MONETARY FACTORS and the U.S. RETAIL FOOD PRICE LEVEL

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Abstract

MONETARY FACTORS and the U.S. RETAIL FOOD PRICE LEVEL

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The following study assesses whether an economic relationship exists between the money supply (*i.e.* M2), interest rates, and the exchange rate and the retail food price level in the United States. Data for the M2 classification of the United States money supply, the Effective Federals Funds (interest) Rate, and the United States Trade Weighted Exchange Index: Major Currencies for the period from January 1974 through December 2007 are evaluated as they relate to the United States Consumer Price Index for all Urban Consumers: Food for the same period. The statistical analysis involves an examination of the autocorrelation and partial autocorrelation functions of each variable, a test for the presence of stationarity in each variable(Augmented Dickey-Fuller test), Johansen's test for co-integrating equations of the variables considered, Granger's test for causality, and finally an estimation of regression models of United States retail food prices as a function of the money supply, interest rates, and exchange rates.

Results indicate that a statistically significant relationship exists among the variables tested. A causal relationship exists between the Federal Funds Rate and the money supply, the money supply and the retail level of food prices, and also between the exchange rate and the retail level of food prices. The implications of the results are assessed through the lens of agricultural producers and processors, investors, lenders, consumers, and monetary and agricultural policymakers.

<u>Keywords:</u> retail food prices, money supply, Federal Funds Rate, exchange rate, augmented Dickey-Fuller, Johansen's test for co-integration, Granger causality

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To Grandma & Grandad

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Chapter 1

INTRODUCTION

The micro and macroeconomic factors in an economic system characterize the manner in which economic agents in all sectors of the economy behave within the confines of the system. In both the short and long terms the behavior of economic agents shifts in response to the changing dynamics of the marketplace (Carbaugh, 2001). At the micro level, changes in household income, tastes and preferences, and prices of goods and services alter the manner in which households consume and invest. The changes in demand in the household component of the micro economy result in the firms in each sector of the economy altering the mix of goods and services they provide in order to more accurately meet the demands of the consumers, thus, reaping profits that will contribute to the viability of the firm (Carbaugh, 2001). As changes occur at the household and firm level of the micro economy, resources, whether they are financial, human, commodity based, or otherwise are shifted to and fro from one sector to another as markets seek to achieve equilibrium by moving resources away from less productive uses to those that are more productive. The sum of economic action taken by individuals and firms in the micro economy defines the macro economy of a state, region, or nation (Kennedy, 2003). Measures of macroeconomic productivity in conjunction with government regulations

regarding the use of resources provides economic agents at the micro level with vital information that shapes the manner in which they choose to utilize resources (Kennedy, 2003; Studenmund, 2006).

One fundamental resource in a modern developed economy is capital - the monetary flows employed by all economic agents in the countless transactions that occur on a daily basis to buy or rent productive inputs or resources. Whether it is fiat money used by households to purchase groceries, a checking account that is drawn upon to finance the daily operations of a business, or financial securities held by an investor, money and its apparent value plays a vital role in a nation's economy as a standardized medium of exchange, unit of account, and investment instrument (Mishkin, 2001). Because money, in the form of a stated currency, is the fundamental unit of exchange for the majority of transactions in the modern, developed economies of the United States and most of the world's nations, it is highly sought after by economic agents.

One basic consumer need that is secured using money is the food that is essential to individual physical existence. Despite varying food tastes and preferences throughout the world, everyone must eat to sustain life. Although food purchases in the United States are a small proportion of total consumption expenditures relative to other nations, the amount of money allocated towards the purchase of food items is still a consideration in consumer budgeting activity (Gómez, *et al.*, 2006). As such, factors of importance to consumers are those that have potential to influence or change food prices because such changes will result in a change in the amount of consumer income allocated towards food

consumption. Additionally, because retail food price inflation is often purported to be a gauge of inflationary trends in the entire macro economy (Van Duyne, 1982), the ability to determine how retail food prices will change is important for determining consumer behavior changes in all sectors of the economy, given changes in the retail price level of food products.

The following study examines if and how monetary factors affect food price levels. What monetary factors affect the retail food price level in the United States? Specifically, do the United States money supply (M2), the United States Federal Funds Rate, and the United States dollar trade weighted exchange rate affect food price levels? The following thesis will primarily provide an answer as to whether the aforementioned monetary factors are causal forces that influence the retail level of food prices in the United States.

Economic Problem

Does a causal relationship exist between changes in monetary factors – such as the money supply, interest rates, and exchange rates – and the retail food price level in the United States? If a causal relationship does exist, does it begin with monetary factors and flow to the retail food price level, or *vice versa*?

Hypothesis

A significant causal relationship exists between monetary factors whereby the money supply, interest rates, and exchange rates influence the retail food price level in the United States. It is expected that changes in the money supply, interest rates, and exchange rates will precede changes in the retail food price level, thus establishing the precedent that the monetary factors spur change in the retail food price level.

Objectives

The objectives of this study are as follows:

- Determine if a causal relationship exists between monetary factors and the retail food price level in the United States.
- 2) Determine the direction in which the causal relationship flows if one is determined to exist.
- 3) Estimate the relationship between the retail level of food prices in the United States and the money supply, interest rates, and exchange rates.

Significance of the Study

Determining whether a causal relationship exists between monetary factors and the food price level is significant for several reasons. The main reasons for which it is significant are that a) it contributes to the ongoing debate between agricultural economists concerning the relationship; b) it contributes a current analysis of the subject; c) it enriches the body of literature pertaining to the retail food price level in the United States for which there is a lack of literature available; and d) it provides valuable information to the many participants throughout the economy.

Review of the literature on the subject reveals that there is considerable debate among agricultural economists concerning whether monetary factors are responsible for changes in the price level of agricultural products (Awokuse, 2005; Barnett, Bessler, and Thompson, 1983; Barnhart, 1989; Bordo and Schwartz, 1980; Devadoss and Meyers, 1987; Frankel, 1984; Gardner, 1981; Isaac and Rapach, 1997; Lai, Hu and Fan, 2005; Lapp, 1990; Saunders, 1988; Schuh, 1974). The following study will provide additional insight to the issue for the purpose of furthering the knowledge base upon which more conclusive results will aid in assuaging the debate.

Also, the study will provide a current analysis of the subject. The majority of the previous studies concerning the subject at hand were performed prior to 1990 (Barnett, Bessler and Thompson, 1983; Barnhart, 1989; Belongia and King, 1983; Bond, 1984; Bordo, 1980; Bordo and Schwartz, 1980; Chambers and Just, 1981; Devadoss and Meyers, 1987; Frankel, 1984; Frankel and Hardouvelis, 1985; Gardner, 1981; Lapp, 1990; Orden and Fackler, 1989; Saunders, 1988; Schuh, 1974; Starleaf, 1982, Van Duyne, 1982). The current study will provide further insight into the subject and will benefit from the development of economic theory and the continual accrual of data that occurs with the passage of time. The analysis of data from a lengthier period will yield results that are more robust because they will provide a conclusion representative of observations that span various monetary regimes. A current study will also provide insight to the resurfacing of issues concerning the retail food price level in popular culture as

noted by Hanke (2008), Martin (2008), *The Economist* (2007), and *The Economist* (2011).

In addition to contributing to an ongoing debate and providing current analysis, the following study will shed light in an area that has lacked examination. With the exception of Barnett, Bessler, and Thompson (1983) and Belongia and King (1983), the remainder of the literature prepared regarding the price level of food products in the United States focused upon commodity prices (for example, refer to Barnhart, 1989; Bond, 1984; Bordo, 1980; Bordo and Schwartz, 1980; Chambers and Just, 1981; Devadoss and Meyers, 1987; Frankel, 1984; Frankel and Hardouvelis, 1985; Gardner, 1981; Lapp, 1990; Orden and Fackler, 1989; Saunders, 1988; Schuh, 1974; Starleaf, 1982, Van Duyne, 1982). Han, Jansen and Penson (1990) note that there is a significant difference in the manner in which processed manufactured goods and unprocessed commodity based goods respond to external economic changes. Because the retail food price level is reflective of goods that are both processed and unprocessed, an examination of it is necessary in order to determine whether it responds to economic change in a fashion that is reflective of processed goods, unprocessed goods, or in a fashion that is unique unto itself.

An additional reason that gives significance to the study is recognized when considering the economic agents affected by the implications of changes in monetary factors and the retail food price level. The economic agents affected by changes in monetary factors and the retail food price levels are producers and processors, consumers, investors, lenders, and policymakers. The conclusions of

the following study will benefit producers and processors because they will be able to make a more informed production decision given the monetary conditions of the time in which production decisions are made. Consumers will benefit because they will be able to make more informed consumption and budgeting decisions with respect to expectations of changes in food prices given the condition of monetary factors. Investors will find the study beneficial because they will be able to gauge the expected performance of food related enterprises given expectations relating to monetary factors of the macro economy with respect to holdings in their investment portfolios. The findings of the study will aid lenders when determining whether to extend loans because they will be able to make more informed decisions regarding the performance and payback potential of food related businesses given the state of monetary affairs. The final economic agent to be considered is the policymaker. Policymakers are responsible for making economic policies that outline the manner in which the economy functions. The results of the following study will aid the policymaker in determining how agricultural and monetary policies will affect the economy and whether those policies need to be changed in order to achieve a more desirable level of economic performance.

Outline of the Study

The following chapter will provide a review of the theoretical and empirical literature previously published. Chapter three outlines and describes the methodology used in the empirical analysis. Details of data used for the empirical

analysis are specified in the fourth chapter, while chapter five presents the results and analysis of the results. The thesis concludes with a summary of the pertinent facts, conclusions and implications based upon the results of the empirical work, and suggestions for further research.

Chapter 2

REVIEW OF LITERATURE

The literature review provides a basic overview of financial markets and the role of monetary authorities in regulating financial markets via monetary policies. It identifies and explains the primary defining characteristics of pricing in agricultural markets at both the commodity and retail levels and presents the two theoretical economic perspectives regarding the relationship between monetary factors and prices. Next, it reviews models, estimation procedures, and conclusions derived in previous studies. Lastly, it reviews the relevant economic and statistical considerations when using time series data.

Financial Markets

Prior to exploring the relationship between monetary factors and the price level it is necessary to establish an understanding of financial markets and the role that the money supply, interest rates, and exchange rates play in them. The following discussion will provide a brief overview of financial markets and the monetary factors that will be evaluated in the empirical analysis that follows.

Financial Markets: Lending and Interest Rates

Throughout the world financial markets exist to facilitate the lending of funds from those individuals with excess funds (borrowable capital) to those households and businesses that are in need of money for various purposes including financing the operations of businesses and the purchase of consumer goods such as cars, houses, education, etc. (Carbaugh, 2001; Mishkin, 2001). The borrowing of money for use by businesses and households is most commonly facilitated by the banking industry and other sources of private investment. Lenders, whether in the form of banks or private investors, charge borrowers a fee for the use of borrowed capital. The fee is an interest whose rate is a percentage of the total quantity of funds lent and is either fixed or variable (Mishkin, 2001). Generally speaking, rates of interest change over time as a function of changes in the conditions of both domestic and international economies, availability of loanable funds, levels of perceived investment risk, and expectations of inflation (Battles and Thompson, 2000; Mishkin, 2001). The fluctuations in interest rates in both the short and long terms encourage investors to seek out those investment opportunities (e.g., stocks, bonds, commodities, etc.), both domestically and abroad, that will maximize the return they receive on their investment(s).

Exchange Rates

As goods and services are exchanged across national borders and investors shift funds between investment instruments internationally, demand for foreign currencies is created (Carbaugh, 2001; Mishkin, 2001; Williamson, 2008). The

demand for foreign currencies requires a method by which the currency of one nation can be traded for the same value of another nation's currency. The system through which foreign currencies are traded is the foreign exchange market (Carbaugh, 2001). It is through the foreign exchange market that the relative price of one nation's currency is determined in relation to other nations' currencies. In the short run exchange rates are determined primarily by investor's demand for currencies of a nation in which they desire to invest. In the long run exchange rates are determined by the level of demand for international goods, which requires exchangeable currencies to purchase goods in international markets (Mishkin, 2001; Williamson, 2008).

The Role of Governing Monetary Authorities

Because of the fundamental use of money in an economy and the complex nature of the network of intermediaries in the market in which funds are lent, borrowed, and invested, the monetary systems of the United States and other developed nations are regulated and manipulated to generate an appropriate quantity of money, thus maintaining the nation's economic stability. A nation's government exists in an external fashion to the market and makes policy that outlines the behavior that is acceptable regarding the manner in which economic agents participate in the economy. Generally speaking, the U.S. federal government implements policy that allows for the provision of public goods, corrects market failures, and seeks to promote the wellbeing of the citizens of the nation (Peterson, 2001). The regulatory actions taken by the U.S. federal

government implicitly alter the allocation of national resources because the regulation of an economic system defines limits for the quantity and allowable uses of the numerous resources that exist in the economy. In regard to the monetary system of the United States, the Federal Reserve exists as the governing monetary authority for the purpose of maintaining a stable monetary and financial system (USFRB, 2005). As a means of exerting its authority on the market, the Federal Reserve imposes regulations on financial institutions, such as reserve requirements, leverage limits, underwriting standards, *etc*. Such regulations define the manner in which financial institutions may operate within the context of the greater financial system. Additionally, the Federal Reserve regulates factors of the monetary system that ensure that the proper level of monetary activity is occurring that will result in stable economic growth (USFRB, 2005).

The Federal Reserve regulates the monetary system through various mechanisms. The first mechanism is the quantity of reserves that banking institutions are required to hold, more commonly known as reserve requirements. While reserve requirements are a tool of monetary policy, they are very seldom changed and therefore are often treated as a constant when assessing the tools utilized by the Federal Reserve (Mishkin, 2001). The second and most common tool utilized in the regulation of the monetary system is Open Market Operations. Open Market Operations involve either the sale or purchase of debt securities for the purpose of sustaining the Federal Funds (interest) Rate. The Federal Funds Rate is the short term interest rate that banks charge one another on short term, generally overnight, loans (USFRB, 2005). The Open Market Operations tool is

the most commonly utilized tool in the regulation of the monetary system because of the ease with which it can be changed (Mishkin, 2001; USFRB, 2005). A third tool that is utilized is the Discount Rate. The Discount Rate is the interest rate that the Federal Reserve charges banks when borrowing directly from the Federal Reserve. Each of the tools of monetary policy utilized by the Federal Reserve is meant to change the sum of currency and reserves – known as base money – in the economy. The changes in base money then influence the overall level of the money supply in the economy.

An additional role that the Federal Reserve plays in the economy relates to the stabilization of the value of the dollar relative to foreign currencies. The value of the dollar is changed as either a primary or secondary effect, depending upon the action taken by the Federal Reserve. The value of the dollar is changed by the United States Government as a primary effect when the Federal Reserve, in conjunction with the United States Treasury, buys or sells holdings of foreign currencies (Mishkin, 2001). The value of the dollar is changed as a secondary effect when changes are made to the Federal Funds Rate for the purpose of changing the monetary base of the United States. The value of the dollar changes, *ceteris paribus*, in a direct relationship to changes in real interest rates. That is, if real interest rates increase, the value of the dollar increases as investors demand more dollars to invest in dollar assets with higher implied returns (Carbaugh, 2001).

