A System Dynamics Perspective on the Build-up to the 1997 South Korean Financial Crisis

by

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Submitted to the System Design and Management Program
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Abstract

Financial panics and crashes have become an item of familiarity to many nations around the world over more than several centuries. If history has taught us nothing else, it has taught us that we can learn from the past with the aim of improving the future. In 1997 a chain of events was set off in Asia that culminated in financial panic and crisis for many of the East Asian countries. The research in this paper focuses on the economic environment in South Korea in the years immediately preceding the 1997 financial crisis. The financial liberalization policy of interest rate de-regulation is modeled using system dynamics and the resultant economic behavior is explored. The feedback structure of the model is used to explain the asset bubble that formed during the height of the build-up. The national reliance on short-term commercial paper to finance long-term investments is explored and its relationship to the crisis is discussed. System dynamics is used to model the policy decisions that were made and explore different policy decisions and scenarios to provide insight into the resulting economic behavior.

Thesis Supervisor: J. Bradley Morrison

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To my Father and Mother, Frank and Carol Kopczynski.

Thank you.

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Table of Contents

Part I: Background

1.1 Introduction

From 1997 to 1998 South Korea's GDP contracted by over 30% with almost a 300% increase in unemployment[1]. It is generally agreed that the South Korean financial crisis did not begin until mid-1997 when a run on the national currency began and foreign credit markets began to shut down. It can be shown that the country had been moving into unchartered financial territory during a period of de-regulation in the years building up to the crisis, and South Korea was in a situation that left them highly vulnerable to changes in foreign financial markets.

The research presented in this paper will provide insight for the reader into the causes of the crisis. The system dynamics modeling will show the reader the impact of de-regulating interest rates on commercial paper ahead of other investment modes. The reader will see the resultant investment behavior that flocks to borrowing short-term from new readily available foreign sources of commercial paper to invest long-term with the hope of achieving large gains. The reader will gain insight into the powerful feedback structure in the economy that can amplify investment behavior driven by de-regulation instead of being driven by demand for a product. Insight will be gained into how this behavior can lead to the development of a bubble. A bubble, by definition, must deflate in

[1] International Monetary Fund, World Economic Outlook Database, April 2008

order to return the economy to a sustainable level[2]. The modeling completed in this research will show the impact of de-regulation on investment behavior and will show the resultant investment bubble.

The modeling effort is scoped to the build-up to the crisis. Simulation results reveal that as long as businesses had access to capital and were able to continue rolling over old debt with new debt they would eventually be able to work their way out of the asset bubble. The factors that sparked off the 1997 crisis are exogenous to the model and resulted in a cutting off from credit that forced bankruptcies and a downward spiral in the economy. The emphasis of this research is on the build-up to the crash that left the nation in an area where they were susceptible to foreign capital market risk. The changes in foreign capital markets could result in a crash to the economy.

[2] Kindleberger, Charles P. and Robert Aliber. Manias, Panics, and Crashes: A History of Financial Crisis 5th ed. John Wiley and Sons Inc. 2005.

1.2 Goals for paper

The goal for this paper is to provide insight into the causes that laid the foundation for and provided the context for the 1997 South Korean financial crisis. The reader should gain an understanding of the causal loops and feedback structures in the South Korean economy that led to a debt-financed bubble in assets. System dynamic modeling is used to highlight decisions that were made in the early 1990's in South Korea and the impact the financial decisions had on the economy. The objective of this paper is for the reader to gain a deeper understanding of the impact of the policy decisions on investment behavior and the resulting impact on the economic situation for the country.

1.3 Historical Crises

Financial crises can be traced back for centuries in world history. A common thread among the crises has been the extensive use of credit and liberalization of the banking systems. In the early 1600's the famous "Dutch Tulip Bulb" asset bubble took place. During the mania rare tulips were being purchased for the equivalent price of a house[3]. In the end, after the bubble burst and panic and crisis ensued investors where left with tulip bulbs that they had paid for with the equivalent amount of funds to purchase a house and were now worth a tiny fraction of their investment. A crisis is defined as a situation in which a large number investors and/or institutions realize large declines in the value of their

[3] Kindleberger, Charles P. and Robert Aliber. Manias, Panics, and Crashes: A History of Financial Crisis 5th ed. John Wiley and Sons Inc. 2005.

assets. Panic can ensue leading to even further declines in the prices of assets and a crash. In periods of economic prosperity investors see healthy returns on assets and continue to expand, some using financing methods to acquire even more assets. When the period of growth slows or reverses the decline in the price of the assets can lead to investors owing more than their assets are worth. As investors try to sell their assets the sales can lead to even further declines in prices of assets potentially leading to a panic and crisis[4].

This paper will explore the asset bubble that developed in South Korea in the early 1990's and laid the groundwork for the 1997 financial crisis.

1.4 1997 Asian Financial Crisis

1.4.1 Description of countries impacted.

July 1997 marked the start of the Asian financial crisis, beginning in Thailand and rapidly crossing international borders to affect South Korea, Indonesia and Malaysia. The crisis began in the foreign exchange markets where the Thai Baht was rapidly devalued leading to loss of market confidence, beginning a chain-of-events where sharp drops in currency values resulted. The ensuring crisis led investors to pull capital out of the region, leading to lowering of the currencies,

[4] Kindleberger, Charles P. and Robert Aliber. Manias, Panics, and Crashes: A History of Financial Crisis 5th ed. John Wiley and Sons Inc. 2005.

crashes in the markets, increases in inflation and steep economic downturns for the economies in the region.[5]

One common factor bonding the countries in the crisis was the relatively new phenomenon of extensive borrowing from international lenders by the private sector[6]. Between 1990 and 1996 the flow of investment funds from developed countries to developing countries increased by a factor of six. The impact of this financial flows resulted in rapid growth in the developing countries. Another impact was to greatly increase the reliance of these countries on foreign capital markets and to amplify the impact of fluctuations in foreign capital markets on the domestic economies. The availability of foreign capital served to increase the amount of investment funds being channeled into the South Korean economy. These funds provided a larger source of credit available to investors and allowed for larger build-ups in expansionary development bubbles. Without the foreign capital availability the impact felt by the domestic economy would have been limited to the fluctuations in domestic credit availability. Due to the use of foreign capital the domestic economy now became susceptible to fluctuations in foreign capital availability as operations became reliant on foreign capital as a source of funding.

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[5] Kim, Anthony B. "The Asian Financial Crisis 10 Years Later: Time to Reaffirm Economic Freedom." Backgrounder Published by the Heritage Foundation, No. 2054, July 19, 2007.
[6] McKibbin, Warwick and Will Martin. "The East Asian Crisis: Investigating Causes and Policy Responses." The Australian National University and Brookings Institution and the World Bank, 1999.

1.4.2 Start of the Financial Crisis

By 1996 the rapid economic growth seen over the start of the decade in the East Asian countries started to slow. Exports began to decrease in several countries including: Indonesia, Korea, Malaysia, and the hardest hit; Thailand. The lowering growth led to a reduction of investor optimism and asset prices began to drop. The value of the banking market began to fall and markets started to show decreased optimism with the banking sector. Investor's lack of faith grew with the focus turning to what was considered the overvaluation of the local currencies. A "speculative attack" took place on the Thai Baht on June 2, 1997 and spread to economies within the geographical region. The countries under attack responded by increasing interest rates, however this did not stop the attack because investors were not hopeful that the rate increases were sustainable because of the challenges on the balance sheets of the nations.[7]

Balance sheets suffered even more because of the hit in exchange rates and recessions began to result. Banks were slammed by losses on loans to the corporate sector that had been collateralized by assets that were now lowering in value, resulting in bankruptcies and an increased level of pessimism in the

[7] Collyns, Charles and Abdelhak Senhadji. "Lending Booms, Real Estate Bubbles and the Asian Crisis." International Monetary Fund (IMF) Working Paper - Asia and Pacific Department, January 2002.

financial sector leading to further reduction in asset prices[8]. The crisis proceeded to impact each of the Asian countries in slightly different manners. This paper will focus on South Korea's economy in the years before the crisis and the regulatory changes and policy decisions in the financial markets that helped lay the groundwork for leaving South Korea vulnerable to the fluctuations in foreign capital markets. This timeframe was chosen in order to provide insight into the causes of the crisis and lay the foundation for the economic environment that provided the context for the crisis.

1.5 South Korea's Historical Economy: 1960's to 1980's

From the 1960's through the 1980's Korea's government was ruled under an authoritarian regime backed by the military. In South Korea, business conglomerates, often family-controlled, are referred to as chaebol. Chaebol have a long history of close relationships with the government. As part of the authoritarian military backed government regime in South Korea the chaebol played an important role in this system of government[9]. The overall goal of the South Korean government was to exercise policies in the pursuit of developing industries within the nation that improved the skills of the national work force and allowed for growth from low-wage heavily labor intense occupations to higher

[8] Collyns, Charles and Abdelhak Senhadji. "Lending Booms, Real Estate Bubbles and the Asian Crisis." International Monetary Fund (IMF) Working Paper - Asia and Pacific Department, January 2002.

[9] Cho, Yoon Je. Edited by Chung H. Lee. "Financial Liberalization and the Economic Crisis in Asia." Routledge Curzon, Taylor & Francis Group. The European Institute of Japanese Studies, Sockholm School of Economics 2003.

wage skilled production[10]. The relationship between the government of South Korea and the chaebol was traditionally very closely held. The chaebol acted as a tool of the government to allow for the implementation of strategic economic policy decisions. The government determined what industries they would like the country to expand into and allowed the chaebol to grow economically in those directions ranging from automobiles to semiconductors. The government was able to determine the outcome of the chaebol's economic decisions by controlling the regulation of bank credit policy and directly overseeing entry into financial and industrial arenas. Additionally the government utilized auditing of taxes to help in directing economic outcomes[11].

A symbiotic relationship developed between the chaebol and the government. The chaebol would provide support for political activities to safeguard their access to credit and expansion potential into new markets. Meanwhile the government would provide lax oversight during tax audits, and provide implicit backing for the chaebol to help ensure they would continue to maintain access to ample credit from banking institutions.

1.6 Government influence over chaebol:

The government utilized several key tools to manage their relationship with the chaebol.

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[10] O'Driscoll, Gerald P[10]. "IMF Policies in Asia: A Critical Assessment." The Heritage Foundation: Leadership for America, March 1999.

[11] Cho, Yoon Je. Edited by Chung H. Lee. "Financial Liberalization and the Economic Crisis in Asia." Routledge Curzon, Taylor & Francis Group. The European Institute of Japanese Studies, Sockholm School of Economics 2003.

The Bank of Korea (BoK) acted as the central bank for South Korea and was held under the direct supervision of the Ministry of Finance (MOF). The government did not officially manage banks: however, the government was able to maintain a great deal of control over them. The government appointed managers and regulated that no controlling private shareholders were allowed. In this way the government was able to exert a great deal of control over the banks through their appointment of management, and without controlling private shareholders there was no group that would counter their actions.

Another tool the government used to influence the chaebol was through the securities market. The government controlled the number of new issues that were allowed. Additionally, the government through their oversight of foreign exchange controlled capital movement. All together, the government kept a tight restriction on the economy through the various levers that were in place to control the financial system and regulate growth and expansion to coincide with political policy.

1.7 Financial Liberalization:

Having completed a period of vast economic expansion and growth in the 1980's, at the start of the 1990's there was great pressure to continue the growth. In 1991 the "Four-Stage Interest Rate Deregulation" plan was begun. The "Blueprint for Financial Liberalization and Market Opening" was announced in

1993 and further worked to liberalize interest rates. Under the blueprint the government first deregulated short-term commercial paper (CP) faster than they deregulated the long-term interest rates of banks. The result of the deregulation was that businesses began to seek out investments using short-term credit.[12] With the election of Kim Young-Sam in 1993 the speed of deregulation began to increase with the goal of increasing the globalization of the Korean economy. One of the goals of the government was by the close of 1996 to join the prestigious Organization for Economic Co-operation and Development (OECD).[13]

The government's plans for deregulation were not carried out as smoothly as intended. To begin with, commercial paper was officially deregulated in 1991: however, it wasn't until 1993 that the deregulation was implemented. Bank loans were officially liberalized in 1993 but were not actually implemented until 1996. The exception is bank loans that were policy-based. The difference between "officially" set interest rates and actually "implemented" interest rates being that the rules were changed at the government level to allow for the interest rates to be officially changed in 1991, however the interest rates did not actually get changed until 1993 due to delays in implementation. This uneven and non-strategic implementation of liberalization had an unintended impact on the

[12] Choi, Jin-Wook. "Regulatory Forbearance and Financial Crisis in South Korea." Asian Survey, March/April 2002, Vol: 42, No: 2, Pages 251-275.
[13] Lee, Jong-Wha, and Rhee, Changvong. "Social Impacts of the Asian Crisis: Policy Challenges and Lessons." Occasional Paper 33 for United Nations Development Programme (UNDP), Human Development Report Office, January 1999.

investment behavior within the nation.[14] Funds quickly began to move toward short-term CP between 1991 and - 1996. This led to a build-up in business expansion for long-term investments financed using short-term CP's.

As part of the strategy to join the OECD the government increased the rate of foreign market liberalization starting in 1994. Several of the actions taken include:

- Increasing the maximum limit on foreign investment into the Korean stock market
- Minimizing controls over short-term borrowing (related to trade deals)
- Issuing Korean corporate securities in foreign capital markets and offshore borrowing
- Removing major restrictions on foreign borrowings by Banks and MBC's, in particular in the short-term

The result of this foreign market opening was a drastic increase in foreign borrowing. Between 1992 and 1997 the total foreign debt/gross national product ratio increased from 14% to 28%. The share of borrowing reliant on foreign debt

[14] Lee, Jong-Wha, and Rhee, Changvong. "Social Impacts of the Asian Crisis: Policy Challenges and Lessons." Occasional Paper 33 for United Nations Development Programme (UNDP), Human Development Report Office, January 1999.

had doubled in South Korea in 5 years[15]. This following analysis will provide insight into the impact of the liberalization policy on the Korean economy.

[15] Cho, Yoon Je. Edited by Chung H. Lee. "Financial Liberalization and the Economic Crisis in Asia." Routledge Curzon, Taylor & Francis Group. The European Institute of Japanese Studies, Sockholm School of Economics 2003.

Part II – Analysis

2.1 Review of model structure and analysis

2.1.1 Core theory of the model

The system dynamics model explores the economic environment in South Korea in which the 1997 financial crisis occurred.

- Asymmetric liberalization of interest rates led to a bubble in investment behavior[16].
- A step change in regulation of the interest rates for commercial paper (CP) led to a massive shift in investment toward CP.
- The CP funds were channeled into investment projects with high projected long-term gains.

    - Investors were taking advantage of available CP. This CP was made available through the liberalization of foreign capital markets by the South Korean government.

    - The model's capital stock feedback structure serves to show the immediate benefit of utilizing the CP to invest long-term. The returns on long-term investment projects are determined as a ratio

[16] Choi, Jin-Wook. "Regulatory Forbearance and Financial Crisis in South Korea." Asian Survey, March/April 2002, Vol: 42, No: 2, Pages 251-275.

of expected income to capital stock with the profitability estimated relative to the cost of loans. When the cost of CP is reduced the profitability of long-term investment projects goes up and drives the acquisition of more capital stock. As capital stock is acquired, with all other items held constant such as demand, the profitability begins to go down. Shortly after ramping up the expected income feedback structure indicates a lack of profitability in continuing to invest due to a build up in capacity without a change in demand. The criticism may be offered that when investment is being expanded without consideration for demand the natural outcome is overexpansion. The model confirms this assertion, showing a decline in profitability when investment is made apart from a change in demand. The point the model makes, and is shown in the "Combinations" cases, is that when there is a change in demand and a change in CP rates the investment behavior can far overshoot the profitability promised by the increased demand.

- The bubble in investment did not match the actual demand for the product, leading to overcapacity.

    - The feedback structure served to reduce the expected returns on the long-term investments as more and more funds were directed toward increasing capacity. At the point where investing using CP

becomes less attractive than other investment modes the investment behavior shifts to the other modes. Capacity utilization must decline because more capacity is being added (capital stock increased) while demand remains steady. This serves to reduce the expected income.

- As the expected income drops due to overcapacity the decision to invest in CP drops off.

    - The model shows the build up in capacity through capital acquisition for capacity that becomes detached from "actual demand." When profits are not recognized the feedback structure of the model "investment decision" shows a shift away from investing using CP because it is no longer profitable due to overcapacity and demand drops off for the CP.

- The model highlights the investment decision process and the overcapacity that resulted, along with the drop in expected income.

At the peak of the bubble, just as demand for CP was dropping off the flow of CP was cut off.

Exogenous to the model are the events of the crisis.

- South Korean companies were highly leveraged in their long-term investments relying on short-term commercial paper to finance their long-term businesses expansion efforts.
- Demand was drying up for future business and the economy was working on paying off the loans, even as business suffered due to overcapacity.
- When the crisis hit the access to CP disappeared and companies could no longer roll-over their short-term debt, leading to bankruptcies. Given more time, and access to funding, companies may have been able to pay off their debts without the need for a bailout.

