (Gharajedaghi 2006).

In the late 19th century and early part of the 20th century, financial institutions were purely local entities. Consequently, an economic cycle (for example a real estate boom & bust cycle) had essentially only local impact. As institutions started to expand and merge, an economic failure in one part of the country could be felt in other parts of the country and indeed internationally. This global interdependence was dramatically demonstrated within the financial markets as a result of World War I and the collapse of the world economy in the 1930s (Ahamed 2009). Today, the interdependence of financial systems has reached a point where there exists a "global economy so tightly linked that problems in the U.S. real estate market can help bring down Icelandic banks and Asian Manufacturers" (Saporito 2009). The question is therefore not how did the credit crisis happen, but rather how do we learn from it so that we recognize that the Savings & Loan fiasco in the U.S. of the 1980s, the dot com boom/bust of the 1990s (Malkiel 2007), and the real estate/financial market collapse of the late 2000's were all driven by the same phenomenon. Indeed, the same underlying dynamic structure is behind every speculative boom/bust cycle going back the tulip bulb bubble of the 1600's. We must learn how to deal with a large, highly interdependent global economy, and how to understand large complex systems

with multiple interdependencies. Such insights may be obtained through the lens of systems thinking

WHAT IS SYSTEMIC THINKING

Ackoff (1981) differentiated between analytical thinking and synthetic (holistic) thinking. Analytical thinking attempts to understand a system by breaking it into small parts and studying them in isolation. Once the parts are understood, the analyst attempts to explain the behavior of the whole based on the behavior of the parts. This approach to decision making is the basis of how decisions are typically made as it allows the decision maker to simplify the complex. In contrast, synthetic thinking attempts to understand the larger context within which the system operates. Once the role of a system within this context is understood, the synthetic thinker tries to explain the behavior of the system based on that role. In other words, while analytical thinking explains *what* the parts do and *how* they work, synthetic thinking explains *why* the parts do what they do. Ackoff further pointed out that when a system is disassembled, it loses essential properties as do its parts. He argued that observation of the interaction between and among the parts is crucial to understanding system behavior. Consequently, it is impossible to fully understand a system through analysis, thereby making the case for developing synthetic/holistic thinking skills.

Forrester (1971) identified additional characteristics of complex systems which make it difficult for people to understand and work with them. These include:

- Cause and effect are often separated in both time and space.
- Problem resolutions that improve a situation in the short term often create larger problems in the long term. Conversely, actions that make things worse in the short term often have positive long-term effects.
- As a result of the first two characteristics, people often fail to learn from mistakes because
    - Long time delays often result in one person creating a cause and another experiencing its effect.

    - Due to differences in short and long term effects, what a person learns from the short-term result of a decision may be different from the long-term outcome.
- Subsystems and parts of a system interact using multiple, nonlinear feedback loops. The complex flow of interactions often creates counterintuitive behavior, and consequently, what appears to be the 'right' decision is in fact often a bad one.

It is not uncommon for decision makers to overlook the phenomena described above when making decisions, and indeed many do not realize they exist. The concept of cause and (instant) effect is generally learned at an early age through simple situations such as 'if I touch a hot stove I get burned.' Subsequent and frequent conditioning results in our developing an event-oriented view of the world (Sterman 2000). We perceive the world as a series of cause and effect relationships in which an effect has a single cause that occurred shortly prior to the effect surfacing. This prompts us to treat problems as isolated events and to solve them using a discrete, linear process; problem recognition, identification of alternative solutions, selection and implementation of a solution that leads to problem resolution. While this may work with simple systems, it oversimplifies the challenges associated with complex social systems. Parts of a social system all have objectives and are constantly interacting. Because of the interdependency of the parts, changes cannot be made in isolation. Moreover feedback loops can create unintended consequences that do not follow a simple linear course and commonly include time delays. Senge (2006) articulated the common misperception of event-oriented thinking in saying that "Today's problems come from yesterday's solutions."

Richmond (2000) defined two types of thinking related to the phenomena described by Forrester. Dynamic Thinking describes a decision maker's ability to see a phenomenon as the result of behavior over time rather than a reaction to an isolated event. Closed-Loop Thinking refers to the decision maker examining the role that the structure of the system (i.e. performance measures, reward systems, and information flows) plays in creating behavior. It also examines

interactions of the system with external forces. Once the structure and interactions are recognized, closed loop thinking seeks to provide an understanding of how these interactions feedback to shape the ultimate result of an intervention. Building on the work of Sterman, Forrester, and Richmond, Atwater et al., (2008) characterized systemic thinking as reflecting synthetic, dynamic, *and* closed loop thinking. Because of the bias towards an event-oriented view of the world, individuals do not readily apply systemic thinking to decision making. However, it is precisely the failure to think systemically, and in particular to consider time delays (sometimes very long time delays), that prevents decision makers from seeing the implications of individual actions. A tool that allows people to visualize complex interactions between both tangible variables (currency, mortgage contracts, credit default swaps, etc.) and intangible variables (attitudes and beliefs) would go a long way to helping us better see when certain conditions arise that can lead to future melt downs. We believe that one tool that can serve that purpose is the Causal Loop Diagram (CLD). In the next section we describe the tool and use it to build a simple structure showing how speculative investment has created similar boom/busts throughout history.

SYSTEMIC THINKING TOOLS

How does one develop systemic thinking skills? No one really teaches another person how to think. However, people can be taught various principles and tools that help the mind focus in a specific way (Zulauf, 2007). In business, several tools have also been developed to help people better understand how parts of a system interact. Value Stream Mapping helps managers trace workflows and see how parts of a process interact and which parts add value. The Balanced Score Card to helps accounting managers assess the performance of a business

across multiple dimensions simultaneously. Policy Deployment was developed to help understand how various initiatives can be deployed horizontally and vertically across an organization.

