THE NET EFFECT OF EXCHANGE RATES ON AGRICULTURAL INPUTS AND OUTPUTS

A Thesis

by

MYRIAH D. JOHNSON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2011

Major Subject: Agricultural Economics

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Approved by:

Chair of Committee,	David P. Anderson
Committee Members,	Henry L. Bryant
	Andy D. Herring
Head of Department,	John P. Nichols

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ABSTRACT

The Net Effect of Exchange Rates on Agricultural Inputs and Outputs.

(August 2011)

Myriah D. Johnson, B.S., Oklahoma State University

Chair of Advisory Committee: Dr. David P. Anderson

For more than thirty years, studies about the effect of the exchange rate on exports have been conducted. However, few have considered the combined effect of the exchange rate on imported inputs into the agricultural system and the exports of final agricultural products those inputs produce. This work contributes to the agricultural economics literature by combining those effects. A current concern is for the net effect as the total value and quantity of inputs imported has increased. This research examines the effect of the exchange rate on imported inputs into the corn, wheat, and beef cattle production systems, breaking it down to a producer's budget, examining how the exchange rate affects profitability. Vector Autoregression (VAR) and Bayesian Averaging of Classical Estimates (BACE) models were estimated to evaluate the effects.

Daily and weekly price data were used for corn, wheat, feeder steers, ethanol, diesel, ammonia, urea, di-ammonium phosphate, and the exchange rate. A VAR model was estimated to model the relationship between the variables. After having incongruous test results in determining the lag length structure it was decided that a BACE model would be approximated. After estimating the BACE model, the price responses of the commodities to the exchange rates were estimated. The price responses were used in demonstrating the effect of the exchange rate on a producer's profitability.

It was determined that, generally, a strengthening exchange rate has a negative impact on prices. It was also found that the exchange rate has a greater impact on prices now than it did 14 years ago, implying that the exchange rate now has a greater affect on profitability. A one percent increase in the value of the dollar led to a decline in profitability ranging from $0.02/bu in wheat to $0.56/cwt in feeder steers. However, agricultural producers should not be overly concerned about a lower valued dollar from the perspective of their agricultural business.

DEDICATION

I would like to dedicate this thesis to my incredible family: my parents and my brother. Without your love and support I would not have made it to where I am today. You have inspired me to work hard and to constantly push myself. While my love for agriculture sometimes wavered, as a child, you let it grow at its own pace until it became a passion for me. I will never be able to repay all that you have given to me, and, for that, I can only say, thank you.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. David Anderson, for his guidance and support throughout this process, as well as the opportunity to work on this project. Particularly, I would like to thank him for all the laughs and the reminder that everything will turn out and that it's really not that serious. I would also like to thank my other committee members for the help and support they offered throughout this time: Dr. Henry Bryant for his many, many explanations on econometrics, making sure that I understood what we were doing throughout the entire process and Dr. Andy Herring for his advice on the production systems researched. Additionally, I owe a great deal of gratitude to the faculty and staff in the Department of Agricultural Economics at Texas A&M University, from whom I have taken courses and learned from their advice.

I would also like to thank Dr. Kim Anderson at Oklahoma State University for all the plane rides and the sounding board he provides for my professional career. He has helped me navigate the storm of life with his insight, support, and advice. Dr. Kim Anderson is one of few people who knows exactly what I am thinking when I look at him. Many smiles and laughs have been shared over exactly this. Whoever breaks the silence first loses.

A big thank you goes to my friends and classmates here at Texas A&M University. Without your laughs and smiles, I may have gone crazy living here in Texas. Many memories have been made that will not soon be forgotten. I would also like to thank my family and friends in Oklahoma and elsewhere who offered a listening ear and support throughout my time here at Texas A&M.

NOMENCLATURE

BACE	Bayesian Averaging of Classical Estimates
BU	Bushel
CWT	Hundred-weight
DAP	Di-ammonium Phosphate
EIA	Energy Information Administration
ERS	Economic Research Service
RFS	Renewable Fuel Standard
SBC	Schwarz Bayesian Criterion
USDA	United States Department of Agriculture
VAR	Vector Autoregression

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

In the United States, less than two percent of people work in production agriculture. However, the agricultural industry and its related jobs are of great importance to the domestic economy. It has been estimated that "in calendar year 2006, the $71.0 billion of agricultural exports produced an additional $117.2 billion in economic activity for a total of $188.2 billion of economic output" (Edmonson 2008, 7). In addition, "agricultural exports also generated 841,000 full-time civilian jobs, including 482,000 jobs in the nonfarm sector" (Edmonson 2008, 7). Agricultural production helps drive the U.S. economy generating jobs, food, and fuel for the country, as well as for the rest of the world. Commodities produced in the U.S. end up in one of two places, consumed domestically or exported to our foreign markets.

Agriculture is one of the few areas where the U.S. trade balance remains positive, meaning that the value of our exports exceeds that of our imports. One of the factors playing a role in our export business is the exchange rate. As the value of the dollar changes in relation to other currencies our products become relatively more or less expensive to other countries' consumers. Based on this, importing countries may choose to import more or less of a given commodity or they may seek out alternative markets to make their purchases. Commodity producers in the U.S. do not want to lose world

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This thesis follows the style of *American Journal of Agricultural Economics*.

market share and are, therefore, sensitive to the value of the dollar. The common belief is that a strong dollar makes U.S. goods less competitive in the world market because U.S. goods become relatively more expensive. U.S. farm groups have often argued that a weaker currency was not necessarily bad for agriculture because it would boost exports. This concern has been addressed in past research papers, but only from the view of how it affects our exports.

It is also important to look at how imported inputs play a role into the cost of production. If a weaker dollar exists as compared to the countries where the inputs are coming from, then those inputs become more expensive to the U.S. The commodities focused on in this paper will be cattle, corn, and wheat, which all have inputs that are affected by imports. Each of these products also stands to benefit from increased exports. Inputs in these systems typically include seed, fertilizer, chemicals, fuel, repairs, irrigation water, and interest on operating capital. A portion of the inputs, fertilizer, chemicals, and fuel, are imported. For corn and wheat, inputs are similar and according to the Federal Reserve Bank of Kansas City "wheat and corn producers feel more of a pinch from higher energy prices relative to other crop producers. For corn producers, fuel and fertilizer account for nearly 50% of variable costs and more than 20% of total costs, a comparable share to land costs (cash rents or mortgage payments). Fuel and fertilizer make up similar shares of wheat production costs"(Novack 2005, 6). As we argue for a weaker dollar to export more these imported inputs also become relatively more expensive. Engel states, "A depreciation may increase the price of imported goods, but if those goods are inputs into the export sector, the country's competitiveness may not be strongly affected"(2009, 8). However, this has not been evaluated in an agricultural context.

