

Dissertation

Inventories, Monetary Factors, and Propagation of Cycles

Submitted by

Osama Daifalla Sweidan

Department of Economics

In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Spring 2004

UMI Number: 3131702

### INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

**UMI**<sup>®</sup>

---

UMI Microform 3131702

Copyright 2004 by ProQuest Information and Learning Company.

All rights reserved. This microform edition is protected against unauthorized copying under Title 17, United States Code.


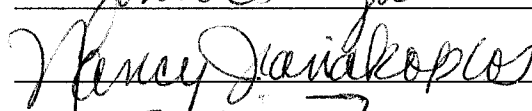

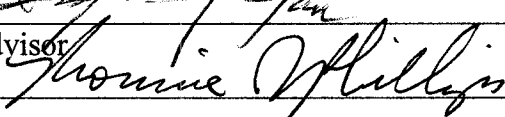
ProQuest Information and Learning Company  
300 North Zeeb Road  
P.O. Box 1346  
Ann Arbor, MI 48106-1346

Colorado State University

November 7, 2003

WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY OSAMA DAIFALLA SWEIDAN ENTITLED "INVENTORIES, MONETARY FACTORS, AND PROPAGATION OF CYCLES" BE ACCEPTED AS FULFILLING IN PART REQUIRMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Committee on Graduate Work

  
\_\_\_\_\_  
John Orlin  
\_\_\_\_\_  
  
\_\_\_\_\_  
Nancy Javakopis  
\_\_\_\_\_  
  
\_\_\_\_\_  
Jeffrey Fan  
\_\_\_\_\_  
Advisor  
  
\_\_\_\_\_  
Ronnie Phillips

Department Head

## ABSTRACT OF DISSERTATION

### INVENTORIES, MONETARY FACTORS, AND PROPAGATION OF CYCLES

A literature review of inventory research showed that there is a disagreement among economists about the relation between inventories and certain macroeconomic variables such as interest rate and prices. The differences in the results among the economists are mainly related to how to investigate this relation or which model to use to study this phenomenon, which is linked directly to the nature of inventories or the purpose of holding inventories. In addition, many economists agreed that understanding the inventories fluctuations is a necessary condition for understanding the business cycle, but there is no general agreement on how inventories propagate the business cycle. The goal of this dissertation is to focus on the macroeconomic level of inventories: specifically, to try to investigate empirically the relation between inventories and both interest rate and price and to study the role of inventories in the propagation of the business cycle.

To achieve the abovementioned objectives, this study employed the cointegration analysis to investigate short-run dynamic relationships among the variables. Moreover, this dissertation utilized both the IS-LM model and the aggregate demand-supply model to illustrate how inventories change in the economy as a result of the reaction to macroeconomic variables and how the change in

inventories, as a feedback, affects those macroeconomic variables, which implies that change in inventories represents a destabilization factor on the macroeconomic level. Furthermore, this theoretical representation was useful in expanding the analysis to show how both the fiscal and monetary policies affect inventories. This dissertation used both aggregated and disaggregated quarterly data from the U.S. economy from the period 1959-1997.

The findings of this dissertation showed that the role of inventories in the monetary transmission is weak on both the aggregate and disaggregate levels. This weak relation is explained in three ways. First, the relation between inventories and interest is determined through a transitive relation between interest rate and both real gross domestic product (RGDP) and real final sales (RFS). Second, other components of money such as inside money have a more significant impact on inventories than the outside money and interest rate. Third, some kinds of inventories such as manufacturing inventories have a positive relation with the interest rate.

The results showed that the relation between inventories and prices is negative but weak because it is indirect relation. The strength of this relation relies mainly on how each variable changes in the economy. And I believe to identify stronger relations between inventories and prices, we need to use higher frequency data or annual data.

This dissertation showed on both the aggregate and disaggregate levels that the change of inventories depends mainly on the relation between RGDP and RFS. The empirical results showed that there is a positive relation between inventories and

both RGDP and RFS over the business cycle. The results also confirmed that in the very short-run the direct relation between RFS and inventories is negative.

The role of increase in inventories in the propagation of business cycle in response to a policy action signals more confidence in the economy because of lower interest rate and lower prices accompanied by higher consumption and investment. Therefore, this dissertation showed that increase in inventories is not only able to decrease the aggregate supply because of decreasing the demand for labor, but also is able to increase the aggregate demand. This means there will continue to be changes in the prices and the interest rate which will make the fluctuation faster.

Osama Daifalla Sweidan  
Department of Economics  
Colorado State University  
Fort Collins, CO, 80523,  
Spring 2004

## Acknowledgements

This work would not have been made possible without the combined efforts of many individuals.

First, I would like to express my gratitude to all the faculty members in the Department of Economics at Colorado State University whom I learned a lot from.

Next, I am deeply thankful to Dr. Liang-Shing Fan, my advisor, for his valuable assistance, guidance, support. I do appreciate his knowledge and touch on this work. With out his encouragement, comments through out this work, this research could have not been done.

Many thanks go to my committee members Dr. Nancy Jianakoplos, Dr. David Mushinski, and Dr. John Olienyk for their useful feedback, comments, and suggestions which enriched this dissertation.

I am grateful to my family who have always been right behind me in achieving all my endeavors. Dad, Mom, my brother; Faris and my sisters; Demah, Najwa, Khawlah and their husbands, thanks for your love, support and encouragement.

Finally, I would like to express my sincere appreciation to my friend Benjamin Widner for his great help which makes my residency in Fort Collins smooth and easy, thank you Benno.

## Table of Contents

	Page
<b>Chapter One Introduction</b>	1
1:1 Introduction	1
1:2 The Statement of the Problem	5
1:3 The Importance of the Study	12
1:4 The Purpose of the Study	16
1:5 The Methodology	18
1:5:1 The VAR Model and Inventories Studies	21
1:6 The Data Used in the Model	22
1:7 The Source of Data	24
1:8 Organization of the Study	25
1:9 Conclusion	26
<b>Chapter Two Literature Review</b>	29
2:1 Introduction	29
2:2 General Overview	30
2:2:1 Using the VAR Model in the Inventories Studies	36
2:3 Inventories During the Period 1930-1960	38

2:3:1 Ralph Hawtrey (1930)	38
2:3:2 John Keynes (1930)	38
2:3:3 Wesley Mitchell (1937)	39
2:3:4 Alvin Hansen (1941)	39
2:3:5 Lloyd Metzler (1941)	39
2:3:6 Moses Abramovitz (1950)	41
2:3:6 Holt, Modigliani, Muth and Simon (1960)	42
2:4 Inventory Researches During the Period 1975-2002	43
2:4:1 Louis Maccini (1976)	45
2:4:2 Alan Blinder (1980)	47
2:4:3 Alan Blinder and Stanley Fisher (1981)	49
2:4:4 Laura Rubin (1979)	50
2:4: 5 Charles Lieberman (1980)	51
2:4:6 Owen Irvine (1981a)	52
2:4:7 Patricia Reagan (1982)	53
2:4:8 M.A. Akhtar (1983)	54
2:4:9 Patricia Reagan and Dennis Sheehan (1985)	55
2:4:10 Lawrence Christiano (1988)	56
2:4:11 Valerie Ramey (1989)	57
2:4:12 Giovanna Mossetti (1990)	58
2:4:13 David Bivin (1993)	59
2:4:14 Michael Lovell (1994)	60
2:4:15 Chan Huh (1994) and Andrew Filardo (1995)	62

2:4:16 Donald Allen (1997)	64
2:4:17 Andreas Hornstien (1998)	65
2:4:18 Ana Maria Herrera (2000)	66
2:4:19 Yi Jin (2001)	67
2:4:20 Maurice Larrain (2002)	68
<b>Chapter Three The Methodology</b>	<b>70</b>
3:1 Historical Brief for Using the VAR Model	70
3:2 Introduction to the VAR Technique	74
3:2:1 Nature of the VAR Model	75
3:2:2 The Shocks in the VAR Model	78
3:3 Uses of the VAR Model	80
3:3:1 Granger Causality Tests	80
3:3:2 Impulse Response Function (IRF)	84
3:3:3 Forecast Error Variance Decomposition (FEVD)	86
3:4 Important Issues Related to the VAR Model	87
3:4:1 Ordering of the Variables	87
3:4:2 Lag Lengths	87
3:5 Cointegration and Error Correction Model	88
<b>Chapter Four Empirical Results and Analysis I</b>	
<b>“Aggregate Data”</b>	<b>92</b>
4:1 Introduction	92
4:2 The Data in the Model	94
4:3 Unit Root Test	96
4:4 Applying the VAR Methodology Using Aggregate Data	99

4:4:1 The Estimated Lag Length	99
4:4:2 Johansen's Cointegration Test	101
4:5 Empirical Results and Analysis Using Aggregate Data	104
4:5:1 The Order of the Variables in the Model	104
4:5:2 The Relation Between Money Supply, Interest Rate and Inventories	109
4:5:3 The Relation Between Money Supply, Prices, and Inventories	113
4:5:4 The Relation Between RGDP, RFS and TINV	117
4:6 The Relation Between the Results and the Implication of the Production Smoothing/ Buffer Stock Model	126
4:7 The Propagation Mechanism	128
4:8 Modeling the Results	132
4:9 A Complete Story	141
4:10 Policy Implication	148
4:11 The Difference Between this Model and Blinder's Model	153
4:12 Comparing the Results with other Empirical Studies.	162
<b>Chapter Five Empirical Results and Analysis II</b> <b>"Disaggregate Data"</b>	165
5:1 Introduction	165
5:2 Empirical Results and Analysis Using Disaggregated Data	168
5:2:1 The Relation Between Money Supply, Interest Rate and Inventories	168
5:2:2 The Relation Between the Prices and Inventories	184
5:2:3 The Relation Between RGDP, RFS and Inventories	188
5:2:4 Relation Among the Inventories	194
5:4 The Propagation Mechanism	197

5:5 Separating the Effect of Outside and Inside Money in the Response Model.	208
<b>Chapter Six Summary and Conclusion</b>	214
6:1 Conclusions and Policy Recommendation	214
6:2 Suggestions for Future Research	222
<b>References</b>	225
<b>Appendices</b>	236
List of Tables	xii
List of Figures	xiii

## **List of Tables**

1. Table (1.1) Changes in Real GDP and Real Inventories during the Period 1947-2001.
2. Table (4.1) Augmented Dickey Fuller Test Statistics.
3. Table (4.2) Lag Lengths Estimation.
4. Table (4.3) Johansen's Cointegration Test.
5. Table (4.4) Forecast Error Variance Decomposition from ECM for the order ( $M_2$ , FFR, P, RFS, RGDP, TINV).
6. Table (4.5) Forecast Error Variance Decomposition from ECM for the order ( $M_2$ , FFR, P, RGDP, RFS, TINV).
7. Table (4.6) The Growth Rate of Consumption, Investment, and Price level for the Periods of Increase and Decrease in Inventories.
8. Table (5.1) Lag Lengths Estimation.
9. Table (5.2) Johansen's Cointegration Test.
10. Table (5.3) Forecast Error Variance Decomposition from ECM

## List of Figures

1. Figure (4.1) The Three Series of Prices; CPI, GDP Deflator, and Inventories Deflator.
2. Figure (4.2) The Impulse Response Function from ECM for TINV.
3. Figure (4.3) The Impulse Response Function from ECM for FFR.
4. Figure (4.4) The Impulse Response Function from ECM for  $M_2$ .
5. Figure (4.5) The Impulse Response Function from ECM for P.
6. Figure (4.6) The Impulse Response Function from ECM for RGDP (RFS First).
7. Figure (4.7) The Impulse Response Function from ECM for RFS (RFS First).
8. Figure (4.8) The Impulse Response Function from ECM for RFS (RGDP First).
9. Figure (4.9) The Impulse Response Function from ECM for RGDP (RGDP First).
10. Figure (4.10) The Impulse Response Function from ECM for TINV (RGDP First).
11. Figure (4.11) The Direct and Indirect Channel of Effect of change in FFR on RGDP.
12. Figure (4.12) The Response Model by Using the IS-LM Model.
13. Figure (4.13) The Self Adjustment Mechanism and the Propagation of Business Cycle.

14. Figure (4.14) The Effect of Expansionary Fiscal policy Assuming Change in Interest Sensitivity.
15. Figure (4.15) The Effect of Expansionary Fiscal policy Assuming Change the Multiplier.
16. Figure (4.16) Blinder's Model by Using the Response Model Formatting.
17. Figure (5.1) The Impulse Response Function from ECM for FFR.
18. Figure (5.2) The Impulse Response Function from ECM for MM.
19. Figure (5.3) The Impulse Response Function from ECM for CC.
20. Figure (5.4) The Impulse Response Function from ECM for MINV.
21. Figure (5.5) The Impulse Response Function from ECM for TINV.
22. Figure (5.6) The Impulse Response Function from ECM for NBR.
23. Figure (5.7) The Impulse Response Function from ECM for RINV.
24. Figure (5.8) The Impulse Response Function from ECM for P.
25. Figure (5.9) The Impulse Response Function from ECM for RGDP.
26. Figure (5.10) The Direct Effect of RFS on MINV, RINV and TINV by ordering RGDP first.
27. Figure (5.11) The Relation Among the Inventories; MINV, RINV and TINV.
28. Figure (5.12) The Impact of MM on MINV, RINV and TINV.
29. Figure (5.13) The Effect of MINV, RINV, and TINV on RGDP.
30. Figure (5.14) Extending the Analysis of the Propagation of Business Cycle.
31. Figure (5.15) Outside and Inside Money in the Response Model.

## Chapter One

### Introduction

#### 1:1 Introduction

“If a man from Mars visited this planet and spent a year or so reading all the macroeconomic literature of the past 15-20 years, he would not come away feeling that inventories are of much importance. If we then give him five minutes with the National Income and Product Accounts of the United States, he would quickly conclude that there was something lacking in his education. Inventories are important.” (Blinder, 1990, p.10).

There is no doubt that the inventory investment plays a crucial role in the business cycle. The quarterly data during the period 1947-2001 about the United States economy shows that despite the fact that the change in inventories is a tiny portion of the GDP, averaging roughly 0.51 percent of the real GDP, but the fluctuations in the change in inventory are not small relative to the fluctuations in the GDP. The same data shows that the volatility of the change in inventory as a percentage of the GDP, on average, is roughly 64 percent<sup>1</sup>. Table 1.1 shows the decline in the real GDP from peak to trough in the postwar recessions and the corresponding decline in the inventory investment for the same period. This Table demonstrates that in many quarters, the fall

---

<sup>1</sup>Following Christiano's (1988) methodology.

Table 1.1

**Changes in real GDP and real private inventories during the period 1947-2001<sup>2</sup>**

Peak to trough	Change in RGDP <sup>(*)</sup> (1)	Change in inventory investment <sup>(*)</sup> (2)	The Ratio = (2)/ (1) ( %)
1948.4 – 1949.4	-24.9	-36.3	145.8
1953.2 – 1954.2	-51.2	-21.6	42.2
1957.3 – 1958.1	-81.5	-18.3	22.5
1960.1 – 1960.4	-38.1	-50.4	132.3
1969.3 – 1970.4	-21.8	-43.6	200.0
1973.4 – 1975.1	-141.1	-62.7	44.4
1980.1 – 1980.3	-108.6	-54.1	49.8
1981.3 – 1982.3	-144.7	-45.6	31.5
1990.2 – 1991.1	-100.3	-51.8	51.6
2000.4 – 2001.3	-57.4	-121.7	212.0

(\*): Data are in billions of chained 1996 dollars

Source: Estimated by the researcher

in the inventory investment dominated the fall in the real GDP, and that a strong relationship exists between those two macroeconomic variables. On average, this Table shows that the drop in real private inventory investment has accounted for 93 percent of the drop in the real GDP<sup>3</sup>. Therefore, some economists say that

<sup>2</sup>Blinder (1990), Blinder and Maccini (1991) and Fitzgerald (1997) used this table.

<sup>3</sup>Blinder and Maccini (1991) reported approximately the same result, which is 87 percent.

understanding the movements in the inventories is a necessary condition to understanding the business cycle or that inventory fluctuations provide important information about cyclical fluctuations in the GDP. Blinder (1990) said that “business cycles are, to a surprisingly large degree, inventory cycles.”

In absolute terms, the data show that the stock of real private inventory investment reached approximately \$1.5 trillion in the first quarter of 2001, or 16.0 percent of the real GDP, and this implies \$5200 per American citizen. Economists believe that this huge amount of inventories is a major player in the propagation of the business cycle, and many of them focus on understanding the behavior of the inventories fluctuations to thoroughly understand the link between the inventories and the other economic variables.

Inventories even play a vital role in computing the equilibrium process of some models. Kydland and Prescott (1982) developed an equilibrium growth model to test whether the comovements of smoothed or interpolated series is quantitatively consistent with the correspondent actual series from the U.S. postwar economy. In their model, Kydland and Prescott modeled the inventories as a factor of production. The fluctuations were driven entirely in the model by unobserved productivity shock. They found that the volatility of inventories and the correlation between inventories investment and output in their model were roughly consistent with the actual data. They said “if the inventories were not a factor of production, it would be impossible to locally approximate the economy using a quadratic objective and linear constraints.” (Kydland and Prescott, 1982, p.1350). Kydland and Prescott (1990) introduced some facts about the behavior of the U.S business cycle and the income

component share. They showed that the inventory stock lags the GNP cycle for half a year. This result confirms the importance of the time lag effect in the inventories studies.

The System of National Accounts (SNA, United Nation, 1993) defines inventories as stocks of outputs that are still held by the units that produced them prior to their being further processed, sold, delivered to other units or used in other way; and stocks of products acquired from other units that are intended to be used for intermediate consumption or for resale without further processing.

The aim of this dissertation is to focus on the behavior of inventories at the macroeconomic level through investigating empirically the relation between the inventories and some macroeconomic variables<sup>4</sup> (such as output, sales, inside money and outside money) determined based on the literature review by using the Vector Autoregression (VAR) approach, which will help in investigating the short run dynamic relation among those variables. As a specific objective among the three, this dissertation will focus on the role of inventories in the monetary transmission mechanism on both the aggregate level of inventories and the sectoral level. To achieve this target, we will disaggregate the money supply into two components: the inside money and the outside money, where the inside money refers to the debt of private economic system, or the money created by the private banking system. The banks' deposits are considered to be an example for this portion of the money supply. For the purpose of this dissertation, I used the money multiplier as a proxy for inside money because some of the previous studies used this variable as a proxy

---

<sup>4</sup>More details about those variables are in section 1:6 the data used in the model.

for inside money. Also, the money multiplier considered an indicator to the ability of the banking system to increase the volume of deposits or the ability to create money. Moreover, the money multiplier is determined not only by the Fed, but also by the behavior of the nonbank public and the banks in the banking system<sup>5</sup>. The outside money refers to the debt of the government which is considered exogenous to the private economic system. Or, it represents the money created by the Monetary Authority, such as high-powered money (monetary base). This example is a broad one and some studies used the total reserves as an example of the outside money and specifically the non-borrowed reserves.

## **1:2 The Statement of the Problem**

Any researcher reviewing the macroeconomic literature written about inventories will note that most studies try to answer the following two related questions:

- 1) Does inventory investment play a crucial role in the business cycle?
- 2) How should the relation between inventory investment and other economic variables that might affect both the inventories and the business cycle be investigated empirically.

It seems that economists who have studied inventories behavior during the last seven decades agree that understanding inventories fluctuation is a necessary condition to understanding the business cycle. Table 1:1 gives a quick answer and hint that a strong relationship exists between the decline in the inventories and the decline in the GDP. However, this Table doesn't imply that there is a causality

---

<sup>5</sup>For more details see Hubbard (1996), chapter 17.

relationship running from inventories to the GDP. On the other hand, the answer to the second question is still debatable, and there is a disagreement about the comovement between the inventories and the macroeconomic variables<sup>6</sup>, and this related to many factors which I will discuss shortly.

In this part I will make a quick overview to the inventories literature review to understand the circumstances around the above two questions. The inventories literature review can be divided into two main directions of research: The microeconomic level tries to show that inventories play an important role in smoothing production and behave as a buffer stock (stabilizing factor), while the macroeconomic level seeks to prove that the inventories are a destabilizing factor in the economy and responsible for the propagation of the business cycle. It is clear from these two facts that there is a kind of tension related to the role of inventories between those two directions. Despite this, it is clear that there is a link between those two directions from a technical point of view.

On the macroeconomic level, Metzler (1941) used a simple Keynesian model in which the goods are storable and there is a desired level of inventories. He showed that an exogenous shock (change in the non-induced investment) to this type of economy makes the inventories produce serially correlated fluctuations in the GDP until the economy reaches again the desired level of inventories. Metzler pointed out that the magnitude of fluctuation depends on the marginal propensity to consume (MPC) and the amount of change in the non-induced investment level. Abramovitz

---

<sup>6</sup>The models in most studies were based on a firm level, and most studies concentrate on subcomponents of the aggregate inventories.

(1950) showed that the inventories fluctuations are important for explaining the short-run business cycle. His study relies on analyzing the statistical records of the manufacturing inventories, which were more available compared to the other branches of inventories at that time. Blinder (1980) used a Keynesian macroeconomic model and modeled the inventories as a factor of production through affecting the demand for labor. He shows theoretically how a change in the money supply or the government spending will affect the inventories by affecting the final sales. Blinder's results confirm the important role of the lag relation among the variables. Blinder and Fischer (1981) used a new classical model to prove theoretically that an external shock to the inventories will persist for the following period because inventories, especially the prices in their model, are sensitive to the different shocks, and this analysis means that inventory plays an important role in the propagation of the business cycle. To this point of development in the macroeconomic literature review, most of the economists agree that inventories play an important role in the propagation of the business cycle.

On the microeconomic level, we have two leading models<sup>7</sup>. First, the (S,s) model, which assumes that the firm tries to keep a certain level of inventory to support its production or that it will not let its inventory fall below that amount. In addition, for this case the firm faces a linear cost function (constant marginal cost) with a high fixed cost in each period. Therefore, from the inventory management technique point of view, the firm tries to batch inventories when it falls below s

---

<sup>7</sup>The difference in the two models is related to two main points: first, the shapes of the cost function, second, the area of interest. The production smoothing model focuses on the time of production, while (S,s) focuses on the time of delivery.

(small  $s$ ); thus it will buy again to keep it at a level below  $S$  (big  $S$ ). The difference between the big  $S$  and the small  $s$  is the optimal level of inventories.

Second, the production smoothing / buffer stock model developed by Holts and others (1960) viewed inventories as a stabilizing factor. The main idea behind this model is that a profit-maximizing firm will use its inventories to smooth the production when the firm faces a variable demand on its goods. Technically, the production smoothing model assumes a convex cost function (quadratic), therefore, we have increasing marginal cost. Based on that, the firm will try to choose the amount of production that maximizes its profit, and it will use the extra production which they produced in the form of finished goods to face the high demand.

Therefore, this model predicts that the output will be less volatile than the sales. But the actual data shows output (GNP) is more volatile than sales, and this is opposite to the production smoothing model prediction. This result makes the economists feel that this model faces a real problem. Therefore, a lot of effort was spent by many economists to modify the production smoothing model to create a kind of consistency between the model prediction and the actual data.

The economists used different modifications or additions<sup>8</sup> to the production smoothing model in order to reduce or eliminate this discrepancy. One of these adjustments is adding a cost shock to the firms' cost function. This adjustment in the model helps to make the production more volatile than the sales, especially when the costs are low; in this case, the production will be high. Some economists such as

---

<sup>8</sup>This includes adding cost shock, adding a target inventory level and adding nonconvexities in technology. For more details see Fitzgerald (1997).

Blinder (1986), Maccini and Rossana (1984), West (1990) and Kollintzas (1995) used the unobserved cost shock that is not directly measured from data. Other economists such as Miron and Zeldes (1988) and Durlauf and Maccini (1995) used the observed cost shock that directly measured from data such as material and energy prices and the wage rate<sup>9</sup>. Despite the fact that the results of this research were mixed, the general conclusion supports the idea that adding a cost shock to the firms' cost function contributes positively to explaining the inventory behavior.

The link between the two directions of research, especially the recent research, can be viewed from the point that most of the economists started their research by deriving their models on the microeconomic level and they ended by applying their model either on the industry level or on the aggregate level by assuming we have a large number of identical individual decision units whose behavior are the same (Horenstein 1998). Additionally, it is clear from the production smoothing model, which is a microeconomic model that the economists applied this model on the macroeconomic level.

At the beginning of 1980, some economists such as Rubin (1979), Lieberman (1980), Irvine (1981) and Akhtar (1983) confirmed that the interest rate has an important effect on inventories. Some of those studies found that even the inflation rate has an effect on the inventories, but it is less significant compared to the interest rate. Blinder (1980) showed that the appearance of inflation as a result of a sudden reduction in inventories is an important factor in rebuilding the inventories and reaching the equilibrium again. Moreover, Mossetti (1990) concluded that inside

---

<sup>9</sup>For more details see Fitzgerald (1997) and Durlauf and Maccini (1995).

money has an important effect on inventories. On the other hand, Ramey (1989) concluded that inventory has a very small role in the monetary transmission mechanism, and that the major role of change in inventory comes from the factors making a shift in the demand for inventory, and he called these factors unobservable cost shocks. Ramey and West (1997) stated that the inventory behavior has two aspects or facts: inventory movements are procyclical, and the inventory-sales relationship is highly persistent. They explained these two facts by persistent shock to the cost function, and high costs of adjusting production and a strong accelerator motive. Jin (2001) proved that the input and output inventories play an important role in the monetary transmission mechanism.

Some economists such as Maccini and Rossana (1981, 1984) considered that the fluctuation in inventories is proportional to the gap between the desired and actual inventory level, and they found that the speed of adjustment is high. Their studies concentrate on the inventories of finished goods. Blinder (1986) stated that despite the excellent effort of Maccini and Rossana, he is not quite sure that they succeeded in explaining why estimated adjustment speeds in stock-adjustment models of inventory behavior are high. In their study Maccini and Rossana (1981) confirmed that real interest rate have no important impact on inventory investment. Christiano<sup>10</sup> (1988) proved that the fluctuation in inventories is due to the role of inventories as a buffer stock or residual in the economy that affected by all the shocks in the economy.

---

<sup>10</sup>The model used by Christiano is a real business cycle model or a modified model of Kydland and Prescott (1982).

Recently, some researchers started to focus on the shift in the inventory management policy as a reason that affects inventories; most the researchers in this direction are Federal Reserve Bank researchers<sup>11</sup>. Others focus on the credit constraint to understand the inventory behavior<sup>12</sup>.

The discrepancy or the disagreements in the results reached by the economists are related directly to the type of the models used to test the relation. Because there are many purposes for holding inventories, there are many different models for inventories. Thus it is impossible for one single model to gather all these motives or factors in one model. Walsh (1998) stated that while he is talking about the monetary theory and policy, using just the representative-agent models alone is incomplete and not enough, and he proposed to use the “ad hoc” models<sup>13</sup> which have played, and continue to play an important role in providing details about the relation among the variables, which is useful to the monetary policy decision makers. Therefore, I believe it is important to investigate the relation between the inventories and the macroeconomic variables by using another technique, the VAR technique, which is able to take into consideration all the important macro variables and pay more attention to the time lag relationship, which is confirmed as an essential key to understanding the comovement mechanism among the variables.

---

<sup>11</sup>For more details see Morgan (1991) Little (1992), Huh (1994) and Filardo (1995).

<sup>12</sup>For more details see Jin (2001) and Kashyap, Lamont and Stein (1994).

<sup>13</sup>This is the name of the group of models which the VAR model belong to, and this name is proposed by the opponents of this methodology of analysis because these techniques often are not derived directly from any decision problem.

It is clear from these quick syntheses of the literature review that the factors affecting inventories can be classified as output, sales, interest rate, money and inflation rate. These variables will be taken into consideration in the empirical work of this study.

### **1:3 The Importance of the Study**

The importance of this study comes from three directions; First, this study will focus on important and debatable issues in the behavior of inventories, such as the role of inventories in monetary transmission mechanism and the relation with the inflation rate. Lovell (Hall and Lovell 1976) concluded that inventories are insulated from credit crunch and inflation; he also concluded from his own empirical work over the years that the probability of obtaining a negative significant relationship between the interest rate and inventories is 50 percent. Despite this conclusion, some economists such as Rubin (1979) and recently Jin (2001) proved the opposite. Each one of those economists used a different model and applied his model to different sectors.

Second, some new findings during the last two decades open new channels for more research. Some economists such as Horenstien (1998) concluded that we cannot attribute total inventory investment volatility to its individual components because all components are highly correlated or because inventory investment moves much the same in each sector, and this implies we have to focus on the both the aggregate and the component levels. For that reason, this study will investigate the dynamic relation among the variables under consideration to compare the behavior on the aggregate and the sectoral levels.

Third, unlike most other studies, this study will explore the behavior of inventories on the macroeconomic level by using the VAR technique or “ad hoc” model, which is widely used among economists, especially in monetary studies, to study the effect of monetary aggregates on the other macroeconomic variables. Also, this study will use three important and related variables in the VAR model at the same time: real gross domestic product, real final sales and inventories. These were not used simultaneously in a VAR model in the previous studies. The reason for using all of them is to focus more on the relation among those three variables together. Granger and Lee (1989) proved that those three variables can be cointegrated, and they call this technique multicointegration. Moreover, the VAR technique is not used extensively in the inventories researches because most of the theoretical and the empirical studies in this field tried to model or find a place for the inventories in the economic literature to introduce a logical analysis for the interrelationship between the inventories and the other macroeconomic variables. The starting point in modeling the inventories is the motivation for holding the inventories on the firm level<sup>14</sup>; therefore, most the inventory models started from the microeconomic level or the firm level<sup>15</sup>. The majority of economists who studied this important variable modeled it as a factor of production. For example, Blinder (1980) modeled the inventories as a factor of production in a Keynesian Macro Model and

---

<sup>14</sup>One of the leading models in inventories is the production smoothing/buffer stock model, which is considered the microeconomic base for most the studies concerning the inventories behavior over the business cycle.

<sup>15</sup>Both Metzler (1941) and Blinder (1980) used a macroeconomic model to study the behavior of inventories. Blinder succeeds in modeling the inventories by using IS-LM and aggregate supply equations.

specifically in the demand for labor (supply side), while, Ramey (1989) modeled the inventories as a factor of production, but she did so by using a cost function or what she called “cost of adjusting inventories.” On the other hand, Akhtar (1983) used a “stock adjustment” or “flexible accelerator” model for studying inventories. Jin (2001) modeled the input and output inventories in a dynamic general equilibrium model as a factor of production. Jin’s study connected the behavior of inventories with two related events: a monetary contraction and a credit-constraint of the firm level.

Modeling the inventories by focusing on the motivation for holding them puts a lot of constraints on these models and makes these models concentrate on some specific variables that might affect the relation, and as a result every study found different results as mentioned above, which is considered biased in favor of the constructed theory or model. Blinder and Maccini (1991) mentioned that modeling the inventories depends on the motivation from holding inventories, and as long as we have many motivations to hold inventories, therefore it is difficult to find one model that can explain the rich variety of inventory behavior. An explanation that is reasonable for one type of inventory may be not reasonable for another. Cooley and LeRoy (1985) pointed out that the large amounts of restrictions lead the economists to depend on a new methodology that has less dependence on the restrictions. These developments lead to using the VAR model in which all the variables are endogenous.

Empirically, the VAR model is able to provide a simultaneous and comprehensive overview for the interrelationship between the inventories and the

macroeconomic variables. The VAR technique gives the researcher the opportunity to choose the variables needed to be tested based on prior information or on the literature review. Further, it is useful in tracking the time lag effect and the feedback among the variables. In addition, this technique helps to investigate the causality among the variables.

Specifically, the VAR model will be useful for this study for several reasons. First, this study focuses on the macroeconomic level, not microeconomic, which means there is no derived model; it is clear from the literature review that the production smoothing model applies to the finished goods of manufacturing industries (linear quadratic cost function), while the (S,s) model (linear cost function with high fixed cost) applies to retail inventories and manufactures' raw materials and supplies inventories. Therefore, the VAR technique helps this study to focus on the behavior of the macroeconomic level of inventories without being affected by the microeconomic level problem. This means it helps to study different kinds of inventories not those just subject to the above-mentioned models. Second, some economists such as Bivin (1993) said that the inventory theory did not provide enough structure to construct the reduced form models which means that applying the autoregressive technique is valid in this case. Third, this study will give attention to the role of inventory in the monetary transmission mechanism. And, it has been proved that the VAR technique is useful in this area by many economists such as Sims (1980), Christiano, Eichenbaum and Evans (1996) and Evans and Kuttner (1998). Fourth, this study will focus on the role of inventories in the propagation of the business cycle; therefore, this model will give this study a high flexibility to

follow up the impacts<sup>16</sup> of different shocks on both inventories and output, which enables us to understand the role of inventories in this mechanism. In addition, this study is interested in highlighting on the short-run dynamic movement of inventories because it has been proved by many economists (Hansen 1941; Abramovits 1950; and Blinder and Maccini 1991b) that the short- run fluctuation in the economy is related to the inventory movement. Based on this fact, the VAR model will be useful in capturing this short-run dynamic if the appropriate frequency of data (monthly or quarterly) is used; this study will use the quarterly data.

#### **1:4 The Purpose of the Study**

The broad goal for this dissertation is to try to contribute to the empirical work of an unanswered problem on the relationship between inventories and macroeconomic variables by using aggregated and disaggregating data for both the monetary aggregates and the total inventories and by employing the VAR model. This study will focus on some selected macroeconomic variables that have been mentioned in the literature review as important variables in this relationship. Therefore, this study can be considered comprehensive and more flexible in determining the interrelationship among the variables under the test.

The first specific objective of this dissertation is to address the role of inventories in the monetary transmission mechanism, that is, to identify if there is a strong relationship running from the money supply through the interest rate to the inventories. In addition, I will investigate this for two important sectors of inventories manufacturing and retail trade, by using disaggregated data for the

---

<sup>16</sup> The length and the degree of volatility.

money supply. The idea from this part of the study is to check if inventories have an important role in the monetary transmission mechanism on both the aggregate level and the sectoral level and at the same trend. Jin (2001) proved that this role exists on the subcomponent of the manufacturing sector (output and input inventories). Also, Hornstein (1998) proved that it is difficult to attribute aggregate inventory volatility to a particular sector.

The second specific objective is to examine the relation between the inventories and inflation rate on both the aggregate level and the sectoral level as I mentioned earlier, and I want to check if this effect occurs because of the sales shock (the role of inventories as a buffer stock) as mentioned by Blinder (1980), or if it is a monetary phenomenon as described by King and Plosser (1984). They concluded that inside money has an impact on real activity while outside money affects the price level.

The third objective of the study is to prove empirically that inventories play a crucial role in the propagation of the business cycle. Based on the literature review, Blinder and Fischer (1981) used a theoretical model to prove the persistence of inventory shocks. The idea of this model shows that there is a direct channel effect from the variables in the model to the output and that there is an indirect channel effect through the inventories. This general shape of their model is close to the VAR model. At the same time, Christiano (1988) concluded that inventories behave as a residual, or affected by all the shocks in the economy, and then it has an impact on the output. Therefore, I will use those two pieces of information to test the role of inventories in the propagation of the business cycle. Empirically, in this part I will

separate the variables into three categories: output, inventories and other. Working in this part requires proving that there are three way effects; first, a direct effect channel running from the variables (other) in the VAR model to the output; second, an indirect channel running from the variables (others) in the VAR model through the inventories to the output; and third, a direct channel running from the aggregate inventories to the output. While demonstrating these channels of effect among the variables, I will analyze the length of the effect and the degree of volatility among the variables. This analysis will give an indicator of the relative importance of each shock on the propagation of the business cycle. Also, I will apply these to the sectoral level.

### **1: 5 The Methodology**

To investigate the short run dynamic relationships among the variables, this study will use the VAR approach, which was introduced by Sims (1972, 1980), who used this approach to estimate the impact of money on economic activity. Sims developed this framework by moving from the original bivariate (1972) to the trivariate (1980).

Walsh (1998) described the group of models that the VAR technique is used as an analytical tool based on sets of equilibrium relationships that are not derived directly from any decision problem, and he said that some opponents called this group of models “ad hoc” models. Despite that, Walsh (1998) mentioned that these models are generally more appropriate compared to the other approaches<sup>17</sup> and demonstrate a great value in helping economists to understand issues in monetary

---

<sup>17</sup>He compared that with the representative-agent models and overlapping-generation models.

economics. In addition, he pointed out that these models can be very supportive in highlighting key issues affecting the relation between monetary and real economic phenomenon.

The main goal of the VAR model is to provide empirical evidence for response of the macroeconomic variables to a shock in one or more macroeconomic variables; this technique therefore doesn't provide advice for the best policy but does describe how the variables react with each other. Tracing the impact of a shock of one variable on the other variables in the system called the dynamic relationship among the variables. In addition, this analysis shows the time lag effect of each shock, or in other words this method shows for how many months or quarters the impact of a shock will persist on the other variables. Moreover, this technique gives an idea about the feedback among the variables for a shock. Lovell (1994) tried to explain why we haven't learned more about inventories. He mentioned the ignorance of the simultaneous feedback effect of inventories on the demand as a reason affecting this knowledge which will lead the firm to respond by revising the production schedule, by manipulating the prices and by changing advertising expenditure.

The VAR models focus on the shocks and the response of the system to the shocks which is described by the forecast error variance decomposition (FEVD) and the impulse response function (IRF), these two techniques from the VAR model are used to examine the directions and the channels of the interrelationships within the macro level variables used in the model. Favero (2001) explained why the VAR approach concentrates on the shocks by giving an example from the monetary policy.

He said that studying the deviation from the monetary rule can be achieved either by studying the effect of the shocks or by changing the response of the policy makers to macroeconomic environment. Therefore, the focus of the VAR approach is on the former because it is easier and available.

The IRF traces the effect of a shock to an endogenous variable on the current and future values of the variables in the VAR, while the FEVD gives information about the relative importance of each random shock (such as introductions of ATM, Credit Cards, on-line banking services) to the variables in the VAR, providing information on whether the movement in a series is due to its own shocks or shocks from other variables.

The VAR model assumes that all variables are endogenous, and each equation in the VAR model is a function of the lagged variables of all the variables in the model. Each equation in the VAR system will be estimated separately by using the Ordinary Least Squares (OLS), which is the best estimator in this case. The general multivariate mathematical form of the VAR model is as follows:

$$X_t = A_0 + A_1 X_{t-1} + A_2 X_{t-2} + a_3 X_{t-3} \dots \dots \dots + A_m X_{t-m} + \varepsilon_t$$

Where  $X_t = (n \times 1)$  vector of  $n$  variables included in the VAR.  $A_0 = (n \times 1)$  vector of intercept terms.  $A_i = (n \times n)$  matrices of coefficients.  $\varepsilon_t = (n \times 1)$  vector of error terms. Based on the general multivariate mathematical form, the specific shape of the model will be as follows:

$$Y_t = C_y + \sum_i^j A_{yi} Y_{t-i} + \sum_i^j B_{yi} X_{t-i} + \sum_i^j E_{yi} Z_{t-i} + \sum_i^j D_{yi} W_{t-i} + \varepsilon_t$$

$$X_t = C_x + \sum_i^j A_{xi} Y_{t-i} + \sum_i^j B_{xi} X_{t-i} + \sum_i^j E_{xi} Z_{t-i} + \sum_i^j D_{xi} W_{t-i} + \varepsilon_t$$

$$Z_t = C_z + \sum_i^j A_{zi} Y_{t-i} + \sum_i^j B_{zi} X_{t-i} + \sum_i^j E_{zi} Z_{t-i} + \sum_i^j D_{zi} W_{t-i} + \varepsilon_t$$

$$W_t = C_w + \sum_i^j A_{wi} Y_{t-i} + \sum_i^j B_{wi} X_{t-i} + \sum_i^j E_{wi} Z_{t-i} + \sum_i^j D_{wi} W_{t-i} + \varepsilon_t$$

The VAR model has been widely used by many economists such as Christiano, Eichenbaum and Evans (1996), Guriguis (1999) and Shbikat (2000). It is used in their studies to estimate the liquidity effect and to measure the impact of monetary policy shocks on the economy. Evans and Kuttner (1998) showed that the VAR method is able to describe the monetary policy, and it is able to mimic the future market and to help forecast the future market. Leeper, Sims and Zha (1996) employed the VAR model to study the effect of the monetary policy in the U.S. economy. They used a large VAR model including 24 variables from different sectors.

### **1:5:1 The VAR model and Inventories Studies**

The VAR model has been recently used in the inventories studies. The literature review showed that there are five studies modeled inventories in a VAR model for different purposes. In this part of this dissertation I will focus only on the study and its target while in Chapter Two I will provide more details about those studies. Reagan and Sheehan (1985) used a five variables VAR model to study the

importance of inventories over the business cycle. Fair (1988) used a VAR model with 23 variables<sup>18</sup> to investigate the source of economic fluctuation in the United States. Huh (1994) and Filardo (1995) used the VAR model to investigate if the role of inventories is still important in the business cycle as before, or if, as mentioned by some economists, this role is muted. In this paper the effort was to test if the relation between inventories and gross domestic product (GDP) has changed or not based on two different time-horizon samples. Moreover, Herrera (2000) employed a VAR model and a structural linear quadratic inventory model to examine the relationship between oil price shocks and aggregate economic behavior through the effects on the U.S. manufacturing sector. Recently, Jin (2001) used the VAR model to investigate empirically the role of inventories in the monetary transmission mechanism, but she concentrated only on subcomponents of the manufacturing sector<sup>19</sup>.

### **1:6 The Data Used in the Model**

As I mentioned earlier, economists tried to explain the role of inventories in the economic fluctuation or the high correlation between the fluctuation in inventory investment and the GDP. The literature review showed that there are three possibilities by which economists can explain this relationship. First, the accelerator effect, which means that businessmen tend to hold stock of inventories proportional to the level of output. Second, the buffer stock effect, which means that an unexpected shock to sales would lead to changing the inventories, and after a while this effect would spread out through the price effect to the output. Blinder's (1980)

---

<sup>18</sup>For more details about the variables used by Fair, consult to the appendix in Fair (1988).

<sup>19</sup>She divided the manufacturing inventories into two subcomponents, input and output.

Macro model introduces a scenario to the comovement between the four macroeconomic variables (GDP, final sales, prices and inventories). Third, Christiano (1988) concluded that inventories are a residual affected by all the shocks in the economy, and which include monetary shock, price shock, cost shock and productivity shock.

Since one of the goals of this study is to concentrate on the role of inventories in the transmission mechanism, I will pay more attention to the policy variables. This study will use the disaggregated money supply because previous studies such as Mishkin (1982), Gordon and Leeper (1994) and Chari, Christiano and Eichenbaum (1995) used the broad measures of money and failed to find a negative relation between money and the interest rate. Christiano and Eichenbaum (1995) argued that innovations to non-borrowed reserve reflect an exogenous shock to monetary policy, while innovations to money aggregates reflect a shock to money demand. Moreover, Friedman (1981) concluded that the relationship between the components of credit and economic activity is clearer than the total credit and economic activity. Furthermore, King and Plosser (1984) concluded that the contemporaneous correlation between money and output is due to inside money, while inflation is related to outside money. This result gives a possibility for a price effect on the inventories in the monetary transmission mechanism role of the inventories. At the same time, Akhtar (1983) concludes that a significant relationship exists between the inventories and the inflation rate from the other direction. Even in Blinder's (1980) analysis the inflation rate played an important role for both the output and inventories to reach the equilibrium path.

Based on the above-mentioned possibilities, the variables that will be chosen in the VAR model include real inventories stock, real GDP (RGDP), real final sales (RFS), interest rate, inside money, outside money and price level.

### **1:7 The Sources of Data**

This study will use quarterly data of the U.S. economy, and the time period for the study will be 1959.1-1997.4. This study will not cover the period after 1997 because at the beginning of 1997, the Standard Industrial Classification (SIC) was replaced by the North American Industry Classification System (NAICS). This means that the aggregate level of the change in both private inventories and real GDP will not be affected, but this replacement will affect the sectoral level. The Bureau of Economic Analysis (BEA) presents the data for 1997 and earlier on the (SIC) bases in tables 5.10A, 5.11A, 5.12A, 5.13A and 7.16A. BEA presents the data for 1997 and later on the NAICS basis in tables 5.10B, 5.11B, 5.12B, 5.13B and 7.16B<sup>20</sup>.

It is useful to mention that NAICS was developed jointly by the U.S., Canada and Mexico to provide a new comparability in statistics about business activity across North America because of NAFTA. This study will rely on three main resources to get the required data: first, the Bureau of Economic Analysis (BEA) through its web page <http://www.bea.gov/>; second, the Federal Reserve Bank of Saint Louis through the web page <http://www.stls.frb.org/>; and, third, the economagic site through its web page at <http://www.economagic.com>, through which many time series data about the U.S.A. economy are available.

---

<sup>20</sup>Survey of Current Business, June 2001.

## **1:8 Organization of the Study**

To achieve the empirical goals of this study I am planning to have six chapters for this study; in addition to the four normal chapters, I expect to have two extra empirical chapters. The reason for this classification is that based on the purpose of the study, it will use both aggregated and disaggregated data. Therefore, I expect Chapter Four to cover the aggregate analysis, while Chapter Five covers the disaggregated analysis. Consequently, this study consists of the six following chapters:

Chapter One is the introduction, which gives a general briefing to the topic of the dissertation including the statement of problem, the purpose of the dissertation and the methodology.

Chapter Two is the literature review. This part will present the historical background for what has been written about the inventories by individual economists, and I follow up the time period in my presentation. This chapter has been divided into two main sections. The first one concentrates on a general overview of the development of inventories in the literature. The purpose of this part is to show the direction of inventory research during the last seven decades and to briefly examine using the VAR model in the inventory studies. The second part focuses on specific empirical or theoretical studies done by individual economists which are useful to this study.

Chapter Three, "Methodology of the Study," will focus on the VAR model. It is divided into five sections: a historical brief for using the VAR model; an

introduction to the VAR model; uses of the VAR model; important issues related to the VAR model; and finally, cointegration and the error correction model.

Chapter Four, “Empirical Results and Analysis I,” will present the empirical findings of the aggregated analysis, which will include the role of inventories in the monetary mechanism, the relation between inventories and the prices on both the aggregate and the sectors level and finally the role of inventories in the propagation of the business cycle

Chapter Five, “Empirical Results and Analysis II,” will present the empirical findings of the disaggregated analysis. It will also include the same topics as in Chapter Four.

Chapter Six, “The Conclusions” will summarize the results of the dissertation and compare the results with previous studies. Some policy implication will be presented.

## **1:9 Conclusion**

This dissertation showed that both interest rate and prices have a weak relation with inventories in both aggregate and disaggregate level of data. Using the multicointegration was useful in this study because it helps to show that inventories are explained mainly through the relation or the difference between RGDP and RFS, which implies that it is established as a residual, supporting the results of Christiano (1988). The main finding of this dissertation supports and explains the relation between inventories from one side and both prices and interest rate from the other, because it seems that monetary factors affect inventories through RGDP and RFS, while the relation between prices and inventories evolves in the economy based on

the reaction between the monetary factors, RGDP and RFS too. This dissertation introduces a complete analysis by using the IS-LM model based on the results of the VAR model of this study. And, this model is considered an adjustment of Blinder's model (1980), which is the only recent model able to describe the evolution of inventories on the macroeconomic level and the relation with the other macroeconomic variables in the economy.

On the disaggregate level, this dissertation shows that inside money plays a crucial role in determining economic activity and even all types of inventories, and also this conclusion supports the main finding of this study which is mentioned above. Those two important findings (the relation between inventories and RGDP, RFS and inside money) are able to explain why the direct relation between inventories and interest rate is relatively weak, because this implies there are relatively more important variables than interest rate that affect inventories.

According to the role of inventories in the propagation of business cycle, this dissertation illustrates that the indirect channel exists based on the logic behind Blinder and Fischer's model (1981). But, the findings of this study do not agree fully with their reasoning, because this study shows that the direct relation of most the variables (interest rate and price) in the model with inventories is weak and affects inventories through RGDP and RFS. Therefore, this study finds that there is a direct and strong relation running from inventories to RGDP and RFS in the long-term horizon. This relation plays an important role in explaining the role of inventories in the propagation of business cycles. The conclusion of this dissertation in this area says that in the short-term horizon, inventories evolve in the economy as a residual.

This conclusion is close to Christiano's, and therefore its effect is not regular from the time horizon point of view. In the long-term horizon, the effect of this important macroeconomic variable starts first to affect both aggregate demand and aggregate supply simultaneously and in the opposite direction, which means that this variable starts to make a quick imbalance in the prices set, such as the price level and the interest rate, which leads to a fluctuation in the economy as a whole until we reach the desired level of inventories or, as in most cases, as we move from increase in inventories to decrease in inventories. Consequently, as long as change in inventories show up in the economy as a residual for the economic performance and its effect exists, whether positive or negative, then we expect this fluctuation to occur continuously.

## **Chapter Two**

### **Literature Review**

#### **2: 1 Introduction**

This chapter will focus on the development of inventory literature from both sides the microeconomic and the macroeconomic points of view during the last seven decades. Some of the works are description analyses and some are empirical works. Even though this study is interested in the macroeconomic aspect of inventories, it is difficult to separate the microeconomic and macroeconomic literatures of inventories. The reason behind this fact is that the two leading economic theories of inventories are the production smoothing/buffer stock model and the (S,s)<sup>21</sup> inventory model, which are the microeconomic foundations for most research on inventories behavior. Those two models apply at the level of firms. And, to understand the behavior at the aggregate level, the macroeconomic level research often assumes that we have a large number of identical individual decision units whose behavior are the same (Hornstein 1998).

---

<sup>21</sup>As long as this study is interested in the Macroeconomic level of inventories I will not focus in the (S,s) but I will focus on the production smoothing model because it has some implication on the Macroeconomic level.

In this chapter I will synthesize what has been written about inventories in chronological order. It will be comprised of two main parts: a general overview of the development of inventories literature, and an examination of some particular studies that are useful for this study. The goal of this presentation is to understand in general the directions of research in inventories in the past and how the literature had been developed by focusing on the important contributions which are useful to this study. In addition, a synthesis of inventory literature<sup>22</sup> will provide helpful knowledge about the development of inventory literature, taking into consideration the point mentioned by Blinder (1980) that macroeconomic theorists had neglected the inventories in their books, which means that the researchers who are interested in inventories have to review what has been written about inventories from the articles and journals.

## **2:2 General Overview**

The goal of this part of the study is to give a general overview of the direction of inventory research during the last seven decades based on the time horizon. The literature review shows that there are many directions of the inventory research. But the target of all these directions has focused on understanding the movement of inventories because it is a dominant feature of the business cycle. Therefore, I will present the direction of research which I believe is vital and important to this study.

The beginning of inventory literature development shows a tension related to the role of inventories on both the macroeconomic and microeconomic levels. On the

---

<sup>22</sup>Blinder and Maccini (1991a) and Fitzgerald (1997) have a useful literature review.

macroeconomic level, Metzler (1941)<sup>23</sup> proved that modeling inventories in a simple Keynesian model will produce cycles in the economy. His work showed the inventories as a destabilizing factor on the macroeconomic level. This work is considered important because during that time the United States economy's fluctuations looked much like the Metzlerian inventory cycle (Blinder 1991).