Each sector of the economy experiences either an increase or decrease in its ability to operate given changes in the monetary system. In strict regard to the

agricultural sector, changes in the monetary base play a role in establishing the level of credit available from commercial banks to be lent to growers for business operations. The level of credit available to growers then in large part determines the amount of land, labor, and capital items they will be able to employ in the season for which they secure external financing. The amount of capital goods employed in the operation directly relates to the total size of the crop grown and harvested. The supply of the commodity harvested directly relates to the prices consumers pay for both processed and unprocessed food items at the retail level.

General Factors Affecting Price Determination

When comparing the nature of agricultural markets to that of other sectors in the economy it is observed that agricultural markets are uniquely characterized due to the nature of production and the products themselves (Cramer, Jensen and Southgate, 2001; Starleaf, 1982). The following discussion will further explore how pricing is influenced by the unique characteristics of agricultural markets.

Primary Agricultural Commodity Price Determinants

Agricultural commodity markets are uniquely characterized because they closely resemble perfectly competitive markets where producers with the objective of profit maximization operate in an environment with many buyers and sellers, minimal barriers to entry and exit, full information, and homogenous products (Carbaugh, 2001; Starleaf, 1982). In addition to the assumed near perfectly competitive nature of agricultural markets, contract length and the

nature of agricultural products cause agricultural markets to differ from other sectors of the economy (Barnhart, 1989; Belongia and King, 1983; Bordo, 1980; Devadoss and Meyers, 1987; Frankel, 1984; Lapp, 1990).

When evaluating agricultural commodity pricing through the lens of perfect competition it is recognized that the primary implication of perfect competition is that agricultural producers are price takers (Cramer, Jensen and Southgate, 2001). Thus, commodity producers are subject to the market conditions of existing supply and demand levels at harvest time, which means that there exists a high level of variation in prices. The variation in prices is termed as risk. One avenue by which producers are able to reduce their exposure to price risk caused by volatility in the marketplace is through contracting (Barnhart, 1989; Bond, 1984). It is well noted that the contract term length heavily influences the price received by growers and the flexibility of prices in agricultural markets (Belongia and King, 1983; Bordo, 1980; Devadoss and Meyers, 1987; Frankel, 1984; Orden and Fackler, 1989). It is generally observed that agricultural production occurs under relatively shorter term horizons than other sectors of the economy (Barnhart, 1989; Belongia and King, 1983; Bordo, 1980; Devadoss and Meyers, 1987; Frankel, 1984; Lapp, 1990). While short term contracts offer growers protection through a guaranteed price in the future, the short term length of commodity contracts also results in a greater degree of price flexibility in the pricing of agricultural commodities (Belongia and King, 1983; Devadoss and Meyers, 1987). The final primary consideration in the determination of agricultural commodity prices is the nature and condition of the

commodities themselves. Agricultural commodities vary in regard to their respective levels of perishability. While feed grains are relatively storable, produce products such as fresh fruits and vegetables have a relatively short shelf life (Barnett, Bessler, and Thompson, 1983). As such, the storable feed grain commodities are priced with respect to supply, demand and ability to be stored for long periods, while produce items are priced as a heavily weighted function of current supply and demand levels with a relatively low expectation of long term storability (Belongia and King, 1983).

Primary Retail Food Price Determinants

While food products at the retail level are processed products of agricultural commodities, the determinants of consumer prices differ from those at the commodity level. The primary reasons that retail price determination differs from commodity price determination are the differences in form and place utility between unprocessed and processed food products (Barnett, Bessler, and Thompson, 1983; Gómez, *et al...*, 2006). As the degree of processing increases, the level of product differentiation increases the value added in the preparation of retail food offerings (Gómez, *et al...*, 2006). As such, the characteristics of perfect competition diminish as product homogeneity decreases. An additional consideration to be made when assessing the attributes of processed retail food products is their increased storability. The increased storability of processed foods increases shelf life and thus decreases the necessity to price them at a level low enough to ensure that all of the product will be sold prior to deterioration.

Thus, the combination of storability and the value added through processing allows processed foods at the retail level to be priced at a generally higher and more stable level than their unprocessed commodity based relatives (Gómez, *et al..*, 2006).

Monetary Theory and Prices

Prior to examining the intricacies of the relationship between monetary factors and the price level of retail food products, it is necessary to examine the monetary theory that assesses the relationship between the role of money in the economy and the general price level. The two prominent theories regarding the relationship between money and the general price level are classified as the "structuralist" and the "monetarist" theories (Barnett, Bessler, and Thompson, 1983; Bordo and Schwartz, 1980).

Structuralist Theory

At the core of the structuralist perspective is the concept that changes in the supply of money are strictly accommodative to supply shocks in commodity markets (Barnett, Bessler, and Thompson, 1983; Bordo and Schwartz, 1980; Mishkin, 2001). A supply shock, generally defined as an event whereby supply of a given commodity is unexpectedly and drastically decreased (increased), results in an initial increase (decrease) in the price of the commodity and also an increase (decrease) in the price of products derived from the commodity whose supply experienced a shock (Barnett, Bessler, and Thompson, 1983; Belongia and

King, 1983). The decreased (increased) supply and subsequent increase (decrease) in price level causes the quantity demanded of the product to decrease (increase). For a structuralist, an increase in price level of the commodity due to the supply shock results in the implementation of accommodative policies by the monetary authority of the affected nation(s) (Barnett, Bessler, and Thompson, 1983; Belongia and King, 1983; Mishkin, 2001). Accommodative monetary policy is characterized as an increase (decrease) in the supply of money for the purpose of "accommodating" the increase (decrease) in the price level that was caused by the supply shock. According to the structuralist perspective, the increase (decrease) in money supply will result in a return of the relative price level to its pre-supply shock equilibrium shortly after the implementation of the policy by the nation's monetary authority (Barnett, Bessler, and Thompson, 1983; Belongia and King, 1983; Mishkin, 2001). Thus, the structuralist asserts that the causal relationship between the price level and the money supply begins with a change in the commodity price level and results in a change in the money supply.

Monetarist Theory

While structuralist theory attributes changes in the money supply to changes in the price level due to supply shocks, monetarist theory holds the opposite perspective, which contends that the general price level inflates as a result of a growing money supply. One of the primary goals of central banking is to sustain real positive economic growth (USFRB, 2005). In order to achieve continual growth and maintain full employment, growth of the money supply

must be constantly moving along an upward trend in order to ensure that money is accessible at a rate of interest that will promote the borrowing of funds for continual capital investment (Mishkin, 2001). Monetarist theory claims that the constant growth of the money supply as directed by monetary authorities is at the core of price inflation (Barnett, Bessler, and Thompson, 1983; Belongia and King, 1983; Bordo and Schwartz, 1980; Mishkin, 2001). In explaining the monetarist perspective, Barnett, Bessler, and Thompson (1983) cite the Quantity Theory of Money in support of the claim that money growth causes an increase in the price level. The theory states:

$$MV = PQ \tag{1}$$

where:

M = the money supply,

V = the rate at which currency in circulation turns over,

P = the price level, and

Q = aggregate output (GDP).

A corollary of the Quantity Theory of Money based on first differences states that:

$$m + v = p + q$$

$$where:$$

$$m = (M_{t} - M_{t-1})/M_{t-1},$$

$$v = (V_{t} - V_{t-1})/V_{t-1},$$

$$p = (P_{t} - P_{t-1})/P_{t-1}, \text{ and}$$

$$q = (Q_{t} - Q_{t-1})/Q_{t-1}.$$
(2)

Monetarists assert that although the first difference of velocity (v) may fluctuate mildly in the short run, in the long run velocity (v) is constant since an

event seldom occurs that significantly shifts the long run trend (Barnett, Bessler, and Thompson, 1983; Belongia and King, 1983; Mishkin, 2001). With the assumption that velocity (v) is constant, the first difference of the money supply (m) is the only variable remaining on the left hand side whose change will result in a change on the right side of the equation. Given the monetarist perspective, money growth is identified as the factor leading to continual economic growth, and it is also named as being the causal factor contributing to growth in the general price level (Barnett, Bessler and Thompson, 1983). Considering monetarist theory, the primary unknown when addressing money growth given the corollary of the Quantity Theory of Money and its accompanying condition of constant currency turnover is the degree to which the price level and output change given a change in the money supply.

Economic and Statistical Considerations When Using Time Series Data

The analysis of price and monetary time series data requires the acknowledgement of a variety of economic and statistical considerations in order to derive models and forecasts that are an accurate reflection of reality (Akaike, 1969; Barnett, Bessler, and Thompson, 1983; Belongia and King, 1983; Engle and Granger, 1987; Granger, 1969; Kennedy, 2003; Orden and Fackler, 1989; Studenmund, 2006; Tsay, 2002). The following discussion will examine the various economic and statistical considerations one must make when analyzing time series data.

Seasonality

Time series data is collected over a specified period of time and is stated in intervals selected by the researcher, *e.g.* weekly, monthly, quarterly, *etc*. (Kennedy, 2003; Studenmund, 2006; Tsay, 2002). Seasonality in time series data is an observable annual fluctuation pattern attributable to production cycles and changes in consumer demand caused by the changing of cultural, environmental, and agricultural seasons (Kennedy, 2003). Although it is not always necessary to do so, issues pertaining to the presence of seasonality can be addressed through adjusting the data to account for seasonal trends.

Stationarity

While seasonality must at least be acknowledged, but not necessarily adjusted for in time series datasets, the issue of stationarity must be addressed in the analysis in order to ensure that the statistical parameters – such as mean, variance, correlation, *etc.* – exhibit constancy, or, more appropriately, *stationarity*. Time series data is known to commonly exhibit nonstationary behavior because it constantly grows over time and does not have a fixed long term mean (Kennedy, 2003; Studenmund, 2006; Tsay, 2002). Macroeconomic data such as interest rates, futures prices, and exchange rates commonly exhibits nonstationary behavior because of the dynamic nature of financial markets (Kennedy, 2003). When performing an econometric analysis of time series data, the issue of nonstationarity can be identified through statistical tests and when necessary can be accounted for by data transformation (Kennedy, 2003; Studenmund, 2006).

Prior to the estimation of a model that utilizes time series data it is necessary to test for the presence of nonstationary behavior in each of the variables to be used. In order to test for nonstationary behavior one can use a variety of statistical techniques to test for the presence of a unit root (the theory behind the statistical test used to test for the presence of a unit root will be discussed later in the "Methods" section of the thesis). The presence of a unit root is indicative of non-stationary behavior, and *vice versa* (Kennedy, 2003; Studenmund, 2006).

Differencing and Co-integration

If one determines that any of the variables are nonstationary, data can either be transformed through differencing or tested for the presence of cointegrated relationships between the variables. Differencing to the first degree will generally render a nonstationary dataset stationary; however, differencing is not always necessary if the variables used are determined to be co-integrated (Kennedy, 2003; Studenmund, 2006, Tsay, 2002). The presence of co-integrated relationships between variables in a model indicates that there is a long term linear trend between the growth patterns of the variables considered (Studenmund, 2006, Tsay, 2002). If it is determined that a co-integrated relationship exists, then differencing is unnecessary and estimation of the model can occur without any transformation. A variety of tests exist for determining whether co-integrated relationships exist between variables (the theory pertaining to tests for co-integration will be discussed in the "Methods" section of the thesis).

Granger Causality

When analyzing macroeconomic events, it can be of great value to determine what events, *e.g.*, changes in interest rates, employment rates, GDP, *etc.*, cause other factors of the macro economy to change. Rather than naively assuming that variables change simultaneously given a traditional approach to regression analysis that is not capable of determining causality, the statistical theory presented by Granger (1969) provides a test for the predictability of the occurrence of one event prior to the other (Granger, 1969; Kennedy, 2003; Studenmund, 2006). The resulting relationship is known as *Granger causality*. While Granger causality does not necessarily prove economic causality, it does allow for the determination to be made as to which changes in variables regularly precede others (Granger, 1969; Kennedy, 2003; Studenmund, 2006), thus reducing the likelihood of perceived spurious causality. The theoretical considerations related to the determination of Granger Causality are discussed in greater depth in the "Methods" section of the thesis.

Regression Analysis

Regression analysis provides the researcher the ability to construct and test an empirical model relating to economic variables under consideration.

Essentially, regression analysis utilizes the Ordinary Least Squares statistical technique to estimate and describe the variation in one variable(s) – the dependent variable – as a function of the variation in another group of variables – the independent variables (Kennedy, 2003; Studenmund, 2006). The dependent

variable is a predetermined variable of interest that is expressed as a function of independent variables that are assumed to be significantly related to the dependent variable per economic theory. While regression analysis is not an indicator of causality, it is a method by which the relationship between the dependent variable and the independent variables can be quantified for the purpose of determining the direction and degree of correlation. The theoretical underpinnings of the Ordinary Least Squares method are detailed in the "Methods" section.

Empirical Modeling and Estimation in Previous Studies

Research previously conducted pertaining to the relationship between monetary factors and the price level of agricultural products offers a great deal of variation in regard to the national economies studied, the variables analyzed, and the theoretical and econometric techniques utilized. Additionally, much of the previous research focused on agricultural commodity price levels as opposed to retail food price levels. The following discussion will provide a description of variables and techniques used in previous studies that have analyzed agricultural price levels and its relationship to monetary factors. Additionally, the following discussion will also highlight the variation in views pertaining to the relationship between monetary factors and the retail food price level.

Models pertaining to the evaluation of monetary effects upon the price levels of end-use agricultural products can be classified into two categories, *1*) those pertaining to the commodity price level, and *2*) those pertaining to the retail price level. Additionally, each category can be further broken down into sub-

classifications to address the primary factors as they exist in *a*) international economies and in *b*) the United States. The first classification helps to acknowledge and explain the differences between unprocessed commodities and processed retail goods. The sub-classifications are relevant because they highlight the factors of the political economy and the level of development present in the nation(s) being evaluated. The factors of the political economy and the level of development present in the nation(s) being evaluated are important because they characterize producer and consumer behavior towards agriculturally based products (Gómez, *et al.*, 2006).

Monetary Factors and Agricultural Products Internationally

Bakucs, Bojnec, and Fertő (2007) explain the speed and degree to which agricultural commodity prices, industrial prices, and exchange rates adjusted to money supply shocks in the developing Slovenian economy. The study also sought to determine whether the three price level variables supported the theory of money neutrality in the real economy. In order to test the monthly data collected from January 1996 through June 2005, a systematic econometric approach was utilized whereby the Augmented Dickey-Fuller test (see the "Methods" section) was used to test for stationarity of variables, the Johansen co-integration test was used to test for long term relationships among variables, and a vector error correction model was used to test for responsiveness of the price variables to money supply shocks.

Bakucs, Bojnec, and Fertő (2007) reported that agricultural and industrial prices are both positively correlated to monetary shocks and also that both overshoot their respective long run equilibriums in the short run. It was also determined that the rate at which agricultural commodity prices respond to monetary shocks is much quicker than industrial prices, thus indicating that industrial prices exhibit less price flexibility than agricultural prices. The responsiveness of agricultural producer prices to monetary shocks is suspected to be the result of the combination of low transactions costs and the short term contract period of agricultural commodity sales. Also reported was the result that agricultural prices were influenced to a greater degree by changes in the exchange rate than in the money supply. The responsiveness of agricultural prices to the exchange rate is attributed to the floating exchange rate policy implemented by the Slovenian government. Finally, the analysis indicated that agricultural producer prices responded quicker in their adjustments back to the long run equilibrium than did industrial prices or exchange rates after a period characterized by overshooting.