Fertilizer

In 2007 and 2008 fertilizer costs accounted for 41% and 47% of corn farm's operating costs, respectively (USDA ERS, 2009a). In 2007, nitrogen fertilizer accounted for 58% percent of fertilizer used followed by phosphorus and potash at 20% and 22%, respectively (USDA ERS, 2009b). Between 1996 and 2002 agricultural demand for nitrogen fertilizer remained fairly constant near 12,000,000 tons. However, during these years imports of nitrogen fertilizer grew by 47% (USDA ERS, 2009b). Now, in 2010, approximately, "half of our nitrogen product is imported" (Klose and Kenkel 2010).

Import data on fertilizer from USDA are listed by product (USDA ERS, 2009c). To graph this, a few key fertilizer products were chosen. The graphed data of anhydrous ammonia, urea, potassium muriate, and phosphate rock show how imports have changed over the past 14 years. In Figure 1, US. fertilizer imports, is expressed in total tons while Figure 2 contains the dollar value of the product imported. In Figure 3, the graph contains imports in tons and dollar value for all fertilizer products. Looking at Figure 1 and Figure 3 a gentle upward trend is seen from 1995 to the early 2000's for fertilizer products. After 2002, fertilizer imports increased at a much faster rate. They continued on this torrid pace through the boom of 2008, but declined sharply in the recession of 2009. Likewise, the dollar value of the imported product held steady before rising sharply in the early 2000's time period (Figure 2). The dollar value of imported product climbed to its high in 2008, with those products alone accounting for over $10 billion dollars in value. By comparing total tons increase to total dollar value in Figure 3 it is seen that the dollar value of the product increased much more rapidly than actual tons of imported product. So, even if similar amounts of fertilizer product are imported compared to years past there is now a greater amount of cash tied up, allowing the exchange rate to play a greater role in the fertilizer industry.

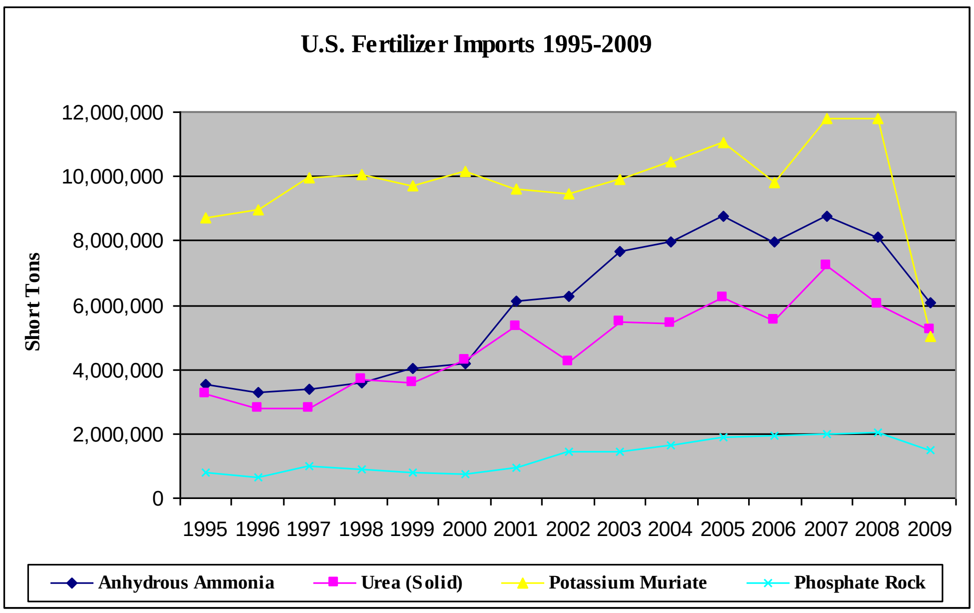

Figure 1. U.S. Fertilizer Imports 1995-2009 in Total Short Tons.

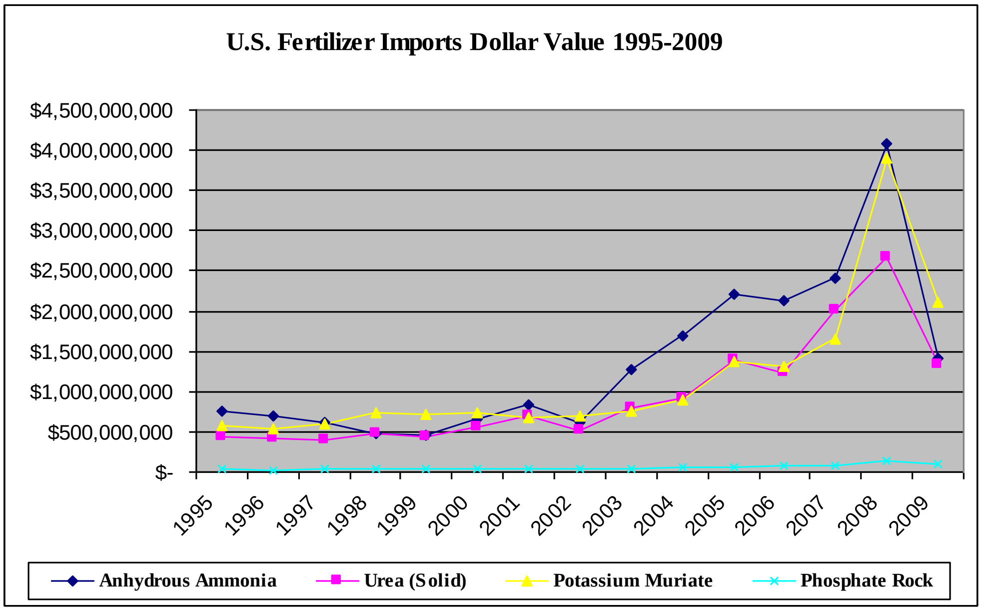

Figure 2. U.S. Fertilizer Imports 1995-2009 in Total Dollar Value.