2.2 Model Overview

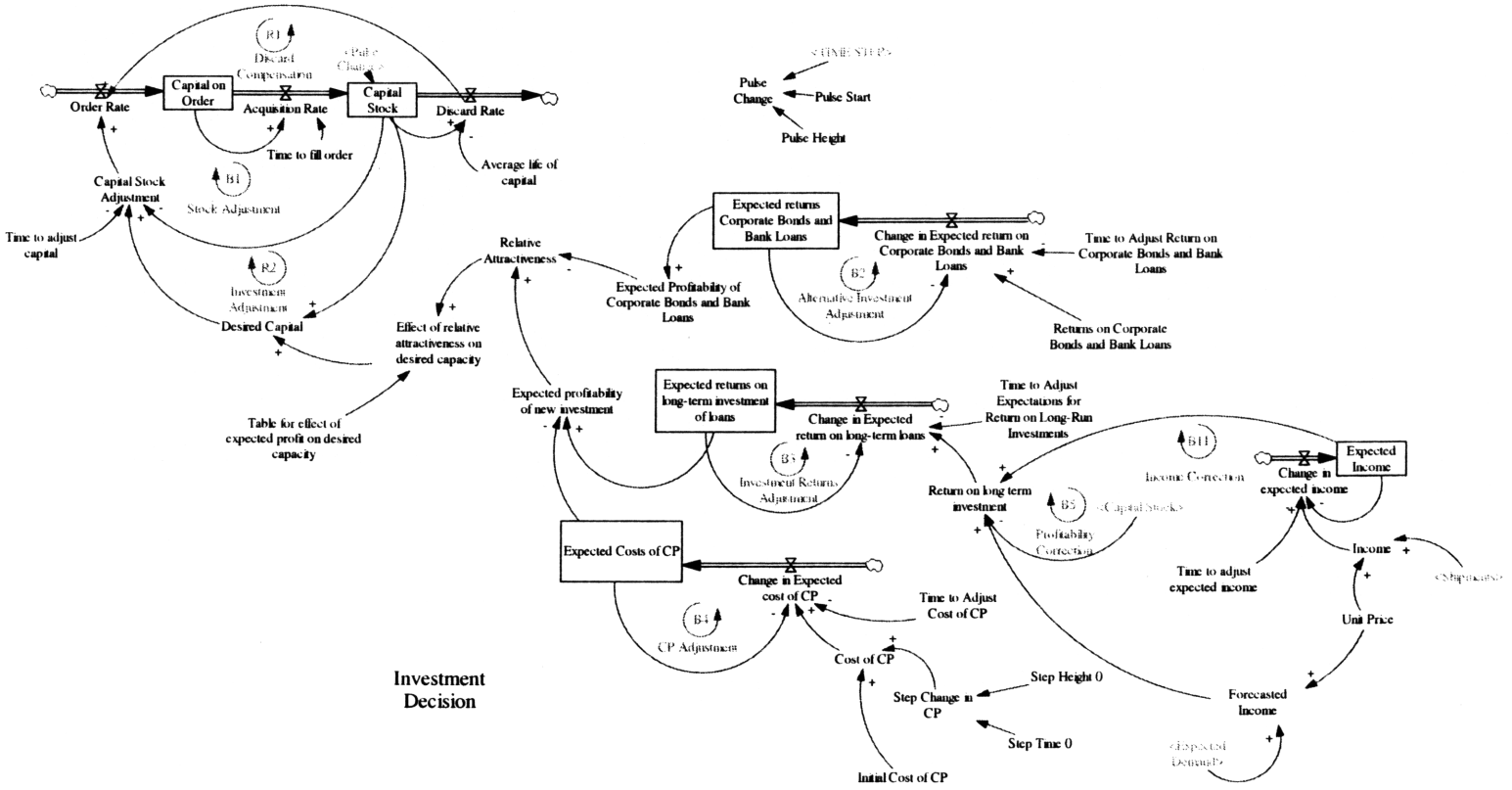
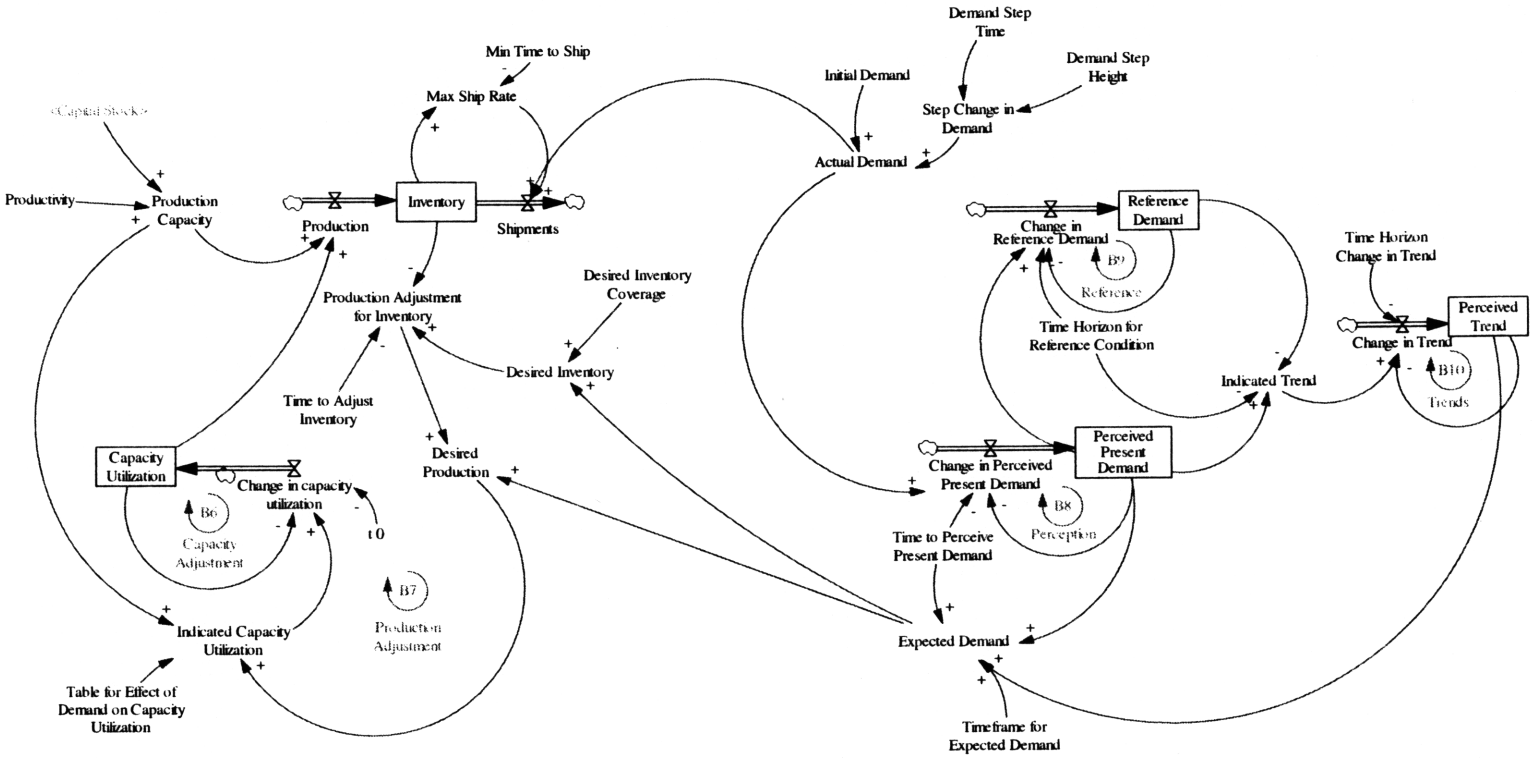


Figure II-1 System Dynamics Model of South Korean Build-up to Financial Crisis (Investment Decision)



Demand & Production

Figure II-1 cont: System Dynamics Model of South Korean Build-up to Financial Crisis (Demand and Production)

2.2.1 Description of System Dynamics Model

The following system dynamics model is made up of two sections. The first sections models the investment decision and includes the information flow used to determine the decision to expand capacity or invest in alternative options. The second section models demand and production and represents the decision structure to determine expected demand and the related behavior to determine production levels. The appendix shows a detailed description of each variable and the formula used for determining the variable values.

Investment Decision:

Figure II-1 "Investment Decision" shows the part of the model that describes the investment decision behavior. The investment decision model comprises six stocks which are; Capital Stock, Capital on Order, Expected Returns on Corporate Bonds and Bank Loans, Expected Returns on Long-Term Investment of Loans, Expected Costs of Commercial Paper (CP), and Expected Income. Important exogenous variables are Step Change in Commercial Paper (CP) and Time to Adjust Expectations for Returns on Long-Term Investments. The analysis portion will provide insight into how changes in these variables impact the stocks in the Investment Decision portion of the model as well as the Demand and Production portion of the model.

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Figure II identifies and labels several feedback loops that are important to gaining insight into the dynamics of the model. The loops are labeled R1 (Discard Compensation), R2 (Investment Adjustment), B1 (Stock Adjustment), B2 (Alternative Investment Adjustment), B3 (Investment Returns Adjustment), B4 (CP Adjustment), B5 (Profitability Correction), and B11 (Income Correction). It is important to gain an understanding of these loops in order to understand the impact of changes in exogenous variables.

Loop R1 (Discard Compensation) is a reinforcing loop.

This loop serves to represent the process of replacing assets that have been discarded or degraded to a point beyond providing a useful return on investment. With time all assets age, so must be phased out and replacement assets be procured to take their place. In the model this behavior is shown with the "Discard Compensation" reinforcing loop.

In this loop the discard rate is increased leading to an increase in the order rate to account for discards of capital stock. An increase in the order rate then produces an increase in the stock Capital on Order. As Capital on Order increases an increase is produced in the Acquisition Rate that produces and increase in the Capital Stock. As the Capital Stock increases an increase in the Discard Rate is produced.

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Loop R2 (Investment Adjustment) is a reinforcing loop.

This loop serves to represent the behavior of adjusting investment levels to match desired capital levels. As more capital is desired more investment is channeled into the acquisition of assets leading to an increase in Capital on Order and an increase in Capital Stock.

In this loop an increase in Capital Stock produces an increase in Desired Capital. As Desired Capital is increased it produces an increase in Capital Stock Adjustment, which produces an increase in Order Rate. An increase in the order rate then produces an increase in the stock Capital on Order. As Capital on Order increases an increase is produced in the Acquisition Rate that produces and increase in the Capital Stock and therefore produces an increase in Desired Capital.

Loop B1 (Stock Adjustment) is a balancing loop.

In this loop an increase in Capital Stock Produces a decrease in Capital Stock Adjustment. As Capital Stock Adjustment increases order rate increases and leads to an increase in Capital on Order. As Capital on Order increases an

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increase is produces in Acquisition Rate that serves to produce an increase in Capital Stock.

Loop B2 (Alternative Investment Adjustment) is a balancing loop.

In this loop Expected Returns on Corporate Bonds and Bank Loans is increased as Change in Expected Return on Corporate Bonds and Bank Loans is increased. An increase in Expected Return on Corporate Bonds and Bank Loans produces a decrease in Change in Expected Return on Corporate Bonds and Bank Loans serving to balance the loop.

Loop B3 (Investment Returns Adjustment) is a balancing loop.

In this loop Expected Returns on Long-Term Investment of Loans increases as Change in Expected Return of Long-Term Loans increases. An increase in Expected Returns on Long-Term Investment of Loans leads to a decrease in Change in Expected Return on Long-Term Loans serving to balance the loop.

Loop B4 (CP Adjustment) is a balancing loop.

In this loop Expected Costs of Commercial Paper (CP) increases as Change in Expected Cost of Commercial Paper (CP) is increased. An increase in Expected

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Costs of CP produces a decrease in Change in Expected Cost of CP serving to balance the loop.

Loop B5 (Profitability Correction) is a balancing loop.

This loop is one of the largest loops in the model. A decrease in Return on Long Term Investment produces a decrease in Change in Expected Return on Long-Term loans, which produces a decrease in Expected Returns on Long-Term Investment of Loans. As Expected Returns on Long-Term investment of Loans decreases a decrease is produced in the Expected Profitability of New Investment leading to a decrease in Attractiveness of Investing. As Attractiveness decreases a decrease is produced in the Effect of Relative Attractiveness on Desired Capacity which when decreasing serves to produce a decrease in Desired Capital. As Desired Capital is decreased it produces a decrease in Capital Stock Adjustment, which produces a decrease in Order Rate. A decrease in the order rate eventually leads to a decrease in the Acquisition Rate that consequently leads to a decrease in the Capital Stock. Thus, the loop acts to offset or balance the original increase in capital stock. A decrease in Capital Stock produces an increase in Return on Long Term Investment, which serves to balance the loop.

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Loop B11 (Income Correction) is a balancing loop.

In this loop, an increase in the number of Shipments increases the value of Income increases serving to increase the Change in Expected Income. As Change in Expected Income increases providing an increase in Expected Income. An increase in Expected Income leads to a decrease in Change in Expected Income serving to balance the loop.

Demand and Production:

Figure II-1 "Demand and Production" shows the part of the model that describes the demand and production behavior.

The demand and production portion of the model comprises five stocks, which are: Inventory, Capacity Utilization, Reference Demand, Perceived Trend and Perceived Present Demand. Important exogenous variables are Step Change in Demand and Timeframe for Expected Demand. The analysis portion will provide insight into how changes in these variables impact the stocks in both the Demand and Production portion of the model as well as the Investment Decision portion of the model.

The second panel of Figure II identifies and labels several feedback loops in this sector that are important to gaining insight into the dynamics of the model. The

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loops are labeled B5 (Capacity Adjustment), B7 (Production Adjustment), B8 (Perception), B9 (Reference), and B10 (Trends). It is important to gain an understanding of these loops in order to understand the impact of changes in exogenous variables.

Loop B6 (Capacity Adjustment) is a balancing loop.

In this loop an increase in the Indicated Capacity Utilization stimulates an increase in Change in Capacity Utilization which in turn increases Capacity Utilization, closing the gap between the indicated and actual capacity utilization, serving to create a balancing loop.

Loop B7 (Production Adjustment) is a balancing loop.

In this loop an increase in Desired Production produces an increase in Indicated Capacity Utilization leading to an increase in Change in Capacity Utilization. As Change in Capacity Utilization increases, Capacity Utilization increases leading to an increase in Production. As Production increases, Production Adjustment for Inventory decreases. A decrease in Production Adjustment for Inventory produces a decrease in Desired Production.

Loop B8 (Perception) is a balancing loop.

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In this loop an increase in Change in Perceived Present Demand produces an increase in Perceived Present Demand. As Perceived Present Demand increases it leads to a decrease in Change in Perceived Present Demand serving to balance the loop.

Loop B9 (Reference) is a balancing loop.

In this loop an increase in Change in Reference Demand leads to an increase in Reference Demand. As Reference Demand increases a decrease is produced in Change in Reference Demand serving to balance the loop.

Loop B10 (Trends) is a balancing loop.

In this loop an increase in Change in Trend produces an increase in Perceived Trend. An increase in Perceived Trend leads to a decrease in Change in Trend serving to balance the loop.

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2.3 Overview of Model Cases Analyzed

In review of the model several parameters will be varied in value to show the impact on the model output. These parameters have been chosen to best illustrate how the model works and provide insight into the structure and outcome of the model. The table below outlines the parameters that are varied and the cases that are explored in the model.

Case	Scenario	Parameter	Notes
1	In this scenario changes in the interest rate charged for Commercial Paper are explored. The variable "Cost of CP" is adjusted to illustrate changes.	Commercial Paper	Parameter used to represent interest rates charged for commercial paper. Lever in model used to show impact of policy decisions to liberalize interest rates. Step change function used to impart changes to variable.
2	In this scenario the impact of changes in demand on investment behavior are explored. The variable "Actual Demand" is adjusted to illustrate changes.	Demand	Parameter used to represent demand for products produced by businesses. Step change function used to implement changes to demand.
3	In this scenario the impact of changes in "Time to Adjust Expectations" are explored. This case is used to show the time it takes for the investing corporations to incorporate into their forecasts changes in their	Time to Adjust Expectations	Parameter used to represent time for forecasters to adjust expected returns on investments based on inflow of new information. Adjusted by directly changing parameter to varying Month values.

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	expected profitability for long-term investment projects The variable "Time to Adjust Expectations" is adjusted to illustrate changes.		
4	In this scenario the impact of changes in "Timeframe Expected for Demand" are explored. The scenario is used to show the timeframe assumptions used by the forecasters at the businesses investing for how long the demand is believed to hold constant. The variable "Timeframe Expected for Demand" is adjusted to illustrate changes.	Timeframe Expected for Demand	Parameter used to represent time expectation for demand. Varied by directly changing value in model by updating Month value.
5	In this scenario combinations of the variables explored in cases 1-4 are used to show the related impact on the investment behavior predicted by the model.	Combinations	Combinations of the above parameters.

Table II-1 Modeling Cases

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2.4 Case 1: Commercial Paper

2.4.1 Description of cases run

In the model the variable "Cost of CP" (commercial paper) is used to show the policy lever that was applied to liberalize interest rates. The variable is adjusted using a step function where the "time" and "height" of the change in the cost of commercial paper is modified. The cases that are explored for changes in the cost of commercial paper include:

Case	Cost of CP
1a.	Reduce by 50% Month 12
1b.	Reduce by 75% Month 12
1c.	Reduce by 100% Month 12

Table II-2: Cost of CP Case Descriptions

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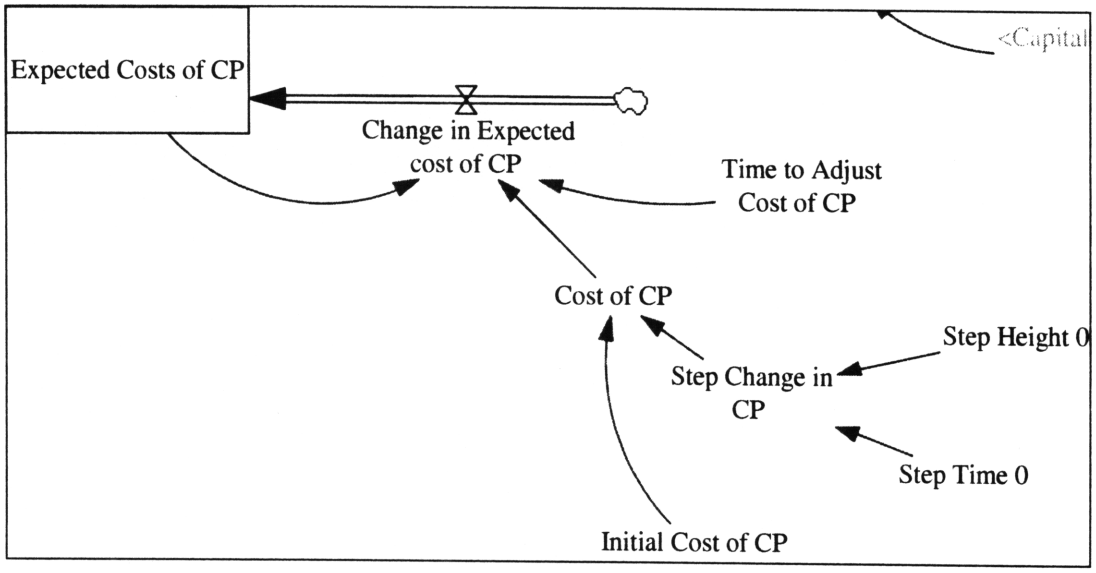

Figure II-2: Cost of Commercial Paper Model Structure

2.4.2 Graphs showing key variables & Description of the behavior

The results of the runs varying the interest rates of commercial paper are shown in the figures II-3 through II-10.