While Bakucs, Bojnec, and Fertő (2007) evaluated monetary factors and the price level of agricultural commodities, Shahnoushi, Henneberry, and Manssori (2009) assessed the relationship between the money supply, interest rates, and the retail food price level in the Iranian economy. It was noted that the Iranian economy is heavily influenced by the global sale of its oil supply. The magnitude of the global oil market and Iran's ability to supply such a large amount to that market leads to a considerably large amount of money circulating

in the Iranian economy, thus prompting inflationary concerns. Shahnoushi, Henneberry, and Massori (2009) hypothesized that high levels of inflation and the relative instability of the Iranian government and its monetary policies over the past thirty years have contributed greatly to high levels of volatility in Iranian food prices.

Shahnoushi, Henneberry, and Manssori (2009) employed an econometric approach whereby annual data from 1976 through 2006 were tested for stationarity, co-integrating relationships, and Granger causality. The results of the study indicate that changes in money supply and interest rates Granger cause changes in food prices in the Iranian economy. It is noted that the Iranian economy is largely undeveloped relative to more advanced economies around the world. Due to the underdeveloped nature of the Iranian economy, agriculturally based productivity is purported to be highly sensitive to policy swings because it accounts for such a large portion of economic activity in the country aside from oil (Shahnoushi, Henneberry, and Manssori, 2009). Therefore, the degree to which monetary factors influence food prices in Iran may be much different than in Western economies characterized by different ideals and varying levels of social development.

Monetary Factors & Agricultural Products in the United States

Despite the findings of a causal relationship between monetary factors and agricultural products in developing international economies, there remains a question as to whether a similar relationship holds true for developed economies.

Barnhart (1989) explored the relationship between the rate of responsiveness of U.S. commodity prices and the announcement of news related to the following thirteen macroeconomic factors: money supply (M1), net free reserves, discount rate, surcharge rate, consumer price index (CPI), producer price index (PPI), industrial price index (IPI), unemployment, consumer installment credit, menu orders of durable goods, housing starts, retail sales, and the trade deficit. The data used in the empirical analysis by Barnhart (1989) was collected on a monthly basis from February 1980 through December 1984. The data was analyzed using a regression technique. The results varied depending upon the announcement considered; however, it was concluded that commodity prices were the most responsive to changes in the money supply and the discount rate (Barnhart, 1989).

Saghaian, Reed, and Marchant (2002) and Devadoss and Meyers (1987) assessed how responsive U.S. agricultural commodity prices and domestic industrial prices were to changes in the money supply, with monthly data from 1975 through 1993 and 1960 through 1985, respectively. Variables included in the studies were money supply (M1), farm price index, and the industrial price index. Their results overwhelmingly indicated that agricultural prices responded at a quicker rate to shocks in the money supply than industrial prices did.

Devadoss and Meyers (1987) noted the responsiveness of farm prices to changes in the money supply is likely due to the short contract lengths in agricultural markets and homogeneity of the products. Thus, a flexible market is created for the products in which market participants can quickly and easily buy and sell as they reorganize their investments as market information is obtained. Devadoss

and Meyers (1987) also noted that consistent monetary growth in the U.S. since World War II is a likely contributor to the benefits farmers have recognized through higher prices.

Despite the similarities in the responsiveness of commodity prices to monetary factors in developing economies and the developed United States economy, the question remains as to whether the retail food price level in the United States responded similarly to changes in monetary factors as in other economies. Gómez, *et al.*. (2006), suggest that the level of socio-economic development and the degree to which food products are processed in developed nations versus developing or underdeveloped nations may result in a food price level that responds differently to changes in monetary factors. Belongia and King (1983) examined the relationship between changes in the money supply (M1) and the retail food price level (FP) in the United States. The study sought to assess whether increases in money supply lead to an increase in commodity prices, purported to be passed on through the supply chain to the consumer at the retail level (Barnett, Bessler, and Thompson, 1983; Belongia and King, 1983; Bordo and Schwartz, 1980).

Belongia and King (1983) suggest that there are two price classifications – nominal and real – that must first be defined in order to more fully understand how and why price changes occur. The nominal price level is the price level that shifts due to exogenous determinants (*e.g.*, macroeconomic shocks – sudden, drastic changes – such as changes in unemployment, money supply, exchange rate, *etc.*). The real price level is that price level defined by changes in quantities

supplied and demanded based upon various changes in production and consumer tastes and preferences. An additional qualification Belongia and King (1983) incorporates is the Quantity Theory of Money, which holds that the variables of money velocity and output are held constant when considering the identity MV =PQ. The assumptions derived from the Quantity Theory of Money imply that changes in the money supply and price level influence one another. Thus, the implicit statement of the writing is such that nominal prices are the primary indicators of movement in retail prices. Changes in commodity prices due to changes in the money supply – a nominal price determinant – are passed on to consumers who either benefit or pay – depending upon the direction of change – for the change in price level spurred by monetary change. The changes in the price level do not necessarily affect the change in the supply or demand for the food products considered because those food prices evaluated in the consumer price index (CPI) measurements are considered to be demand inelastic (Belongia and King, 1983).

Utilizing a variable autoregressive technique, Belongia and King (1983) analyzed monthly data from 1960 through 1977. It was expected that the relative change in food prices was dependent upon the relative changes in: money supply (M1), real income, and relative wholesale food prices. Two dummy variables were also included to represent the two periods of agricultural price controls imposed under the Nixon administration. All data was lagged one year based upon macroeconomic theory suggesting that the cost of not adjusting to changes in the money supply was excessive, thus responsiveness on the part of the

consumer is quick, one year or less. The results of the empirical analysis indicate money growth and rising price levels of retail food was positively correlated at a ratio of nearly one-to-one. The authors concluded that volatility of food prices was linked to monetary policy targets.

Similarly, Barnett, Bessler, and Thompson (1983) tested for the presence of causality between the retail food portion of the consumer price index (CPI) and changes in the money supply in the United States on a monthly basis between 1970 and 1978. Utilizing Granger's test for causality, they found changes in the money supply did precede changes in the retail food price level. It was noted that though changes in the money supply were not likely to be the sole factors contributing to the change in the retail food price level, they were a significant contributing factor.¹

Despite the findings in numerous studies that monetary factors are at least partially responsible for changes in the commodity and retail food price levels, there exists a debate as to which monetary factors actually spur change. Awokuse (2005) found changes in the money supply did not affect the price level of agricultural products. Rather, he asserts that commodity prices were influenced by fluctuations in interest and exchange rates. Using similar methodologies as those studies with opposing conclusions, Belongia (1991) finds that retail food prices were not significantly affected by changes in the money supply, while Lapp

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¹ Special consideration must be given to the fact that during the 1970's monetary growth occurred at a relatively high rate (Bordo and Schwartz, 1983; Mishkin, 2001), thus giving rise to the possibility that the Granger causal relationship between the money supply and the retail food price level may be significant only in that period.

(1990) determined that changes in the money supply did not have a significant effect upon the change in commodity price level. Additionally, Saunders (1988) found that the retail food price level was significantly influenced by changes in the money supply, while the agricultural commodity price level is not. Various studies reported utilizing similar methodologies, thus highlighting the controversy among agricultural economists regarding the relationship between monetary factors and the price level of agricultural products at both the commodity and retail levels (Awokuse, 2005; Devadoss and Meyers, 1987; Frankel, 1984; Isaac and Rapach, 1997; and Saghaian, Reed, and Marchant, 2002). Isaac and Rapach (1997) also noted the likely factors contributing to the variation in findings from study to study were the intervals of time from which data was collected, the accompanying variation in economic conditions associated with each unique variable, and the lag intervals used during econometric analysis.

Summary of the Literature Review

In order to investigate the intricacies of the relationship between monetary factors and the price level of retail food products one must have a fundamental understanding of financial markets and their participants, the factors that define agricultural production and pricing, monetary and price theory, prior models pertaining to the relationship of monetary factors and prices, and econometric techniques.

Financial markets exist for the purpose of allowing for the lending and borrowing of money between lenders who have excess funds and borrowers who

are in need of funds. Aside from the providers and consumers of funds, there exists a third, external party to financial markets that provides regulatory oversight in order to ensure that financial markets operate in a manner that will promote healthy economic activity within the confines of the law. In the United States the Federal Reserve exists for the purpose of providing financial oversight through its regulatory decree over the banking system and the monetary base.

Agricultural products at the commodity and retail levels are both derived from a production system that results in the determination of prices in a fashion that is distinctly unique when compared to products produced in other sectors of the economy. The perishable nature of commodities coupled with relatively short contract terms create an environment in which prices for commodities are subject to variation given changes in external factors to production processes such as weather and economic phenomena. The processed nature of many retail food products creates an increased level of storability and also diminishes the product homogeneity that exists at the commodity level. Thus, a wider degree of pricing strategies and ranges exist at the retail level as opposed to the commodity level.

When evaluating monetary theory pertaining to the relationship of money and prices there exist two prevailing perspectives regarding the nature of the relationship, the structuralist and monetarist perspectives. Structuralists assert that increases in the price level are the result of supply shocks initiated at the commodity level. According to the structuralist, the increase in the price level results in accommodative monetary policy whereby the money supply is increased and interest rates decreased in order to minimize the negative effects of growth in

the price level. Monetarists, on the other hand, claim that loose monetary policy aimed at promoting economic growth actually exerts a negative force upon the macro economy by way of causing an increase in the price level.

An extensive body of literature in defense of both the structuralist and monetarist theories exists wherein researchers utilize similar economic principles and econometric techniques in order to arrive at varying outcomes. Much of the variation in results from one study to the next is attributable to differences in the time from which data was collected, the degree to which data was or was not transformed, and the lag intervals used during empirical testing.

Additionally, the literature expresses the various perspectives held by scholars in regard to the relationship between monetary factors and the price level of food products. The literature that exists with respect to commodity and retail price levels of food products is representative of various economies studied including those that are underdeveloped, developing, and developed.

Chapter 3

METHODS

The following chapter outlines the theoretical foundations for the general modeled relationship between monetary factors and the retail food price level while also detailing the theoretical framework for each of the statistical techniques used to establish the parameters of the data being used. The statistical techniques to be utilized include the auto and partial autocorrelation functions, the Augmented Dickey-Fuller test, and Johansen's test for co-integration, Granger's test for causality, and regression analysis. For the purpose of providing a robust examination of the data, the auto and partial autocorrelation functions were executed as a qualitative and quantitative assessment of the presence of a unit root in the individual variables while the Augmented Dickey-Fuller test provided a quantitative assessment of the data regarding the presence of a unit root. Johansen's test for co-integration was used to determine whether and to what degree co-integrated relationships exist among the variables considered. Granger's test for causality provides insight as to whether a causal relationship exists among the variables in question. Additionally, Granger's test for causality allows the researcher to define the order of causality, if it is determined to exist. Lastly, the regression analysis allows the researcher the ability to examine the

quantified level of influence that each independent variable exerts upon the dependent variable.

Theoretical Model

Prior to the econometric estimation of the relationship between the retail food price level and the monetary factors of money supply, interest rates, and exchange rates, it is necessary to establish the theoretical foundation for the hypothesized relationship. Given the information derived from previous studies and economic considerations, it is hypothesized that the United States retail food price level is a function of the money supply, interest rates, and exchange rates.

The model used herein to describe the hypothesized relationship, presented in variable autoregressive form, is based upon work by Shahnoushi, Henneberry, and Mansorri (2009), which states that the following relationship exists:

$$Y_{t} = \sum_{i=1}^{k} \Phi_{i} Y_{t-i} + \psi D_{t} + \varepsilon_{t} \qquad t = 1, 2, ..., T$$
 (3)

where:

 $Y_t = l x l$ vector of endogenous variables

 $D_t = q \times 1$ vector of exogenous terms

 $\Phi_i = l \times l$ coefficient matrix i = 1, 2, ..., T

 $\psi = l x q$ coefficient matrix, and

 $\varepsilon_t = l \ x \ l \ vector \ of innovations$

For the purpose of answering the economic question set forth at the beginning of this study l = 4, $Y_t = [FP, MS, FFR, ER]$, where FP is the retail food price level; MS is the M2 money supply, which includes fiat money in circulation,

checkable deposits, demand deposits, time deposits and savings deposits (USFRB, 2005); FFR is the Federal Funds interest rate; and ER is the United States trade weighted exchange rate. Variables for D_t were not considered in this study.

In order to answer the economic question presented herein, quarterly data from 1974 through 2007 was analyzed. Each measure of econometric analysis was performed using the EViews 4.1 econometric analysis software (Quantitative Micro Software, LLC, 2002).

Empirical Evaluation of the Retail Food Price Level and Monetary Factors

The following section details the theoretical and empirical foundations of each of the four tests utilized: auto and partial autocorrelations, the Augmented Dickey Fuller test, Johansen's test for co-integration, and Granger's test for causality.

Autocorrelation & Partial Autocorrelation Functions (ACF & PACF)

The inclusion of the autocorrelation and partial autocorrelation functions provides a quantitative and qualitative analysis of the presence of a unit root in the dataset of each individual variable. Output from the tests for autocorrelation and partial autocorrelation functions provides geometric graphs that were qualitatively analyzed to detect whether they fit the characteristic patterns of variables with a unit root. Additionally, the output provided quantitative results that were analyzed to determine whether they existed in the expected range of a variable that contains a unit root. In terms of time series analysis, autocorrelation

describes the degree to which error terms are related from one period to the next, thus providing a signal as to the level of stationarity – whether the variable holds to a long term mean – of the given variable(s) (Kennedy, 2003; Quantitative Micro Software, LLC, 2002; Studenmund, 2006; Tsay, 2002). The estimated autocorrelation of the variables considered (series *Y*) at lag order *k* is theoretically defined as (Quantitative Micro Software, LLC, 2002):

ACF:
$$\tau_{k} = \frac{\sum_{t=k+1}^{T} (Y_{t} - \overline{Y}) (Y_{t-k} - \overline{Y})}{\sum_{t=1}^{T} (Y_{t} - \overline{Y})^{2}}$$
(4)

where:

 \overline{Y} = sample mean of series Y.

If τ_l is nonzero, then series Y is said to be serially correlated to the first order and if τ_k tapers off in a geometric fashion as lag period k increases, then series Y follows a low-order autoregressive pattern. Additionally, it is noted that if τ_k moves to zero after a minimal number of lags, then it is said that series Y follows a low-order moving average pattern (Quantitative Micro Software, LLC, 2002).

Assessment of the partial autocorrelation function allows for the identification of appropriate autoregressive models and the determination of the order of the lag models (Kennedy, 2003). The partial autocorrelation of lag k is the coefficient of Y_{t-k} when Y_t is regressed against a constant Y_{t-1} , ..., Y_{t-k} and that if an autocorrelation is described by an autoregressive model of order less than k,

then at lag k the partial autocorrelation will be approximately zero. At lag order k, EViews 4.1, estimates the partial autocorrelation as follows:

PACF:
$$\Box_{k} = \begin{cases} \tau_{I} & \text{for } k = 1 \\ \tau_{k} - \sum_{j=1}^{k-1} \Box_{k-1, j} \tau_{k-j} & \text{for } k > 1 \\ 1 - \sum_{j=1}^{k-1} \Box_{k-1, j} \tau_{k-j} & \text{for } k > 1 \end{cases}$$
 (5)

where:

 τ_k = estimate of autocorrelation at lag k, and $\Box_{k,j} = \Box_{k-1, j} . \Box_k \Box_{k-1, k-j}$.