Abramovitz (1950) showed that inventories movements are important in the short-run expansion and contraction. This conclusion is consistent with what is mentioned by Hansen (1941) about the difference between the different waves of the business cycles and which factors are responsible for each type. Moreover, it is even consistent with the reasoning submitted by Blinder and Maccini (1991b) to explain why the inventory research dried up in the 1960s. They mentioned that this happened because of the long economic expansion at that time which reduced the macroeconomists' interest in inventory fluctuations, which are important during depressions and around cyclical turning points, i.e. troughs and peaks. For this reason this study is interested in using the VAR model with a quarterly frequency data to capture the dynamic of the short-run fluctuation.

On the microeconomic level, the production smoothing model developed by Holt et al. (1960) viewed inventories as a stabilizing factor. The main idea behind this model is that a profit maximizing firm will use its inventories to smooth the production when the firm faces a variable demand on its goods. Therefore, this model predicts that the output will be less volatile than the sales. Blinder and

---

<sup>23</sup>Metzler's model took into consideration Lundberg type lags which implies that output lags sales;  $Output_t = F(Sales_{t-1})$ .

Maccini (1991a) asked an important question: how could something that was stabilizing at the microeconomic level be actually destabilizing at the macroeconomic level? Another problem related to the production smoothing model showed up when the economists discovered that on the macroeconomic level, the output (GNP) is more volatile than sales, and this feature is common to all sectors<sup>24</sup>, which is contrary to the production smoothing model prediction.

Consequently, on the microeconomic level a new direction of research started, beginning in 1980, and tried to solve the above-mentioned dilemma by modifying the production smoothing model to create a kind of consistency between the model prediction and the actual data. Economists used different modifications or additions<sup>25</sup> to the production smoothing model in order to reduce or eliminate this discrepancy. One of these adjustments was adding a cost shock to the firms' cost function. This adjustment in the model helped to make the production more volatile than the sales, especially when the costs are low, which results in high production. Some economists such as Blinder (1986), Maccini and Rossana (1984), West (1990) and Kollintzas (1995) used the unobserved cost shock that is not directly measured from data. Other economists such as Miron and Zeldes (1988) and Duraluf and Maccini (1995) used the observed cost shock that directly measured from data such as material and energy prices and the wage rate<sup>26</sup>. Despite the fact that the results of this research were mixed, the general conclusion supported the idea that adding a

---

<sup>24</sup>For more details see Hornstein (1998), Blanchard (1983) and Blinder (1981).

<sup>25</sup>This includes adding cost shock, adding a target inventory level and adding nonconvexities in technology. For more details see Fitzgerald (1997).

<sup>26</sup>For more details see Fitzgerald (1997) and Duraluf and Maccini (1995).

cost shock to the firms' cost function contributes positively to explaining the inventory behavior. The notable point on this phase of research is that economists started deriving their models on the microeconomic level and they ended by applying their model either on the industry level or on the aggregate level.

During the same period, on the macroeconomic level Blinder (1980) built a macroeconomic model by using the IS and LM equations and an aggregate supply equation. This model considered a modification to Metzler's model (1941). Blinder, in his model, dealt with inventories as a factor of production through affecting the demand for labor. But his model is still affected by the production smoothing/ buffer stock model and this is clear in the model itself, because he assumes that any policy shock, a change in money supply and government spending, will affect the sales but not the output, and this is a sign of the buffer role of inventory in the economy. Blinder and Fischer (1981) used a new classical model to prove theoretically that inventory plays an important role to the propagation of the business cycle. This dissertation will utilize the logic behind this model and the VAR model to test how macroeconomic variables react with inventories to propagate the business cycle. Kydland and Prescott (1982) built a general equilibrium model to study the cyclical fluctuation in the output that is driven entirely by unobserved productivity shock. They introduced inventories as a factor of production which played an important role in the model. They found that inventories smooth production and are negatively correlated with the output. Christaino (1988) assumed that inventories in any economy represent a shock or a residual in a way that is affected by all the shocks in the economy because inventories behave as a buffer. He proved his statement by

modifying the general equilibrium model used by Kydland and Prescott (1982). This conclusion is consistent with some economists' point of view that inventories have a crucial role in the propagation of business cycles. This means that any shock in the economy will affect the inventories directly in a stronger way, compared to the direct effect on the GDP. And this effect (through the inventories) will transfer to the GDP and will persist for a longer period. Blinder and Maccini (1991b) showed that on average the drop in real private inventory investment has accounted for 87 percent of the drop in the gross national product (GNP) from peak to trough during recessionary periods in the postwar period.

During the last two decades many empirical studies concentrated on the behavior of the inventories and each study had different results; I will focus on these studies in the second part of this chapter.

Recently, Horenstein (1998) differentiated between the supply shocks (cost shocks on production side) and the demand shocks (sales side) in order to give an explanation of why the inconsistency in the production smoothing model results: the contradiction between the prediction and the actual data. He stated that the production smoothing model predicts that the production will be more volatile than sales if supply shocks are more important than demand shocks. On the other hand, the production smoothing model predicts that the production will be less volatile than sales if supply shocks are less important than demand shocks.

A new important finding about the behavior of inventories opens the door for more investigations and researches. Horenstien (1998) concluded that we cannot attribute inventory volatility to its individual components because all components are

highly correlated and fluctuate in a close way. Bain (1985) raised this point in different way, mentioning that the different components of aggregate inventories do not behave uniformly, especially the amplitudes of fluctuation and the phase shifts relative to GNP. Sprague and Wacker (1996) pointed out that good modeling depends on finding the right level of aggregation that enables the researcher to have a good explanation and good insight without getting lost in details. They believed that aggregation done by Blinder and Maccini (1991a), which disaggregated down to the sector level but not the firm level, is the best one. This implies that each sector or even sub sector has its own behavior and need to be tested.

In sum, it clear that there is still a gap in understanding some phenomena related to inventory behavior as mentioned by Blinder and Maccini<sup>27</sup> in several papers. For example production is more variable than sales and the most volatile components of inventories are retail inventories and inventories of raw materials and supplies at the manufacturing sector. The literature review gives an indication that there are four main problems in the inventories to be studied more. First, there are many motives or reasons to hold inventories and it is impossible for one single model to gather all these motives therefore it is difficult to explain fully the inventories behavior (Blinder and Maccini (1991a)). Second, both the aggregate inventory and its components have special behavior, which means understanding the behavior of one kind of inventories cannot be generalized to the aggregate level or to the other components. Third, before 1990 most the inventory research concentrated on the inventories of finished goods at the manufacturing sector. Fourth, the production smoothing/ buffer stock model is

---

<sup>27</sup>For more details see Blinder and Maccini (1991a, 1991b).

considered to be one of the main theories for studying the behavior of inventories on the macroeconomic level, despite the fact it is a microeconomic theory.

### **2:2:1 Using the VAR Model in the Inventories Studies**

The VAR model has been recently used in inventory studies. Reviewing the literature illustrates that just only five studies used the VAR model to study inventories, and I can consider just three of these studies pure inventory ones. Therefore, in this part I will give a general idea about those studies, and then I will concentrate more on some of them in one of the next sections.

Reagan and Sheehan (1985) used a five variable VAR model to study the relation between inventories and output. They focused on the manufacturing inventories by stage of fabrication and used data from the U.S. economy. The conclusion of their study showed that inventories can explain the fluctuations in output.

Fair (1988) used the VAR model to study the source of fluctuations in the United States economy, using 23 variables in his model. He concluded that inventory investment is one of the important factors that causes a fluctuation in the GNP. The difference between Fair's (1988) study and mine can be summarized in two points. Firstly, that Fair's study has interested in investigating the source of variability in the GNP, while this study tries, as stated above, to investigate the source of fluctuation in the inventories with more concentration on the role of inventories in the monetary transmission mechanism and the propagation of the business cycle. Second, even the group of variables that are used in Fair's study differ completely from the group of variables that will be used in my study.

Huh (1994) and Filardo (1995) used the VAR model to investigate if the role of inventories are still important in the business cycle as before, or if as mentioned by some economists, this role is muted. In those two papers the main focus was to test whether the relation between inventories and gross domestic product (GDP) has changed or not based on two different time-horizon samples. They investigated this relation by testing the prediction performance for 4-laged variables VAR model, and they applied that to two different samples, 1959.Q2-1980.Q4 and 1959.Q2-1989.Q4.

Herrera (2000) employed a VAR model and a structural linear quadratic inventory model to examine the relationship between oil price shocks and aggregate economic behavior through the effects in the U.S. manufacturing sector. Herrera used the VAR model to test the dynamic relation among the variables in the model as a first step in her research. In the second step she used those facts about the behavior to build a structural linear quadratic inventory model to study the behavior on the firm level. She found that inventories act as a buffer. In addition, the existence of inventories is responsible for the sluggishness of the aggregate output response to an oil price shock.

Jin (2001) used the VAR model to study the role of inventories in the monetary transmission mechanism, focusing on subcomponents of the manufacturing sector, which is the input inventory and the output inventory. My study however, will concentrate on the aggregate level of inventories and check if that role also exists on the sectors level (manufactories and retail trade inventories) and which is stronger. This target takes into consideration the results of other research such as Horenstein

(1998) and Bain (1985), who confirmed different behavior of different kinds of inventories.

## **2:3 Inventories During the Period 1930-1960**

### **2:3:1 Ralph Hawtrey (1930)**

In 1930, Hawtrey<sup>28</sup> considered that the analysis of business cycle relies on the analysis of inventories cycle. He said that the business cycle is a monetary phenomenon through a channel in which easy credit conditions and low interest rate enforce businessmen or producers to borrow to build up large inventories to support their businesses. These procedures stimulate both production and employment and lead to higher income and consumer expenditure. After that, the economic expansion and the rise in income cause the banks to lose reserves, which increases the interest rate and puts restrictions on bank loans. Thus, the producers try to liquidate the inventories stock, which means that the economy is going to a depression. Hawtrey argued that a large portion of the inventories is affected by the interest rate. At the same time, Hawtrey denied that the price inspires businessmen to produce more, which is considered by some economists as an extra award for the producers.

### **2:3:2 John Keynes (1930)**

In 1930 and 1936, contrary to Hawtrey, Keynes<sup>29</sup> divided inventories into two main parts: working capital and liquidity capital. Keynes considered that the working capital is a large portion of the inventories which support production and distribution; therefore, it fluctuates simultaneously with the output and

---

<sup>28</sup>For more details see Abramovitz (1950), pages 12-14.

<sup>29</sup>Keynes (1932).

approximately in the same proportion. In addition, Keynes believed that increase in prices is an incentive to invest more in the working capital or inventories, while the liquidity capital (extra inventories) is a small part of inventories and is affected by interest rate and insurance.

### **2:3:3 Wesley Mitchell (1937)**

In 1937, Mitchell<sup>30</sup> stated that inventories are an auxiliary factor in the business cycle in both the expansion and the contraction. In Mitchell's opinion, the incentive to build up inventories is the increase in prices and the rise in the economic activity.

### **2:3:4 Alvin Hansen (1941)**

In 1941, based on historical data from the United States economy concerning the business cycle, Hansen<sup>31</sup> distinguished between two kinds of cycles, major and minor. The former are due to fluctuation in the real investment in fixed capital including plant and equipment, housing and public construction, and their average length is eight years. The latter result from fluctuation in inventories, and their average length is four years. Based on the historical data, Hansen concluded that inventories consistently play an important role in the initiation of stimulation the economy after a major depression.

### **2:3:5 Lloyd Metzler (1941)**

Metzler (1941) made an important contribution to the body of inventory literature. He used a simple Keynesian model to show that fluctuation in inventory

---

<sup>30</sup>For more details see Abramovitz (1950), pages 9-11.

<sup>31</sup>For more details see Hansen (1941) pages 16-19, 60.

investment leads to a short-run business cycle. Metzler's work is an important contribution for two reasons: first, he showed that inventories play a leading role in the business cycle, and secondly his work gave some economists such as Blinder (1980) a hint for more research and development, which led to more pioneering developments and interesting results. Metzler's work consisted of six dynamic sequences based on different assumptions in a system consisting of output, sales, expectations, accelerator and desired level of inventories. The main idea in his contribution is that the economy searches to reach a desired level of inventories. If there is a disturbance in the economy, such as a change in the non-induced investment, then the economy will keep fluctuating until it reaches the desired level of inventories, which is considered a new stable equilibrium or a sign for the economy that this is the new equilibrium point. Metzler shows that the high parameters for the expectations and inventory accelerator make these fluctuations larger and it takes the economy longer time to reach the equilibrium. He used numerical examples to show his results. The general results of Metzler work can be summarized as follows:

- 1) Inventories tend to decrease as income increases because businessmen are unable to increase the output by the same amount as income increases.
- 2) After that, output tends to increase to meet both the increase in demand and to rebuild the inventories. The amount of replenished inventories depends on consumer spending.
- 3) Inventory investment cannot alter the equilibrium of income, which depends only upon the marginal propensity to consume and the amount of non-induced

investment. But it is clear from the six sequences that as long as the economy is far from the desired level of inventories, the fluctuations will keep occurring.

- 4) Inventory investment is an important source of destabilization of the economy.
- 5) There is a time lag relation among the variables, and order of which occurs first is based on Metzler's model; sales, output, and inventories<sup>32</sup>.

### **2:3:6 Moses Abramovitz (1950)**

Abramovitz studied the behavior of the manufacturing industry inventories and how that affected the business cycle during the interwar period based on statistical records of the U.S. economy. He chose the manufacturing industry because to a degree the data for other branches are less plentiful and partly because the study of the manufacturing stocks is complicated. He showed that inventories movements are important in the short-run business cycle; this result is consistent with Hansen's (1941) result mentioned above.

Abramovitz got his main result by calculating the average changes and business cycles to the GNP and its main components during the period 1919-1938.

After this estimation he wrote,

“These estimates are, of course, crude, but they are sufficiently accurate to establish several important propositions. One is that, on the average, a very considerable portion of the cyclical change in total output has taken the form of an alteration in the volume of goods added to stocks. A second is that, during ordinary business cycles, fluctuations in the rate of inventory investment as a whole have been larger, in terms of the value of goods involved, than those in construction or in the flow of durable goods to either producers or consumers. And a third proposition is that inventory investment, in terms of the violence of

---

<sup>32</sup>The order of the variables will be important in the empirical part of this study, and I will follow this order in the VAR model.

fluctuation, is the most volatile of the main components of output.” (p. 476).

Then he tested all the propositions and observations and found that they applied to every individual cycle and are not peculiar to only one or two<sup>33</sup>. Thus, he concluded fluctuations in inventory investments have a very great effect on the fluctuations of the gross national product.

In pages 93-94 Abramovitz described the behavior of total manufacturing inventories in constant price which is estimated by Kuznets and Terborgh during business expansion and contraction in the period 1915-1939. He explained,

“Perhaps the most striking feature of the graph is the regularity with which the peak and trough values of inventories lag behind the monthly reference dates. Beginning with the reference peak in 1920, a peak in inventories follows every peak in business and a trough in inventories every trough in business. This regularity is broken only in the expansion and of World War I and in the subsequent short contraction.” (p. 94).

### **2:3:7 Holt, Modigliani, Muth and Simon (1960)**

Until 1960s most the analysis of inventories was on the macroeconomic level. In 1960, Holt, Modigliani, Muth and Simon introduced the production smoothing / buffer stock model which is considered crucial for studying inventories behavior on the microeconomic level. This model is designed most naturally to study the inventories of finished goods in the manufacturing sector. Blinder and Maccini (1991a) explained that this type of model may not be the best choice<sup>34</sup>. The model is built based on the question of why firms hold inventories, and because there are different purposes for holding inventories, there are different models for studying the

---

<sup>33</sup>For more details see Abramovitz (1950) Table I page 5 and Table 84 pages 476-477.

<sup>34</sup>For more details see Blinder and Maccini (1991a) pages 78-79.

behavior of inventories. This model<sup>35</sup> has three assumptions: goods are storable, firms face a variable demand and the cost of production is convex. The main idea behind this model is that as long as the goods are storable, then a firm seeking to maximize its profit will use the inventories to smooth the production when the firm faces a variable demand on its goods or sales; or, in other words the main target is to reduce the variance of the output. Technically, the model has three implications. First, the production smoothing case arises from anticipated demand shock and forces the firm to have a higher output, higher sales and lower inventories. Second, excess inventory provides an incentive for the firm to reduce production, raise sales and carry some of the excess inventory to the next period. Third, an unanticipated sales shock will come entirely out of inventories and the production will increase in the next period. The increase in production will be less than the increase in sales. So, based on this model we can conclude the following two results: the sales have a positive relation with the output and negative relation with inventories, and the variance of the sales is greater than the variance of the output. The first conclusion is consistent with Metzler's numerical example results. The actual data on the aggregate level showed that this model did not work well. The behavior of data is exactly the opposite of what this model predicts: output is more volatile than sales and the inventories has a positive relation with the output and the sales. The discrepancies which showed up between theory and actual data motivate many economists to research more to explain this phenomenon.

---

<sup>35</sup>For more details see Fitzgerald (1997).

I can summarize what has been written about inventories during the period 1930-1960 by the following: economists agreed that inventories are responsible for the short-run fluctuation in the economy. Metzler (1941) gave a description to how inventories react with the other macroeconomic variables and showed that reaching the desired level of inventories is considered a sign for the economy that it is in disequilibrium. Also, it is clear there is a disagreement among the economists about the relation between inventories from one side and both the interest rate and prices from the other side. Furthermore, this period showed the appearance of the Production Smoothing Model (PSM), which is considered a new methodology to look to the inventories despite its being in trouble.

#### **2:4 Inventory Research During the Period 1975-2002**

Blinder and Maccini (1991b) pointed out that the interest in inventories behavior had declined during the period 1962-1975, and they explained this lack of research to the long economic expansion that occurred during this period, taking into consideration that inventories behavior is responsible for short-run economic fluctuations. In addition, scholars at that time started to believe that essential intellectual problems had been solved. In the mid of 1970s economists developed a renewed interest in the movements of inventories because they realized that the inventories fluctuations were the main cause of the 1973-1975 contraction in the U.S. economy. Blinder (1990) wrote the following paragraph in the introduction of his book (Page viii) describing this fact:

“I remember one day in the summer of 1975 when a CBO<sup>36</sup> staffer returned from congressional hearing with some amazing news. Alan Greenspan, then President Gerald Ford’s chief economic advisor, had just testified that the recession was mostly an inventory correction. We all snickered at the idea that what was, up to then, the deepest recession since the Great Depression could have been “only” an inventory cycle. When I subsequently studied the data more carefully, however, I learned that Greenspan had been right.”

During this period, economists succeeded in developing more techniques and methodologies and even models to study inventories and testing different hypotheses related either to the behavior of inventories or to its relation with other variables in the economy. In the next section, I will introduce some studies that are consistent with the general trend of this study.

#### **2:4:1 Louis Maccini (1976)**

The goal of Maccini’s paper was to describe the short-run dynamic relation between the price and the output in a product market behavior by using an aggregate model. The paper consisted of two main sections. In the first one, Maccini derived a model of a representative firm. In the second section, he constructed an aggregate model to study the aggregate behavioral relationship between the price and the output by making a suitable aggregation of the behavioral relationships for the price and the output derived in section one.

In this model, Maccini assumed that the firm holds finished goods inventories. He defined the inventories as a difference between output and orders. Technically, he assumed that the firm’s expected real cost function is a function of output, orders and inventories, and he explained the appearance of inventories in the

---

<sup>36</sup>CBO is The Congressional Budget Office.

firm's cost function for three reasons: to protect the firm against stockouts, holding large amount of inventories implies cost savings due to the greater production and distribution flexibility, and to increase storage costs and insurance costs that result from large inventories. Moreover, he assumed that the representative firm exhibits a monopolistic behavior.

Also, he defined the optimal plan of both price and output as a function of finished good inventories, orders, nominal wage and average price level. The behavioral assumption of the relation between the price and those variables is as follows: a reduction in the stock of inventories, an increase in the market orders, an increase in the money wage and an increase in the average price level will all motivate the firm to raise its prices, while, according to the output, a reduction in the stock of inventories, an increase in the market orders, a decrease in the money wage and an increase in the average price level will all motivate the firm to raise its output. The behavioral assumption is important in this model to follow up the dynamic relation among the variables in this model.

Based on the above behavioral relationships, Maccini introduced a theoretical dynamic analysis for two kinds of shocks for his model: a shock represented by an increase in aggregate orders, and a shock represented by a change in the money wage rate. In general, both shocks have the same impact on the path of output, inventories, orders and prices, therefore I will just show the dynamic behavior for the first shock. Maccini mentioned that an increase in the aggregate orders will have a direct effect on the system represented by an increase in price level and the output, but the output will increase less proportionally than the increase in the orders. As a result, the

inventory stocks will decline. These changes in the market force the firm to revise upward the price levels and the output. Ultimately, the increase in the price level and the decline in inventory stock motivate the output to rise to a level higher than the orders. When this happen, inventories start to increase, while, the output tends to decline until it reaches the new level of orders. At the same time, the increase in inventories tends to slow down the rising price level. In the end, these variables will reach the new equilibrium.

#### **2:4:2 Alan Blinder (1980)**

In 1980 Blinder made an important contribution to the body of inventory literature. His work came to develop Metzler's (1941) work. Blinder said that "Metzler's work lacks most of the meat that decorates the bones of contemporary macro models." (p. 90). Blinder (1980) added IS and LM equations and an aggregate supply curve and showed that inventory investment is countercyclical in the very short run but predominately procyclical over the business cycle.

Contrary to Metzler's belief, the main goal for Blinder's paper was to prove that inventories play a stabilizing role among the markets (commodity market and labor market) by explaining the link between the aggregate demand and the real output. Blinder used Barro's and Grossman's (1971, 1976) analysis to show his idea, which says if the prices and wages are sticky the market will not adjust in a flexible way or will not attain the full Walrasian general equilibrium in the short run. They explained that by assuming that if the producers cannot sell all the output they produced, the producers will react directly by cutting off the production and firing the workers. And, in this case, they say that the excess supply in the commodity

market “spills over” into the labor market. However, in the case of excess demand the workers are unable to buy the commodities they desire and therefore will react by reducing the hours of work. And, as in the above case, the excess demand in the commodity market “spills over” into the labor market.

The idea of Blinder’s in this paper is that, based on Barro-Grossman’s analysis, if the goods are storable this will help to reduce the imbalances in the goods market and as a result the producers will have enough time to adjust their employment and production decisions gradually and smoothly. Blinder mentioned that the motives for holding inventories (either input or output) play an important role for modeling them in a conventional macroeconomic model. He synthesized these motives as improved production scheduling, buffer stock, speculation on future price movements, reduced delivery lags and saved purchasing costs.

Blinder modeled the inventories as a factor of production by affecting the demand for labor, and he assumed that a policy change will affect the final sales but has no effect on the output. Blinder introduced a description to the dynamic adjustment path for a monetary shock. This model has many important results and I will mention the important ones:

- 1) A positive shock in the money supply will increase the final sales, which implies that inventories are affected in the opposite direction, because the model concludes that the policy will not affect the aggregate demand instantaneously. This conclusion implies an implicit positive relation between inventories and interest rate.

- 2) The effect (increase) of the output (or the supply side effect) happens when inventories start to decline to a noticeable level. Also, this increase is due to the inflation pressure which emerges in the economy because of the decline in the inventories.
- 3) The sales have a positive relation with the output and a negative relation with inventories. The output has a positive relation with the change in inventory.
- 4) This paper showed that a money supply shock will have a negative impact on the inventories. In addition, a reduction in the inventories will lead to increase the demand for labor.
- 5) The inflation rate plays an important role in restoring the equilibrium.
- 6) There is an important lag relation among the macro variables.

#### **2:4:3 Alan Blinder and Stanley Fischer (1981)**

In their paper, Blinder and Fischer proved theoretically an important fact about inventories. The existence of inventories in a model will make the shocks persist. In addition, they showed that adding inventories to the model makes the anticipated change in the money supply have a real effect through the inventories.

Blinder and Fischer used Lucas' supply function and an equation representing the demand for inventories to prove their point of view. Both equations technically are function of the same variables (inflation and inventories), and this way of modeling gives them the ability to show that inflation affects the output in two ways, directly and indirectly, through the inventory channel which lags the direct effect and continues for many periods because of the process of building back the inventories. The amount of effect depends on the values of the coefficients. We

can conclude from this result that if both inventories and output are affected by the same factors with a time lag effect, then as long as the inventories are part of the output this implies that the inventories dynamics play an important role in the propagation mechanism of the business cycle. And this result is important for this dissertation.

#### **2:4:4 Laura Rubin (1979)**

At that period of time, the relation between the interest rate, inflation and the inventories started to motivate the economists for more research because of the unacceptable conclusions. Lovell (1976) concluded that inventories are insulated from credit crunch and inflation, and he also said that from his own empirical work over the years the probability of obtaining a negative significant relationship between the interest rate and inventories is 50 percent. Based on the above-mentioned facts, Rubin (1979) tried to study the effects of uncertainty, interest rates and inflation on aggregate inventories behavior by using quarterly data during the period 1965-1978.

To achieve this goal, Rubin used the flexible accelerator model to test her hypothesis. As a general principle, this model assumes that the planned inventories are a fraction of the difference between the desired level of inventories and the actual level. Rubin derived this model, concluding that the aggregate total inventories is a function of the following variables: current and lagged consumption, current and lagged new orders, uncertainty<sup>37</sup>, the interest rate of four to six month commercial

---

<sup>37</sup>She measured this variable as the absolute value of the change in the percentage change in the real final sales, intended to isolate the volatility of sales movements and times trend.

paper, imports, the industrial production and the inflation rate measured by the percentage change in the inventory stock deflator.

Rubin found the interest rate has a significant negative effect on the inventories. Also, she found that inflation has a positive effect on the inventories but at the 5 percent level of significance. Rubin explained this positive relation as the increase in the price level providing the incentive for firms to build more inventories.

#### **2:4:5 Charles Lieberman (1980)**

It is clear from the previous works of Rubin (1979) and Irvine (1981) that there is a lack of empirical evidence for the cost of capital as a major factor affecting inventories. Therefore, Lieberman tried to re-examine the size and the significance of the cost of capital effect on inventories by utilizing a new measurement for the cost of capital proposed by the finance theory. Lieberman computed the cost of capital by using the actual balance sheet capitalization particular to each firm in the sample for each point in time. He explained using this method instead of the market interest rate to avoid the measurement errors. In the case studies, Lieberman used two samples of firms, each sample disaggregated by stage of fabrication (total inventory, raw materials, work in process and finished goods). The first sample consisted of 40 firms which produce heavy machinery (output produced to order). The second sample was comprised of 19 firms of textile companies (output produced to stock). Lieberman used data from the annual industrial compustat tapes, produced by the Standard and Poor's Corporation, covering the period 1970-1976.

To test this relation Lieberman used a model justified by many economists<sup>38</sup>. His final model shows that the demand for inventories is a function of the following variables: the level of real sales, the real cost of capital, an appropriate price index to obtain real magnitude<sup>39</sup> and the real order backlog. The real cost of capital, which is something new in this study, consists of the weighted average of each firm's after-tax cost of debt, preferred stock and common stock.

Lieberman's main conclusion showed that the inventories are sensitive for both the change in the cost of capital and the inflation rate. The degree of sensitivity varies from one sample to another and from one stage of fabrication to another. Specifically, his results confirmed a negative relation between inventories and the cost of capital. However, the relation with inflation rate doesn't have a unified sign because sometimes it turns out to be negative.

#### **2:4:6 Owen Irvine (1981a)**

As mentioned by Irvine, the motive behind his study is that earlier empirical studies failed to find a significant relation between the interest rate and inventories, despite the fact that economic theory confirms that the level of inventory a firm desires to hold should have a negative relation with the cost of holding that amount of inventory. In addition, he said that most of the recent studies have ignored the possible relation between inventory target level and inventory carrying cost. He

---

<sup>38</sup>For more details see Lieberman (1980) page 349.

<sup>39</sup>He used not-seasonally-adjusted wholesale price index for machinery and equipment to deflate nominal terms associated with the machinery industry, and a not-seasonally-adjusted wholesale price index for textile products and apparel to deflate the nominal magnitude related to the textile industry.

defined the target inventory as a function of expected future sales and expected inventory carrying costs.

Irvine used a derived linear inventory cost function to test his hypothesis. He applied his study to the merchant wholesaler (MW) inventories which form approximately 18% of both the manufacturing and trade stocks at that time, and he used a monthly data during the period 1968-1980. In his estimations, he used Hall-Jorgenson's (H-J) service cost of capital which is comprised of the following components<sup>40</sup>: consumer price index, production price index, expected inflation rate and short term interest rate. In addition, in some equations he used those components separately, short term interest rate (prime bank interest rate) and the expected inflation with equal weight, and he concluded that the separation gives better results (Irvine, p. 96).

Irvine found that there is a very significant negative relationship between the inventories and the short-term interest rate. But, he failed to find a statistically significant effect of the inflation on the inventories. The results in Table 2 showed that the relation between inventories and inflation rate tend to be negative in some cases. It is useful to mention that Irvine applied the same methodology on retail inventories and got the same results<sup>41</sup>.

#### **2:4:7 Patricia Reagan (1982)**

This study aimed to explore the role of inventories in the optimal pricing and production decisions of a monopolist facing uncertain demand. Therefore, Reagan

---

<sup>40</sup>For more details to this formula look at Irvine (1981a) page 25.

<sup>41</sup>For more details look at Irvine (1981b).

developed a theoretical model for a monopolist that holds inventories and seeks to maximize the present discount value of an intertemporal profit function subject to demand uncertainty.

The main conclusion of Reagan's paper is that if the demand is low, this means that the firm accumulates inventories which in turn reduce the pressure on the prices. But, if the demand is high, this implies that the inventories are depleted, which will lead to more pressure on the price to rise to clear the market. This conclusion is close to the result reached by Blinder (1980) in his model.

#### **2:4:8 M.A. Akhtar (1983)**

The main goal of Akhtar's work was to investigate the effect of the interest rate and the inflation rate on the behavior of the aggregate inventory level. Akhtar pointed out that most of the inventory studies focused on the behavior of specific sectors or components of the total inventories, therefore making it difficult to generalize the results. For this reason he used the aggregate inventory level in his model.

Akhtar used the stock-adjustment or flexible accelerator model, and this kind of model assumes each firm tends to adjust its inventories to a desired level. His model assumed that inventories are a function of expected aggregate sales, short-term nominal interest rate, expected inflation and capacity utilization. He used a quarterly data for the sample period 1965-1981 and for the subperiod 1972-1981. The reason for using a subperiod is based on the fact that starting from 1972 the economy was marked with high and more variation in inflation and interest rate than the main part of the sample period. His results confirmed his hypothesis: both the

interest rate and the inflation rate have a statistically significant effect on the behavior of the inventories. And, the results confirmed that the relation between inventories and interest rate is negative, while the relation with inflation rate is positive.

#### **2:4:9 Patricia Reagan and Dennis Sheehan (1985)**

Reagan and Sheehan tested two main hypotheses: First, do manufacturing inventories by stage of fabrication<sup>42</sup> in both durable and non-durable sectors move together over the business cycle? Second, do final good inventories and backorders behave in a negative and symmetric manner over the business cycle?

To achieve the goal of this study, they used a VAR model with five variables: materials and supplies inventory, work in progress inventory, final goods inventory, unfilled orders and output, which is measured by the industrial production index. They used monthly data from the manufacturing sector of the U.S. economy over the period 1959-1980 and used 12 months as a lag length in their model.

The study has many conclusions; the main one is that this study rejected the above two hypotheses which implies that different types of inventories have different behavior. Both inventories of final goods and backorders play an important role in explaining the movement in output. In general, this study proved that disaggregating manufacturing inventories by stage of fabrication is helpful in predicting fluctuations in output. Also, they found that input inventories play a crucial role in explaining the fluctuation in output in both the durable and the non-durable sector.

---

<sup>42</sup>These are divided into materials and supplies, work in process and final goods.

## **2:4:10 Lawrence Christiano (1988)**

Christiano tried to answer the question of why the inventory investment fluctuates so much. He used a modified real business cycle developed earlier by Kydland and Prescott (1982) in which unexpected shocks to the technology and preferences cause a disturbance to the economy.

Christiano proposed two casual explanations to show the importance of the role played by the inventories in the economy: First, the fixed investment decisions in any quarter have been made before the agents have full information about the economy. Second, consumption is a very smooth time series and appears to be relatively unresponsive to disturbances. Those two observations clarify the role that the inventories are supposed to have in the economy. Based on the first observation, unexpected preference or technology shock will fall on the consumption and the inventories because the fixed investment decisions have already been made, whereas the second observation proposes that most of the burden will fall on the inventories. This scenario means that the role of inventories in the economy as a buffer stock or as a residual explains the volatility of the inventories in the economy.

Empirically, Christiano used the modified real business cycle model to prove this fact. He found that if there is no residual role for the inventories the model can only explain less than half the observed volatility in inventories. However, if there is a residual role for the inventories, the model can account for most of the observed volatility in inventories. The result of his research implies that all the shocks in the economy directly affect inventories even more than direct impact on output; this supports the propagation role of inventories.

## 2:4:11 Valerie Ramey (1989)

The main goal of Ramey's paper is to investigate the role of inventories in economic fluctuations, to achieve this goal she treated inventories as a factor of production. Technically, Ramey derived the demand for inventories by stage-of-processing<sup>43</sup>, applicable to industries that produce to order. She did so by assuming that the cost function of holding inventories is a function of the prices of different inventories<sup>44</sup>, nominal wage rate, interest rate, the capital and the level of shipment (output). And by using Shephard's Lemma, the derivatives of the cost function with respect to the factor prices, she got the factor demands. Then she estimated the coefficients of these demand functions for the three inventories in addition to the demand for labor. The empirical part of this study applied to the industrial level, and she used non-seasonally-adjusted quarterly data over the period 1960-1984.

The main conclusion of Ramey's paper is that the unobserved shocks<sup>45</sup> (error terms), or what is called the factors that make a shift in the demand for inventories, can explain 60 percent of the change in inventory investment during a recession period. Ramey pointed out that these shocks may represent a specification error due to measurement error or the functional form. On the other hand, she stated that the proponents of real business cycle theories argue that those shifts are technological

---

<sup>43</sup>This includes materials and supplies inventories, goods-in-process inventories and finished goods inventories.

<sup>44</sup>The rental price for materials and supplies, goods-in-process and finished goods.

<sup>45</sup>Represents the fluctuations in inventories not explained by the measured factor prices and the output.

shocks. Moreover, Ramey found that 40 percent of the change in inventory investment could be explained by change in output (accelerator effect). Consequently, Ramey found that inventories do not play an important role in the monetary transmission mechanism. This result is consistent with Sprague and Wacker (1996), who said that from their experience in working with firms on inventory issues and problems the firms in the short run do not change their inventory planning and control practices. Even Blinder and Maccini (1991a) confirmed that there is no strong empirical evidence for the relationship between interest rate and inventories. In general, Ramey concluded that inventories are an important propagation mechanism and an important source of shocks.

#### **2:4:12 Giovanna Mossetti (1990)**

This paper used a theoretical dynamic general equilibrium model of a competitive monetary economy with a storable good and cash-in-advance constraint where output, inside money and inventories are determined endogenously to describe the comovements of output, inventories and inside money. In this model inventories are held because of speculative purposes.

Mossetti highlighted the different roles played by inside and outside money in the business cycle. He mentioned that the former fluctuates when inventories change in response to a labor productivity shock in order to take advantage of future capital gains. The latter is used for transaction purposes and affects the price level. This implies that the inside money is related more to the economic activity in comparison with the outside money. This conclusion was first proved by King and Plosser (1984).

The main result of the model is that output, inventories and inside money are positively and serially correlated. He explained the positive relation by saying a labor productivity shock increases the wages in the economy and this means increasing the saving deposits or the inside money. Increasing the inside money implies that economic activity will rise which motivates the firms to borrow to invest more in production and investment because of the expected capital gains due to the change in future prices. In addition, he concluded that inventories smooth the fluctuation of prices, real wages, real interest rate and sales and inventories enlarge changes in production. Mossetti explained this result by saying that inventories help the firm to react to a positive productivity shock by increasing production.

#### **2:4:13 David Bivin (1993)**

Based on the evidence that inventory behavior in the manufacturing sector differs by stage of fabrication, Bivin (1993) tried to explore the impact of the different types of inventories behavior in the manufacturing sector on the output, price and total inventory.

To achieve his goal, Bivin used a model consisting of three equations<sup>46</sup> which were not derived in his paper but exist in the literature. The structure of these equations rely on a technique developed by Hansen and Sargent (1981) which implies that the endogenous variables are expressed as a function of their lagged values and anticipated values of the exogenous variables in each period. And, as long as expected values of the exogenous variables are unknown, they assumed that those variables follow an autoregressive process.

---

<sup>46</sup>Output equation, price equation and total inventory equation.

The difference between Bivin's study and the study of Reagan and Sheehan (1985) relies on three areas; first, Bivin's study used more disaggregated data<sup>47</sup>; second, the estimation approach was considered a fundamental difference; and third, Bivin's study used monthly data from the U.S. economy over the period February 1968 to October 1989, while Reagan's and Sheehan's (1985) study covered the period 1959-1980.

The main conclusion for Bivin's (1993) paper was that manufacturing inventories by stage of fabrication has a significant impact on the price and the output, but this effect varies from one type to another. Also, his results confirmed that price and output have a less sensitivity for the finished goods of the manufacturing inventories. Moreover, the results confirmed that inventory behavior differs by stage of fabrication.

#### **2:4:14 Michael Lovell (1994)**

The goal of Lovell's paper is to focus on why we didn't learn more about inventories during the last four decades, especially in the fundamental policy area or the sensitivity of inventories to the short term interest rate. Many papers, research studeis and dissertations were written on this topic. Lovell mentioned several factors that play important roles for not learning more about inventories, including:

- 1) Feedback effect: Lovell mentioned that Metzler's (1941) model shows how inventories can make cycles in the economy but at the same time there is a high probability for a feedback effect running from the inventories to the effective

---

<sup>47</sup> He used data on the industrial level.

demand, enforcing the firm to respond by revising the production schedule, manipulating prices changing advertising expenditure and adjusting delivery lags.

2) Production smoothing: Lovell explained that the firm is, in general, interested in smoothing the production efficiently, but this does not necessarily make the variance of the production less than the variance of sales for two reasons: first, the production process behaves irregularly, and it depends on the speed and the capacity of the machines, in addition to the setup costs for every process of production. Second, he called this “the fallacy of composition,” meaning that in the case of interacting firms, if the individual firms attempt to smooth production relative to the sales, this might affect the sales of a group of firms which are the supplying firms.

3) Speed of adjustment: This is the time needed to fill the gap between actual and desired inventory level. Lovell mentioned that the speed of adjustment based on the flexible accelerator model is slow because the speed is related to many factors, for example seasonal merchandise, the wait for the construction of additional storage capacity and inventories at the storage place which comprises some defective items, wrong orders and certain items which have production mistakes and which are not replaced in a timely manner. Therefore, this slow speed of adjustment might not give a complete idea about the behavior of inventories. Contrary to Lovell’s belief, Maccini and Rossana (1984) formulated a multivariate flexible accelerator or stock-adjustment model for investment in finished good inventories, and they found that

the speed of adjustment is high<sup>48</sup>. Moreover, Maccini and Rossana (1981) had the same results. Lovell's general conclusion was that we have been trying to answer fundamental, important and difficult questions using an inexpensive research paradigm: a lot of calculus, a little data and a fast computer.

#### **2:4:15 Chan Huh (1994) and Andrew Filardo (1995)**

Because of the uncertain nature of inventories fluctuation in the U.S. economy, a new idea showed up in the 1990s. This idea can be synthesized in the following way: During the last two decades many firms have succeeded in managing and controlling their inventories by reducing the costs and strengthening their balance sheets, thus this new methodology<sup>49</sup> in dealing with inventories at the firm level has raised the possibility that inventory behavior has changed in the economy, which implies that the behavior of the business cycle has changed too. Based on the above-mentioned idea, some economists suggest that the inventories movements look less obvious; therefore, they conclude that the business cycle might be more muted. On the contrary, some economists said that this idea might be premature and inventories are still as important in the business cycle as before.

Huh (1994) used the VAR technique to examine whether the prediction performance of the VAR model had remarkably deteriorated as a tactic to check whether the role of inventories in the business cycle has changed or not. He relied on the fact that if there is a significant shift in the relation between the output and the

---

<sup>48</sup>Blinder (1986) mentioned that despite the excellent effort of Maccini and Rossana, he is not quite sure that they succeeded in explaining why estimated adjustment speed in stock-adjustment models of inventory behavior is high.

<sup>49</sup>For more details see Allen (1995).

inventories then this implies that there will be a change in the forecasting power of the VAR model. To test this important fact, he calculated a VAR model using four variables: change in RGDP, change in inventory investment, consumer price index and the six-month commercial paper rate, and he estimated his model for two different periods 1959.Q2-1980.Q4 and 1959.Q2-1989.Q4. And then he used both models to forecast the inventory investment for the period 1994 through 1996. He found that the difference in the forecast is small and statistically insignificant. Therefore, he concluded that the effect of technological developments in the management inventory is not significant at this point. Also, the relation between inventories and output does not appear to have shifted since 1980.

Filardo (1995) tried in his paper to test whether the role of inventories in the business cycle has changed or not. He used two methodologies, trend analysis and regression evidence. The former is called a model-based method<sup>50</sup>, and the latter updated Huh's (1994) study (VAR model) for five more years. He applied three additional tests in order to explore a change in the link between inventories and aggregate output. These tests were, a test to measure stability of the regression parameter, a test to measure stability of the response of inventories and aggregate output to unforeseen changes in economic activity and a test to measure the forecast accuracy. Filardo found a little evidence to support the idea that inventories are playing a reduced role in the business cycle. Therefore, he concluded that adopting new inventory control practices failed to make the inventory and the business cycle more muted. It is useful to mention that the results in Table 1.1 support this

---

<sup>50</sup>This is an economic model developed by Bechter and Stanley (1992).

conclusion because this table shows that during the period 2000.4-2001.3, the ratio of the change in inventory to the change in RGDP is 212.0%, which implies the relation still strong and not muted.

#### **2:4:16 Donald Allen (1997)**

In his paper, Allen was motivated to answer two questions raised by Lovell (1994). First, do firms use inventories to schedule production efficiently? Or, in other words do firms use inventories to smooth production in the face of uncertain demand? Second, do the problems of data aggregation play a crucial role in confirming the production smoothing role of inventories? To answer those two questions, Allen used firm level data from compustat<sup>51</sup>, and he relied on the 2-digit Standard Industrial Classification (SIC) code for both the firm level and aggregate level.

Allen found that the aggregation of data does not present a major obstacle in confirming the production smoothing role of inventories. But, Allen's work failed to confirm that the firms use inventories to smooth production at this level<sup>52</sup>. Allen explained this result by differentiating between the planned (target) inventories and unplanned inventories. The former increases when the demand on the firm's product increases, and this means that there is a positive relation between the planned inventories and the sales, which makes the production more variable than the sales. The latter reflect the buffer stock motive, which implies that unexpected positive

---

<sup>51</sup>This is a data base which contains financial information from 6984 firms across several SIC codes.

<sup>52</sup>He failed to prove that the variance of the value of production to the variance of the value of sales is less than one.

shock to the sales will be compensated from the inventories, but this decline in inventories is insufficient to make the variance of production less than the sales. In other words, this explanation is related to the methodology by which the firms manage their inventories.

**2:4:17 Andreas Hornstein (1998)**

Horenstein used the Bandpass filters<sup>53</sup> to distinguish between the irregular components and the business cycle components of the inventories, output and sales. Then he analyzed the data, and he found the following results. First, the inventory investment fluctuations are not important for output fluctuation over the business cycle, but are important for short-term output fluctuation, which is consistent with Abramovitz (1950) and Hansen (1941). Second, over the business cycle, we cannot attribute total inventory investment volatility to its individual components, because all components are highly correlated or inventory investment moves much the same in each sector, which means all of them are fluctuate. Consequently, Bain (1985) mentioned that the different components of aggregate inventories do not behave uniformly, especially the amplitudes of fluctuation and the phase shifts relative to GNP. Also, he said some components of total inventories show more volatility than the total inventory does. Third, inventory investment is positively correlated with sales over the business cycle but tends to be uncorrelated or negatively correlated with sales for short-term fluctuations. Fourth, production tends to be more volatile than sales, and this implies that the cost shocks are more important than demand shocks.

---

<sup>53</sup>Those filters are moving average and are used to separate the business cycle (regular) components from the irregular components for a time series variable. For more details see Baxter and King (1995).

In general, the results of Horenstein gave an indicator that there is a feedback relation among the variables. So, we have to pick up these feedbacks to see how those variables comove with each other.

**2:4:18 Ana Maria Herrera (2000)**

The main goal of Herrera's paper was to study the dynamic effect between the price of oil and the economic growth. To achieve this goal Herrera divided her paper into two main parts. The first one used the VAR model to investigate the relation among the variables. Herrera used the 4-lag VAR model with the following variables: real sales, oil prices and inventory-sales ratio. In addition, she applied this model at the U.S manufacturing sector and its components which include twenty two-digit manufacturing industries, three-digit industries (motor vehicles and other transportation equipment) and three aggregates (total manufacturing, durable and nondurable manufacturing goods) measured in 1992 chained dollars. In the second part of her study, she built a structural linear quadratic inventory model to represent the dynamics of an oil shock with a rational behavior by the firms and apparent production-cost schedules.

The main finding of her paper was that inventories in the short run act as a buffer; in addition, the existence of inventories is responsible for the sluggishness of the aggregate output response to an oil price shock. Also, she found that the various industrial sectors respond in different way to the oil shock and that this response depends on the cost structure of the industry, the dynamics of the demand and cost and oil shocks.

## **2:4:19 Yi Jin (2001)**

In a recent dissertation Jin aimed to investigate empirically the role of inventories in the transmission mechanism by concentrating just on the components of manufacturing inventories by dividing them into input inventories and output inventories<sup>54</sup>. Her dissertation follows this methodology because input inventories are twice as large as output inventories<sup>55</sup> and three times more variable. It is useful to mention that Allen (1995) proved that there is a noticeable decline in the inventories of the work-in-progress, and in the materials and supplies even more than the finished goods, Allen attributed that to the new inventory management used at the beginning of the 1980s.

In the first part of the study Jin used the VAR model, focusing only on the response of the two components of manufacturing inventories to a monetary shock; her paper was silent on issues such as the relation between the inventories and output, sales and other kind of shocks in the economy. The VAR model in Yin's paper was comprised of eight variables: which they are; real sales, real stock of input inventories, real stock of finished goods inventories, price index, total reserves, non-borrowed reserves plus extended credit, money stock and federal fund rate.

In the second part of her study, Jin built a dynamic quantitative general equilibrium model to study the impact of the credit constraint on the behavior of inventories. In addition, she made a connection between the monetary contraction

---

<sup>54</sup>Input inventories: the sum of materials and supplies and work-in-progress inventories. Output inventories are the manufacturing finished goods inventories.

<sup>55</sup>Manufacturing inventories accounts for 37% of the total inventories in 2001.

and the credit constraint. Jin modeled both components of manufacturing inventories (input and output inventories) and dealt with them as factors of production.

Jin's work proved first that inventories of the submanufacturing level (input and output inventories) play an important role in the monetary transmission mechanism; this result is completely opposite of that reached by Ramey (1989). Second, Jin showed that, on the firm level, when credit constraints are imposed to a subset of firms, a monetary contraction hits the credit-constrained firm more than the non-constrained firms. The size of contraction for credit-constrained firms is much larger. According to inventories behavior, she found that the non-credit-constrained firms build up inventories slightly before declining, while credit-constrained firms have to shed inventories due to lack of financing funds.

#### **2:4:20 Maurice Larrain (2002)**

The target of Larrain's paper was to study the aggregate sales, inventories and interest rate from a macroeconomic point of view, specifically to answer the following question: Do interest rates lead real sales and inventories? Larrain used the spectral analysis which seeks to identify the statistically significant cycles and lead-lag relationships by decomposing the time series into their component frequencies. This kind of analysis is a useful applied technique in economics.

Larrain found that changes in the interest rate have a leading long-run negative statistical relation with sales growth. In addition, he found that sales are positively correlated and lead the inventories. Based on the above two relationships, Larrain considered that there is an indirect negative and leading relationship running

from the interest rate to the inventories or, in other words a monetary transmission mechanism through the aggregate sales.

## **Chapter Three**

### **The Methodology**

#### **3:1 Historical Brief for Using the VAR Model**

In the 1940s and 1950s some economic theorists and econometricians developed an econometric technique to estimate macro econometric models. Those economists were known as the Cowles Commission for Research in Economics, which was founded by businessman and economist Alfred Cowles in 1932. The Cowles Commission was initially established in Colorado Springs under the directorship of Charles F. Roos, and then in 1939 it moved to the University of Chicago under the directorship of Theodore O. Yntema. The Cowles Commission was dedicated the efforts to link economic theory to mathematics and statistics. Its main contributions in economics lie in two fields, general equilibrium theory and econometrics. The names of Koopmans, Tobin, Simon and Marschak are famous in this school. This methodology has been known as the traditional structural model or structural multi-equation modeling<sup>56</sup>.

In the 1970s and 1980s some economists such as Sims (1980) criticized this technique. These criticisms took three dimensions. The first is related to determining

---

<sup>56</sup>For more details please check:  
<http://cepa.newschool.edu/het/schools/cowles.htm>  
[http://cowles.econ.yale.edu/reports/20yr/his\\_index.htm](http://cowles.econ.yale.edu/reports/20yr/his_index.htm)

the endogenous and the exogenous variables in the model or endo-exogenous division of variables, because in the simultaneous models some variables are considered endogenous and at the same time exogenous. From a formal point of view, the endogenous variables are defined as the variables determined inside the model, and the exogenous variables are defined as the variables determined outside the model. Usually, it is known that in a single equation the variables on the right hand-side of the equation are exogenous, while the variables on the left hand-side are endogenous variables, but this doesn't apply in the structural multi-equation modeling. The following simple Keynesian model shows this idea:

$$Y_t = C_t + I_t \quad (3:1)$$

$$C_t = a + b \cdot Y_t + e_t \quad (3:2)$$

Where  $Y_t$  stands for the level of aggregate demand,  $C_t$  for the level of consumption,  $I_t$  for the level of investment,  $a$  and  $b$  are the estimated coefficients, and  $e_t$  is the stochastic error. Based on the above definition, it is clear from the equations (3:1) and (3:2) that it will be confusing to determine which variables are endogenous and which are exogenous. In addition, it is important in this kind of model to determine which variables are exogenous and which variables are endogenous because the Cowles economists became clear with exogeneity, the causation running from the exogenous variables to the endogenous variables. It is apparent from equation (3:2) that an unexpected positive shock in  $C_t$  through the error term ( $e_t$ ) will affect  $Y_t$  through equation (3:1), which in turn will affect  $C_t$ . Thus, in this kind of model it is impossible to change  $C_t$  without changing  $Y_t$  and at

the same time it impossible to change  $Y_t$  without changing  $C_t$ . But, it is possible to change both of them if  $I_t$  is changed. Therefore, in such a model, both  $C_t$  and  $Y_t$  are described as endogenous variables and  $I_t$  is considered an exogenous.