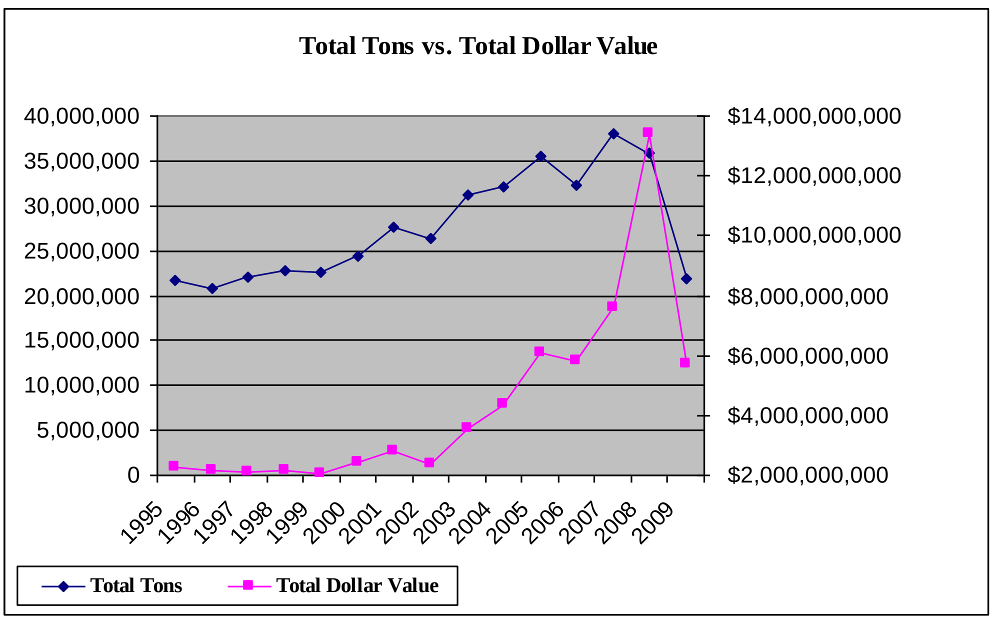

Figure 3. U.S. Fertilizer Imports in Total Tons and Total Dollar Value.

Fuel

In this paper, diesel will be considered for the fuel costs because according to the U.S. Energy Information Administration “in agriculture, diesel fuels more than two-thirds of all farm equipment in the United States”(US EIA, 2010b). In 2007 and 2008, fuel costs were 14% of the operating costs for corn farms, which makes it an important input to consider (USDA ERS, 2009a). Diesel fuel is refined from crude oil. The United States typically refines crude oil domestically and produces or imports the crude oil needed to make the petroleum products, currently, “the United States produces more than 90% of the petroleum products it consumes, it imports about 3 million barrels per day of refined petroleum products”(US EIA, 2010a).

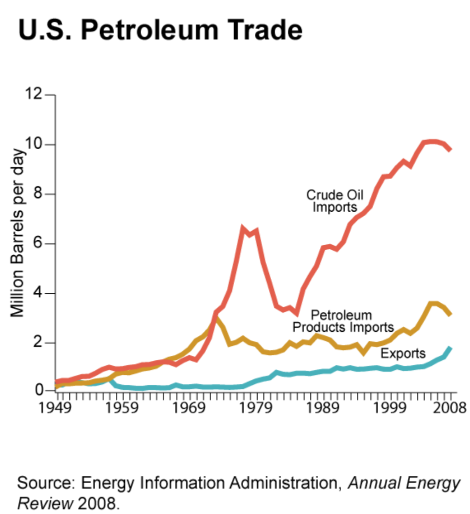

Figure 4. U.S. Petroleum Trade 1949-2008 in Million Barrels per day.

In 2009 “net imports of crude oil and petroleum products (imports minus exports) accounted for 51% of our total petroleum consumption”(US EIA, 2010a). It is approximated that in 2008 “about two-thirds was imported”(US EIA, 2010c) and used for the production of diesel. So, consequently approximately two-thirds of the diesel used has exchange rate risk.

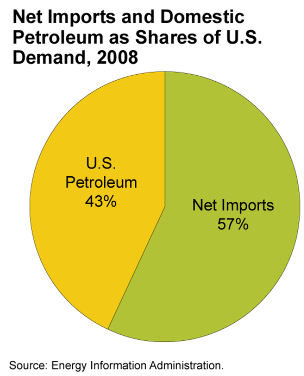

Figure 5. Net Imports and Domestic Petroleum as Shares of U.S. Demand, 2008.

Ethanol, made largely from corn is a fuel additive in the U.S. The Renewable Fuel Standard (RFS) was created by the Energy Policy Act of 2005. RFS2 followed in 2010. RFS2 mandates that 36 billion gallons of renewable bio-fuel, ethanol primarily derived from corn starch, be produced by 2022. While mandates for ethanol blends exist, ethanol is also a substitute for gasoline. Flex fuel vehicles run on an 85% blend of ethanol and gasoline. Additionally, many other vehicles are now able to take up to a 15% blend of ethanol in gasoline. Fuel and ethanol are both derived from oil and corn, respectively. As fuel and ethanol become competitors, oil and corn prices become linked. As oil prices begin to rise or fall it will affect corn prices. The exchange rate plays a role here because if the U.S. dollar depreciates then it is more expensive for us to import oil, but our corn also becomes cheaper as an export, creating further demand for corn to be exported and used for ethanol production. Corn, used for feed, is an input for the livestock industry. If corn prices rise with oil prices, livestock producers have higher input costs from two sides, fuel and feed, unless they use mainly biodiesel on their operation. It is a double edged sword.

The Economic Research Service reported in 2008, “the weakening U.S. dollar, which has now fallen to a 30-year low compared with the world’s other major currencies makes the price of U.S. goods increasingly competitive abroad.”(Edmonson 2008, 2). On the flip side, as the dollar strengthens our products become more expensive and less attractive. Shane and Liefert state, “for example, the period 1970-80, a time of high growth in U.S. agricultural exports, was accompanied by a long period of depreciation of the U.S. dollar”(2007, 3). These comments, along with others have led farm groups to lobby for, or at least support, a weaker dollar. There has been additional evidence such as, “since 1970, several substantial periods of persistent appreciation or depreciation of the dollar have mostly mirrored corresponding fluctuations in U.S. agricultural exports”(Shane and Liefert 2007, 3).