Augmented Dickey-Fuller Test (ADF)

After examining the auto and partial autocorrelation functions for each of the variables considered, each individual variable was tested for the presence of a unit root² using the Augmented Dickey-Fuller test. The statistical theoretical foundation set forth in equation (3) can be expressed in vector error correction form as follows (Shahnoushi, Henneberry, and Mansorri, 2009):

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² According to Kennedy (2003), when considering the equation $y_t = \alpha y_{t-1} + \varepsilon_t$, if $|\alpha| < 1$, then y is a level series (*i.e.*, I(0), or, more simply put, *stationary*). However, if $\alpha = 1$, then y is I(1), or *nonstationary*. Tests for stationarity, such as the Augmented Dickey Fuller Test, test for the presence of $\alpha = 1$. If $\alpha = 1$ exists, the dataset is said to contain a unit root. A unit root must be adjusted for through differencing if the variables are determined not to be co-integrated through the use of tests such as Johansen's test for co-integration. A unit root must be adjusted for through differencing if the variables considered are not co-integrated because neglecting to do so yields results that are spurious in that they falsely indicate that a meaningful relationship exists through skewed estimates of \mathbb{R}^2 , *t*-statistics, *p*-values, *etc*.

where:

ADF-1:
$$\Pi = \sum_{j=1}^{k} \Phi_j - I$$
, *I* is the identity matrix, and (7)

ADF-2:
$$\Gamma j = -\sum_{i=j+1}^{k} \Phi_i I_j$$
 (8)

Parameter Π was tested for the presence of a unit root using the Augmented Dickey-Fuller test in EViews 4.1. If the null hypothesis that P=0 cannot be rejected then it can be concluded that a unit root does exist, and *vice versa* (Shahnoushi, Henneberry, and Mansorri, 2009; Studenmund, 2006; Quantitative Micro Software, 2002).

Johansen's Test for Co-integration (JTC)

After the data was tested for the presence of a unit root, and thus nonstationarity, through the qualitative and quntitative assessments of the auto and partial autocorrelation functions, and quantitatively through the use of the Augmented Dickey-Fuller test, the variables were then tested for the presence of co-integration among variables using Johansen's test for co-integration.

Johansen's test for co-integration provides insight as to whether specific combinations of individual non-stationary variables are stationary when considered as long term linear functions (Kennedy, 2003; Studenmund, 2006). The determination of whether co-integrated equations exist allowed for the decision to be made as to how, if at all, the data needed to be transformed to render the variables stationary prior to proceeding with further statistical testing.

According to Granger's representation theorem, if the coefficient matrix Π in equation (6) is of reduced rank r < l, then $l \times r$ matrices α and β exist with rank r such that $\Pi = \alpha \beta$ ', and $B'Y_t$ is stationary, where r represents the number of cointegrated variables and vectors and l represents the number of variables – in this case, four – included in Y_t . α identifies the parameters of the vector error correction model and each β column represents a co-integrated vector whose presence negates the necessity of data transformation to render the variable stationary. Hence, the determination of the existence of co-integration can be tested by placing restrictions upon matrix Π such that the number of co-integrated relationships is represented by r. In order to test for the maximum number of co-integrated relationships, r, the following trace statistic is calculated (Engle & Granger, 1987; Granger, 1981; Quantitative Micro Software, LLC, 2002; Shahnoushi, Henneberry, and Mansorri, 2009):

JTC:
$$\lambda_{trace} = -T \sum_{i=r+l}^{k} ln(l - \lambda_i)$$
 (9)

where:

T = the number of observations, λ_i = the ith largest eigenvalue,

 H_O : Co-integration rank is r, and H_A : Co-integration rank is k.

Granger's Test for Causality (GTC)

The fourth step includes testing for the presence of causality based on variables preceding changes in the other model variables being considered. While Granger causality describes a lead/lag relationship among variables, it is not

sufficient to state that Granger causality is equivalent to economic causality. Economic theory posits that if *event M* causes *event N*, then *M* must occur prior to *N*. Granger causality only allows for the assessment of what event(s) occurs prior to another event(s) considered in the evaluation. Additionally, from an economic standpoint it is important to note that an event(s) that is determined to be statistically significant in its ability to Granger cause another event(s) is not necessarily the sole causal factor. For instance, if *event P* is determined to Granger cause *event Q*, it is possible that *events C*, *D*, *and F* were also factors of economic causality that were not considered in the econometric analysis due to time restrictions, availability of data, significance to the study, *etc*. Thus, it is vital not to assert that the burden of causality rests solely upon one singular event or small group of events considered (Shahnoushi, Henneberry, and Mansorri, 2009).

The theoretical underpinnings of the manner in which EViews 4.1 estimates the presence of Granger causality are stated in the following bivariate regression equations:

where:

 $Y_{1t} = food \ prices \ (FP),$

 Y_{2t} = monetary factors (MS, FFR, ER), and

 $D_t = 3 \times l \text{ vector of deterministic variables (MS,FFR, ER)}.$

If Wald's T- statistics for the parameters α_{2i} in equation (10) are determined to be statistically significant at the 95 percent confidence level, it can be concluded that the considered monetary factors Granger cause the price level of retail food products in the United States. Additionally, if Wald's T-statistics for the parameters β_{1i} in equation (11) are determined to be statistically significant at the 95% confidence level, it can be statistically concluded that the hypothesized economic relationship of monetary factors leading changes in food prices is true (Shahnoushi, Henneberry, and Mansorri, 2009). Per economic theory and considerations made in regard to production and processing time, a lag interval of three quarters (nine months) will be used in the analysis.

Regression Analysis: the Ordinary Least Squares Method (RA)

After determining whether the variables considered are statistically significant causal forces in terms of influencing change in one another, the final step in the empirical analysis is the regression analysis. While Granger causality allows the researcher the ability to determine whether a statistically significant lead/lag relationship exists among the variables considered, the results of the regression analysis yield an indication signifying the degree of dependency among variables and an estimate of the contribution each independent variable (*MS*, *FFR*, *ER*) makes to changes in the dependent variable (*FP*). The statistical underpinnings of regression analysis based upon the linear Ordinary Least Squares method is represented by the following (Kennedy, 2003; Mittelhammer, Judge, and Miller, 2000; Studenmund, 2006):

RA-1:
$$y_i = \alpha + \beta_1 x_{i1} + \dots + \beta_p x_{ip} + \varepsilon_i$$
 (12)

where:

 $y = dependent \ variable \ (FP)$ $x = independent \ variables \ (MS, FFR, ER)$ i = 1, ..., n, where n=3.

Equation (12) in estimated form is as follows:

RA-2:
$$\hat{\mathbf{y}}_i = \hat{\boldsymbol{\alpha}} + \hat{\mathbf{g}}_1 x_{i1} + \dots + \hat{\mathbf{g}}_p x_{ip}$$
 (13)

Summary of Methods

The econometric analysis conducted herein consists of five parts. Initially, the auto and partial autocorrelation functions will be determined and analyzed as a quantitative and qualitative approach to determining whether a unit root exists in each of the variables considered. Secondly, the Augmented Dickey-Fuller test will be performed in order to establish quantitative evidence pertaining to the presence of a unit root in each of the variables. Thirdly, Johansen's test for cointegration will be performed in order to determine whether linear combinations of the variables considered are stationary. Lastly, Granger's test for causality will be utilized for the purpose of determining whether a causal relationship exists between the retail food price level (FP) and the United States money supply (MS), Federal Funds Rate (FFR), and the trade weighted exchange rate of the United States dollar (ER). Granger's test for causality also permits the researcher the ability to determine the order of causality among the variables included in the study. All tests were performed using the student edition of EViews 4.1 econometric software from Quantitative Micro Software, LLC, 2002.

Chapter 4

DATA AND INFORMATION

Source and Nature of Data Used in the Empirical Estimation

All of the data used herein was collected from the Research and Economic Data portal of the United States Federal Reserve Bank of St. Louis. The data collected was transformed from a monthly basis to a quarterly basis using a simple average. The period studied begins in the first quarter of 1974 and terminates in the final quarter of 2007, resulting in a total of 136 observations. Data pertaining to the retail food price level (*FP*) was identified as the "Consumer Price Index for all Urban Consumers: Food," while data used for (*MS*) was "M2 Money Stock." Data for the Federal Funds Rate (*FFR*) was identified as the "Effective Federal Funds Rate," while data pertaining to the exchange rate (*ER*) was named "Trade Weighted Exchange Index: Major Currencies." None of the data used was seasonally adjusted. Additionally, after testing for stationarity and the presence of co-integrated equations among the variables, none of the data was transformed beyond the initial change from monthly data to quarterly data.

Table 1: Summary of Descriptive Statistics of Model Variables

	Retail Food Prices (FP)	M2 Money Stock (MS)	Federal Funds Rate (FFR)	Exchange Rate (ER)
Mean	129.21	3390.77	6.61	98.27
Median	134.82	3291.60	5.76	96.04
Maximum	206.26	7379.50	17.78	142.13
Minimum	53.43	863.73	1.00	73.27
Std. Dev.	42.56	1791.13	3.50	13.02
Skewness	-0.09	0.52	0.94	0.99
Kurtosis	1.91	2.32	4.05	4.02
Sum Sum Sq.	17572.33	461144.17	898.40	13365.22
Dev.	244578.62	433100110.61	1655.49	22883.05
Observations	136.00	136.00	136.00	136.00

For a graphical representation of all data, please refer to **Appendix A**.

Table 1 illustrates that each of the variables considered in the model exhibits a slightly skewed distribution compared to a standard normal distribution. The measure of skewness of -0.09 indicates that the distribution of *FP* has a slightly longer tail to the left of the mean of 129.21. The kurtosis statistic of 1.91 for *FP* indicates that the peak of the distribution is flatter than that of a normal distribution. The high standard deviation of 42.56 and the high sum of squared deviations of 244,578.62 for *FP* indicate that the values of the variable do not exist extremely close to the mean.

The skewness of 0.52 for *MS* indicates that the distribution of *MS* has a slightly longer tail to the right of the mean of 3390.77. The kurtosis of 2.32 of *MS* is indicative of a peak that is slightly flatter than that of a normal distribution. The

high standard deviation and sum of squared deviations of *MS* signify that the distribution of values in the variable is not particularly close to the mean of 3390.77.

The distributions for *FFR* and *ER* are similar in that they both show longer tails to the right of their respective means and both exhibit higher peaks than a normal distribution with measures of kurtosis at 4.05 and 4.02, respectively. Each variable has a low to moderate standard deviation and sum of squared deviations, which both indicate that the distribution of values for each variable is relatively close to their respective means.

Chapter 5

RESULTS

Autocorrelation and Partial Autocorrelation Functions

Through examination of each variable and its lags, the following autocorrelation and partial autocorrelation functions will allow for qualitative and quantitative assessments to be made of the behavior of each variable included in the study and, more specifically, will allow for expectations to be made as to what the Augmented Dickey-Fuller test will reveal about the presence of a unit root.

Table 2: ACF and PACF of Retail Food Price Level (FP) 1974:Q1 – 2007:Q4

Included observations: 136 Autocorrelation Partial Correlation Lag AC PAC Q-Stat 1 0.976 0.976 132.32 2 0.951 -0.007 259.11 3 0.928 -0.005 380.55 4 0.904 -0.004 496.82 5 0.881 -0.003 608.11 6 0.858 -0.013 714.49 7 0.836 -0.003 816.14 8 0.813 -0.021 913.02 9 0.790 -0.018 1005.2 10 0.766 -0.015 1092.6 11 0.743 -0.018 1175.5 12 0.719 -0.019 1253.7 13 0.695 -0.011 1327.4 14 0.672 -0.005 1396.9 15 0.649 -0.013 1462.2 16 0.626 -0.014 1523.5 17 0.603 -0.004 1580.8 18 0.581 0.010 1634.6 The autocorrelation function for the retail food price level (FP) indicates that there exists significant correlation among the lagged expressions of the variable. While examination of only the autocorrelation suggests that significant correlation exists beyond lag one (0.976), the partial autocorrelation function demonstrates that lag one (0.976) is responsible for subsequent correlation that is observed in the autocorrelation function. The correlation at lag one is purported to be responsible for correlation at subsequent lags since the values are near zero at each lag beyond lag one of the partial autocorrelation function. Additionally, the Q-statistic at lag one (132.32) is indicative of significant correlation at lag one only. The strong presence of correlation establishes the expectation that further testing will likely reveal that a unit root exists in FP.

Table 3: ACF and PACF of Money Supply (MS) 1974:Q1 – 2007:Q4

Included observations: 136

Autocorrelation	Partial Correlation	Lag	AC	PAC	Q-Stat
******	*****	1	0.974	0.974	131.81
*****	. .	2	0.948	-0.010	257.59
*****	.j. j	3	0.921	-0.020	377.35
*****	.j. j	4	0.895	-0.006	491.30
******	. .	5	0.869	-0.011	599.57
. *****	. .	6	0.844	-0.004	702.41
. *****	. .	7	0.818	-0.019	799.85
. *****	. .	8	0.793	-0.012	892.03
. *****	. .	9	0.768	-0.012	979.08
. *****	. .	10	0.743	-0.007	1061.2
. *****	. .	11	0.717	-0.015	1138.5
. ****	. .	12	0.692	-0.013	1211.1
. ****	. .	13	0.667	-0.021	1279.0
- * * * * *	. .	14	0.642	-0.008	1342.4
****	.j.	15	0.617	-0.018	1401.5
- ****	.j. j	16	0.593	0.000	1456.5
****	.j.	17	0.568	-0.021	1507.4
. ****	.j. j	18	0.543	-0.025	1554.3

The autocorrelation function for the money supply *(MS)* indicates that there exists significant correlation among the lagged expressions of the variable. Examination of only the autocorrelation function may suggest that significant correlation exists beyond lag one (0.974), yet the partial autocorrelation function demonstrates that lag one (0.974) is responsible for correlation in subsequent lag levels that is observed in the autocorrelation function. The correlation at lag one is responsible for correlation at subsequent lags since the values are near zero at each lag beyond lag one of the partial autocorrelation function. Also, the Q-statistic at lag one (131.81) is indicative of significant correlation at lag one only. Correlation at lag one establishes the expectation that further testing will reveal that a unit root exists in *MS*.

Table 4: ACF and PACF of Federal Funds Rate (FFR) 1974:Q1 – 2007:Q4

Included observations: 136					
Autocorrelation	Partial Correlation	Lag	AC	PAC	Q-Stat
*****	******	1	0.951	0.951	125.84
******	** .	2	0.883	-0.235	235.01
*****	. *	3	0.828	0.155	331.67
*****	* .	4	0.774	-0.086	416.91
*****	<u>.</u> j. j	5	0.722	0.024	491.69
- ****	** .	6	0.655	-0.234	553.60
. ****	. <u> .</u>	7	0.584	0.035	603.26
. ****	<u>.</u>]*	8	0.538	0.168	645.70
. ****	* .	9	0.495	-0.109	681.89
- ***	* .	10	0.439	-0.115	710.53
***	<u>.</u> j. j	11	0.383	0.041	732.54
***	. *	12	0.341	0.112	750.16
. **	* .	13	0.307	-0.095	764.56
. **	<u>.</u> j. j	14	0.273	-0.027	776.00
. **	.j. j	15	0.236	0.057	784.61
. **	. *	16	0.207	0.069	791.32
. **	. *	17	0.202	0.108	797.75
. **	* .	18	0.201	-0.059	804.17

The autocorrelation function for the Federal Funds Rate (*FFR*) indicates that significant correlation exists among the lagged expressions of *FFR*. While an evaluation of the autocorrelation function indicates that autocorrelation exists beyond lag number one (0.951), the partial autocorrelation function indicates that the autocorrelation at lag one (0.951) is likely to be most responsible for subsequent correlation that is observed in the autocorrelation function since lags beyond lag one of the partial autocorrelation function are near zero. Additionally, the Q-statistic at lag one (125.84) is the only Q-statistic indicative of significant correlation at any of the lags considered. The presence of correlation at lag one is likely to result in the Augmented Dickey-Fuller test yielding positive results for the presence of a unit root in *FFR*.