"Capital Stock" shows the results of the build-up of capital used to invest in long-term investments. The first line "Equilibrium" is the baseline case where all parameters all held constant. Cases 1a, 1b and 1c illustrate the impact of interest rate changes to commercial paper on the acquisition of capital used to invest long-term. The magnitude of investment build-up varies by the magnitude of the cut in interest rates.

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Case	Cost of CP	Peak Capital Build-up
1a.	Reduce by 50% Month 12	437% Increase
1b.	Reduce by 75% Month 12	757% Increase
1c.	Reduce by 100% Month 12	1080% Increase

Table II-3: Cost of Commercial Paper Model Peak Results

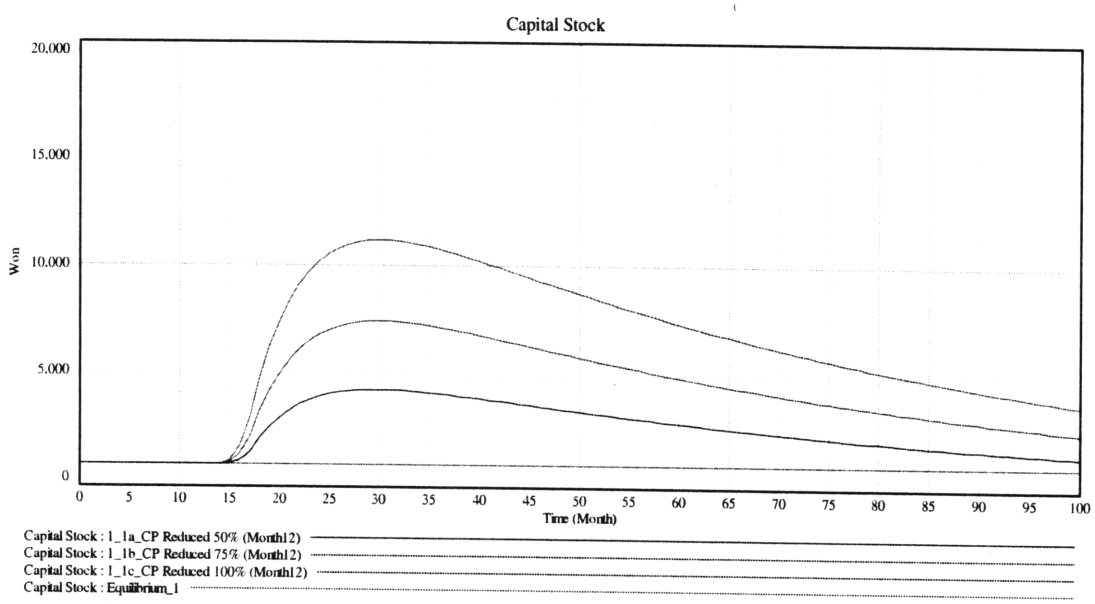

Figure II-3: Capital Stock Model Results for CP Changes

To provide insight into the structure of the model and how the results of the "Capital Stock" parameter were created, several additional variables are explored.

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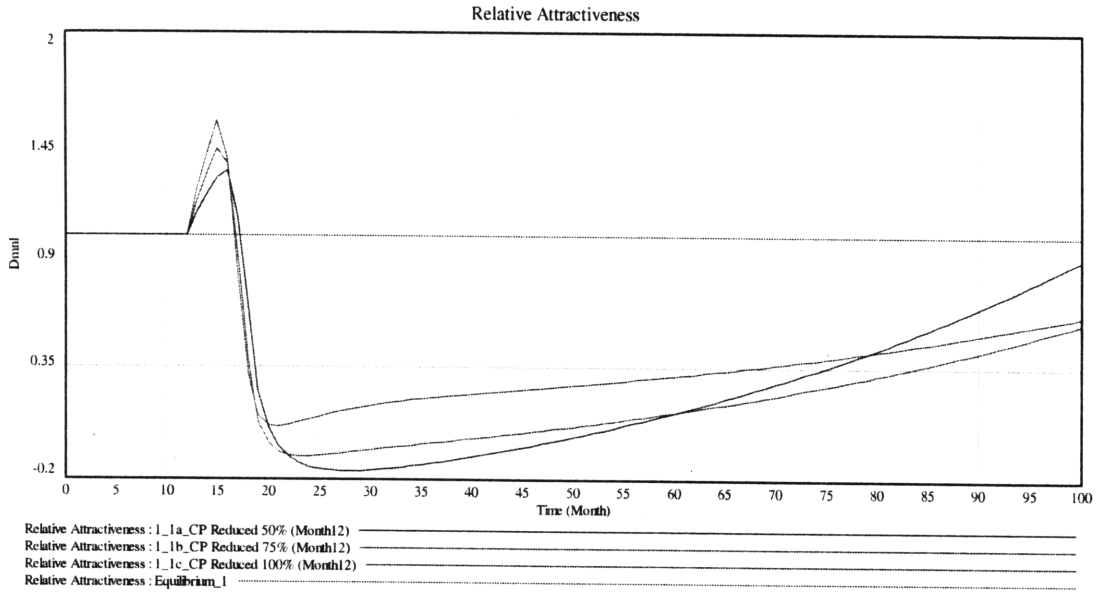

Figure II-4: Relative Attractiveness Model Results for CP Changes

"Relative Attractiveness" is the variable in the model that describes the decision-makers comparison of the option to invest in long-term return projects with investing in other avenues. The decision is made based on the expected returns on investing in long-term projects versus other investment avenues. The blue line in Figure II-4 represents a 50% reduction in CP rates. It can be seen that the peak in investment occurs several months after the peak in investment for a 75% and 100% reduction in CP rates, and additionally, the blue line crosses the other cases several years out as the attractiveness of investment increases. This behavior can be explained by exploring the feedback structure in the model. When the investment decision begins to look unattractive the model reduces investment financed through CP. The 50% case crosses over the 75% and 100% cases as it peaks because the feedback structure of the model drives a much steeper decline in the expected returns in long-term investment of loans for

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the 75% and 100% reduction cases. The expected profitability is determined by using the difference between the expected returns and the costs of the loans. This shift serves to provide a crossover in relative attractiveness for the less-steep 50% reduction with the 75% and 100% reduction cases. The fact that the 50% reduction case peaks at a lower level than the 75% and 100% case illustrates that less capacity was added in the overshoot leading to less capacity that needs to be shed to return to profitable levels. This explains why the eventual increase in the relative attractiveness of expansion is faster with the 50% CP reduction than the other two cases and leads to a crossing. Given a longer time frame it can be seen from the trajectory of the 75% reduction that it too would cross over the 100% reduction case in its return to relative attractiveness.

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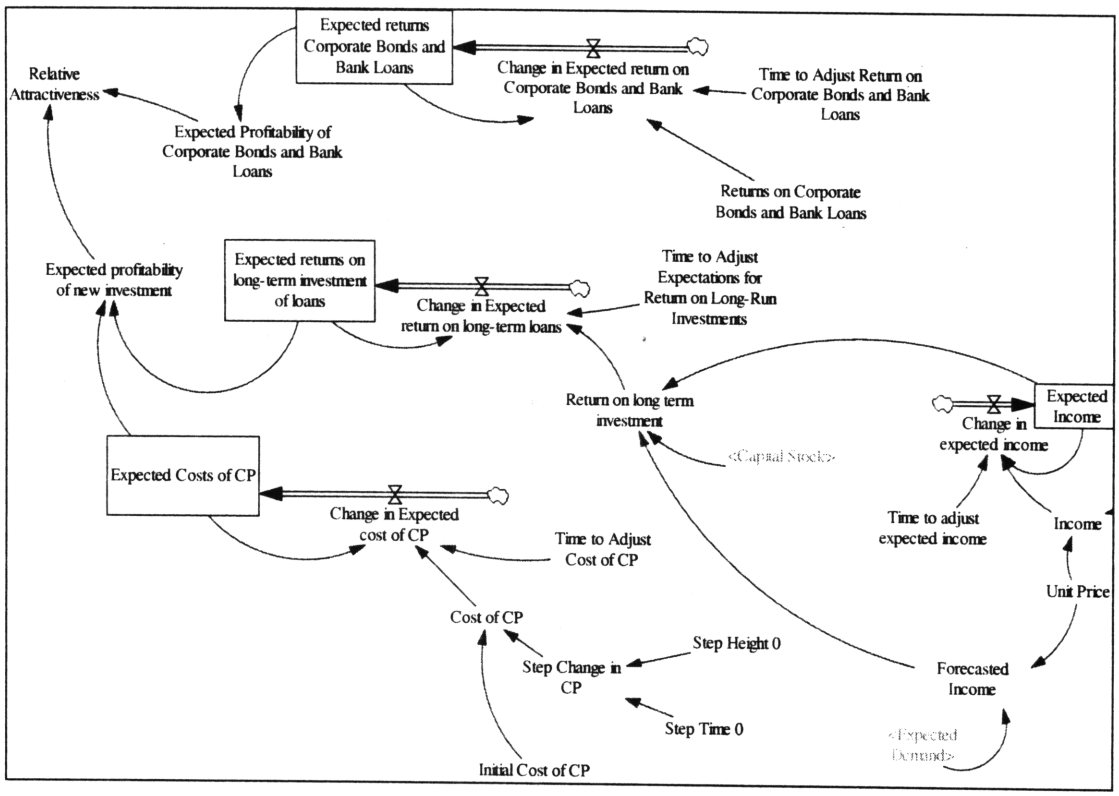

Figure II-5: Relative Attractiveness Model Structure

The model structure shown serves to drive the investment decision process. The top structure flow for "Expected returns Corporate Bonds and Bank Loans" is held fixed in the model showing a constant level of expectations for the returns from these vehicles, so "Expected Profitability of Corporate Bonds and Bank Loans," is also constant This part of the model is held constant for the purposes of this analysis because the model is being used to illustrate the impact of the policy decisions related to the liberalization of interest rates, with the emphasis on the first round of liberalization that lowered interest rates on commercial paper while other rates were held constant.

The lower part of the structure is tied together by "Expected Returns on Long-Term Investment of Loans" and "Expected Costs of CP." The difference between

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these variables determines the "Expected Profitability of New Investment." A ratio comparison of the profitability of "Long-Term Investment" using commercial paper to finance the venture is made versus using the returns on "Corporate Bonds and Bank Loan Investments." The ratio of these two variables forms the "Relative Attractiveness" variable. The graph below for "Relative Attractiveness" shows that for all three cases of changes in commercial paper interest rates the relative attractiveness of investment spikes directly after the interest rate cut around Month 12. When the relative attractiveness parameter is greater than "1" then investing in long-term projects financed by commercial paper is more attractive than other investment modes. The model shows that within 3 months the relative attractiveness of investing in long-term projects financed by commercial paper begins to drop off precipitously and slowly begins to gain in attractiveness after another 5 months. The driver for this drop in attractiveness is the "Capital Stock" variable that has bubbled up to anywhere from ~400% to ~1000% greater than its original value. The attractiveness of long-term investing is a function of the "Forecast Income" ratio to the "Capital Stock" parameter. As the "Capital Stock" parameter spikes and the "Forecast Income" parameter is held constant the "Expected Returns of Long-Term Investments" plummets. The plunge in "Expected Returns of Long-Term Investments" is shown in the graph below, along with the steady value of "Forecasted Income." "Forecasted Income" remains steady because there has been no indication of a change in demand or price of the product. The decision to increase capacity was made entirely based on the forecast long-term investment returns expected due to the

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lowered cost of borrowing the finance the investments. Once the capacity has been added, but demand and price are constant, the attractiveness plummets, as shown in the structure discussed below.

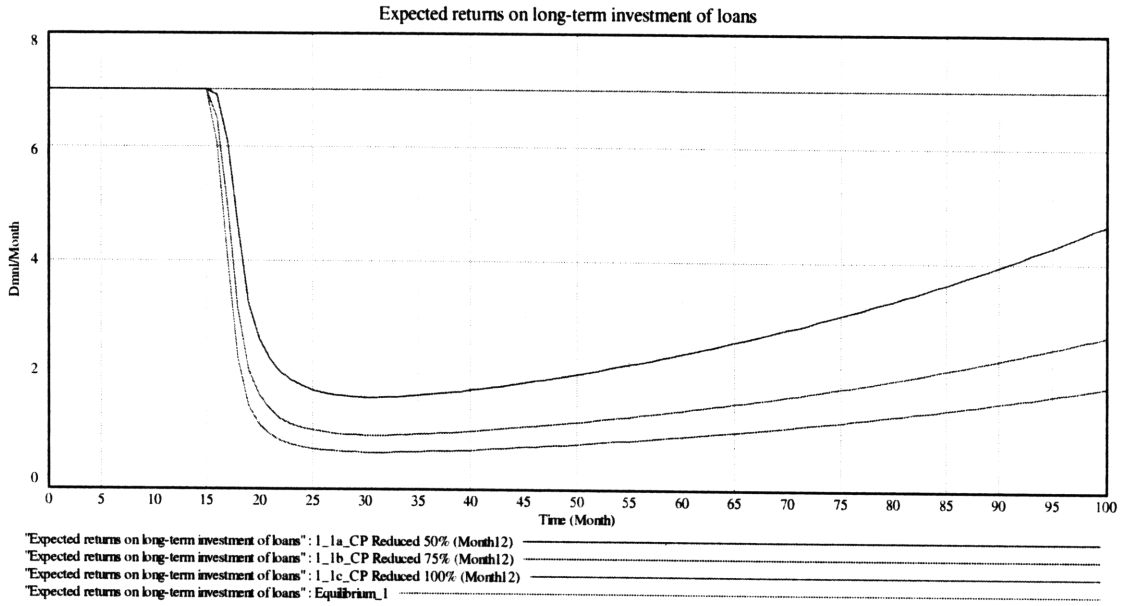

Figure II-6: Expected Returns on Long-Term Investment of Loans Model Results for CP Changes

After the variable "Relative Attractiveness" quantifies the comparative benefits of investing in long-term investment projects versus other modes of investment, the "Relative Attractiveness" parameter is flowed to "The Effect of Relative Attractiveness on Desired Capital"

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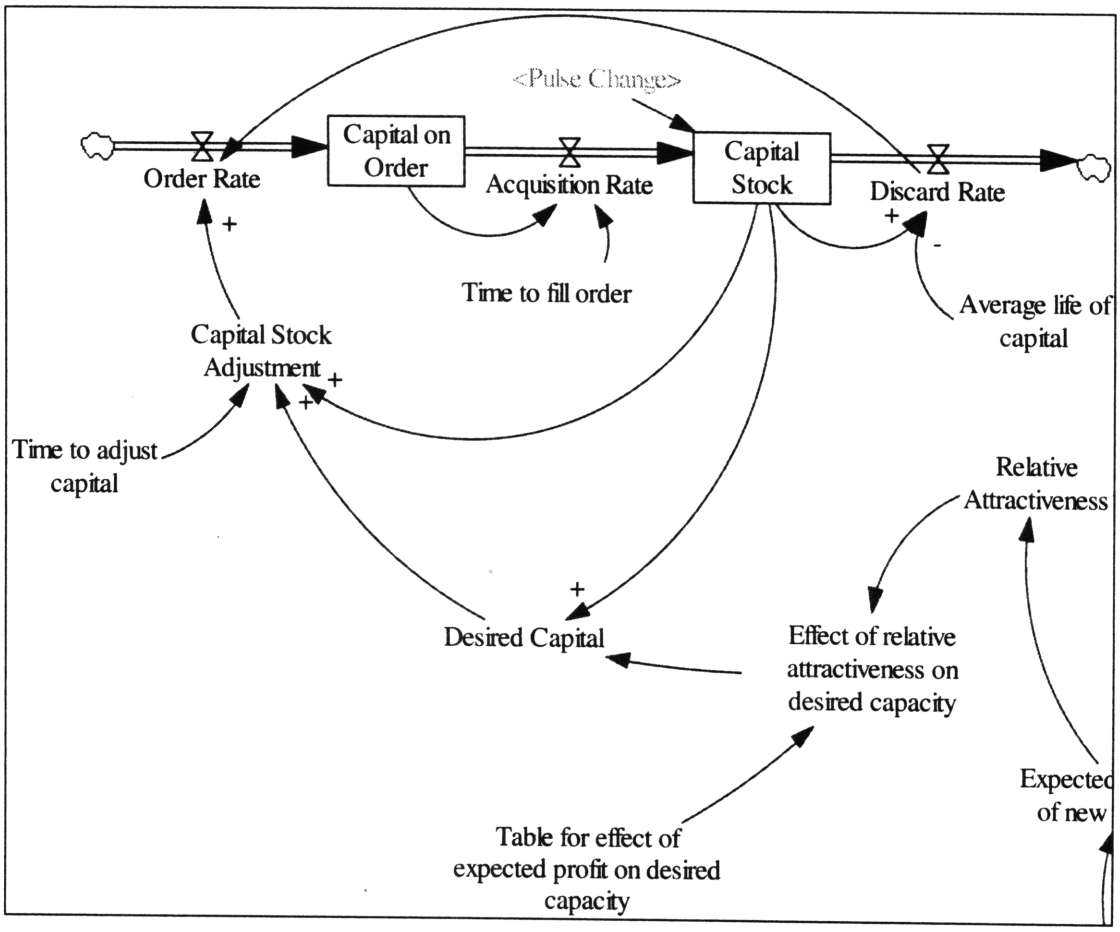

Figure II-7: Investment Decision Model Structure

A lookup table is used to relate the "Relative Attractiveness" of investing to the amount of "Desired Capital." Values may be found in the appendix. The graph of "Desired Capital" is shown below. It can be seen that for the points in the model where the attractiveness of making long-term investments was high that the "Desired Capital" response also spiked. The highest response level is found with the most drastic interest rate cut (100%). For values where investing long-term is not attractive it can be seen that "Desired Capital" levels fall to near zero levels.