Imported inputs are playing an increasing role in U.S. agriculture, giving rise to concern for how they affect the bottom line for producers. It is, therefore, important to address the tradeoff between having a weaker dollar to boost exports versus how that affects imported input costs into U.S. production of corn, wheat, and beef. This thesis examines the net effect of exchange rates on agricultural producers.

CHAPTER II

LITERATURE REVIEW

Economic Theory

As the world becomes more interdependent, exchange rates play an increasingly important role in agriculture. There has been a significant amount of work done on the effect of exchange rates on exports, imports, as well as exchange rate pass-through. Exchange rate pass-through is the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries. Few studies have combined the effect of exchange rates on imports as they pass through production as inputs into end products that will be exported in the agricultural sector. Living in an interdependent world it is important to understand how the exchange rate affects both imported inputs and exports. The stage has changed since agricultural groups began lobbying for a weaker dollar years ago, in attempt to boost exports. New dynamics surround agriculture, and the topic of exchange rates effects, with respect to imports and exports, needs to be visited.

For many years the importance of the exchange rate was overlooked, until the 1970's when Edward Schuh began working in the area. In Schuh's classic 1974 article, he argued that the dollar was overvalued, causing a decline in agricultural exports because of their relative expense in other countries. He reasoned that this in turn led to depressed farm prices and lower farm profits, causing producers to miss out on fully capitalizing on technological advances made during the time period. Additionally, there was an oversupply of commodities in the United States because of the decrease in exports. Schuh was the first to call attention to the relationship between the exchange rate and agricultural products and markets.

In 1975, Grennes commented on Schuh's classic article and stated that exchange rate policy may alter the distribution of income between countries as well as between U.S. producers and consumers. He also stated that many agricultural export commodities were subsidized and the subsidies were positively correlated with the degree of overvaluation. Because of this, the two effects cancel and agricultural prices are not affected by exchange rate policy.

In Schuh's 1975 reply he gave supporting evidence to his belief that there was not much correlation between the magnitude of subsidies and the degree of overvaluation. The evidence that led him to believe this was that the high point of subsidies in the 1963-1973 period was in the 1963-1964 fiscal year, whereas the overvaluation of the dollar did not hit its peak until 1971.

Continuing his work in 1984, Schuh once again asserted his belief that changes in imports and exports were due to changes in the value of the dollar. He believed the result of the shift from fixed to flexible exchange rates was significant because of the emergence of well-integrated international capital markets. A fixed exchange rate, or a pegged exchange rate, is an exchange rate regime where a currency's value is matched to the value of another single currency or to a basket of other currencies. Flexible, or floating, exchange rates are allowed to fluctuate according to the foreign exchange market. Schuh believed that under these changed conditions, changes in monetary policy induced international capital flows, which in turn caused changes in the value of the dollar. Changes in the dollar impacted the level of imports and exports. The net result was that agriculture, together with other export and import competing sectors had to bear the brunt of the burden brought on by monetary and fiscal policies.

Orden (2000) suggested that Schuh's classic 1974 article overstated the argument of macroeconomic circumstances. He also believed it was fortunate that the process of revising price support policy to accommodate a strong dollar occurred about the time the dollar depreciated. With this devaluation, U.S. exports were restored and excess stocks decreased, which contributed to the easing of acreage supply controls. Exchange rate movements created a difference in foreign and domestic prices of a single good, and monetary shocks had non-neutral effects that explained some of the variability in agricultural prices. Macroeconomic conditions often played a large role in domestic agricultural policies and therefore a role in world market competitiveness and trade relations. Orden stated that these structural policy implications of exchange rate movements coupled with their direct effect on markets are why exchange rates are important to agriculture.

Figure 6, shows the fundamental economics of the effect of exchange rate movements on an exporting country. The four panel diagram contains the U.S. as an exporter on the left, trade in the second panel, exchange rates on the third, and the rest of the world as an importer on the far right panel. A stronger dollar increases the relative price of the product in the rest of the world, causing quantity exported to decrease while also decreasing demand.

In Figure 6, Q_t is the original quantity traded before the appreciation of the U.S. dollar, and P_t is the price of the good at this quantity traded. A strengthening dollar is modeled graphically by a downward rotation from the exchange rate line (1:1). This effectively devalues the importer's currency. The rotation of the exchange rate is used to reflect the new currency value relationship by constructing a new excess demand function, ED', (moving through points B, C, D, and E). Point F now represents the equilibrium point of ED and excess supply, ES. Price in the exporting country is reduced and importing countries price is raised from the initial price level. The changing price relationship between the two countries due to the changing exchange rate is illustrated. Empirical studies, reviewed below, often model or estimate these price and quantity changes due to exchange rate moves. This graphical representation assumes linearity in the supply and demand functions for simplicity only. Empirical estimates may not be linear.

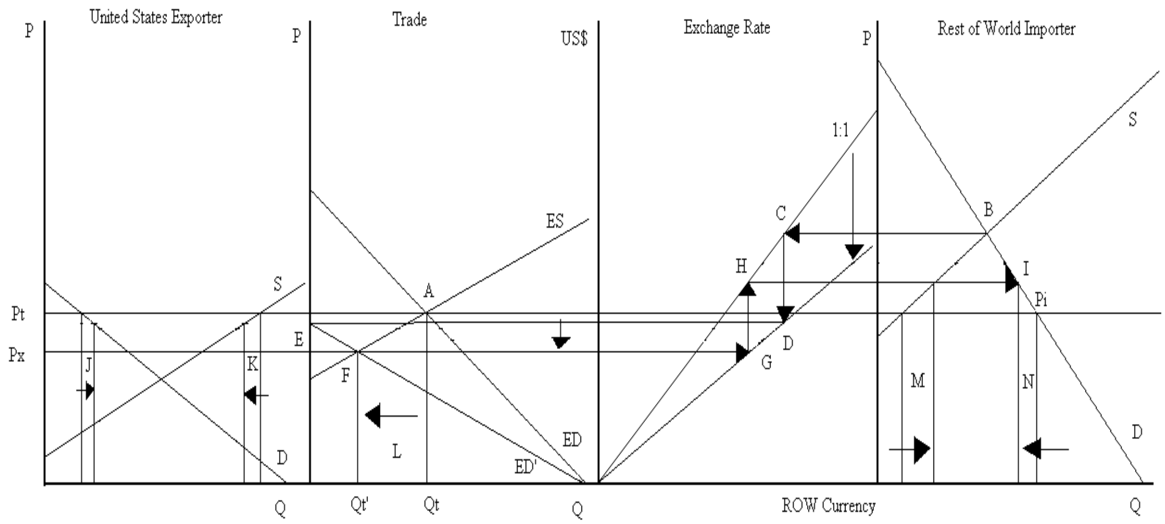

Figure 6. The Impact of Exporter Currency Appreciation on Trade.