Table 5: ACF and PACF of Exchange Rate (ER) 1974:Q1 – 2007:Q4

Included observations: 136 Autocorrelation Partial Correlation Lag AC PAC Q-Stat 0.958 0.958 127.53 2 0.903 -0.168 241.83 0.846 -0.045 342.84 0.780 -0.135 429.29 0.706 -0.110 500.62 0.632 -0.016 558.24 0.557 -0.054 603.35 0.484 -0.008 637.64 0.415 0.011 663.14 0.347 -0.067 681.08 0.278 -0.055 692.72 0.209 -0.082 699.32 0.146 0.033 702.60 0.100 0.134 704.13 0.052 -0.107 704.54 704.55 0.002 -0.078 17 -0.040 0.027 704.79 18 -0.076 -0.026 705.70

The autocorrelation function for the exchange rate (*ER*) indicates that there exists significant correlation among the lagged expressions of the variable beyond the first order lag (0.958). While an assessment of the partial autocorrelation function exhibits the presence of autocorrelation beyond lag number one (0.958), the spike in correlation that occurs at lag one of the partial autocorrelation function indicates that the autocorrelation at lag one is most responsible for subsequent correlation that is observed in the autocorrelation function. Additionally, the significance of the Q-statistic (127.53) at the first order lag only, also indicates that the first order lag is likely to be responsible for any correlation recognized beyond lag one. The determination that correlation exists in both the auto and partial autocorrelation functions indicates that a unit root will likely be found to exist when the Augmented Dickey-Fuller test is performed for *ER*.

Augmented Dickey-Fuller Test Results

The Augmented Dickey-Fuller test was performed in order to quantitatively conclude whether or not a unit root exists in each of the variables examined in the study. The Augmented Dickey-Fuller test output from EViews 4.1 and interpretation of the output is stated below.³ For additional details regarding the output of the Augmented Dickey Fuller test, please refer to

Appendix B.

³ Lag lengths for each of the variables were selected automatically by EViews 4.1 based upon Akaike Information Criteria (AIC).

Table 6: ADF Test for Retail Food Price Level (FP) 1974:Q1 – 2007:Q4

Null Hypothesis: FP has a unit root

Exogenous: None

Lag Length: 9 (Automatic based on AIC, MAXLAG=12)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	2.179510	0.9930
Test critical value: 5% level	-1.943385	

^{*}MacKinnon (1996) one-sided p-values.

Test results for the retail food price level (FP) at lag length nine indicate a t-statistic of 2.17 and a p-value of 0.993. The positive t-statistic of 2.17 is not statistically different from zero and the p-value, at the 95% confidence level, indicates that one cannot reject the null hypothesis that FP has a unit root. Thus, given the quantitative precedent set forth in the results of the Augmented Dickey-Fuller test, the remainder of the econometric analysis is performed under the assumption that FP does contain a unit root.

Table 7: ADF Test for Money Supply (MS) 1974:Q1-2007:Q4

Null Hypothesis: MS has a unit root

Exogenous: None

Lag Length: 6 (Automatic based on AIC, MAXLAG=12)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	1.763027	0.9810
Test critical value: 5% level	-1.943324	

^{*}MacKinnon (1996) one-sided p-values.

Test results for the money supply (MS) at lag length six yield a positive tstatistic of 1.76 and a p-value of 0.981. The p-value, at the 95% confidence level, indicates that the t-statistic of 1.76 is not statistically different from zero.

Therefore, it is concluded that one cannot reject the null hypothesis that *MS* has a unit root. Thus, given the precedent set forth in the results of the Augmented Dickey-Fuller test, the remainder of the econometric analysis is performed under the assumption that *MS* has a unit root.

Table 8: ADF Test for Federal Funds Rate (FFR) 1974:Q1 – 2007:Q4

Null Hypothesis: FFR has a unit root

Exogenous: None

Lag Length: 7 (Automatic based on AIC, MAXLAG=12)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-0.806001	0.3650
Test critical value:		_
5% level	-1.943344	

^{*}MacKinnon (1996) one-sided p-values.

Test results pertaining to the Federal Funds Rate (*FFR*) at lag length seven yield a *t-statistic* of -0.806 and a *p-value* of 0.365. At the 95% confidence level, the *p-value* of 0.365 indicates that the *t-statistic* of -0.806 is not statistically different from zero. Therefore, the null hypothesis that *FFR* has a unit root cannot be rejected. Thus, from this point forward the econometric analysis is performed given the assumption that *FFR* does contain a unit root.

Table 9: ADF Test for Exchange Rate (*ER***) 1974:Q1 – 2007:Q4**

Null Hypothesis: ER has a unit root

Exogenous: None

Lag Length: 3 (Automatic based on AIC, MAXLAG=12)

t-Statistic	Prob.*
-0.758267	0.3861
-1.943266	
	-0.758267

^{*}MacKinnon (1996) one-sided p-values.

Test results pertaining to the exchange rate (ER) at lag length three yield a t-statistic of -0.758 and a p-value of 0.386. At the 95% confidence level, the p-value of 0.386 indicates that the t-statistic of -0.758 is not statistically different from zero. Therefore, the null hypothesis that ER has a unit root cannot be rejected. Thus, the analysis is performed given that ER does contain a unit root.

Johansen's Test for Co-integration

The determination that all four variables contain a unit root sets the precedent for cross-correlation to exist among the variables considered. As such, Johansen's test for co-integration was performed in a pairwise fashion to determine whether any of the six possible linear combinations of the variables (*FP*, *MS*, *FFR*, *ER*) exist in such a manner that each variable is rendered stationary in the long run. Johansen's test for co-integration yielded the following results:

Table 10: Johansen Test for Co-integration

			n Test for Co- on (<i>Trace Test</i>)		sen Test for Co- n (Max-Eigen Test)	
Pairwise Combination of Variables Considered	Hypothesized Number of Co-integrated Equations	Trace Statistic	Trace Test 5% Critical Value	Max- Eigen Statistic	Max-Eigen Test 5% Critical Value	Log- Likelihood
ER, FFR	0	18.03	15.41	12.91	14.07	
ER, TTR	1	5.12	3.76	5.12	3.76	-534.19
ER, FP	0	13.59	15.41	12.94	14.07	
ER, 11	1	0.66	3.76	0.66	3.76	-494.08
ER, MS	0	92.06	15.41	91.60	14.07	
EK, WIS	1	0.46	3.76	0.46	3.76	-961.90
FFR, FP	0	9.49	15.41	9.48	14.07	
11K, 11	1	0.01	3.76	0.01	3.76	-350.16
FFR, MS	0	69.63	15.41	64.83	14.07	
TTK, MS	1	4.80	3.76	4.80	3.76	-829.06
FP, MS	0	68.89	15.41	63.86	14.07	
11, MS	1	5.04	3.76	5.04	3.76	-790.38

Based upon the trace values, max-eigenvalues, and log-likelihood values for the Johansen test at the 95% confidence level, an examination of the values generated for the six pairwise combinations considered are indicative of the conclusion that there are three co-integrated equations. The three normalized co-integrated equations that render each variable stationary in the long run are as follows (standard errors in parenthesis):

Co-Int-1:
$$ER MS (14)$$

$$1.000000 = 0.014436 (0.00112)$$

Co-Int-3:
$$FP MS (16)$$
$$1.000000 = -0.046607 (0.00267)$$

Each variable is rendered stationary in the long-run when expressed in terms of the money supply, thereby supporting the theory that monetary change has a long term real effect upon the exchange rate, Federal Funds Rate, and retail food prices in the United States. Since co-integration was determined to exist, the remaining empirical tests can be performed without differencing to eliminate non-stationarity.

Granger's Test for Causality

Thus far, two primary determinations have been made, 1) that the data for FP and MS contains a unit root, and 2) that three co-integrating equations exist, each of which is a function of the money supply. The penultimate stage of the analysis will utilize Granger's test for causality.

Granger's test for causality will allow the researcher the ability to determine if a causal relationship exists, i.e., changes in monetary variables (FFR, ER, MS) cause change in retail food prices (FP). If it is determined that a causal relationship exists, Granger's test for causality will also allow for the determination to be made regarding the direction of the relationship. Essentially, Granger's test for causality will yield results that indicate what events precede following events. While Granger causality is one qualifying condition for economic causality, Granger causality and economic causality are not interchangeable terms. Thus, it cannot be concluded with absolute certainty that the results of Granger's test for causality are indicative of the sole factors of economic causality, but rather that they are contributors to economic causality (Quantitative Micro Software, LLC, 2002; Shahnoushi, Henneberry & Mansorri, 2009). The following results of Granger's test for causality support a statistical inference of causal relationships for retail food prices (FP) determined to exist. As was the case with the test for co-integration, Granger's test for causality was performed in a pairwise fashion.

Table 11: Federal Funds Rate (FFR) and Money Supply (MS) Granger Test

Pairwise Granger Causality Tests

Sample: 1974:Q1 2007:Q4

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Probability
MS does not Granger Cause FFR FFR does not Granger Cause MS	133	0.52998 2.38293	0.66251 0.07252

The pairwise Granger test for causality assessing the relationship between the Federal Funds Rate (FFR) and the money supply (MS) indicates that at the 90% confidence level the null hypothesis that the money supply (MS) does not Granger cause the Federal Funds Rate (FFR) cannot be rejected. On the other hand, at the 90% confidence level, the null hypothesis that the Federal Funds Rate (FFR) does not Granger cause the money supply (MS) can be rejected. The conclusion that the Federal Funds Rate (FFR) Granger causes the money supply (MS) is in agreement with the reality that the Federal Funds Rate (FFR) is the primary tool used in the Open Market Operations of the United States Federal Reserve to bring about change in the monetary base of the nation (USFRB, 2005).

Table 12: Money Supply (MS) and Exchange Rate (ER) Granger Test

Pairwise Granger Causality Tests

Sample: 1974:Q1 2007:Q4

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Probability
MS does not Granger Cause ER	133	3.79974	0.01197
ER does not Granger Cause MS		3.85175	0.01120

The pairwise Granger test for causality assessing the relationship between the money supply (MS) and the exchange rate (ER) revealed that at the 95%confidence level the null hypothesis that the money supply (MS) does not Granger cause the exchange rate (ER) can be rejected. At the same time, given the same confidence level, the null hypothesis that the exchange rate (ER) does not Granger cause the money supply (MS) can also be rejected. Thus, the statistical results of the test indicate bi-lateral causality because of the virtual equivalence of the likelihood of both events occurring, 1) money supply (MS) Granger causing the exchange rate (ER), and 2) the exchange rate (ER) Granger causing the money supply (MS). Therefore, economic theory must be considered to make a conclusive evaluation of the relationship. Economic theory posits that as the money supply increases, the value of a currency decreases due to the increase in supply of currency in circulation (Mishkin, 2001). The bi-lateral causality discovered herein is likely described by the dynamics implicit in the following chain of events: as the money supply increases, the value of the dollar decreases, thus increasing the demand for U.S. goods and services abroad which in turn causes an increase in the money supply (M2) in circulation in the United States as foreigners increase their consumption of U.S. goods and services, and vice versa. Therefore, while a change in the money supply may be credited with initially changing the exchange rate, the exchange rate subsequently causes a change in the money supply as dollars held by foreigners either reenter or are withdrawn from the United States economy, depending upon the direction of change of the money supply.

Table 13: Exchange Rate (ER) and Retail Food Price (FP) Granger Test

Pairwise Granger Causality Tests

Lags: 3

Sample: 1974:Q1 2007:Q4

Null Hypothesis:	Obs	F-Statistic	Probability
FP does not Granger Cause ER	133	0.76423	0.51616
ER does not Granger Cause FP		4.34526	0.00598

The results of the pairwise Granger test for causality that evaluates the relationship between the exchange rate (ER) and the retail food price level (FP)signify that at the 95% confidence level the null hypothesis that the retail food price level (FP) does not Granger cause the exchange rate (ER) cannot be rejected. On the other hand, given the same confidence level, the null hypothesis that the exchange rate (ER) does not Granger cause the retail food price level (FP)can be rejected. Thus, it can be concluded that changes in the exchange rate (ER) lead changes in the retail food price level (FP). The conclusion that the exchange rate (ER) Granger causes the retail food price level (FP) is consistent with economic theory as it is expected that an increase in the value of the dollar relative to the value of a foreign currency will decrease the quantity demanded of United States food products abroad, subsequently causing an increase in the domestic supply of food products in the United States, thus resulting in a decline in the price of United States food products, and vice versa. Regardless of the direction of change of the exchange rate (ER) relative to a foreign currency, economically speaking, it is expected that the prices of United States food products (FP) will likely change as a result.

Table 14: Money Supply (MS) and Retail Food Price (FP) Granger Test

Pairwise Granger Causality Tests

Sample: 1974:Q1 2007:Q4

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Probability
MS does not Granger Cause FP	133	3.13655	0.02786
FP does not Granger Cause MS		0.25168	0.86002

The results of the pairwise Granger test for causality examining the United States money supply (*MS*) and the retail food price level (*FP*) indicate that at the 95% confidence level the null hypothesis that *MS* does not Granger cause *FP* can be rejected, while given the same confidence level one must not reject the null hypothesis that *FP* does not Granger cause *MS*. Thus, it can be concluded that during the period under examination, *MS* Granger causes *FP*. While the results of the test do not prove absolute economic causality, the results set the precedent for the existence of economic causality whereby changes in *MS* lead changes in *FP*.

Regression Analysis Results

Per economic theory, it is expected that the various lagged combinations of FP = f(MS, FFR, ER) considered herein will yield estimated models with the following signs: +MS, +FFR, -ER. The money supply (MS) is expected to have a positive relationship with food prices (FP) as monetary growth(contraction) increases(decreases) the price level due to more(fewer) dollars being available to purchase limited goods. The Federal Funds Rate (FFR) is expected to have a positive relationship with food prices because as FFR increases, costs of capital

increase, which translates into processors passing along increased costs in the form of higher prices to consumers at the retail level. The exchange rate (*ER*) is expected to have a negative relationship with retail food prices (*FP*) because as the exchange rate decreases (increases) the demand for U.S. products increases (decreases) which results in more (fewer) dollars seeking after a limited number of goods, thus increasing (decreasing) the price level.