While the tools above enable connections between parts of a system to be explored, they focus on discrete events, activities, or metrics. In short, they don't help us truly see the bigger picture so we don't develop more complete mental models of reality. Senge (2006) pointed out that because of our event oriented view of the world we often feel we are victims of circumstances that happen to us rather than co-creators of those events. Because we feel that events are the results of external forces that converge on us we fail to learn how we can influence our environment. Dorner (1996) showed how people with event oriented mental models became frustrated when dealing with the interrelated nature of problems occurring in complex systems and in turn typically resorted to suboptimal behavior.

The focus of systemic thinking is on understanding the dynamic behavior of systems over time. The field of systems dynamics has developed tools to help people understand the feedback loops that create seemingly counterintuitive outcomes that make people with event oriented mental models feel like victims of their environments. Sterman (2000a) demonstrated that people cannot mentally simulate even the simplest possible feedback system, and argued that it is our lack of representations of complex systems that leads to poor decisions.

Basic Causal Loops

A causal loop diagram (CLD) enables individuals to communicate mental models to others in a way that can be easily understood. As people learn how to develop CLDs, they improve their ability to organize and articulate their own understanding about the behavior of systems. As individuals share and discuss their diagrams with others, they are able to acquire multiple perspectives and refine their understanding of the system's behavior.

The basic building blocks of a CLD are the links between variables. Variables are linked using arrows, each arrow representing a link between two variables. In each two variable link, the variable at the back of the arrow is said to ***cause*** a change in the behavior of the variable the arrow points to. A plus or minus signs represents link polarity. Positive polarity signifies that the two variables change in the same direction, and negative polarity means that the two variables change in opposite directions. Figure 1 shows three causal links between variables that are part of any discussion about the pricing of a commodity. For example, every asset (e.g., real estate) has a true value. However, the market valuation may not reflect the asset's true value. If the perceived value of an asset is different from its true value, this creates a value gap. The arrow with a plus sign indicates that if the perceived value increases, the value gap (i.e. the difference between its true value and the perceived value) also increases. If perceived value decreases, then the value gap also decreases. The arrow from the variable True Value to Value Gap has a minus sign indicating that as the true value increases the value gap decreases and vice-versa.

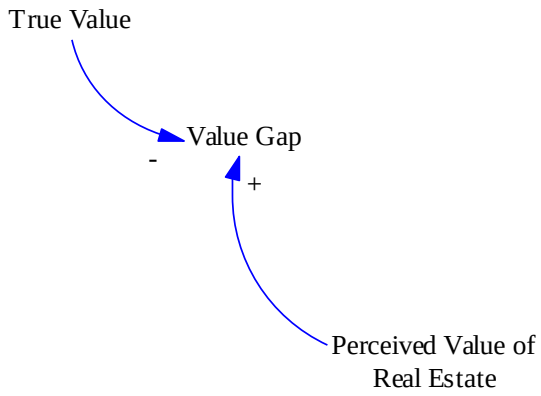

Figure 1: Causal Links

CLDs are created when two or more variables are linked to form a closed loop. Figure 1 may be completed by adding the variable Demand for Housing in Figure 2. To interpret the loop start with the variable Value Gap. As Value gap increases, demand decreases because

buyers don't feel they are getting a good return on their investment. As demand decreases the perceived value of the real estate goes down. This is basic supply and demand economics. The drop in perceived value works to bring the Value Gap back down as well [1]

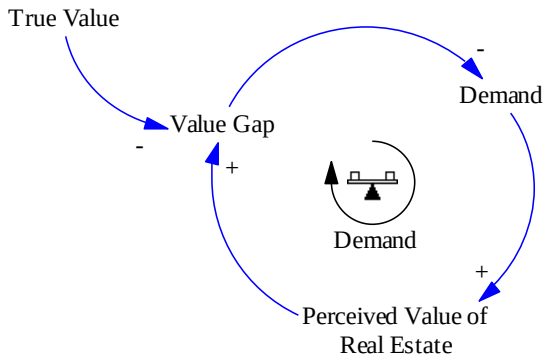

Figure 2: Balancing Loop

CLDs can represent either balancing or reinforcing loops. Figure 2 represents what is called a balancing or goal seeking loop. This is signified by the teeter totter in the loop's center. The concept of a balancing loop is introduced here because this loop 'seeks' true value in the housing market. A reader can use any variable as a starting point when interpreting loops. Balancing loops result in the value of a variable moving in the reverse direction when a cycle is completed. For example, when demand increases, perceived value increases, the value gap increases, and thus demand decreases.

Figure 3 is an example of a reinforcing loop that represents another dynamic of commodity pricing. This loop also has four variables but all the arrows have + signs indicating that a change in a variable causes the next variable to change in the same direction, thus reinforcing an ever increasing or decreasing outcome. Operating in isolation, this loop illustrates exponential change in the values of all its variables. For example, when demand goes up, the

[1] Readers interested in a more complete description of building a CLD may consult Anderson and Johnson (1997), Maani and Cavana (2000), and Sterman (2000).

perceived value of housing increases which drives up the price of the commodity. As the price increases, expectations for capital gains also increase which stimulates further growth in demand. The snowball running downhill is used to signify reinforcing behavior. The loop is referred to as Speculative Demand because it shows how speculation drives prices. A phenomenon that has happened many times throughout history!

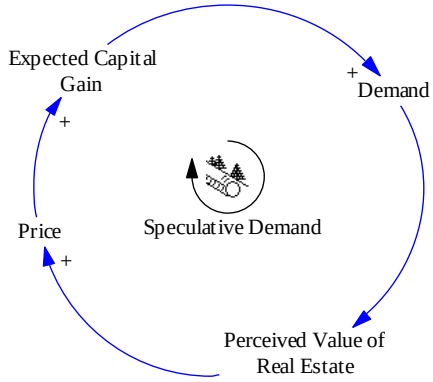

Figure 3: Reinforcing Loop

As experience has taught us, growth has its limits. This occurs when balancing and reinforcing loops are combined in the same system as shown in Figure 4. This is a classic example of a recognized system archetype in the systems dynamics literature, known as the "limits to growth."