For the purpose of this research it is important to remember that the U.S. is not just an exporter, but an importer of inputs for final export commodities as well. A weaker dollar would have the effect of decreasing imports and increasing exports, while a stronger dollar would increase imports and decrease exports. For example, the U.S. is increasingly reliant on imported fuel and fertilizer to produce wheat, but remains a major wheat exporter.

Empirical Research

Research results evaluating the effect of exchange rates on exports and imports have varied. Some have found that the exchange rate has little effect, while some believe it to be of great importance. Throughout this research, though, there has been none that has combined the two effects of exchange rates on imports and how that passes through the production system to exports in the agricultural industry.

In 1976 Kost reviewed the theoretical framework used to assess the trade impact of currency devaluation or revaluation on commodities, or any subsector of a country's economy. He first examined the effect of currency devaluation by the exporter, which would be the same as an appreciation in currency by the importer. The result was the same for each country: there would be an increase in the quantity exported along with an increase in price in the exporting country, which caused an increase in production and decrease in consumption in the exporting country. Graphically, the opposite scenarios are shown in Figure 6. In the importing country consumers consumed more while producing less because of the lower price. Overall, the quantity traded increased. With a depreciation of the importer's currency or an appreciation of the exporter's currency, the importing country would have a reduced demand, increased production, and decreased consumption. In the exporting country, prices and consumption would increase while exports and production would decrease.

Kost pointed out that there is an upper limit on how much the prices and quantities traded could change in response to an exchange rate change. The maximum amount of the price rise for the traded goods was by the same percentage as the amount of the devaluation. The maximum price rise occurred only when the export supply curve was perfectly inelastic. Additionally, the maximum amount of increase in the quantity traded (also the same percentage as the amount of the devaluation) occurred only when the export supply curve was perfectly elastic. The impact of an exchange rate change on imports and exports depended on the magnitude of the exchange rate change. Kost expected only a small impact on agricultural trade as a result of a change in exchange rates and the effect primarily to be on price rather than quantity.

Along the same line as Kost, Vellianitis-Fidas (1976) tested the hypothesis that changes in exchange rates have a significant effect on the demand for U.S. agricultural exports. Two steps were taken to test the hypothesis: (1) a cross-sectional study used an ordinary least squares regression (OLS) to measure the changes in quantity demanded for U.S. agricultural exports (wheat, corn, and soybeans) by major U.S. trading partners from 1971-1973 and (2) past exchange rate changes in other countries were examined to establish if alterations in these rates explained variations in imports over time, from both the world and the U.S. in the 1954-1969 period. Vellianitis-Fidas found that the two studies strongly implied that the change in the exchange rate of the U.S. dollar did not significantly affect agricultural trade. Nor did they find that changes in exchange rates of major or minor importers have any great effect on their agricultural trade. In the OLS step for the study, exchange rate changes, per capita income growth, population growth, foreign supplies, expected export quantities for the U.S. and rest of the world (ROW), actual exported quantities for the U.S., and actual imported quantities for the ROW are regressed on the difference in the quantities of wheat, corn, or soybeans being exported from the U.S. between 1971-1972 and 1972-1973. The exchange rate was found not to be significant when regressed on wheat and corn and not important in the soybean equation as its sign was inconsistent with theory. Furthermore, they found that for the change in quantities exported between 1971-1972 and 1972-1973, almost none of the variation in imports and exports among trading partners can be explained by the variation in exchange rates.

Certain implications can be taken from the results of the OLS equations by examining them on the basis of value of good traded. Value consists of price and quantity together. The U.S. did not export relatively more or less to countries whose currencies had changed most against the dollar. Wheat prices were stable from January 1971, through August of that year when it was announced that the dollar would be allowed to float, until July of 1972 when it began to increase. The U.S. Gulf export price per bushel of hard winter wheat rose from $1.76 in July 1972 to $2.95 in July 1973. By the end of 1973 the price had hit $5.44. Soybean prices were equally stable until November 1972 when they began to rise as well. On the other hand, corn prices generally moved down from January 1971 to October of that year when they stabilized and then increased from September to November 1972 from $1.50 per bushel to $2.83 in mid-December of 1973. Even allowing for a three or six month lag, these large price increases suggested that neither the August 1971 nor February 1973 devaluations were instrumental in raising the domestic prices of these commodities because the price increases were greater than both of the official devaluations, according to Vellianitis-Fidas.

In the second part of her study, Vellianitis-Fidas (1976) evaluated 20 countries in the 1960 to mid-1969 time period that had each devalued or revalued their currency at least once. U.S. exports for five commodities – wheat, corn, cotton, tobacco, and oilseeds were modeled. To summarize the results, two kinds of nonparametric tests were conducted for each individual country's equation. The first test was used to see if the majority of countries for any one equation did not have significant t-statistics for the exchange rate dummy variable. With the exception of tobacco, test results indicated that the majority of countries importing the five commodities did not significantly change their level of trade from the U.S. or from the world after changing their exchange rate. The second test ranked the commodity's t-stats for a U-test, a non-parametric significance test. For commodities imported from the world cotton seemed more likely to be affected by the exchange rate, while wheat appeared to be less affected than they rest of the commodities. The two tests strongly implied that a change in the exchange rate of the U.S. or major or minor importers did not significantly affect agricultural trade. While some may have found this conclusion surprising, the author suggested it should not be based on the conditions within agriculture, such as the inelasticities of demand and supply of agricultural commodities, particularly in the short run. Exchange theory, combined with these special conditions, provided a logical explanation of why the exchange rate variable was found to be insignificant. The author noted that Kost (1976) assumed there would be a small shift in demand with an exchange rate for agricultural goods. According to this study, two explanations were offered in support of a small shift in demand. The first was that the maximum amount of the demand shift would be by the amount of the devaluations (or appreciation) of the currency. The trade-weighted exchange rates indicated maximum price changes for wheat and corn were less than the amount of the official U.S. dollar devaluation versus gold. Secondly, the author states that institutional factors prevented the full impact of the devaluation from manifesting, particularly in European Community (E.C.) member countries because of the provisions of the Common Agricultural Policy of the E.C., specifically the variable levy. Long-term analysis indicated that the import quantity demanded by countries revaluing or devaluing was small or zero because the shift of the import supply curve was small and/or demand for imports was fairly inelastic. It was also determined that changes in value due to exchange rate changes were small as well, demonstrated by the time series analysis. If the change in value and quantity were both small, and if value equals price times quantity, then the change in the price must also be small. The degree to which exchange rate devaluations or revaluations affected exports, imports, or both, depended solely on the degree of elasticity. The inelasticity of supply and demand in the agricultural sector suggested that exchange rate changes by countries will not greatly affect the level of their agricultural trade. In conclusion, Vellianitis-Fidas' study provided empirical support for the theoretical conclusions given in Kost's article. Combined, their analysis indicated that the U.S. devaluations in 1972-1973 did not explain the high U.S. agricultural prices.