The second criticism is related to estimation of the equation (3:1): this equation cannot be estimated by the ordinary least squares because there is a relation between the stochastic error ( $e_t$ ) and the explanatory variable ( $Y_t$ ), and this criticism arises up because of the simultaneity of both  $C_t$  and  $Y_t$ . This point is a violation for one of the classical linear regression assumption models<sup>57</sup>. And to solve this problem we have to translate the structural system in (3:1) and (3:2) to a restricted reduced form as follows:

$$Y_t = (a/1-b) + (1/1-b)*I_t + (1/1-b)*e_t \quad (3:3)$$

$$C_t = (a/1-b) + (b/1-b)*I_t + (1/1-b)*e_t \quad (3:4)$$

The reduced form in equation (3:3) proves that the covariance between  $Y_t$  and  $e_t$  is not equal to zero or  $E(Y_t * e_t) = (\sigma_{e_t}^2 / 1-b)$ .

The third one is related to the identification problem,<sup>58</sup> which means whether numerical estimates of the parameters of a structural equation can be obtained from the estimated reduced form coefficients. So, if this can be done we say the system of equation is identified. But, if we cannot do this kind of estimation and we have to add new variables to the structural form to help in identifying the system of equations, we call this case underidentified. And, in some cases we have to exclude some variables if we have too much information, which is known as zero restrictions

---

<sup>57</sup>This is a violation for the assumption 6 in Gujarati (1995) which proposed zero covariance between the error term and the explanatory variables.

<sup>58</sup>For more details about the identification problem see Gujarati (1995), pages 657-669.

criterion or overidentified. Based on that, the identification problem requires adding or excluding some variables, and this addition or subtraction may be without any economic meaning or economic explanation<sup>59</sup>.

In the same direction, Enders (1995) pointed out that Sims also criticized what is known as the “Saint Louis equation” estimated by Anderson and Jordan in 1968. This equation has been used to measure the effect of government policies (monetary and fiscal policies) on the gross national product (GNP). Sims’ criticism was that this equation did not take into consideration the feedback effect from the GNP to both the monetary base and the budget deficit. Sims said that this assumption is not reasonable, because if the government through its policies tries to change the GNP there will be a feedback effect from the GNP to the government policies. Besides, he assured the lag length of the Saint Louis equation and mentioned that the lag length is supposed to be appropriate unless the equation has serially correlated residuals, which leads to biased coefficient estimates.

Sims (1980) in his work tried to eliminate these problems, and he viewed all these theoretical restrictions as an obstacle to the estimation process. Thus, in Sims VAR model there is no problem of exogenous variables and there no restrictions imposed. In addition, there is no strict economic theory to formulate a VAR model, and there is room for the feedback effect among the variables. In sum, Sims’ work means that everything causes everything to change which implies that all the variables are endogenous and there is no reason to have a lot of incredible restrictions. Charemza and Deadman (1997) pointed out that the above simplification

---

<sup>59</sup>For more details about those criticisms see Charmeza and Deadman (1997).

made some economist call Sims' methodology atheoretical macroeconometrics, but those two economists considered Sims work revolutionary with far-reaching consequences. Sims developed this framework by moving from the original bivariate (1972) to the trivariate (1980).

### **3:2 Introduction to the VAR Technique**

The main goal of this study is to examine the short-run dynamic relation between inventories and selected macroeconomic variables based on the literature review. This investigation will help to explain the role of inventories in economic fluctuation. The VAR model will be used as the main technique to investigate the interrelationship among the variables. There are several reasons behind using the VAR technique in this study. First, as mentioned by Sims above, this technique is simple and has few restrictions and not much strict theoretical ground. Second, this technique acknowledges the feedback effect among the variables. Lovell (1994) confirmed lack of knowledge about the feedback effect of inventories on the other variables in the economy as a reason for not learning more about inventories. Also, this point was confirmed by Sims as an important point to verify the feedback impact among the variables, especially in the case of studying the policy behavior. Third, it has been proved by many economists such as Evans and Kuttner (1998) and Christiano, Eichenbaum and Evans (1996) that the VAR technique is useful in describing the monetary policy and studying the monetary transmission mechanism. My study will focus on the role of inventory in the monetary transmission mechanism as the first specific objective. Also, Bivin (1993) pointed out that using the VAR model is needed and valid in the area where the underlying theory is not

able to provide enough structure to build a reduced form models, and this applies in the case of inventories. Fourth, in the case of inventories, Granger and Lee (1989) used a new concept, multicointegration, which means a vector of integrated series is multicointegrated if the accumulated sum of stationary (cointegrated) linear combination is again cointegrated with itself. They concluded this based on data for 27 US industry and industrial aggregates for the period January 1967 to April 1987 in 1982 constant dollars and seasonally adjusted that those three variables, RGDP, RFS and TINV, can be cointegrated, as long as the VAR model is a special case of the cointegration and error correction model. Therefore, my study is trying to investigate the dynamic relation among the variables within the new concept.

### **3:2:1 Nature of the VAR Model**

The VAR technique assumes all the variables inside the model are endogenous. This assumption means dealing with all the variables equally because of the endo-exogenous definition of the variables or the lack of confidence to divide the variables into either exogenous or endogenous. Assume we have a first-order bivariate vector autoregression model (VAR):

$$X_t = a_{10} + a_{11} Y_t + a_{12} X_{t-1} + a_{13} Y_{t-1} + e_{xt} \quad (3:5)$$

$$Y_t = a_{20} + a_{21} X_t + a_{22} X_{t-1} + a_{23} Y_{t-1} + e_{yt} \quad (3:6)$$

Where both  $X_t$  and  $Y_t$  are stationary,  $e_{xt}$  and  $e_{yt}$  are uncorrelated white noise disturbances with a standard deviations of  $\sigma_{ext}$  and  $\sigma_{eyt}$ , respectively. It is clear from the above VAR system that all the variables are endogenous and it includes a feedback effect among the two variables since each one affects the other. Equation

(3:5) in the above system shows that the coefficient  $a_{11}$  measures the contemporaneous effect of a unit change of  $Y_t$  on  $X_t$ , while the coefficient  $a_{13}$  measures the effect of a unit change in  $Y_{t-1}$  on  $X_t$ . On the other hand, equation (3:6) shows that the coefficient  $a_{21}$  is the contemporaneous effect of a unit change in  $X_t$  on  $Y_t$ , and the coefficient  $a_{22}$  measures the effect of a unit change in  $X_{t-1}$  on  $Y_t$ . It is important to note that if the coefficient  $a_{11}$  is not equal to zero, then  $e_{yt}$  has an indirect contemporaneous effect on  $X_t$ . And, if  $a_{21}$  is not equal to zero too, then  $e_{xt}$  has an indirect contemporaneous effect on  $Y_t$ . The system of equations in (3:5) and (3:6) is called the structural VAR model because it includes the contemporaneous effect among the variables.

This structural VAR system cannot be estimated because of two reasons. First, it is clear from equations (3:5) and (3:6) that  $X_t$  is correlated with stochastic term  $e_{yt}$  and at the same time  $Y_t$  is correlated with the stochastic term  $e_{xt}$ . And this fact goes against the assumption of the classical linear regression model which requires that the explanatory variables not be correlated with the error terms<sup>60</sup>. To identify the model and make it solvable by using the ordinary least squares (OLS), we need to get the reduced VAR model. To write the reduced form we need to directly substitute the value of  $Y_t$  from equation (3:6) into equation (3:5) and the value of  $X_t$  from equation (3:5) into equation (3:6), and we get the following reduced form:

$$X_t = A_{10} + A_{11}X_{t-1} + A_{12}Y_{t-1} + U_{xt} \quad (3:7)$$

$$Y_t = A_{20} + A_{21}X_{t-1} + A_{22}Y_{t-1} + U_{yt} \quad (3:8)$$

---

<sup>60</sup>This is exactly the same point which is mentioned as a criticism by Sims (1980) against the Cowles Commission structural model.

Where

$$A_{10} = (a_{10} + a_{11}a_{20}) / (1 - a_{11}a_{21})$$

$$A_{11} = (a_{12} + a_{11}a_{22}) / (1 - a_{11}a_{21})$$

$$A_{12} = (a_{13} + a_{11}a_{23}) / (1 - a_{11}a_{21})$$

$$A_{20} = (a_{20} + a_{21}a_{10}) / (1 - a_{21}a_{11})$$

$$A_{21} = (a_{22} + a_{21}a_{12}) / (1 - a_{21}a_{11})$$

$$A_{22} = (a_{23} + a_{21}a_{13}) / (1 - a_{21}a_{11})$$

$$U_{xt} = (e_{xt} + a_{11}e_{yt}) / (1 - a_{11}a_{21}) \quad (3:9)$$

$$U_{yt} = (e_{yt} + a_{21}e_{xt}) / (1 - a_{21}a_{11}) \quad (3:10)$$

A second reason why the above structural VAR model cannot be estimated is that the number of parameters to be estimated in the structural VAR is ten parameters<sup>61</sup>, while the number of the parameters in the reduced VAR is nine<sup>62</sup>. Therefore, to make this system exactly identified we have to restrict one of the parameters in the structural VAR model. The above-mentioned way is a general external way to transfer the structural form to a reduced form. Internally, we have to impose a restriction on one of the structural equations' parameters (such as  $a_{11}=0$ ), which means that  $Y_t$  doesn't have a contemporaneous effect on  $X_t$ . Imposing restrictions has an important implication on how the shocks will affect the endogenous variables in the reduced form. From (3:9) and (3:10), it is clear that both innovations ( $e_{xt}$  and  $e_{yt}$ ) have a contemporaneous effect on both  $X_t$  and  $Y_t$ , respectively. However, if we impose one restriction such as  $a_{11}=0$ , it is obvious from

---

<sup>61</sup>They are  $a_{10}$ ,  $a_{20}$ ,  $a_{11}$ ,  $a_{21}$ ,  $a_{12}$ ,  $a_{22}$ ,  $a_{13}$ ,  $a_{23}$ ,  $\sigma_{e_{xt}}$  and  $\sigma_{e_{yt}}$ .

<sup>62</sup>They are  $A_{10}$ ,  $A_{20}$ ,  $A_{11}$ ,  $A_{21}$ ,  $A_{12}$ ,  $A_{22}$ ,  $\text{Var}(U_{xt})$ ,  $\text{Var}(U_{yt})$  and  $\text{Cov}(U_{xt}, U_{yt})$ .

(3:9) that the shock term ( $e_{xt}$ ) only has a contemporaneous effect on  $X_t$ , and this means that shock term ( $e_{yt}$ ) has no impact on  $X_t$ . Decomposing the impact of the residuals in this way called the Choleski decomposition<sup>63</sup>.

Applying the VAR requires testing whether the time series used in the model is stationary or non-stationary (has a unit root). So, if the series is stationary on the level we can apply the VAR model, and it may be applied to the first difference of the data<sup>64</sup>. If the data is non-stationary cointegration, a test will be applied. Cointegration means that the variables have long-run equilibrium. Variables to be cointegrated are supposed to have the same order level, which means that all the non-stationary variables are stationary after making the same difference, but not all similarly integrated variables are cointegrated. Therefore, the practitioners of the VAR model run another test called the cointegration test after running the stationary test. The dynamic relation between the variables is determined by the values and the sign of the estimated coefficient.

### **3:2:2 The Shocks in the VAR Model**

The VAR analysis depends mainly on the shock analysis through two techniques; forecast error variance decomposition (FEVD) and impulse response function (IRF), which I will explain in detail in the coming section. Thus, the question arises of why this analysis depends on shocks. The VAR method concentrates on the deviation from the rule, which is defined as the policy makers will announce in advance how the policy will respond to different economic

---

<sup>63</sup>For more details see Enders (1995) pages 291-304.

<sup>64</sup>This represents the case where all the error correction terms in the cointegration equations are equal to zero, which means the error correction model doesn't work correct, and as a result we apply the VAR model to the first difference.

situations and commit themselves to follow up this announced promise<sup>65</sup>. So, from the VAR model point of view this deviation can be measured by two methods. The first one can be obtained by changing the systematic components of the monetary policy or the coefficient of the factors determining the money supply equation<sup>66</sup>, whereas the second can be attained by using shocks or the unsystematic portion of the policy while leaving the systematic components of the money supply unchanged. The first method does not take into consideration the change in people's expectations which in turn affects the economic behavior, which is known as the Lucas Critique. On the other hand, using the shocks method just describes how the variables react with each other and there is no issue related to people's expectations.

Favero (2001) pointed out that some economists criticize the choice of the VAR models for using shocks in the analysis<sup>67</sup>. The main reason for this criticism is that the shocks concentrate on the unsystematic portion of the monetary policy which is small and leave the systematic component, the larger portion, unchanged. Consequently, Favero (2001) said that "the simulation of systematic monetary policy requires, for robustness to the Lucas Critique, the specification of a forward-looking model in which 'deep parameters' are identified independently from nuisance parameters and describing expectations formation and dependent on the policy regime" (p. 173).

---

<sup>65</sup>Mankiw (2000), Pages 392-393.

<sup>66</sup>For more details about those coefficients and equation see Favero (2001), pages 162-174.

<sup>67</sup>For more details about the criticisms of the VAR model see Walsh (1998).

Also, Favero (2001) mentioned that the VAR approach to the monetary transmission mechanism is fruitful because it concentrates on the deviation from the rules, not on the rules themselves, and this enables the central banks to collect interesting information for the response of the different macroeconomic variables to the deviation in the monetary policy. Besides, this valuable information could be compared with the prediction of different theoretical models.

### **3:3 Uses of the VAR Model**

The properties of the VAR model can be described by its uses. The literature review revealed many uses for the VAR such as causality test, impulse response analysis, variance decomposition, forecasting, hypothesis-seeking and tests of theories<sup>68</sup>. This study will focus on the first three uses which I will describe in the following part of this study.

#### **3:3:1 Granger Causality Tests**

Granger (1969) defined the causality among the time series variables in a context of the VAR model, assuming only stationary series are involved. His definitions of the causality concept concentrate entirely on the ability of one series to predict the other series. This point was confirmed by Hamilton (1994, p. 307) who used empirical examples to show his ideas, and he said that:

...this does not mean that these series *cause* GNP or inflation to move up or down. Instead, the values of these series reflect the market's best information as to where GNP or inflation might be headed. Granger-causality tests for such series may be useful for assessing the efficient markets view or investigating whether markets are concerned with or are able to forecast GNP or inflation, but should not be used to infer a direction of causation.

---

<sup>68</sup>For more details about these uses Cooley and LeRoy (1985) and Enders (1995).

In his paper, Granger (1969) defined causality in many ways. In general, his definition is: if we have two series ( $X_t$  and  $Y_t$ ), we say  $Y_t$  is causing  $X_t$  if the variance of the error term of forecasting the series  $X_t$ , using only the lagged values of the series  $X_t$ , is greater than the variance of the error term of forecasting the series  $X_t$  using the lagged values of both series  $X_t$  and  $Y_t$ . Another way to say this is that, we are better able to predict the series  $X_t$  by using all the available information of the both series  $X_t$  and  $Y_t$  than by using only the information of the  $X_t$  series. If  $Y_t$  fails to Granger-cause  $X_t$ , we say that  $X_t$  is exogenous in the time series sense with respect to  $Y_t$ . Or,  $Y_t$  is linearly informative about the future of  $X_t$  (Hamilton 1994, p. 303). In addition, Granger (1969) stated that if  $Y_t$  Granger-causes  $X_t$ ,  $Y_t$  is said to be causally prior to  $X_t$ . Hamilton (1994) didn't agree with this direction of relation, and he proved by an empirical example that this statement is not precise for some time series. To show those forms of definitions, assume the following structural VAR model and its reduced form:

$$X_t = a_{10} + a_{11}Y_t + a_{12}X_{t-1} + a_{13}Y_{t-1} + e_{xt} \quad (3:11)$$

$$Y_t = a_{20} + a_{21}X_t + a_{22}X_{t-1} + a_{23}Y_{t-1} + e_{yt} \quad (3:12)$$

$$X_t = A_{10} + A_{11}X_{t-1} + A_{12}Y_{t-1} + U_{xt} \quad (3:13)$$

$$Y_t = A_{20} + A_{21}X_{t-1} + A_{22}Y_{t-1} + U_{yt} \quad (3:14)$$

Where  $U_{xt}$  and  $U_{yt}$  are uncorrelated.

- 1) Unidirectional<sup>69</sup> causality from  $Y_t$  to  $X_t$  takes place in the model if the estimated coefficient on the lagged value of  $Y_t$  ( $Y_{t-1}$ ) in the reduced form (equation 3:13) is statistically different from zero ( $A_{12} \neq 0$ ) and if the estimated coefficient on the lagged value of  $X_t$  ( $X_{t-1}$ ) in equation (3:14) is not statistically different from zero ( $A_{21} = 0$ ). In contrast, there will be a unidirectional causality from  $X_t$  to  $Y_t$  if the estimated coefficient on the lagged value of  $X_t$  ( $X_{t-1}$ ) in equation (3:14) is statistically different from zero ( $A_{21} \neq 0$ ) and the estimated coefficient on the lagged value of  $Y_t$  ( $Y_{t-1}$ ) in equation (3:13) is not statistically different from zero ( $A_{12} = 0$ ).
- 2) Feedback effect: This means that  $Y_t$  is causing  $X_t$  and at the same time  $X_t$  is causing  $Y_t$ . This kind of causality is proposed in the reduced form when the estimated coefficient on the lagged value of  $Y_t$  ( $Y_{t-1}$ ) in equation (3:13) is statistically different from zero ( $A_{12} \neq 0$ ) and at the same time the estimated coefficient on the lagged value of  $X_t$  ( $X_{t-1}$ ) in equation (3:14) is also statistically different from zero ( $A_{21} \neq 0$ ).
- 3) Instantaneous causality: This kind of causality occurs when the current value of  $X_t$  is better predicted if the current value of  $Y_t$  is included in the prediction than if not included. This kind of causality can be shown in the structural model. If the estimated coefficient of the current  $Y_t$  ( $a_{11}$ ) in equation (3:11) is statistically different from zero, then we can say  $Y_t$  is instantaneously causing  $X_t$ . On the other hand, if the estimated coefficient of the current  $X_t$  ( $a_{21}$ ) in equation (3:12) is

---

<sup>69</sup>This concept used by Gujarati (1995), page 621.

statistically different from zero, and then we can say  $X_t$  is instantaneous causing  $Y_t$ .

The relationship between the instantaneous causality and the lagged causality<sup>70</sup> is justified through the relation derived earlier, which is:

$$A_{12} = (a_{13} + a_{11}a_{23}) / (1 - a_{11}a_{21})$$

This equation connects the coefficients of the structural form with the reduced one. It is clear from this relation that to have a case in which  $Y_t$  fails to Granger-cause  $X_t$ ,  $A_{12}$  should be equal to zero, i.e. both  $a_{11}=0$  and  $a_{13}=0$  in equation (3.11). This then implies that we have neither instantaneous causality nor any kind of causality from  $Y_t$  to  $X_t$ . On the contrary, if  $Y_t$  fails to instantaneously cause  $X_t$  ( $a_{11}=0$ ), then this doesn't imply that  $Y_t$  fails to Granger-cause  $X_t$  ( $A_{12} = 0$ ). This means that this test may show an instantaneous causality from  $Y_t$  to  $X_t$  despite  $X_t$ ' being exogenous with respect to  $Y_t$ .

Sims (1972) studied empirically the causality between money and income. Sims proposed a methodology to test the causality between the variables based on analogue to Wold's causal chain form for a static econometric model. In addition, his methodology assumed a unidirectional causality (no feedback causality) according to the definition developed by Granger (1969). Similar to the Granger test,  $Y_t$  fails to Granger-cause  $X_t$  in Sims test (1972) if, in a regression of  $Y_t$  on lagged and future value of  $X_t$ , the coefficient values of the future values are not statistically different from zero. Hamilton (1994, p. 308) expressed Sims' causality test in an econometric form as:

---

<sup>70</sup>In this case I am talking about the causality from  $Y_t$  to  $X_t$ .

$$Y_t = c + \sum_{j=0}^{\infty} b_j X_{t-j} + \sum_{j=1}^{\infty} d_j X_{t+j} + \eta_t \quad (3:15)$$

Where  $E(\eta_t X_\tau) = 0$  for all  $t$  and  $\tau$ .

According to equation (3:15)  $Y_t$  fails to Granger-cause  $X_t$  if and only if  $d_j = 0$  for  $j=1, 2, 3, \dots$

Cooley and LeRoy (1985, p. 286) gave an example to clarify the difference between Granger and Sims tests, and they said as long as the present and the past values of  $Y_t$  fail to predict  $X_t$  (Granger test,  $X_t$  is strictly exogenous), then, according to Sims' test, the future values of  $X_t$  will not change or effect the prediction of  $Y_t$ .

### **3:3:2 Impulse Response Function (IRF)**

As I mentioned earlier, the analysis of the VAR model depends on analyzing the impact of the shocks. The IRF is one of the two tools used by the VAR model to examine the effect of the shocks. This technique was introduced by Sims (1980) to inspect the directions and the channels of the interrelationships among the variables. The main task for the IRF is to trace the effect of a one standard deviation to one of the innovation on the current and future values of the endogenous variables in the VAR (E-views user guide 1994-1997).

Technically, the IRF connects the shocks or innovations in the structural VAR model to the endogenous variables in the reduced VAR form through innovations in the reduced form. A complete derivation for the IRS is in Appendix A, and I will just use the final equation to describe the characteristics of this technique.

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} \mu_{yt} \\ \mu_{xt} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \Phi_{11}(i) & \Phi_{12}(i) \\ \Phi_{21}(i) & \Phi_{22}(i) \end{bmatrix} \begin{bmatrix} e_{yt-i} \\ e_{xt-i} \end{bmatrix} \quad (3:16)$$

It is clear from the moving average representation form<sup>71</sup> (3:16) that it contains the innovations of the structural VAR model. The coefficient matrix  $\Phi_i$  is used to show the impact of the innovations  $e_{yt}$  and  $e_{xt}$  on the time path of both series  $Y_t$  and  $X_t$ . Therefore, the coefficients of the matrix ( $\Phi_{jk}$ ) are called the impulse response functions. To give an example of how those coefficients work, the coefficients  $\sum \Phi_{11}$  and  $\sum \Phi_{12}$  show the impact of a unit change over time in  $e_{yt-i}$  and  $e_{xt-i}$  on  $Y_t$ , while the coefficients  $\sum \Phi_{21}$  and  $\sum \Phi_{22}$  show the effect of a unit change over time in  $e_{yt-i}$  and  $e_{xt-i}$  on  $X_t$ .

The IRF will not be available or cannot be estimated if the estimated VAR model is under identified or, alternately if the innovations of the reduced VAR form are correlated to each other. This implies, as stated above, that we have to impose some restrictions on the structural VAR form, especially the values of the contemporaneous effect to transfer the model from under identification to either exact identification or over identification to make it potentially estimated.

The shape of the IRF gives an indicator if the results are consistent with the theory or not. In general, the empirical results of many economists<sup>72</sup> confirmed two

---

<sup>71</sup>It represents a manner which is able to express or construct a time series by multiplying the stochastic error for each period by the associated value of the coefficient. For more details see Enders (1995), pages 63-68.

<sup>72</sup>For more details see Lutkepohl and Reimers (1992), Shbikat (2000), Favero (2001) and Jin (2001).

main points about the shape of the IRF. First, the shape is supposed to be constant, or a straight line after some quarters from the shock, which implies that a shock has an effect for a certain period of time, and besides, this tells that the effect of the shock is decayed. Second, the IRF has to converge either to zero (in this case the effect is called transitory) or to a new level, where the effect is called permanent. Therefore it is not expected to see an explosive impulse response function.

### **3:3:3 Forecast Error Variance Decomposition (FEVD)**

To understand the forecast error variance decomposition statistically, detailed analysis is provided in Appendix A. It is clear from the equations (13 and 14) in appendix A that the VAR model splits the variance into several parts related to the shocks in the model. This equation shows that the forecast error variance of each variable can be expressed as a linear combination of its own current and lagged errors and the current and lagged errors of all the variables in the model. Therefore, the FEVD shows the relative importance of each shock in the VAR model. Or, the variance decomposition gives information about the relative importance of each random innovation to the variable in the VAR. From a technical point of view, if  $U_{yt}$  shocks do not explain any of the error variance of  $X_t$ , then we can say that  $X_t$  is exogenous.

It is clear from the statistical appendix that the equation of FEVD depends on the IRF. Therefore, the FEVD has the same problem as the IRF. That is, this technique cannot be used if the estimated VAR model is under-identified, and in that case we have to use the Choleski decomposition to solve this problem.

### **3:4 Important Issues Related to the VAR Model**

There are many issues which are important in applying the VAR model; researchers are supposed to take those matters into consideration when they use this technique. Those issues include ordering of the variables and the lag length.

#### **3:4:1 Ordering of the Variables**

Ordering of the variables in the VAR model is related directly to the use of Choleski decomposition to make the model either exact identification or over-identification. As I mentioned earlier, if I want the system of the VAR model to be solved, then I have to impose a restriction on either equation (3:9) or (3:10) by assuming either  $a_{11}$  or  $a_{21}$  equal to zero. Therefore, if we assume that  $a_{11}=0$ , this implies from (3:10) that both  $e_{yt}$  and  $e_{xt}$  shocks have a contemporaneous effect on  $Y_t$ . But, from (3:9) it is clear that  $e_{xt}$  has a contemporaneous effect on  $X_t$  while  $e_{yt}$  shocks have an indirect effect on  $X_t$  through the lagged values of  $Y_t$ . Thus, based on this reasoning, it is clear that  $e_{xt}$  shock directly affects  $U_{xt}$  and  $U_{yt}$ , whereas  $e_{yt}$  shock affects only  $U_{yt}$ . Hence we can consider  $X_t$  an exogenous variable and is supposed to be ordered before to  $Y_t$ . The empirical results of the VAR model are sensitive to the ordering of variables and there is no econometric method to help in ordering those variables. Most researchers order the variables based on the previous information on how those variables affect the economy. This problem is considered one of the deficiencies of the VAR model.

#### **3:4:2 Lag Length**

As a general principle, it is clear that it is possible to use a large number of variables in the VAR model, and we assume the existence of a theoretical base for

their selection<sup>73</sup>. In addition, it is important to determine the appropriate lag length for the VAR model because the empirical result is sensitive to the chosen lag length in the systems of equation in the VAR model. There are many techniques that can help to determine the lag length. In this study I will use the two forms of the likelihood ratio statistic (LR), akaike information criterion (AIC), and schwarz bayesian criterion (SBC).

It is useful to mention that the frequency of the data in the VAR model plays a crucial role in determining the time horizon of the relation among the variables. That is, if the study seeks to capture the short-run relation between the variables, monthly data or quarterly data might be used, while if the study is interested in the long-run relation, yearly data are supposed to be used.

### **3:5 Cointegration and the Error Correction Model**

Cointegration is needed when we have a linear combination of two or more nonstationary variables. Cointegration means that the integrated variables have a long-run equilibrium. Therefore, the time paths behavior of the cointegrated variables is affected by the deviation from the long-run equilibrium. Hence, if the economy is out of the long-run equilibrium, for the economy to return to the equilibrium at least one of the variables will respond to the magnitude of the disequilibrium, which is known as the error correction model (ECM). Based on that, if we have  $(n \times 1)$  vector  $X_t = (X_{1t}, X_{2t}, X_{3t}, \dots, X_{nt})$  of cointegrated variables, then

---

<sup>73</sup>Fair (1988) used 23 variables in his VAR model.

the ECM representation can be written in the following form<sup>74</sup>:

$$\Delta X_t = \pi_0 + \pi X_{t-1} + \pi_1 \Delta X_{t-1} + \pi_2 \Delta X_{t-2} + \pi_3 \Delta X_{t-3} + \dots + \pi_p \Delta X_{t-p} + \epsilon_t \quad (3:17)$$

Where

$\pi_0$  : an  $(n \times 1)$  vector of intercept term with elements  $\pi_{i0}$ .

$\pi$  : is a matrix with element  $\pi_{ik}$  such that one or more of the  $\pi_{ik} \neq 0$ . Those elements are known as the speed of adjustment parameters or long-term parameters.

$X_{t-1}$  : is the cointegrating vector.

$\pi_i$ :  $(n \times n)$  coefficient matrices with elements  $\pi_{ik}$  (i). Those coefficients are known as short-run parameters.

$\epsilon_t$ : an  $(n \times 1)$  vector with elements  $\epsilon_{it}$ .

The term  $\pi X_{t-1}$  is the error correction term. It is clear from the above form that the ECM model is in the difference form, and for this reason the data on the level are supposed to be non-stationary to apply the cointegration, and as a second step we need to test that all the integrated variables in the model are stationary of the same order. If there are variables and all of them are stationary after applying the same difference or they have the same order, this doesn't mean that they should be cointegrated. A cointegration test should be made to determine that. If this test fails to prove the cointegration relation among the variables, this means there is no long-run equilibrium among those variables.

---

<sup>74</sup>Source Enders (1995) page 367.

It is important to note that if all the elements  $\pi_{ik}$  in the matrix  $\pi$  are equal to zero, then this means that  $\Delta X_t$  doesn't respond to the deviation from the long-run equilibrium, which confirms that the error correction model doesn't work in this case. Moreover, in this case the model is transformed to a traditional VAR in the first difference. On the contrary, if one or more of the elements  $\pi_{ik}$  differs from zero, then this implies that the error correction model works in this case. It is obvious based on the above presentation that the VAR model is considered a special case of cointegration and the error correction model; the only difference is the error correction term. Both of them used the IRF and FEVD to analyze the results.

It is useful to mention that the existence of cointegration will limit the work of Granger causality. The reason is that in the cointegration technique the variables are ordered in the model based on their exogeneity. Therefore, a necessary condition for the exogeneity of the first variable in order is not to be affected by the current and past values of the variable(s) ordered later. This means that we may have just only one direction of the Granger causality, whereas the other direction is already eliminated. In the error correction model, equation (3:17), we have two sources of Granger causality which are represented by the speed of adjustment parameters ( $\pi$ ) and the short term parameters ( $\pi_i$ ). Therefore, we can say that  $X_t$  does not Granger cause  $\Delta X_t$  if and only if the long-term parameter of  $\Delta X_t$  and all the short-term parameters of  $X_t$  are equal to zero<sup>75</sup>.

---

<sup>75</sup>For more details see Engle and White (1999), page 117, and Enders (1995) pages 315-316 and 366-367.

As long as the individual coefficients of both the ECM and VAR models are very difficult to interpret, the users of those two techniques depend mainly on both the impulse response function (IRF) and the forecast error variance decomposition (FEVD) tools to investigate the dynamic relationship among the variables in the model. In analyzing the IRF, we expect to see two shapes for this tool. To explain this important point, assume that we have a system of cointegrated variables and it is placed on the equilibrium which is represented at the origin of the coordinate system, and this implies that all variables have a zero value in the equilibrium. Thus, if we have a one-time shock on a variable and this variable returns to its previous equilibrium (zero) after a period of time, this effect is called transitory. But, if this variable doesn't return to the zero equilibrium and settles at different equilibrium value, the effect will be called permanent<sup>76</sup>.

---

<sup>76</sup>For more details see Lutkepohl and Reimers (1992).

**Chapter Four**  
**Empirical Results and Analysis I**  
**“Aggregated Data”**

**4:1 Introduction**

This chapter examines the dynamic relationship on both sides; the role of inventories in the monetary transmission mechanism and the relation between inventories and prices. In addition, it investigates the role of inventories in the propagation of business cycle by studying the feedback effect from inventories to the different macroeconomic variables. This chapter deals with these targets from the aggregate data point of view, while the next chapter will investigate the same targets from the perspective of disaggregating data. The VAR model is the main technique used to investigate these relationships, and it will be applied to data from the U.S economy over the sample period 1959.1-1997.4. As long as the VAR model is a special case of the cointegration and the error correction model (ECM) techniques, we must go through several steps to determine the best model to fit the data under investigation.

The first step<sup>77</sup>, is to find out the best model is to test the stationarity of each series in the model by using the augmented Dickey Fuller test (ADF) because the data the first difference of each series, it must be stationary (less than unity) of the same degree. This condition, i.e. “the stability condition,” is important for the cointegration and the VAR analysis because of two reasons. First, it is important to derive the IRF and to show that the series converges to the long-run level, which implies that the shape of the response function will be a straight line after the effect of the shock is decayed. The second reason is to guarantee that the effects of the past disturbances turn out to be smaller over time<sup>78</sup>.

The second step is to determine the lag length. Because the VAR model is sensitive to this issue, inappropriate lag length leads to misspecification of the model, while long lag length leads to the loss of degrees of freedom and reduces the confidence of the estimations. To determine the appropriate lag length, this study will use three measures: likelihood ratio (LR), akaike information criterion (AIC), and schwarz criterion (SC).

The third step is to check if the group of the non-stationary series is cointegrated, or whether there is long-run equilibrium, by applying Johansen’s cointegration test. If this group of series is cointegrated we have to use the error correction model (ECM). Johansen’s test gives an idea about the number of the cointegration vectors or what is known as the cointegrating ranking. Thus, if we have N endogenous variables, each of which is stationary at the first difference, there can

---

<sup>77</sup>For more details see E-views 3, user guide 1994-1997, chapter 19.

<sup>78</sup>For more details see Enders pages 297-310.

be from zero to  $N-1$  cointegrating relations. If there are no cointegrating vectors then we can apply the unrestricted VAR model to the first difference of the data. On the other hand, if there is only one cointegrating vector, it implies that we have to add one error correction term to each equation in the VAR model. Each additional cointegration relation means we have to add additional error correction terms to each equation in the model. But, if there are exactly  $N$  cointegration relations, and none of the series has a unit root, then we can apply the unrestricted VAR model on the levels of the series<sup>79</sup>.

#### **4:2 The Data in the Model**

The variables in this study can be divided into two categories: real term variables and nominal term variables. The former is comprised of; RGDP, RFS, TINV, MINV and RINV. The latter encompasses  $M_2$ , MM, NBR, CC, FFR, and P. Appendix B defines all these variables. All the variables are in log linear form except for FFR, in percent. It is important to mention that P is the price index measured by the implicit price deflator for private inventories 1996=100<sup>80</sup>. The reason for choosing this index is that the ADF test shows this index is the only stationary P variable at the first difference for different lags over the period of the study, while the CPI and GDP deflator are stationary at the second difference. Figure 4.1 shows the three series of prices, and it is clear that the implicit price deflator for inventories has the same trend as the CPI and the GDP deflator, but it is flatter over

---

<sup>79</sup>For more details see E-views 3 user guide, pages 506-507.

<sup>80</sup>Rubin (1979) used the percentage change in this index in her study as a proxy for inflation rate. Also, Akhtar (1983) used price deflator for inventory investment as one scheme for price expectations.

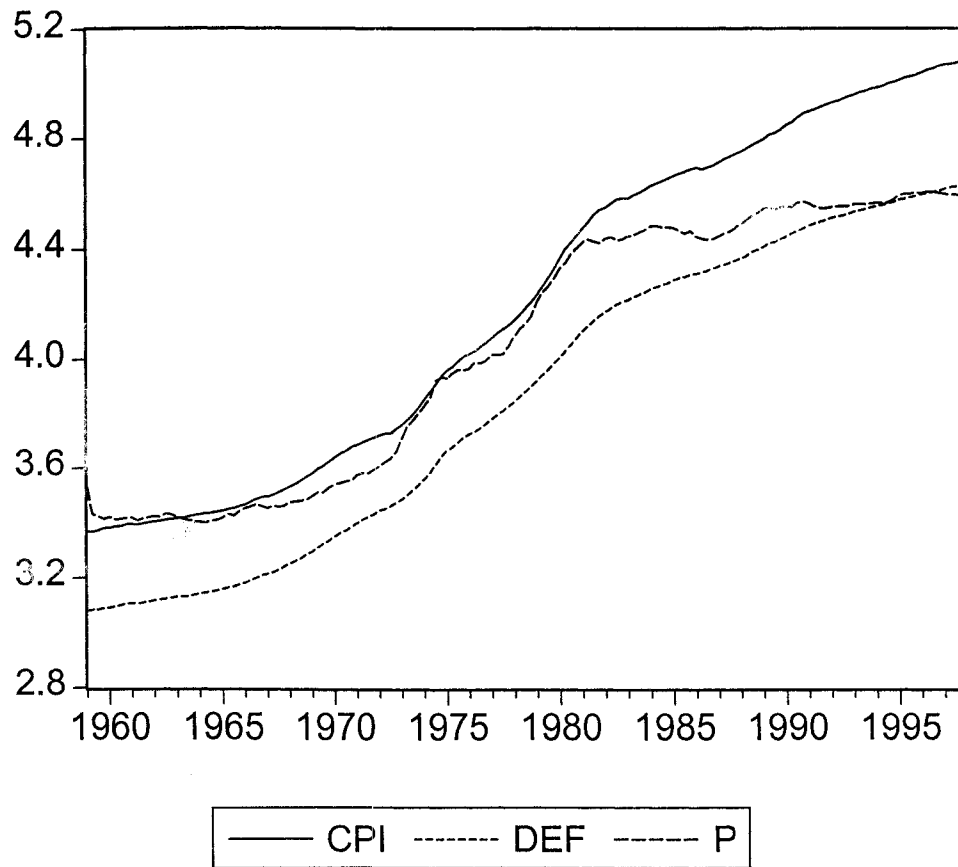


Figure 4.1 : The Three Price Indicators; CPI, GDP Deflator (DEF) and Inventory Deflator (P)

the period of the study which makes it stationary at the first difference; therefore, I chose it as a proxy for the price indicator.

It is useful to mention that the data for inventories in this study represents stock. Therefore, the change in inventories in this study is calculated based on change from quarter to quarter, and this means those numbers will not fit the numbers appearing in the national accounts because the ones that appear in the national accounts are calculated based on change from quarter to quarter at the annual rate. This implies that the data in this dissertation doesn't fit the equation  $\Delta \text{INV} = \text{RGDP} - \text{RFS}$ .

#### 4:3 Unit Root Test

Usually, the macroeconomic time series data has a time trend and we can say that this series has a unit root, which implies that the mean and the variance of the series vary over time. For this reason, it is hard to evaluate the effect of a shock on this series or to try to make a forecast until we transform this series into stationary or detrended.

To figure out if a series has a unit root or not, this study will apply the augmented Dickey-Fuller test (ADF). The ADF test can be expressed in three regression equations<sup>81</sup>:

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{i=2}^p \beta_i \Delta Y_{t-i+1} + \epsilon_t \quad (4:1)$$

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + \sum_{i=2}^p \beta_i \Delta Y_{t-i+1} + \epsilon_t \quad (4:2)$$

---

<sup>81</sup>See Enders, pages 221-222.

$$\Delta Y_t = a_0 + a_2 t + \gamma Y_{t-1} + \sum_{i=2}^p \beta_i \Delta Y_{t-i+1} + \epsilon_t \quad (4:3)$$

It is clear from the above regression equations that the first one is a random walk model, the second has a drift term<sup>82</sup> ( $a_0$ ) and the third one has both a drift term and a linear time trend ( $a_2 t$ ). Practically, those three options are available when we run the test through a statistical package, i.e. E-views. In addition, we have the option to include the desired number of lag length in the regression to test the hypothesis on different lags to confirm the results. Regardless of how many lags we have in the model or if we have drift or linear time trend or both, the test of the unit root test is the interest in the coefficient of  $Y_{t-1}$  in the regression ( $\gamma$ ). Therefore, if this coefficient is significantly different from zero, then the null hypothesis that  $Y_t$  has a unit root is rejected. Basically, to reject the null hypothesis at 10% confidence level, the augmented Dickey Fuller test statistic is supposed to be negative and less than (-2.58). It is useful to mention that the unit root statistic test does not follow the usual t-student's distribution. Dickey and Fuller (1979) and recently MacKinnon (1991, 1996) derived asymptotic results and simulated critical values for various test and sample sizes.

Table 4.1 shows the augmented Dickey Fuller test statistic for both the series level and the first difference and four lags. For the series level, comparing the statistics presented in the table with the critical values of the augmented Dickey Fuller test reported at the bottom of the table proves that the hypothesis of unit root

---

<sup>82</sup>Means intercept.

cannot be rejected at any series level and at any significant level, and this implies that all the series are non-stationary. According to the first difference level of the data, it is obvious from the augmented Dickey Fuller test statistic that the hypothesis of unit root can be rejected at any significant level and this means that the first difference for all the series are stationary.

**Table 4.1 Augmented Dickey Fuller Test Statistics**

Series	No. of Lags	The Level	1 <sup>st</sup> Difference	Series	No. of Lags	The Level	1 <sup>st</sup> Difference
RGDP	1	-0.99	-6.36	NBR	1	-0.45	-9.44
	2	-1.09	-5.70		2	-0.35	-7.11
	3	-1.21	-5.20		3	-0.43	-5.42
	4	-0.93	-5.26		4	-0.56	-4.49
RFS	1	-1.36	-6.18	MM	1	-1.66	-3.84
	2	-1.08	-4.98		2	-1.90	-3.10
	3	-1.32	-4.77		3	-1.90	-3.26
	4	-1.31	-4.53		4	-1.75	-2.84
P	1	-1.20	-5.27	FFR	1	-2.49	-8.29
	2	-1.00	-4.07		2	-2.21	-6.36
	3	-1.34	-2.71		3	-2.32	-5.24
	4	-1.31	-2.81		4	-2.52	-4.92
TINV	1	-1.55	-5.56	CC	1	2.36	-3.74
	2	-1.77	-4.96		2	1.32	-4.00
	3	-1.67	-5.29		3	1.28	-4.12
	4	-1.57	-4.67		4	1.44	-3.71
MINV	1	-2.14	-4.62	M <sub>2</sub>	1	-1.87	-4.59
	2	-2.15	-4.73		2	-1.89	-3.72
	3	-2.14	-4.64		3	-1.96	-3.67
	4	-2.05	-4.73		4	-2.13	-2.81
RINV	1	-0.86	-7.63				
	2	-0.90	-5.60				
	3	-0.97	-5.54				
	4	-0.57	-5.00				

Note: The critical values for the ADF test are -3.47, -2.88 and -2.58 at 1%, 5% and 10%, respectively.

#### 4: 4 Applying the VAR Methodology Using Aggregate Date

In this part of the study I will use aggregate data for six variables to investigate the dynamic relation among them. Those variables include money supply ( $M_2$ ), federal fund rate (FFR), real final sales (RFS), real gross domestic product (RGDP), price index (P) and total inventories (TINV). It has been proved in the above section that these variables are non-stationary at each series level and stationary at the first difference level or integrated at the same order  $d(1)$ . Therefore, these variables have the chance to be cointegrated. Before running the cointegration test (Johansen's test), I want first to determine the appropriate lag length among those six variables.

##### 4:4:1 The Estimated Lag Length

As I mentioned at the beginning of this chapter, this study will use three measures<sup>83</sup> to find out the suitable lag length. These measures are:

First, Likelihood Ratio (LR)

$$LR = (T-c) (\log |\sum L_i| - \log |\sum L_j|) \sim \chi^2 ([L_j-L_i] n^2)$$

Where  $T$  is the number of the usable observation,  $c$  is the number of regressors included in the longest equation,  $|\sum L_i|$  determinant of the residuals covariance matrix for  $L_i$  lag,  $\log$  is the natural logarithm,  $L$  is the number of the lags, and  $n$  is the number of the restrictions in the system. Empirically, we have to compare the calculated LR, which has a  $\chi^2$ -distribution, with the tabulated value and

---

<sup>83</sup>For more details see Enders (1995).

then choose the lag length, which makes the calculated LR higher than the tabulated one.

Second, Akaike Information Criterion (AIC)

$$AIC = T \log \left| \sum Li \right| + 2N$$

Where all the variables are the same ones in LR, while N is the total number of the parameters estimated in the system including the intercept  $N = n^2L+n$ .

Third, Schwarz Criterion (SC)

$$SC = T \log \left| \sum Li \right| + N \log (T)$$

The variables in this formula are the same ones in LR and AIC. In both criteria (AIC and SC) we are looking to the lag length that minimizes each criterion. This minimization process relies on two elements working in opposite directions inside each criterion. Adding more lags to the VAR model will reduce the value of  $\log \left| \sum Li \right|$  at the expense of increasing N. The difference between the two criteria is that SC penalizes more for additional lags, which is clear from the second term in each criterion.

Table 4.2 shows LR and the values of (AIC) and (SC) calculated up to eight lags. Moreover, the critical value at 99% confidence interval of the  $\chi^2$  distribution that is linked to the LR with 36 degrees of freedom is 60.5. All three measures confirmed that two lags is the appropriate lag length for this model. In addition, I used another formula for the LR<sup>84</sup> which takes the form  $-2(H_i-H_j)$ , where H is the log likelihood. This ratio is asymptotically distributed  $\chi^2$  with degrees of freedom ( $n*Li$ ).

---

<sup>84</sup>For more details see E-views 3, user guide 1994-1997, page 517.

And, even this measure confirms the above result of two lags. The previous inventories studies such as Reagan and Sheehan (1985), Herrera (2000) and Jin (2001) used a four-lag-length<sup>85</sup> VAR model to study the dynamic relation among the variables, but in their papers there is no clear clue of why they chose the four lags model. Jin (2001) mentioned clearly that it was a four-lag-length VAR model by assumption<sup>86</sup>.

**Table 4.2 Lag Lengths Estimation**

<b>Increased Lag from</b>	<b>LR</b>	<b>Degrees of Freedom</b>	<b>Critical value</b>	<b>AIC</b>	<b>SC</b>
<b>1 to 2</b>	<b>219.1</b>	36	60.5	<b>-8286.9</b>	<b>-8050.0</b>
<b>2 to 3</b>	35.4	36	60.5	-8200.5	-7855.0
<b>3 to 4</b>	13.5	36	60.5	-8089.5	-7636.0
<b>4 to 5</b>	43.1	36	60.5	-8016.6	-7455.4
<b>5 to 6</b>	16.4	36	60.5	-7910.8	-7242.5
<b>6 to 7</b>	24.6	36	60.5	-7817.8	-7042.8
<b>7 to 8</b>	0.8	36	60.5	-7691.0	-6809.8

#### **4:4:2 Johansen's Cointegration Test**

The goal of this test is to check if an integrated series that has the same order, which is  $d(1)$  in this case, can be cointegrated. Or, alternately, to explore if there is a long-run equilibrium relationship among the cointegrated variables. Technically, Johansen's cointegration test provides a table contains the eigenvalues ( $E_i$ ) or the

---

<sup>85</sup>From a quarterly perspective, because some of them used monthly data.

<sup>86</sup>See Jin (2001) page 9.

characteristics roots, and based on these values this test calculates two values: Max-Eigen statistics,  $\lambda_{\max}(r, r+1) = -T \ln(1-E_{r+1})$ , and Trace Statistics,  $\lambda_{\text{trace}}(r) = -T \sum_{i=r+1}^n \ln(1-E_i)$ . The main difference between the two statistics is in the alternative hypothesis. In the  $\lambda_{\max}$  statistics case, if the null hypothesis is  $r = 0$  (No cointegration vector), the alternative hypothesis will be  $r = 1$  (one cointegration relation), while if the null hypothesis is  $r = 1$ , the alternative hypothesis is  $r = 2$  (two cointegration relations). But in the  $\lambda_{\text{trace}}$  case the situation is different: if the null hypothesis is  $r = 0$ , the alternative hypothesis  $r = 1, 2, 3 \dots$  number of variables minus one. And, if the null hypothesis is  $r = 1$ , the alternative hypothesis  $r = 2, 3 \dots$  number of variables minus one. To decide whether to reject the null hypothesis, Johansen's cointegration test provides 1% and 5% critical values. So, if the calculated value ( $\lambda_{\max}$  and  $\lambda_{\text{trace}}$ ) is greater than the critical value, we reject the null hypothesis and move directly to test the next one until we cannot reject the null hypothesis. It is useful to mention that Enders<sup>87</sup> (1995) relied more on the Max-eigenvalue ( $\lambda_{\max}$ ) to identify the number of cointegration vectors because it has sharper alternative hypothesis.

Table 4.3 shows Johansen's cointegration test. According to trace statistics,  $\lambda_{\text{trace}}$ , the first row tests the null hypothesis of no cointegration against the alternative hypothesis that we have from one to five cointegration relations. The result of the test shows that the calculated value of  $\lambda_{\text{trace}}$  is greater than the critical values at both the 5% and 1% confidence levels. Therefore, the null hypothesis is rejected, and this means that we have cointegration relations among the variables. In order to

---

<sup>87</sup>For more details see Enders (1995) page 392-393.

**Table 4.3 Johansen's Cointegration Test**

<b>Trend assumption: linear deterministic trend.</b>							
<b>Series: M<sub>2</sub>, FFR, P, RFS, RGDP, and TINV</b>							
<b>Lag interval (in first difference): 1 to 2</b>							
<b>Hypothesis</b>	<b>Eigenvalues</b>	$\lambda_{\text{trace}}$	$\lambda_{\text{max}}$	<b>5% for <math>\lambda_{\text{trace}}</math></b>	<b>1% for <math>\lambda_{\text{trace}}</math></b>	<b>5% for <math>\lambda_{\text{max}}</math></b>	<b>1% for <math>\lambda_{\text{max}}</math></b>
None	0.335498	134.07	62.53	94.15	103.18	39.37	45.10
At most 1	0.198285	71.53	33.81	68.52	76.07	33.46	38.77
At most 2	0.110049	37.72	17.84	47.21	54.46	27.07	32.24
At most 3	0.073009	19.88	11.60	29.68	35.65	20.97	25.52
At most 4	0.037469	8.28	5.84	15.41	20.04	14.07	18.63
At most 5	0.015817	2.43	2.44	3.76	6.65	3.76	6.65

Trace and Max-eigenvalue tests indicate one and two cointegration equations at both the 1% and 5% confidence levels, respectively.

determine the exact amount of cointegration relations we have to keep testing. The second row tests the hypothesis that we have one cointegration relation against the alternative hypothesis that we have from two to five cointegration relations. To figure out the result we have to look again to  $\lambda_{\text{trace}}$ , in the second row. It is clear in this case that the value of  $\lambda_{\text{trace}}$  is smaller than the critical values at the 1% confidence level and greater than the critical value at the 5% confidence level, thus the null hypothesis cannot be rejected at the 1% confidence level but it can be rejected at 5%. To continue the test we have to look at the third row. This row tells us that  $\lambda_{\text{trace}}$  is smaller than the critical values at both confidence levels, thus the test is over. The final result shows that we have two cointegration equations at the 5% confidence level and one cointegration equation at the 1% confidence level. Repeating the same test for the max-eigenvalue,  $\lambda_{\text{max}}$ , gives us exactly the same result as the trace

statistics,  $\lambda_{\text{trace}}$ . For the purpose of this study, and in order not to repeat the same work twice, I will analyze the results of the one cointegration equation at the 1% confidence level because the trend of the results in both equations are the same, and the only difference is that in the two cointegration equations the long-term horizon relation looks stronger between TINV and  $M_2$ , while in the one cointegration equation the relation between TINV and FFR looks stronger.