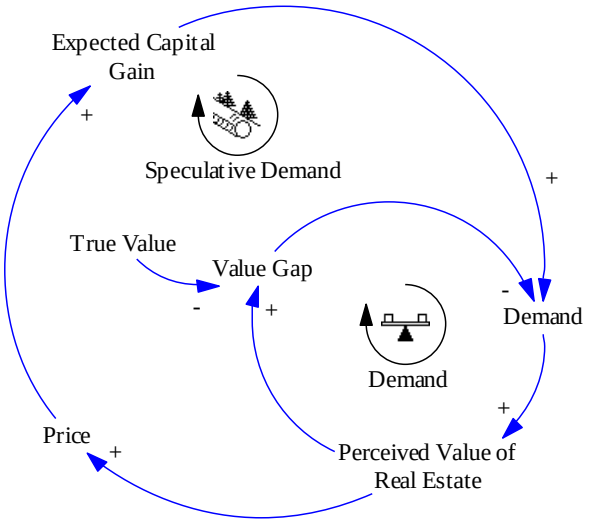

Figure 4: Limits to Growth

System archetypes are generic structures that represent specific combinations of feedback loops that occur in a wide variety of complex systems (Senge, 2006). Awareness of archetypes makes it possible to recognize them at work within a particular system, and to use them to both explain counterintuitive outcomes and identify leverage points for improving system performance. They are powerful, both for diagnosing problems and for identifying high-leverage interventions that will create fundamental change (Kim, 1992).

In Figure 4 the reinforcing, *Speculative Demand* loop drives prices up until investors began asking the question what is the true value of this asset? At this point, concern that the value gap is too large creates a 'tipping point' which causes the balancing loop *Demand* to dominate. When this occurs, the belief that real estate is overvalued causes demand for real estate to decline, and the *virtuous cycle* of increasing perceived value changes to a *vicious cycle* of decreasing value. While these diagrams are oversimplified to introduce the CLD tool, they capture the essence of the underlying phenomenon behind all speculative bubbles. Our particular financial story is one of repeated speculative bubbles as described by Malkiel (2007) and Kindleberger (1996). Knowing the story, the next step is to diagram its underlying structure. Causal-loop diagrams offer a method to do this.

CAUSAL LOOP DIAGRAMS AND SPECULATIVE BUBBLES

Adam Smith introduced the term the "invisible hand" to reflect how the market defines its own balance in the pricing of assets or commodities. While the invisible hand has become the mantra of proponents of a free market, Smith himself issued a note of caution, saying "this at least would be the case where there was perfect liberty." Perfect liberty may be argued to be synonymous with perfect markets (i.e. no cost to trade within markets, perfect and instantaneous

information concerning demand, supply, costs etc., homogeneous investor expectations about future events, returns, etc. and the ability to transfer land, labor, and material freely from one investment/investor to another).

An assumption underlying perfect markets is that of instantaneous adjustment. As discussed previously, cause and effect are often separated in both time and space. In the real estate market a delay typically occurs between an increase in demand and the supply of new properties. This delay causes existing real estate to become more valuable, at least in the short term. Delays such as these are represented in CLDs as illustrated in Figure 5.

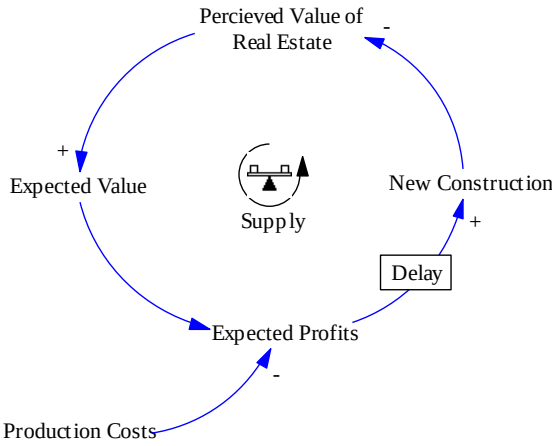

Figure 5: Supply (Balancing Loop)

As expected profits increase, there is an incentive for developers to capitalize by increasing the supply of new housing. However, it takes 2 to 3 years for new properties to come on line. This is depicted in the CLD by the delay box between profits and construction. During the delay, expected profits continue to increase spurring more and more construction. Once the new construction comes on line, the increased supply leads to a decrease in the perceived value of housing, which in turn leads sellers to decrease their price demands. Once prices start to fall, expected profits decrease. This motivates developers to cut back on new construction, but again, delays cause problems. Projects already under construction continue, and as they come online,

this further contributes to oversupply, fueling a downward price spiral. Thus, expanded construction has caused supply to overshoot demand causing rapid price declines.

Combining the Supply and Demand loops (Figures 2 and 5) results in the CLD model of Smith's invisible hand (Figure 6). The upper Demand loop in Figure 6 illustrates how the value gap regulates perceived value. In the perfect market as hypothesized by Smith, (i.e. delays may be ignored), when demand increases the price of housing increases, this causes the value gap between value of housing and its perceived value by investors to also increase, and as the value gap increases, concern about overvaluation causes demand to go down.

The lower Supply loop illustrates how the supply side of the invisible hand also regulates perceived value. When demand exceeds supply the perceived value of real estate goes up. In response developers seek to cash in on the increasing expected value and profits by engaging in new construction. This results in an increase in supply. As the supply catches up with demand it drives down the perceived value.