Regression analyses performed herein were assessed at lag intervals of one (-1), two (-2), three (-3), and four (-4) for all independent variables with all intervals being expressed in quarterly terms. The lag intervals were chosen based upon the production cycles of agricultural products. For example, a lettuce crop requiring 90 to 120 days growing in a coastal climate where multiple harvests can be anticipated throughout the year sets the precedent for a minimum lag length of one (-1) quarter. On the other hand, a permanent planting of a crop, such as apples, with one harvest per year sets the precedent for a maximum lag length of four (-4) quarters. Of the lag combinations of independent variables regressed against the dependent variable – retail food prices (FP) – the optimal model that was generated is as follows (Please refer to **Appendix D** for test results of all combinations tested):

RA-3:
$$FP = f(MS(-4), FFR(-4), ER(-4))$$
 (17)

Table 15: Regression Results

Dependent Variable: FP Method: Least Squares Date: 12/11/11 Time: 20:15 Sample(adjusted): 1975:1 2007:4

Included observations: 132 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
С	63.82580	7.822775	8.158971	0.0000
MS(-4)	0.024264	0.000623	38.97107	0.0000
FFR(-4)	0.704584	0.286641	2.458074	0.0153
ER(-4)	-0.166916	0.066866	-2.496293	0.0138
R-squared	0.956362	Mean deper	ndent var	131.4538
Adjusted R-squared	0.955340	S.D. depend	dent var	41.16086
S.E. of regression	8.698528	Akaike info	criterion	7.194019
Sum squared resid	9685.042	Schwarz cri	terion	7.281377
Log likelihood	-470.8053	F-statistic		935.0822
Durbin-Watson stat	0.019358	Prob(F-stati	stic)	0.000000

The estimation of the relationship FP = f(MS(-4), FFR(-4), ER(-4)), is as follows:

RA-4:
$$\vec{FF} = 63.83 + 0.024MS + 0.705FFR - 0.167ER$$
 (18)

Therefore, *ceteris paribus*, a 0.024 percent change in the level of the money supply will result in a one percent change in the United States retail food price level (*FP*). Additionally, a 0.705 percent change in the Federal Funds Rate (*FFR*) will result in a one percent change in the United States retail food price level (*FP*), *ceteris paribus*. Lastly, a -0.167 percent change in the United States trade weighted exchange rate (*ER*), will result in a one percent change in the United States retail food price level, *ceteris paribus*.

Per monetarist economic theory, the positive correlation between the money supply (MS) and retail food prices (FP) is expected because as the money supply rises, inflationary tendencies are exacerbated, and vice versa.

Additionally, the positive correlation between the Federal Funds Rate (FFR) and

the retail food price level (*FP*) is expected as an increase in the Federal Funds
Rate (*FFR*) leads to an increase in the cost of capital production of retail food
products, which translates into higher prices at the retail level, and *vice versa*.

The negative correlation among the exchange rate (*ER*) and the retail food price
level (*FP*) is also expected because as the dollar increases in value products from
the United States become more expensive in international markets. Thus,
international consumption of goods from the United States declines which leads
to an increased supply in the United States that drives prices downward, and *vice versa*.

Based upon an F-statistic that is statistically significant at the 95% confidence level and an adjusted R^2 of 0.96, the model as a whole satisfactorily explains the variation in retail food prices. While the model as a whole may satisfactorily explain the variation in retail food prices when assessing the R^2 figures, the strength of that figure lies in question when other critical statistics are analyzed. The Durbin-Watson statistic near zero indicates that there is a high degree of correlation among the independent variables considered. As such, the R^2 may overstate the ability of the model to satisfactorily explain the variation in retail food prices (FP). Also, the Akaike Information Criterion and Schwarz Criterion values of 7.19 and 7.28, respectively, indicate that the variables considered do not fully explain the variation in the dependent variable (FP). Monetary variables were the focus of this study and it can be concluded that they are causal factors in the variation of retail food prices (FP) in the United States. However, in order to fully model the variation in retail food prices (FP),

additional factors must be considered and included in the model in order for inferences to be made accurately.

Summary of Results

The results of the study included an analysis of the auto and partial autocorrelation functions, the Augmented Dickey-Fuller test, Johansen's test for co-integration, and Granger's test for causality. Additionally, regression analyses were performed at various lag intervals to determine the most optimal estimation of the relationship presented herein. Of the combinations tested, the most optimal estimation of the relationship is expressed as FP = f(MS(-4), FFR(-4), ER(-4)).

An assessment of the autocorrelation and partial autocorrelation functions indicated that further quantitative testing would likely confirm that a unit root exists in each of the variables considered. Analysis of the Augmented Dickey-Fuller test results revealed that all four variables contained a unit root. Johansen's test for co-integration indicated that three co-integrated equations exist that render stationary each variable in the long run. Granger's test for causality yielded the results that the Federal Funds Rate (*FFR*) Granger causes the money supply (*MS*). The statistical results of the Granger test for causality between the money supply (*MS*) and the exchange rate (*ER*) indicated bi-lateral causality and when viewed through the lens of economic theory, it is likely that the money supply (*MS*) is the instigating factor of change in the relationship between the money supply (*MS*) and the exchange rate (*ER*). Granger's test for causality also revealed that the money supply (*MS*) and the exchange rate (*ER*) are both statistically significant

causal factors that lead changes in the retail food price level (*FP*) in the United Sates. While Granger causality was determined to exist among the variables considered, Granger causality only sets a partial precedence for the existence economic causality. As such, those factors that were determined to exert causality can only be firmly concluded to be one factor among various others that result in economic causality.

Lastly, the regression analysis of the model FP = f(MS(-4), FFR(-4), ER(-4))4)) indicated that there exists positive correlation between retail food prices (FP) and the money supply (MS) and the Federal Funds Rate (FFR), while negative correlation was determined to exist between retail food prices (FP) and the exchange rate (ER). While FP = f(MS(-4), FFR(-4), ER(-4)) yielded an estimated equation with a statistically significant adjusted R^2 figure and F-statistic, an evaluation of additional test statistics indicated that the model does adequately identify all factors that contribute to variation in retail food prices (FP). The near zero Durbin-Watson statistic for the model indicated that a high level of correlation exists among the variables considered to such an extent that the values of goodness of fit for the model may be inflated. Thus the ability to make sound inferences based upon the model is limited. The Akaike Information Criterion, and Schwarz Criterion of the model indicate that the model does explain variation in the level of retail food prices (FP), however, the high values indicate that the variables considered are not the sole factors in explaining the variation in the retail food price level (FP).

Chapter 6

CONCLUSIONS

Summary

Recent economic events pertaining to monetary factors and the prices of food products both domestically and abroad have rekindled the debate as to if and how monetary factors and the prices of food products are related (*The Economist*, 2007; *The Economist*, 2011). The preceding study was conducted as a means to provide a current analysis of the topic, thus providing insight by contributing to the existing body of literature. Review of the existing body of literature revealed that two predominant perspectives exist that attempt to explain the relationship between monetary factors and food prices, the Structuralist and the Monetarist perspectives. The structuralist perspective holds that supply shocks in commodities markets and the subsequent increase in the price level cause monetary authorities to increase the money supply of a nation in order to decrease the relative price level to pre-supply shock levels. The monetarist perspective holds that the goal of monetary authorities in a nation to sustain economic growth results in the growth of the price level in the nation being directly related to the changes in money supply which are viewed by the monetary authority as necessary to sustain economic growth.

The preceding analysis was conducted to test the structuralist and monetarist theories regarding the presence of causality as it pertains to the price level of retail food products and the monetary factors of money supply, interest rates, and exchange rates in the United States. After an analysis of previous studies in which a similar examination was performed, it was determined that there exist mixed statistical results regarding the relationship in question. Much of the variation in results is attributed to the variation in world economies studied, time periods studied, monetary factors examined, and statistical parameters used in testing the various hypotheses. Based upon economic theory and conclusions derived from the literature review, the hypothesis was established for this thesis that the monetary factors of money supply, interest rates, and exchange rates are statistically and economically significant causal forces contributing to the variation in retail food prices in the United States.

In order to test the hypothesis, a testing procedure similar to that presented in previous studies was used. Data used for each of the variables in the statistical analysis was obtained from the Federal Reserve Bank of St. Louis where "Consumer Price Index for all Urban Consumers: Food," "M2 Money Stock," "Effective Federal Funds Rate," and "Trade Weighted Exchange Index: Major Currencies" where used to represent the retail food price level, money supply, interest rate, and exchange rate, respectively. For the purpose of testing the hypothesis, a similar statistical methodology as that utilized by Shahnoushi, Henneberry & Manssori (2009) was employed. Statistical testing of the hypothesized relationship began with estimation of the autocorrelation and partial

autocorrelation functions, and then proceeded with the Augmented Dickey-Fuller test for the presence of a unit root in each variable. Thirdly, Johansen's test for co-integration was used to determine whether or not linear combinations of the variables exist in such a manner as to render stationary those variables that were determined to contain unit roots per the results of the Augmented Dickey-Fuller test. The fourth test, Granger's test for causality, provided information that would allow for the determination to be made as to whether or not there exists a statistically significant causal relationship among the variables considered. Additionally, Granger's test for causality provides an indication as to the order of causality among the variables considered. Lastly, regression analyses were performed for the purposes of verifying correlation and estimating the degree to which each independent variable contributes to variation in the dependent variable.

Upon conclusion of the statistical testing, it was determined that a significant relationship does indeed exist among the variables considered. An analysis of the autocorrelation and partial autocorrelation functions established the expectation that each variable would contain a unit root with further statistical testing. The results of the Augmented Dickey-Fuller test proved to support the expectations set forth in the evaluation of the autocorrelation and partial autocorrelation functions that each variable contained a unit root.

Johansen's test for co-integration yielded three equations that rendered each variable stationary in the long run. Granger's test for causality indicated that a significant causal relationship does exist among the variables considered.

Specifically, the results indicated that the Federal Funds Rate (*FFR*) is a causal factor that leads changes in the United States money supply (*MS*). Granger's test for causality also indicated that the money supply (*MS*) and exchange rate (*ER*) are statistically significant causal factors in changes in one another. Statistically speaking, the results of Granger's test for causality between the money supply (*MS*) and the exchange rate (*ER*) were causal in a bi-lateral manner. When viewed through the lens of monetary economic theory; it is likely that the money supply is the instigator of change between the back-and-forth causal relationships between the two variables. Additionally, Granger's test for causality revealed that change in the exchange rate (*ER*) and the money supply (*MS*) lead changes in the retail food price level (*FP*) in the United States during the period examined. While the presence of Granger causality does not allow for the conclusion that economic causality exists with absolute certainty, it empirically establishes the precedent that economic causality is likely to exist.

Lastly, the regression analysis performed indicated that positive correlation exists between retail food prices and the two independent variables money supply (MS) and Federal Funds Rate (FFR), while the exchange rate (ER) was determined to be negatively correlated to retail food prices (FP). The adjusted R^2 and F-statistics indicated that the model as a whole provides a statistically significant explanation of the variation in United States retail food prices (FP). While R^2 values were indicative of a good fit for the model as a wholes, a near zero Durbin-Watson statistic indicates that high levels of correlation exist among the independent variables considered. Additionally,

positive mid to high range Akaike Information Criterion and Schwarz Criterion signify that additional independent variables are necessary to more fully describe why change occurs in the retail food price level.

The hypothesis at the beginning of the thesis stated that the monetary factors evaluated herein (MS, FFR, ER) would prove to be causal factors contributing to the variation of the retail food price level (FP) in the United States. Of the three monetary factors examined herein, two – money supply (MS) and the exchange rate (ER) – were determined to be related in a statistically significant causal manner to changes in the retail food price level (FP) in the United States, while the third – Federal Funds Rate (FFR) – was determined to be a secondary causal factor related to the changes in the retail food price level (FP) because of its primary causal relationship to the money supply (MS).

The regression analyses performed also confirmed that correlation exists among retail food prices (*FP*) and the monetary factors evaluated herein. While each of the monetary variables considered is significant in explaining the variation in food prices, the money supply (MS) stands out as the most prominent of the factors considered. The fact that each variable in the study was rendered stationary by the money supply (*MS*) per Johansen's test for co-integration and that the money supply (*MS*) was the most statistically significant variable in each of the regression models indicates that monetary growth is a significant contributor to changes in the price level of retail food products.

<u>Implications of the Results</u>

The conclusion that causality exists whereby changes in the Federal Funds Rate (*FFR*) lead changes in the money supply (*MS*), changes in the money supply (*MS*) lead changes in the exchange rate (*ER*), and changes in the exchange rate (*ER*) and the money supply (*MS*) lead changes in the retail food price level (*FP*) in the United States have implications that reach throughout the economy. The following groups are specifically affected by the results of the test: agricultural producers and processors, consumers, investors, lenders, and policymakers.

Based upon the variables considered and the results presented herein, producers and processors of retail food products should consider monetary factors such as the money supply, interest rates, and the exchange rates when making production decisions. Aside from having implications regarding the price of borrowing funds for the financing of an agricultural business, changes in interest rates will affect the level of the money supply. Producers and processors of retail food products will benefit from an increase in the money supply as prices increase following the increase of the money supply, and *vice versa*. Additionally, producers and processors of retail food products will benefit from a weak dollar exchange rate which results in higher prices spurred by an increase in the quantity of food products demanded in the international food economy.

Variation in interest rates and the subsequent changes in the monetary factors of money supply and exchange rate also have potential implications as to how consumers budget for and allocate personal funds towards the purchase of retail food products. The potential impact that price changes in retail food

products due to changes in monetary factors has upon consumers is dependent upon the elasticity of demand for the product in consideration. For the purposes of this study the elasticity of demand for the products that comprise the food portion of the consumer price index were assumed to be demand inelastic. As such, changes in retail food prices would not necessarily change the basket of goods purchased by consumers at the retail level. However, what would change from the consumer standpoint is the amount of money that remains after food purchases that is to be allocated towards other uses. When retail food prices rise consumers have fewer dollars to spend after purchasing food products when working within the confines of one's available funds, and *vice versa*. Therefore, during times of an increased money supply and a weak dollar, prices are likely to increase, thus leaving consumers with fewer dollars after food purchases, and *vice versa*.

The results of the study also influence the decisions of those who invest or lend money to agricultural producers and processors. To begin, in addition to influencing change in the money supply, changes in the Federal Funds Rate also influence the price of borrowing funds (Mishkin, 2001). As such, a change in the Federal Funds Rate can make it either more costly or less expensive for producers and processors to borrow funds for the financing of their operations, depending upon the direction of change. Additionally, the ability of agricultural producers and processors to be profitable and, thus, be able to offer consistent returns to investors or payback lenders is directly related to the prices they earn for their products in the marketplace. As such, given the results of this study, investors

and lenders must not neglect the current and expected levels of the money supply and exchange rate as they will both influence the performance of agricultural companies. During times of loose monetary policy and a weak dollar, investors and lenders can expect that the ability of agricultural producers and processors to pay will be satisfactory, and *vice versa*. Thus, among other market factors, investors and lenders must carefully weigh the expected state of monetary affairs over the life of their investment in an agricultural firm.

The final group to consider when evaluating the implications of the results stated herein is the policymakers. Policymakers have the duty of establishing laws that act as the parameters in which the economy functions, thus assuring that there is some level of equity regarding the manner in which public and private resources are allocated. Given the results of this study that the Federal Funds Rate influences change in the money supply and that the money supply and the exchange rate in turn influence changes in retail food prices in the United States, monetary policymakers at the United States Federal Reserve and the United States Treasury must set policy so as not to artificially contort markets in such a manner that favors participants in one sector of the economy while damaging participants in other sectors both at the domestic and international levels. From an agricultural standpoint, policymakers must be aware of the dynamics of current and projected monetary affairs so as to ensure that agricultural policies are established in a manner that does not encourage producers to over or under produce given the manner in which current and projected monetary policies are expected to influence prices.