#### **4: 5 Empirical Results and Analysis Using Aggregate Data**

The above conclusion proves that we have to use the error correction model (ECM) in the estimation. Economically, this means that some variables in the model will respond to the size of the disequilibrium and try to return the economy to the long-run equilibrium. The ECM will be analyzed by using the impulse response function (IRF) and the forecast error variance decomposition (FEVD). The reason that this technique relies on those two devices in the analysis is that the individual coefficients in the estimated VAR model are difficult to interpret. Dicky (1988) proved by giving an example the power of those two devices in explaining the coefficient of a cointegration system. Tables 4.4 and 4.5 show the FEVD from ECM model for different orders of the variables, and the next nine figures show the IRF from the same ECM model for the variables under study.

##### **4:5:1 The Order of the Variables in the Model.**

The aim of this part is to figure out how the variables affect each other or which variables occur first. Based on different scenarios of ordering the macroeconomic variable in the VAR model, the forecast error variance decomposition (FEVD) in Tables 4.4 and 4.5 shows that  $M_2$  innovations are able to

**Table 4.4 Forecast Error Variance Decomposition from ECM**Order ( $M_2$ , FFR, P, RFS, RGDP, TINV)

Variance Decomposition of $M_2$			Explained By			
Period	$M_2$	FFR	P	RFS	RGDP	TINV
1	100.0	0.0	0.0	0.0	0.0	0.0
8	96.5	0.2	0.2	1.0	1.5	0.6
16	93.0	0.8	1.3	0.7	2.7	1.6
24	90.6	1.3	2.3	0.5	3.3	2.0
Variance Decomposition of FFR			Explained By			
Period	$M_2$	FFR	P	RFS	RGDP	TINV
1	24.2	75.8	0.0	0.0	0.0	0.0
8	7.2	56.2	12.9	18.6	1.4	3.7
16	3.8	52.3	14.3	22.4	1.9	5.2
24	2.7	50.9	15.0	23.7	2.2	5.6
Variance Decomposition of P			Explained By			
Period	$M_2$	FFR	P	RFS	RGDP	TINV
1	0.4	5.2	94.4	0.0	0.0	0.0
8	1.3	10.9	85.0	1.6	0.5	0.7
16	4.9	12.6	77.4	2.1	1.6	1.3
24	7.2	13.1	73.7	2.2	2.2	1.6
Variance Decomposition of RFS			Explained By			
Period	$M_2$	FFR	P	RFS	RGDP	TINV
1	1.7	7.7	0.9	89.8	0.0	0.0
8	23.2	3.7	2.8	56.4	1.7	12.2
16	22.8	7.1	7.6	45.2	1.2	16.2
24	20.5	8.9	10.4	41.4	0.8	17.9
Variance Decomposition of RGDP			Explained By			
Period	$M_2$	FFR	P	RFS	RGDP	TINV
1	1.0	7.4	0.0	58.0	33.5	0.0
8	23.1	4.5	2.7	53.3	4.7	11.8
16	23.3	7.5	7.7	43.5	2.4	15.5
24	21.3	9.2	10.6	40.1	1.7	17.1
Variance Decomposition of TINV			Explained By			
Period	$M_2$	FFR	P	RFS	RGDP	TINV
1	0.1	0.4	1.6	0.3	95.0	2.6
8	1.1	2.8	0.3	20.6	65.6	10.7
16	2.0	1.2	2.4	22.4	56.2	15.8
24	1.8	1.1	4.2	22.2	52.2	18.5

**Table 4.5 Forecast Error Variance Decomposition from ECM**

Order (M<sub>2</sub>, FFR, P, RGDP, RFS, TINV)

Variance Decomposition of M <sub>2</sub>			Explained By			
Period	M <sub>2</sub>	FFR	P	RFS	RGDP	TINV
1	100.0	0.0	0.0	0.0	0.0	0.0
8	96.5	0.2	0.2	2.4	0.03	0.8
16	93.0	0.8	1.3	3.2	0.2	1.6
24	90.6	1.3	2.3	3.3	0.4	2.0
Variance Decomposition of FFR			Explained By			
Period	M <sub>2</sub>	FFR	P	RFS	RGDP	TINV
1	24.2	75.8	0.0	0.0	0.0	0.0
8	7.2	56.2	12.9	3.0	17.1	3.7
16	3.8	52.3	14.3	3.2	21.1	5.2
24	2.7	50.9	15.0	3.2	22.7	5.6
Variance Decomposition of P			Explained By			
Period	M <sub>2</sub>	FFR	P	RFS	RGDP	TINV
1	0.4	5.2	94.4	0.0	0.0	0.0
8	1.3	10.9	85.0	0.2	1.9	0.7
16	4.9	12.6	77.4	0.1	3.6	1.3
24	7.2	13.1	73.7	0.1	4.3	1.6
Variance Decomposition of RFS			Explained By			
Period	M <sub>2</sub>	FFR	P	RFS	RGDP	TINV
1	1.7	7.7	0.9	32.9	56.9	0.0
8	23.2	3.7	2.8	12.7	45.3	12.2
16	22.8	7.1	7.6	10.5	35.8	16.2
24	20.5	8.9	10.4	10.2	32.0	17.9
Variance Decomposition of RGDP			Explained By			
Period	M <sub>2</sub>	FFR	P	RFS	RGDP	TINV
1	1.0	7.4	0.0	0.0	91.6	0.0
8	23.1	4.5	2.7	9.1	49.0	11.8
16	23.3	7.5	7.7	8.9	37.0	15.5
24	21.3	9.2	10.6	9.2	32.5	17.2
Variance Decomposition of TINV			Explained By			
Period	M <sub>2</sub>	FFR	P	RFS	RGDP	TINV
1	0.1	0.4	1.6	65.5	29.8	2.6
8	1.1	2.8	0.3	15.9	70.3	10.7
16	2.0	1.2	2.4	10.6	68.0	15.8
24	1.8	1.1	4.2	9.1	65.4	18.5

explain more than 91.0% of its fluctuation, which confirms that  $M_2$  is a strongly exogenous macroeconomic variable in this model. The federal fund rate (FFR) explains no less than 51.0% of its variation. According to P, its innovations can justify at least 74.0% of its fluctuation. Also, Table 4.4 shows that RGDP and RFS innovations explain to more than 33.0% and 41.0% of their variation, respectively<sup>88</sup>.

TINV in this model has an interesting behavior. It is the only variable in this model whose innovations have the ability to explain its own fluctuation in an increasing way, around 19.0% of its own variation in the long-term horizon. This feature only exists in this macroeconomic variable. Tables 4.4 and 4.5 illustrate that the ability of each variable in the model to explain itself declines over time, but TINV behaves in an opposite way. The FEVD shows that the ability of this macroeconomic variable (TINV) to explain that all the other variables in the model increase over time. These facts are considered important because inventories are a small portion in the national accounts and their role, still ambiguous in the economy, is still under study. I believe this evidence gives an indication of how the role played by TINV in the long run affects or feedbacks, which is the propagation of the business cycle. Moreover, the impulse response function (IRF) in Figure 4.2 demonstrates that TINV responds positively and instantaneously to a shock in itself and this effect keeps increasing until it becomes constant<sup>89</sup> after a long period of time. This feature exists only in the behavior of both  $M_2$  and P in this model.

---

<sup>88</sup>Those figures from Tables 4.4 and 4.5 based on which is ordered first, RFS or RGDP.

<sup>89</sup>The shape of the impulse response function is consistent with the theoretical expectations mentioned in the methodology part of this study.

Response to Cholesky One S.D. Innovations

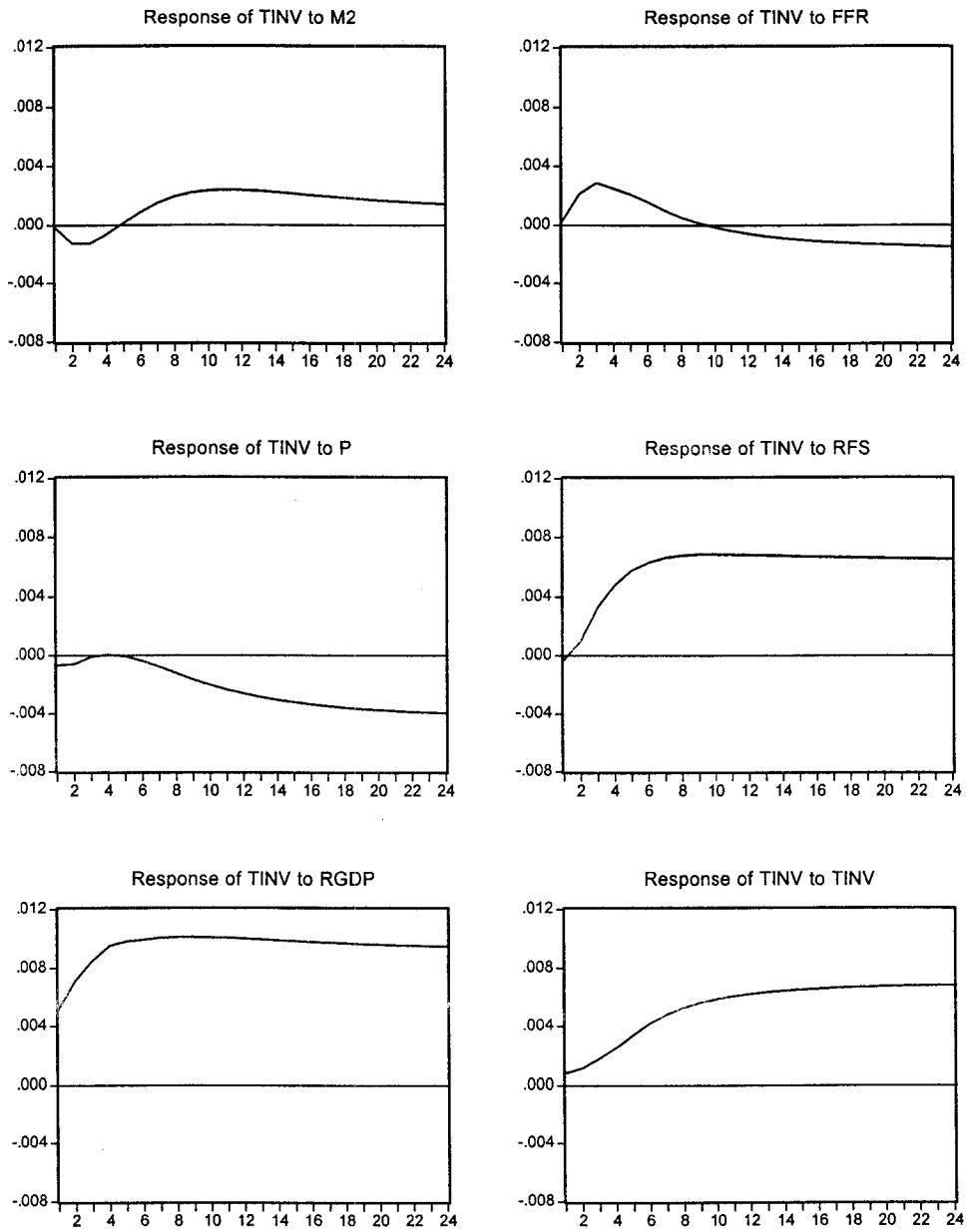


Figure 4.2 : The Impulse Response Function From ECM For TINV

In general, FEVD in Tables 4.4 and 4.5 show that the nominal terms ( $M_2$ , FFR, and P) are able to explain approximately 40.0% of the fluctuation in each RGDP and RFS. At the same time, it is clear that RGDP and RFS can explain 52.0%-65.0% and 10.0%-22.0% of the fluctuation in TINV, respectively. Based on the above results, the variables will follow this order:  $M_2$ , FFR, P, RFS and RGDP and finally TINV. This result confirms that  $M_2$  is the exogenous variable while the real terms (RGDP, RFS, and TINV) are the endogenous variables in the model. This conclusion is consistent with the results of Shbikat (2000), despite the difference in the variables in the model. Also, the order of the variables is close to the theoretical analysis of Blinder's inventory macroeconomic model, Metzler's (1941) model and consistent with the findings of Larrain (2002).

#### **4:5:2 The Relation Between the Money Supply, the Interest Rate and Inventories.**

The FEVD in Tables 4.4 and 4.5 show that  $M_2$  innovation can explain 24.2% of FFR fluctuation in the instantaneous time horizon. At the same time,  $M_2$  explains a small constant portion (2.0%) of TINV fluctuation. Also, both FFR and TINV are unable to justify  $M_2$  variation in the short-term horizon but they are able to explain not more than 2.0% of the variation in  $M_2$  in the long-term horizon. FFR innovations are able to explain around 7.0% of the variation in the TINV in the short-term horizon, while TINV is able to explain 5.6% of the FFR fluctuation in the long-term. Therefore, the type of dynamic relation among the variables implies the direction of relation in the short-term horizon running from  $M_2$  to FFR and from FFR to TINV. Also, there is a long-term horizon relation running from TINV to FFR.

The IRF in Figure 4.3 showing a positive shock to  $M_2$  has an abrupt and strong negative impact on the FFR up to the eighth quarter, which turns to be positive after this period. This change in the relation from negative to positive is related to the use of the aggregate  $M_2$  in the analysis, not the disaggregated money supply: it is called the effect of the endogenous part of  $M_2$ . Many studies such as Mishkin (1982), Gordon and Leeper (1994), Chari, Christiano and Eichenbaum (1995) and Shbikat (2000) reported that using  $M_2$  failed to capture a negative relation between  $M_2$  and interest rate. In addition, Figure 4.4 shows that the feedback relation from FFR to  $M_2$  is weak and negative until the fifth quarter and becomes positive afterwards. I think this change in the relation from negative to positive is also related to using the aggregate money supply in this scenario because it is expected by the theory that the total demand for reserves will decline with a rise in the market interest rate, i.e. FFR. Also, the theory expects that this increase in the interest rate will increase the deposits, and at the same time the money multiplier will increase because of the expected decline in the excess reserve, and this contradiction in the time lag response of the components of the aggregate money supply may cause this reverse<sup>90</sup>. Figure 4.2 shows that  $M_2$  has a negative effect on TINV for the first four quarters and at the fifth quarter this relation changes its direction to positive. The same figure shows that a positive shock to the FFR will have a positive effect on increasing rate on the TINV until the third quarter; and this effect starts to decline but is still positive. It becomes negative in the tenth quarter. From Figure 4.3 it is clear that TINV has a positive and long term effect on FFR.

---

<sup>90</sup>For more detail about the theoretical background see Walsh (1998).

### Response to Cholesky One S.D. Innovations

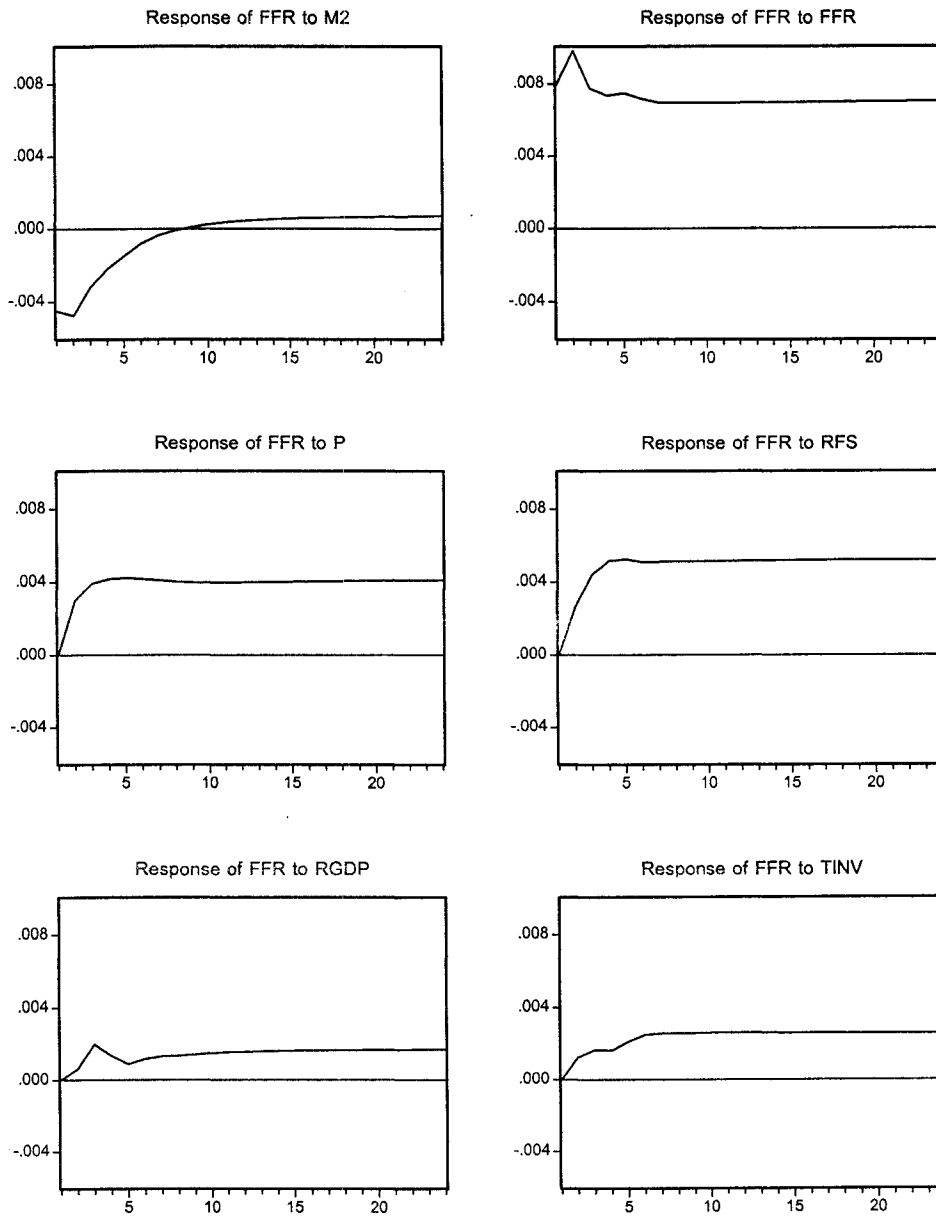


Figure 4.3 : The Impulse Response Function From ECM For FFR

### Response to Cholesky One S.D. Innovations

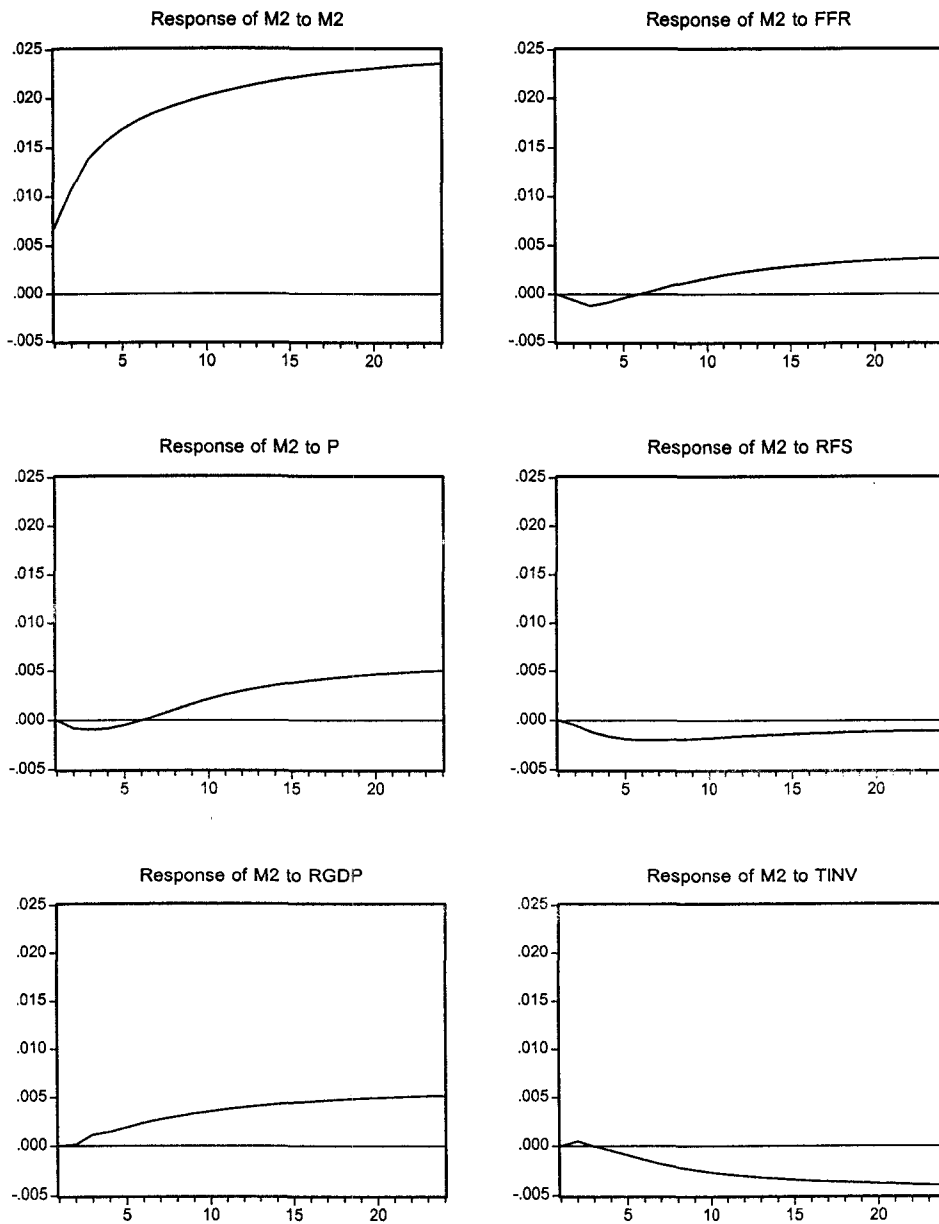


Figure 4.4 : The Impulse Response Function From ECM For M2

The main conclusion of this part of the study gives the impression that there is a relation running from the monetary factors ( $M_2$  and FFR) to the TINV in the short- term horizon. But, this relation faces two facts: first, it is not as strong and immediate enough as expected, and second, this relation involves some time lag to respond correctly to the monetary factors or at least to catch the right direction. Those two facts indicate that there are other relatively more important variables that may describe the behavior of TINV more than the monetary factors. Moreover, the FEVD proves that there is a long-run effect running from TINV to the monetary factors, especially the FFR, and I believe this is the key relation for the propagation of the business cycle.

#### **4:5:3 The Relation Between the Money Supply, Prices, and Inventories.**

The FEVD of P in Table 4.4 shows that 74.0% of P fluctuations are accounted for by its own innovations. Monetary factors are able to explain part of the variation in  $P^{91}$ . In the long-run perspective, the estimations show that  $M_2$  and FFR can clarify 7.0% and 13.0% of the oscillation in P, respectively. In the short-run FFR can explain less than 10.0% of this movement, while at the same time 10.0% of the variation in FFR can be explained by P. Consequently, P can explain 15.0% of the FFR variation in the long run. Furthermore, P is unable to explain any variation in  $M_2$  in the short run but able to explain 2.0% in the long run.

The IRF in Figure 4.3 illustrates that FFR responds more immediately and quickly to  $M_2$  more than to P. Furthermore, Table 4.4 shows that the effect of  $M_2$  on

---

<sup>91</sup>The disaggregated analysis shows a stronger relation between P and both RFS and RGDP compared to the aggregated analysis.

P is stronger than the effect of P on  $M_2$ . And, it is clear from Figure 4.5 that P responds negatively to a shock in  $M_2$  up to the first three quarters before it turns to be positive, meaning it catches the right signs, which is consistent with the theory. Also, Figure 4.3 demonstrates that the FFR responds highly to a shock in P. This result is consistent with Fischer's equation because we are talking about nominal terms. The above dynamic relations among the macroeconomic variables illustrate that there is a relation running from  $M_2$  to the price level. Besides, there is a mutual relation between P and FFR and this relation looks stronger when it runs from FFR to P (Figure 4.5) compared to when it runs in the opposite direction (Figure 4.3). According to the above analysis, it is clear that  $M_2$  is a strongly exogenous variable and to some extent we can consider P an exogenous variable despite its being affected by the  $M_2$ .

The relation between P and TINV is interesting. Table 4.4 illustrates that P innovations are able to elucidate 4.0% of the oscillation in the TINV in the long time horizon. The IRF in Figure 4.2 shows a positive shock to P affects TINV immediately and negatively at increasing rate until it turns positive just in the fourth quarter and then becomes negative again while it declines significantly. In the opposite direction, Table 4.4 shows that TINV is unable to explain more than 1.6% of the movement in P in the long-term horizon. Consequently, IRF in Figure 4.5 shows that P responds negatively for a shock in TINV. From the IRF, I compared the above two effects and I found that the effect of TINV on P is larger than the effect of P on TINV by five times on average. As a result, it is very hard from the above dynamic relation to say that there is a relation running from P to TINV. Hence, I

### Response to Cholesky One S.D. Innovations

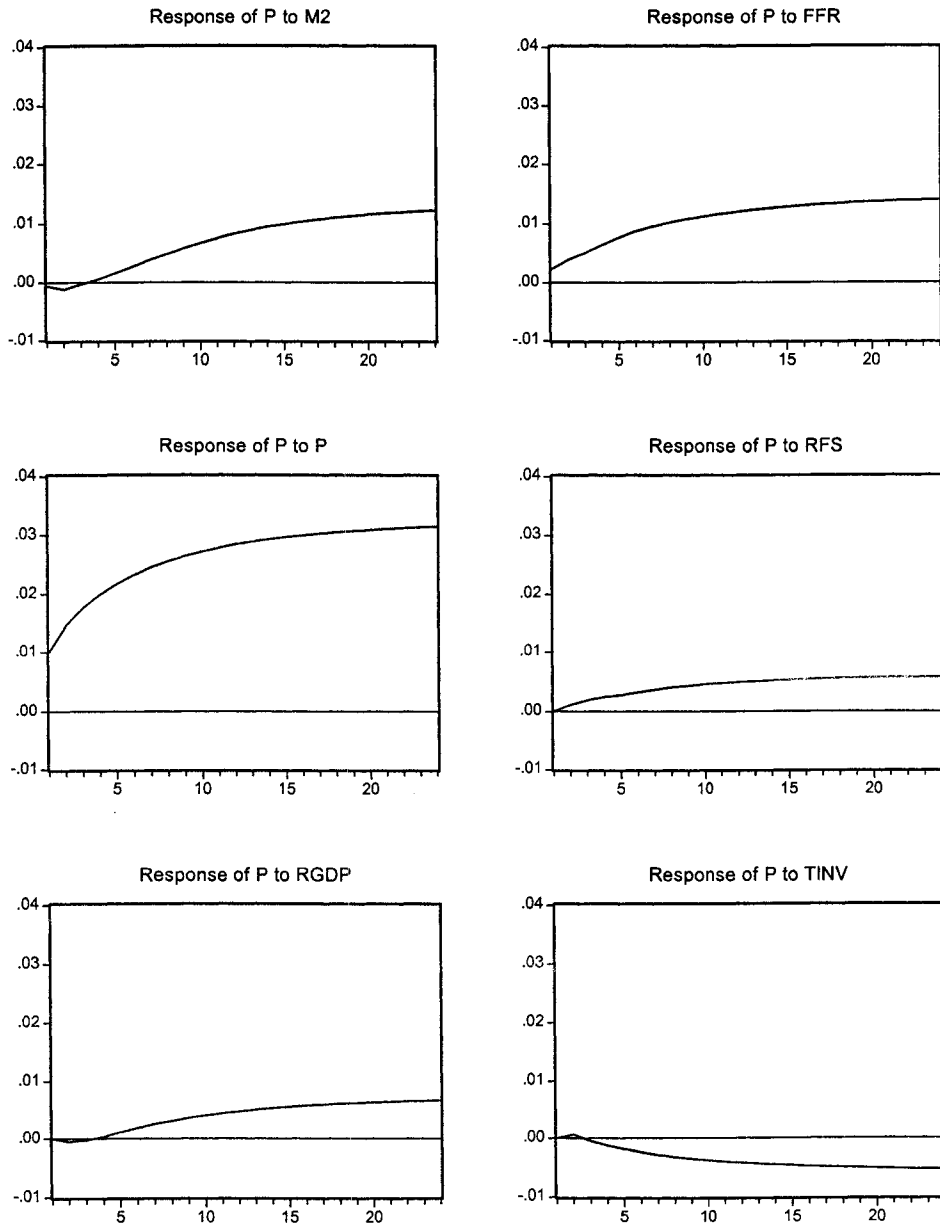


Figure 4.5 : The Impulse Response Function From ECM For P

believe the relation between those two macroeconomic variables evolves based on the reaction of each variable with the other variables in the model. But, I would like to emphasize the relation from TINV to P, which is negative. This relation implies that more inventories in the economy are accompanied by a decline in the prices for a short period of time, which doesn't mean that the increase in inventories caused the decline in the prices. After that, inventories and how the macroeconomic variables react in the economy put a pressure on the prices to increase. Therefore, based on this relation we expect to have in the next period lower inventories accompanied by higher prices. This analysis shows how the relation between those two macroeconomic variables (TINV and P) evolves in the economy, relying on the idea that this relation is not a direct one, which implies it occurs through the reaction of the macroeconomic variables in the economy. This relation will be useful in the coming sections.

Overall, the relation between P and TINV is opposite to what is expected, that there is a speculation motive for holding inventories. This implies a positive shock to P will decrease inventories, not increase them. One explanation for this relation is that we are looking to this relation from the aggregate demand point of view and there is no role for the aggregate supply, therefore this conclusion is not far from a normal negative relation between real term i.e. RGDP and the price level as described by the macroeconomic theory. The results of the above two sections (4:5:2 and 4:5:3) confirm one thing, which is the above two forces are unable to explain the behavior of inventories as strongly as expected using the VAR model or the cointegration analysis, and there are more variables that can explain it more

significantly. Unexpectedly, the results of this model point out that the relation between RGDP and RFS seems able to explain the behavior of inventories. Therefore, in the next section I will focus on this relation.

#### **4:5:4 The Relation Between RGDP, RFS and TINV**

It is clear from the results of this aggregate model that to understand the behavior of inventories it is important to understand their relation with both RGDP and RFS. Regardless of the order of RGDP and RFS in the VAR model, the FEDV in Table 4.4 shows that the RGDP and RFS on average can explain more than 32.0% and 41.0% of their own fluctuation, respectively. In addition, the same table illustrates that those two macroeconomic variables (RGDP and RFS) together are able to account for around 88.0% of the variation in TINV in the short-term horizon and more than 70.0% in the long-term horizon. Moreover, Table 4.4 demonstrates that the innovation of TINV can explain approximately 19.0% of its own variation and approximately can do that for each RGDP and RFS in the long-term horizon by the same percentage. This result is important because it confirms the result of Table 1.1, which says that inventories are able to explain the fluctuation in RGDP. The importance of each RGDP and RFS to explain TINV relies mainly on which variable is ordered first or assumes its occurrence before the other, because the response of the TINV to a shock to RFS or RGDP differs based on this ordering. Therefore, to draw a clear conclusion I would like to present two scenarios.

With the first scenario, in the empirical work we assume that RFS is the exogenous variable or a primary shock happens to this variable, and the previous theoretical works also used this assumption. This means that RFS is ordered before

RGDP in the model. The FEVD in Table 4.4 shows that RFS can explain at least 60.0% of the fluctuation in RGDP in the immediate run. The IRF in Figure 4.6 shows that RGDP responds positively, immediately and very strongly for this shock in RFS, and it reaches its maximum level in the third quarter. The response of RGDP to RFS seems greater than the response of RFS to RFS in Figure 4.7, through the second quarter to the seventh quarter before the latter becomes larger than the former. The strong response of the RGDP at the beginning of the RFS shock makes TINV in Figure 4.2 increase positively, strongly and immediately. The FEDV in Table 4.4 shows that the RGDP can explain at least 85.0% of the variation in TINV in the short-term horizon and more than 50.0% in the long-term horizon. The pattern of dynamic relation among those three variables proves the direction of relation running from RFS to RGDP and from RGDP to TINV. The size of TINV reaction started to exceed the RGDP effect starting from the fourth quarter; it reaches its maximum in the eighth quarter, which is clear from the IRF in Figure 4.2. Therefore, it is expected that the final impact of RFS on TINV will be positive. This result is clear in the IRF in Figure 4.2 which shows that the net impact of RFS on TINV is positive, medium but high, and reaches its maximum in the tenth quarter. An important guide for this relation provided by IRF in Figure 4.2 is that the impact of RFS on TINV is negative in the first quarter, which is justified as the time lag needed for the RGDP to respond to this shock which looks very fast, and as mentioned above, in the first quarter RFS response is greater than the RGDP response. The main result in this part is that, according to the behavior of the data, unexpected shock to RFS directly faced by a strong and greater RGDP reaction starting from the

Response to Cholesky One S.D. Innovations

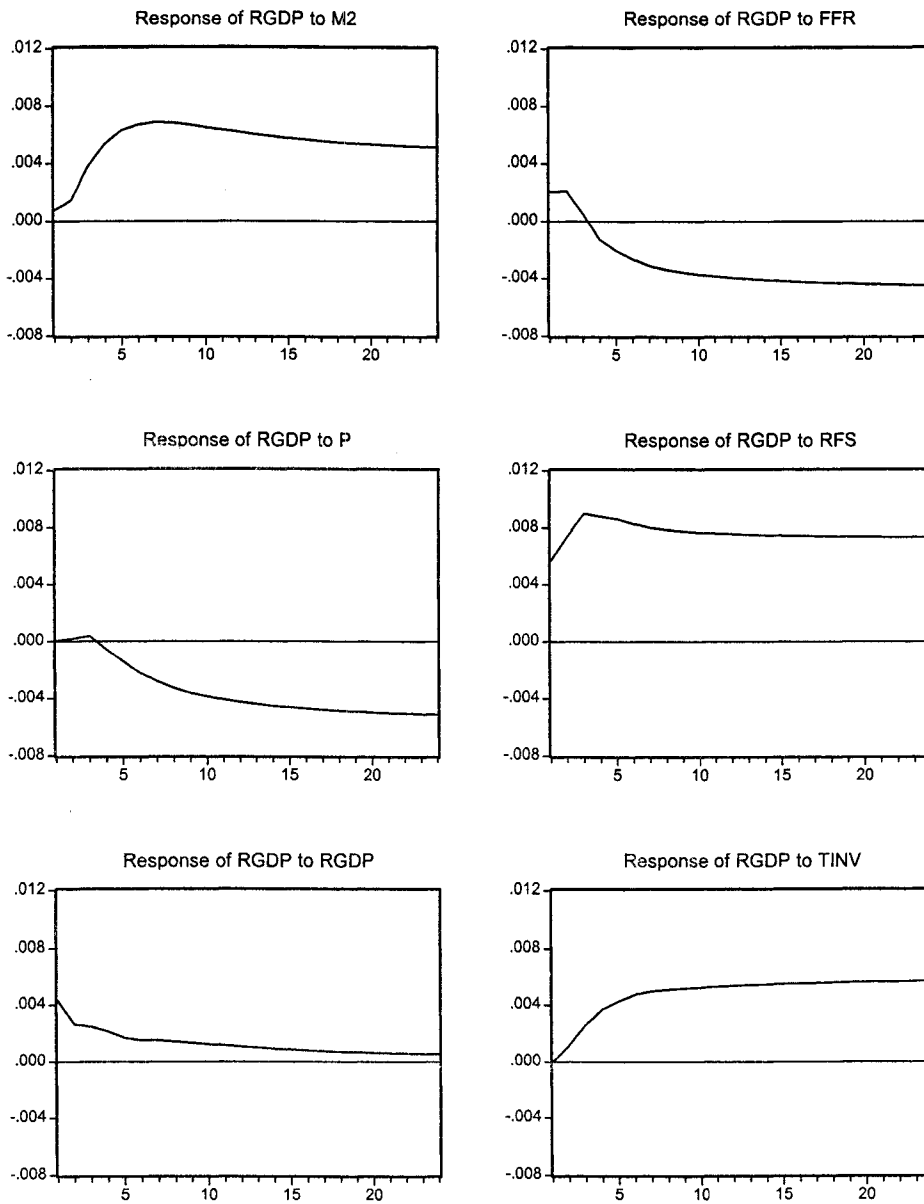


Figure 4.6 : The Impulse Response Function From ECM For RGDP

Response to Cholesky One S.D. Innovations

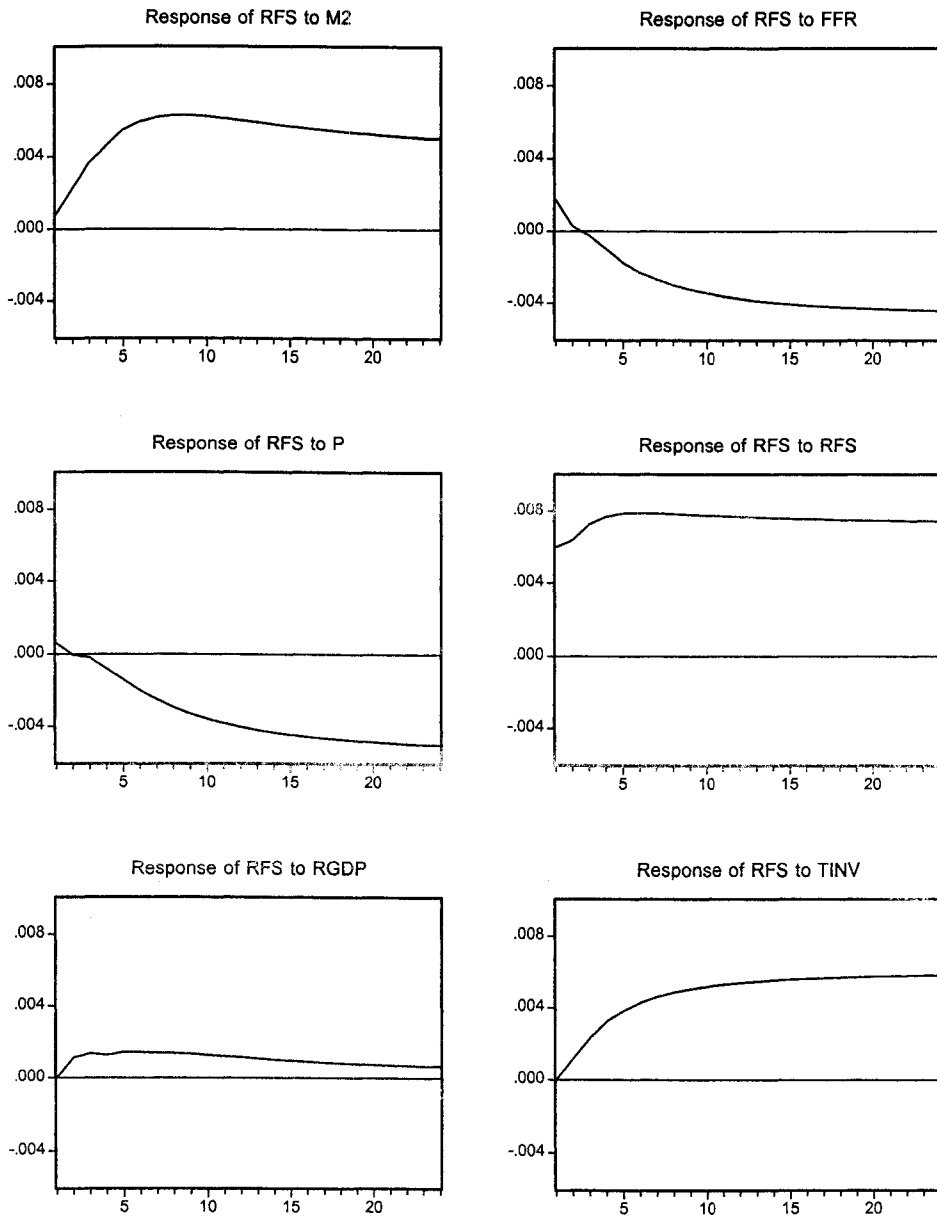


Figure 4.7 : The Impulse Response Function From ECM For RFS

second quarter; therefore, TINV did not behave as a buffer stock or the RGDP response did not give TINV the chance to behave as a buffer stock for a long period of time, for only one quarter. Therefore, this strong reaction from RGDP makes the inventories increase.

The second scenario is exactly the opposite for the first one, and it helps to see the other part of the relation between those three macroeconomic variables. In this case, assume that RGDP is the exogenous variable ordered ahead of RFS. The FEVD in Table 4.5 shows that RGDP explains more than 55.0% of the variation in RFS in the immediate run. And, it shows that RFS can explain at least 57.0% of the variation in TINV abruptly. The IRF in Figure 4.8 shows that even in this case RFS responds immediately and strongly to a shock in RGDP. More to the point, it is obvious from Table 4.5 that RGDP has big share in explaining the variation in TINV in the long-term horizon which is more than 65.0% of the variation in TINV, and this result confirms that the relation between RGDP and TINV is stronger or more sustainable, which proves or highlights the accelerator effect. To compare the final impact on TINV, based on the above two scenarios, we have to go back to IRF in both Figures 4.7 and 4.9. Relatively, the response ratio of (RGDP to RGDP/ RFS to RGDP) from the second scenario and the response ratio of (RGDP to RFS/ RFS to RFS)<sup>92</sup> in the first scenario are both greater than one, which means that the RGDP response is larger than the RFS response in both cases. Therefore, regardless the order of RGDP and RFS, it will be expected that the final impact on TINV is positive and the effect in the second scenario is larger than the first one. And this actually is

---

<sup>92</sup>The ratio from the second scenario is larger than the one from the first scenario.

Response to Cholesky One S.D. Innovations

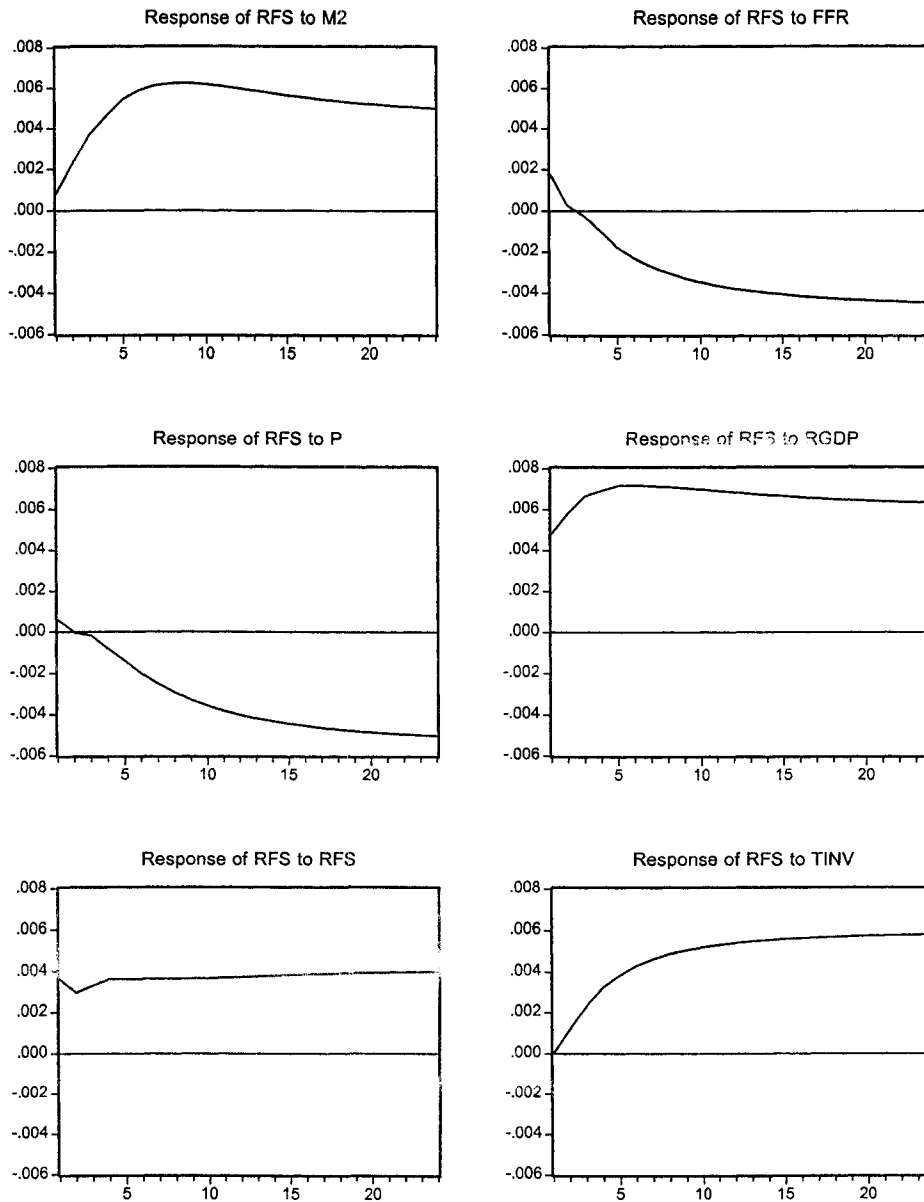


Figure 4.8 : The Impulse Response Function From ECM For RFS (RGDP First)

Response to Cholesky One S.D. Innovations

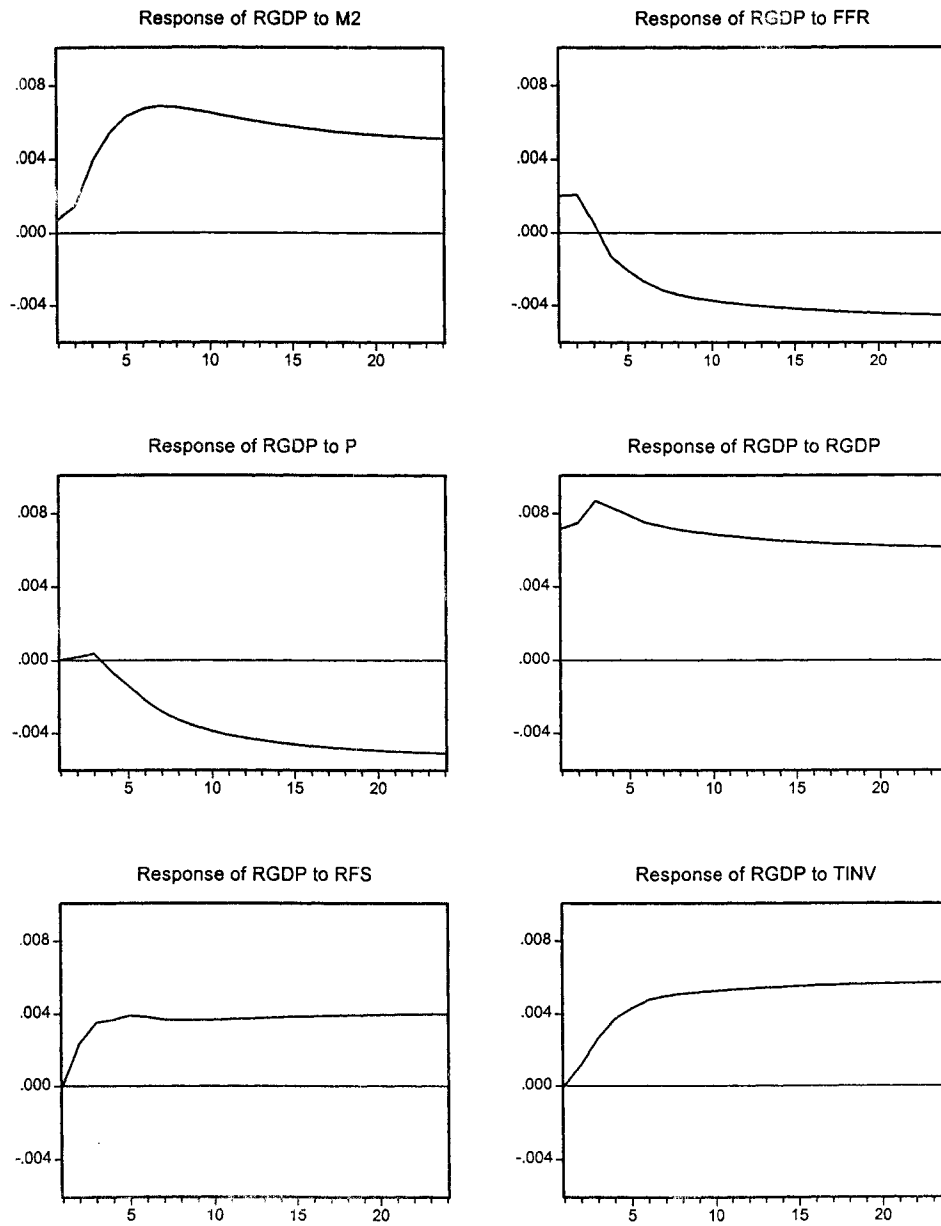


Figure 4.9 : The Impulse Response Function From ECM For RGDP (RGDP First)

clear by comparing IRF in both Figures 4.7 and 4.9. In addition, the two scenarios of ordering both RGDP and RFS in the VAR model both gave important results, especially for the relation between RFS and TINV. It is apparent from the IRF in Figure 4.10 that TINV responds negatively to a direct shock in RFS. This effect reaches its minimum in the second quarter before it starts to increase slowly and become approximately constant. Thus, this case shows a direct relation between TINV and RFS without the intervention of RGDP as in the first scenario, and I can say in this case that inventories behave as a buffer stock. Also, the IRF in Figure 4.10 reveals that the final impact of RGDP on TINV is positive, similar to the first scenario.

In sum, comparing the positive final impact on TINV over the business cycle of the two scenarios gives evidence that the second scenario (RGDP first) outcomes are larger. Explaining this result depends mainly on the size of response of both RGDP and RFS. It can be concluded that RGDP responds more to a shock in itself or a shock in RFS, compared to the response of RFS. And, this makes the final impact on TINV positive in both cases. This relation among the three variables shows that RFS has a positive effect on TINV over the long run of the business cycle, but it is also has a negative impact for the very short run.