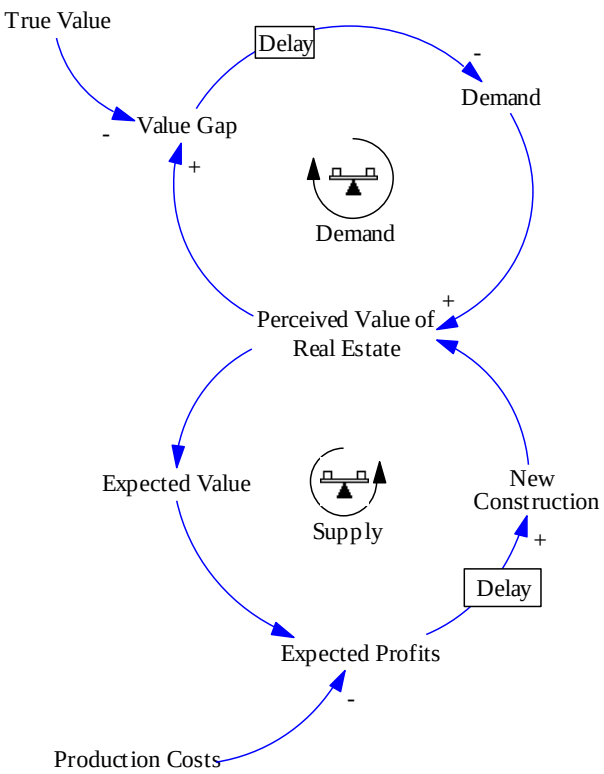

Figure 6: Invisible Hand

However, delays are a reality in both loops. Delays in the supply loop are particularly problematic and may cause the value gap between perceived value and true value to to continually be out of alignment over a long term. The result is that rather than long term price stability, the market may observe persistent oscillations in price.

John Stuart Mill (1848) provided an early description of speculative bubbles. His observations have current relevance when one substitutes the terms real estate, sub-prime lending, Collateralized Debt Obligations (CDOs), etc. into his description. According to Mills, a speculative reinforcing loop is created:

> When there is a general impression that the price of some commodity is likely to rise, from an extra demand, a short crop, obstructions to importation, or any other cause, there is a disposition among dealers to increase their stocks, in order to profit by the expected rise. This disposition tends in itself to produce the effect which it looks forward to, a rise of price: and if the rise is considerable and progressive, other speculators are attracted, who, so long as the price has not begun to fall, are willing to believe that it will continue rising. These, by further purchases, produce a further advance: and thus a rise of price for

> which there were originally some rational grounds, is often heightened by merely speculative purchases …"

Adding the speculative demand component (Figure 3) to Figure 6, results in a model which provides a reasonable description of Mills' speculative bubble (Figure 7). It is important at this point to recognize the impact of a variable that is increasing in value but at a decreasing rate (e.g., a price goes from 100 to 150 to 190 to 220 to 240 to 250 etc.). Thus, a slowdown in price increases, not just a price drop, can be the tipping point that causes speculative demand to fall and ultimately reverse the virtuous cycle and turn it into a vicious cycle (Lewis, 2010).

Note that Mills indicates that expectations of gains are based on price trends comparing recent prices to historical prices. Because of delays in making the expanding supply available (i.e. new construction can take months to be ready for occupation), the balancing Supply loop is slow in adjusting prices to their true value.

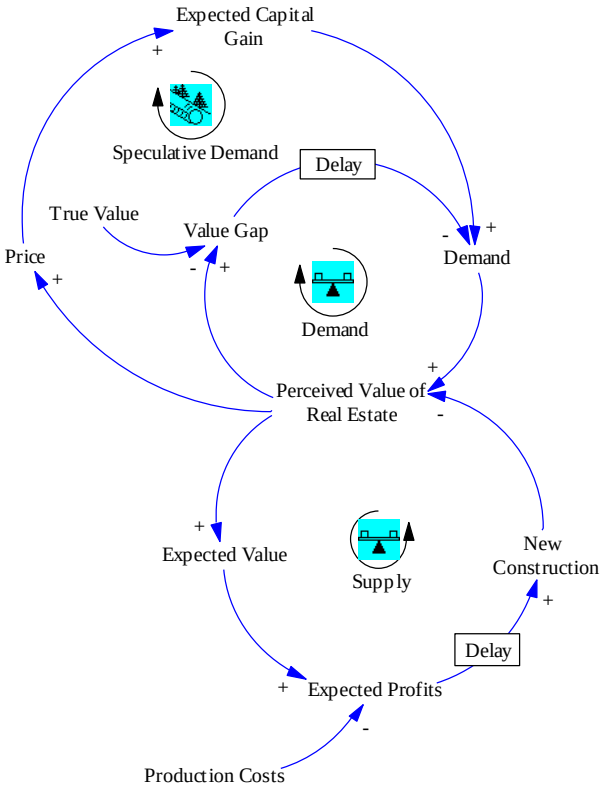

Figure 7: Speculative Bubbles

Mills continues:

> After a time this begins to be perceived; the price ceases to rise, and the holders, thinking it time to realize their gains, are anxious to sell. Then the price begins to decline: the holders rush into market to avoid a still greater loss, and, few being willing to buy in a falling market, the price falls much more suddenly than it rose.

Figure 8 includes one final loop, Speculative Supply. Speculative developers, wishing to capitalize on expected profits while prices are increasing, also add to new construction, which in turn decreases the perceived value of housing and causes price to decrease. However, due to the delay in adding to the supply, it often comes on line at the time of the collapse in demand, leading to an oversupply that depresses prices long after the initial collapse.