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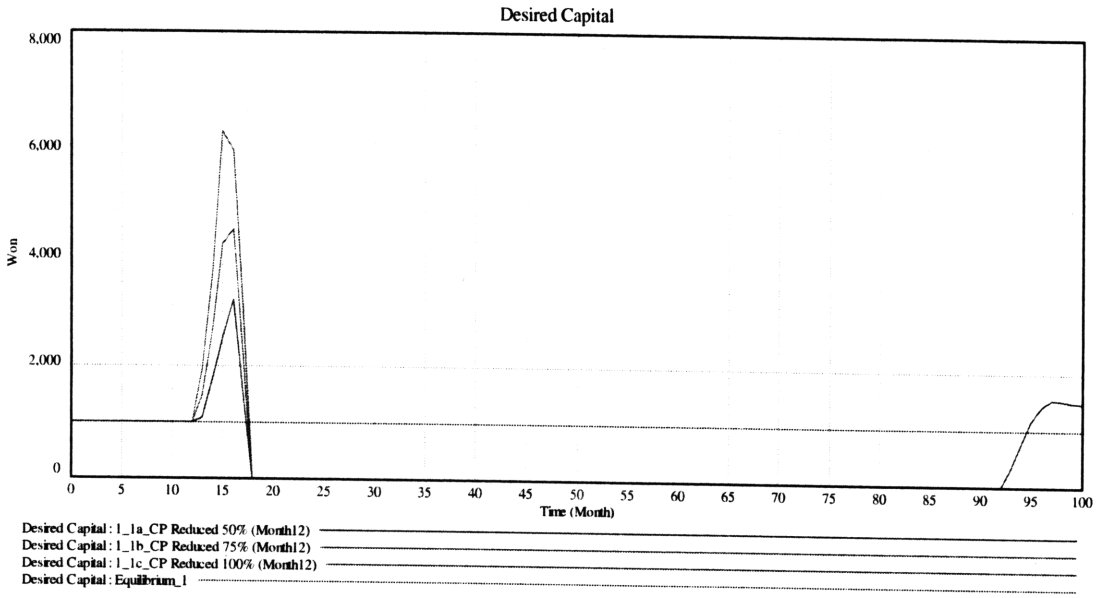

Figure II-8: Desired Capital Model Results for CP Changes

"Desired Capital" feeds the "Order Rate" variable and the "Capital on Order" stock in the model. It can be seen in the "Order Rate" graph that the value spikes in magnitude immediately after the interest rate cuts, proportional to the magnitude of the cut, and then drops off quickly as the investment attractiveness drops. The "Capital on Order" stock shows a similar spike in demand at the time of the cut and a sharp drop after the attractiveness decreases. The drop off is slower for "Capital on Order" than for "Order Rate" because Capital on Order is a stock. It takes some time for the existing orders for capital to be completed, modeled by the "Acquisition Rate" flowing value out of the stock.

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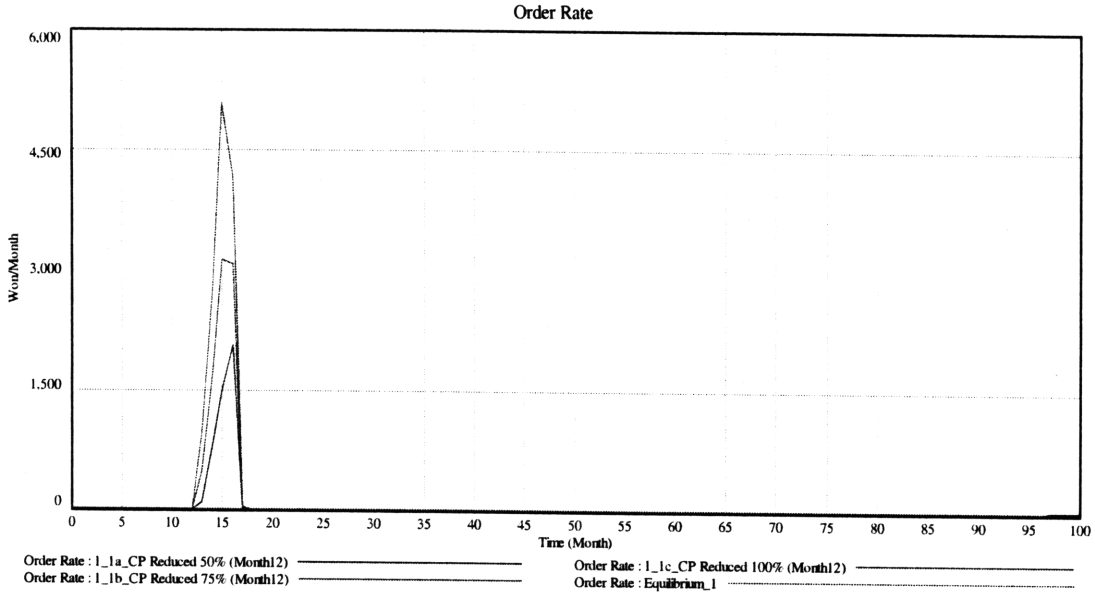

Figure II-9: Order Rate Model Results for CP Changes

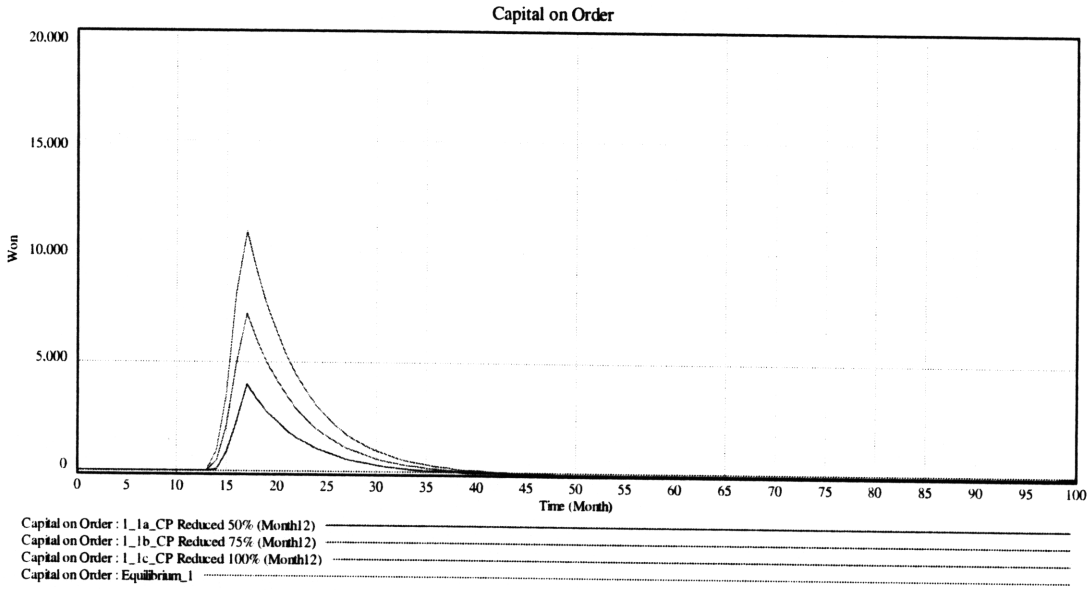

Figure II-10: Capital on Order Model Results for CP Changes

2.4.3 Feedback Structure Influencing Model Behavior

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Cases 1a, 1b, and 1c explored the impact of changes in the cost of commercial paper on the behavior of the model. In each of these cases the balancing loop B5 (Profitability Correction) served to significantly influence the model behavior. As described in the methods section, the Profitability Correction balancing loop takes the value of Capital Stock and feeds it back into the logic to determine the Expected Returns on Long-Term Investments. Cases 1a, 1b and 1c all explored decreases in the cost of commercial paper with other variables held constant. The impact of this change as shown in the graphs above was to create a build-up in the Capital Stock variable as more assets are acquired due to the Relative Attractiveness of investing. As the Capital Stock increases this feeds back into the model through the Profitability Correction balancing loop and shows that the profitability of continuing to invest is decreasing because the Forecasted Income has remained constant and is now being divided by an increasing stock of capital. This balancing loop serves to provide the feedback in the structure to limit further expansionary behavior until some other variable changes that would again make the investment decision appear profitable.

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2.5 Case 2: Demand

2.5.1 Description of cases run

In the model the variable "Step Change in Demand" is used to show the impact of changing levels of demand on the model structure. The variable is adjusted using a step function where the **time** and **height** of the change in the level of demand is modified. The cases that are explored for changes in the demand are:

Case	Change in Demand
2a.	Increase by 30% Month 12
2b.	Increase by 40% Month 12
2c.	Decrease by 30% Month 12

Table II-4: Change in Demand Model Cases

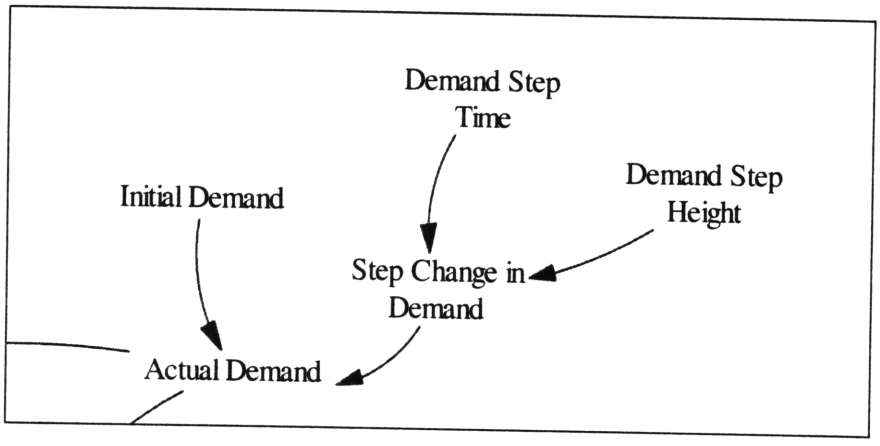

Figure II-11: Demand Model Structure

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The structure above shows the variable "Actual Demand" and shows that it is influenced directly by the step function "Step Change in Demand." The value of "Actual Demand" is fed through the trend structure[17] shown below and adjusted to "Expected Demand." It will be shown in the following graphs that the "Expected Demand" is determined as a function of past behavior with the lessons of the past driving future expectations.

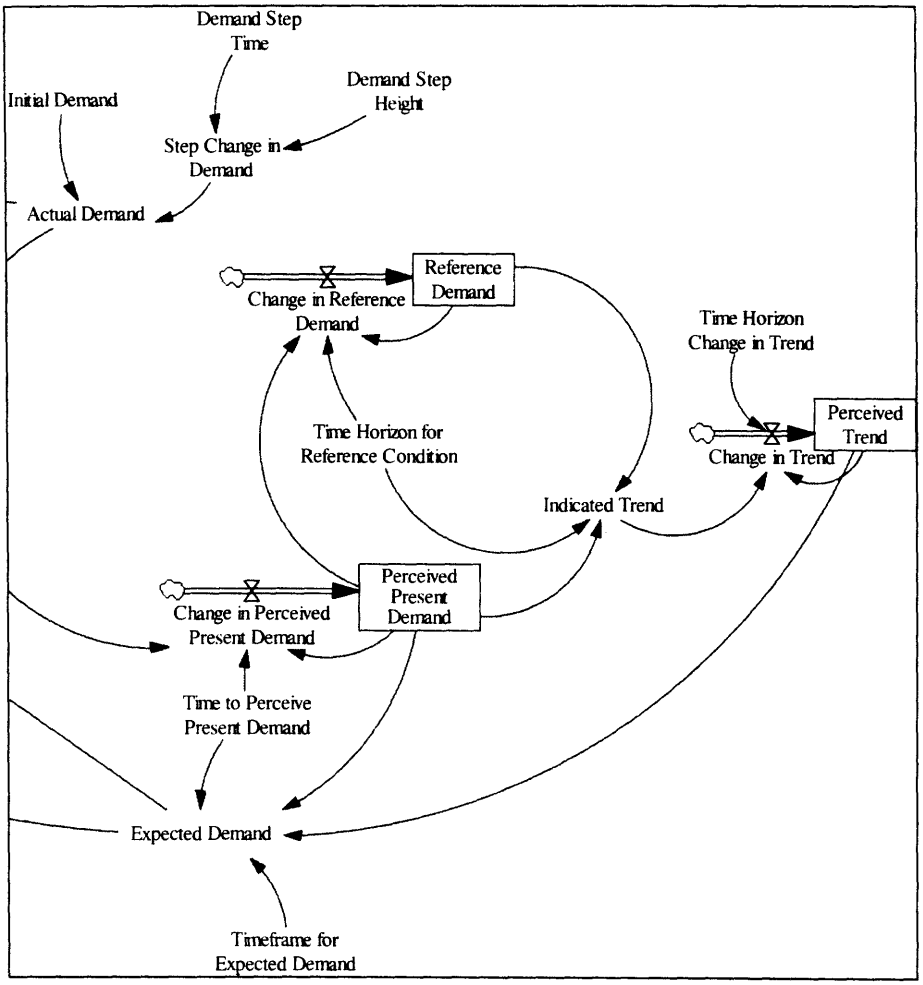

Figure II-12: Expanded Demand Trend Model Structure

[17] Sterman, John. Business Dynamics: Systems Thinking and Modeling for a Complex World. Irwin, McGraw-Hill 2000.

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2.5.2 Graphs showing key variables & Description of the behavior

The results of the runs varying the demand are shown in the figures below.

"Capital Stock" shows the results of the build-up of capital used to invest in long-term investments. Cases 2a, 2b and 2c illustrate the impact of changes in demand on the acquisition of capital used to invest long-term. The magnitude of investment build-up varies by the magnitude of the change in demand. Cases 2a and 2b illustrate the impact of an increase in demand. Both show the "Capital Stock" variable responding after the change in demand takes effect. A 30% increase in demand leads to a 300% increase in capacity at the peak. A 40% increase in demand leads to an even greater increase in magnitude of increase in capacity, peaking at a 450% increase in capacity at the peak. Both cases begin to adjust and return to a lower value of capacity as all other variables are held constant and the spike in capacity increase overshot the income benefits of the demand spike. This is shown by the gradual return to lower levels of capacity over time, as demand remains constant after the first step input without continuing to increase. This behavior is driven by the model feedback structure of relative attractiveness. The increase in demand leads to investment. As capacity is increased and the profitability of further investment drops off the relative attractiveness drops and the "Investment Adjustment" feedback loop feeds less orders for investment based on the lowered attractiveness.

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The third case, case 2c, shows the impact of a lessening in demand where demand decreases by 30% after Month 12. The graph shows that faced with a decrease in demand the system responds by lessening demand for capital and the capital stock begins to dip below its starting level. This behavior is driven by the feedback from "Forecast Income" that decreased with lower levels of demand being introduced while price is held constant.

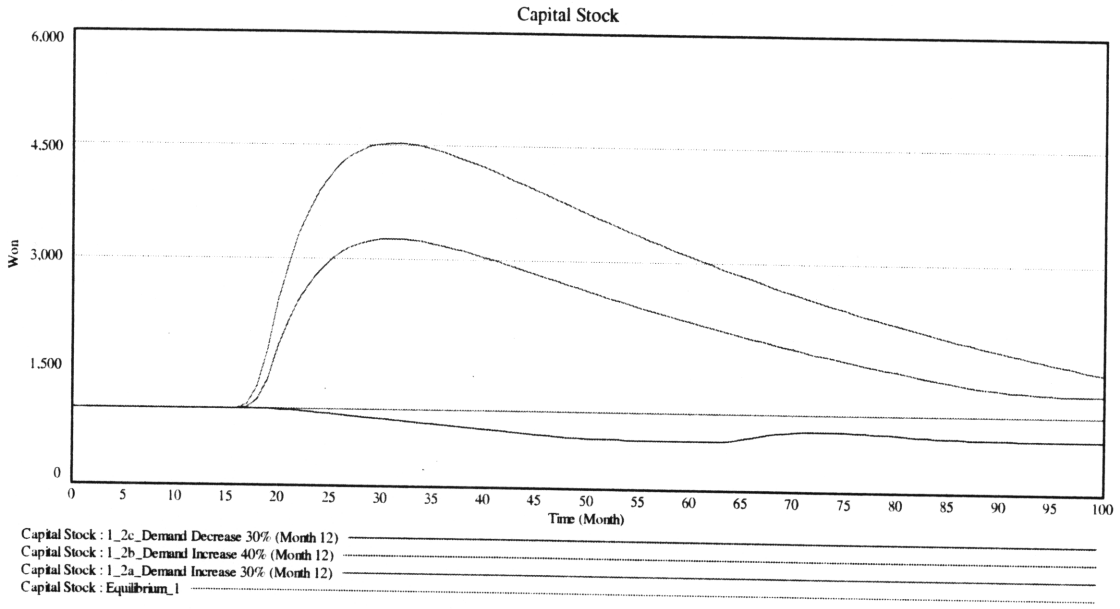

Figure II-13: Capital Stock Model Results for Changes in Demand

The graph for "Forecasted Income" shows the impact of the change in demand on the expectations for what future income will result.

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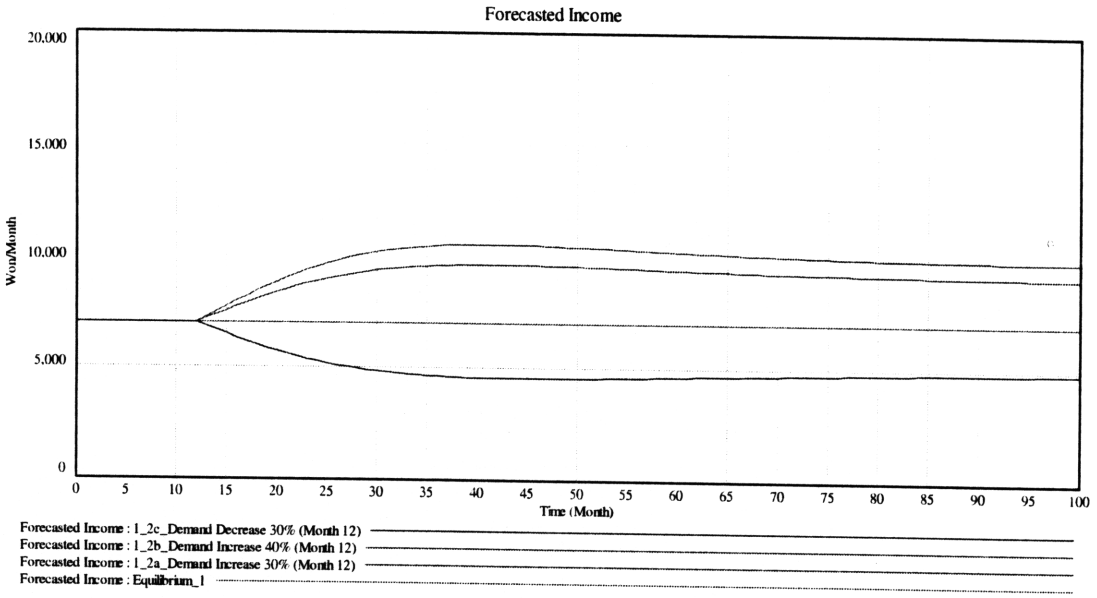

Figure II-14: Forecasted Income Model Results for Changes in Demand

The graph shows that for cases 2a and 2b with demand increases of 30% and 40% respectively in Month 12 that the forecast income increases and overshoots slightly and then returns to a steady state value after several years. The overshoot in "Forecasted Income" is small on the order of a 7% overshoot in expectations at the peak value. Case 2c illustrates the scenario where demand is reduced. The graph shows that the impact on "Forecasted Income" is the mirror image of the impact of increasing demand by 30% with a similar 7% overshoot in expectations for income drop and return to steady state levels after several years. "Forecasted Income" is directly influenced by changes in the "Expected Demand."