In order to close the dynamic relation between the variables in the model and to have a clear picture, I would like to point out that both the aggregate and disaggregate analysis showed that the relation between both FFR and P from one direction and the real terms (RGDP and RFS) is stronger compared to the relation

Response to Cholesky One S.D. Innovations

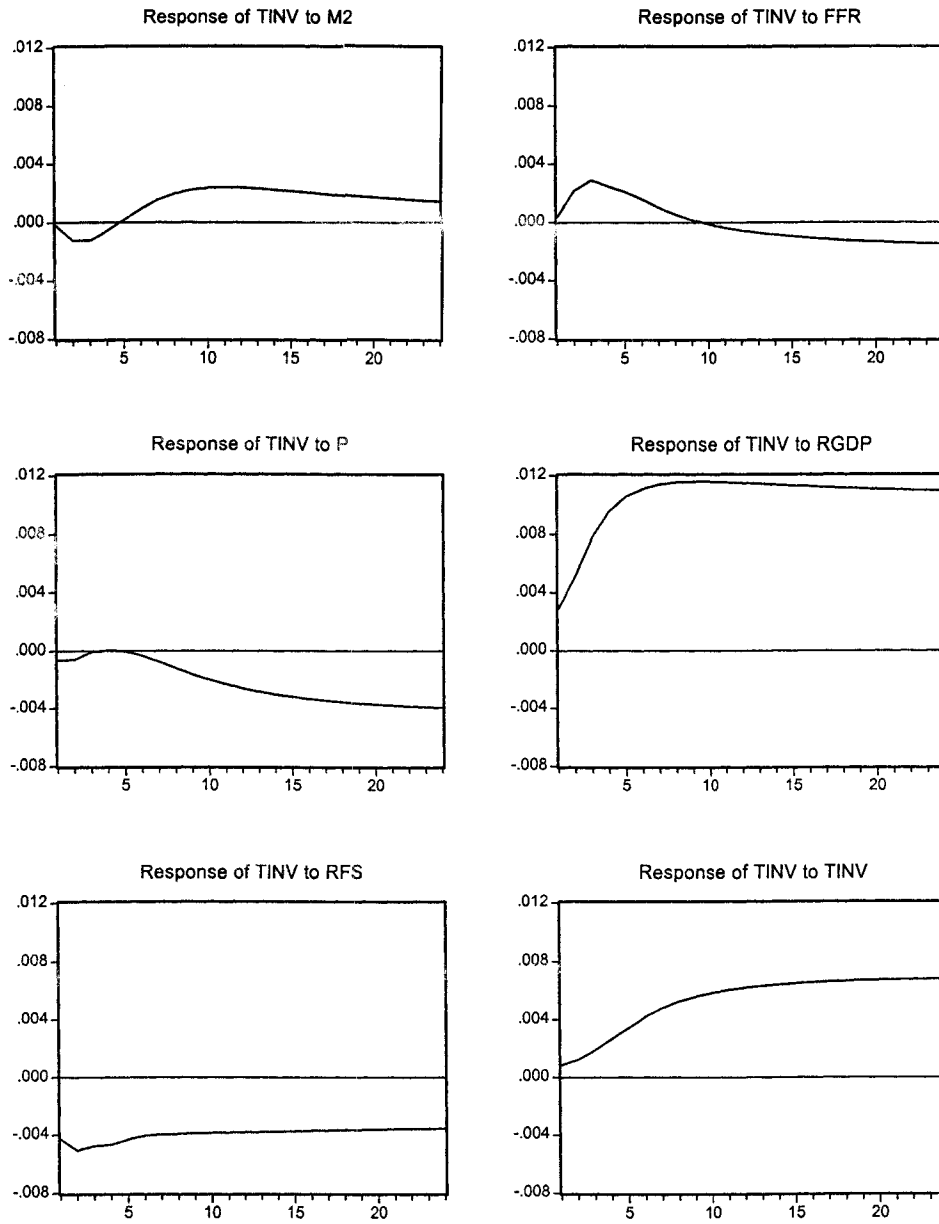


Figure 4.10 : The Impulse Response Function From ECM For TINV (RGDP First)

with inventories. The IRF in Figures 4.6 and 4.7 shows that a positive shock to the interest rate leads to declines in both RGDP and RFS, even faster than the decline in inventories. Moreover, a positive shock to either RGDP or RFS leads to an increase in the price level as in Figure 4.5.

#### **4:6 The Relation Between the Results and the Implication of the Production Smoothing/ Buffer Stock Model**

Despite that the production smoothing model (PSM) is a microeconomic analysis of the inventories and this study is on the macroeconomic level, it seems that the results of this study have a close relation to the implication of PSM<sup>93</sup>. It is obvious from the results that an unexpected shock to RFS will be met by a strong and instantaneous response from RGDP, which implies that the level of inventories increase but will stay low. Also, we will get the same result even if the shock happens first to RGDP. This conclusion is consistent with the first implication of the PSM.

Also, the results showed that in both cases either if RGDP is ordered first and RFS second or RGDP is ordered second and RFS first, RGDP has more flexibility to respond than RFS to any shock that occurs in the economy, which guarantees that a positive shock such as expansionary monetary policy will increase change in inventories, while expansionary fiscal policy will decrease the change in inventories<sup>94</sup>. This conclusion confirms three important points. First, this may answer the question of why RGDP is more volatile than RFS. Second, change in inventories

---

<sup>93</sup>For more details see Blinder and Maccini (1991a).

<sup>94</sup>For more details see section 4:10 policy implications.

has a positive relation with RGDP and negative with RFS, which implies that inventories behave as a buffer stock, but this effect stays for a short period of time because of the quick response of RGDP, which is consistent with the second implication. Technically, based on the empirical results, for inventories to behave clearly as a buffer stock we have to shock the RGDP first, or in another way the shock to RGDP should precede the shock to RFS. Third, the long-run relation over the business cycle between RFS and TINV is positive. Furthermore, the results show that both RGDP and RFS respond positively to a positive shock in TINV and this is consistent with the third implication of PSM<sup>95</sup>.

In conclusion, I would like first to divide the time horizon of this study into two phases: the first phase or short-run effect in which the macroeconomic variables react with each other because of a monetary shock that leads to build inventories, and the second phase or long-run effect in which the inventories have already been built and the economy starts to feel that this new situation represents a state of disequilibrium, therefore the self-adjustment mechanism of the economy begins by making inventories feedback to the macroeconomic variables in the model in order to reach the equilibrium. Based on this division, the second phase represents the propagation of the business cycle. The previous part of this chapter explored only the first phase and it is clear from the aggregated analysis that this study found a weak role for inventories in monetary transmission mechanism. What I mean by weak relation is that this relation is not as strong as expected and needs some lag time to respond correctly to the monetary factors. Also, the empirical results did not confirm

---

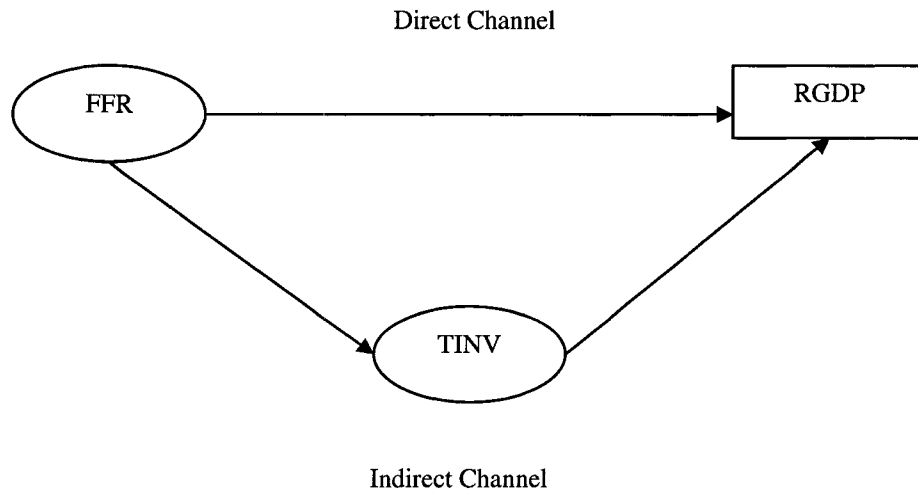
<sup>95</sup>This statement is based on the results from section 4.7.

that there is a speculative motive for holding inventories or a positive relation between prices and aggregate inventories. On the contrary, this study found a negative relation between those two macroeconomic variables. The next part of this chapter will explore the second phase.

#### **4:7 The Propagation Mechanism**

This part of the study seeks to explore the role of inventories in the propagation of the business cycle, and it is considered the second phase or how inventories affect the economy. This part relies on the results of the VAR model in this study. The results of the VAR model show that in the short-term horizon the change in inventories is determined mainly by the reaction of the relation between RGDP and RFS and the response of TINV to the shock to those macroeconomic variables. The monetary factors (a positive monetary shock) are considered to be a necessary and an important policy to provide the spark to this reaction to start accumulating inventories. This conclusion gives a possibility that the negative relation between the interest rate and inventories reveals because there is already a negative relation between the interest rate (FFR) from one side and both RGDP and RFS from the other side.

The analysis of the propagation mechanism of the business cycle in this study relies on the logic behind Fischer's and Blinder's model (1981) which says that macroeconomic factors such as monetary factors have a direct channel effect on the output and an indirect one through the inventories and that the latter may be stronger than the former (Figure 4.11). Therefore, the goal of this part is to investigate if this indirect channel exists. Based on the results of the VAR model of this study, I will



**Figure 4.11: The Direct and Indirect Channel of Effect of Change in FFR on RGDP**

make this comparison based on two time horizons: First, in the short-term horizon<sup>96</sup>, the FEVD shows that the monetary factors ( $M_2$  and FFR) together can explain at least 25.0% of the variation in the RGDP and RFS for each. The IRF in Figure 4.6 shows that both  $M_2$  and FFR affect RGDP directly, but it seems the effect of  $M_2$  on FFR is more immediate and stronger compared to the effect on RGDP. This direct channel explains the relation from the monetary factors to RGDP. On the other direction, the FEVD shows that the monetary factors can explain in the short-term horizon not more than 7.0% of the variation in the TINV. Making a comparison based on the response of the variables from IRF shows that the relation from the monetary factors either  $M_2$  or FFR (direct channel) to RGDP is stronger and greater approximately by five times than the relation from the same monetary factors to TINV. Second, the short-term horizon<sup>97</sup> represents the condition required to build this important macroeconomic variable (TINV) and the long-term horizon gives the change in inventories (either positive or negative) the chance to react with all the previous macroeconomic variables. Consequently, I mentioned earlier that TINV behaves as an exogenous variable in the long-term horizon. The FEVD in Table 4.4 shows that TINV is the only variable in the model which is able to explain itself in an increasing way over time. Also, IRF in Figure 4.2 shows that TINV responds positively and immediately to a shock in itself. This effect keeps increasing until it becomes constant after a long period of time, and it is useful to mention that this same feature exists only in  $M_2$  and P in this model.

---

<sup>96</sup>Less than two years.

<sup>97</sup>More than two years.

In the short-term horizon, the FEVD in Table 4.4 shows that TINV is able to explain not more than 3.0% of the movement in the FFR and 11.0% of the variation for each of RGDP and RFS, while in the long-term horizon its ability jumps to 6.0% and 18.0%, respectively. These facts from the results prove the impact of inventories on macroeconomic variables and provide evidence of the important role of this factor in the propagation of the business cycle in the long time horizon. The IRFs in Figures 4.2 and 4.6 illustrate two conclusions by comparing the size of the responses of the variables over the time horizon based on the relations of Figure 4.11. First, on average, the response of RGDP to TINV is twice as much the response of RGDP to the FFR, and second on average, the response of RGDP to TINV is approximately eight times greater than the response of TINV to FFR. These two findings confirm that the indirect channel (the relation from TINV to RGDP) exists and even stronger than the direct one. Or, in other words, in the long-term horizon the inventory will magnify all the effects of the other macroeconomic variables on itself and feedback with an even larger impact to the other macroeconomic variables in the model, which will cause the propagation of the business cycle.

Besides the relation between the direct and indirect channels the IRF demonstrates that the effect of TINV on RGDP is larger and more significant in a noticeable way compared to the effect on FFR. These facts about the behavior of inventories give evidence that the existence of inventories in the economy represents a sign of instability or disequilibrium and that the role of this macroeconomic variable (TINV) started in the long-term horizon. This important relation shows that inventories in the long-term horizon have a feedback effect on FFR by affecting

RGDP to make the economy reach the equilibrium. But, during this adjustment process, the movement of some variables will overshoot,<sup>98</sup> and this causes more fluctuation in the RGDP.

#### **4:8 Modeling the Results**

In this part of the study I will try to model the results in an IS-LM model to check two points: first, to expand the theoretical analysis, and second, to check if these results can be described in this macroeconomic model. The main point in modeling the results relies on one of the core features or results which I found in the behavior of the macroeconomic variables in the VAR model. This point shows that inventories emerge in the economy because of the gap between RGDP and RFS, and this gap comes out because the response of RGDP is stronger positively or negatively than that of RFS to the different shocks; it is either a monetary shocks ( $M_2$  and FFR) or a price shock.

It is only true that in equilibrium income (RGDP) is equal to planned expenditure (RFS). And, it is always true by definition that income is equal to planned expenditure (RFS) plus change in inventories ( $\Delta TINV$ )<sup>99</sup>. We use a simple IS model which has a private sector only as follows:

$$Y = C + I_p \quad (4:1)$$

$$C = a_0 + c Y^d, \quad Y^d = Y - T, \quad T = 0 \quad (4:2)$$

$$I_p = I_0 + ir \quad (4:3)$$

---

<sup>98</sup>This overshooting related to the time horizon of the dynamic relation among the variables.

<sup>99</sup>For more details see Gordon (1987).

Where RGDP stands for real gross domestic product, C: real consumption,  $I_p$ : real planned investment,  $Y^d$ : disposable income, T: taxes, c: marginal propensity to consume, i: interest sensitivity to investment, and r: interest rate.

Based on the this model the equilibrium income (RGDP) is

$$RGDP = (1/1-c) (a+ I_0 - i r) = RFS \quad , \quad \Delta TINV=0 \quad (4:4)$$

For the purpose of this analysis, I will assume I have a regular upward sloping LM curve as a general case:

$$M/P = K RGDP - L r \quad (4.5)$$

Where M/P stands for real money balances, K: income elasticity of money demand, L: interest elasticity of money demand.

As I said above at the equilibrium  $RGDP=RFS^{100}$ , this means that both portions have the same response or coefficient (c and i), therefore  $\Delta TINV = 0$ . This is out of equilibrium according to the results I have in the VAR model, which proves that the RGDP response is greater than RFS for  $M_2$  FFR, and P regardless which occurs first, RGDP or RFS. And, as long as I am talking about the IS equation, to simplify the case I will analyze only one case where RGDP has higher interest sensitivity than the RFS. This means that the coefficient ( $i_y$ ) in the income equation will be greater than ( $i_s$ ) in the sales equation in absolute terms. Therefore, if the interest rate increases RGDP will decrease more than the decrease in RFS, and we will have a case of decrease in inventories. But, if the interest rate decreases RGDP

---

<sup>100</sup>In general, the equilibrium point is a hypothetical case in order to help to start the analysis. The quarterly data during the period 1959-1997 showed that there is no single quarter at which the change in inventories is equal to zero.

will increase more than the increase in RFS, which is the case of accumulating inventories.

$$\text{RGDP} = (1/1-c) * (a + I_0 - i_y r) \quad (4:6)$$

$$\text{RFS} = (1/1-c) * (a + I_0 - i_s r) \quad (4:7)$$

Where  $i_y > i_s$

Out of the equilibrium point, this difference will make the IS curve of the RGDP flatter because the slope of the IS curve ( $\partial r / \partial \text{RGDP}$ ) is equal to  $(1-c/-i)$  from (4.4)<sup>101</sup>, and as long as  $i_y$  is greater than  $i_s$  based on the results, then the above-mentioned result hold assuming  $c$  is the same in both equations . Given that, this analysis is valid only out the equilibrium, which implies that the change inventories is not determined by the multiplier effect. This feature is obvious because inventories are the difference between two macroeconomic variables (RGDP and RFS) already determined by the multiplier and the other macroeconomic variables. This means that inventories show up in the economy as residual which implies that it is sometimes positive and sometimes negative. Also, they show up in small amounts relative to both RGDP and RFS. Therefore they are unable to make big shifts or movements in the business cycle but can be described as more responsible for making continues fluctuation in the RGDP and RFS, which is called propagation of the business cycle. I believe that the propagation of cycles is related mainly to three factors: first, the meaning of inventories as an indicator for economic expansion,

---

<sup>101</sup>For more details about simple algebra of IS-LM model and the aggregate demand curve see Mankiw (2000), pages 307-311.

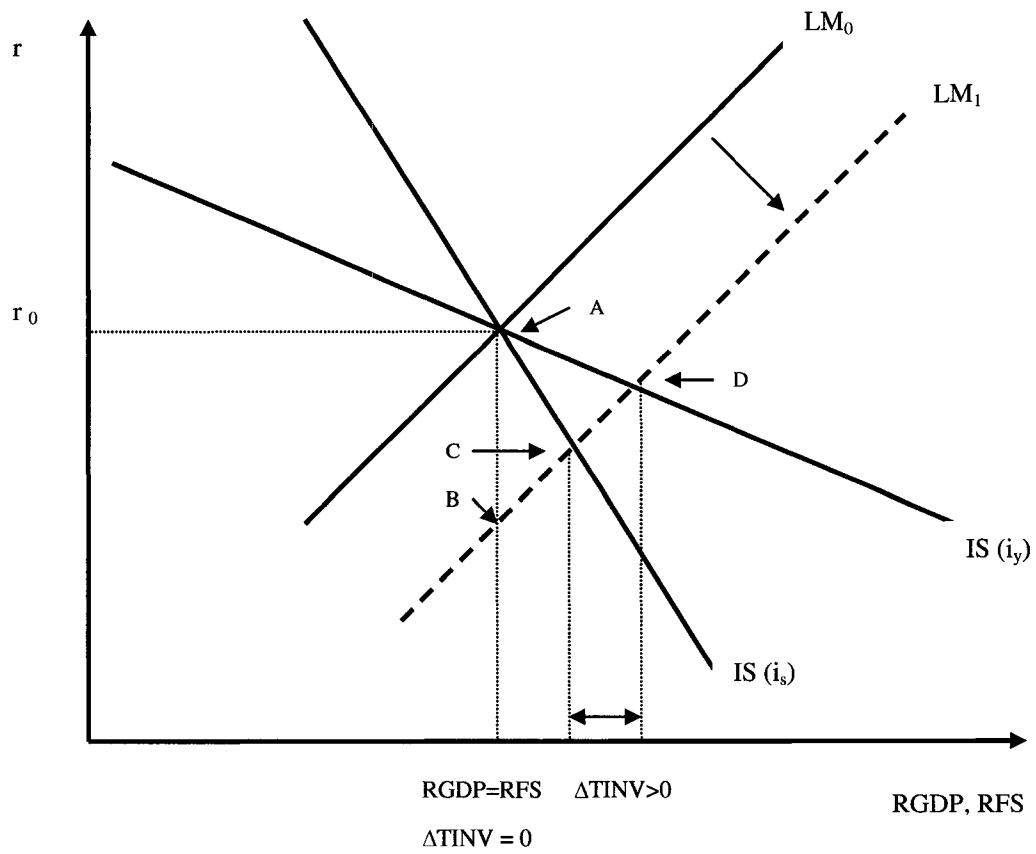
second, the economic circumstances accompanied with inventories, i.e. lower interest rate, and third, the evolution of inventories in the economy as a residual.

Figure 4.12 shows the idea of the response model by using the IS-LM curves. Point A represents the equilibrium point at which the interest sensitivity for both RGDP and RFS is the same, and based on this, the change in inventories is equal to zero ( $\Delta TINV = 0$ ). Out of this point the absolute value of the interest sensitivity for RGDP is larger than RFS. Figure 4.12 shows that a shift in the LM curve to the right by a monetary expansion, i.e.  $LM_0$  shifts to  $LM_1$ , will induce the interest rate to decline to point B, which in turn encourages both RGDP and RFS to increase. The difference in response, different interest sensitivity of planned expenditure with the negative sign, makes the RGDP increase more than the RFS to reach the new respective equilibria, i.e. C and D. The difference between C and D is the change in inventories. Or, in other words, the large response in absolute terms makes the drop in interest rate smaller for RGDP than RFS. Therefore, the size of inventory change relies on two factors, the difference in the size of response to the interest sensitivity  $i_y \neq i_s$  and the size of the shift in the LM curve.

Consequently, accumulating inventories<sup>102</sup> in the economy creates two forces pushing the economy towards the equilibrium. First, theoretically from the IS-LM model point of view, there are two points (C and D) with different interest rates, which means different a velocity of money, and this puts pressure on the interest rate to adjust: the larger the response, the larger the interest rate gap. And, even

---

<sup>102</sup>This analysis will be silent in the case of desired level of inventories, which means that the economy seeks to return to the equilibrium point, not to a desired level of inventories.



**Figure 4.12: The Response Model by Using the IS-LM Curves.**

theoretically based on the Keynesian<sup>103</sup> model, the equilibrium point is supposed to be where income is equal to expenditures (RFS); in this case income is greater than expenditure, thus we have inventories to fill the gap. Hence, I will consider those two points are disequilibrium ones, and this in turn means more pressure on the interest rate to be adjusted or to converge, and the best solution is to go back to point A or any point on the same level of  $r_0$ , that is, the intervention of fiscal policy in this case. Implicitly, all the above events mean more pressure on the prices to reach point A.

Second<sup>104</sup>, expanding the analysis, from the aggregate supply viewpoint, an increase in inventories reduces the demand for labor, which will reduce the aggregate supply prompt producers to reduce production<sup>105</sup>. From the aggregate demand perspective<sup>106</sup>, if we consider the inventories as real assets (both output and input assets) available to the private sector in the economy, this may have two effects: businessmen may increase their planned investment in the next period and this will shift the aggregate demand, and if those assets (inventories) are in huge amounts there will be an incentive for businessmen to make them available at lower prices which will increase aggregate consumption. The above description of the movement in the aggregate demand-supply model leads to increase the aggregate price level,

---

<sup>103</sup>For more details see Gordon (1987), pages 67-72.

<sup>104</sup>Assume we have a regular downward-sloping aggregate demand curve and upward-sloping aggregate supply curve as a general case.

<sup>105</sup>For more details see Blinder (1990) pages 14 -21.

<sup>106</sup>Blinder (1990), page 14, says that there is no persuasive reason to think that inventories have any direct effect on any component of the aggregate demand.

which will be the start of the self-adjustment mechanism to converge to the equilibrium, and this hints that during the period of increase in inventories the prices will be lower compared to the following period or period of decrease in inventories.

Logically, accumulating inventories in the economy faces three possible solutions in an aggregate demand–supply model. Either businessmen reduce the production and the economy will slow down into a recession, or the private sector behaves as mentioned above or the government intervenes by motivating the economy. Contrary to Blinder’s opinion,<sup>107</sup> “which is no persuasive reason to think that inventories have any direct effect on any component of the aggregate demand,” I believe that there is a room for the aggregate demand solution which put stronger pressure on the price and accelerates the propagation effect of inventories. Therefore the above two solutions by the private sector are as persuasive as a reaction compared to Blinder. If we read the economic circumstances of existing inventories generally from Irving Fisher’s consumption theory “The Intertemporal Budget Constraint<sup>108</sup>” we can notice the following features: Based on the results of the VAR model it is obvious that the periods of increase in inventories compared to the periods of decrease in inventories is accompanied<sup>109</sup> by lower interest rate, higher RGDP and greater than RFS and lower prices. And, based on this mode, this implies

---

<sup>107</sup>For more details see Blinder (1990), page 14.

<sup>108</sup>For more details see Mankiw (2000) pages 439-450; simply, this constraint measures the total resources available for consumption today and in the future.

<sup>109</sup>I would like to exclude from this analysis the extreme cases like the one mentioned in Figure 4.15.

that people tend to consume and invest more in the periods of increase in inventories and save in the periods of decrease in inventories because the interest rate will be higher. An important assumption in the “Intertemporal Budget Constraint Model” is that the consumer lives for just two periods, youth and old age, but in my current model I would like to adjust that to “the consumer lives for two periods: first, summation of all increasing inventories, and second, summation of all decreasing inventories across the time horizon.”

Table 4.6 provides evidence, based on quarterly data from the U.S. economy during the period 1973-2001 for the above analysis, that periods of increase in inventories represent periods of higher confidence in the economy and more economic activity. This table illustrates the growth rates of real personal consumption, real fixed private domestic investment and inflation rate for periods of increase in inventories and decrease in inventories. On average the growth rate of consumption is greater in the periods of increase in inventories compared to the periods of decrease in inventories. In addition, on average the growth rate of investment registers a positive rate in the periods of increase in inventories compared to a negative growth rate in all the periods of decrease in inventories. Moreover, the growth rate of the prices on average is lower in the periods of increase in inventories compared to the periods of decrease in inventories. And, it has been confirmed by the results of the VAR model that the feedback effect from TINV to P is negative (see Figure 4.5).

**Table 4.6 The Growth Rate of Consumption, Investment and Price Level for the  
Periods of Increase and Decrease in Inventories**

Increase in Inventories	(1)	(2)	(3)	Decrease in Inventories	(1)	(2)	Percent (3)
	Cons.	Invs.	Price		Cons.	Invs.	Price
<b>1975.3-1977.3</b>	1.19	2.98	1.55	<b>1973.4-1975.2</b>	0.07	-2.83	2.49
<b>1980.4-1981.3</b>	0.54	1.33	2.61	<b>1979.2-1980.3</b>	-0.03	-1.47	3.13
<b>1983.4-1984.3</b>	1.19	3.77	1.06	<b>1981.3-1982.4</b>	0.48	-1.58	1.46
<b>1987.1-1987.4</b>	0.67	0.27	1.08	<b>1990.3-1991.2</b>	-0.05	-2.02	1.19
<b>1993.3-1994.4</b>	0.94	2.24	0.65	<b>2000.4-2001.3</b>	0.45	-1.28	0.57
<b>1996.2-1997.2</b>	0.77	2.39	0.63				
<b>AVERAGE</b>	<b>0.88</b>	<b>2.16</b>	<b>1.26</b>		<b>0.19</b>	<b>-1.84</b>	<b>1.77</b>

(1): measured by Real Personal Consumption, Billions of Chained 1996 Dollars, SAAR.

(2): measured by Real Fixed Private Domestic Investment, Billions of Chained 1996 Dollars, SAAR.

(3): measured by Consumer Price Index: All Items, 1982-1984=100.

Consequently, Fisher's theory says that consumers try to smooth their consumption based on their lifetime resources (interest rate and income). In this current model people tend to save more in the period of higher interest rate because this will make the cost the consumer forgo less between the two periods, i.e. as  $r$  is higher,  $1/(1+r)$  is lower. And, in a declining inventories period even the income will be lower, as stated above. Therefore, based on the above economic conditions, consumers tend to consume and invest relatively more in the periods of increase in inventories. As a result, the aggregate demand will be higher. The final result of existing an increase in inventories from aggregate demand-supply model is that the increase in the aggregate demand and the decline of the aggregate supply will force

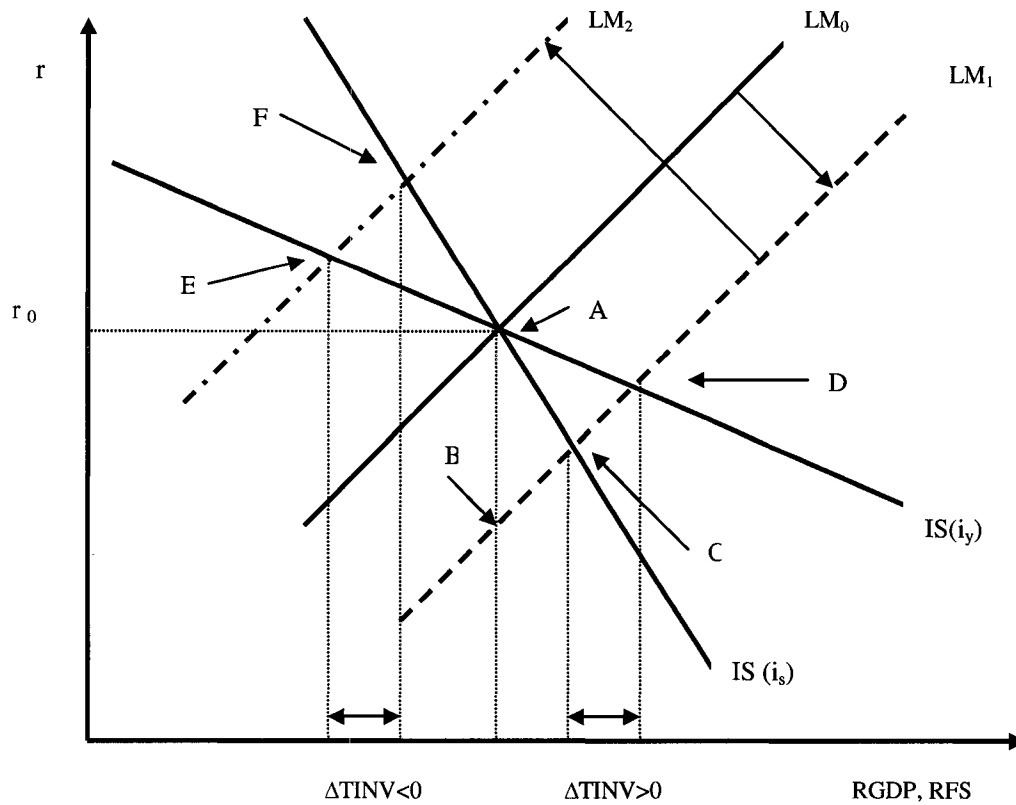
the prices to go up, which will decrease real  $M_2$  and put pressure on the interest rate to rise and return to the equilibrium point A again.

#### **4:9 A Complete Story**

In this part of the study the analysis will rely on the model in which RFS is ordered ahead of RGDP because it seems that RGDP responds, regardless of the order, more to the different variables in the model. This indicates that it tends to be more endogenous (follower) relative to RFS. Besides, in the previous sections it was shown that RGDP is able to explain TINV more compared to RFS.

The goal of this part is to look for the story of inventories by making all the variables move simultaneously. The analysis in this part relies on two resources, the results from the VAR model and the analysis of the IS-LM and aggregate demand-supplies models from the previous section. Essentially, I am trying to put all the pieces together to make a complete picture of inventories.

Suppose that we have an expansionary monetary shock in the economy. This shock will affect the interest rate negatively as a first variable in the economy, and this effect occurs instantaneously in the first quarter after the shock because the money market adjusts quickly. Figure 4.13 shows this monetary shock moves LM curve from  $LM_0$  to  $LM_1$ . This shock in the monetary factors has two effects, the first one is on the RFS and RGDP, which can be described as faster than the second one, because the increase in  $M_2$  has a positive effect on RFS and RGDP and the interest rate decline for  $M_2$  shock has another positive impact. The second effect is on the price level. This effect can be described as slower than the first one or, occurring after the first one, because we have two forces working in two different directions;



**Figure 4.13: The Self Adjustment Mechanism and the Propagation of Business Cycle**

the increase in  $M_2$  tends to increase  $P$ , but the decline in the interest rate has a tendency to decrease  $P$  because the relation between those two variables is positive<sup>110</sup> as proved by the VAR results. The results from the disaggregated model show that certain types of money (currency) have a positive impact on prices, and other types have a negative impact, such as non-borrowed reserve (NBR). In this regard, Christiano, Eichenbaum and Evans (1996) concluded that a GDP price deflator does not respond to a contractionary monetary policy shock for roughly a year, and after that it declines. Also, they mentioned that some economists such as Eichenbaum (1992) and Sims (1992) got abnormal results saying that the price level rises for over two years after a contractionary monetary policy shock. Walsh (1998)<sup>111</sup> mentioned that this abnormal result is due to the positive relation between federal fund rate and price level because the Fed is unable to offset the factors that led it to forecast higher inflation rate. Furthermore, Fama (1982) showed that interest rate has a positive relation with inflation rate, which is proved by my study. Also, Fama (1982) concluded that interest rate play an important role in determining the inflation rate. Putting these pieces of information together means the price during this short period suffers from fluctuation, and there is a high possibility that  $P$  may decline for a short period. The results of the aggregate VAR model show that  $P$  responds negatively to a positive shock in  $M_2$  for the first three quarters before it

---

<sup>110</sup>The empirical part of my study assumed implicitly that the monetary variables are determined before the price level. This result is the same as Fama's (1982) conclusion who explained this relation by using the quantity theory of money and assuming that interest rate is largely exogenous with respect to the price level. See Fama (1982) pages 202-204.

<sup>111</sup>Walsh (1998) reported some puzzling results, see pages 26-31.

becomes positive. From the IS-LM model point of view, the decline in the price means that the real money increases and the interest rate declines. This implies more inventories because the gap between RGDP and RFS is larger now, and this relation may help to explain the negative relation between inventories and the interest rate. After a while and as a net effect the prices have a general trend to increase despite fluctuations, because the economy will have an excess demand from the aggregate demand-supply model and this puts more pressure on the prices to go up, which is consistent with the theoretical analysis. Also, this analysis is consistent with the empirical results of my study<sup>112</sup> because the results showed that the relation between the inventories and the prices tend to be negative.

As I mentioned above, the economy has an excess demand and this puts a pressure on the prices, thus the prices will go up until they reach the new intersection of the aggregate demand and aggregate supply, i.e. the equilibrium. From the IS-LM model, both RGDP and RFS decline because the real money supply declines which means that the inventories decline too. Assuming that the prices in this case did not respond fully to the increase in the money supply<sup>113</sup>, this means that we still have inventories in the economy, which represents the continuous instability or disequilibrium case in the economy. This case can be seen in Figure 4.13 by shifting the LM from  $LM_1$  to a position between  $LM_1$  and  $LM_0$ .

---

<sup>112</sup>From both aggregated and disaggregated analysis.

<sup>113</sup>The reason for adopting this assumption is to show the effect of inventories on the aggregate demand.

To make the analysis simple and make sense, I would like to focus on the meaning of inventories in economy. It is clear from the analysis that inventories are accompanied by economic expansion, and this implies that the existence of inventories mean more growth and high confidence in the periods of increase in inventories compared with the period of decrease in inventories. Next, the pure inventory effect will be considered. Inventories create two strong forces affecting the prices and working in the same direction. First, on the aggregate demand side, inventories, based on the above mentioned circumstances, have a direct effect on the economy, to stimulate the aggregate demand through both increasing planned investment and consumption with the lower interest rate, and as a result the prices will increase. This result is confirmed by the VAR model in Figures 4.6 and 4.7 which show that TINV has a positive impact on RGDP and RFS, respectively<sup>114</sup>. On the aggregate supply, it is expected that the businessmen tend to reduce the production to abolish inventories and this procedure tend to increase the prices more. Those two forces tend to increase the prices abruptly, and based on the results of the VAR model this will increase the interest rate significantly by affecting the real money supply and the location of LM curve. The final result will be a decline in inventories accompanied with higher interest rate, higher prices, lower consumption and lower RGDP. Consequently, I believe that the self adjustment mechanism or the feedback effect from the inventories to the other macroeconomic variables is larger, and this analysis is supported by the results of the VAR model. Accordingly, the

---

<sup>114</sup>This implies that I can expand the analysis based on IS-LM model and show that inventories make a shift in both IS ( $i_y$ ) and IS ( $i_s$ ), which implies more declines in inventories because of the increase in the interest rate. I did this analysis in section 5:4 of the next chapter.

economy will converge to a new situation to the points E and F at  $LM_2$  as shown in Figure 4.13 or in a situation where there is a decrease in inventories (change in inventories is negative), then the same process will occur, and the RGDP keeps oscillating until reaching point A again or to close point which represents the desired level of inventories<sup>115</sup>. Empirically, this shows based on the actual data how the economy moves from a point where there is an increase in inventories (change in inventories is positive) to another point directly with a decrease in inventories (change in inventories is negative). In the case of using either a monetary or fiscal policy to help the economy to adjust, it may reduce the swings and get to point A faster. The desired level of inventories may be a good indicator for the producers that they reached their desired equilibrium point or close to the general equilibrium.

The above description demonstrates how the macroeconomic variables react in the IS-LM model and the aggregate demand-aggregate supply model. This reaction is based on the results from the aggregate and disaggregate analysis<sup>116</sup>. This analysis supports the empirical results of this study. The main point is that inventories are evolving in the economy as a result of the relation between RGDP and RFS and that inventories react with those two macroeconomic variables. The analysis gives an explanation or possibility that the weak role of inventories in the monetary transmission mechanism may come from the relation between RGDP and RFS from one side and from the interest rate from another side. The outcomes show

---

<sup>115</sup>Based on this analysis, the desired level of inventories may help to reduce the fluctuations of the business cycle.

<sup>116</sup>The disaggregate analysis in next chapter gives more details about many relations.

that both RGDP and RFS respond negatively to a positive shock in the FFR after the second quarter based on the aggregate analysis. And, as long as FFR has already determined the levels of both RGDP and RFS, inventories are just subtractions of the difference between the two variables. Then we can conclude that the negative relation between inventories and interest rate emerges as a transitive relation. Furthermore, the hint for this result is that inventories required a long time lag, around ten quarters, to respond correctly (negatively) to a positive shock in FFR. And, some kinds of inventories in the disaggregate analysis failed to prove this negative relation. According to the relation between the price and inventories, it is clear from the model that this relation is determined based on the relation between the monetary factors and the prices and the relation between both RGDP and RFS and the prices.

Generally, the feedback effect from TINV to the other macroeconomic variables can be described as strong and continuous because it affects the cost part, which is the prices and the interest rates through RGDP and RFS. In addition, its effect persists over time at an increasing rate, which implies it is hard to reach a real equilibrium where  $\Delta\text{TINV}=0$ . This conclusion does not agree fully with the idea derived by Blinder and Fischer (1981) which implies that the macroeconomic variables such as prices affect directly RGDP and indirectly through TINV. But, as long as the results shows that the relations between inventories and the other economic variables evolve in the economy based on the relation between RGDP and RFS and those macroeconomic variables, I expect to find that the direct relation from those variables to TINV is not strong as expected; my results confirm this.

Consequently, the analysis of this paper agrees with this logic in that there is a strong effect from TINV to RGDP and RFS as I mentioned earlier.

#### **4:10 Policy Implications**

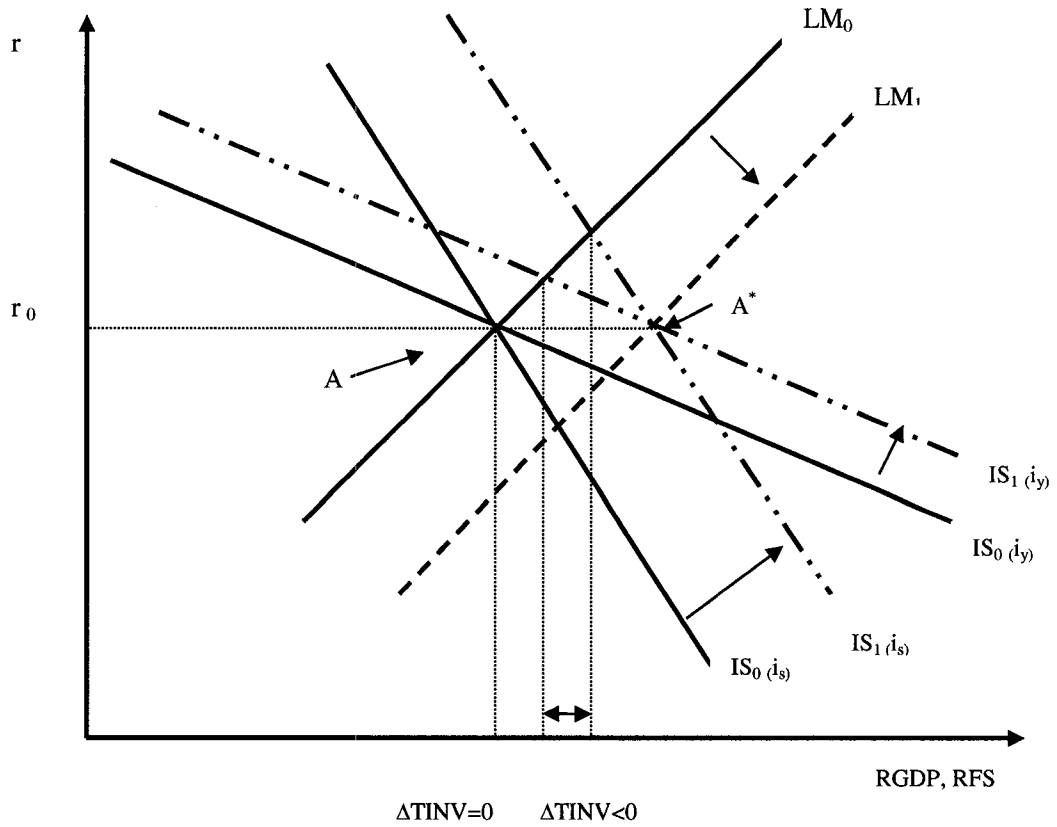
Based on the proposed IS-LM model (the response model), it seems that there is room for the fiscal<sup>117</sup> and the monetary policies to re-establish the equilibrium point again, also those two policies may cooperate to restore the equilibrium and this role will be quicker compared to the self-adjustment mechanism. This model shows that expansionary monetary policy and contractionary fiscal policy have the same effect, an accumulation of inventories, because those two policies cause lower interest rate. On the other hand, the contractionary monetary policy and expansionary fiscal policy have the same impact of decreasing inventories, since they cause higher interest rate.

The monetary case is explained in Figure 4.12 above. Consequently, Figure 4.14 shows the expansionary fiscal policy case. Assume that the economy is at point A where  $RGDP=RFS$  and  $\Delta TINV = 0$ . An expansionary fiscal policy will make a right-ward shift in both  $IS_{(iy)}$  and  $IS_{(is)}$ , which corresponds to RGDP and RFS. As long as the difference between RGDP and RFS is the interest sensitivity of planned expenditure and we have same multiplier, then it is expected that the horizontal shift will be equal. Therefore, both IS curves must intersect at point A<sup>\*118</sup>. Then the graph clearly reveals that we have a case of decrease in inventories with higher interest

---

<sup>117</sup>We can add the government sector to the response model in section 4:8 by adding the government expenditure (G) or taxes (T) to equation 4:1.

<sup>118</sup>For more details about the effectiveness of fiscal and monetary policies see Revier (2000).



**Figure 4.14: The Effect of Expansionary Fiscal Policy Assuming Change in the Interest Sensitivity.**

rate<sup>119</sup>. To reach an equilibrium point where there is no change in inventory then it is expected that the aggregate demand will decrease because, as I explained earlier the decrease in inventories will create two forces which make the consumption and planned investment decline. In addition, the decrease in inventories stimulates the production process to increase, and those two forces make the prices decline, which in turn makes the real  $M_2$  increases<sup>120</sup>; therefore, the LM curve will shift to the right until we reach a new equilibrium point which is point  $A^*$  or close to it.

It is important to mention that we assume in the case of the fiscal policy that the response of both  $IS_{(iy)}$  and  $IS_{(is)}$  are the same, which means both have the same multiplier effect for government spending or a tax change, and this graphically means a fiscal expansion must cause identical increases in both RGDP and RFS, because if there is a large difference in response in favor of RGDP (different multiplier)<sup>121</sup> this will change the results mentioned above and make the

---

<sup>119</sup>The results of the VAR model showed that FFR responds positively to a shock in RFS more than RGDP.

<sup>120</sup> This point shows that the economy started to move to a situation where there are inventories with a decline in the prices and lower interest rate.

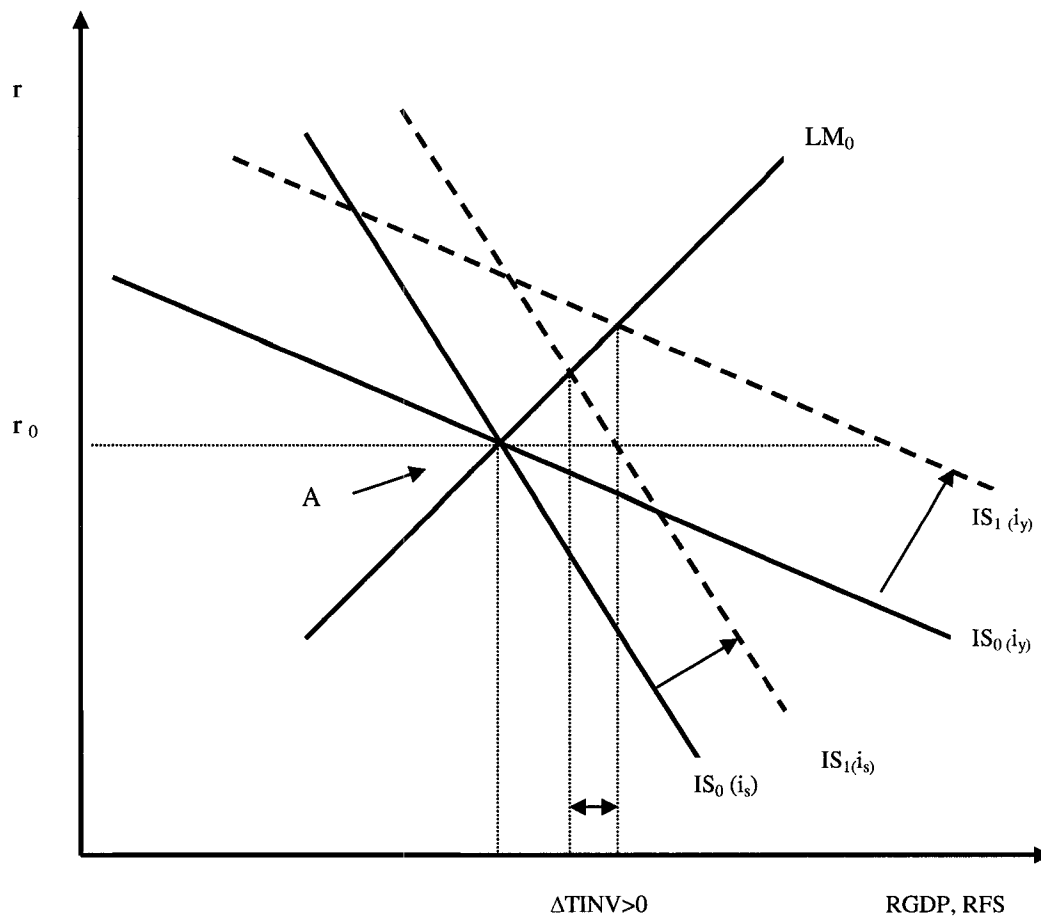
<sup>121</sup>In this case we implicitly assume the same interest sensitivity of planned expenditure, and this is clear from Figure 4.15.

expansionary policy accumulate inventories (Figure 4.15)<sup>122</sup>. However, in the case of the monetary policy we have just the above-mentioned results, thus I believe the monetary policy is dominant and has a unique solution in the case of inventories because the final results of this policy are known.

It is useful to pay attention to the difference in the outcomes in the above two different policy implications. It is apparent that the expansionary monetary case will create an increase in inventories and a lower interest rate; this case has also higher RGDP relative to the expansionary fiscal case in which there is a decrease in inventories with higher interest rate. According to the prices, it is clear that after accumulating inventories in the monetary policy case, the prices tend to increase in order to restore the equilibrium, and this is opposite from the fiscal policy case. The outcomes from the policy implication analysis are consistent with the above-mentioned theoretical analysis in the response model. Moreover, it is clear from the policy implication of the response model that there is a negative relation between an expansionary fiscal policy and accumulating inventories. In this regard, the data from the U.S. economy showed on average that during the periods of decrease in inventories as appears in Table 4.6, the growth rate of the federal government's real current expenditures is 1.28%, compared to 0.63% for the periods of increase in inventories. Also, the growth rate of the real government consumption expenditures and gross investment in the periods of decrease in inventories is 0.60% compared to 0.52% for the periods of increase in inventories.

---

<sup>122</sup>This is the case of assuming that the response is due to change in the marginal propensity to consume, not the interest sensitivity of the planned expenditure, which implies different assumptions and different policy implications.



**Figure 4.15: The Effect of Expansionary Fiscal Policy Assuming Change in the Multiplier.**

As with another alternative process as I mentioned earlier, we can reach point  $A^*$  in Figure 4.14 by adopting expansionary monetary policy shifts LM curve rightward. This policy will get the same results as in the self-adjustment case, but it may be faster, and this helps to reduce the negative effects on the economy. This analysis supports the idea that both policies can be used simultaneously to eliminate the increase or decrease in inventories. Whether to use one policy or two policies is determined by the priority of the economy. It is useful to mention that using different combinations of monetary and fiscal policies to control inventories depends mainly on whether we have different interest sensitivity of investment expenditure and the same multiplier or same interest sensitivity of investment expenditure and a different multiplier. For example, in the first case, using an expansionary fiscal policy will cause a decrease in inventories, therefore to abolish this unstable situation we can use an expansionary monetary policy. The final result will be an increase in RGDP and restoration of the interest rate level. However, in the second case the situation is different. Using expansionary fiscal policy causes accumulating inventories (Figure 4.15), thus to eliminate or reduce this amount of added inventories, we can use contractionary monetary policy, which will lead to restore the RGDP and increase the interest rate.

#### **4:11 The Difference Between the Current Model and Blinder's Model**

In this part of the dissertation, I would like to highlight the major differences between the model of this paper (the response model) which is built based on the result of the VAR model, and Blinder's model (1980). Blinder's model tries to prove that inventories are a stabilizing factor by reducing the spillover from the commodity

market to the labor market<sup>123</sup>. Therefore, he modeled inventories as a factor of production, and he relied mainly on the aggregate demand-supply model to describe how the macroeconomic variables react with each other to reach the equilibrium point. In this part, I am interested in illustrating the portion of the model that is related to inventories.

On the aggregate demand side, Blinder derived a positive relation between the RGDP and RFS. He started this relation from the IS curve after he showed that when  $RFS=RGDP$  then  $\Delta TINV=0$ <sup>124</sup>. Also, he used a regular upward sloping LM curve<sup>125</sup>, and finally he concluded that RFS at the equilibrium point is a function of RGDP, monetary policy, fiscal policy and the rate of inflation. On the aggregate supply, Blinder assumed that increasing the existing level of inventories will decrease the demand for labor, which will reduce production. Therefore, RGDP (supply) depends on the level of inventories, which means that the aggregate supply is a vertical line. Moreover, the relation between inventories and aggregate supply is negative because increase in inventories reduces the demand for labor, which in turn will reduce the aggregate supply.

---

<sup>123</sup>The response model seeks to show how the relation between inventories and both interest rate and prices evolve in the economy, and to prove that inventories have a destabilizing role on the macroeconomic level.

<sup>124</sup>This means we have a certain level of inventories but it is constant or unchanged.

<sup>125</sup> $M/P = F(R, Y)$  where  $F_r < 0$ ,  $F_y > 0$ .

As a final step Blinder substituted the value of aggregate supply (RGDP) into the aggregate demand equation<sup>126</sup>, and he got RFS as a function of inventories, monetary policy, fiscal policy and the rate of inflation. Based on this final result, he concluded that monetary and fiscal policy affects RFS but will not affect RGDP<sup>127</sup>. His model focuses on analyzing the equilibrium itself because at the equilibrium RFS represents the aggregate demand. Therefore, a positive monetary shock will increase RFS and this consume all the inventories, which means that the relation between RFS and inventories is negative over the business cycle<sup>128</sup>; this action stimulates the aggregate supply to produce more and to return to the equilibrium. This conclusion implies that an increase in the money supply will reduce inventories, and implicitly this means there is a positive relation between interest rate and inventories which looks inconsistent with the finding of other papers such as Rubin (1979) and Jin (2001) who confirm this relation is negative and strong.