As demonstrated herein, the results of this study have implications that reach throughout the economy from producers to lenders, investors, consumers and policymakers. The monetary and agricultural factors studied must be weighed as significant factors among the many that are considered by each group as they make decisions as participants in the agricultural economy.

Suggestions for Further Research

Two avenues for further research related to the topic presented herein present themselves as demanding further investigation: *1*) evaluating the demand elasticity of the food products that make up the food portion of the consumer price index, and *2*) evaluating whether an interest rate other than the Federal Funds Rate has a significant causal relationship that *directly* influences the price level of retail food products.

As a topic for future study, it is suggested that the price elasticities of the food products included in the food portion of the consumer price index be evaluated. The demand elasticities of the products considered will directly influence pricing decisions made by producers and retailers, and consumption decisions made by consumers. If the retail food products are demand inelastic then producers have the ability to sustain high prices and/or increase them without the result of a decrease in the volume of product sold. Given a demand inelastic scenario whereby retail food producers keep prices relatively high, consumers lose as they are left with fewer dollars after making food purchases. On the other hand, if the products are determined to be demand elastic, then producers must be

more sensitive to market dynamics when pricing their retail food products in order to ensure that their customer base is retained. Given a demand elastic scenario, consumers are more likely to benefit in terms of retaining dollars after food purchases due to the sensitivity producers must show to market dynamics, including consumer behavior, when pricing items.

The final suggestion for further research is to conduct the previous study using a different interest rate in order to determine whether or not an alternative interest rate yields an outcome that differs from the one presented herein.

Alternative interest rates to be considered include the interest rate on United States Treasury bills (one, three, six or twelve month rate), bank prime rate, corporate bond rates, *etc*. The significance in testing different rates of interest is due to the variability in economic conditions and expectations that each of the various rates captures, such as time, economic agents affected, and other terms of the debt instrument to which the rate of interest is applied.

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APPENDIX A: Graphical Representation of Data

Figure A-1: "CPI for all Urban Consumers: Food" (Q1 1974 – Q4 2007)

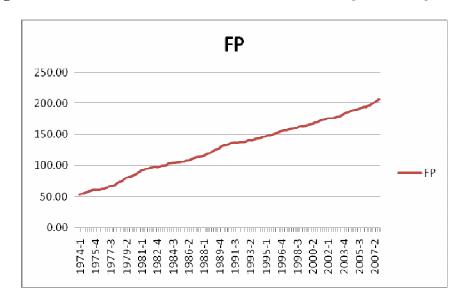


Figure A-2: United States "M2 Money Stock" (Q1 1974 – Q4 2007)

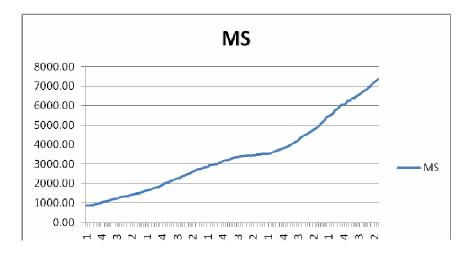


Figure A-3: United States Effective Federal Funds Rate (Q1 1974 – Q4 2007)

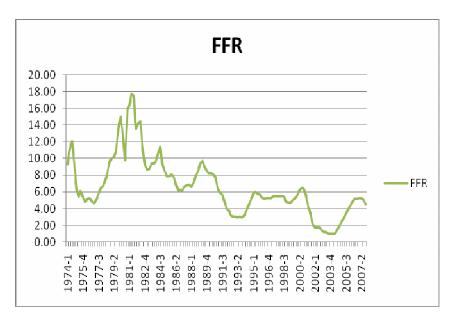
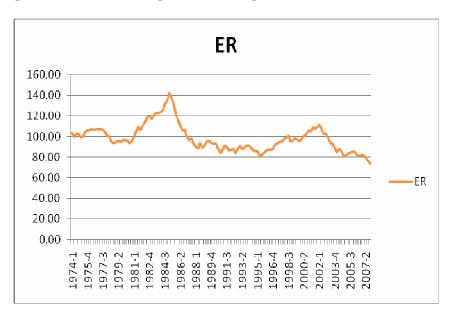


Figure A-4: Trade Weighted Exchange Index (Q1 1974 – Q4 2007)



APPENDIX B: Additional Augmented Dickey-Fuller Test Output

Figure B-1: Retail Food Price Level ADF Output

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(FP) Method: Least Squares

Sample(adjusted): 1976:3 2007:4

Included observations: 126 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FP(-1)	0.002414	0.001108	2.179510	0.0313
D(FP(-1))	0.250748	0.091829	2.730593	0.0073
D(FP(-2))	0.099758	0.091005	1.096187	0.2753
D(FP(-3))	0.180977	0.091465	1.978647	0.0502
D(FP(-4))	0.263894	0.092715	2.846287	0.0052
D(FP(-5))	-0.166460	0.094847	-1.755037	0.0819
D(FP(-6))	0.004676	0.092834	0.050367	0.9599
D(FP(-7))	-0.042860	0.092015	-0.465796	0.6422
D(FP(-8))	0.281536	0.091709	3.069891	0.0027
D(FP(-9))	-0.157520	0.092815	-1.697152	0.0923
R-squared	0.223854	Mean deper	ndent var	1.149939
Adjusted R-squared	0.163636	S.D. depend	dent var	0.786081
S.E. of regression	0.718894	Akaike info	criterion	2.253833
Sum squared resid	59.94981	Schwarz criterion		2.478935
Log likelihood	-131.9915	Durbin-Wats	son stat	1.988068

Figure B-2: Money Supply ADF Output

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(MS) Method: Least Squares

Sample(adjusted): 1975:4 2007:4

Included observations: 129 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MS(-1)	0.002863	0.001624	1.763027	0.0804
D(MS(-1))	0.253150	0.085543	2.959321	0.0037
D(MS(-2))	0.051695	0.089098	0.580204	0.5628
D(MS(-3))	0.019344	0.088980	0.217399	0.8283
D(MS(-4))	0.235387	0.088765	2.651802	0.0091
D(MS(-5))	-0.094536	0.092209	-1.025228	0.3073
D(MS(-6))	0.358032	0.090064	3.975291	0.0001
R-squared	0.541826	Mean dependent var		49.58140
Adjusted R-squared	0.519292	S.D. depend	dent var	33.52213
S.E. of regression	23.24193	Akaike info	criterion	9.182529
Sum squared resid	65902.83	Schwarz cri	terion	9.337712
Log likelihood	-585.2731	Durbin-Wats	son stat	1.936722

Figure B-3: Federal Funds Rate ADF Output

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(FFR) Method: Least Squares

Sample(adjusted): 1976:1 2007:4

Included observations: 128 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FFR(-1)	-0.009026	0.011199	-0.806001	0.4218
D(FFR(-1))	0.218455	0.088828	2.459290	0.0153
D(FFR(-2))	-0.171917	0.090815	-1.893045	0.0608
D(FFR(-3))	0.191143	0.089404	2.137971	0.0345
D(FFR(-4))	-0.077050	0.089629	-0.859654	0.3917
D(FFR(-5))	0.206252	0.087070	2.368809	0.0194
D(FFR(-6))	-0.024420	0.086643	-0.281848	0.7785
D(FFR(-7))	-0.197369	0.083193	-2.372417	0.0193
R-squared	0.181876	Mean deper	ndent var	-0.007161
Adjusted R-squared	0.134152	S.D. depend	dent var	0.995915
S.E. of regression	0.926708	Akaike info	criterion	2.746106
Sum squared resid	103.0546	Schwarz cri	terion	2.924358
Log likelihood	-167.7508	Durbin-Wats	son stat	1.968875

Figure B-4: Exchange Rate ADF Output

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(ER) Method: Least Squares

Sample(adjusted): 1975:1 2007:4

Included observations: 132 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ER(-1)	-0.001927	0.002541	-0.758267	0.4497
D(ER(-1))	0.327621	0.086559	3.784949	0.0002
D(ER(-2))	-0.077234	0.090311	-0.855204	0.3940
D(ER(-3))	0.208394	0.085726	2.430935	0.0164
R-squared	0.142771	Mean deper	ndent var	-0.220011
Adjusted R-squared	0.122680	S.D. depend	dent var	3.089843
S.E. of regression	2.894113	Akaike info	criterion	4.993069
Sum squared resid	1072.114	Schwarz cri	terion	5.080426
Log likelihood	-325.5425	Durbin-Wats	son stat	2.003996

APPENDIX C: Additional Johansen Test for Co-integration Test Results

Figure C-1: JTC for Exchange Rate (ER) and Federal Funds Rate (FFR)

Sample(adjusted): 1974:Q2 2007:Q4

Included observations: 135 after adjusting endpoints Trend assumption: Linear deterministic trend

Series: ER FFR

Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test

Hypothesized	Eigenvalue	Trace	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None *	0.091199	18.02530	15.41	20.04
At most 1 *	0.037183	5.115362	3.76	6.65

 $^{^{\}star(\star\star)}$ denotes rejection of the hypothesis at the 5%(1%) level Trace test indicates 2 cointegrating equation(s) at the 5% level

Trace test indicates no cointegration at the 1% level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.091199	12.90994	14.07	18.63
At most 1 *	0.037183	5.115362	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

ER	FFR
-0.025773	0.306958
0.079722	-0.019904

Unrestricted Adjustment Coefficients (alpha):

1 Cointegrating Equation(s): Log likelihood -534.1902

Normalized cointegrating coefficients (std.err. in parentheses)

ER FFR 1.000000 -11.90996 (3.03695)

Adjustment coefficients (std.err. in parentheses)

D(ER) -0.021687 (0.00660) D(FFR) 0.002768 (0.00233)

Figure C-2: JTC for Exchange Rate (ER) and Retail Food Price (FP)

Sample(adjusted): 1974:Q2 2007:Q4

Included observations: 135 after adjusting endpoints

Trend assumption: Linear deterministic trend

Series: ER FP

Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test

Hypothesized	Eigenvalue	Trace	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None	0.091401	13.59536	15.41	20.04
At most 1	0.004843	0.655457	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Trace test indicates no cointegration at both 5% and 1% levels

Hypothesized	Eigenvalue	Max-Eigen	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None	0.091401	12.93991	14.07	18.63
At most 1	0.004843	0.655457	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

ER	FP
0.088627	0.013832
-0.003306	0.023287

Unrestricted Adjustment Coefficients (alpha):

D(ER)	-0.343291	-0.198537	
D(FP)	-0.221181	0.018366	

1 Cointegrating Equation(s): Log likelihood -494.0837

Normalized cointegrating coefficients (std.err. in parentheses)

ER FP 1.000000 0.156066 (0.07338)

(0.07338)

Adjustment coefficients (std.err. in parentheses)

D(ER) -0.030425 (0.02345) D(FP) -0.019603 (0.00573)

Figure C-3: JTC for Exchange Rate (ER) and Money Supply (MS)

Sample(adjusted): 1974:Q2 2007:Q4

Included observations: 135 after adjusting endpoints

Trend assumption: Linear deterministic trend

Series: ER MS

Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test

Hypothesized	Eigenvalue	Trace	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None **	0.492633	92.06106	15.41	20.04
At most 1	0.003408	0.460867	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels

Hypothesized	Eigenvalue	Max-Eigen	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None **	0.492633	91.60020	14.07	18.63
At most 1	0.003408	0.460867	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

ER	MS
0.044682	0.000645
0.076241	-2.46E-05

Unrestricted Adjustment Coefficients (alpha):

D(ER)	-0.528014	-0.173783	
D(MS)	22.82452	-0.415909	

1 Cointegrating Equation(s): Log likelihood -961.9020

Normalized cointegrating coefficients (std.err. in parentheses)

ER MS 1.000000 0.014436 (0.00112)

Adjustment coefficients (std.err. in parentheses)

D(ER) -0.023593 (0.01172) D(MS) 1.019844 (0.09389)

Figure C-4: JTC for Federal Funds Rate (FFR) and Retail Food Price (FP)

Sample(adjusted): 1974:Q2 2007:Q4

Included observations: 135 after adjusting endpoints

Trend assumption: Linear deterministic trend

Series: FFR FP

Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test

Hypothesized	Eigenvalue	Trace	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None	0.067792	9.487406	15.41	20.04
At most 1	7.81E-05	0.010542	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Trace test indicates no cointegration at both 5% and 1% levels

Hypothesized	Eigenvalue	Max-Eigen	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None	0.067792	9.476864	14.07	18.63
At most 1	7.81E-05	0.010542	3.76	6.65

Log likelihood

-350.1617

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

FFR	FP
0.360299	0.019173
-0.013894	0.023065

Unrestricted Adjustment Coefficients (alpha):

D(FFR)	-0.203989	0.006180
D(FP)	0.116673	0.005617

1 Cointegrating Equation(s):

Normalized cointegrating coefficients (std.err. in parentheses)

FFR FΡ 1.000000 0.053215

(0.02123)

Adjustment coefficients (std.err. in parentheses)

D(FFR) -0.073497

(0.03218)

D(FP) 0.042037

(0.02402)

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Figure C-5: JTC for Federal Funds Rate (FFR) and Money Supply (MS)

Sample(adjusted): 1974:Q2 2007:Q4

Included observations: 135 after adjusting endpoints

Trend assumption: Linear deterministic trend

Series: FFR MS

Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test

Hypothesized	Eigenvalue	Trace	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None **	0.381324	69.62808	15.41	20.04
At most 1 *	0.034964	4.804658	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Trace test indicates 2 cointegrating equation(s) at the 5% level

Trace test indicates 1 cointegrating equation(s) at the 1% level

Hypothesized	Eigenvalue	Max-Eigen	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None **	0.381324	64.82342	14.07	18.63
At most 1 *	0.034964	4.804658	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Max-eigenvalue test indicates 2 cointegrating equation(s) at the 5% level

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 1% level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

FFR	MS
0.073232	0.000651
0.364955	0.000353

Unrestricted Adjustment Coefficients (alpha):

Log likelihood

-829.0593

Normalized cointegrating coefficients (std.err. in parentheses)

FFR MS 1.000000 0.008891 (0.00086)

1 Cointegrating Equation(s):

Adjustment coefficients (std.err. in parentheses)

D(FFR) -0.001798

(0.00667) 1.496496

D(MS) 1.496496

(0.16688)

Figure C-6: JTC for Retail Food Price (FP) and Money Supply (MS)

Sample(adjusted): 1974:Q2 2007:Q4

Included observations: 135 after adjusting endpoints

Trend assumption: Linear deterministic trend

Series: FP MS

Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test

Hypothesized	Eigenvalue	Trace	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None **	0.376877	68.89434	15.41	20.04
At most 1 *	0.036629	5.037798	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Trace test indicates 2 cointegrating equation(s) at the 5% level

Trace test indicates 1 cointegrating equation(s) at the 1% level

Hypothesized	Eigenvalue	Max-Eigen	5 Percent	1 Percent
No. of CE(s)		Statistic	Critical Value	Critical Value
None **	0.376877	63.85654	14.07	18.63
At most 1 *	0.036629	5.037798	3.76	6.65

^{*(**)} denotes rejection of the hypothesis at the 5%(1%) level

Max-eigenvalue test indicates 2 cointegrating equation(s) at the 5% level

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 1% level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