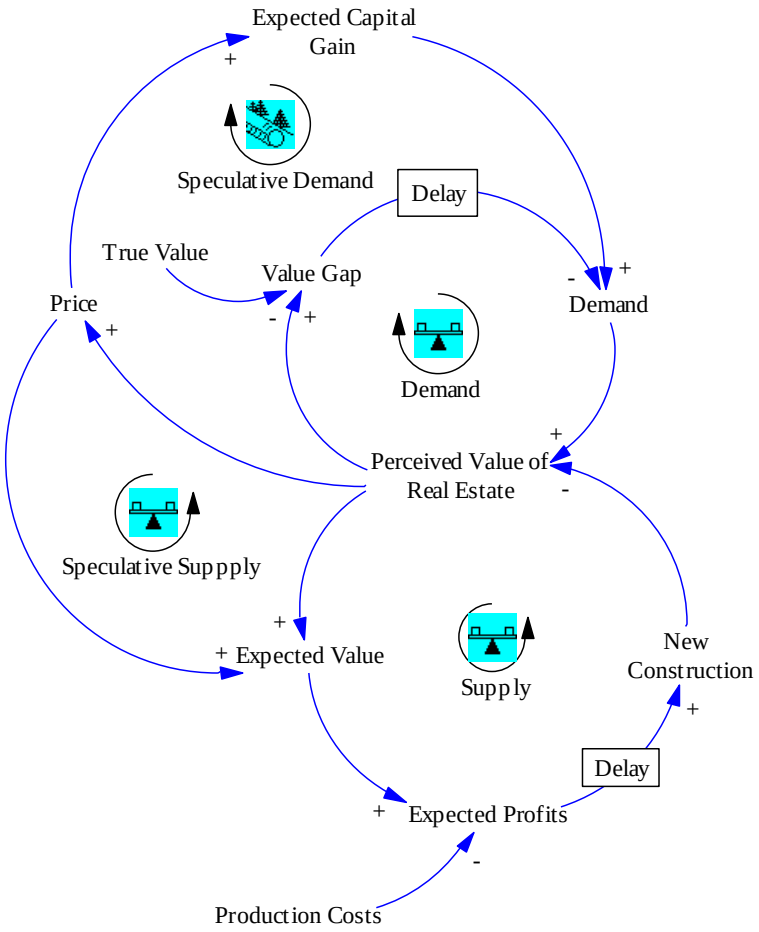

Figure 8: Speculative Bubbles

The models leading to description of speculative bubbles, shown in Figure 8, do not represent new research. Indeed, the creation of these CLDs and Mills insights on speculative bubbles are part of an exercise in Sterman (2000). It is used here to demonstrate 'forgotten' knowledge.

We argue that the behavior related to the CLD for a speculative bubble is so common throughout history that it should be seen as a systems archetype - an extension of the limits to growth archetype – that describes the foundation of all speculative bubbles over the last 400 years. Key to these models is the concept of delay between cause and effect (Forrester, 1971). With respect to the US real estate market, delays allowed several years of unbroken increases in real estate values to create the illusion that the cyclical real estate market was no longer cyclical.

CLDS AND THE FINANCING OF SPECULATIVE BUBBLES

Figure 9 is a CLD representing one of the initiators of the real estate speculative bubble that ultimately led to the collapse of the U.S. and world markets. The U.S. government sought to stimulate economic activity and employment at the time of the dot com collapse. Real estate constitutes a large fraction of the total wealth in any economy and generates a significant fraction of banking activity. Home ownership also drives consumption of a variety of products and services, and thus has a significant influence on the job market. Consequently, the government put pressure on quasi-government entities (QGEs) such as Ginnie Mae and Freddie Mac to expand their portfolios of sub-prime mortgages to increase access to funding for home owners. In response, the QGEs reduced their standards for purchasing portfolios of mortgages. As a result, credit standards throughout the mortgage industry declined.

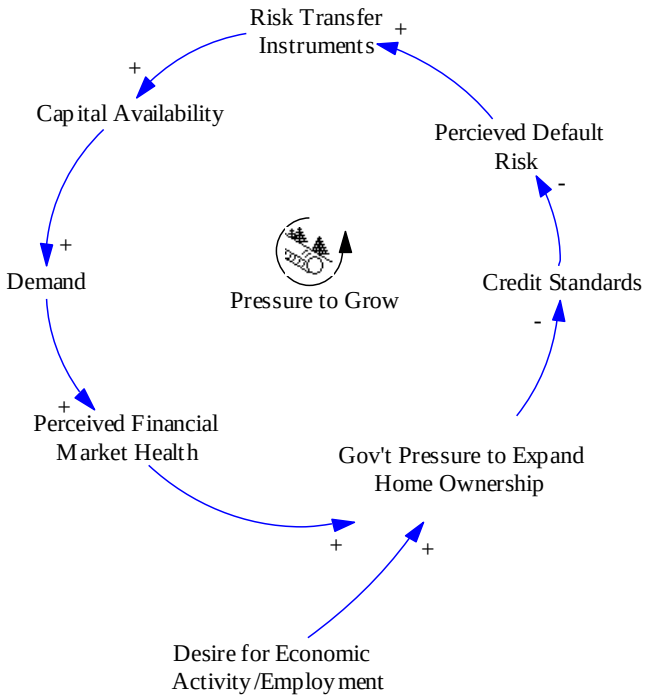

Figure 9: Pressure to Grow

Financial institutions competed to be part of the expanded sub-prime market and expand their access to mortgage instruments and their derivatives. Innovative financial instruments such as credit default swaps were borrowed from other financial markets and applied to the real estate sector. These instruments diversified the risks of individual mortgage obligations creating the illusion of financial protection without the burden of traditional regulation. This motivated the industry to provide more capital to the real estate market.

The increase in capital created a corresponding increase in demand. This combined with the already high demand from traditional customers and speculators outlined in Figure 4 caused the perceived risk of default on real estate financial securities to decrease. The decreased perception of defaults caused investors to believe real estate markets were safe, a conclusion which was further supported by government pressure to increase real estate activity and the lack of scrutiny of that market.

Figure 10 combines the Limits to Growth archetype of Figure 4 with the Pressure to Grow CLD of Figure 9. The resulting CLD is a simplified system illustrating only the financing of the demand cycle of a speculative boom. Indeed, it may have been the financing CLD that triggered the speculative demand (Brueckner, Calem, and Nakamura, 2012). The Pressure to Grow loop illustrates why financial institutions, faced with limited growth opportunities, perceived the new financial instruments as a safe way to generate new growth. Investors flocked to purchase these instruments, fuelling a significant increase in leverage. However, the capital that entered the financial markets was inextricably linked to speculation in the real estate market. This was not seen as a problem since many years of prosperity had created the illusion that real estate never lost value and that the resulting financial instruments were always safe.