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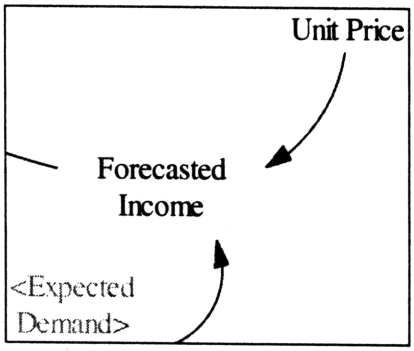

Figure II-15: Model Structure for Forecasted Income

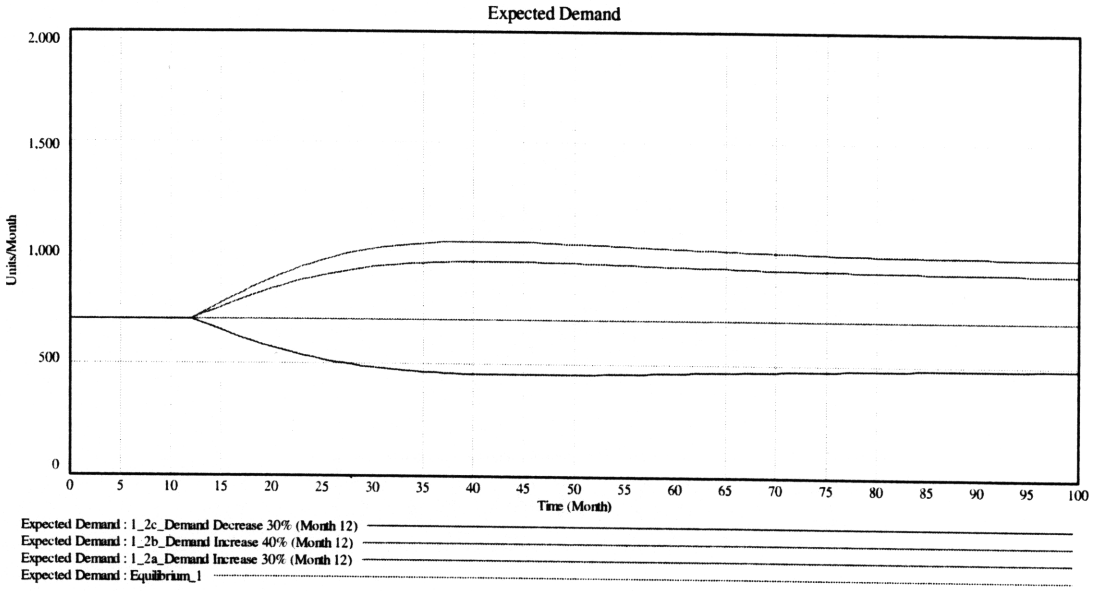

Figure II-16: Expected Demand Model Results for Changes in Actual Demand

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The graph for "Expected Demand" shows the same trend as what is shown in the forecasted income. The "Expected Demand" behavior is driven by the trend structure.

The "Actual Demand" graph below shows the inputs that were provided to the model with step changes in the "Actual Demand" all implemented at 12 Months.

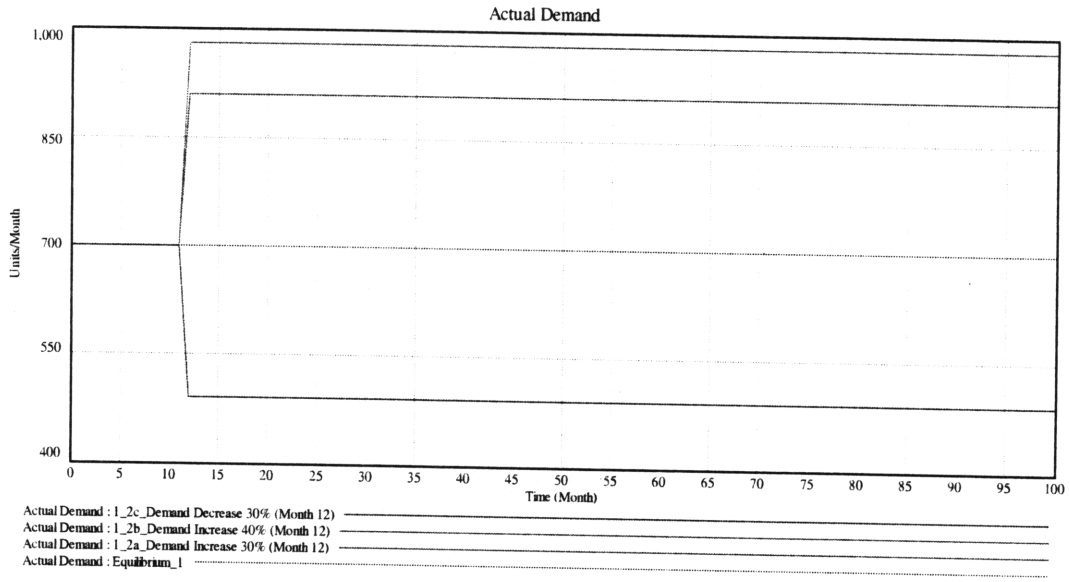

Figure II-17: Actual Demand Model Input

The graph of the "Expected Demand" can be held in comparison and the impact of the trend structure becomes clearly evident. The first item to note is the response time for the forecast to match the actual demand. The change in actual demand made to the model is immediate and happens at month 12. In the "Expected Demand" graph it is shown that the expected demand does not reach the magnitude of the actual demand until almost 12 months has passed, and it reaches the value gradually with a gentle build-up. Figure II-18 shows a comparison of "Expected Demand" to "Actual Demand" for the case of increasing

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demand by 30%. The comparison illustrates the delay and overshoot of "Expected Demand" with the "Actual Demand" level not reached until almost a year after the demand increase occurs, and an overshoot to almost 25% beyond the actual demand level.

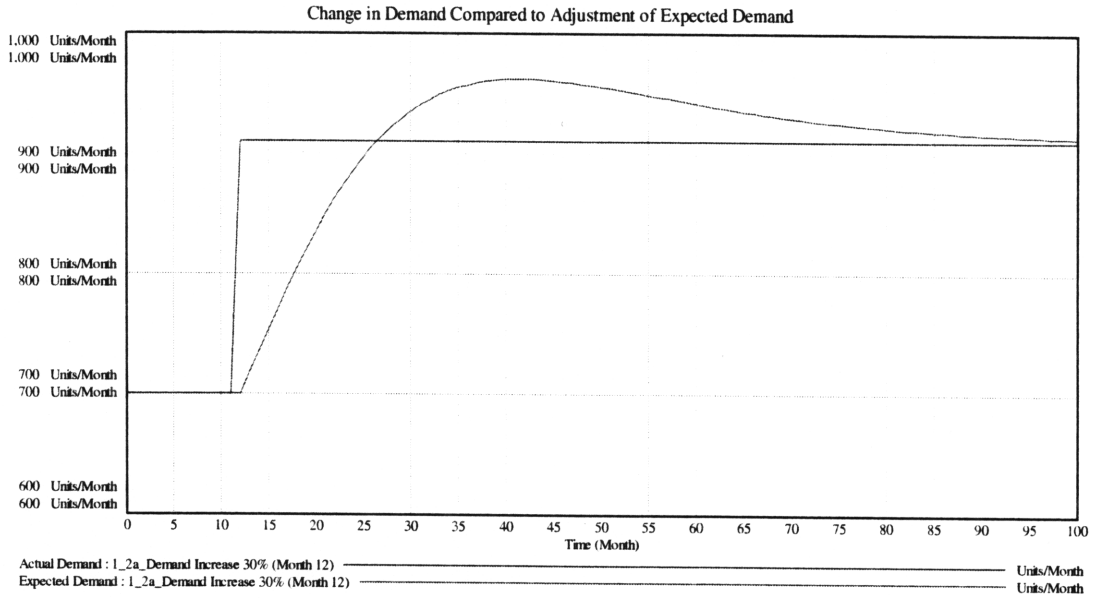

Figure II-18: Change in Demand Compared to Adjustment of Expected Demand

The pace of the adjustment is controlled by the variables "Time to Perceive Present Demand" and "Time frame for Expected Demand." "Timeframe for Expected Demand" is the time period over which the forward forecast is made. "Time to Perceive Present Demand" serves as the response time needed for forecasters in the investing corporations to recognize current demand conditions and adjust their beliefs based on the signals they are getting from the market. As this time varies the response of the model "Expected Demand" and "Actual Demand" varies. With small values of "Time to Perceive Present Demand" the company adjusts quickly to indicators that demand is dropping off and more

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immediately reflects the value of actual demand. With larger values there is more of a long and gradual build-up to actual levels. The opportunity loss of not immediately adjusting to new levels of demand is the missed income opportunity. However, the flip side risk is reacting too quickly to changes in demand that may be only temporary and passing. Immediate reaction may lead a company to decrease capacity, as shown in case 2c. The risk is that the drop in demand was temporary and picks back up soon after leaving the corporation with less capacity to meet the demand and even larger levels of lost income opportunity.

2.5.3 Feedback Structure Influencing Model Behavior

Cases 2a, 2b, and 2c explore the impact of changes in demand on the behavior of the model. In each of these cases the balancing loops B8 (Perception), B9 (Reference) and B (Trends) influence the model behavior. Because of delays in information gathering and process and updating perceptions, forecasters can never use the instantaneous rates of demand in determining the production values and influencing the production rates. What these loops serve to do is model the likely behavior of trending the demand values resulting in an expected demand that has margin beyond the actual demand. Balancing loop B8 (Perception) takes the Change in Perceived Present Demand and is smoothed out over the Time Horizon to Perceive Present Demand. This Perceived Present Demand then influences a Change in Reference Demand that is smoothed out over the Time Horizon for Reference Condition by balancing loop B9 (Reference). This reference demand then influences indicated trend in-turn

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influencing Change in Trend. Change in Trend is then smoothed out over the Time Horizon for Change in Trend resulting in a perceived trend that then influences expected demand. Each of these balancing loops serve to smooth out the information flow and leaves the resulted expected demand as a result of the feedback structure of these balancing loops tied to the past behavior of the demand movement.

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2.6 Case 3: Time to Adjust Expectations

2.6.1 Description of cases run

In the model the variable "Time to Adjust Expectations for Return on Long-Run Investments" is used to show the time it takes for the investing corporations to incorporate into their forecasts changes in their expected profitability for long-term investment projects. This variable is adjusted by setting it to different Month values. The cases that are explored for changes in the "Time to Adjust Expectations for Return on Long-Run Investments" include:

Case	Time to Adjust Expectations	Commercial Paper
3a.	Increase to 6 Month	Reduce 50% Month 12
3b.	Increase to 12 Months	Reduce 50% Month 12
3c.	Increase to 24 Months	Reduce 50% Month 12

Table II-5: Model Cases for Time to Adjust Expectations

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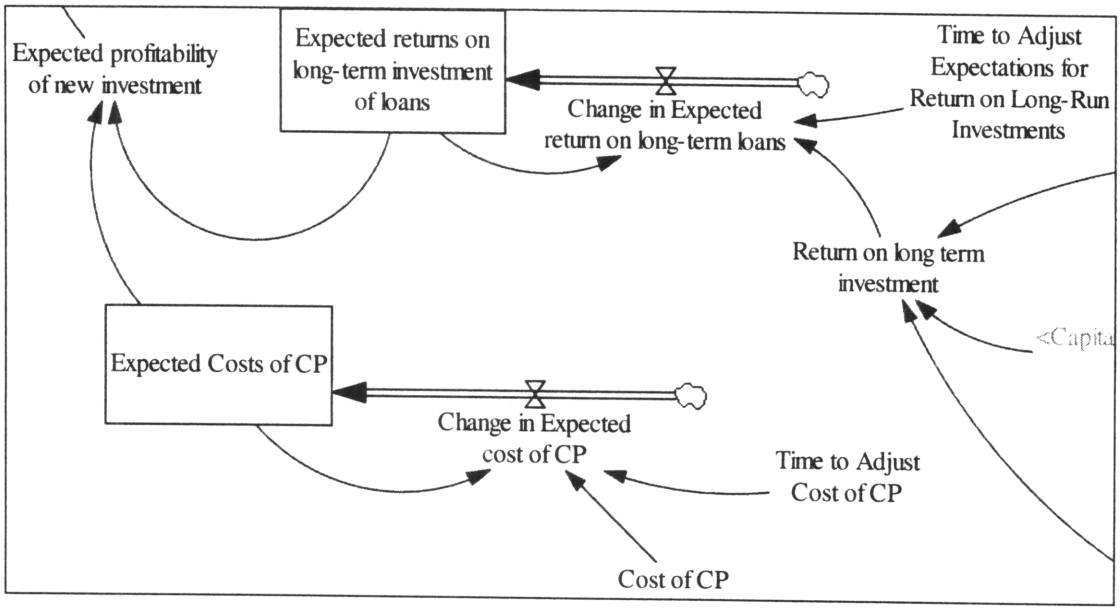

Figure II-19: Model Structure for Time to Adjust Expectations

The structure above highlights where "Time to Adjust Expectations for Returns on Long-Run Investments" fits into the model structure. The variable "Change in Expected Returns on Long-Term Loans" takes the difference between "Expected Returns on Long-Term Investment of Loans" and "Return on Long-Term Investments" and divides the difference by the parameter of interest for this case "Time to Adjust Expectations for Returns on Long-Run Investments." When this time parameter is small then the model reacts rapidly to new information that is fed into the investment decision loop based on the "Forecasted Income" that would either result in a profitable or unprofitable long-term investment relative to other investment modes. As the time parameter gets larger the model slows its reaction time and takes longer to integrate the new information on profitability of long-term investments serving to delay the decision to stop investing or continuing to invest. This can result in bubble behavior where the peak investment in capacity can far overshoot the behavior of the model in the event

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the information was readily available. This variable provides a great deal of insight into the potential to have large investment overshoots and goes a long way toward helping to explain the reasoning behind an investment bubble. Large values of Time to Adjust Expectations lead to large overshoots in investment.

For the purposes of this model the parameter serves to emphasize the importance of keeping forecasts current and closely watching leading indicator metrics to ensure forecasts are accurate and future investment decisions are made wisely. It should be noted however that faster reaction time is not always a desirable behavior. In other instances it could mean that the investment behavior is responding to short-term fluctuations and making decisions based on a short-term horizon leaving the business susceptible to unwise investment cut-backs or build-ups that are reactionary in nature. A careful sensitivity analysis should be conducted of decision structure subjecting it to noise and various inputs before launching on major changes based on short-term fluctuations.

2.6.2 Graphs showing key variables & Description of behavior

The results of the runs varying the time to adjust expectations are shown in the figures.

"Capital Stock" shows the results of the build-up of capital used to invest in long-term investments. Cases 3a, 3b and 3c illustrate the impact changes in "Time to Adjust Expectations for Returns on Long-Run Investments" on the acquisition of

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capital used to invest long-term. The magnitude of investment build-up varies by the magnitude of the change in demand.

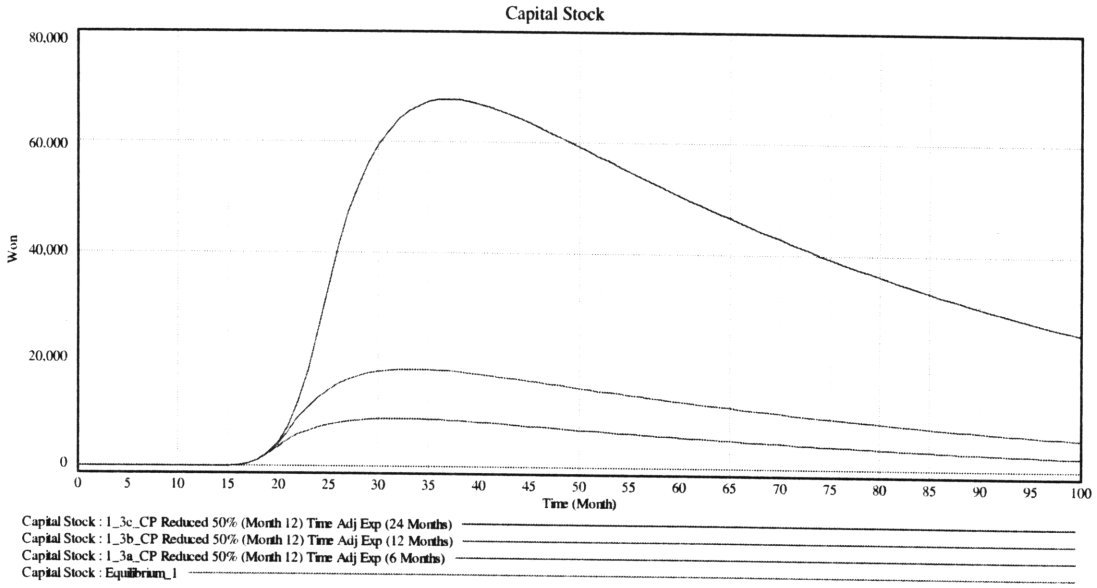

Figure II-20: Capital Stock Model Results for Changes in Time to Adjust Expectations

The "Capital Stock" graph shows the impact of varying the time parameter to 6, 12, and 24 months. The graph shows that the investment magnitude spikes up to values as great as 6000% the original investment value. As a baseline, a graph is shown below comparing the model output for the same change of a 50% reduction in Commercial Paper interest rates with the time parameter held constant at 1 Month versus the time parameter changed to 24 Months.