FP	MS
-0.023747	0.001107
-0.101153	0.002225

Unrestricted Adjustment Coefficients (alpha):

Log likelihood

-790.3790

Normalized cointegrating coefficients (std.err. in parentheses)

FP MS 1.000000 -0.046607 (0.00267)

1 Cointegrating Equation(s):

Adjustment coefficients (std.err. in parentheses)

D(FP) -0.001999 (0.00159)

D(MS) -0.480445

(0.05444)

APPENDIX D: Regression Output

	Function	R 2	Adj R²	DW Stat	F-Stat	AIC Criterion	Schwarz Criterion
FP =	f(MS(-4), FFR(-4), ER(-4))	0.96	0.96	0.02	935.08	7.19	7.28
FP =	f(MS(-4), FFR(-3), ER(-4))	0.96	0.95	0.02	922.38	7.21	7.29
FP =	f(MS(-4), FFR(-4), ER(-3))	0.96	0.95	0.02	921.98	7.21	7.29
FP =	f(MS(-3), FFR(-4), ER(-4))	0.96	0.95	0.02	917.97	7.21	7.3
FP =	f(MS(-4), FFR(-2), ER(-4))	0.95	0.95	0.02	914.54	7.22	7.3
FP =	f(MS(-4), FFR(-4), ER(-2))	0.96	0.95	0.02	910.74	7.22	7.31
FP =	f(MS(-4), FFR(-3), ER(-3))	0.95	0.95	0.02	910.68	7.22	7.31
FP =	f(MS(-4), FFR(-1), ER(-4))	0.96	0.95	0.02	909.68	7.22	7.31
FP =	f(MS(-3), FFR(-3), ER(-4))	0.96	0.95	0.02	907.38	7.22	7.31
FP =	f(MS(-3), FFR(-4), ER(-3))	0.95	0.95	0.02	903.67	7.23	7.31
FP =	f(MS(-4), FFR(-2), ER(-3))	0.95	0.95	0.02	902.09	7.23	7.32
FP =	f(MS(-4), FFR, ER(-4))	0.95	0.95	0.02	901.86	7.23	7.32
FP =	f(MS(-4), FFR(-3), ER(-2))	0.95	0.95	0.02	900.71	7.23	7.32
FP =	f(MS(-4), FFR(-4), ER(-1))	0.95	0.95	0.02	900.02	7.23	7.32
FP =	f(MS(-3), FFR(-2), ER(-4))	0.95	0.95	0.02	899.77	7.23	7.32
FP =	f(MS(-2), FFR(-4), ER(-4))	0.95	0.95	0.02	898.88	7.23	7.32
FP =	f(MS(-4), FFR(-1), ER(-3))	0.95	0.95	0.02	896.81	7.23	7.32
FP =	f(MS(-3), FFR(-1), ER(-4))	0.95	0.95	0.02	895.19	7.24	7.32
FP =	f(MS(-4), FFR(-2), ER(-2))	0.95	0.95	0.02	893.43	7.24	7.32
FP =	f(MS(-4), FFR(-4), ER)	0.95	0.95	0.02	892.28	7.24	7.33
FP =	f(MS(-4), FFR(-3), ER(-1))	0.95	0.95	0.02	891.85	7.24	7.33
FP =	f(MS(-3), FFR(-4), ER(-2))	0.95	0.95	0.02	891.26	7.24	7.33
FP =	f(MS(-4), FFR, ER(-3))	0.95	0.95	0.02	889.07	7.24	7.33
FP =	f(MS(-3), FFR, ER(-4))	0.95	0.95	0.02	888.21	7.24	7.33
FP =	f(MS(-4), FFR(-1), ER(-2))	0.95	0.95	0.02	887.96	7.24	7.33
FP =	f(MS(-2), FFR(-3), ER(-4))	0.95	0.95	0.02	859.59	7.24	7.33
FP =	f(MS(-4), FFR(-3), ER)	0.95	0.95	0.02	885.94	7.25	7.33
FP =	f(MS(-4), FFR(-2), ER(-1))	0.95	0.95	0.02	885.84	7.25	7.33
FP =	f(MS(-2), FFR(-2), ER(-4))	0.95	0.95	0.02	884.8	7.25	7.33
FP =	f(MS(-3), FFR(-3), ER(-3))	0.95	0.95	0.02	899.87	7.25	7.34
FP =	f(MS(-1), FFR(-4), ER(-4))	0.95	0.95	0.02	883.14	7.25	7.34
FP =	f(MS(-2), FFR(-4), ER(-3))	0.95	0.95	0.02	882.92	7.25	7.34
FP =	f(MS(-4), FFR(-1), ER(-1))	0.95	0.95	0.02	881.63	7.25	7.34
FP =	f(MS(-4), FFR(-2), ER)	0.95	0.95	0.02	881.5	7.25	7.34
FP =	f(MS(-2), FFR(-1), ER(-4))	0.95	0.95	0.02	880.55	7.25	7.34
FP =	f(MS(-4), FFR, ER(-2))	0.95	0.95	0.02	879.94	7.25	7.34
FP =	f(MS(-4), FFR(-1), ER)	0.95	0.95	0.02	878.5	7.25	7.34
FP =	f(MS(-3), FFR(-4), ER(-1))	0.95	0.95	0.02	877.52	7.25	7.34
FP =	f(MS(-1), FFR(-3), ER(-4))	0.95	0.95	0.02	875.81	7.26	7.34

FP =	f(MS(-2), FFR, ER(-4))	0.95	0.95	0.02	874.36	7.25	7.35
FP =	f(MS(-4), FFR, ER(-1))	0.95	0.95	0.02	873.94	7.26	7.35
FP =	f(MS(-4), FFR, ER)	0.95	0.95	0.02	872.02	7.26	7.35
FP =	f(MS(-1), FFR(-2), ER(-4))	0.95	0.95	0.02	871.69	7.26	7.35
FP =	f(MS(-2), FFR(-4), ER(-2))	0.95	0.95	0.02	869.49	7.26	7.35
FP =	f(MS(-1), FFR(-1), ER(-4))	0.95	0.95	0.02	868.78	7.26	7.35
FP =	f(MS(-3), FFR(-2), ER(-3))	0.95	0.95	0.02	888.28	7.27	7.35
FP =	f(MS(-3), FFR(-3), ER(-2))	0.95	0.95	0.02	887.56	7.27	7.35
FP =	f(MS(-3), FFR(-4), ER)	0.95	0.95	0.02	867.15	7.27	7.35
FP =	f(MS(-1), FFR(-4), ER(-3))	0.95	0.95	0.02	866.99	7.27	7.35
FP =	f(MS(-3), FFR(-1), ER(-3))	0.95	0.95	0.02	882.33	7.27	7.36
FP =	f(MS(-2), FFR(-3), ER(-3))	0.95	0.95	0.02	881.7	7.27	7.36
FP =	f(MS, FFR(-4), ER(-4))	0.95	0.95	0.02	864.98	7.27	7.36
FP =	f(MS(-1), FFR, ER(-4))	0.95	0.95	0.01	863.28	7.27	7.36
FP =	f(MS(-3), FFR, ER(-3))	0.95	0.95	0.02	878.88	7.28	7.36
FP =	f(MS, FFR(-3), ER(-4))	0.95	0.95	0.02	858.22	7.28	7.36
FP =	f(MS(-3), FFR(-3), ER(-1))	0.95	0.95	0.02	877.29	7.28	7.37
FP =	f(MS(-3), FFR(-2), ER(-2))	0.95	0.95	0.02	877.17	7.28	7.37
FP =	f(MS(-2), FFR(-2), ER(-3))	0.95	0.95	0.02	872.07	7.28	7.37
FP =	f(MS, FFR(-2), ER(-4))	0.95	0.95	0.02	854.88	7.28	7.37
FP =	f(MS(-2), FFR(-4), ER(-1))	0.95	0.95	0.02	854.32	7.28	7.37
FP =	f(MS, FFR(-1), ER(-4))	0.95	0.95	0.02	853.23	7.28	7.37
FP =	f(MS(-1), FFR(-4), ER(-2))	0.95	0.95	0.02	852.09	7.28	7.37
FP =	f(MS(-3), FFR(-1), ER(-2))	0.95	0.95	0.02	870.89	7.29	7.37
FP =	f(MS(-3), FFR(-3), ER)	0.95	0.95	0.02	869.18	7.29	7.37
FP =	f(MS, FFR(-4), ER(-3))	0.95	0.95	0.02	849.59	7.29	7.37
FP =	f(MS, FFR, ER(-4))	0.95	0.95	0.02	849.24	7.29	7.37
FP =	f(MS(-3), FFR(-2), ER(-1))	0.95	0.95	0.02	868.19	7.29	7.38
FP =	f(MS(-2), FFR(-3), ER(-2))	0.95	0.95	0.02	868	7.29	7.38
FP =	f(MS(-1), FFR(-3), ER(-3))	0.95	0.95	0.02	867.28	7.29	7.38
FP =	f(MS(-3), FFR, ER(-2))	0.95	0.95	0.02	867.25	7.29	7.38
FP =	f(MS(-2), FFR(-1), ER(-3))	0.95	0.95	0.02	866.47	7.29	7.38
FP =	f(MS(-2), FFR, ER(-3))	0.95	0.95	0.02	863.35	7.29	7.38
FP =	f(MS(-3), FFR(-1), ER(-1))	0.95	0.95	0.02	863.02	7.29	7.38
FP =	f(MS(-3), FFR(-2), ER)	0.95	0.95	0.02	861.84	7.3	7.38
FP =	f(MS(-2), FFR(-4), ER)	0.95	0.95	0.02	841.1	7.3	7.38
FP =	f(MS(-1), FFR(-2), ER(-3))	0.95	0.95	0.02	859.55	7.3	7.39
FP =	f(MS(-3), FFR, ER(-1))	0.95	0.95	0.02	859.49	7.3	7.39
FP =	f(MS(-3), FFR(-1), ER)	0.95	0.95	0.02	857.84	7.3	7.39
FP =	f(MS(-2), FFR(-3), ER(-1))	0.95	0.95	0.02	856.2	7.3	7.39
FP =	f(MS(-3), FFR, ER)	0.95	0.95	0.02	855.39	7.3	7.39
FP =	f(MS(-1), FFR(-1), ER(-3))	0.95	0.95	0.02	855.25	7.3	7.39

FP =	f(MS(-1), FFR(-4), ER(-1))	0.95	0.95	0.02	835.62	7.3	7.39
FP =	f(MS, FFR(-4), ER(-2))	0.95	0.95	0.02	834.67	7.3	7.39
FP =	f(MS(-1), FFR, ER(-3))	0.95	0.95	0.01	852.35	7.31	7.39
FP =	f(MS(-1), FFR(-3), ER(-2))	0.95	0.95	0.02	851.82	7.31	7.39
FP =	f(MS, FFR(-3), ER(-3))	0.95	0.95	0.02	850.57	7.31	7.4
FP =	f(MS(-2), FFR(-3), ER)	0.95	0.95	0.02	845.09	7.31	7.4
FP =	f(MS(-2), FFR(-2), ER(-2))	0.95	0.95	0.02	863.7	7.32	7.4
FP =	f(MS, FFR(-2), ER(-3))	0.95	0.95	0.02	843.96	7.32	7.4
FP =	f(MS, FFR(-1), ER(-3))	0.95	0.95	0.02	841	7.32	7.41
FP =	f(MS, FFR, ER(-3))	0.95	0.95	0.02	839.11	7.32	7.41
FP =	f(MS(-1), FFR(-3), ER(-1))	0.95	0.95	0.01	838.63	7.32	7.41
FP =	f(MS(-1), FFR(-4), ER)	0.95	0.95	0.02	820.69	7.32	7.41
FP =	f(MS, FFR(-4), ER(-1))	0.95	0.95	0.02	816.69	7.32	7.41
FP =	f(MS(-2), FFR(-1), ER(-2))	0.95	0.95	0.02	855.38	7.33	7.41
FP =	f(MS, FFR(-3), ER(-2))	0.95	0.95	0.02	834.68	7.33	7.41
FP =	f(MS(-2), FFR(-2), ER(-1))	0.95	0.95	0.02	852.44	7.33	7.42
FP =	f(MS(-2), FFR, ER(-2))	0.95	0.95	0.02	851.46	7.33	7.42
FP =	f(MS(-1), FFR(-2), ER(-2))	0.95	0.95	0.01	849.69	7.33	7.42
FP =	f(MS(-2), FFR(-1), ER(-1))	0.95	0.95	0.02	845.16	7.34	7.42
FP =	f(MS(-1), FFR(-3), ER)	0.95	0.95	0.01	825.57	7.34	7.42
FP =	f(MS(-2), FFR(-2), ER)	0.95	0.95	0.02	844.46	7.34	7.43
FP =	f(MS(-1), FFR(-1), ER(-2))	0.95	0.95	0.01	842.74	7.34	7.43
FP =	f(MS(-2), FFR, ER(-1))	0.95	0.95	0.02	841.22	7.34	7.43
FP =	f(MS, FFR(-3), ER(-1))	0.95	0.95	0.02	819.94	7.34	7.43
FP =	f(MS, FFR(-4), ER)	0.95	0.95	0.02	800.36	7.34	7.43
FP =	f(MS(-1), FFR, ER(-2))	0.95	0.95	0.01	839.04	7.35	7.43
FP =	f(MS(-2), FFR(-1), ER)	0.95	0.95	0.02	838.36	7.35	7.43
FP =	f(MS(-1), FFR(-2), ER(-1))	0.95	0.95	0.01	836.66	7.35	7.43
FP =	f(MS(-2), FFR, ER)	0.95	0.95	0.02	835.3	7.35	7.44
FP =	f(MS, FFR(-2), ER(-2))	0.95	0.95	0.01		7.35	7.44
FP =	f(MS, FFR(-1), ER(-2))	0.95	0.95	0.01	828.83	7.36	7.44
FP =	f(MS(-1), FFR(-2), ER)	0.95	0.95	0.01	826.63	7.36	7.45
FP =	f(MS, FFR, ER(-2))	0.95	0.95	0.01	826.13	7.36	7.45
FP =	f(MS, FFR(-3), ER)	0.95	0.95	0.02	805.3	7.36	7.45
FP =	f(MS, FFR(-2), ER(-1))	0.95	0.95	0.02	819.32	7.37	7.45
FP =	f(MS(-1), FFR(-1), ER(-1))	0.95	0.95	0.01	835.19	7.37	7.46
FP =	f(MS(-1), FFR, ER(-1))	0.95	0.95	0.01	829.83	7.38	7.47
FP =	f(MS(-1), FFR(-1), ER)	0.95	0.95	0.01	826.06	7.38	7.47
FP =	f(MS, FFR(-2), ER)	0.95	0.95	0.02	807.62	7.38	7.47
FP =	f(MS(-1), FFR, ER)	0.95	0.95	0.01	821.54	7.39	7.47
FP =	f(MS, FFR(-1), ER(-1))	0.95	0.95	0.01	819.62	7.39	7.48
FP =	f(MS, FFR, ER(-1))	0.95	0.95	0.01	815.34	7.4	7.48

FP =	f(MS, FFR(-1), ER)	0.95	0.95	0.01	808.42	7.4	7.49
FP =	f(MS, FFR, ER)	0.95	0.95	0.01	810.02	7.43	7.51