Unlike Vellianitis-Fidas (1976), Johnson, Grennes, and Thursby (1977) contrasted the impact of the exchange rate on U.S. wheat pricing versus the impact of foreign policy. They used a deterministic short-run forecasting model to evaluate the international pricing of wheat and concluded that foreign commercial policy, designed to insulate consumers from increasing prices, was more influential in the pricing of domestic wheat than U.S. policy. Additionally, there was some indication that a continuation of distortions in U.S. shipping policy was as important as the devaluation of the dollar in influencing the wheat price. Consistent with economic theory, they also found that a devaluation of the dollar had a positive impact on domestic wheat prices through increased export demand, which in turn caused lower domestic supplies.

After evaluating past studies, Chambers and Just (1979) offered a critique on the use of the exchange rate in agricultural models. In their arguments, they concluded that the usual approach to evaluating the effects of exchange rate movements on U.S. agricultural commodities was too restrictive. They believed that the conditions surrounding U.S. trade more closely aligned with results found from using a more general model with excess supply and demand where the response to the exchange rate could be bigger or smaller than the restrictive models indicated. Additionally, their arguments suggested that most of the problem in measuring exchange rate effects on agriculture was due to a lack of appropriate price indices for certain commodity bundles, internationally traded versus non-traded bundles. They pointed out that there was a growing need for more international trade appropriate price indices and that they should include price indices for traded and non-traded goods with weightings pertaining to internal decisions in the importing countries.

Similar to Vellianistis-Fidas (1976), Collins, Meyers, and Bredahl (1980) evaluated the impact of multilateral exchange rate variations on U.S. prices of major agricultural commodities. They used a simple analytic model for their research. In the model they included multiple exchange rate changes, rates of inflation, and trade restrictions. The research contained two parts: (1) an expression for short-run U.S. commodity price changes caused by both nominal and real exchange rate changes and (2) calculated annual changes in U.S. prices of wheat, corn, cotton, and soybeans attributed to exchange rate variations and inflation rates of major noncommunist nations during the period 1971 to 1977. The authors compared those changes with the observed price changes for the time period in order to determine where, in the range from large to small, exchange rate impacts on U.S. agriculture fell. The model and its applications had limitations because they abstracted from many, possibly significant factors. When the authors compared price effects under the selected best policies with actual price changes the data suggested that inflation-adjusted exchange rates had a minor role in the large increases in commodity prices of wheat, corn, and soybeans during the early 1970s. The size of the exchange rate effect was dependent on many variables such as crop, year, country, government influence in markets, alternative prices considered, the price variable that is measured, elasticities, and the definition of exchange rate effect. The authors concluded that if the exchange rate changes reflect only differential rates of inflation, then under free trade, nominal commodity prices change, but the underlying demand and supply do not. On the other hand, if the exchange rate was fixed, differential inflation rates caused supply and demand changes, and as the use of nominal price insulation policies increased, the impact of inflation and exchange rate variations on U.S. export demand and real commodity prices increased significantly.

Although research had been done Chambers (1981) called attention to the need for further research on the effect of monetary instruments on agricultural trade. He believed there were three main issues that needed research in the area. The first was the establishment of a satisfactory theoretical model of the interaction between monetary factors and agricultural commodity trade. The second major problem was the construction of empirical models, whether econometric or programming, recognizing the linkages between the agricultural trade sector and the financial part of the economy. Chambers believed there was one greater, ultimate issue that had to be faced in econometric or programming exercises, though, and that was whether or not to build models specific to the problem at hand or whether to aim the construction of models that were sufficiently general to allow for a wide-ranging series of empirical examinations.

Chambers and Just (1981) based their research off of their previous paper, written in 1979. In their new paper they developed a quarterly dynamic econometric model for wheat, corn, and soybeans. In the model they considered the exchange rate adjustment as a monetary effect with adequate flexibility in specification, in order to reflect exchange rate effects on the domestic sector as well as the foreign sector of U.S. agriculture. Their results indicated that exchange rate fluctuation had a significant real impact on agricultural markets by altering the volume of exports and the relative split between exports and domestic use of the three commodities. They also found that for corn, soybeans, and wheat there is a complex and long-term adjustment to the exchange rate. For each crop the adjustment is different, but for all three, exports increased rapidly and then declined somewhat after several quarters. Finally, the authors noted that an important implication from the research was that policy tools, such as open market operations, which were usually viewed as having little or no effect on agriculture, could instead have significant effects via the exchange rate.

In 1982, Chambers and Just again tackled agriculture and the exchange rate. This time, however, they conducted the research with the perspective of trying to link together monetary factors to empirical models of agricultural activity. To link these together, they created a three-block recursive econometric model, a multiplier analysis. The three blocks were an agricultural, aggregate export, and exchange rate determination block. The agricultural blocks contained models of the wheat, corn, and soybean markets. The aggregate block had a model of the current account net of the value of wheat, corn, and soybean exports. The last block was a reduced-form model of exchange rate determination. Chambers and Just agreed with earlier findings that open-market operations can have a heavy impact on the agricultural sector. Additionally, they believed the same held true for speculation in international currency markets. Their results also suggested that the burden of restrictive monetary policy may be unusually great for agricultural producers. Their results indicated that a tight monetary policy will lower prices and increase domestic demand, but that the upward pressure on the exchange rate seriously affected the competitive position of U.S. exports in international markets.