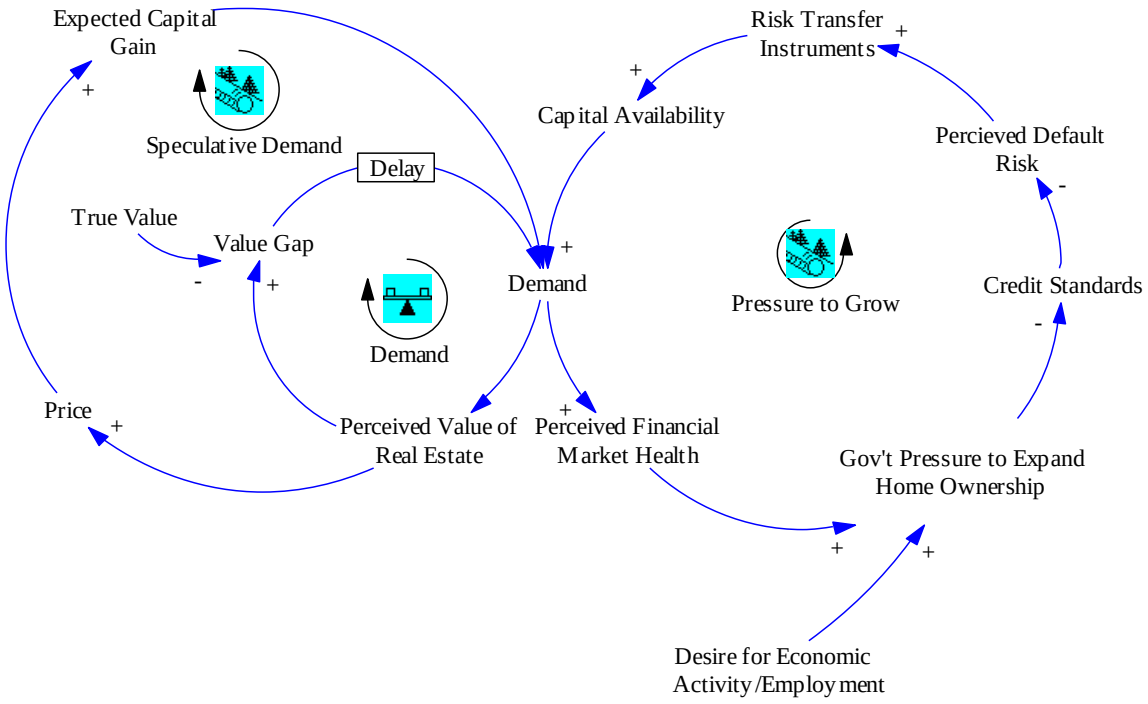

Figure 10: Financing the Boom

As seen in the Limits to Growth archetype, reinforcing loops such as the Pressure to Grow cannot run indefinitely. After a period of delay, the lower credit standards resulted in

cascading defaults. Figure 11 adds a new loop called Reality Kicks In. This loop shows how the *virtuous* cycle in the Pressure to Grow loop turned into a *vicious* cycle. The reduction in credit standards eventually led to a number of actual loan defaults. This in turn resulted in claims on insurance instruments (e.g. the credit default swaps) that exceeded what anyone had the capability to pay. The resulting defaults led to a decrease in capital availability that reversed the cycle from virtuous growth to a vicious downward cycle.

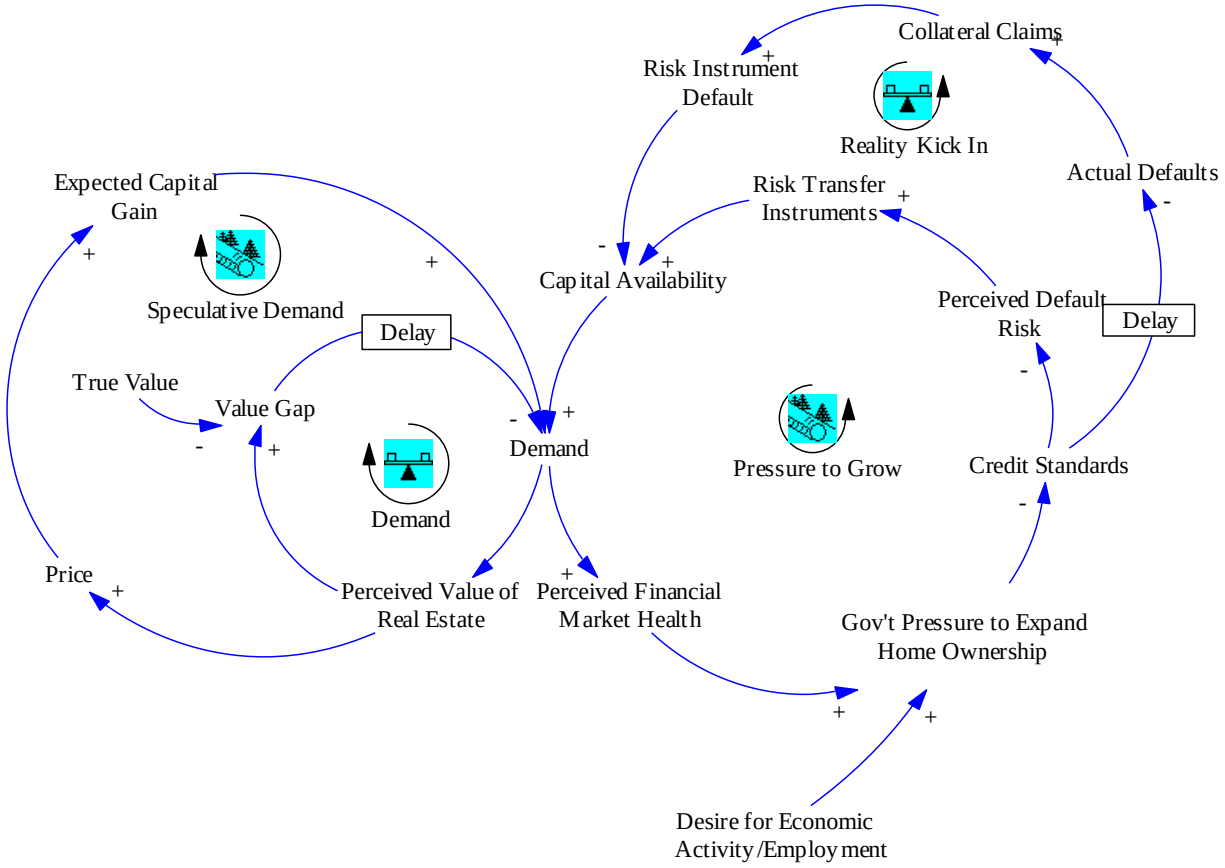

Figure 11: Financial Collapse

Defaults on a small percentage of loans in a small percent of counties in the U.S. had an adverse impact on the health of those financial institutions that had borrowed large sums of money to participate in the speculation. The loan defaults caused the holders of subprime mortgage portfolios to make claims on the new financial insurance instruments. Since these