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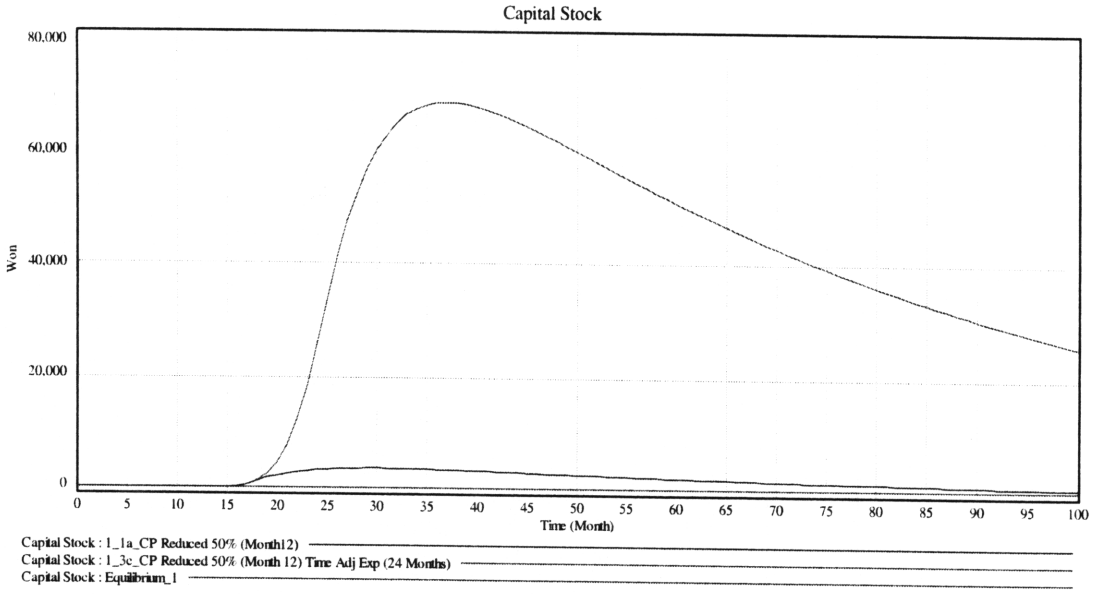

Figure II-21: Capital Stock Model Results for Changes in Time to Adjust Expectations

The "Capital Stock" parameter illustrates the enormity of the magnitude shift in the peak capital stock build-up. In the first case, where the time parameter is held constant at 1 Month when the interest rates for Commercial Paper is reduced by 50%, the peak magnitude reached is 15 time greater when the time parameter is set to 2 years than when it is set to 1 month. This model behavior serves to illustrate the impact of delays in information flow on investment decisions. The bubble behavior exhibited here is a function of not integrating the information that the demand has not changed and the forecast income remains constant making further investment of minimal value to the business. In a situation where access to debt financing is readily available and there is not pressure to repay loans this bubble investment behavior could continue on until the profitability issue cannot be ignored.

2.6.3 Feedback Structure Influencing Model Behavior

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Cases 3a, 3b, and 3c explore the impact of changes in Time to Adjust Expectations on the behavior of the model. In each of these cases the balancing loops B3 (Investment Returns Adjustment) and B5 (Profitability Correction) influence the model behavior strongly. A change in the variable Time to Adjust Expectations directly influences loop B3 (Investment Returns Adjustment). In this balancing loop the difference between Returns on Long-Term Investments and Expected Returns on Long Term Investment of Loans is smoothed out over the Time to Adjust Expectations. A change in the Time to Adjust Expectations has a direct impact on the smoothing and increases or decreases the time before the information is passed along in the balancing feedback loop B5 (Profitability Correction). As the B3 loop (Investor Returns Adjustment) is influenced by a change in value for Time to Adjust Expectations the B5 loop (Profitability Correction) is influenced by holding off on passing along the information that the profitability levels may be changing. This feedback loops serves to continue to maintain the current level of Relative Attractiveness until the new information is passed serving to continue to increase the acquisition of assets in the Capital Stock. This can lead to a large overshoot in Capital Stock relative to profitable levels of investment. Reinforcing loops R1 (Discard Compensation) and R2 (Investment Adjustment) and balancing loop B1 (Stock Adjustment) continue to feed back into the model the same information to increase or decrease investment and no change is made until the Time to Adjust Expectations has been reached and the impact of the change in Capital Stock is then fed through to the loops via the B5 loop for Profitability Correction.

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The structure described above generates an overshoot due to the behavior of R2 (Investment Adjustment) continuing to reinforce investment decisions until the time that the new information relative to profitability has been delivered by the variable Time to Adjust Expectations. This variable plays a very important role in the model due to the large impact it can have on the investment overshoot developed as a function of variation in this variable. Time to Adjust Expectations represents the time the investing company takes to recognize changes in its business metrics that indicate investments may or may not be profitable relative to market demand corresponding to capacity increases. As discussed above, delays in this information flow allow for the reinforcing loops to continue flowing additional investment capacity into the business apart from the information needed to alert the business that the capacity increase may not be profitable. A faster response time in this case would serve to greatly limit the overshoot in expansion and more closely match capacity to demand.

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2.7 Case 4: Timeframe for Expected Demand

2.7.1 Description of cases run

In the model the variable "Timeframe for Expected Demand" is used to show the timeframe assumptions used by the forecasters at the businesses investing for how long the demand is believed to hold constant. The following cases are explored:

Case	Timeframe For Expected Demand	Demand
4a.	Increase to 6 Month	Increase 30% Month 12
4b.	Increase to 12 Months	Increase 30% Month 12
4c.	Increase to 24 Months	Increase 30% Month 12

Table II-6: Cases for Changes in Timeframe for Expected Demand

The parameter "Actual Demand" is increased by 30% at Month 12 for each of the cases run. This parameter is adjusted to provide a stimulus to the model to illustrate the impact of the changes in "Timeframe for Expected Demand" on the model output.

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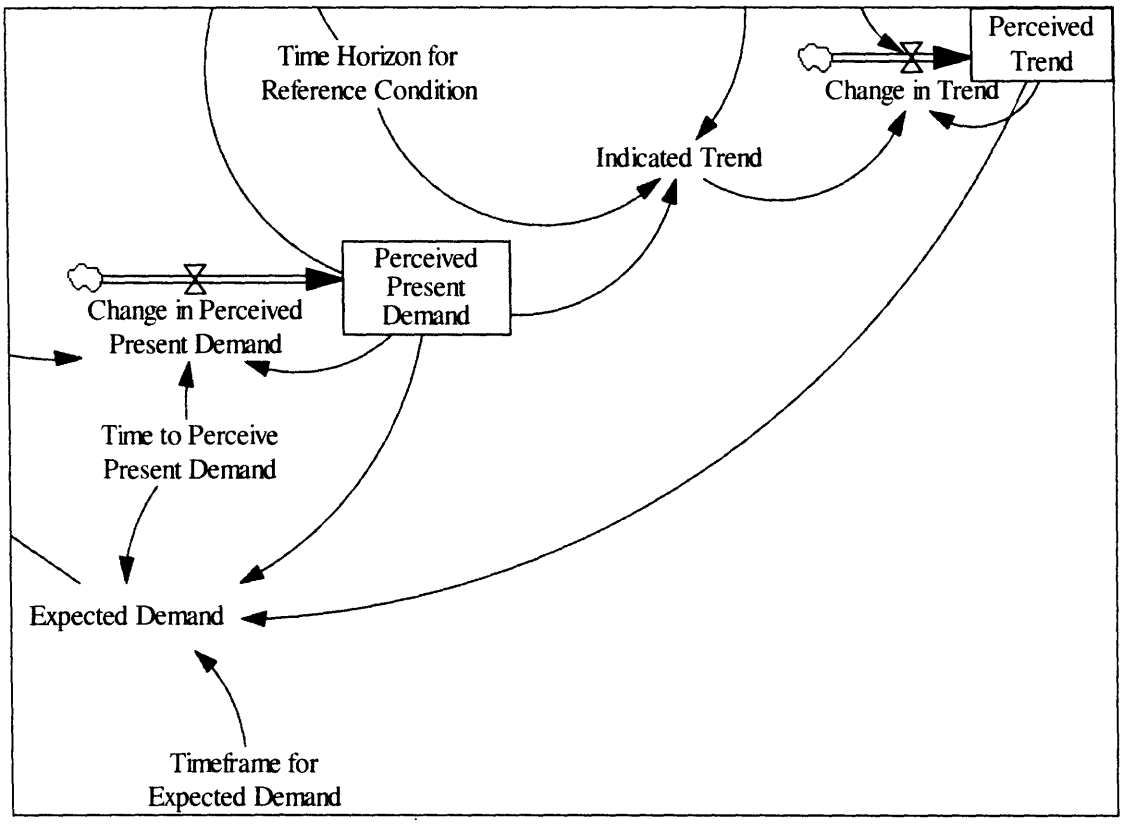

Figure II-22: Model Structure for Timeframe for Expected Demand

The model structure shown above illustrates the role that "Timeframe for Expected Demand" plays in influencing "Expected Demand." The parameter is part of the trend structure discussed earlier and serves to influence the "Expected Demand" resulting from the input "Actual Demand."

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2.7.2 Graphs showing key variables and Description of Behavior

The results of the runs varying the demand are shown in the figures below.

"Capital Stock" shows the results of the build-up of capital used to invest in long-term investments. Cases 4a, 4b and 4c illustrate the impact changes of varying the timeframe parameter from 6 Months to 24 Months. It can be seen from the graph that the magnitude of the peak value of capital stock varies by more than 100%.

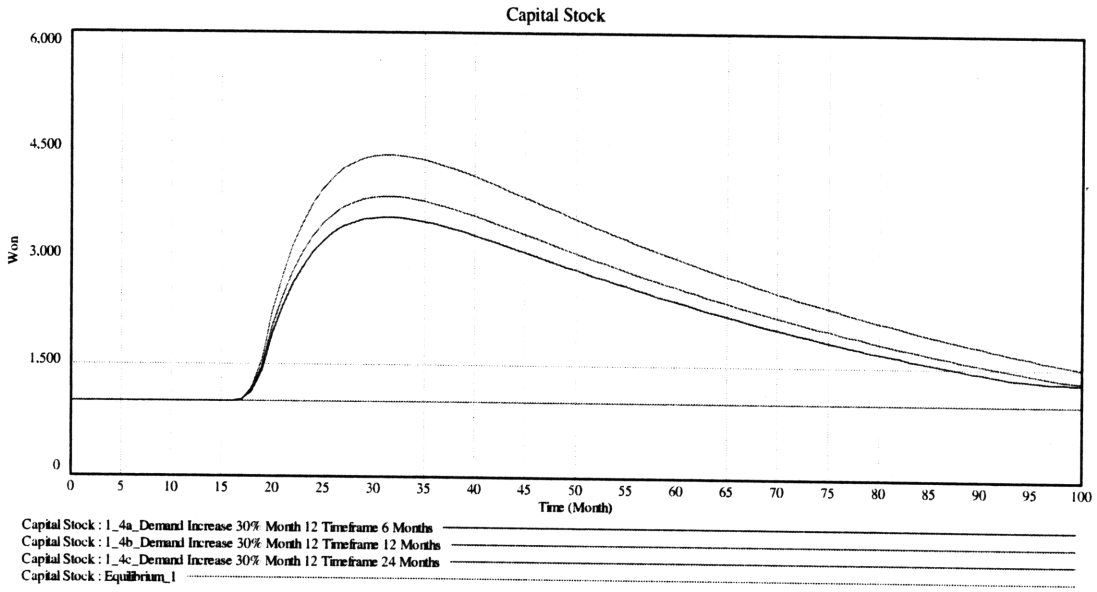

Figure II-23: Capital Stock Model Results for Changes in Timeframe for Expected Demand

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The variable "Forecasted Income" uses the "Expected Demand" information to set expectations for future returns used in the investment decision structure of the model. It can be seen from the "Forecasted Income" graph that the longer the time horizon for expected demand the higher the overshoot in expected income, with the peak value realized at the largest time horizon value of 24 Months.

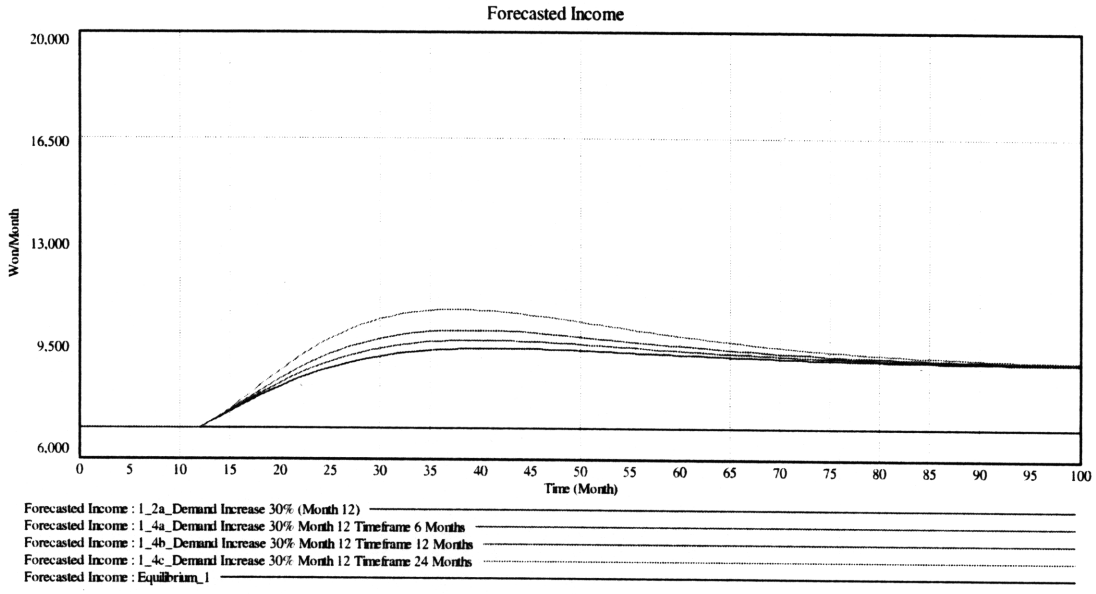

Figure II-24: Forecasted Income Model Results for Changes in Timeframe for Expected Demand

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2.8 Case 5: Combinations

2.8.1 Description of cases run

For this final case, several parameters are varied simultaneously to determine the impact on the model output. These combination scenarios will serve to provide insight into the dynamic behavior of the model and the interactions that varying several parameters at once has on the output of the model. "Commercial Paper," "Demand," "Time to Adjust Expectations," and "Timeframe" are all varied slightly to show the differences in impact. The following cases are explored:

Case	CP	Demand	Time Adjust Expectations	Timeframe
5	Decrease 50% Month 12	Increase 30% Month 12	N/A	N/A
5a.	Decrease 50% Month 12	Increase 30% Month 12	6	N/A
5b.	Decrease 50% Month 12	Increase 30% Month 12	12	N/A
5c.	Decrease 50% Month 12	Increase 30% Month 12	N/A	6
5d.	Decrease 50% Month 12	Increase 30% Month 12	N/A	12

Table II-7: Cases for Combination Changes to Parameters

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2.8.2 Graphs showing key variables and Description of Behavior

The results of the runs varying the demand are shown in the figures below.

"Capital Stock" shows the results of the build-up of capital used to invest in long-term investments. The first of the 5 cases depicted is the "Baseline" case where CP and Demand are varied by –50% and +30% respectively with all other parameters held constant. Cases 5a – 5d all build off of the baseline case and vary only by changes in the "Time to Adjust Expectations" parameter and "Timeframe" parameter. Six and 12 Month cases are used to show the comparative differences vary each of the time parameters. The graph for "Capital Stock" shows the difference in magnitude of the capital stock build-up for each of the scenarios. It can be seen that the greatest change in magnitude is a function of the "Time to Adjust Expectations" parameter, with values up to 5 times greater than "Baseline" and "Timeframe" scenarios.

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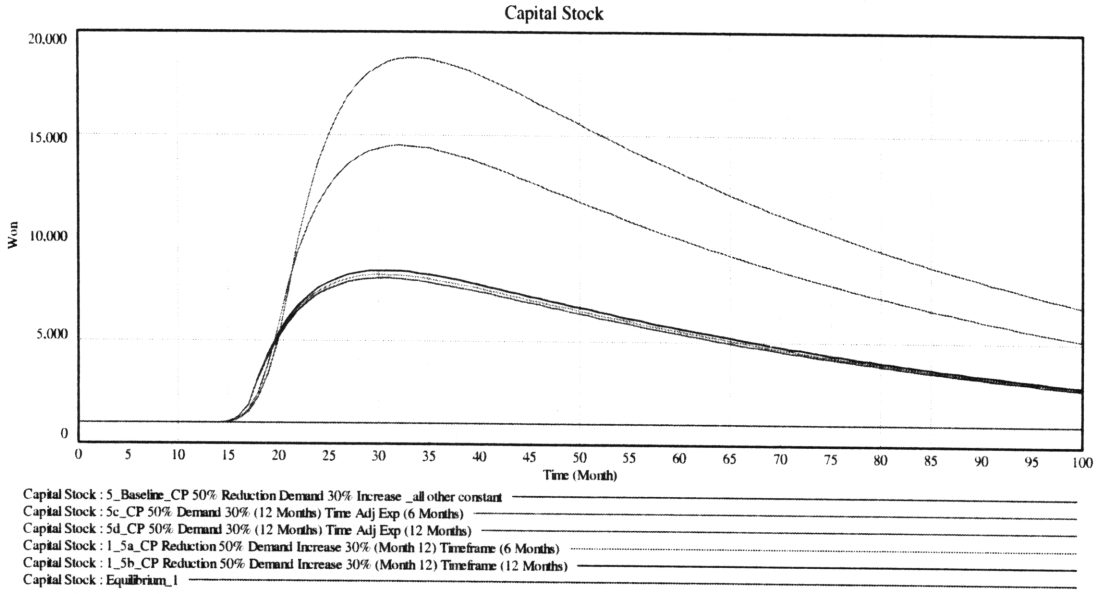

Figure II-25: Capital Stock Model Results for Combination Changes

2.8.3 Feedback Structure Influencing Model Behavior

In cases 5a – 5d the cost of Commercial Paper and the level of Demand are varied by the same amount with the only differences being that in cases 5a and 5b Time to Adjust Expectations are adjusted and in cased 5c and 5d the Timeframe for Expected Demand is adjusted. In each of these cases the loop that most strongly influences the model behavior is balancing loop B5 (Profitability Correction). The strongest feedback is shown by loop B5 because it provides the information feedback to changes in the Capital Stock which then influences the Relative Attractiveness variable leading to an adjustment in loops R1 (Discard Compensation) and R2 (Investment Adjustment) and B1 (Stock Adjustment). The behavior of the model, relative to the capital stock value, is influenced to a lesser extent by the Demand and Production portion of the model

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balancing loops B9 (Perception), B10 (Reference) and B11 (Trends). These loops, as described in section 2.5.3 reviewing the impact of these balancing loops on the expected demand, serve to provide margin to the actual demand and provide and overshoot in Capital Stock adjustment relative to the actual demand levels.