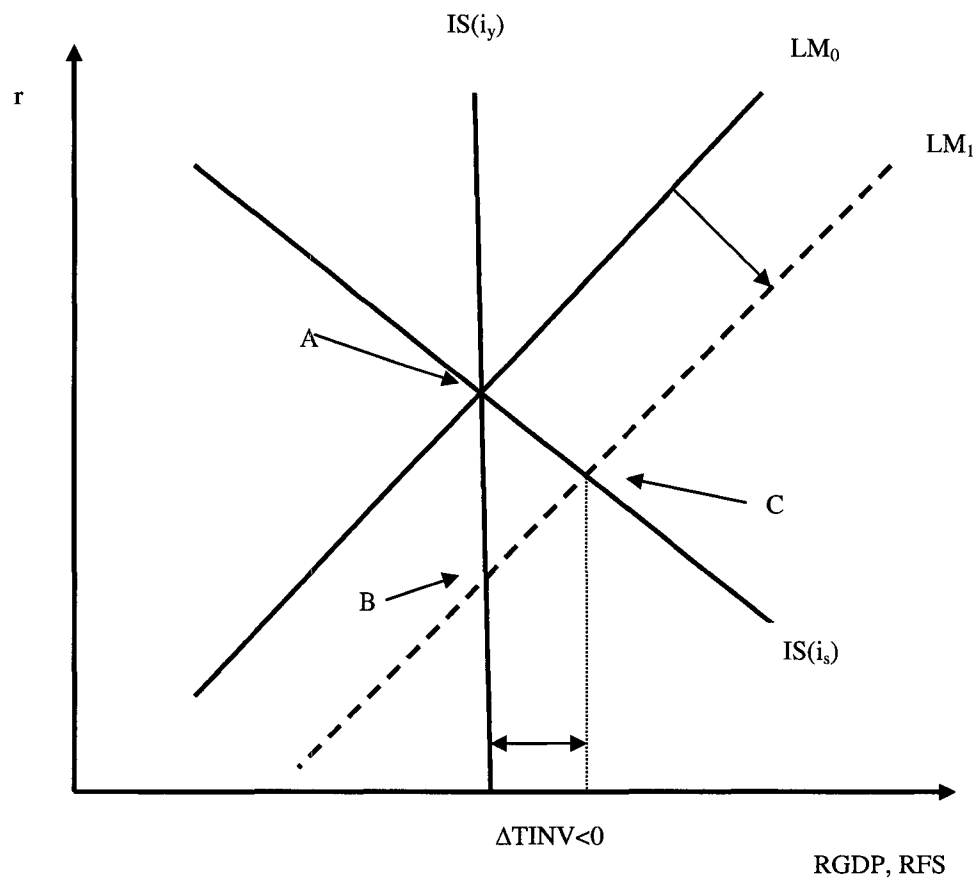
Next, I am trying to convert Blinder's model to fit into the IS-LM format in order to be able to compare with the response model to show exactly the difference between both models. From Figure 4.16, it is clear that the main feature of Blinder's model is that RGDP is constant and moves to the right or to the left based on accumulating inventories. Also, a change in the monetary policy will affect RFS but

---

<sup>126</sup>At the equilibrium aggregate demand is equal to aggregate supply.

<sup>127</sup>This conclusion shows that this model is affected by the idea of the production smoothing model (PSM), because a shock to RFS will consume all the inventories.

<sup>128</sup>Hornstein (1998) and the empirical part of this study proved that the relation is positive over the business cycle and just negative in the very short run.



**Figure 4.16: Blinder's Model from the Response Model Formatting**

will not affect RGDP. Thus, this figure shows the main difference between the two models, which in turn leads to the difference in the results. It is apparent that in Blinder's model RGDP is not responsive at all to the interest rate, i.e.  $i_y=0$ , while RFS is, but in the response model RGDP responds more than RFS to any shock in the economy, i.e.  $i_y > i_s$ .

To show how this model works, suppose we have a positive monetary shock; the economy will move from point A, which represents a stable equilibrium where the three curves meet<sup>129</sup>, to points B and C respectively. It is obvious at the new point C that RFS is greater than RGDP at point B; thus we have a decrease in inventories. This case shows that there is a positive relation between the interest rate and the increase in inventories (inventories),<sup>130</sup> which is opposite from the results of the response model. This new situation represents disequilibrium and the economy will keep adjusting itself. At this time, there are two economic forces. First, RGDP<sup>131</sup> responds positively to the decline in inventories by moving the vertical  $IS(i_y)$  to the right, which slows down the decrease in inventories. At the same time, inflation appears<sup>132</sup> in the economy reducing real money supply and as a result RFS declines,

---

<sup>129</sup>At this point  $RGDP=RFS$ , so  $\Delta TINV=0$  or the level of inventories is unchanged.

<sup>130</sup>This result is related to the main feature of Blinder model which is RFS responds to a monetary shock while RGDP is not.

<sup>131</sup>RGDP is equivalent to aggregate supply in this model.

<sup>132</sup>Because aggregate demand is greater than aggregate supply. In Blinder's model it is easy to see that because  $RFS=aggregate\ demand$  and  $RGDP=aggregate\ supply$ . But, in the response model we have to visualize an upward sloping aggregate supply curve and a downward sloping aggregate demand curve.

leading to an increase in inventories. I believe that when the real money supply decreases to the point where the LM returns to its previous position at point A, the economy will have a case of increase in inventories because  $IS(i_y)$  will be to the right of point A, which means RGDP is greater than RFS, and this forces the businessmen to reduce their production. So, the three curves will meet again on point A, which represents an equilibrium with a constant level of inventories or  $\Delta TINV=0$ .

In Blinder's model, the vertical  $IS(i_y)$  curve represents the aggregate supply. Therefore, when we move toward point C we place a pressure on the prices to go up because we are in a situation where aggregate supply is less than aggregate demand (RFS) as a result of the monetary shock. In the response model, with the same positive monetary shock we have an increase in inventories, as I explained above, and we have the same effect on the prices for this reason. In addition, the price will increase for two reasons related to the inventories: first, increase in inventories will motivate businessmen to reduce their production, and second, the increase in inventories has a positive impact on the aggregate demand by affecting both consumption and fixed investment which exists only in the response model analysis.

The response model focuses on the IS-LM model to explain the relation among the macroeconomic variables and also utilizes a regular aggregate demand-supply model to focus on the price movement because it is important to restore the equilibrium through the self-adjustment mechanism<sup>133</sup>. Contrary to Blinder's model, the response model looks to the inventories from a pure aggregate demand point of

---

<sup>133</sup>The goals of this dissertation require using IS-LM and the aggregate demand-supply model in such a way.

view and uses the aggregate demand–supply model to reflect the increase in the price. Thus, a monetary policy affects both RGDP and RFS, and the response of RGDP is greater because of the response of RGDP to the interest rate; i.e., FFR is greater in absolute terms than RFS's response to FFR. As a result, a positive monetary shock will increase inventories and a negative shock will decrease inventories. This conclusion confirms that the relation between money supply and inventories is positive and this implies indirectly a negative relation between inventories and interest rate. The main difference between the two models is that Blinder's model says that a positive monetary shock will increase RFS, which will make the inventories decline and this in turn prompts the output to increase. But the response model says that a positive monetary shock will increase both RFS and RGDP, while at the same time the increase in RGDP is greater than RFS, therefore inventories increase. Hence, according to the response model, the relation between the money supply and inventories represents a normal positive relation which implies a negative relation between inventories and interest rate. This is exactly the same as the relation between money supply and RGDP or the real economic activity.

According to the price level, as a response to a monetary shock Blinder's model says that inflation appears because inventories disappear in the economy and the aggregate supply is increases to compensate for the decline in inventories, as a result price increases and this erodes RFS, which is the first sign that the economy is returning to equilibrium. Therefore, opposite from the response model, Blinder's model shows a negative relation running from increase in inventories to prices and a positive relation running from prices to increase in inventories. Nevertheless,

according to the response model I differentiate between short-run and long-run effects. In the short run there is an indirect negative relation running from the prices to inventories because the negative relation between them is formulated based on the reaction of each variable with the other variables in the model. But, in the long run, an increase in inventories represents an unstable situation and this will therefore put some pressure on prices, indirectly through the aggregate demand and supply, to move, causing prices to go up and reach equilibrium again. This implies a negative relation between them in the second phase too. Both models show that the price level plays a crucial role in restoring the equilibrium.

In this part of the analysis I would like to focus on the role of prices in both models in restoring the equilibrium and the relation with the propagation of the business cycle. Both models rely on adjustment of prices to reach the equilibrium point again. I believe that this point is hypothetical and the desired level of inventories may be more realistic. In the response model the pressure on the prices to adjust is more than in Blinder's model because we assume that inventories will affect both aggregate demand and aggregate supply, while in Blinder's Model it only affects the aggregate supply. In addition, in the response model the positive relation between the money supply and inventories tends to increase the prices more compared to Blinder's model, which concludes that the relation is negative. This means that in the response model the monetary shock will increase prices, while at the same time the increase in inventories leads to a decrease in the aggregate supply and an increase in the aggregate demand, beginning about a greater increase in prices. However, in Blinder's model it seems that the increase in the prices because

of the monetary shock will be canceled or lightened by the increase of the aggregate supply, because inventories decline from a monetary shock. Therefore, as long as the equilibrium point is a hypothetical case, meaning that there is always an increase or decrease in inventories in the economy, then I can say based on the response model analysis that inventories are able to affect the prices strongly and continuously compared to Blinder's model. This strong effect on prices is able to create a case of a permanent fluctuation in the economy in order to reach equilibrium or the desired level of inventories, and this process is known as the role of inventories in the propagation of the business cycle.

In the area of policy implication, both models approve that expansionary fiscal policy will generate a decrease in inventories and that a contractionary fiscal policy accumulates inventories. The basic difference between the two models is that in the monetary policy, a positive monetary shock causes a decrease in inventories in Blinder's model, while in the response model it increases inventories. In general, in the response model it has been proved that the relation between inventories and interest rate is negative; therefore any policy leads to increasing interest rate such as contractionary monetary policy and expansionary fiscal policy causes a decrease in inventories. While, in Blinder's model a contractionary monetary policy leads to an increase in interest rate and causes inventories to increase (positive relation). However, an expansionary fiscal policy which leads to an increase in interest rate leads to a decrease in inventories (negative relation), and this reflects an inconsistency in Blinder's policy implications.

#### **4:12 Comparing the Results with other Empirical Studies.**

Despite of the differences in the models and the different sectors or sub-sectors of inventories used in the empirical studies of inventories, the findings of this paper are consistent with the results of those studies, especially in the role of inventories in the monetary transmission mechanism. It is clear that inventories respond positively to a shock in money supply and negatively to the interest rate. Also, the results show that the relation between interest rate and inventories doesn't apply to all kinds of inventories. This relation needs some time lag to respond correctly to what is expected by the theory.

The current study concluded that both RGDP and RFS are the most important variables that determine inventories. As long as these two variables are affected negatively by the interest rate (FFR), then we can logically expect that the relation between inventories and FFR is negative. The hint for this relation is that the time lag needed for inventories to respond to FFR is longer than that for both RGDP and RFS. Therefore, I would like to state that inventories are affected by monetary factors through the relation between the RGDP and RFS and that this mechanism requires a time lag for the inventories to show the right negative sign or to behave in an appropriate way consistent with the theory. This result is close to the conclusion reached by Larrain (2002) in spite of the fact that both studies used different methodologies and different variables. As for prices and inventories, it is expected by the theory that the relation between prices and inventories is positive because of the speculative motive. The results of this study assure that the relation is negative

and it is determined through the reaction of each variable to the other variables in the model.

In general, the literature review showed that before 1978 a bulk of empirical studies failed to find a negative relation between the economic activity represented by the fixed investment and interest rate<sup>134</sup>. Specifically, despite the fact that in the field of inventories there are not many empirical studies, the conclusion of those studies<sup>135</sup> confirm the above-mentioned result, which pushed Lovell (1976) to say the probability of obtaining a negative relation between inventories and interest is 50%. The more recent studies have shown different results.

After 1978, the empirical findings of many studies such as Rubin (1979), Lieberman (1980), Irvine (1981a, 1981b) and Akhtar (1983) concluded that the relation between interest rate and inventories is negative. At the same time, the results of these studies failed to confirm that prices have an important relation with inventories; some of them found it significant and positive, some found it insignificant, some found it negative and others were not quite sure. My study confirms that the above two relations are negative but weak, because they happen indirectly through the relation between RGDP and RFS. Based on my classification of the results of this study, the role of inventories in the monetary transmission mechanism is closer to Ramey (1989) than to Jin (2001).

Theoretically, the results of this study are consistent with the analysis of both Metzler (1941) and Blinder (1980) concerning the feature of inventories, which says

---

<sup>134</sup>For more details see Savage (1978). This survey is focused on the U.S and the U.K.

<sup>135</sup>For more details see Irvine (1981b).

that the existence of inventories in an economy means that this economy is out of equilibrium and the economy will go through more fluctuations until it reaches an equilibrium characterized by zero inventories or a desired level of inventories. Also, Ramey (1989) proved as in this study that inventories are a source for shocks and significant propagation mechanism. Moreover, this study agrees with Christiano's (1988) result which describes inventories as a residual. Consequently, the results of this dissertation don't agree with the logic or explanation behind Blinder and Fischer's (1981) model which is there is an indirect channel effect running from some macroeconomic variables such as the prices to RGDP through inventories. This disagreement relies on two points; first, the direct relation between those macroeconomic variables and inventories is weak. Second, inventories are residuals, therefore all the macroeconomic variables affect inventories through RGDP and RFS. And in return, inventories affect the other macroeconomic variables through those important macroeconomic variables (RGDP and RFS).

Furthermore, the conclusion of this study, which is related to the relation between RGDP, RFS, and TINV, is consistent with the results of both Hornstein (1989) and Allen (1997) despite the fact that every study used different methodology. This consistency in the results confirms that the relation between RFS and TINV is positive over the long-run business cycle but negative over the very short-run business cycle. Also, this study confirms that different kinds of inventories behave in a different way, as was concluded by both Bain (1985) and Hornstein (1989).

**Chapter Five**  
**Empirical Results and Analysis II**  
**“Disaggregated Data”**

**5:1 Introduction**

The goal of this chapter is the same as in the previous one, but this chapter will focus more on the disaggregated data for both the money supply and inventories. I will disaggregate the money supply into outside money<sup>136</sup> which includes non-borrowed reserves (NBR) and currency held by the public i.e. currency in circulation (CC), and inside money, which consists of bank deposits. In this study, money multiplier (MM) is used as a proxy for inside money. The reason for choosing these components as a representation for the money supply is that every component has been proved by the previous studies to have a relation with a specific variable in the model. The previous studies proved that NBR is the only component of the money supply which has a negative relation with the interest rate, i.e. FFR. MM has a direct and strong relation with the economic activity, while the currency held by the public has a strong relation with the price level (P). Total inventories (TINV)<sup>137</sup> will be

---

<sup>136</sup>In general outside money refers to the high powered money or monetary base, which is defined as the summation of total reserve and currency in circulation.

<sup>137</sup>Total inventories will be part of the VAR system to compare the results with the aggregate model.

disaggregated into manufacturing inventories (MINV) and retail trade inventories (RINV). Specifically, disaggregating data will be useful in two directions; first, we can check whether it will quicken the response of the variables or reduce the lag effect. Second, we can check whether the component of inventories acts and reacts with the macroeconomic variables in the same way as in the previous chapter.

In this chapter I will not go through the same technical steps which I provided in Chapter Four but I rather directly analyze the main results. Table 5.1 shows the estimated lag length based on the three measures LR, AIC, and SC. It is obvious from the table that the three measures still confirm the two lags as the proper lag length even for the disaggregated model. Also, I applied here the second LR ratio I used in the previous chapter, which provides the same result too.

**Table 5.1 Lag Lengths Estimation**

<b>Increased Lag from</b>	<b>LR</b>	<b>Degrees of Freedom</b>	<b>Critical value<sup>(1)</sup></b>	<b>AIC</b>	<b>SC</b>
<b>1 to 2</b>	<b>215.3</b>	100	135.8	<b>-13811.3</b>	<b>-13173.6</b>
<b>2 to 3</b>	54.3	100	135.8	-13587.0	-12647.6
<b>3 to 4</b>	54.2	100	135.8	-13368.4	-12128.6
<b>4 to 5</b>	71.8	100	135.8	-13183.4	-11644.6
<b>5 to 6</b>	12.2	100	135.8	-12909.8	-11073.4
<b>6 to 7</b>	48.9	100	135.8	-12709.1	-10576.3
<b>7 to 8</b>	51.4	100	135.8	-12527.8	-10100.1

(1) The critical value for LR at 99% confidence level.

According to Johansen's cointegration test, as long as I analyzed the results of the previous chapter at 99% confidence level or 1% critical value, then I will use the same values in this chapter; therefore, in Table 5.2 Johansen's cointegration test

**Table 5.2 Johansen's Cointegration Test**

<b>Trend assumption: linear deterministic trend.</b>					
<b>Series: NBR, MM, CC, FFR, P, RFS, RGDP, MINV, RINV, and TINV</b>					
<b>Lag interval (in first difference): 1 to 2</b>					
<b>Hypothesis</b>	<b>Eigenvalues</b>	$\lambda_{\text{trace}}$	$\lambda_{\text{max}}$	<b>1% for <math>\lambda_{\text{trace}}</math></b>	<b>1% for <math>\lambda_{\text{max}}</math></b>
None	0.438976	318.1	88.4	247.3	69.1
At most 1	0.305000	229.7	55.7	205.0	62.8
At most 2	0.262249	174.0	46.5	168.4	57.7
At most 3	0.219431	127.5	37.9	133.6	51.6
At most 4	0.198551	89.6	33.9	103.2	45.1
At most 5	0.117081	55.7	19.1	76.1	38.8
At most 6	0.105410	36.7	17.0	54.5	32.2
At most 7	0.082324	19.6	13.1	35.7	25.5
At most 8	0.041089	6.5	6.4	20.0	18.6
At most 9	0.000427	0.07	0.07	6.7	6.7

Trace and Max-eigenvalue tests indicate 3 and 1 cointegration equations at 99% confidence levels, respectively.

includes the 1% critical value. Also, the table shows that the trace statistics indicate that we have three cointegration relations, while max statistics points out that it is just only one cointegration relation. This difference in the results is expected because I as explained in Chapter Four, the alternative hypothesis is different between the two tests. Therefore, I will use Enders' (1995) opinion<sup>138</sup> that max statistics is preferred to pin down the number of cointegration equations because it has a sharper alternative hypothesis. As for the orders of the variables in this model, I will follow

---

<sup>138</sup>Enders (1995) page 393.

the same ordering as in Chapter Four. As for the ordering of the monetary variables, the monetary theory indicates that the outside money and particularly non-borrowed reserves represents the policy tools of the Federal Reserve; therefore it will be ordered as the first one. The order continues with inside money, which represents the action of both the private sector and the banking regulation, and then CC followed by the FFR. The results of different scenarios of the FEVD prove this result.

## **5:2 Empirical Results and Analysis Using Disaggregated Data**

The results of the cointegration test show that these variables can be cointegrated, or that the variables are able to converge to long-run equilibrium. As a result, the ECM will be used in this chapter. The IRF and FEVD from the ECM will be used to analyze the results. Table 5.3 shows the FEVD from the ECM, and next thirteen figures show the IRF from the same ECM for the variables in the model. In order to make the analysis consistent with that of Chapter Four, I will analyze the results in this chapter with the same section names as before.

### **5:2:1 The Relation Between Money Supply, Interest Rate and Inventories.**

Using different scenarios of ordering the variables, the FEVD shows that NBR is the policy tool or the first exogenous variable and then MM is considered as a second one. The one I am following in Table 5.3 shows that both of them are able to explain more than 77.0% of their fluctuations. In the short-term horizon, the same table shows that NBR shocks are able to explain not more than 21.1% of the fluctuation in FFR, while MM shocks are able to explain not more than 8.0%.

**Table 5.3 Forecast Error Variance Decomposition from ECM**

Order (NBR, MM, CC, FFR, P, RFS, RGDP, MINV, RINV, TINV)

Variance Decomposition of NBR				Explained by						
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	84.7	5.5	0.2	0.2	1.2	1.0	0.6	6.2	0.3	0.1
16	78.5	9.8	0.3	0.1	1.3	0.9	0.3	7.9	0.8	0.1
24	76.4	11.2	0.3	0.1	1.8	1.0	0.2	8.0	0.9	0.1
Variance Decomposition of MM				Explained by						
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	1.8	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.2	90.0	3.4	1.0	0.2	0.1	0.9	0.6	3.1	0.6
16	0.2	81.7	4.8	2.5	1.5	0.9	1.6	1.1	4.5	1.3
24	0.3	77.1	4.5	3.2	3.3	2.0	2.3	1.2	4.6	1.5
Variance Decomposition of CC				Explained by						
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	0.03	14.4	85.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.50	16.4	67.2	4.8	2.6	0.6	0.04	3.6	3.8	0.4
16	0.4	19.9	58.6	4.6	3.2	0.5	0.2	6.7	5.6	0.4
24	0.3	20.6	55.7	4.2	4.0	0.7	0.5	7.5	6.3	0.4
Variance Decomposition of FFR				Explained by						
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	17.9	8.1	8.5	65.5	0.0	0.0	0.0	0.0	0.0	0.0
8	11.2	3.4	2.1	47.6	13.9	18.6	1.0	0.9	0.2	1.0
16	10.2	1.8	1.1	43.6	16.8	22.3	1.0	1.6	0.2	1.4
24	9.8	1.3	0.7	41.8	18.4	23.7	1.1	1.7	0.1	1.4
Variance Decomposition of P				Explained by						
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	3.9	0.2	0.0	2.1	93.8	0.0	0.0	0.0	0.0	0.0
8	3.6	3.0	2.7	1.5	76.4	10.5	1.4	0.2	0.6	0.1
16	3.0	1.3	4.3	1.7	68.9	14.9	4.6	0.5	0.9	0.1
24	2.8	0.6	4.4	2.0	66.4	16.6	5.9	0.4	0.8	0.2

**Table 5.3 continued**

Variance Decomposition of RFS Explained by										
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	1.0	2.6	0.1	7.1	3.7	85.6	0.0	0.0	0.0	0.0
8	0.8	39.2	4.4	0.8	1.4	42.7	0.3	3.8	0.1	6.4
16	1.0	50.9	3.5	1.0	3.2	24.6	1.5	7.2	0.7	6.4
24	1.3	52.0	2.8	1.4	5.9	18.2	3.0	8.1	1.0	6.4
Variance Decomposition of RGDP Explained by										
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	1.3	1.5	0.3	7.7	1.1	54.8	33.3	0.0	0.0	0.0
8	0.7	38.9	4.2	1.9	2.0	39.3	3.2	5.3	0.1	4.5
16	0.9	51.4	3.4	1.4	3.6	23.3	2.9	7.8	0.7	4.5
24	1.2	52.9	2.9	1.5	6.2	17.6	3.8	8.3	0.9	4.5
Variance Decomposition of MINV Explained by										
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	4.0	1.4	0.0	0.3	1.1	0.2	32.8	60.3	0.0	0.0
8	6.1	1.5	0.4	5.3	4.3	14.8	13.2	53.8	0.6	0.1
16	4.9	5.6	0.1	3.3	3.4	13.9	7.6	59.7	1.2	0.2
24	4.7	7.1	0.1	2.8	2.9	13.0	5.9	61.8	1.5	0.2
Variance Decomposition of RINV Explained by										
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	2.6	0.2	0.4	1.2	3.1	0.5	32.8	13.2	45.9	0.0
8	4.0	17.9	6.6	4.5	3.2	4.6	15.4	4.6	33.8	5.5
16	5.7	27.3	7.9	2.1	4.4	2.4	7.4	2.1	33.2	7.4
24	7.0	25.2	7.4	1.6	8.4	3.0	4.9	1.5	33.2	7.9
Variance Decomposition of TINV Explained by										
Period	NBR	MM	CC	FFR	P	RFS	RGDP	MINV	RINV	TINV
1	0.6	0.2	1.9	0.4	1.0	0.8	91.9	0.3	0.0	2.8
8	3.3	3.9	0.8	6.4	1.0	12.5	54.2	12.3	0.2	5.3
16	2.5	13.7	0.9	3.7	0.8	10.2	36.5	24.8	0.3	6.7
24	2.2	16.7	0.7	2.8	1.8	8.0	30.0	30.2	0.5	7.2

Consequently, the IRF in Figure 5.1 shows that NBR is the only monetary variable in this model that has a permanent negative impact on FFR, which confirms that NBR is the main part of the exogenous monetary policy, while MM has a negative effect on FFR until the eighth quarter and then it changes to positive. This conclusion supports my results from analyzing the aggregate data in the previous chapter, which show that the effect of  $M_2$  on FFR is negative until the eighth quarter and then turn to be positive after that.

The pure negative relation between NBR and FFR has been confirmed by Shbikat (2000), who used the same technique as in this study, but there are three main differences between those two studies. First, he used the three-month treasury bill rate as an indicator for the interest rate, while in this study I used the federal fund Rate. Second, in his study a positive shock to MM leads to an increase in the interest rate, but in this study it has a negative effect until the eighth quarter and then reverses direction to positive. And this study shows that there is an instantaneous effect from MM to FFR while in his study it doesn't. Third, the response of the interest rate to both NBR and MM looks stronger in this study.

Returning to the FEVD, Table 5.3 illustrates that FFR is able to explain more than 42.0% of the variation in itself. Also, it is unable to explain the fluctuation in NBR, but can explain 4.0% and 5.0% of both MM and CC, respectively. Consequently, the IRF in Figure 5.2 shows that a positive shock to FFR has a positive impact on MM. This result is consistent with the theory because a rise in the interest rate reduces the excess reserve, assuming the demand deposit is constant and

Response to Cholesky One S.D. Innovations

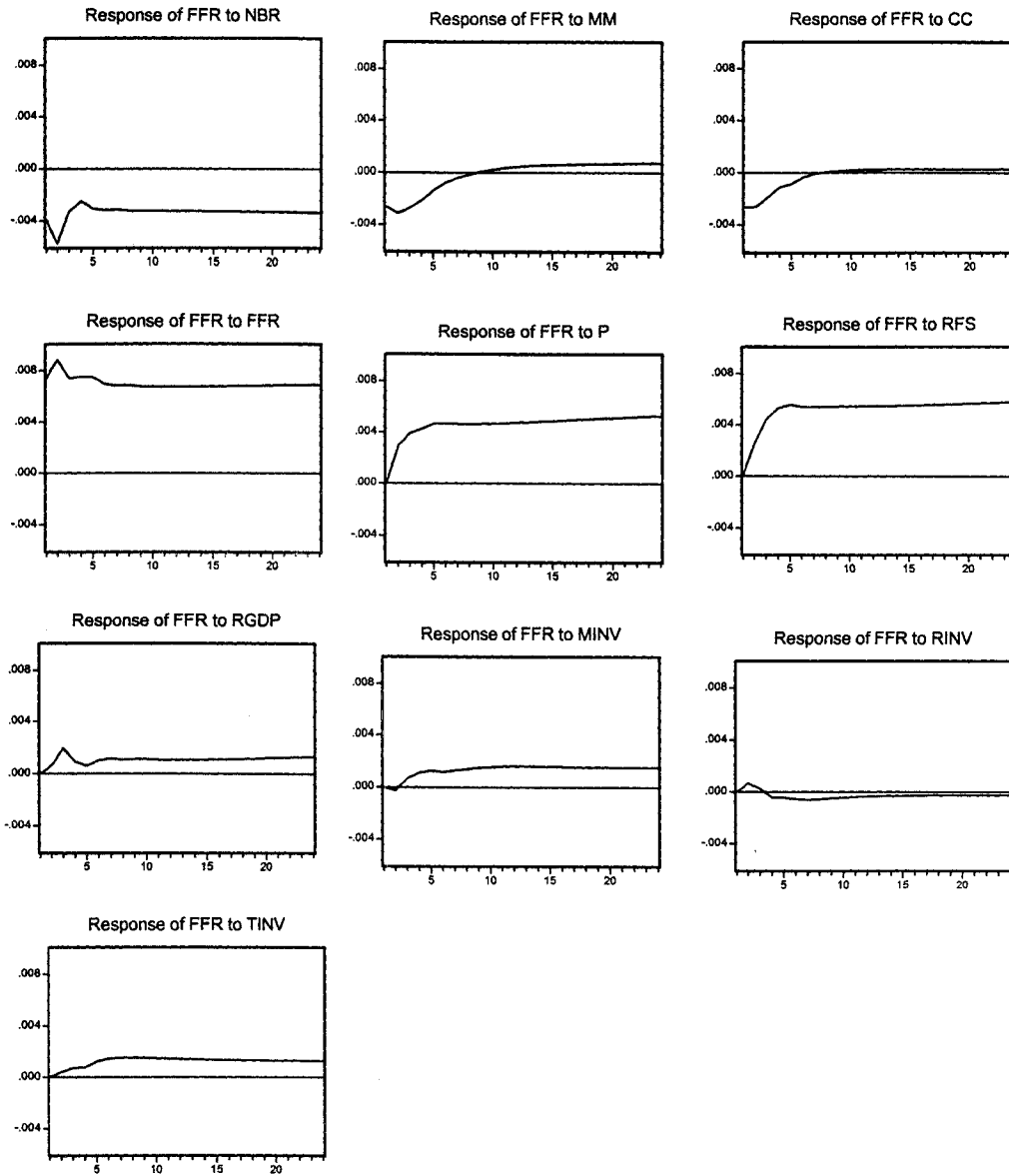


Figure 5.1 : The Impulse Response Function From ECM For FFR

Response to Cholesky One S.D. Innovations

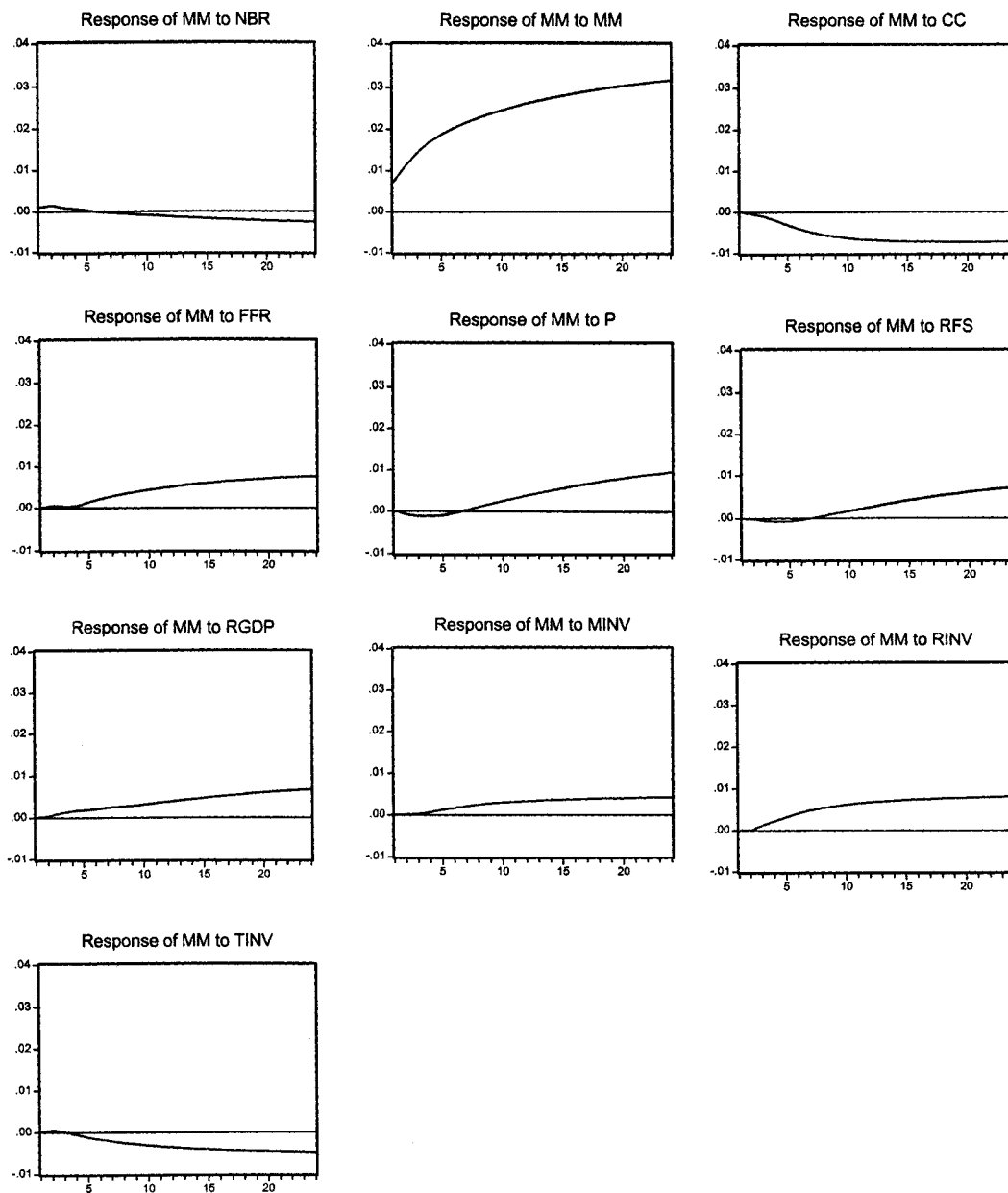


Figure 5.2 : The Impulse Response Function From ECM For MM

will cause the MM to increase<sup>139</sup>. And, even the results of the IRF in Figure 5.3 show that a positive shock to FFR reduces the currency held by the public, which leads to an increase in MM too, because the opportunity cost of holding currency is higher and the demand for currency decreases.

The relation between the monetary factors and the different kinds of inventories show interesting stories. FEVD in Table 5.3 shows that MINV can be explained by both outside money and inside money. NBR and FFR can explain not more than 10.0% and 7.0% of MINV movements in the short-term horizon, respectively. In the long run, MM takes the main role in explaining the fluctuation in MINV but merely 7.0%. Consequently, the IRF in Figure 5.4 shows that the relation between NBR and MINV is negative and the relation between FFR and MINV is positive; these two relations are consistent with each other because it means a positive shock to NBR reduces the interest rate, which in turn will reduce MINV. It is clear that the result is opposite from what is expected. The same IRF in Figure 5.4 shows that a positive shock to MM affects MINV negatively for the first four quarters and then this effect turns out to be strongly positive.

As for TINV in this model, it has the same behavior as MINV. In the short-term horizon, both NBR and FFR can explain not more than 6.0% and 8.0% of the variation in TINV, respectively, while in the long-term horizon, MM is able to explain around 16.7% of the fluctuation in TINV. The difference between the MINV and TINV is that the role of MM is greater in explaining the movement of TINV. The IRF in Figure 5.5 shows that a positive shock to NBR has a negative impact on

---

<sup>139</sup>For more theoretical background see Walsh (1998) pages 404-406.

Response to Cholesky One S.D. Innovations

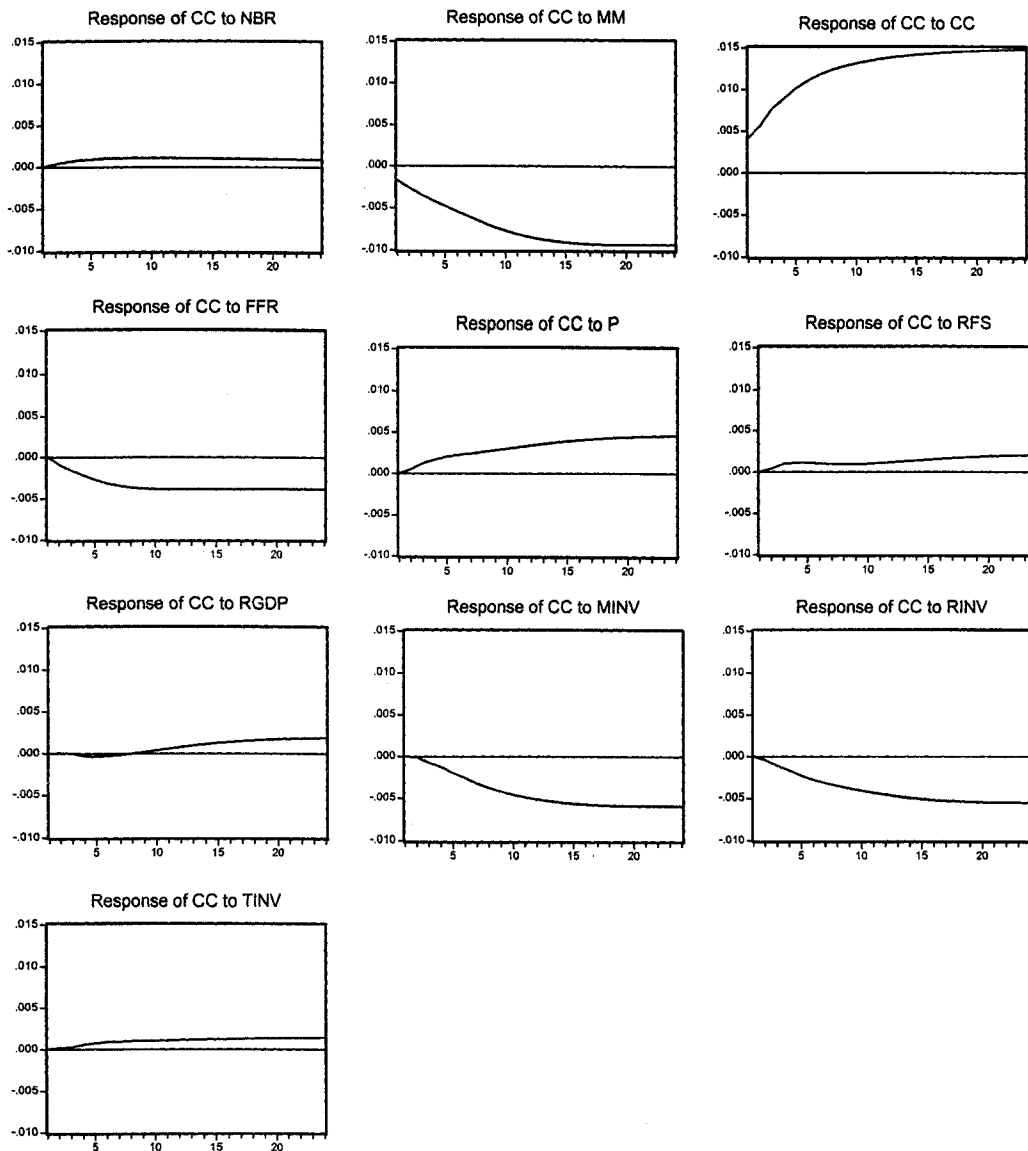


Figure 5.3 : The Impulse Response Function From ECM For CC

Response to Cholesky One S.D. Innovations

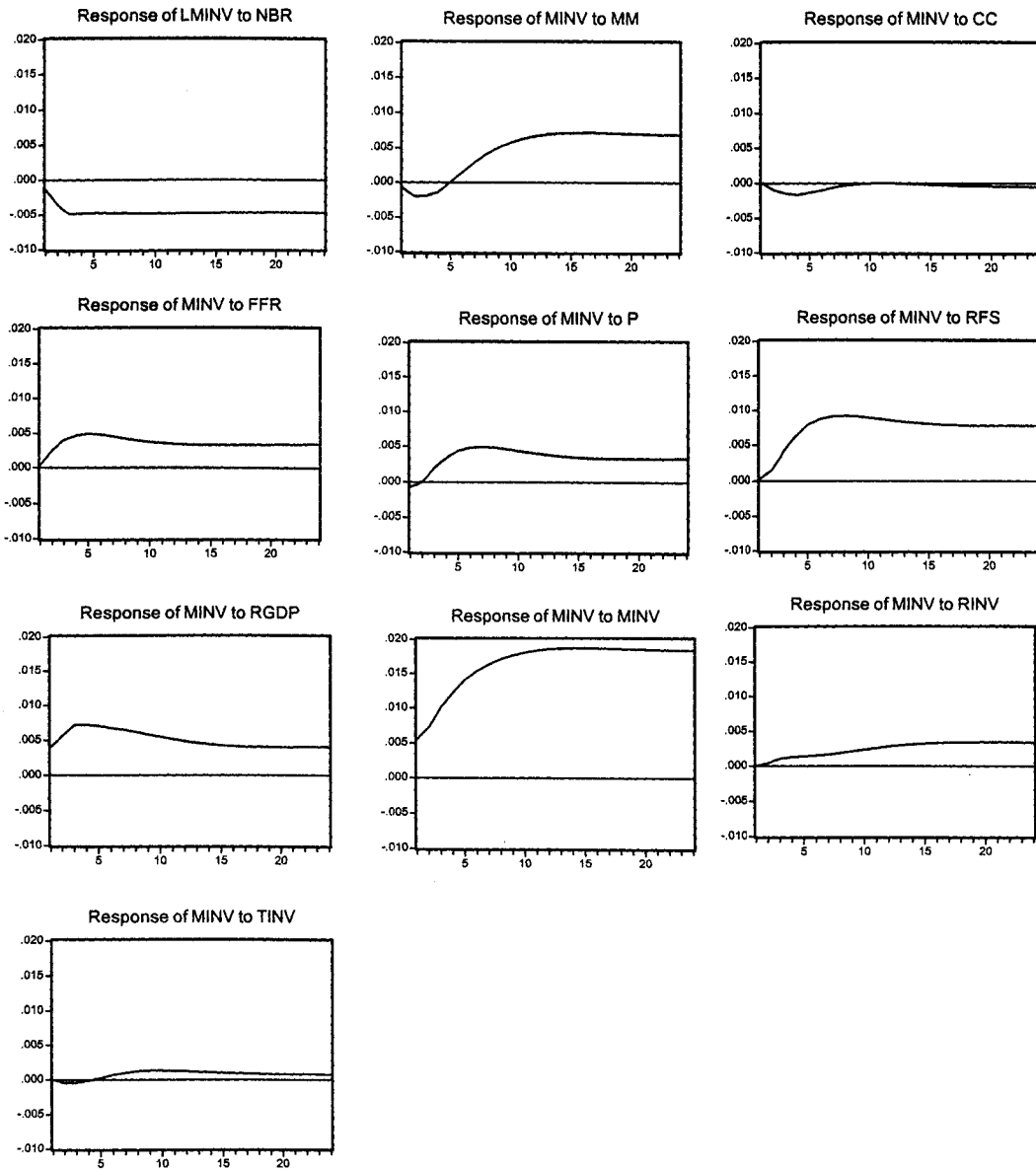


Figure 5.4 : The Impulse Response Function From ECM For MINV

Response to Cholesky One S.D. Innovations

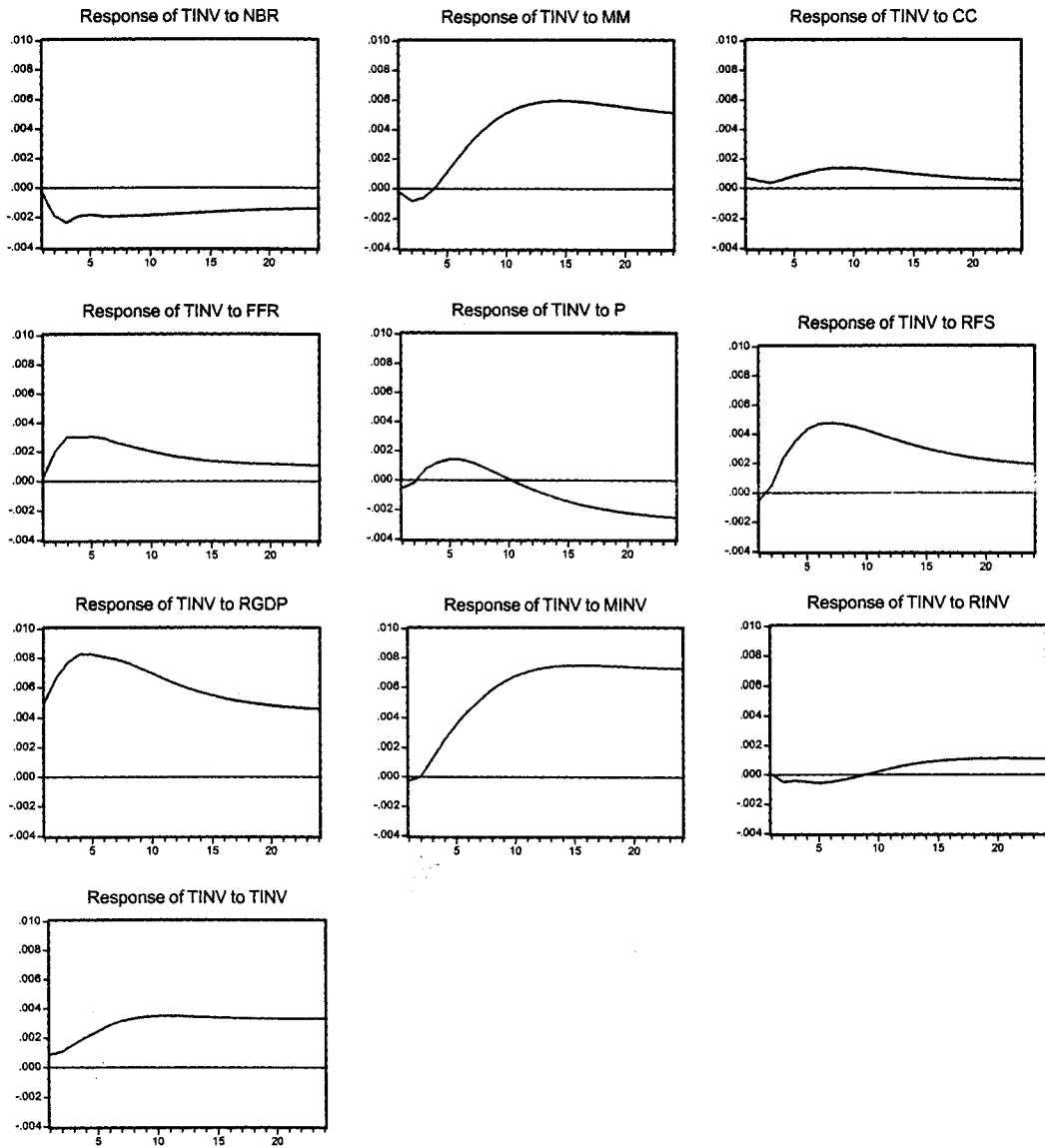


Figure 5.5 : The Impulse Response Function From ECM For TINV

TINV, while a positive shock to FFR has a positive impact on TINV<sup>140</sup>, and this result is the same as in MINV. In addition, the IRF in Figure 5.5 demonstrates that MM has a negative impact on TINV until the third quarter; then this effect turns positive which is similar to the MINV case.

The negative relation between inventories and NBR is unexpected because NBR is a part of the money supply and it is supposed to have a positive impact on economic activity. But, in this case and based on the results of the previous studies such as King and Plosser (1984), it seems that MM is related strongly to economic activity relative to NBR, which has a small relation especially with different types of inventories. In this regard, the FEVD in Table 5.3 confirmed that MM is able to explain around 53.0% of the variation in RGDP in the long run, compared to around 8.0% of RGDP fluctuation explained by FFR in the short run. Therefore, I believe the negative relation between NBR and MINV confirms that MINV in the disaggregate model failed to play a crucial role in the monetary transmission mechanism. To focus more on this issue, the literature review shows that previous studies have the same conclusion; Christiano, Eichenbaum and Evans (1996) reported a contractionary monetary shock is associated with an increase in manufacturing inventories. Also, Chari, Christiano and Eichenbaum (1995)<sup>141</sup> found NBR is negatively correlated with current and past level of output, and their study failed to find a negative relation between FFR and the output. They explained the negative correlation between NBR and output to the policy of “leaning against the

---

<sup>140</sup>It useful to mention that changing the order of FFR to be behind NBR changes this relation to negative only in the tenth quarter, exactly as in chapter four.

<sup>141</sup>For more details see the last paragraph of page 1384.

wind” followed by the Fed. The IRF in Figure 5.6 proved that NBR responds negatively to most of the variables and this supports the above explanation. These results confirm that if the Fed felt that the economy is passing through an expansion stage and is accumulating inventories<sup>142</sup>, then they will start to slow down by reducing NBR, which instantaneously increases FFR. As long as the economic activity or accumulating inventories does not respond as quickly as the monetary factors, then we have a situation in which we have a high MINV, lower NBR and higher FFR, which will make the relation between NBR and MINV look negative.

Theoretically, this result is expected because when Gurley and Shaw (1964)<sup>143</sup> differentiated for the first time between inside and outside money, they mentioned that using outside money will cause a wealth transfer from the private sector to the government sector because of the inflation rate, and this in turn will negatively affect the private demand for money, goods and labor, which implies a negative effect on the economic activity. On the contrary, using inside money will not make such a transfer, which means it doesn't have a negative impact on the private sector. Also, King and Plosser (1984) found that outside money affects the price level while inside money has an impact on real activity. Besides, they consider that inside money is a store of wealth and a temporary element of credit.

RINV shows a different behavior and it is opposite to the behavior of TINV and MINV. FEVD in Table 5.3 shows that the monetary factors affect RINV in the

---

<sup>142</sup>This explanation gives a hint that MINV may be the first kind of inventories that appears in the economy, and this is consistent with the fact that it is the largest component of TINV which is 37.0%.

<sup>143</sup>For more details see pages 72-75.

Response to Cholesky One S.D. Innovations

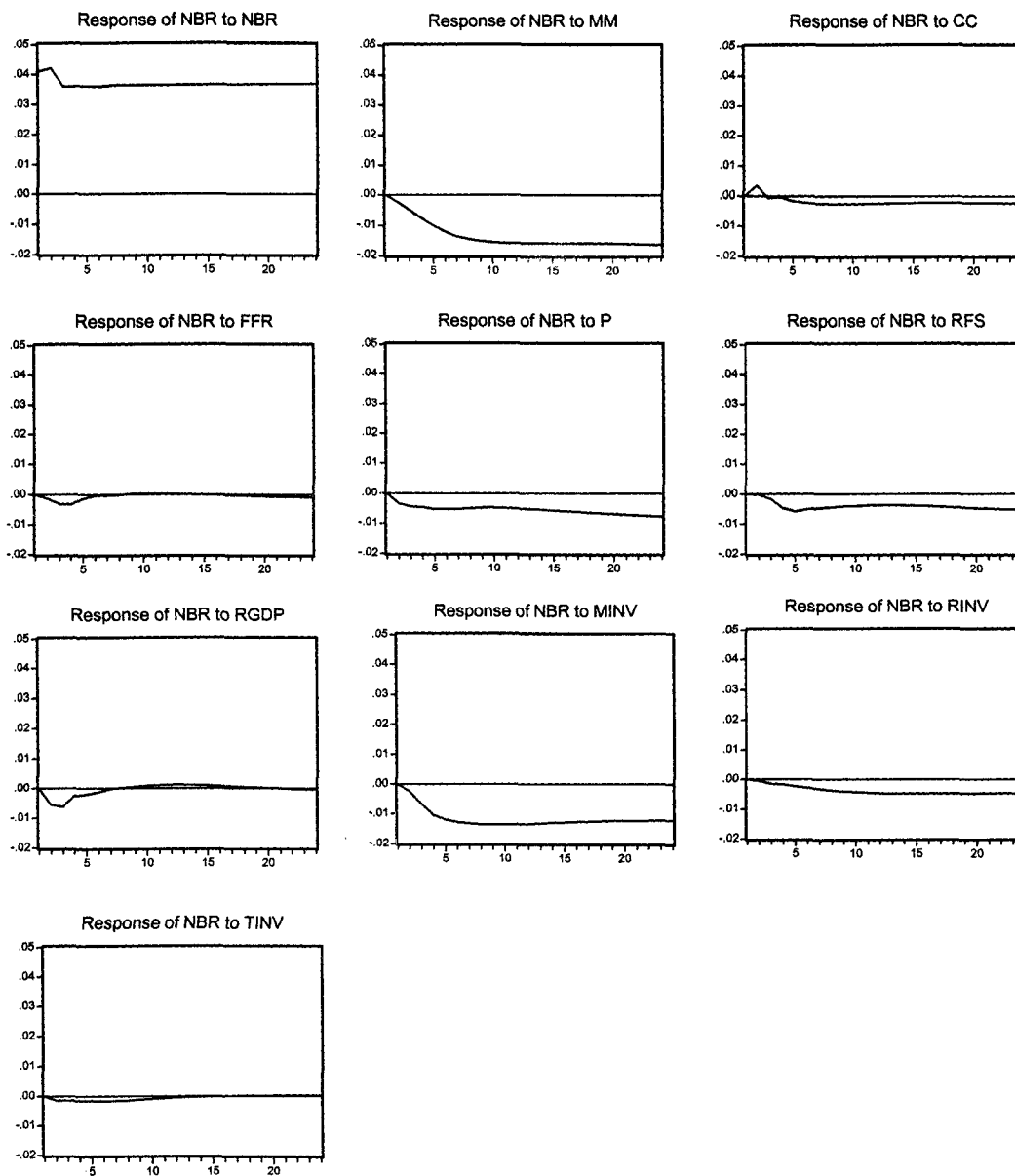


Figure 5.6 : The Impulse Response Function From ECM For NBR

long-term horizon and have the largest effect. The components of the monetary policy NBR, CC and MM can explain around 7.0%, 8.0% and 26.0% of the variation of RINV, respectively. In addition, it seems that FFR can explain not more than 8.0% of the movement in RINV. The IRF in Figure 5.7 shows that NBR has a positive impact on RINV and that a positive shock to the FFR affects RINV negatively. This analysis confirms that retail trade inventories (RINV) have a role in the monetary transmission mechanism, but this role can be described as a weak one because it takes this effect ten quarters to show the right sign. This result is consistent with what I found in the previous chapter. In addition, Figure 5.7 shows that RINV responds positively and immediately to a positive shock in both MM and CC. The difference in the response between RINV and the response of both MINV and TINV may be related to the fact that RINV is considered to be finished goods and therefore easy to liquidate in reaction to a higher cost such as the increase in the interest rate, while both MINV and TINV consist of a large portion of non-finished goods which are materials and supplies and work-in-progress goods.