instruments did not have the funds necessary to pay the clams issuers of these instruments were forced into default. This compromised the integrity of those financial instruments that relied on steady income streams from loan payments, bringing into question the financial health of a broad range of financial institutions. The failure of large institutions caused a reversal in the ability of those working in that area of the financial markets to attract and retain capital, bringing the speculation to an end. With the collapse of the market's ability to provide capital, the broader financial markets began to melt down. Financial institutions now held large portfolios of non-performing loans. Losses, magnified by the effects of leverage, drove real estate valuations below what was owed. Positive reinforcing loops that drove the market and the economy became negative reinforcing loops. The resulting vicious cycles affected more than just real estate. Ultimately they caused the collapse of **ALL** credit markets and the larger economy.

CONCLUSION

We have used the subprime mortgage market to illustrate the use of systems dynamics tools to improve our ability to think systemically. It was chosen because it is both an excellent example of a complex system in action, and because recent behavior within the market illustrates a dangerous yet recurrent problem, the consequences of which are more significant each time the problem occurs. The subprime mortgage market is the latest episode in history where speculative investment has played out to disastrous results. Each time this behavior has surfaced it has generated larger scale ramifications. We feel this is due to the removal of the slack in the system (i.e. the world is growing smaller and economies are becoming ever more intertwined). The use of the CLD tool however allows us to draw several important insights.

The basic systems archetype known as Limits to Growth provides the first insight. This archetype suggests that positive reinforcing loops cannot run indefinitely, as counter-balancing

events, which are ALWAYS present within a system, eventually constrain growth. The event may be an investor asking the question what is an asset really worth, or a Federal Reserve Governor such as Edward Gramlich raising concern over sub-prime lending practices. Growth may also slow down because of mortgage defaults as illustrated. Failure to recognize the Limits to Growth within the U.S. real estate market played a major role in its collapse. We argue that the speculative bubble shown in Figure 8 should be considered a fundamental archetype since institutions, companies, governments, and individuals have not learned the lessons, except with 20-20 hindsight, of the last 400 years. Indeed, at the time this article is being written, we are witness to a speculative bubble in energy pricing that some are predicting is the wave of the future. Learning organizations embody both theory and practice to allow policy makers to learn to recognize the dynamics of this type of behavior and develop mechanisms that address the development of speculative bubbles.

The second insight is that delays play multiple roles within a system. Delays can make a bad situation worse. Delays inherent in the construction industry resulted in new properties being completed at precisely the time when housing prices started to decline. Delays frequently result in people not learning lessons from past events. The perception that real estate values would never go down encouraged many individuals and financial institutions, to link their financial positions to the real estate market. In reality, real estate boom and bust cycles are well documented. Ten years of increasing real estate values are not unusual and certainly no indication that values never fall. Following the Savings and Loan Collapse, Hernandez (1990) interviewed several participants in the market. As one developer noted, "Will the banks or the developers learn? Well, a number of lenders are now saying that they will never again lend on real estate. I have an answer for that. All it takes is just one generation of bankers and developers to churn through that hasn't been through the cycles." Here again we feel the Speculative Bubble

archetype needs to be more widely developed and used to teach future decision makers so they better understand how the interconnections of complex systems create counterintuitive outcomes.

The third insight is the realization that reinforcing loops can cause both growth and decline. The same variable that created the positive reinforcing loops that drove the market and the economy also caused the negative reinforcing loops or vicious cycles that collapsed the real estate market, and, in the end, brought down the larger U.S. and global economy. The market collapse of 2008-2009 is certainly unprecedented in its scope, but despite claims to the contrary, financiers should have seen it coming. Prior boom/bust cycles have had less impact, but the impact of successive cycles seems to grow. In a globally inter-connected economy, the implication is that if people do not learn how to see the big picture, society will face similar situations again and quite possibly with more disastrous repercussions.

A final point to consider is that while the models presented in this paper necessarily over-simply the events of the last several years, they accurately describe phenomena underlying the collapse of the real estate and financial markets. Moreover, the figures contained in this paper rely heavily on the work of Sterman (2000) in his modeling of the collapse of the Savings and Loan industry in the 1980's. What is particularly revealing is that while his causal loop diagrams offered a way to understand the dynamics of that speculative bubble and to draw parallels with the growth of the real estate market prior to 2007, it did not prevent a repeat.

This paper demonstrates that despite the surface level uniqueness and complexity of the recent economic collapse, there is an underlying thread that links the recent collapse with speculative boom/busts going back over 400 years. Malkiel (2007) and Sterman (2000) demonstrate that that history repeats itself particularly with respect to speculative bubbles. It is likely that there are other complex events that have played out repeatedly in history that also have an inherent structure that can be better understood through the use of tools like CLDs.

Saveland (1998) notes "Reflective conversion offers a mechanism to change ourselves and our culture … Systems thinking, with its causal-loop diagrams and simulation models, provides a language to facilitate this conversation." This is a key point of this paper – to provide a framework that can be part of the conversation. CLD's allow one to make tangible something that is otherwise not. It is important to note that many other balancing and reinforcing loops could be added to the model presented. These might deal with, for example, inflation, default risk, regulation, the liquidity crunch, and incentives that motivate loan officers to lie and cheat. However, in the interests of trying to limit our portrayal to the essential foundations of the crisis, we did not include them. Future work could certainly include expanding the CLD.

Several other opportunities exist to extend the current work. For example, an important question is why some institutions that did not get drawn into the speculative bubble. Insights gained from their behavior provide an opportunity to add richness to the model. In addition to extending the model, creating a simulation of the model would help us to better understand the dynamics of how various loops interact. For example, we cannot know if the variables in a CLD will create a virtuous or vicious cycle, but a simulation model can help us better understand the circumstances that lead to one type of cycle or another. Moreover, a simulation may provide a means to understand how specific actions influence the behavior of the system.