Picking up the issue again in 1984, Chambers asserted that policies designed to meet macroeconomic objectives, such as lower inflation rates or a strengthened currency, may depress agriculture. That contradicted the argument that the recent agriculture commodity price boom had caused the increase in inflation. Chambers also stated that in order to bring the inflation rate down in the short-run, industries (such as agriculture) whose prices exhibit short-run, downward flexibility would be affected. The question he then posed was: “Can countries with strong agricultural bases afford to enact that?” Most people with an interest in farms would say no. With that argument accepted the question remained as to what the appropriate policy response is. Chambers stated that the answer laid in an increased government involvement in encouraging agricultural exports. However, Chambers noted that increased government involvement was ironic since tight monetary policy was usually correlated with a decreased willingness of the government to become involved in the marketplace.

Batten and Belongia (1984) took a different approach than other studies that had been done over exchange rates. They isolated the marginal impact of the exchange rate on trade, holding constant all other factors that effected export flows. Batten and Belongia asserted that past studies had simply compared exchange rates and exports. Instead, they stated that differences between the nominal and real exchange rates must be taken into account. In their study, tabular data for the 1981-1983 period indicated no consistent pattern between changes in the real value of the dollar and imports of U.S. agricultural commodities by foreign countries. Overall their analysis suggested a weak link between U.S. money growth and real exchange rates. The foregoing indicated that foreign income, not exchange rates, was the primary determinant of agricultural exports.

In 1986 Batten and Belongia took another look, similar to Chambers and Chambers and Just, at the relationship between monetary policy, the exchange rate, and agricultural exports. From their point of view, several past papers had linked the influence of the exchange rate on agricultural exports. The general belief was that a stronger U.S. dollar put a burden on export industries. While Batten and Belongia agreed with the link between the exchange rate and agricultural exports they attempted to look at the magnitude and short-run effects of this relationship by identifying policy variables that could be used to decrease the value of the dollar if this were a desirable effect. They found that there was little question whether the real value of the dollar had contributed to the reduced volume of U.S. exports since 1981. However, they noted that the answer to the relative, normative problem of identifying policy variables that could decrease the value of the dollar was not clear at all. They stated that the inference to be made from their inconclusive results was that attributions of the decline in farm exports to monetary policy or the deficit were difficult to support empirically.

Grigsby and Arnade (1986) took on a different view in the study of exchange rate effects on domestic prices. Their study looked at the consequences of exchange rate policies in competitor countries, specifically Argentina. They were a large competitor with the U.S. in wheat and other course grains, as well as soybeans. Additionally, many U.S. competitors used a floating exchange rate; however, Argentina did not. The authors also believed it would be easier to identify Argentina's exchange rate distortions, since it was not a floating exchange rate. There were two objectives in the study: (1) examine how Argentina's distorted exchange rates influenced domestic and world prices and its competitive position in export markets and (2) examine how distorted exchange rates could result in a divergence between competitiveness and comparative advantage. Argentina utilized a different exchange rate for its commodity exports, rather than the "official" exchange rate used for other foreign transactions. They found that Argentina's distorted exchange rates enhanced the magnitude of world demand shocks on export prices, increasing or decreasing the competitiveness of their grain exports, depending on the policy objective. The distorted exchange rates also reduced domestic price variability. Ultimately, the degree of price and quantity changes depended on domestic and world supply and demand elasticities in retail and production markets.

Grigsby and Arnade then went on to address Argentina's competitive position. Argentina's exchange rate policy affected a commodity export's price competitiveness and comparative advantage without changing signals to producers. Lastly, changes in Argentina's price competitiveness had short-run domestic costs. Increased supply to the world came at the expense of domestic supplies in the short run. The authors believed changes in price competitiveness would reflect changes in comparative advantage. However, they also noted, exchange rate adjustments that kept domestic prices constant would cut off price signals to producers and would have consequences in the long run for increased productivity.

Schwartz (1986) looked at the exchange rate from a different perspective and answered a new question. She suggested that the world wheat market was not characterized by competitive trade. With the U.S. and Canada accounting for over half of the world's wheat exports, she believed the world market exhibited noncompetitive trade behavior. In her study, she considered how the effects of exchange rate and other certain macroeconomic changes differ in a competitive market versus a noncompetitive framework. Schwartz found that in a competitive market U.S. export revenues and volume would be more variable with greater volatility in exchange rates. However, in a noncompetitive market the possibility existed for large traders to mitigate some of the effects of exchange rate changes through their stockholding policies. Greater exchange rate variability increased the likelihood that traders would cooperate with each other less often, as well as if the dollar appreciated. If the dollar appreciated, the world price would approach the lower bound supported by the U.S. loan rate at the current exchange rate. Schwartz did point out that her analysis was highly simplified, but that it served as a starting point for additional research into the role of market structure in transmitting macroeconomic and exchange rate changes into sectoral price and trade effects.

Orden (1986) commented on the preceding three studies done by Battan and Belongia, Grigsby and Arnade, and Schwartz. Battan and Belongia wrote a paper challenging the reasoning that monetary and fiscal policies had substantial impacts on agriculture through their effects on the exchange rate. Orden believed that their empirical analysis fell short with respect to clarifying the effects of macroeconomic policies on international capital and commodity markets. Fundamentally, he thought they viewed three issues from too narrow a perspective. The first issue was that they restricted their observations on money growth and the value of the dollar to the period since 1980. Their association of high money growth and depreciation of the dollar was also consistent with observations in the 1970s. The second issue was that they examine money growth almost without any other considerations. Battan and Belongia believed that their figure “clearly” showed that U.S. monetary policy had not been restrictive since 1980. Orden argued that comparing money growth before and after 1980 is misleading. He noted that there were major shifts in the configuration of monetary and fiscal policy during the 1980s compared to earlier years. Orden stated that an appropriate measure of the tightness of monetary policy would account for the change in the role of money in that context. The final and third sense in which Battan and Belongia’s paper was too narrow, as viewed by