The overall conclusion of this part of the study is consistent with the conclusion of the analysis with the aggregate data. First, in Chapter Four I found that TINV responds negatively until the third quarter to a positive shock in  $M_2$  and then it turns out to be positive. This result is supported by the fact that NBR has a negative impact on some kinds of inventories while MM has a positive one on all of them. Therefore, the disaggregated analysis highlights the fact why inventories respond negatively and then positively to a shock in  $M_2$  in the aggregated case. Second, the results on both the aggregated and disaggregated levels confirm that inventories in

Response to Cholesky One S.D. Innovations

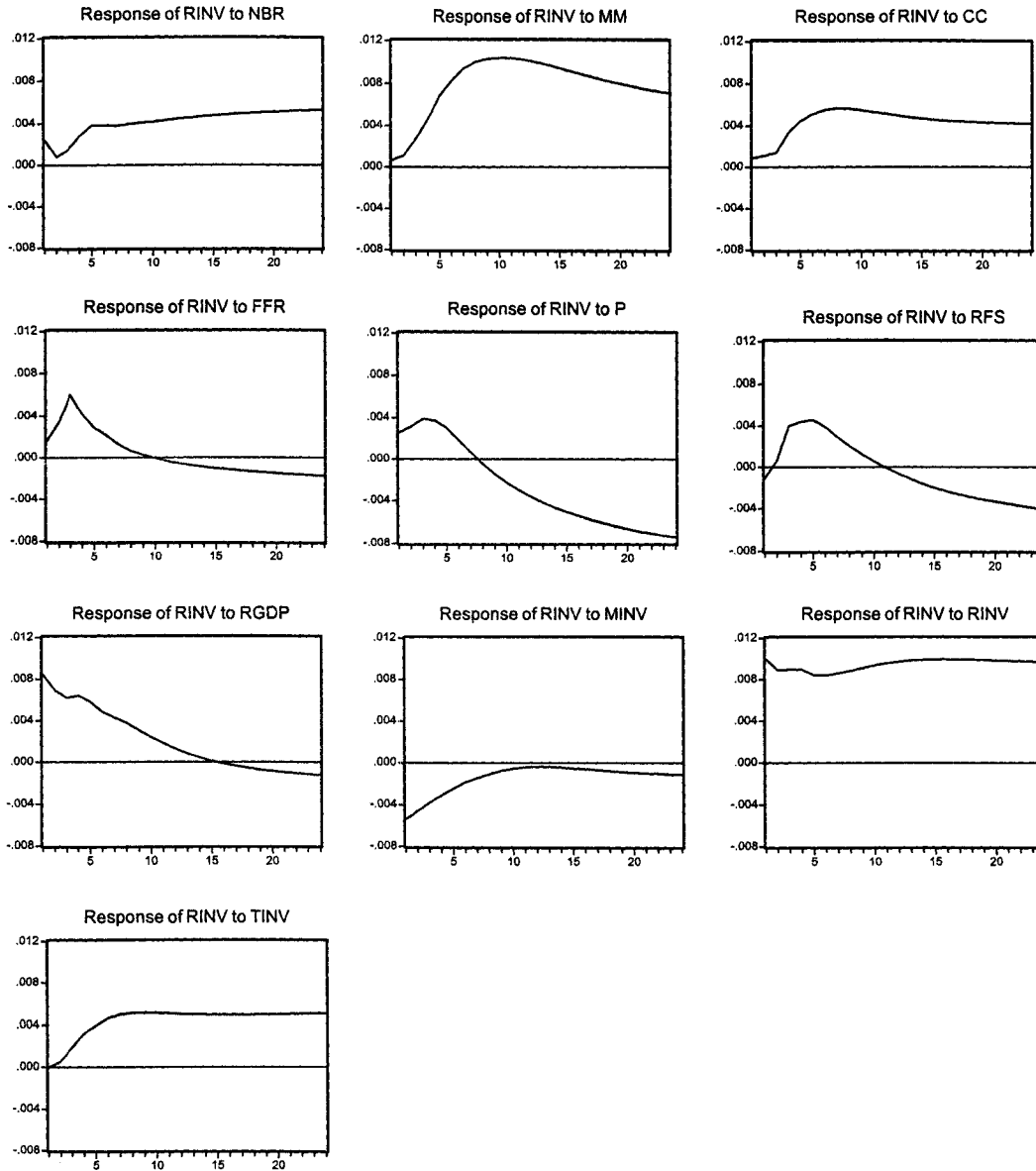


Figure 5.7 : The Impulse Response Function From ECM For RINV

general have a weak role in the monetary transmission mechanism, which implies that interest rate level doesn't have a significant role in holding inventories because it takes this variable ten quarters to respond negatively to a positive shock in FFR.

The results confirm that the behaviors of various inventories are different from each other. It seems that MINV and TINV respond positively to a positive shock in FFR while RINV respond negatively. Moreover, it seems that all three types of inventories respond positively to inside money which confirms the main result of King and Plosser (1984) assuming that inventories is an indicator for economic activity, despite the fact that the response differs from one type to another. The IRF in Figure 5.4 shows that MINV responds negatively for the first four quarters to a positive shock in MM and then reverses direction to positive, while TINV does that just for three quarters. RINV responds immediately and positively to a positive shock in MM.

Logically, if the results of this study and the other studies confirm that inside money plays a crucial role in affecting economic activity, including inventories positively, then we have to expect that the role of outside money, including the monetary transmission mechanism, will be relatively less important or weak. And this analysis is consistent with the results of the current study and other studies which conclude the same result. But this raises the question of how some studies prove a significant relation between the inventories and the interest rate. Kashyap, Lamont and Stein (1994) explained the failure of empirical models of inventories to find a significant role for financial variables to the inadequacies of the specifications used in these models than about any thing else. In this regard, it is useful to mention

that in the case of dropping the inside money variable<sup>144</sup> from the model of the current study I noticed that both RGDP and RFS respond more quickly to the FFR, which means it shortens the time lag to capture the negative sign, and this in turn makes all kinds of inventories respond negatively to a positive shock in the FFR with a lag period of less than ten quarters to capture the right negative sign<sup>145</sup>.

### **5:2:2 The Relation Between the Prices and Inventories**

The FEVD in Table 5.3 illustrate that P can explain more than 66.4% of its movement. Currency held by the public and FFR are considered to be the only two monetary factors that have a positive impact on P and can explain around 4.5% and 2.0%, respectively. Both NBR and MM can explain in the short-term horizon not more than 5.3% and 3.5%, respectively<sup>146</sup>. But it seems from IRF in Figure 5.8 that the effects of those two variables are negative; in the case of MM the negative sign changed to be positive in the nineteenth quarter. This result is consistent with the results in the aggregate data because it has been shown that a positive shock to  $M_2$  has a negative effect on the prices for the first three quarters before it turns to be positive. In addition, it gives an idea that not all types of money have a positive effect on prices. The negative relation between NBR and MM from one side and P

---

<sup>144</sup>This procedure gives more relative importance to outside money and the interest rate.

<sup>145</sup>MINV requires seven quarters, RINV requires four quarters, and TINV requires five quarters.

<sup>146</sup>In the disaggregated analysis, the monetary factors do not explain much of the variation in P and this is related to the disaggregating process. But this analysis is useful because it shows that some components of money have a negative effect on P. And, RFS plays an important role in the long run in explaining the variation in P. This point supports the analysis in chapter four, which is P in the short run fluctuates and starts to increase in the long run.

Response to Cholesky One S.D. Innovations

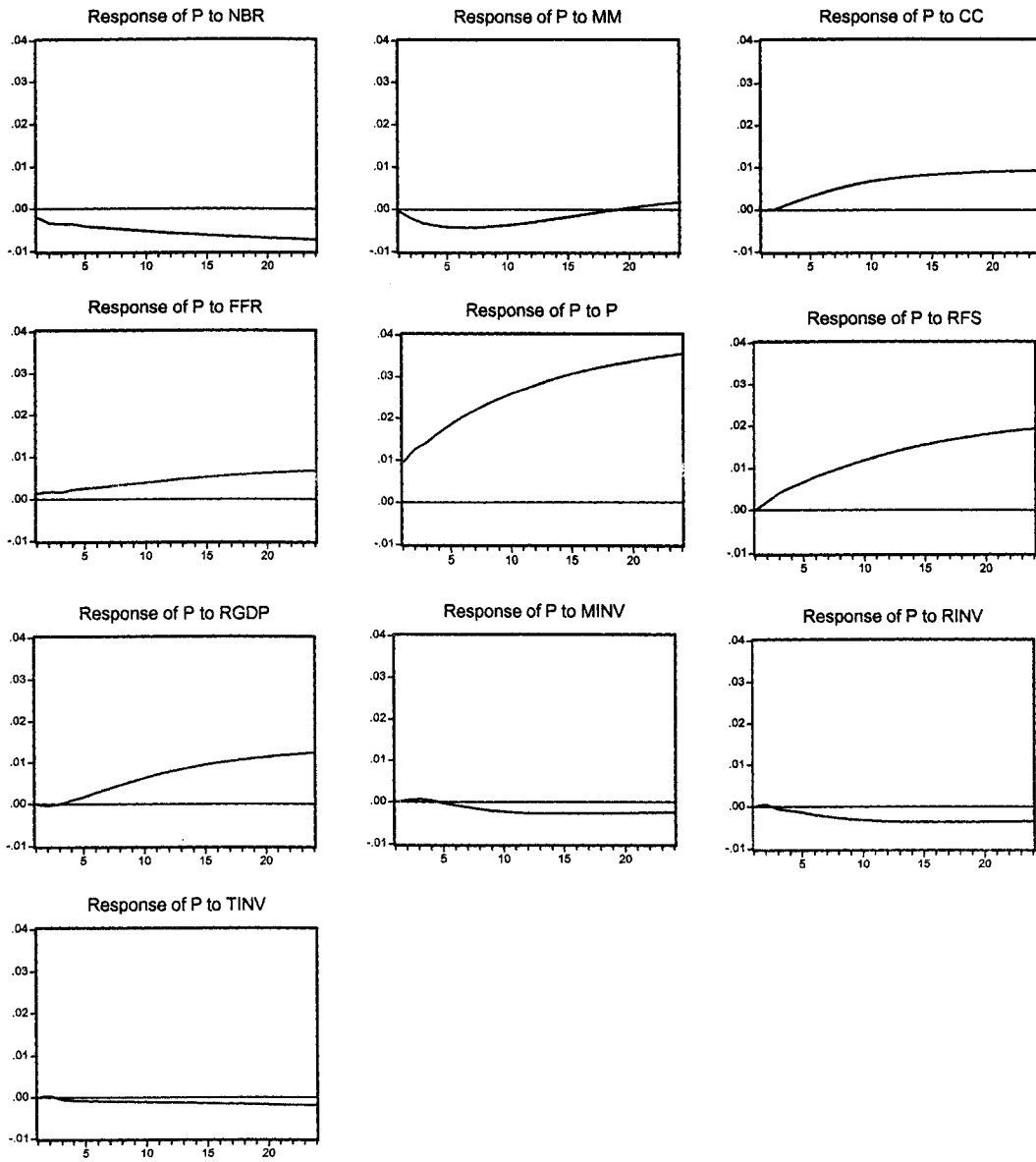


Figure 5.8 : The Impulse Response Function From ECM For P

from another side may be explained by the relation through the interest rate. Fama (1982) showed a positive relation between interest rate and inflation, concluding that the interest rate contains the best possible forecasts of inflation. Also, Eichenbaum (1992) and Sims (1992) show that a contractionary monetary policy will raise the prices for more than two years. The IRF in Figure 5.1 shows that NBR affects FFR negatively, and MM does the same until the eighth quarter. And, as long as this study proves the relation between FFR and P is positive on both the aggregate and disaggregated data, then a positive shock to NBR reduces FFR and this in turn makes P decline. This transitive relation implies that the relation between P from one side and both NBR and MM is negative. The hint for this relation is that both P and FFR respond negatively to a shock in NBR, while according to MM the IRF in Figure 5.1 shows that FFR responds negatively until the eighth quarter and then changes to positive, while P in Figure 5.8 does the same thing until the eighteenth quarter.

Moreover, it seems that in the disaggregated data both RGDP and RFS play a crucial role in explaining the fluctuation in P. The FDEV in Table 5.3 shows that both of them explain 5.9% and 16.6% of the variation of P in the long-term horizon, respectively. Besides, the IRF in Figure 5.8 shows that a positive shock to either RGDP or RFS has a positive impact on P. This result is consistent with that in the aggregated data, but the FEVD in Chapter Four illustrates that RGDP and RFS are only able to explain not more than 2.0% of the movement in P. Therefore, the results on the disaggregated level confirm the idea stated by Blinders (1980) that price occurs because of a sales shock more than a monetary shock, as stated by King and Plosser (1984). This conclusion hints that there is an additional important positive

effect on prices other than outside money, and the increase in prices will be faster after the sales shock or the decline in inventories.

Also, the disaggregated data provide useful evidence not available in the aggregated data analysis; this estimation shows that RFS is able to explain around 24.0% of the variation in FFR, and IRF in Figure 5.1 shows that the relation between RFS and FFR is strongly positive. The above two conclusions support the explanation of the response model that a positive shock in the monetary policy leads to a decrease in the interest rate. This will increase both RGDP and RFS and as a result, inventories accumulate, which represents a disequilibrium, and therefore the self-adjustment mechanism pushes some variables such as FFR and P to move to equilibrium.

As for the relation between P and the different kinds of inventories, the FEVD in Table 5.3 shows that P innovations can explain not more than 3.0% of both MINV and TINV but is able to explain around 8.0% of RINV. The IFR in Figures 5.4, 5.5 and 5.7 show different behaviors for different kinds of inventories with P. MINV responds negatively for the first two quarters then becomes positive. RINV responds immediately, strongly and positively to a positive shock in P until the seventh quarter, and then it twists to negative.

In the case of TINV, the situation is in the middle of the above two behaviors. The IRF in Figure 5.5 shows that TINV responds negatively for the first two quarters and then becomes positive until the tenth quarter when it returns to negative. This behavior confirms the result that different kinds of inventories behave in a different way. Moreover, it seems that three different types of inventories are unable to

explain P. The result of IRF in Figure 5.8 shows that these three types of inventories have at least a positive relation with P for the first two quarters before it turns negative.

The overall evidence from this part of the study confirms that the relation between price and inventories is not as strong as expected and does not show a real speculative motive in holding inventories because, even though the relation tends to fluctuate between positive and negative, in the long run it tends to be negative. Therefore, the results in this chapter don't deviate much from the results in Chapter Four.

### **5:2:3 The Relation Between RGDP, RFS and Inventories**

The findings of the above two sections encourage us to investigate the relation between RGDP, RFS and the different kinds of inventories. It was obvious from the results of the previous chapter that the behavior of inventories can be explained through the relation between RGDP and RFS and how the inventories respond to each one. Thus, I will use the same methodology in this part but I will talk about only one scenario in order not to repeat the same analysis.

I will assume that RFS is the exogenous variable that happens first. The FEVD in Table 5.3 shows that RGDP in the short run can explain not more than 33.0% of the variation in both MINV and RINV, while RFS can explain only around 13.0% and 3.0% in the long run for both, respectively. However, in the case of TINV it seems that RGDP can explain in the short-run around 92.0% of the fluctuation in this variable, and this ability declines to 30.0% in the long-term horizon. RFS can explain around 8.0% in the long run. This primary analysis confirms the idea I got

while analyzing the disaggregated data, which is that there is a large difference in the behavior of those variables. This leads us to believe that each one of these inventories has a different set of variables that can explain it, including the mutual relation among them. This primary conclusion is consistent with that mentioned by Hornstein (1998). In addition, based on the analysis of both chapters, it is clear that inventories can be explained by four factors, RGDP, RFS, inside money (MM) and FFR, in order of importance.

The FEVD in Table 5.3 demonstrates that RFS can explain more than 55.0% of the variation in RGDP in the immediate run. Consequently, the IRF in Figure 5.9 proves that RGDP responds strongly and immediately to a shock in RFS and that it reaches its peak in the third quarter exactly as in the aggregate case, but in this case it seems that the response of RGDP declines faster than that in the aggregate case. The IRF in Figure 5.9 shows that the response of RGDP to RFS seems greater than the response of RFS to RFS (the shock itself) through the second quarter to the fifth quarter, and the latter becomes larger than the former. The response of MINV to RGDP looks instantaneous and high, reaching its maximum level in the fourth quarter. This response started in the fifth quarter to be greater than the response of RGDP itself to RFS. As a result it is expected that the final impact of RFS on MINV is positive. This result is clear in the IRF in Figure 5.4 which shows that the final indirect impact of RFS on MINV is positive and reaches its maximum in the eighth quarter. This analysis needs two comments on the effect of RFS on MINV; first, it is expected to have a negative effect in the first quarter as what I found in the aggregate level case. Second, this effect, i.e. the effect of RFS on MINV, becomes greater than

Response to Cholesky One S.D. Innovations

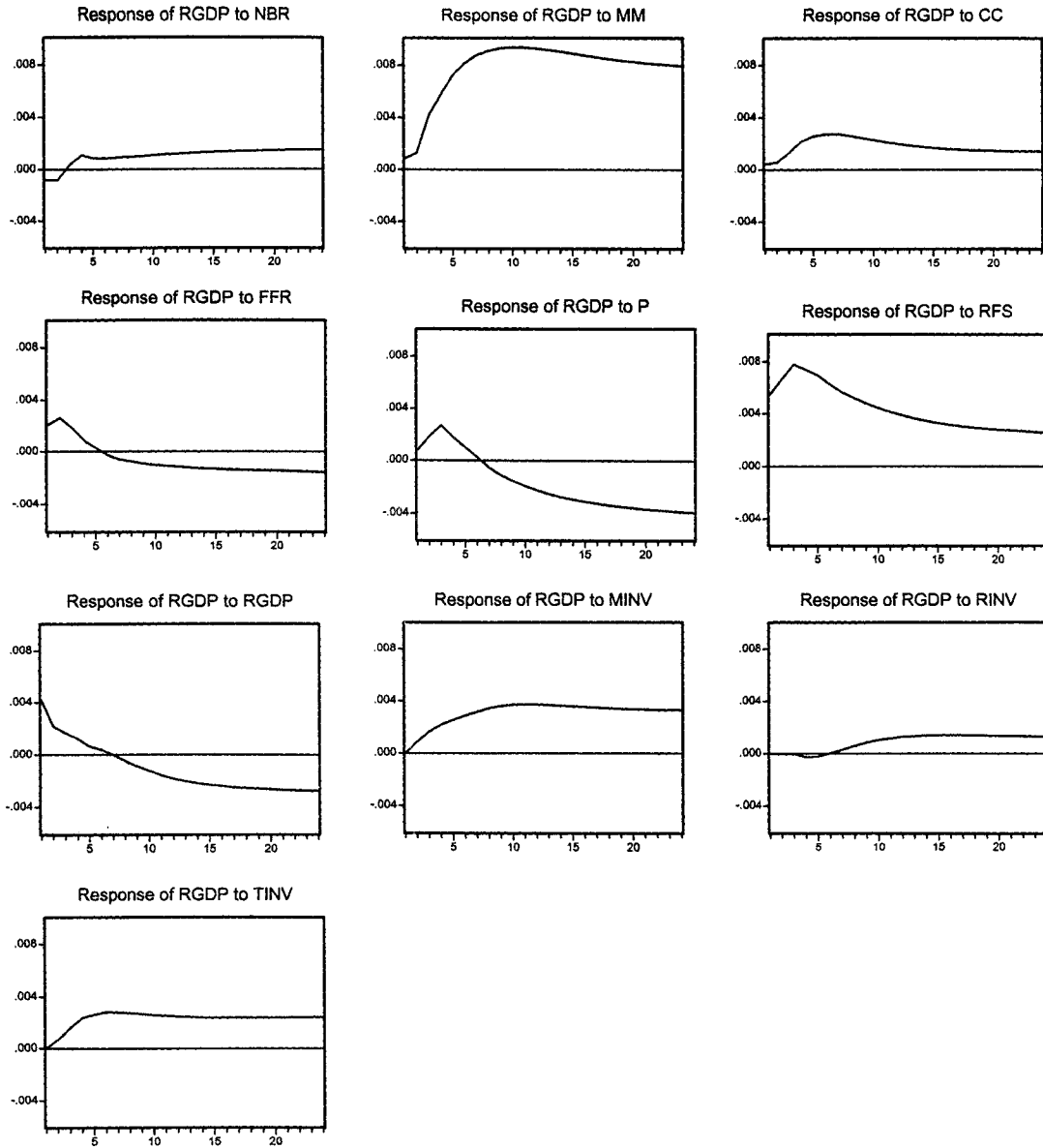


Figure 5.9 : The Impulse Response Function From ECM For RGDP

the direct effect of RGDP on MINV starting in the fifth quarter. This confirms that the direct effect from RFS to MINV is negative for many quarters but not large enough to be greater than the positive direct effect of RGDP; then this effect becomes positive. To test this relation empirically, I use the second scenario by assuming RGDP occurs first so then I can get the direct relation between RFS and MINV. Figure 5.10 shows that the impact of RFS on MINV is negative for the first five quarters and then becomes positive after that.

According to the response of RINV to RGDP, the IRF in Figure 5:7 shows that this relation is completely different from the relation between MINV and RGDP. This relation is positive and more instantaneous and it declines over time until it becomes negative in the sixteenth quarter. An explanation for the unexpected switch in the sign is that the FEVD shows that the relative importance of RGDP in explaining the movements in RINV declines sharply from around 33.0% in the first quarter to 7.4% in the sixteenth quarter, at which point the reversal in the sign starts. The inside money takes the leading role in explaining the fluctuation in RINV because FEVD shows that its role jumps from 0.2% in the first quarter to 27.3% in the sixteenth quarter. This implies that the leader in pushing RINV in the long time horizon is the inside money, not RGDP, and this may be related to the fact that RINV consists of finished goods. Also, around 46.0% is non-durable goods, which may be damaged if not met with a real effective demand. The final effect of RFS on RINV shows that this relation is immediate and negative for the first quarter and then starts to be positive like a hump shape until the eleventh quarter, at which point the relation again becomes negative. The final impact of the direct relation between RFS

Response to Cholesky One S.D. Innovations

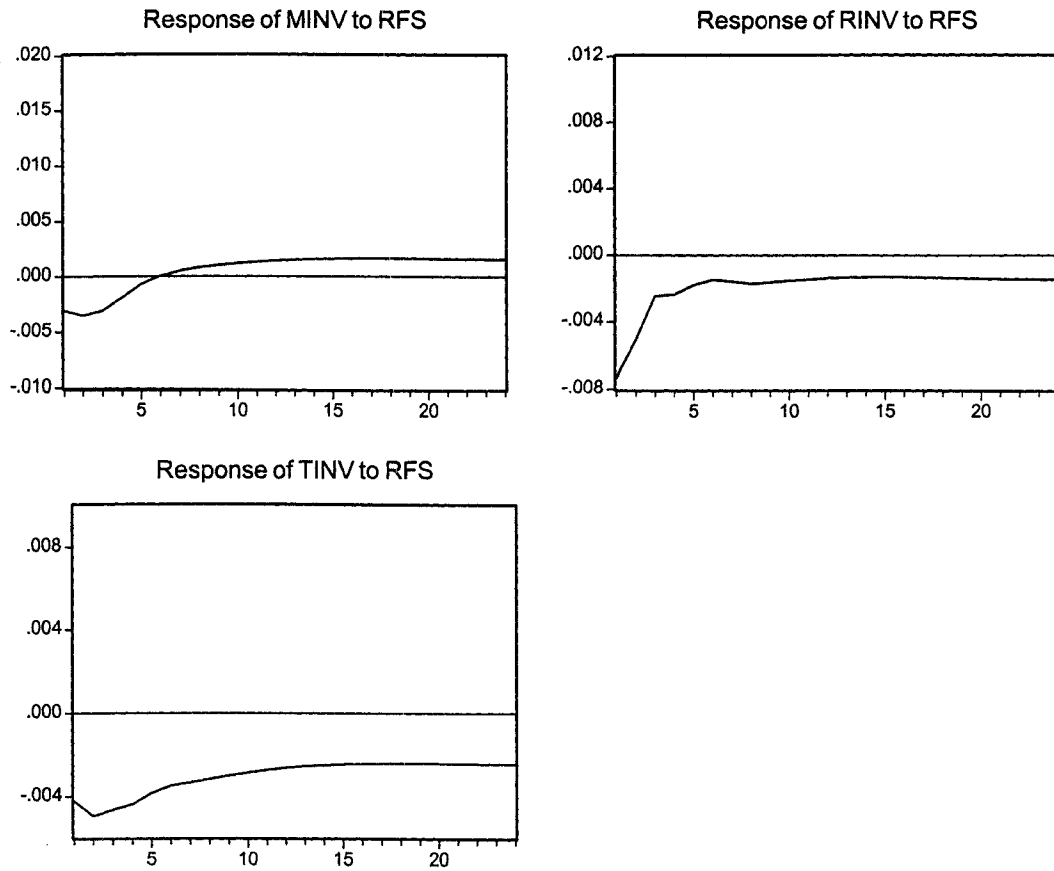


Figure 5.10 : The Impulse Response Function From ECM For the Direct Effect of RFS on MINV, RINV and TINV (RGDP First)

and RINV is negative. By using a similar idea to the one used in the case of MINV, the IRF in Figure 5.10 shows that the relation between RINV and RFS is negative and keep increasing before it becomes constant in the twelfth quarter. It seems RINV behaves as a buffer stock for the first quarter because RGDP responds directly and greater than the shock in RFS. This result agrees with the result of the aggregate case.

The final relation between TINV and RFS looks exactly like the one I found in the aggregated data, and I can describe this relation as a case between the above two cases, i.e. MINV and RINV. The IRF in Figure 5.5 illustrates that TINV responds without delay, strongly and positively to a positive shock in RGDP, and it reaches its maximum in the fourth quarter. The final impact of RFS on TINV looks exactly like the effect of RGDP on TINV but this effect for the first quarter is negative, which implies that TINV reacts as a buffer stock for the first quarter exactly as in RINV and TINV in the aggregate case. In addition, this behavior implies that the direct impact from RFS to TINV is negative, which is apparent when I change the order of variables and put RGDP first (Figure 5.10).

The conclusion of this part is completely in agreement with the one I found in the aggregate data analysis. The conclusion confirms that the relation between RGDP and RFS and the response of every type of inventory to the shocks of those two macroeconomic variables are able to explain the behavior of inventories as expected. Despite the fact that this analysis is on the macroeconomic level, it confirms two applications of production smoothing model/ buffer stock model. It is clear from the analysis on both the aggregate and disaggregate level that a positive

unseen shock in RFS will be followed by a strong, positive and greater response of RGDP which is able to build a moderate amount of inventory in the economy, and this application is very close to the first implication of the production smoothing model. I would like to point out that in both aggregate and disaggregate analysis RGDP responds stronger than RFS for any shock in the economy, which implies that the variance of RGDP is greater than that of RFS. A positive shock to RFS will affect inventories negatively but in order to test this effect, we have to let this shock affect inventories directly without affecting RGDP, or let RFS shock happen after RGDP shock. This implies that the relation between those variables in the long run is positive, while there is a negative relation in the short run between RFS and inventories. Moreover, if the RGDP shock happens first then the effect on any kind of inventories is approximately double compared to the case if RFS happens first, and this result been confirmed in the aggregate data case. The disaggregated data shows that different kinds of inventories behave differently.

### **5:3:3 Relation Among the Inventories**

The FEVD in Table 5.3 shows that MINV is able to explain 62.0% of the variation in itself. However, it can explain not more than 13.0% of the fluctuations in RINV in the short-term horizon, and not more than 30.0% of the movements in TINV in the long-term horizon. In the case of RINV, it accounts for 33.0% of its movements and is unable to explain the movements in both MINV and TINV, While TINV can explain 7.3% of its fluctuation in an increasing way, which is the same characteristic I mentioned in the previous chapter; it is the only inventory type which has this feature. In addition, it is able to justify 7.9% of the movement in RINV but

unable to explain any variation in MINV. It is clear from this basic comparison that every type of inventory has different behavior and different effects on the other types. An interesting point in this analysis is the ability of MINV to explain a large portion of RINV in the short-term horizon and a larger portion of TINV in the long-term horizon. This result confirms that understanding MINV gives a lot of insight into the behavior of both TINV and RINV. Moreover, it is obvious from the FEVD in Table 5.3 that MINV is the only type of inventory which has a higher ability to explain most of the macroeconomic variables NBR, FFR, CC, RGDP and RFS in the long run, and this feature confirms the role of MINV in the propagation of business cycle.

Taking into consideration only the results of the above FEVD analysis<sup>147</sup>, the IRF in Figure 5.11 demonstrates that a positive shock to TINV has a positive impact on RINV; this relation is expected because RINV is part of TINV. A positive shock in MINV has a positive impact on TINV, and this relation is expected because MINV accounts for 38.0% of TINV. But, interestingly, RINV responds negatively to a positive shock in MINV. I believe this relation is important because it may give an indication which kinds of inventories accumulate in the economy first or if it is simply a normal result because of the large size of MINV relative to the other kinds of inventories. In order to explore further, I will start from the point where there is an increase in inventories in the economy and this important macroeconomic variable starts to affect the economy. It is clear from the FEVD that MINV can explain around 8.0% of the variation of both NBR and RGDP and it is obvious from

---

<sup>147</sup>This is the case in which the inventories are able to explain each other.

Response to Cholesky One S.D. Innovations

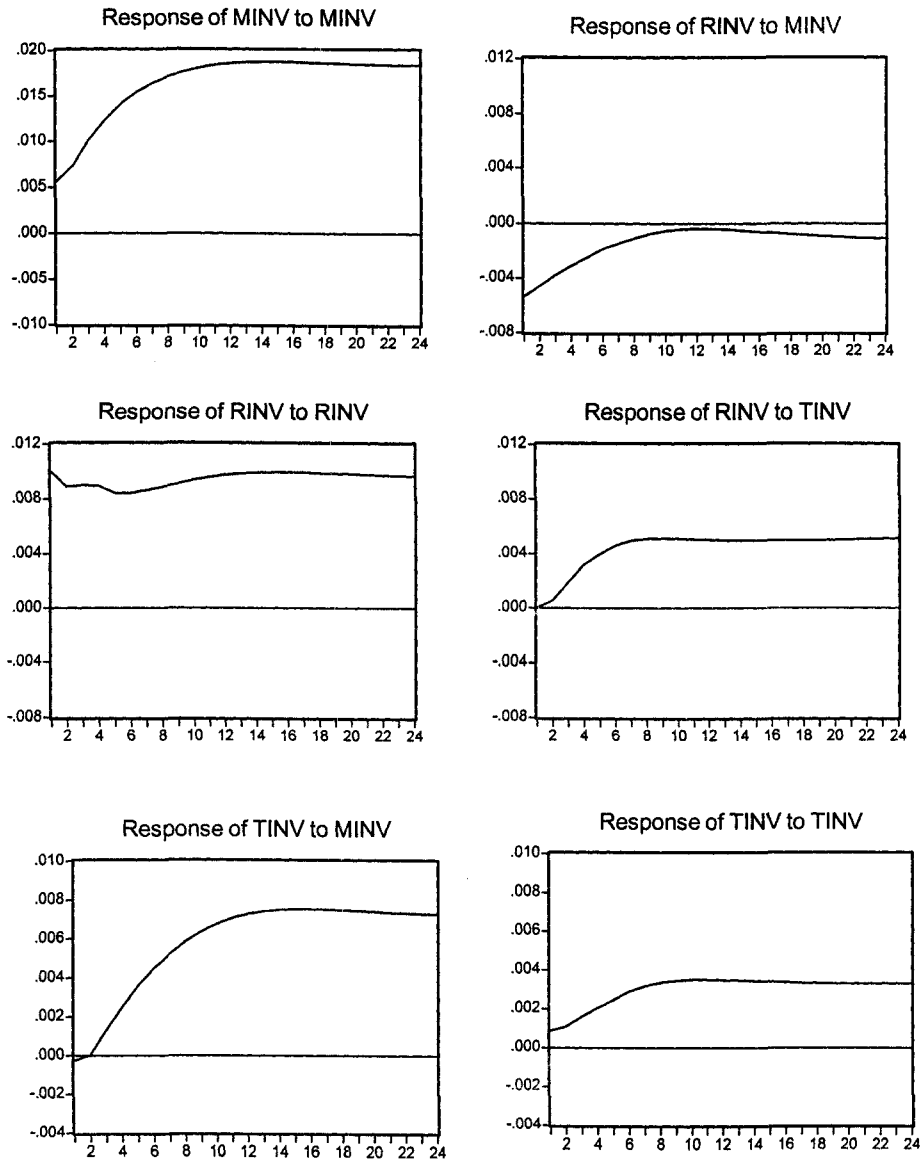


Figure 5.11 : The Impulse Response Function From ECM For the Relation Among the Inventories

the IRF in Figures 5.6 and 5.9 that MINV affects NBR negatively as a feedback and RGDP positively (implicitly increases FFR and P). This means that the effect on these two macroeconomic variables is consistent with the analysis I did in the response model in Chapter Four. If there is an inventory in any type, it will push the other macroeconomic variable to reach a new equilibrium. A larger size of MINV relative to RINV prompts the economy to move to a new equilibrium, leading to a decrease in all kinds of inventories. The analysis shows that the inventories affect each other through the feedback effect relation with the other macroeconomic variables in the model because in the model of disaggregating inventories it is very hard to deal with inventories as substitutes to each other. This analysis is consistent with the feature I mentioned about the ability of MINV to explain both kinds of inventories RINV and TINV, and the macroeconomic variables in the model.

It is obvious from the FEVD in Table 5.3 that inventories can explain their own fluctuations, RGDP, RFS and some other monetary factors such as NBR, MM, CC and FFR. This reflects the ability of this important macroeconomic variable in the propagation of the business cycle. Reagan and Sheehan (1985) found the same feature in their empirical findings but they used in their VAR model disaggregated inventories based on the stage of fabrication and output.

#### **5:4 The Propagation Mechanism**

The VAR model in this study concentrated on inventories and used different types of inventories, but the results from the first phase of this study are completely consistent with the results of different studies, especially in the relation between

monetary variables, real variables and prices<sup>148</sup>. And, this indicates that the research is going in the right direction.

Based on the results of the disaggregated model of this study, it is obvious that inside money has a strong positive impact on economic activity, including inventories, because it shows this money component is able to explain a large portion of all components of the real variables or the variables that represent an indicator for the economic activity. NBR specifically plays a crucial role in affecting the level of the interest rate, and it has been proved that it is the only monetary variable in this model that has a permanent negative effect on FFR.

As for price level, it was proved in Chapter Four that monetary factors play a crucial role in determining price level, but in this chapter using the disaggregated data it seems that RFS and RGDP also play an important role in determining the price level, in addition to CC, as a part of the monetary factors. Both Fama (1982) and King and Plosser (1984) confirmed that currency held by the public and monetary base in general determines the price level.

Based on the analysis of Chapter Four, all these reactions among the variables that happen in the economy in the first phase lead to change in inventories, which represents a case of instability or disequilibrium then in the second phase, represented by the feedback effect from inventories to the macroeconomic variables in order to reach an equilibrium point. It was shown in Chapter Four that in the second phase inventories have a feedback effect on RGDP, RFS and FFR. Using the

---

<sup>148</sup> These studies concentrate on studying the relation between money supply, output and inflation such as Fama (1982), King and Plosser (1984), Chari, Christiano and Eichenbaum (1995) and Shbikat (2000).

disaggregated data in this chapter shows that inventories still affecting the same variables in addition to inside and outside money. To give more details about this point, the FEVD in Table 5.3 shows that MINV is able to explain 8.0% of the variation in NBR and RINV is able to explain 5.0% of the movement of MM. Both MINV and RINV are able to explain 8.0% and 6.0% of the fluctuation in CC, respectively. Also, both MINV and TINV are able to explain 8.0% and 6.0% of the fluctuation in RGDP and RFS, respectively.

If inventories play an important role in the propagation of the business cycle, I have to check two possibilities; first, I need to see if the indirect channel works in the disaggregated data. I will focus in this part on inside money because it is responsible for affecting economic activity as mentioned above. Second, using the disaggregated data gives more details and allows more explanation of how inventories affect the economy. Therefore, I am going to explore the impact of the different types of inventories on the different macroeconomic variables by using the IRF analysis to check how those variables respond and what the effect on the RGDP is.

The FEVD in Table 5.3 illustrates that MM can explain 53.0% of the variations in the RGDP, while IRF in Figure 5.9 shows that RGDP responds positively and immediately to a positive shock in MM. On the indirect channel side, the FEVD in Table 5.3 shows that MM can explain 7.0%, 25.0% and 16.6% of the movements in MINV, RINV and TINV respectively. The IRF in Figure 5.12 demonstrates that MINV, RINV and TINV respond positively to a positive shock in

Response to Cholesky One S.D. Innovations

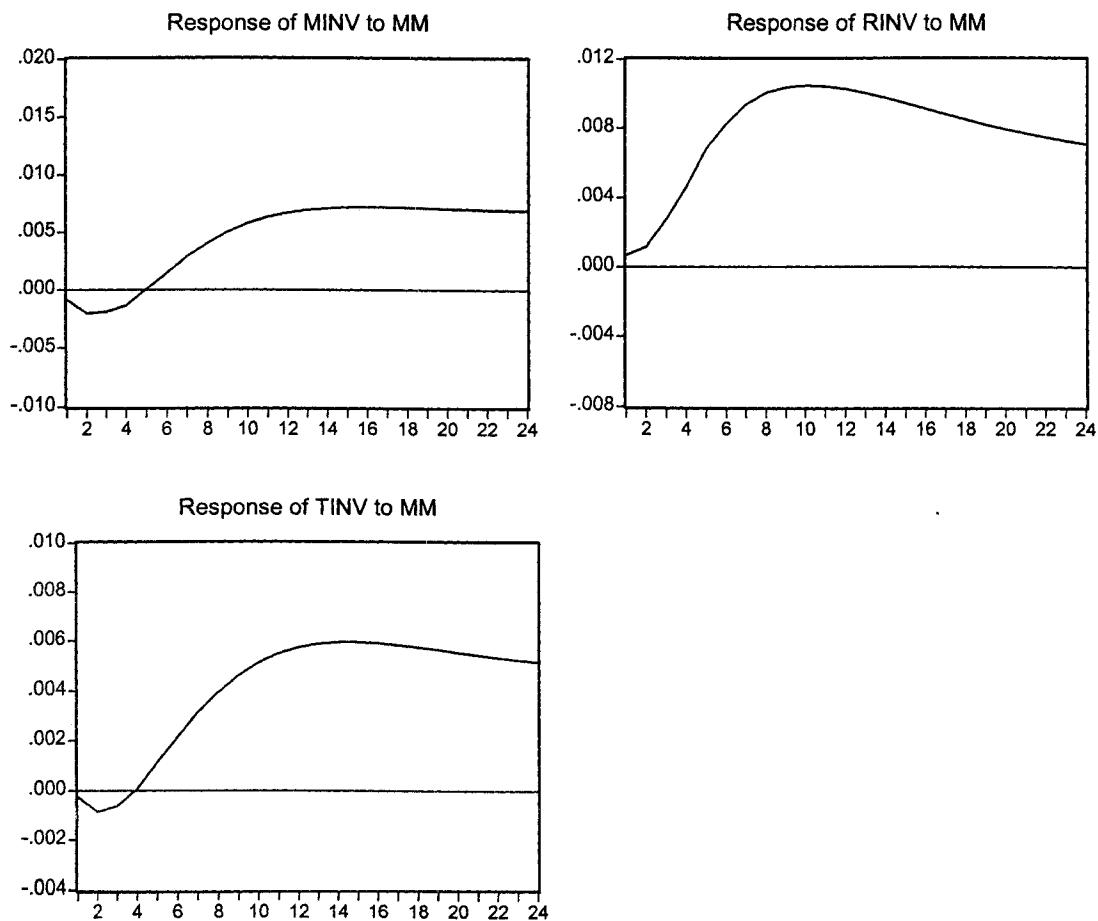


Figure 5.12 : The Impulse Response Function From ECM For the Impact of MM on MINV, RINV and TINV

MM, but it seems that MINV and TINV respond for the first three quarters negatively before they respond positively, while RINV doesn't have this feature. Moreover, the FEVD shows that MINV, RINV and TINV are able to elucidate around 8.0%, 1.0% and 5.0% of the fluctuation in RGDP, respectively. At the same time, the IRF in Figure 5.13 shows that RGDP responds positively for all types of inventories. This analysis shows that the indirect channel effect exists, implying that the effect of shocks of inventories exists and persists in the economy. In the previous chapter, comparing the size of effect between the indirect and direct channels shows that the size of the response of RGDP to TINV (indirect effect) is larger than the response of RGDP to FFR (direct effect). While it is hard to make a comparison here because we are talking about disaggregated data, a rough estimate shows that the response of RGDP to MM is larger than the response of RGDP to different types of inventories. Actually, this result doesn't make a big difference because the main goal is to make sure that inventories in the long run have an impact on the output, and this has been proved in both cases.

In addition, this result confirms that the effect of inside money in absolute term on RGDP is larger than that of FFR and even larger than the effect of inventories. Moreover, this comparison confirms the result as in Chapter Four, that the direct response relation between MM and the different type of inventories is the weaker, and this proves that this relation comes through the relation between both RGDP and RFS from one side and MM from the other side.

It has been proved by the FEVD results that the different type of inventories affect most of the macroeconomic variables in the model differently. Thus, I am

Response to Cholesky One S.D. Innovations

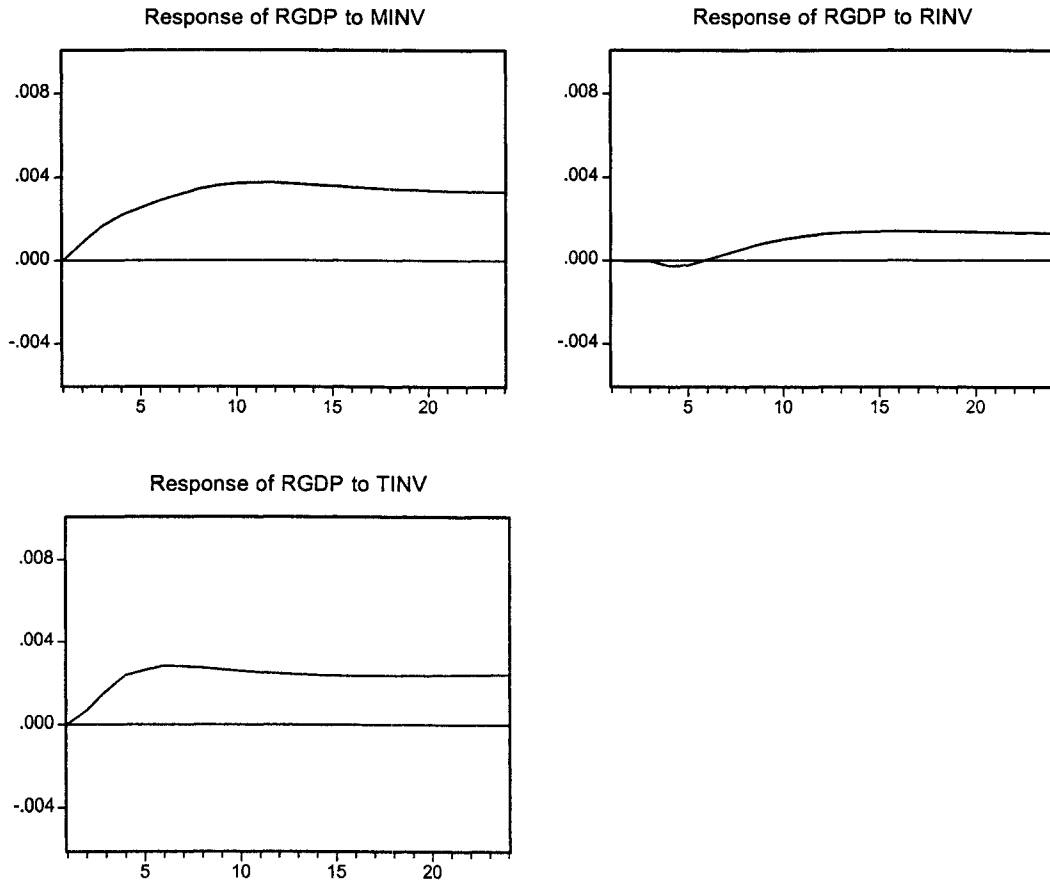


Figure 5.13 : The Impulse Response Function From ECM For The Impact of MINV, RINV and TINV on RGDP

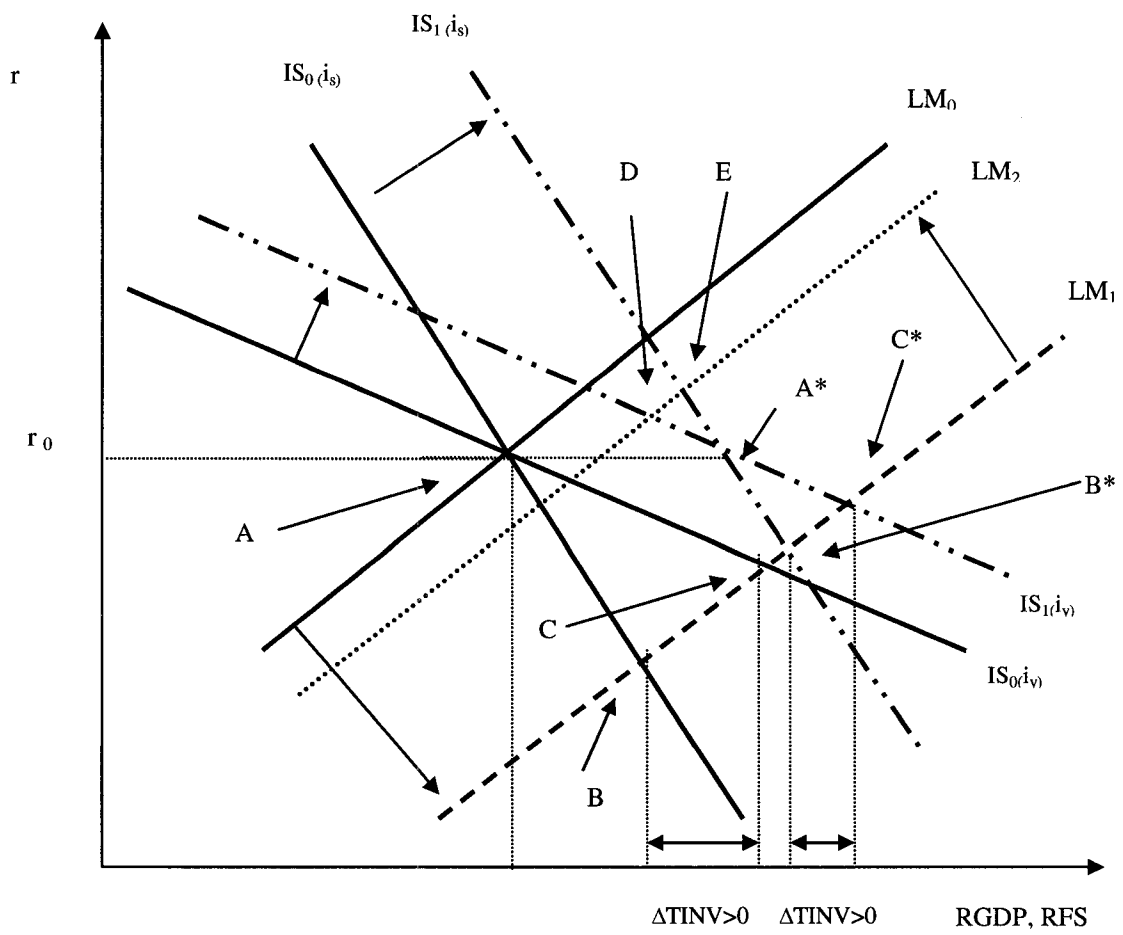
trying in this part of the study to follow up every channel of the effect to see either if all the effect goes in one direction, such as to increase or decrease the output, or if these effects create fluctuations in the economy, which is consistent with the view of propagation of the business cycle. The IRF in Figure 5.6 shows that NBR responds negatively to a positive shock in MINV; this implies that FFR will go up, which in turn reduces both RGDP and RFS. Additionally, it has been demonstrated by the results in Figure 5.1 that FFR responds positively to MINV and both RGDP and RFS respond negatively to FFR. Figure 5.2 shows that MM responds positively to a shock in RINV and this in turn will increase the output because it has been proved that MM has a strong positive effect on RGDP. It is clear from the above two effects that the first one decreases the money supply and reduces the RGDP, while the second does exactly the opposite. As for CC, it is obvious from the IRF in Figure 5.3 that both MINV and RINV have a negative impact on this part of the money. Thus, based on the results of the VAR model, the outcome has two effects working in the same direction. First, the decrease in CC, assuming constant demand deposits, increases the MM, which will have a positive impact on RGDP. And, decrease in CC decreases the P, which leads to an increase the real money supply, which will increase the output too. Finally, the IRF in Figure 5.9 demonstrates that inventories have a positive relation with RGDP. In sum, these descriptions of the directions of how the inventories affect the different macroeconomic variables in the model give an indication that inventories create a kind of fluctuation in the economy that supports the idea of propagation.