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Part III – Results and Conclusions

3.1 Results

3.1.1 Review of linkage between policy decisions for liberalization of interest rates to investment decisions.

The five cases reviewed in the analysis section serve to illustrate the predictions that the model makes based upon various changes in parameters. The model is intended to depict the economic environment in South Korea leading up to the 1997 financial crisis. The policy decisions that were implemented several years before the crisis helped in setting the stage for the collapse. This model focused on one of the crisis drivers, liberalization of interest rates, with an emphasis on the asymmetric liberalization of commercial paper rates. Commercial paper was liberalized in advance of other rates leading to a shift in investment behavior to try to capture the benefits of the readily available affordable source of financing investments. This policy action helped lead to a debt-financed bubble in assets that became unprofitable when it was not aligned with demand for the product.

Liberalization:

In all cases explored in the model a policy decision leading to a step change in interest rates drives a run-up in investment into long-term projects with expected high returns that look lucrative with very low costs of financing. The behavior depicted in the model shows a bubble run-up in the acquisition of assets that drops off precipitously once the capacity is not profitable and matched by

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demand. This behavior is reflective of the actual investing behavior seen in South Korea.

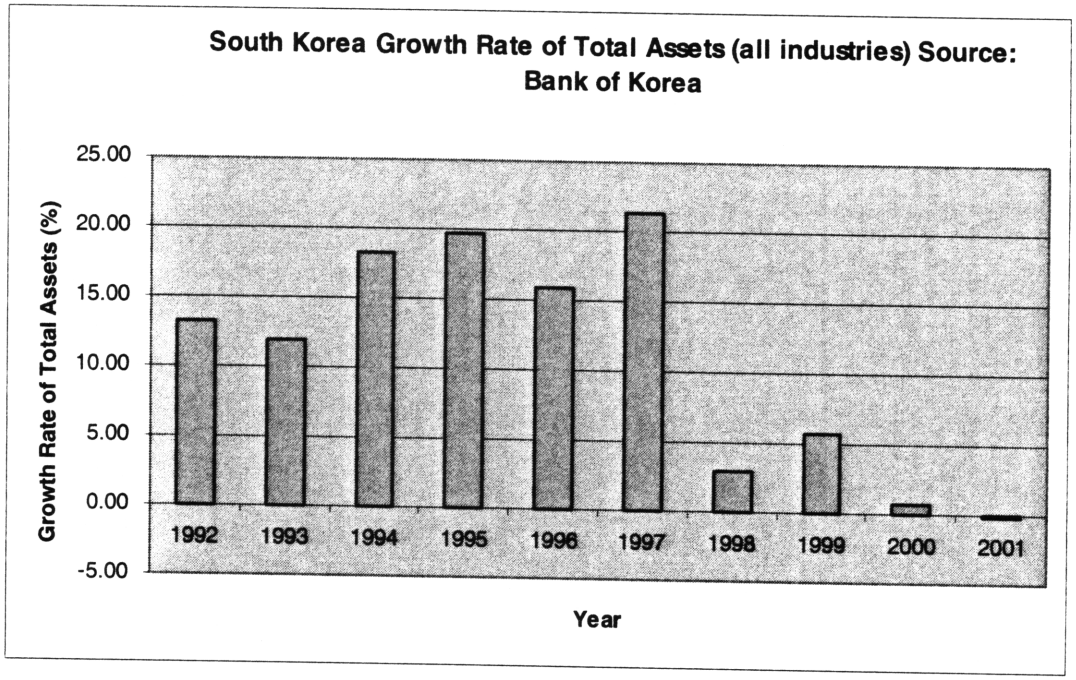

Figure III-1: South Korean Growth Rate of Total Assets (1992-2001)

The figure above shows the actual growth rate of total assets by all industries in South Korea during the build-up to the crisis (early 1990's) and immediately following the crisis (crisis and accelerated by late 1997). The story this chart shows is one of double-digit growth expansion of assets followed by a sharp contraction in growth immediately following the crisis. From 1992 to 1997 assets grew to more than 2.5 times their original value in 1992.

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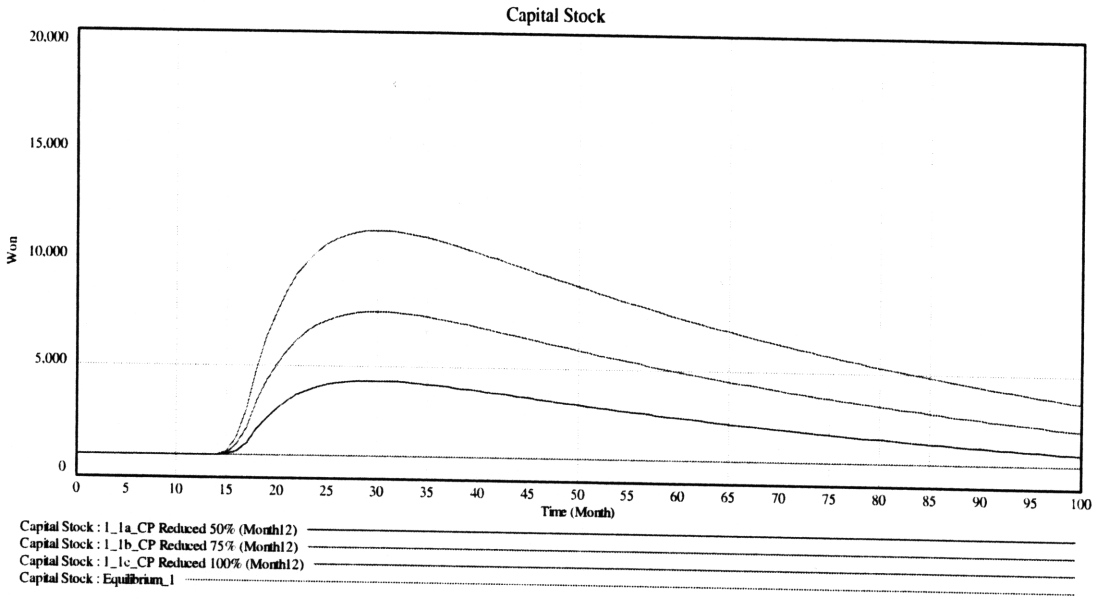

Figure III-2: Capital Stock Model Results for Changes in CP Rates

The "Capital Stock" graph shows the model results for reducing the cost of commercial paper by 50%, 75% and 100%. The model shows a similar behavior with a 50% reduction in the cost of commercial paper there is almost a 4 times increase in capacity at peak. The model structure does not incorporate a feedback loop for bankruptcies so the drop off in assets takes longer. Future modeling effort may include this feedback structure.

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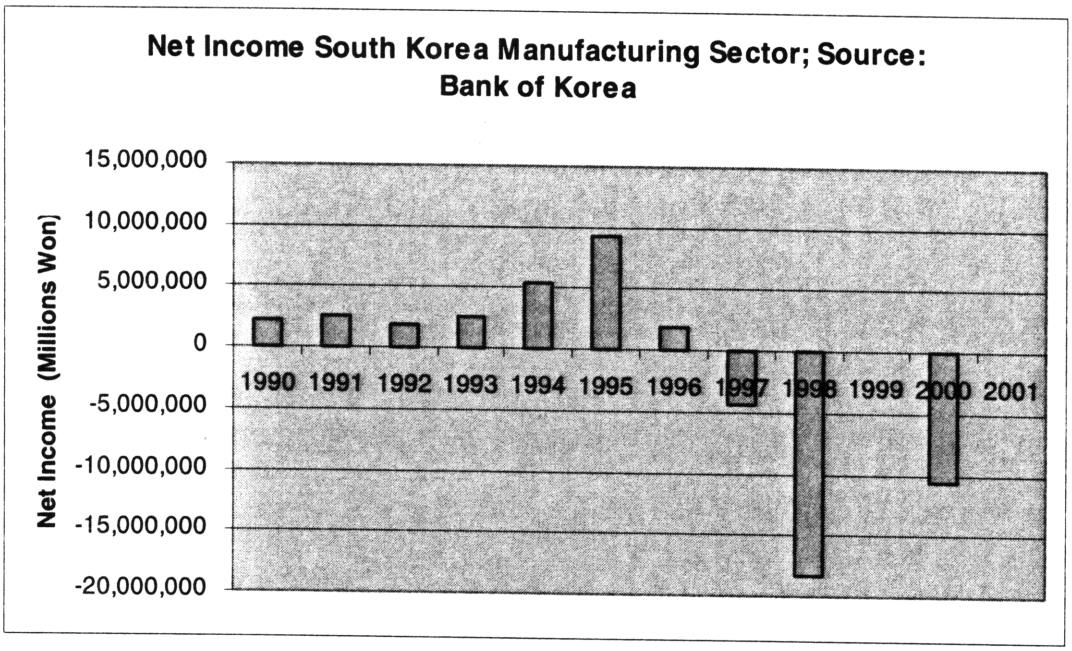

Figure III-3: Net Income of South Korea's Manufacturing Sector 1990-2001

The graph above shows Net Income for the manufacturing sector in South Korea for the same timeframe. The story of build-up in income this chart tells is consistent with the model behavior showing an increase in income when capacity is added to match demand, and a drop in income when there is overcapacity that is underutilized. In the graph shown above, net income is increasing and peaking out in 1995 to a value of 3.5 times early 1990 levels. Immediately before the crash net income drops precipitously and then losses begin to accrue hitting a major trough the year after the crisis started.

There are several key takeaways from the story told by the net income graph. First, net income peaked two years before the crisis even hit. In 1996, more than a year before the financial crisis began net income dropped off drastically from its 1995 peak levels. This takeaway would indicate that the financial environment in South Korea was changing before the external drivers of the East Asian crisis

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had a chance to make an impact. For income to drop between 1995 and 1996 as drastically as it did, there would have to have been another driver.

The modeling effort completed in this research provides insight into what the potential driver was; likely overexpansion that was out of check with actual demand. The fact that income increased by more than 3.5 times from the start of liberalization shows that there was demand available for products. As new capacity was brought on line the demand was met and income was increased. However, capacity was over expanded and soon after 1995 demand either was met or dropped off leaving too much capacity with too little demand to sustain the previous levels of income growth. Additionally, the capacity was brought online using debt financing.

To illustrate the point that the potential driver of the drop in net income shown in Figure III-3 was likely overexpansion Figures III-4 and III-5 generated by the model are reviewed.

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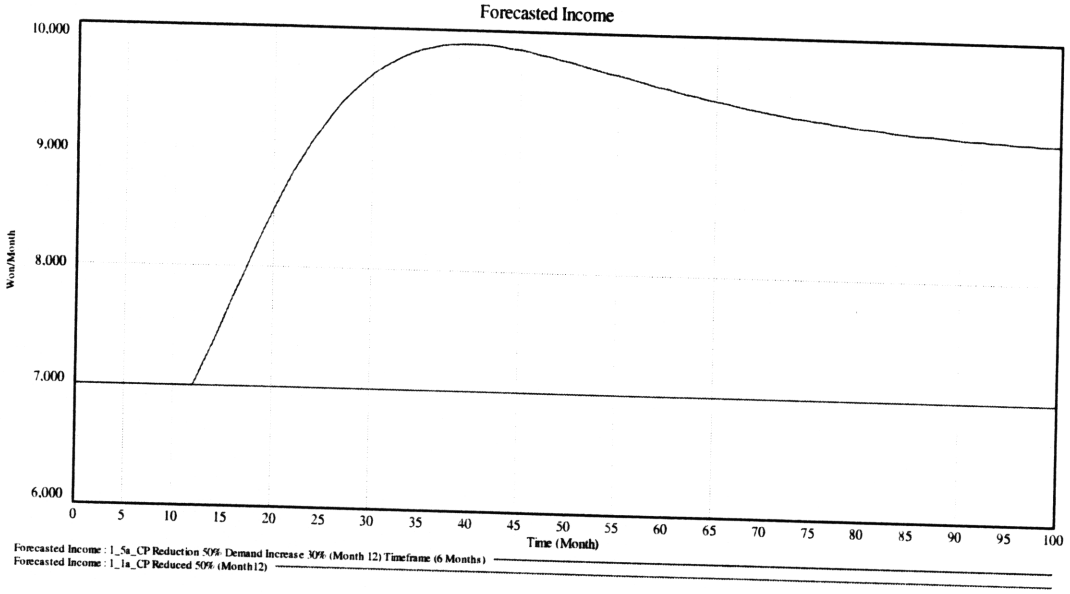

Figure III-4: Forecast Income Comparison Demand Comparison

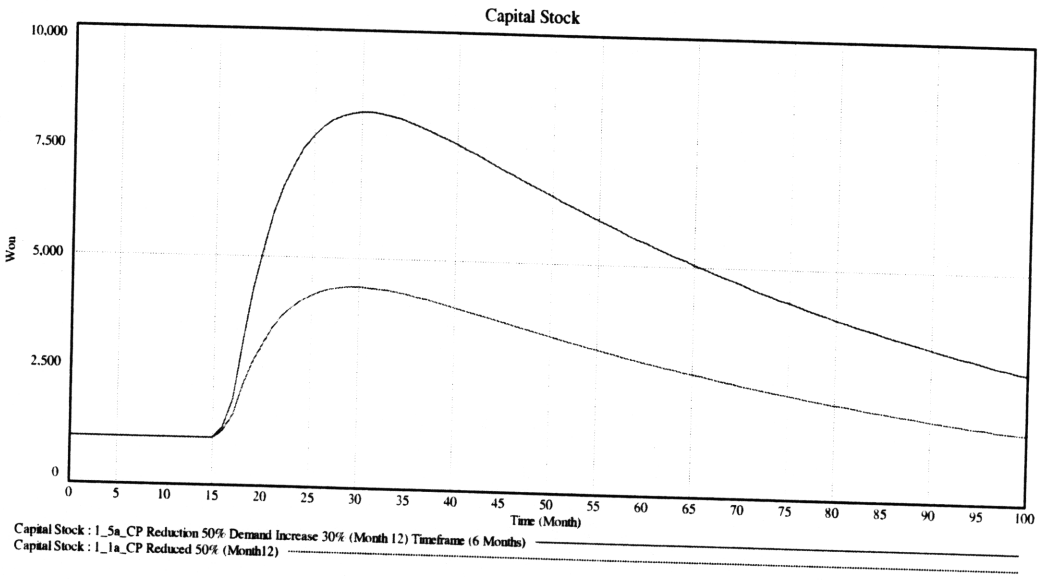

Figure III-5: Capital Stock Demand Comparison

Figures III-4 and III-5 below provide a comparison of model behavior for a decrease in the cost of Commercial Paper with Demand held constant and with Demand increased. Figure III-4 shows the models predicted forecast income

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and shows that with an increase in demand coupled with an increase in assets that can be used to meet the production demand the forecasted income increases. The second case illustrated on the figure shows the case where assets are increased apart from and increase in demand. The model shows that forecast income stays constant with no additional income realized due to the increase in capacity because the demand is not there for the product. For the purposes of the modeling in this research the feedback structure to adjust forecasted income for non-utilized capacity is not included, therefore the forecasted income stays constant. Future work could include incorporating this structure, and would show that the forecasted income would dip as more capacity is brought online that is not used to meet demand. Figure III-5 provides insight into the Capital Stock and shows an increase in capital stock for both cases where demand is held constant and demand is increased. Coupling together Figures III-4 and III-5 it can be seen that when capacity is increased apart from a change in demand there is no positive impact on income. Depending on the magnitude of the capacity expansion the coupling of increased capacity with lack of demand can lead to reductions in income. Future modeling efforts would provide insight into the feedback structure to show the negative income effect, however, the point is made that the asset procurement needs to be coupled with demand in order to maintain profitability levels.

The graphs below provide insight into the debt driven asset build-up during the early 1990's in South Korean.

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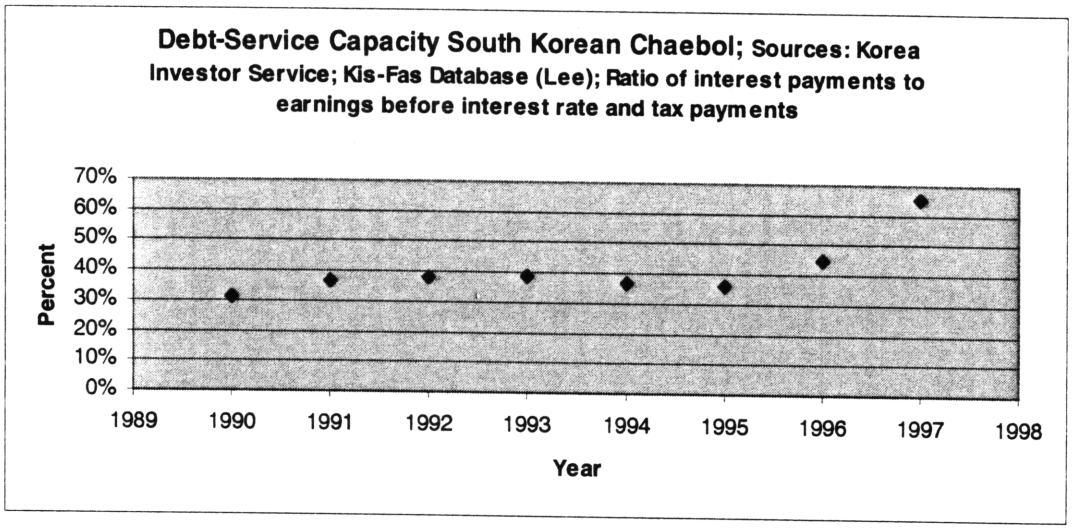

Figure III-6: Debt Service Capacity of South Korean Chaebol (1989-1998)[18]

The "Debt-Service Capacity South Korean Chaebol" graph shows that debt service (defined as the ratio of interest payments to earnings before interest rate and tax payments) grew steadily during the early 1990's spiking in growth in 1996 and 1997 ending in over 60%. This graph provides insight into the run-up in debt and the impact on the business – percentage wise a large portion of proceeds had to be channeled to paying for debt, more than doubling in percentage over seven years. This data serves to further corroborate the result of the model analysis showing that debt was used to accrue assets creating a bubble that was out of check with demand and income flow for the products, leading to an unprofitable situation.