Moving leaning organizations forward is an exercise in personal mastery, mental models, shared learning/vision and community building (Senge et al. (1994). Moreover, the reality that decision-makers face inherent challenges as well as factors beyond their control when responding to complex situations is not new. Causal Loop Diagrams are not a solution to addressing these challenges. We do however believe that such diagrams are necessary, even essential, but not sufficient. They can help us to build mental models and facilitate the development of personal mastery and shared learning in a way that complements the decision-

making process. It is our hope that this paper will serve to stimulate people to apply systemic thinking to future speculative bubbles, and also develop archetypes that can be used to address other complex problems that have repeated throughout history.

References

Ackoff, R. L., 1981, "Our Changing Concept of the World," In C*reating The Corporate Future*, New York, John Wiley and Sons, pp. 3-26.

Ahamed, L., 2009, *Lords of Finance:The Bankers Who Broke the World,* New York, The Penguin Press.

Anderson, V. & Johnson, L., 1997, "System Thinking Basics: From Concepts to Causal Loops," Pegasus Communications Inc., Waktham, MA. pp. 51-76.

Atwater, J. B., Kannan, V. R., & Stephens, A. A., 2008, "Cultivating Systemic Thinking in the Next Generation of Business Leaders," *Academy of Management Learning and Education,* 7 (1), pp. 9-25.

Brueckner, J.K., Calem, P.S., & Nakamura, L.I., 2012, "Subprime Mortgages and the Housing Bubble", Journal of Urban Economics. 71(2) pp. 230-243.

Demyanyk, Y. & Von Hemert, O., 2011 "Understanding the Subprime Mortgage Crisis." *The Review of Financial Studies*. 24 (6), pp. 1848-1880.

Dorner, D., 1996, "So Now What Do We Do? In *The Logic of Failure*, New York, Metropolitan Books. pp. 185-200.

Forrester, J.W., 1971, "The Counterintuitive Behavior of Social Systems," *Technology Review*, 73 (3), pp. 52-68.

Gharajedaghi, J., 1999, "How The Game Is Evolving," In *Systems Thinking: Managing Chaos And Complexity,* Woburn, Butterworth-Heinemann, pp. 3-27.

Hernandez, K., 1990, "Learning In Real Estate: The Role Of The Development System In Creating Oversupply," *MS thesis, MIT Sloan School of Management*, Cambridge, MA 02142 (unpublished).

Kindleberger, C. P., 1996, *Manias, Panics, and Crashes: A History of Financial Crises,* New York, John Wiley and Sons.

Kim, D.H., 1992, *Systems Archetypes I: Diagnosing Systemic Issues and Designing High-Leverage Interventions,* Cambridge, Pegasus Communications Inc.

Lewis, M., 2010, *The Big Short; Inside the Doomsday Machine*, London, W.W. Norton & Company, Inc.

Mackay, C., 1852 (22nd printing 1974), *Extraordinary Popular Delusions and the Madness of Crowds,* New York, Farrar, Straus and Giroux.

Malkiel, B. G., 2007, "The Madness Of Crowds," In *A Random Walk Down Wall Street: The Time Tested Strategy For Successful Investing*, New York, W. W. Norton & Company, Inc., pp. 34-51.

Maani, K. E., & Cavana, R. Y., 2000, "Systems Thinking and Modeling: Understanding Change and Complexity," Prentice Hall, Pearson Education, New Zealand, pp. 12-55.

Mill, J. S., 2004 (original 1900), *Principles of Political Economy*, New York, Prometheus Books.

Richmond, B., 2000, *The Thinking In Systems Thinking: Seven Essential Skills*, Waltham, Pegasus Communications Inc.

Richmond, B., 2003, *An Introduction to Systems Thinking: STELLA Software*, New Hampshire, High Performance Systems, Inc., pp. 3-6.

Saporito, B., 2009, "How AIG Became Too Big To Fail," Time Magazine, March 30, 2009, pp. 24-30.

Saveland, J., 1998, *"*Prescribed fire: the fundamental solution," In *Fire in ecosystem management: shifting the paradigm from suppression to prescription*, Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL.

Senge, P.M., 1990a, *The Fifth Discipline: The Art and Practice of the Learning Organization*, New York, Currency Doubleday.

Senge, P.M., 1990b, "The leader's new work: building learning organizations," *Sloan Management Review* 32, pp.7-23.

Senge, P.M., Roberts, C., Ross, R.B., Smith, B.J. and Kleiner, A., 1994, *The Fifth Discipline Fieldbook: Strategies and Tools for Building a Learning Organization*, New York, Currency Doubleday.

Senge, P.M., 2006, "Prisoners of The System or Prisoners of Our Own Thinking," In *The Fifth Discipline: The Art And Practice Of The Learning Organization*, New York, Doubleday/Currency, pp. 27-54.

Sterman, J.D., 2000a, "Learning In and About Complex Systems," In *Business Dynamics: Systems Thinking And Modeling For A Complex World*, Burr Ridge, Irwin-McGraw-Hill, pp. 3-39.

Sterman, J.D., 2000b, "Causal Loop Diagrams," In *Business Dynamics: Systems Thinking And Modeling For A Complex World*, Burr Ridge, Irwin-McGraw-Hill, pp. 135-190.

Sterman, J.D., 2000c. "Case Study: Boom And Bust In Real Estate Markets," In *Business Dynamics: Systems Thinking And Modeling For A Complex World*, Burr Ridge, Irwin-McGraw-Hill, pp. 686-707.

Thornton, L., 1992, "Real Estate Development Firms as Learning Organizations: Systems Thinking as a Methodology for Strategic Planning," *MS thesis, MIT Center for Real Estate Development*, Cambridge, MA 02130 (unpublished). Cited by Sterman (2000c).

Zulauf, C.A., 2007, "Learning to Think Systemically: What Does it Take?," *The Learning Organization*, 14 (6), pp. 489-498.