Overall, analysis in both the aggregate and disaggregate data shows that the interaction of the macroeconomic variables in the economy leads to change in inventories. This will put pressure on the economy to move either forward or backward to a new equilibrium. It has been proved that in the long run this reaction of inventories took a leading role in this movement by affecting different macroeconomic variable; this impact seems not to be in the same direction because both the government and the private sector behave based on the information they receive. The increase in inventories in the economy gives a signal to the Fed that the economy is overheated, thus the Fed reduces the money supply by reducing the NBR, which will increase the FFR directly. The private sector looks at this (the increase in inventories) from a different viewpoint; as I mentioned in the previous chapter, an increase in inventories in the economy accompanied by lower price, lower interest rate and higher consumption is a sign of expansion in the economy for the private sector. Therefore, this situation will give the private sector higher confidence in the economy, which has three impacts based on the VAR results. First, it will motivate the private sector to hold less currency, increasing the money multiplier, and this effect is opposite to the Fed's action. Second, an increase in consumption will put pressure on the aggregate demand to increase and eventually the price will go up. On the aggregate supply side, the producer tends to reduce the production and this will raise the prices more. These different responses from both the monetary policy (the Fed) and the private sector contribute to greater fluctuation in the RGDP, but it seems that the final net effect is, as in Chapter Four, to move the economy to a new equilibrium.

It is important to mention that the analysis about the behavior of inventories in the economy is determined through the relation between RGDP and RFS, and any other effect of any variable in the economy such as monetary variables or prices, will be through those two important macroeconomic variables, i.e. RGDP and RFS. Therefore, the current findings don't fully agree with the idea of the propagation mechanism presented by Blinder and Fischer (1981); the only agreement is that in both cases there is an important and direct feedback effect from TINV to RGDP. The analysis in this dissertation showed that an expansionary monetary policy moves the LM curve from  $LM_0$  to  $LM_1$ , and this will move the economy from equilibrium at point A to a disequilibrium situation which is points B and C where RGDP (point C) is larger than RFS (point B) which implies we have an increase in inventories (Figure 5.14). In Chapter Four I called this effect the short run or the first phase effect. In the long run, change in inventories (increase in inventories in this case) starts. As I mentioned in Chapter Four, the increase in inventories is to be considered an increase in the assets, which will raise the confidence in the economy from the private sector point of view. This means that the private sector will increase its planned investment and consumption in the economy and this will cause a rightward shift from  $IS_0(i_y)$  to  $IS_1(i_y)$  and from  $IS_0(i_s)$  to  $IS_1(i_s)$ <sup>149</sup> (Figure 5.14). I believe that this is the first effect of an increase in inventories in the economy. Assuming we have same multiplier, graphically this shift will move point A to point A\*.

---

<sup>149</sup>This analysis is an expansion to the analysis of figure 4.13 in chapter four. See footnote 114



**Figure 5.14: Extending the Analysis of the Propagation of Business Cycle**

The increase in RGDP will increase the demand for money, and as long the money supply is constant at  $LM_1$  this will put pressure on the interest to go up to keep the economy in equilibrium; therefore, the economy will move to new position, points  $B^*$  and  $C^*$ . Figure 5.14 reveals that we have a negative relation between increase in inventories and interest rate. The economy is trying to move from disequilibrium points  $B^*$  and  $C^*$ , where we have an increase in inventories to point  $A^*$  at which the change in inventories is zero, or to a point close to  $A^*$  where there is a desired level of inventories.

The price effect will start after the first effect and the prices will increase because of the increase in the aggregate demand<sup>150</sup> and the reduction in the production (decrease in the aggregate supply) as explained in Chapter Four. The increase in the prices tends to decrease the real money supply (shifting the  $LM_1$  to  $LM_2$ ) and this will result in more fluctuation in the economy. But, the increase in prices is able to move the economy to a new situation due to the shift of the LM curve, i.e. move point  $B^*$  to point E and point  $C^*$  to point D where we have a decrease in inventories. Also, in this analysis we can observe the negative relation between price and inventories.

This analysis shows that in the second phase, change in inventories has a direct effect on the other real terms in the model, i.e. RGDP and RFS, this effect spills over to the set of variables, such as prices and interest rate, which make adjustments among the variables in the economy. As long as inventories are considered as a residual due to the difference between RGDP and RFS, then these

---

<sup>150</sup>This shift in RGDP and RFS increases the prices and decreases inventories.

movements of the variables will affect inventories again within a short period of time. Figure 5.14 shows that an expansionary monetary policy causes a change in inventories; then in the next period the effect of inventory change shifts both  $IS(i_y)$  and  $IS(i_s)$  curves, and as a result the increase in inventories will shrink because of the increase in RGDP and RFS with a rise in the interest rate. And, then the increase in the prices reduces the real money supply and this will revert from the case of increase in inventories to a decrease in inventories.

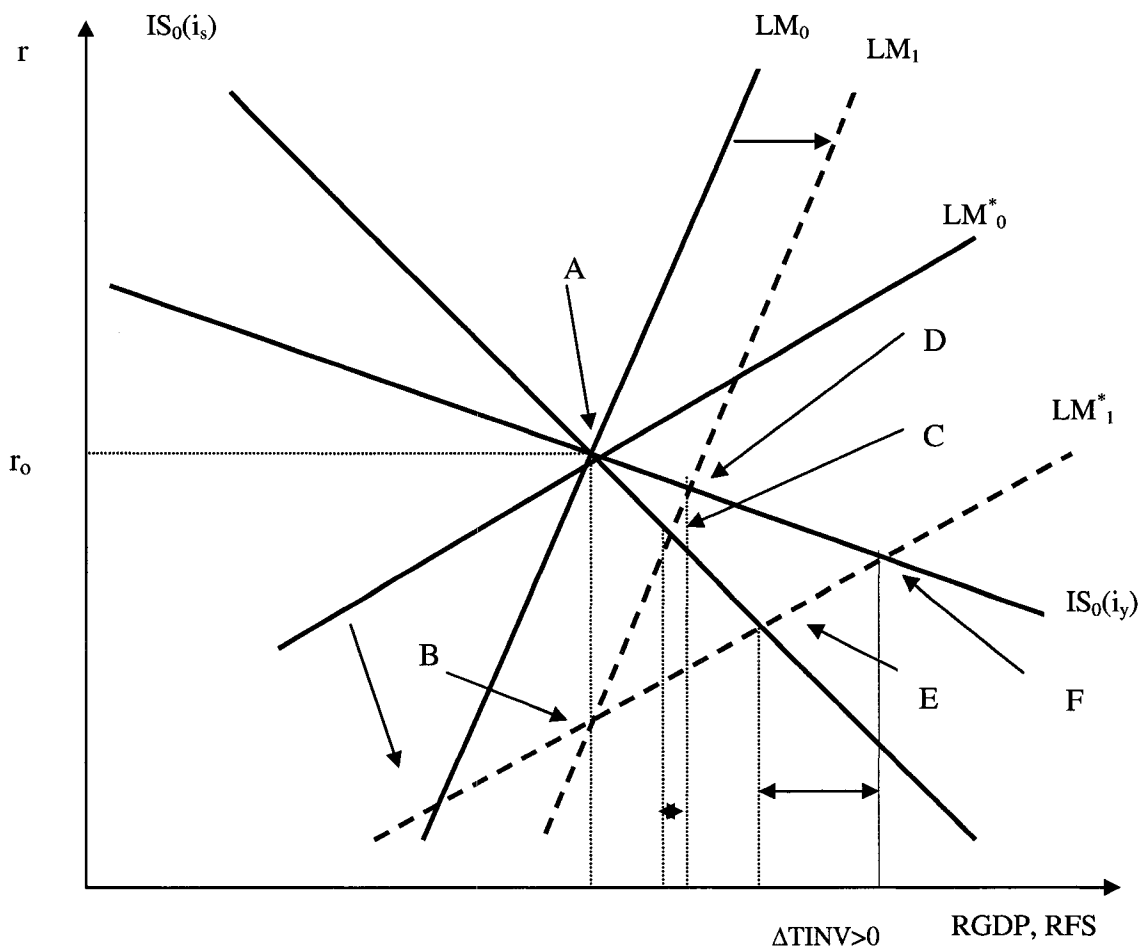
### **5:5 Separating the Effect of Outside and Inside Money in the Response Model.**

The main goal of this part of the study is to introduce theoretically the differential effects of both inside money and outside money in the response model based on the results of the cointegration analysis. Figure 5.15 is used to illustrate the case. To introduce this idea, I would like to state some important points: the effect of the outside money (NBR) will be measured by the degree the LM curve shifts while the effect of the inside money (MM) will be measured by moving along the LM curve due to change in the interest rate. It is known theoretically that the positive interest sensitivity of the money supply is due to the negative relationship between the interest rate and the excess reserve as I explained earlier<sup>151</sup>. This implies that there is a positive relation between the interest rate and MM, which is confirmed by the results of the VAR model.

Theoretically, the slope of the LM curve with an endogenous money supply will be flatter than the LM curve with an exogenous money supply. Therefore, I will

---

<sup>151</sup> For more details look McCallum (1989), pages 56-60.



**Figure 5.15: Inside and Outside Money in the Response Model.**

draw two LM curves, one steeper ( $LM_0$ ) and the other flatter ( $LM^*_0$ ), as shown in Figure 5.15.

It is clear from Figure 5.15 that a positive shock to NBR shifts the LM curve to the right from  $LM_0$  to  $LM_1$ . This shift decreases the interest rate from A to B. The decline in the interest rate pushes both RGDP and RFS to increase. At the same time, the difference in the response between those two variables makes RGDP increase more than RFS. The movement from point B to the new situation C and D on  $LM_1$  does not imply an increase in MM, because on  $LM_1$  we assume the real money balance is constant or is a policy tool. This part of the analysis is a pure effect of a change in NBR. The effect of the inside money, i.e. MM, starts by moving from point B along  $LM^*_1$  because the money supply curve with endogenous money is upward sloping.

Actually, I went through this analysis in order to highlight two important points; first, it is clear that in the case of inside money the responsiveness of the money supply to higher interest rate is larger, i.e. a flatter LM curve. Therefore, we not only failed to find a positive relation between NBR and MINV, we actually found a negative relation. However, we found a positive relation between MM and MINV. This implies that the slope of the LM for NBR is not able to affirm the right positive relation, but more flatness in the LM curve is able to assert this relation. This analysis confirms an important idea that inventories are a major part of economic activity, and the relation between inventories and money is a normal positive relation like the relation between RGDP and money, which was proved in Chapter Four.

The response model in Figure 5.15 can be used to show a case of a negative relation between NBR and inventories, which implies a positive relation between interest rate and inventories. But, the new case can be considered a new dimension to the study of inventories because the current study considers change in inventories as the difference between RGDP and RFS. However, the new case deals with the economy as moving from equilibrium to a situation where we have either excess supply (increase in inventories) or excess demand (decrease in inventories), i.e. moving from A to B. The degree of movement is related directly to the responsiveness of the interest rate inside the sector or economy. To illustrate the situation, we assume there is an increase in the NBR which leads to a decrease in the interest rate which is considered significant to MINV to create a large excess demand (decrease in inventories) in this sector. As mentioned above, it is a movement from point A to point B which represents a disequilibrium point, because at point B the money market is in equilibrium while the commodity market is in excess demand condition. This analysis shows a positive relation between the interest rate and the change in inventories. Theoretically, point B is a disequilibrium condition and the economy will move towards a stable equilibrium along the  $LM_1$  curve. However, the results of the VAR model indicate that the MINV will stop on point B or in the neighborhood of B and does not move to points C and D because the effect of outside money vanishes. But at B the effect of the inside money (MM) takes over and the economy will move along  $LM_1^*$  to points E and F. Thus, the results show that MINV has a negative relation with NBR and positive with MM. The RINV since has a positive relation with both NBR and MM, so the movement from B to C and D,

then to E and F occurs. This conclusion shows that there is a big difference between the two sectors in the response to a shock in the monetary factors, especially the interest rate. The results of the VAR model support this conclusion because it shows that the response of MINV to a positive shock in MM is on average around 40% of the response of RINV to the same shock. This conclusion opens a channel for a future research to make a comparison between the MINV and RINV by disaggregating for RGDP and RFS of each sector and the interest rate.

It is clear from the analysis above that the change in the interest rate that affects MM has to be measured by the movement along the LM curve. But, empirically, the change in interest rate can be either due to the change in NBR or movement along the LM curve, and we cannot distinguish between them. Therefore, I would like to conclude that the existence of NBR, MM and the interest rate in the same system of equations may affect the ability and the power explanation of both the interest and MM.

In general, the conclusions of the two chapters of empirical work are consistent with each other. It is apparent that the disaggregated analysis gives more details about specific relations which were useful to this dissertation. The overall conclusion of Chapters Four and five is that changes in inventories are determined in the economy as a residual based mainly on the relation between RGDP and RFS. As long as both RGDP and RFS are affected by the other macroeconomic variables such as interest rate and prices. Then, the relation between change in inventories and both interest rate and prices is affected by the latter relation. Our analysis supports this conclusion because it shows that all types of inventories are affected by inside

money (MM) as positively and strongly as both RGDP and RFS, and this proves simply that inventories are important part of the economic activity.

This current study concluded that economic changes pass through two time phases; in the first phase a change in inventories takes place in the economy in response to a policy shock (i.e. monetary shock). And, in the second phase change in inventories affects other macroeconomic variables in the economy by affecting RGDP (i.e. feedback effect), which is known as the propagation of the business cycle. Those two phases together show that change in inventories represents a case of disequilibrium therefore the economy will move towards equilibrium by the self-adjustment process, which may be quickened by monetary or fiscal policy.

## **Chapter Six**

### **Summary and Conclusions**

#### **6:1 Conclusion and Policy Recommendations**

Reviewing what has been written about inventories in the literature, I noticed that there are two main lines of research in this important field of economics: macroeconomic and microeconomic approaches. The contrast between these two branches is that each one views the role of inventories differently. The former (macro) seeks to prove that inventories are a destabilizing factor in the economy and responsible for the propagation of the business cycle, while the latter (micro) tries to show that inventories play an important role in smoothing production and behave as a buffer stock. The link between the two directions of research, especially recent research, is that most economists started their research by the micro foundation of inventories and then applied it on the aggregate or macroeconomic level. Modeling inventories on the microeconomic level is a complicated issue because there are many different motives for holding inventories, which implies that different models are obtained, and this leads to disagreement in the conclusions reached by different researches.

On the macroeconomic level, which is the field of this study, Blinder (1980) succeeded to build a theoretical model which showed how the inventories emerge in the economy and described the feedback effect of this important macroeconomic variable in the economy. However, Blinder model is affected by the view of the microeconomic analysis or specifically the production smoothing model (PSM), because Blinder assumed implicitly that inventories behave as a buffer stock, and any shock in the economy will affect real final sales (RFS) but not the real gross domestic product (RGDP). During the last forty years, the empirical work in inventories concentrated on studying the relation between inventories and both interest rate and prices, but it seems that there are still disagreements among economists about the results.

The broad goal of this dissertation is to contribute to the empirical work on this still debated and important economic issue, which is the relation between inventories and the macroeconomic variables, i.e. interest rate and prices, by using both aggregated and disaggregated data for both monetary aggregates and inventories. This broad goal is divided into three specific objectives: first, to investigate the role of inventories in the monetary transmission mechanism; second, to investigate the relation between inventories and the price level; third, to prove empirically that inventories play a crucial role in the propagation of the business cycle.

To achieve the above-mentioned goals, this dissertation adopted the VAR model or the cointegration analysis, including what is called the multicointegration vector introduced by Granger and Lee (1989), who proved that RGDP, RFS, and

TINV can be cointegrated. This new econometric concept means “A vector integrated series is multicointegrated if the accumulated sum of stationary (cointegrated) linear combination is again cointegrated with itself” (Granger and Lee 1989, page S145). The literature review shows that only four studies in the past have used the VAR technique to study the inventories and that none of them used the multicointegration vector technique. Using this new concept was useful in this study because it helps to investigate simultaneously the relationship among some selected macroeconomic variables that were mentioned in the literature review as important variables, and also to observe some evidences about inventories and to draw some conclusions.

This dissertation used quarterly data from the U.S. economy during the period 1959-1997. This study was not able to cover the period after 1997 because at the beginning of 1997, the Standard Industrial Classification (SIC) was replaced by North American Industrial Classification System (NAICS). This implies that the aggregate level of both change in private inventories and RGDP will not be affected by the replacement but this replacement affects the sectoral level.

The main contributions of this study are its ability to describe the dynamic relationship between change in inventories and the other macroeconomic variables in the model and its ability to use the empirical findings to build an IS-LM model or to refine Blinder’s model (1980). This model, after the adjustment, is able to tell a complete story about inventories based on the results of this study. Also, this dissertation converts Blinder’s model to an IS-LM format to compare the differences between the two models. In addition, this dissertation succeeds in expanding the

analysis of the effect of change in inventories on the aggregate demand, and introduces some evidence from the U.S. economy which is considered to be important in quickening the self-adjustment process.

According to the robustness of the results of the cointegration analysis, this technique doesn't have a specific test to make a final judgment about the results. But, with in this technique there are few indications that we are moving in the right direction; for example, the ADF test shows that all the macroeconomic variables in this dissertation are non-stationary at the level, while all of them are stationary at the first difference. The test of the residuals shows that all the residuals are stationary at the level and that they are a white noise error, which confirms that the lag lengths are appropriate. In addition, the shape of the impulse response function (IRF) shows that the effect of each single shock in the system for all the variables decays after some period of time, which is consistent with what is expected by the theory. Furthermore, the results prove that more than one of speed of adjustment coefficients is statistically significant; this is an important condition to prove that the error correction model (ECM) is working in this case, as I mentioned when I defined the cointegration and the error correction model. Moreover, one of the most important indicators is that the findings of this study concerning the relation between the monetary variables with each other, and the relation between the monetary variables and the economic activity are consistent with the previous studies.

The findings on both the aggregate and disaggregate levels are consistent with each other, even though at the disaggregate level detailed results are obtained which support the analysis of this dissertation. The evidence in this dissertation

supports the idea that inventories play a weak role in the monetary transmission mechanism. This evidence shows that there is a negative relation between interest rate and inventories, but this effect is not as strong and not as immediate as expected. In addition, it needs some time lag to show the right sign. Furthermore, at the disaggregate level, the results show that some types of inventories, such as retail inventories, respond negatively to a positive shock in the interest rate, while other types, such as manufacturing inventories, respond positively.

This dissertation went on to investigate the relation between prices and inventories. The findings of this study confirm the idea that the relation between P and inventories is negative despite its being positive in some periods. Empirically, this implies that the speculation motive from holding inventories cannot be strong enough, as expected theoretically. On the contrary, the results showed that manufacturing inventories respond positively to a positive shock in the prices. Such findings confirm the conclusion obtained by economists such as Hornstein (1998) which says that different types of inventories behave in different way.

The results of the cointegration system showed that the relation between the real gross domestic product (RGDP) and the real final sales (RFS) is able to explain the behavior of inventories at both the aggregate and the disaggregate level. This finding provided a turning point in this dissertation to focus on the above-mentioned relation between both RGDP and RFS and inventories. Therefore, the new point of view for the negative relation between inventories and both interest rate and price level comes from the negative relation between RGDP and RFS from one side and both interest rate and price. This negative relation was confirmed by the results of the

cointegration analysis in this dissertation. The results of the VAR model show an interesting feature in the behavior of both RGDP and RFS; that is, RGDP responds more strongly in absolute terms to any shock in the economy, whether it is a price shock or a shock of any component of the monetary variables, including the interest rate.

By utilizing one fact, that RGDP has higher interest sensitivity than RFS, this dissertation succeeds in building an IS-LM model (the response model) to explain the dynamic relation among the variables. This theoretical analysis proved that there is a negative relation between inventories and both interest rate and price level. The empirical evidence is necessary and useful to the theoretical analysis to show the role of time lag among the variables in drawing a complete picture for the dynamic behavior. Contrary to Blinder's results, the response model shows that inventories respond positively to a positive shock in the money supply, and this result is consistent with the theoretical view of the inventories as an important part of the economic activity. To focus more on this result, the empirical results show that all types of inventories respond positively to inside money. At the same time, only RINV responds positively to a positive shock in outside money, while both MINV and TINV respond negatively to outside money. This result confirms two main points: first, there is a clear difference in the response to the interest rate among the different types of inventories. Second, inside money is related more than outside money to the economic activity. Theoretically, the response model shows that the existence of inside money is able to reduce the interest rate more, which leads to increase in the size of inventories compared to outside money.

As for the role of inventories in the propagation of business cycle, this study proved empirically that the indirect channel or the feedback effect from inventories to RGDP exists. But, the general results or the description of how inventories occur in the economy illustrate that the relation between prices and interest rate to inventories goes through the intermediate stage of the impact of those two macroeconomic variables on RGDP and RFS. This finding weakens the propagation mechanism or the inventories shock persistence presented by Blinder and Fischer (1981), because they showed that there is a direct relation running from interest rate and prices to RGDP and an indirect one through inventories. But, this dissertation illustrates that part of the indirect relation which runs from both price and interest rate to inventories is weak. Also, this dissertation illustrates that the change in inventories happens in the first phase (short run) due to a monetary shock and that its effect on the other variables, i.e. RGDP and P, started in the second phase (long run). Moreover, it seems that the relation among the different types of inventories plays a crucial role in the propagation of the business cycle because the results show that the relation between some types of inventories is negative and that there is a difference in the behavior of inventories.

The production smoothing model (PSM) is a microeconomic analysis for the inventories and this dissertation is on the macroeconomic level, but it seems that the empirical findings have a close relation to the implication of PSM. The results show that an unanticipated shock to RFS will be met by a strong and immediate response from RGDP, as immediate as the second quarter. It seems that the response of RGDP is greater than the shock of RFS itself and this make the net effect on TINV positive

except for the first quarter. To figure out the direct effect of RFS on inventories, we have to make the shock first in RGDP or order RGDP before RFS, and the results show that RFS has a strong negative effect on TINV. But even in this case the response of RGDP is greater than RFS, which makes the final effect on TINV positive. This conclusion highlights an important unanswered puzzle which is as long as the role of inventories in this model (PSM) is to smooth production, then why is RGDP more volatile than RFS. The answer based on the empirical results confirms that RGDP responses are greater than RFS to all shocks in the economy, which is the core of the answer. Therefore at the equilibrium  $RGDP = RFS$  then  $\Delta TINV=0$ , but if we have a positive monetary shock then RGDP increases more than RFS, and this creates inventories in the economy. The accumulation of inventories represents a disequilibrium case. Therefore, there is pressure on the economy to adjust toward equilibrium. The issue of the high responsiveness of RGDP leads to large number of swings because if the economy doesn't succeed in reaching an equilibrium point where  $\Delta TINV=0$ , then the fluctuation will keep on until the economy succeeds in reaching a more stable point or what is called the desired level of inventories. Hence, economic policies play an important role in reducing the time needed to reach equilibrium again.

The theoretical analysis based on the IS-LM model shows that there is room for both the monetary and fiscal policies to restore the equilibrium. The analysis shows that an expansionary monetary policy and contractionary fiscal policy have the same effect, which is to accumulate inventories, while contractionary monetary policy and expansionary fiscal policy lead to decrease in inventories.

## **6:2 Suggestions for Future Research**

This dissertation suggests several directions for future research which can help to explore the results of this dissertation and expand the analysis more. First, it has been proved theoretically and empirically that there is a positive relation between interest rate and inside money (money multiplier), but this relation is valid theoretically when the economy moves along the LM curve. Therefore, any change in the interest rate for a change in outside money (NBR) will affect MM, which is not exactly fit with the theory, and this may reduce the significance and the strength of both interest rate and money multiplier, especially it has been proved in this study that economic activity, including inventories tends to be affected strongly and immediately by inside money. Therefore, this study suggests re-estimating a similar VAR model separately with inside money and outside money. Also, we can expand this analysis by using different types of inventories other than those in this study to compare the results and check if different types of inventories will give different results.

The second direction of research is to investigate the effect of inventories on the components of the aggregate demand, such as the consumption and fixed investment. This dissertation introduces some evidence from the U.S. economy based on quarterly data during the period 1973-2001 that in periods of increase in inventories, the economy will have lower interest rate, lower prices and higher consumption. Thus, additional investigation will be useful to understand more about the role of inventories in the propagation of business cycle.

The third direction requires focusing more on understanding the characteristics of the different types of inventories in order to understand better the difference in their behavior, especially since it has been proved that some types of inventories respond negatively to other types. This investigation may even require disaggregating RGDP and RFS based on the industrial origin and also disaggregate inventories more than I have done in this dissertation.

The fourth direction is to focus more on the role of inventories in the propagation of the business cycle. This dissertation concluded that there is a second phase effect which is a completely a pure inventories effect, in which inventories affect the other macroeconomic variables in the economy. Therefore, this dissertation suggests empirically to study the relation among the variables in this study or to add more variables by using a VAR model, but the new study is to order the variables opposite from this study by starting from inventories, then RFS and RGDP and finally the monetary factors and the prices. On the theoretical part of this direction of research, this dissertation suggests to work on proving mathematically that inventories affect the macroeconomic variables through the relation between RGDP and RFS.

The current study relies mainly on the aggregate demand analysis. Therefore, this study suggests a fifth direction expanding the analysis by including the supply side by adding some macroeconomic variables such as real wages. In this regard, Mossetti (1990) built a theoretical model which needs to be tested.

A sixth direction of research is to study the relation among the variables from the long-run point of view, which means different frequency of data, such as yearly

instead of quarterly. I expect that using a higher frequency of data may capture a clearer relation between inventories and both prices and interest rate.

## References

Abramovitz, Moses. (1950) Inventories and Business Cycles with Special Reference to Manufacturing Inventories, New York: National Bureau of Economics Research.

Akhtar, M. A. (1983) "Effects of Interest Rates and Inflation on Aggregate inventory Investment in the United States," The American Economic Review, Vol. 73, no. 3 (Jun.), 319-328.

Allen, Donald S. (1995) "Change in Inventory Management and the Business Cycle," Federal Reserve Bank of Saint Louis Review, July/August, 17-26.

\_\_\_\_\_. (1997) "Do Inventories moderate Fluctuations in Output?" Federal Reserve Bank of Saint Louis Review, July/August, 39-50.

Bain, Ian. (1985) "A Theory of Cyclical Movements of Inventory Stock," A Ph. D. Dissertation, University of Minnesota, April.

Barro, R. J. and H. I. Grossman. (1971) "A General Disequilibrium Model of Income and Employment," American Economic Review, Vol. 61, March, 82-93.

\_\_\_\_\_. (1976) Money, Employment and Inflation.

Cambridge: Cambridge University Press.

Baxter, Marianne and Robert G. King. (1995) "Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series," Working paper 5022. Cambridge, Mass: National Bureau of Economic Research, February.

Bechter, Dan M. and Stephen Stanley. (1992) "Economic Stability in the 1990s: The Implications of Improved Inventory Control," Business Economics January, 8-35.

Bivin, David. (1993) "The influence of Inventories on Output and Prices: A Stage of Fabrication Approach," Journal of Macroeconomics, Vol. 15, no. 4, Fall, 627-651.

Blanchard, Oliver. (1983) "The Production and Inventory Behavior of the American Automobile Industry," Journal of Political Economy, June, 91, 365-400.

Blinder, Alan S. (1980) "Inventories in the Keynesian Macro Model," Kyklos, 33, 585-614.

\_\_\_\_\_. (1981) "Retail Inventory Behavior and Business Fluctuations," Brookings Papers on Economic Activity, 2, 443-505.

\_\_\_\_\_. (1986) "More on the speed of Adjustment in Inventory Models." Journal of Money, Credit and Banking, Vol. 18, No.3, August, 355-365.

\_\_\_\_\_. (1990) Inventory Theory and consumer Behavior, Ann Arbor, Michigan: University of Michigan Press.

Blinder, Alan S. and Stanley Fischer. (1981) "Inventories, Rational Expectations, and the Business Cycle," Journal of Monetary Economics, November 1981, 8, 277-304.

Blinder, Alan S. and Louis J. Maccini. (1991a) "Taking Stock: A Critical Assessment of Recent Research on Inventories." The Journal of Economic Perspectives, Vol. 5, no. 1, Winter 1991, 73-96.

\_\_\_\_\_. (1991b) "The Resurgence of Inventory Research: What Have We Learned?" Journal of Economic Surveys, Vol.5, No.4.

The Bureau of Economic Analysis (BEA) Web Site.  
<http://www.bea.gov/>;

Chari, V. V., Lawrence J. Christiano and Martin Eichenbaum. (1995) "Inside Money, Outside Money, and the Short-Term Interest Rate," Part 2: Liquidity, Monetary Policy, and Financial Intermediation (Nov., 1995), Journal of Money, Credit and Banking, Vol. 27, No. 4, 1354-1386.

Charemza, Wojciech W. and Derek F. Deadman. (1997) New Directions in Econometric Practice, Second Edition, Edward Elgar Publishing, Inc. UK.

Christiano, Lawrence J. (1988) "Why does inventory investment fluctuate so much." Journal of Monetary Economics, Vol. 21, March/May, 247-280.

Christiano Lawrence J. and Martin Eichenbaum. (1995) "Liquidity Effects, Monetary Policy, and the Business Cycle." Journal of Money, Credit and Banking, Vol. 27, no. 4, Part 1, November, 1113-1136.

Christiano Lawrence J., Martin Eichenbaum and Charles Evans. (1996) "The Effect of Monetary Policy Shocks: Evidence from the Flow of Funds." The Review of Economics and Statistics, Vol. 78, Issue 1, February, 16-34.

Cooley, Thomas F. and Stephen F. LeRoy. (1985) "A Theoretical Macroeconomics A Critique." Journal of Monetary Economics, Vol. 16, 283-308.

David, Savage. (1978) "The Channels of Monetary Influences: A Survey of the Empirical Evidence," National Institute Economic Review, Vol. 83, 73-89.

Dickey, D. A., 1988 Comment, Journal of Business and Economic Statistics, Vol. 6, 410-412.

Dickey, D.A. and W.A. Fuller (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," Journal of the American Statistical Association, 74, 427-431.

Durlauf, S. N. and L.J. Maccini. (1995) "Measuring Noise in Inventory Models," Journal of Monetary Economics, Vol. 36, no. 1, December, 65-89.

The Economagic Web Site. <http://www.economagic.com>.

Eichenbaum, Martin. (1992) "Comments on Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy European Economic Review 36, 1001-1011.

Enders, Walter. (1995) Applied Econometric Time Series, John Wiley and Sons, Inc.

Engle, Robert F. and C.W. Granger. (1987) "Cointegration and Error Correction: Representation and Testing", Econometrica, Vol. 55, Issue 2, March, 251-276.

Engle, Robert F. and Halbert, White. (1999) Cointegration, Causality, and Forecasting, Oxford University Press Inc., New York.

Evans, Charles L. and Kenneth N. Kuttner. (1998) "Can VARs Describe Monetary Policy?" Federal Reserve Bank of Chicago, Research Department, Working paper Series (WP-98-19).

E-Views, User Guide 1994-1997.

Fair, Ray C. (1988) "Source of Economic Fluctuation in the United States." The Quarterly Journal of Economics, Vol. 103, no.2, May, 313-332.

Fama, Eugene F. (1982) "Inflation, Output, and Money," The Journal of Business, Vol. 55, Issue 2, Apr., 201-231.

Favero, Carlo A. (2001) Applied Macroeconometrics, Oxford University Press.

The Federal Reserve Bank of Saint Louis Web Site.  
<http://www.stls.frb.org/>;

Filardo, Andrew. (1995) "Recent Evidence on the Muted Inventory Cycle", Federal Reserve Bank of Kansas City Economic Review, second quarter, 27-43.

Fitzgerald, Terry J. (1997) "Inventories and the Business Cycle: An Overview." Federal Reserve Bank of Cleveland, Economic Review, Third Quarter.

Friedman, Benjamin. (1981) "The Relative Stability of Money and Credit Velocities in the United States; An Overview of the Evidence," Working Paper, Harvard University, November.

Gordon, David B. and Leeper, Eric M. (1994) "The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification." The Journal of Political Economy, Vol. 102, no.6, December, 1228-1247.

Gordon, Robert, J. (1987) Macroeconomics, Fourth Edition, Canada, Little, Brown and Company.

Granger, C.W.J. (1969) "Investigating Causal Relations by Econometric Models and Cross-spectral Methods", Econometrica, Vol. 37, Issue 3, August, 424-438.

Granger, C.W. and T. H. Lee. (1989) "Investigation of Production, Sales and Inventory Relationships Using Multicointegration and Non-Symmetric Error Correction Models" Issue supplement: Special Issue on Topics in Applied Econometrics, Journal of Applied Econometrics, Vol. 4 Dec., S145-S159.

Gujarati, Damondar N. (1995) Basic Econometrics, Third Edition, McGraw-Hill, Inc.

Guriguiz, Hany S. (1999) "Properly Estimating the Liquidity Effect: Why Accounting for Stationarity and Outliers is Important." Journal of Economic and Business 51, 303-314.

Gurley, John G. and Edward S. Shaw. (1964) Money in a Theory of Finance, The Brookings Institution, Washington, D. C.

Hall, Robert E. and Michael C. Lovell. (1976) "Behavior in Durable Goods Manufacturing: Target-adjustment model. Comments and Discussion" Brooking Papers on Economic Activity, Vol. 1976, Issue 2, 397-408.

Hamilton, James. (1994) Time Series Analysis, Princeton University Press, Princeton.

Hansen, Alvin. (1941) Fiscal Policy and Business Cycle, New York, Norton and Company Inc.

Hansen, Lars P. and Thomas J. Sargent. (1981) "Linear Rational Expectations Models for Dynamically Interrelated Variables." In Rational Expectations and Econometric Practice Vol. 1 edited by Robert E. Lucas, Jr., and Thomas J. Sargent. Minneapolis: University of Minnesota Press.

Herrera, Ana Maria (2000) "Inventories, Oil Shocks, and Aggregate Economic Behavior" Ph.D. dissertation, University of California, San Diego.

Holt, C.C., F. Modigliani, J. F. Muth, and H. Simon. (1960) Planning Production, Inventories, and work Force, Englewood Cliffs. N. J.: Prentice-Hall.

Hornstein, Andreas. (1998) "Inventory Investment and the Business Cycle," Federal Reserve Bank of Richmond Economic Review Quarterly Volume 84/2 Spring.

Hubbard, R. Glenn. (1996) Money, the Financial System and the Economy, Second Edition, Addison Wesley Longman, Inc.

Huh, Chan. (1994) "Just-in-Time Inventory Management: Has It Made a Difference?" Federal Reserve Bank of San Francisco, FRBSF Weekly Letter, Number 94-18, May 6.

Irvine, Owen F., Jr. (1981a) "Merchant Wholesaler Inventory Investment and the Cost of Capital." The American Economic Review, Vol. 71, no. 2, Papers and Proceedings of the Ninety-Third Annual Meeting of the American Economic Association, May, 23-29.

\_\_\_\_\_ (1981b) "Retail Inventory Investment and the Cost of Capital." The American Economic Review, Vol. 71, no. 4, Sep., 633-648.

Jin, Yi. (2001) "Inventory Behavior, Credit Constrains, and the Monetary Transmission Mechanism" A Ph.D. Dissertation. University of Iowa. March.

Kashyap, A. K., O.A. Lamont, and J. C. Stein. (1994) "Credit Conditions and the Cyclical behavior of Inventories," Quarterly Journal of Economics, Vol. 109, No. 3, August, pp 565-92.

Keynes, John M. (1932) A Treatise on Money, Vol. II Chapter 29, New York, Harcourt, Brace and Company.

King, Robert G. and Charles I. Plosser. (1984) "Money, Credit, and Prices in a Real Business Cycle." The American Economic Review, Vol. 74, No. 3, June, 363-380.

Kollintzas, T. (1995) "A Generalized Variance Bounds Test with an Application to Holt et al. Inventory Model," Journal of Economic Dynamics and Control, Vol. 19, January/February, pp59-89.

Kydland, Finn E. and Prescott, Edward C. (1982) "Time to Build and Aggregate Fluctuations," Econometrica, 50, no. 6 (November): 1345-1370.

Kydland, Finn E. and Edward C. Prescott. (1990) "Business Cycle: Real Facts and a Monetary Myth." Federal Reserve Bank of Minneapolis, Quarterly Review, Vol. 14, no. 2, Spring.

Larrain, Maurice (2002) "Do Interest Rate Lead Real Sales and Inventories," The Journal of the National Association for Business Economics, Vol. XXXVII, No. 2, April.

Leeper, Eric M., Christopher A. Sims and Tao Zha. (1996) "What Does Monetary Policy Do?" Brooking Papers on Economic Activity, Vol., No. 2, 1-78.

Lieberman, Charles. (1980) "Inventory Demand and cost of Capital Effects," The Review of Economics and Statistics, Vol. 62, Issue 3, August, 348-356.

Littile, Jane Sneddon. (1992) "Changes in Inventory Management: Implications for the U.S. Recovery," Federal Reserve Bank of Boston New England Economic Review November/December, 37-65.

Lovell, Michael C. (1976) "Comments on Inventory Behavior and Durable-Goods Manufacturing: The Target-Adjustment Model," Brooking Papers on Economic Activity, 2, 397-408.

Lovell, Michael C. (1994) "Researching Inventories: Why haven't We Learned more?" International Journal of Production Economics. Vol.35, No.1-3, 33-41.

Lutkepohl, Helmut and Hans-Eggert, Reimers. (1992) "Impulse Response Analysis of Cointegrated System" Journal of Economic Dynamics and Control, Vol. 16, January, 53-78.

McCallum, B. (1999) "Analysis of the Monetary Transmission Mechanism: Methodological Issues". Paper Presented at the Deutsche Bundesbank Conference "The Monetary Transmission Process: Recent Developments and Lessons for Europe", Frankfurt.

McCallum, Bennett T. (1989) Monetary Economics, New York, Macmillan.

Maccini, Louis J. (1976) "An Aggregate Dynamic Model of Short-Run Price and Output Behavior," The Quarterly Journal of Economics, Vol. 90, Issue 2, May, 177-196.

Maccini, Louis J. and Robert J. Rossana. (1981) "Investment in Finished Goods Inventories: An Analysis of Adjustment Speeds." The American Economic Review, Vol. 71, No. 2, Papers and Proceedings of the Ninety-Third Annual Meeting of the American Economic Association, May, 17-22.

\_\_\_\_\_. (1984) "Joint Production, Quasi-Fixed Factors of Production, and Investment in Finished Goods Inventories." Journal of Money, Credit and Banking, Vol. 16, No.2, May, 218-236.

MacKinnon, James. G. (1991) Critical Values for Cointegration Tests, Chapter 13 in R. F. Engle and C. W. J. Granger (eds.), Long-run Economic Relationships: Readings in Cointegration, Oxford University Press.

MacKinnon, James G. (1996). "Numerical Distribution Functions for Unit Root and Cointegration Tests," Journal of Applied Econometrics, 11, 601-618.

Mankiw, N. G. (2000) Macroeconomics, Fourth Edition, New York, Worth.

Metzler, Lloyd A. (1941) "The Nature and Stability of Inventory Investment." The Review of Economics Statistics, Vol. 23 No. 3, August, 113-129.

Miron, J. A., and S. P. Zeldes. (1988) "Seasonality, Cost Shocks, and Inventories," Econometrica, Vol. 56, no. 4, July, 877-908.

Mishkin, Frederic S. (1982) "Monetary Policy and Short-Term Interest Rate: an Efficient Markets-Rational Expectations Approach" The Journal of Finance, Vol. 37, Issue 1, Mar, 63-72.

Mossetti, Giovanna. (1990) "Inside Money, Output, and Inventories in a Business Cycle," The Canadian Journal of Economics, Vol. 23, No. 2, May, 381-399.

Ramey, Valerie A. (1989) "Inventories as a Factor of Production and Economic Fluctuations." The American Economic Review, Vol.79, no. 3, June, 338-354.

Ramey, Valerie A. and Kenneth D. West. (1997) "Inventories," National Bureau of Economic Research, Working Paper Series, Working Paper no. 6315, December.

Reagan, Patricia B. (1982) "Inventory and Price Behavior," The Review of Economic Studies, Vol. 49, Issue 1, Jan 137-142.

Reagan, Patricia and Dennis Sheehan, P. (1985) "The Stylized Facts About the Behavior of Manufacturing Inventories and Backorders Over the Business Cycle: 1959-1980," Journal of Monetary Economics, Vol. 15, 217-246.

Revier, Charles, 2000 "Policy Effectiveness and the Slopes of IS and LM Curves: A Graphical Analysis" Journal of Economic Education, Fall, 374-381.

Rubin, Laura S. (1979) "Aggregate Inventories Behavior: Response to Uncertainty and Interest Rates." Journal of Post Keynesian Economics." Vol. 2, Winter 1979/1980.

Shbikat, Gazi. (2000) "The Money-Output Relationship: A disaggregated Approach." A Ph.D. Dissertation, University of Tennessee, Knoxville.

Sims, C. A. (1972) "Money, Income and Causality" American Economic Review, Vol. 62, no. 4 (September): 540-542.

Sims, C. A. (1980) "Comparison of Interwar and Postwar Business Cycles," American Economic Review, 70, no. 2 (May): 250-257.

Sims, C. A. (1992) "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," European Economic Review 36 (1992), 975-1000.

Sprague, Linda G., John G. Wacker. (1996) "Macroeconomic Analyses of inventories: Learning from Practice," International Journal of Production 45, 231-237.

Survey of Current Business, June 2001.

United Nations (1993) "System of the National Accounts 1993."

Walsh, Carl E. (1998) Monetary Theory and Policy, Massachusetts Institute of Technology, Cambridge, Massachusetts.

West, Kenneth D. (1990) "The Sources of Fluctuation in Aggregate Inventories and GNP." The Quarterly Journal of Economics, Vol. 105, No. 4 November, 939-971.

## Appendix A

### Derivation of the IRF and FEVD

Assume we have a simple bivariate system with a lag length of unity

$$Y_t = a_{10} - b_{10} X_t + a_{11} Y_{t-1} + a_{12} X_{t-1} + e_{yt}$$

$$X_t = a_{20} - b_{20} Y_t + a_{21} Y_{t-1} + a_{22} X_{t-1} + e_{xt}$$

Where (1) both  $Y_t$  and  $X_t$  are stationary. (2)  $e_{yt}$  and  $e_{xt}$  are a white noise disturbances with standard deviation of  $\sigma_{eyt}$  and  $\sigma_{ext}$ , respectively. (3)  $e_{yt}$  and  $e_{xt}$  are uncorrelated white noise disturbances.

The above system is not a reduced system since  $X_t$  has a contemporaneous effect on  $Y_t$  and  $Y_t$  has a contemporaneous effect on  $X_t$ . This system can be transformed to a reduced form which is more usable, by using matrix algebra it will be as follows;

$$\begin{bmatrix} 1 & b_{10} \\ b_{20} & 1 \end{bmatrix} \begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \dots\dots\dots (1)$$

Multiply both sides of (1) by  $\begin{bmatrix} 1 & b_{10} \\ b_{20} & 1 \end{bmatrix}^{-1}$  we will get

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} A_{10} \\ A_{20} \end{bmatrix} + \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} U_{yt} \\ U_{xt} \end{bmatrix} \dots\dots\dots (2)$$

Where;

$$\begin{bmatrix} A_{10} \\ A_{20} \end{bmatrix} = \begin{bmatrix} 1 & b_{10} \\ b_{20} & 1 \end{bmatrix}^{-1} \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} \dots\dots\dots (3)$$

$$\begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} = \begin{bmatrix} 1 & b_{10} \\ b_{20} & 1 \end{bmatrix}^{-1} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \dots\dots\dots (4)$$

$$\begin{bmatrix} U_{yt} \\ U_{xt} \end{bmatrix} = \begin{bmatrix} 1 & b_{10} \\ b_{20} & 1 \end{bmatrix}^{-1} \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \dots\dots\dots (5)$$

As long as we assume the  $Y_t$  and  $X_t$  are stationary which means the stability condition is met, and this guaranteed that variables of  $Y_t$ , and  $X_t$  are expressed in the current and past value of the shocks ( $U_{xt}$ ,  $U_{yt}$ ). Therefore we can write the reduced form by using the moving average representation, as follows;

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} \mu_{yt} \\ \mu_{xt} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}^i \begin{bmatrix} U_{yt-i} \\ U_{xt-i} \end{bmatrix} \dots\dots\dots (6)$$

We can express  $Y_t$  and  $X_t$  in (6) in terms of  $e_{yt}$  and  $e_{xt}$  from (5)

$$\begin{bmatrix} U_{yt} \\ U_{xt} \end{bmatrix} = [1/(1-b_{20}b_{10})] \begin{bmatrix} 1 & -b_{10} \\ -b_{20} & 1 \end{bmatrix} \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \dots\dots\dots (7)$$

Then substitute (7) in (6)

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} \mu_{yt} \\ \mu_{xt} \end{bmatrix} + [1/(1-b_{20}b_{10})] \sum_{i=0}^{\infty} \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{10} \\ -b_{20} & 1 \end{bmatrix} \begin{bmatrix} e_{yt-i} \\ e_{xt-i} \end{bmatrix} \dots\dots\dots (8)$$

We can simplify (8) by defining a 2 x 2 matrix  $\Phi_i$  with elements  $\Phi_{jk}(i)$

$$\Phi_i = [A^i / (1 - b_{20}b_{10})] \begin{bmatrix} 1 & -b_{10} \\ -b_{20} & 1 \end{bmatrix}$$

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} \mu_{yt} \\ \mu_{xt} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \Phi_{11}(i) & \Phi_{12}(i) \\ \Phi_{21}(i) & \Phi_{22}(i) \end{bmatrix} \begin{bmatrix} e_{yt-i} \\ e_{xt-i} \end{bmatrix} \dots\dots\dots(9)$$

The impulse response functions of  $Y_t$  are;

$\Phi_{11}(i) = \partial Y_{t+i} / \partial e_{yt}$ : Shows over time a unit change in  $e_{yt}$  on  $Y_t$ .

$\Phi_{12}(i) = \partial Y_{t+i} / \partial e_{xt}$ : Shows over time a unit change in  $e_{xt}$  on  $Y_t$ .

The impulse response functions of  $X_t$  are;

$\Phi_{21}(i) = \partial X_{t+i} / \partial e_{yt}$ : Shows over time a unit change in  $e_{yt}$  on  $X_t$ .

$\Phi_{22}(i) = \partial X_{t+i} / \partial e_{xt}$ : Shows over time a unit change in  $e_{xt}$  on  $X_t$ .

The general form for the moving average representation in (9) is as follows;

$$Y_t = \mu_{yt} + \sum_0^{\infty} \Phi_i e_{t-i} \dots\dots\dots (10)$$

We can use this formula to forecast the value of  $Y_t$  for n period;

$$Y_t = \mu_{yt} + \sum_0^{\infty} \Phi_i e_{t+n-i} \dots\dots\dots (11)$$

The n-period forecast error;

$$Y_{t+n} - E_t Y_{t+n} = \sum_0^{n-1} \Phi_i e_{t+n-i} \dots\dots\dots (12)$$

Expand (12) more based on (9)

$$Y_{t+n} - E_t Y_{t+n} = \Phi_{11}(0)e_{yt+n} + \Phi_{11}(1)e_{yt+n-1} + \dots + \Phi_{11}(n-1)e_{yt+1} + \Phi_{12}(0)e_{xt+n} + \Phi_{12}(1)e_{xt+n-1} +$$

$$\dots + \Phi_{12}(n-1)e_{xt+1} \dots \dots \dots (13)$$

Rising both sides for the power of two and taking the expected value

$$E[Y_{t+n} - E_t Y_{t+n}]^2 = [\Phi_{11}(0)e_{yt+n} + \Phi_{11}(1)e_{yt+n-1} + \dots + \Phi_{11}(n-1)e_{yt+1} + \Phi_{12}(0)e_{xt+n} + \Phi_{12}(1)e_{xt+n-1} + \dots + \Phi_{12}(n-1)e_{xt+1}]^2 \dots \dots \dots (14)$$

Defining the n-step ahead forecast error variance as  $\sigma_{Yt}(n)^2$

$$\sigma_{Yt}(n)^2 = \sigma_{eyt}^2 [\Phi_{11}(0)^2 + \Phi_{11}(1)^2 + \dots + \Phi_{11}(n-1)^2] + \sigma_{ext}^2 [\Phi_{12}(0)^2 + \Phi_{12}(1)^2 + \dots + \Phi_{12}(n-1)^2] \dots \dots \dots (15)$$

It is clear from (15) that the n-step ahead forecast error variance affected by shocks of both  $Y_t$  and  $X_t$ , and we can decompose that to;

$$1 = \sigma_{eyt}^2 [\Phi_{11}(0)^2 + \Phi_{11}(1)^2 + \dots + \Phi_{11}(n-1)^2] / \sigma_{Yt}(n)^2 + \sigma_{ext}^2 [\Phi_{12}(0)^2 + \Phi_{12}(1)^2 + \dots + \Phi_{12}(n-1)^2] / \sigma_{Yt}(n)^2 \dots \dots \dots (16)$$

Based on (15), it is clear that the Forecast Error Variance Decomposition (FEVD) from  $Y_t$  and  $X_t$  are given by the following expressions:

$$\text{FEVD of } Y_t \text{ explained by a shock in } Y_t = \sigma_{eyt}^2 \left[ \sum_0^{n-1} \Phi_{11}(i) \right] / \sigma_{Yt}(n)^2$$

$$\text{FEVD of } Y_t \text{ explained by a shock in } X_t = \sigma_{ext}^2 \left[ \sum_0^{n-1} \Phi_{12}(i) \right] / \sigma_{Yt}(n)^2$$

$$\text{FEVD of } X_t \text{ explained by a shock in } X_t = \sigma_{ext}^2 \left[ \sum_0^{n-1} \Phi_{22}(i) \right] / \sigma_{xt}(n)^2$$

$$\text{FEVD of } X_t \text{ explained by a shock in } Y_t = \sigma_{eyt}^2 \left[ \sum_0^{n-1} \Phi_{21}(i) \right] / \sigma_{xt}(n)^2$$

## **Appendix B**

### **The Definition of the Variables in the Model**

**RGDP:** Real Gross Domestic Product, Billions of Chained 1996 Dollars, Seasonally Adjusted Annual Rate (SAAR).

**RFS:** Real Final Sales, Billions of Chained 1996 Dollars, SAAR.

**TINV:** Total Private inventories, Billions of Chained 1996 Dollars, SAAR.

**MINV:** Manufacturing Private Inventories, Billions of Chained 1996 Dollars, SAAR.

**RINV:** Retail Trade Private Inventories, Billions of Chained 1996 Dollars, SAAR.

**FFR:** Federal Fund Rate.

**M<sub>2</sub>:** Money Stock, Billions of Dollars, Seasonally Adjusted.

**NBR:** Non-Borrowed Reserve, Billions of Dollars, Seasonally Adjusted.

**MM:** Money Multiplier.

**CC:** Currency held by the non-Bank Public, Billions of Dollars, Seasonally Adjusted.

**P:** Price Index Measured by the Implicit Price Deflator for Private Inventories  
1996=100.