[18] Cho, Yoon Je. Edited by Chung H. Lee. "Financial Liberalization and the Economic Crisis in Asia." Routledge Curzon, Taylor & Francis Group. The European Institute of Japanese Studies, Sockholm School of Economics 2003.

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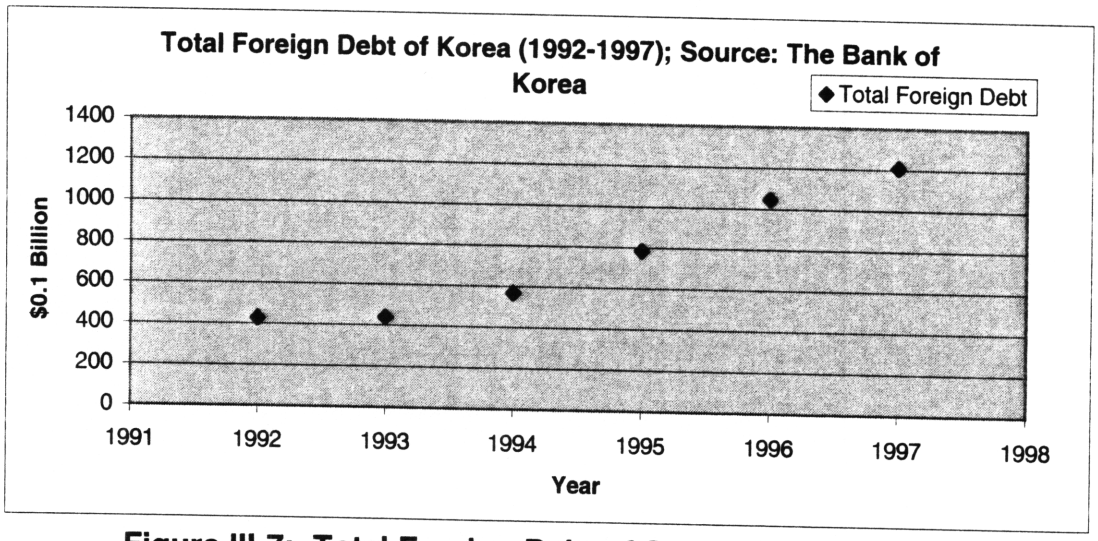

Figure III-7: Total Foreign Debt of South Korea (1992-1997)

The graph "Total Foreign Debt of South Korea" shows the rapid increase in foreign debt taken on by South Korea after the interest rate liberalization was introduced. This graph shows that foreign debt exposure increased by a factor of 300% in less than 5 years. This graph helps to show the impact of liberalization and corroborates the models prediction of a run-up in commercial paper debt (from foreign sources) as a result of interest rate liberalization.

With debt financing the businesses involved must repay their loans on their assets regardless of the demand being there to support their expansion efforts and make their investments profitable. For years the South Korean economy has functioned without trouble using debt financing for expansion by the chaebol to grow business into new fields. There were two things that were different this time.

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First, a significant portion of the debt now came from foreign creditors, creditors that the South Korean government did not have influence over and could not influence to forgive loans or change terms as they could influence domestic lenders traditionally. Traditionally the government had been able to step in to help businesses when they reached near bankruptcy, and because credit had been traditionally from domestic sources the magnitudes of the overruns were limited and manageable within the domestic sphere under the historical regulatory regime. The bubble realized during the South Korean financial crisis was larger in magnitude this time because new sources of funding had recently been opened up with the liberalization efforts and opening of foreign capital markets shifted the ceiling on the amount of debt that could be accrued. Second, the debt accrued was from short-term sources requiring that it be paid back quickly over a short period of time. Paying back short-term credit is not a problem if you have the capital on-hand to pay it or if you have a readily available stream of new credit to rollover your old credit with. When the 1997 financial crisis hit credit markets dried up and businesses were not able to immediately roll-over old debt and did not have the cash on-hand to pay off the loans. Businesses began to go bankrupt, and a vicious cycle of new losses began.

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Time to Adjust Forecasted Expectations:

A second key take away from the model analysis is the insight provided into the impact of reaction time to adjust forecasted expectations. The model shows that the magnitude of the peak value of the bubble reached is directly related to the time taken to integrate the information that the profits will not be realized on the new capacity given that demand has not increased correspondingly. This insight is particularly powerful because it provides a glimpse at the incredible build-up in capital that can occur due to a delay in processing information. The takeaway from this finding is that keeping leading indicator metrics in place and monitoring them to determine the validity of past forecasts can be crucial to avoiding costly investment mistakes.

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3.2 Conclusions & Recommendations

In conclusion this model it has been shown that when investors behave according to the assumed investment decision rules of the model the external economic policies can interact with the investor behavior in a manner resulting in very unfavorable results. In the case of the South Korean crisis in the model it is assumed that the liberalization policy decision drove investors to fund long-term investment projects using short-term commercial paper. The modeling in this research provides insight into the magnitude of the investment in debt-financed long-term projects. The model assumes these investment decisions were not driven by demand or other factors that indicated that the capacity would be profitable; instead they were driven by the lucrative gap between the highly affordable credit and the forecast long-term returns leading to the expectation of future gains.

Liberalization policy decisions can lead to high-risk financial behavior that if left unchecked can lead the economy as a whole into a financial situation that allows the nation to become unstable. In the case of South Korea the nation's businesses became highly leveraged using short-term debt, and they were dependent on the short-term debt to stay solvent. This left the nation in a high-risk area economically as was seen when the 1997 financial crisis began when foreign markets stopped the flow of available credit. The nation was not able to function in the short-term because the businesses were so highly leveraged

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using short-term credit. In the case of South Korea the nation had to turn to an international lender of last resort, the International Monetary Fund, for assistance.

Valuable lessons can be learned from the crisis and from the insights gained from the modeling in this research. The most poignant takeaway is that all policy decisions should be planned and implemented strategically and monitored closely. The asymmetric liberalization policy implemented in South Korea drove investment behavior into a risky territory for the nation and left the country vulnerable in the face of foreign market turmoil. The modeling provides insight into the value of reacting in a timely manner when investment behavior becomes out of check with profitability metrics. A matter of months in reaction time can have a significant impact of the size of the bubble. In conclusion, liberalization policies helped to set the stage for the South Korean financial crisis. Ultimately it is up to the governments entrusted with safeguarding the economic systems of nations to understand the impacts of economic policy decisions on the nations' economies. The modeling in this research helps provide insight into the powerful feedback loops that drove an asset bubble and lack of profitability based on liberalization policies. Future modeling should be conducted to exercise and understand the impact of policy decisions and help ensure that the resulting behavior will be stable and achieve the desired outcome, and not push the economy into a high risk area that can easily end in crisis.

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3.3 Future work

Future work that might be completed would explore expanding the boundaries of the model in several manners. The model currently is scoped to focus on the build-up to the crisis with emphasis on structure that allows the user to implement policy decisions relative to interest rate deregulation.

3.3.1 Adding debt financing structure to the model

One of the first places the model could be expanded is by adding structure that shows the impact of debt financing. Structure could be added showing the repayment of loans over time funded by sources varying from income, to new debt, the selling of assets. This structure could be utilized to show the impact of cutting off access to new debt to roll over old debt. This structure would aid in showing the onset of the financial crisis and the impact on the economy of cutting off access to short-term debt when businesses were highly leveraged by short-term debt. This structure would be useful to exercise to show the impact of cutting off access to short-term debt for varying periods of time, reflecting the urgency of providing bailout funds to a debt driven economy in times of crisis. The impact could range from a short-term drop to a massive fall-out of bankruptcies.

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3.3.2 **Adding structure showing relationship to show social indicators**

The model could also be expanded to show the impact on social indicators as a function of policy decisions. For example job growth and loss could be added to the model linked to the build-up in decrease in assets. An indicator for inflation and deflation could be added to the model as well to help show the impact of policy decisions on prices. Additionally, structure could be added to the model showing the gini coefficient and providing insight into the distribution of wealth within the economy, another useful social indicator.

3.3.3 Adding prices growth to the model

Currently the model assumes fixed prices for products. Adding structure to the model to show changes in price and relationship of price to supply and demand would serve to provide additional insight into the economic environment.

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Appendix A: Model Equations:

(01) Acquisition Rate=
Capital on Order/Time to fill order
Units: Won/Month

(02) Actual Demand=
Initial Demand+Step Change in Demand
Units: Units/Month
This variable represents the actual level of demand that is
expressed by consumers of the inventory.

(03) Average life of capital=
60
Units: Month

(04) Capacity Utilization= INTEG (
Change in capacity utilization,
1)
Units: Dmnl

(05) Capital on Order= INTEG (
Order Rate-Acquisition Rate,
100)
Units: Won
This variable represents the back-log of orders for additional
capital.

(06) Capital Stock= INTEG (
Acquisition Rate-Discard Rate+Pulse Change,
1000)
Units: Won
This variable represents the stock of capital. As capital is
acquired or expended to invest in assets this stock changes
to
represent the build-up or run-off in assets.

(07) Capital Stock Adjustment=
(Desired Capital-Capital Stock)/Time to adjust capital
Units: Won/Month

(08) Change in capacity utilization =
(Indicated Capacity Utilization-Capacity Utilization)/t 0
Units: Dmnl/Month
Structure to show the expected capacity utilization

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(09) Change in Expected cost of CP=
(Cost of CP-Expected Costs of CP)/Time to Adjust Cost of CP
Units: Dmnl/(Month*Month)

(10) Change in expected income=
(Income-Expected Income)/Time to adjust expected income
Units: Won/(Month*Month)

(11) Change in Expected return on Corporate Bonds and Bank Loans=
(Returns on Corporate Bonds and Bank Loans-Expected returns Corporate Bonds and Bank Loans
)/Time to Adjust Return on Corporate Bonds and Bank Loans
Units: Dmnl/(Month*Month)

(12) "Change in Expected return on long-term loans"=
(Return on long term investment-"Expected returns on long-term investment of loans"
)/"Time to Adjust Expectations for Return on Long-Run Investments"
Units: Dmnl/(Month*Month)

(13) Change in Perceived Present Demand=
(Actual Demand-Perceived Present Demand)/Time to Perceive Present Demand
Units: Units/(Month*Month)

(14) Change in Reference Demand=
(Perceived Present Demand-Reference Demand)/Time Horizon for Reference Condition
Units: Units/(Month*Month)

(15) Change in Trend=
(Indicated Trend-Perceived Trend)/Time Horizon Change in Trend
Units: 1/(Month*Month)

(16) Cost of CP=
Initial Cost of CP+Step Change in CP
Units: Dmnl/Month

(17) Demand Step Height=
0
Units: Units/Month
-50

(18) Demand Step Time=
12

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Units: Month

(19) Desired Capital=
Capital Stock*(Effect of relative attractiveness on desired capacity)
Units: Won

(20) Desired Inventory=
Expected Demand*Desired Inventory Coverage
Units: Units
This variable represents the desired level of inventory.

(21) Desired Inventory Coverage=
6
Units: Month
This variable represents the desired number of months to have inventory on hand to cover desired inventory.

(22) Desired Production=
max(0,Expected Demand+Production Adjustment for Inventory)
Units: Units/Month

(23) Discard Rate=
Capital Stock/Average life of capital
Units: Won/Month

(24) Effect of relative attractiveness on desired capacity=
Table for effect of expected profit on desired capacity(Relative Attractiveness
)
Units: Dmnl

(25) Expected Costs of CP= INTEG (
Change in Expected cost of CP,
Cost of CP)
Units: Dmnl/Month
This stock represents the expected costs of commercial paper.

(26) Expected Demand=
Perceived Present Demand*(1+Perceived Trend*(Timeframe for Expected Demand
+Time to Perceive Present Demand))
Units: Units/Month
This variable represents the expected demand level.

(27) Expected Income= INTEG (
Change in expected income,

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Income)
Units: Won/Month

(28) Expected Profitability of Corporate Bonds and Bank Loans=
Expected returns Corporate Bonds and Bank Loans
Units: Dmnl/Month

(29) Expected profitability of new investment=
("Expected returns on long-term investment of loans"-Expected Costs of CP
)
Units: Dmnl/Month

(30) Expected returns Corporate Bonds and Bank Loans= INTEG (
Change in Expected return on Corporate Bonds and Bank Loans,
Returns on Corporate Bonds and Bank Loans)
Units: Dmnl/Month
This stock represents the level of expected returns on corporate bonds and banks loans.

(31) "Expected returns on long-term investment of loans"= INTEG (
"Change in Expected return on long-term loans",
Return on long term investment)
Units: Dmnl/Month
This stock represents the expected returns on long-term investment of loans.

(32) FINAL TIME = 100
Units: Month
The final time for the simulation.

(33) Forecasted Income=
Expected Demand*Unit Price
Units: Won/Month

(34) Income=
Unit Price*Shipments
Units: Won/Month

(35) Indicated Capacity Utilization =
Table for Effect of Demand on Capacity Utilization(Desired Production/Production Capacity
)
Units: Dmnl

(36) Indicated Trend=

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((Perceived Present Demand-Reference Demand)/Reference Demand)/Time Horizon for Reference Condition
Units: 1/Month
Indicated trend in the input.

(37) Initial Cost of CP=
4
Units: Dmnl/Month

(38) Initial Demand=
700
Units: Units/Month

(39) INITIAL TIME = 0
Units: Month
The initial time for the simulation.

(40) Inventory= INTEG (
Production-Shipments,
Desired Inventory)
Units: Units
This variable represents the inventory that is currently being carried.

(41) Max Ship Rate=
Inventory/Min Time to Ship
Units: Units/Month
This variable represents the maximum ship rate and is limited by the inventory and minimum time to ship.

(42) Min Time to Ship=
1
Units: Month
This variable represents the minimum time needed to ship inventory.

(43) Order Rate=
max(0,Capital Stock Adjustment+Discard Rate)
Units: Won/Month

(44) Perceived Present Demand= INTEG (
Change in Perceived Present Demand,
Actual Demand)
Units: Units/Month

(45) Perceived Trend= INTEG (

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Change in Trend,
Indicated Trend)
Units: 1/Month
Perceived fractional growth rate of the input variable.

(46) Production=
Production Capacity*Capacity Utilization
Units: Units/Month
This variable represents the production levels that are set by the institutions.

(47) Production Adjustment for Inventory=
(Desired Inventory-Inventory)/Time to Adjust Inventory
Units: Units/Month
This variable represents the ajdustment made to production based on the level of inventory that is being carried.

(48) Production Capacity=
Capital Stock*Productivity
Units: Units/Month
This variable represents the ability of the institutions to produce additional inventory and is a funcation of the productivitiy and capital stock.

(49) Productivity=
0.7
Units: Units/Won/Month

(50) Pulse Change=
PULSE(Pulse Start, TIME STEP)*Pulse Height/TIME STEP
Units: Won/Month

(51) Pulse Height=
0
Units: Won

(52) Pulse Start=
0
Units: Month

(53) Reference Demand= INTEG (
Change in Reference Demand,
Perceived Present Demand)
Units: Units/Month

(54) Relative Attractiveness=

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Expected profitability of new investment/Expected Profitability of Corporate Bonds and Bank Loans
Units: Dmnl

(55) Return on long term investment=
(Expected Income/Capital Stock)*0+1*(Forecasted Income/Capital Stock)
Units: Dmnl/Month

(56) Returns on Corporate Bonds and Bank Loans=
3
Units: Dmnl/Month

(57) SAVEPER =
TIME STEP
Units: Month [0,?]
The frequency with which output is stored.

(58) Shipments=
min(Actual Demand,Max Ship Rate)
Units: Units/Month
This variable represents the shipments that leave the
institutions serving to reduce the level of inventory.

(59) Step Change in CP=
STEP(Step Height 0, Step Time 0)
Units: Dmnl/Month

(60) Step Change in Demand=
STEP(Demand Step Height, Demand Step Time)
Units: Units/Month

(61) Step Height 0=
0
Units: Dmnl/Month

(62) Step Time 0=
6
Units: Month

(63) t 0=
1
Units: Month

(64) Table for Effect of Demand on Capacity Utilization(
[(-1,0)-(2.5,2)],(-1,0),(0,0),(0.5,0.62),(0.75,0.85),(1,1),(1.25,1.1),(1.5

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,1.17),(1.75,1.22),(2,1.25),(2.25,1.25),(2.5,1.25))
Units: Dmnl

(65) Table for effect of expected profit on desired capacity(
[(0.6,0)-
(2,10)],(0.7,0),(0.75841,0.701754),(0.8,1),(0.9,1),(1,1),(1.1,1)
,(1.16514,1.44737),(1.3107,2.7193),(2,10))
Units: Dmnl

(66) Time Horizon Change in Trend=
12
Units: Month

(67) Time Horizon for Reference Condition=
12
Units: Month

(68) TIME STEP = 1
Units: Month [0,?]
The time step for the simulation.

(69) Time to adjust capital=
1
Units: Month

(70) Time to Adjust Cost of CP=
6
Units: Month

(71) "Time to Adjust Expectations for Return on Long-Run Investments"=
1
Units: Month

(72) Time to adjust expected income=
12
Units: Month

(73) Time to Adjust Inventory=
1
Units: Month

(74) Time to Adjust Return on Corporate Bonds and Bank Loans=
6
Units: Month

(75) Time to fill order=

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6
Units: Month

(76) Time to Perceive Present Demand=
12
Units: Month

(77) Timeframe for Expected Demand=
1
Units: Month

(78) Unit Price=
10
Units: Won/Units

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