Orden, was overreliance on the notion of long-run purchasing power parity (PPP). They failed to recognize the potential magnitude and persistence of various policy and non-policy factors - shifters of the real exchange rate. Battan and Belongia also asserted that current and lagged trade deficits "should" cause a currency to depreciate. However, Orden believed that this ignored the voluntary capital inflows associated with trade deficits. He also stated these inflows may persist for a long period of time. Finally, turning from Battan and Belongia, Orden criticized Grigsby and Arnade. Orden's first criticism was Grigsby and Arnade's distinction between competitive and comparative advantage. Grigsby and Arnade emphasized a distinction between competitiveness and comparative advantage based on short-run effects on consumption and exports versus determination of the level of supply. As opposed to Grigsby and Arnade, Orden thought policy-induced distortions would keep a country from being competitive in the world market, despite its inherent comparative advantage. Additionally, he found troublesome the central role assigned to revenue maximizing traders and the strictly concave marketing possibilities frontier. Orden's last condemnation was made on Schwartz. He found Schwartz's caveats on complicated issues such as cross-price effects, input prices, the distinction between traded and non-traded goods, shifts in consumption expenditures from surplus to debtor nations, and market asset linkages to be too informal. He also believed the framework of analysis applied to exchange rate impacts on agricultural markets to be highly simplified. Praise was given over two points, though. The first point was the illustration that intervention can insulate markets from exogenous shocks, similar to a basic point made by Grigsby and Arnade. The second point receiving praise was that exchange rate movements made market intervention schemes difficult to enforce. Orden found these to be interesting points that had the potential for development.

Pagoulatos (1986) also commented on the studies done by Batten and Belongia, Grigsby and Arnade, and Schwartz. In his eyes, Batten and Belongia's important contribution from their approach was in placing the real exchange rate and its determinants at the center of attention in the debate over agricultural exports. However, Pagoulatos believed there were several problems with their statistical analysis which limits the usefulness of their empirical conclusions. Pagoulatos' first problem was with the specification of equation two, the real exchange rate equation. The author pointed out that theory suggests that real exchange rates are best interpreted as deviations from purchasing power parity. Deviations from the PPP have been explained by the real shocks, productivity differentials, inflationary expectations, and unanticipated money growth. Pagoulatos believed that Batten and Belongia treated the above factors too casually when they used them as a proxy for real interest rate differentials and the current account balance in their estimating equation. Pagoulatos also had problems with their use of *ex post* real interest rates with no concern about expected inflation. An additional issue was their treatment of money and GNP growth acceleration as synonymous with "unanticipated" changes of these variables. He found the lack of theoretical justification "equally disturbing" for including the cumulative federal government deficit and the private saving-investment differential. Furthermore, he was uneasy with their lack of concern for the potential presence of autocorrelation as suggested by the low Durbin-

Watson statistics. Due to the limitations in Batten and Belongia's paper, Pagoulatos believed their results could not be used conclusively. Next, Pagoulatos turned his attention to Schwartz. In her paper, Schwartz presented a few different hypotheses regarding the strategies of Canada and the United States under the floating exchange rate system. While Pagoulatos thought the hypotheses were intriguing and merited further empirical testing, he would have preferred more discussion of the validity of the non-competitiveness assumption in the world wheat markets. Lastly, Pagoulatos turned his attention to research done by Grigsby and Arnade. His complaint about their research was simple: they did not test their hypothesis on Argentina, the country evaluated in their paper. Pagoulatos concluded that the three papers stimulated interest in the subject matter, but that there was still a great amount of work to be done.

Nearly ten years of research had been done on exchange rates, but Rausser, Chalfant, Love, and Stamoulis (1986) delved into a new research on the exchange rate that had not yet been conducted. They simulated the impact of subsidies and taxes on wheat, feed grains, corn, and livestock using quarterly data from 1984-1986 by using a short-run econometric model. They stated that exports played a major role in transmitting the effects of macroeconomic/monetary fiscal policy to the agricultural sector. Moreover, wheat was far more sensitive to exchange rate movements than feed grains. This was because a greater quantity of it was exported than feed grains. They also found that long-run agricultural policy played a larger role in resource allocation decisions than did macroeconomic policies. Additionally, the authors believed that the failure to adapt to new macroeconomic developments was an additional shortcoming of the agricultural policy process.

Bessler (1986) looked outside the United States for his research and used a vector autoregression (VAR) model to investigate the dynamic relationships between Brazilian agricultural prices, industrial prices, and the money supply. The model used in the paper suggested a causal relationship between money and agricultural prices with no direct feedback; however, a feedback relationship was suggested between money and industrial prices. The causal relationships were found to be positive, as expected. Additionally, the dynamic lags in the study were shorter than those found in a study done by Barnett on the United States. Relative prices adjusted at lags of one to two months in Bessler's study as compared to Barnett who found dynamic lags of four to six months. The fact that different methods and definitions were used in the studies could account for some of the differences in lags. Also, the Brazilian economy during the time of study had been operating under significant growth rates in money and prices for much longer than the U.S. economy, or perhaps economic agents in Brazil had learned to adjust more quickly than those in the U.S.

Bessler and Babula (1987) continued work on exchange rates by studying the effect of exchange rates on wheat price, sales, and shipments. In the study, Bessler and Babula used Akaike's final prediction error (FPE) and prior information on rank of importance of manipulated variables to identify a vector autoregression. Their results found that exchange rates adjust real purchasing power, which had no real effect. Accordingly, sales and shipments of agricultural products could not be expected to respond to changes in the exchange rate. Additionally, they discovered that wheat sales and shipments could be forecasted as well or even better by leaving out the exchange rate in the model specification. Lastly, they did find that under an unrestricted vector autoregression wheat prices responded substantially to shocks in the real exchange rate. This indicated real exchange rates do have an effect on wheat prices.

In 1987 Haley and Krissoff, prompted by the decline throughout the eighties of U.S. grain exports tested whether changes in the value of the dollar inversely affected grain exports in the 1973-1985 period. They based their analysis on a partial equilibrium model of the world grain market, deriving reduced-form equations from structural equations. The authors believed the exchange rate and domestic policy instruments would only affect grain export levels after a considerable lag. It was noted that it was hard to determine when the exchange rate began to affect grain export volume because of the high degree of collinearity within each of the exchange rate series. To account for this, a polynomial degree restriction was placed on the impact of the variables within the series. The polynomial specification smoothed the impact of the exchange rate change on export volume over the lag period, and the degrees of freedom increased. The evidence suggested that exchange rate changes affected wheat exports only over a long lag of 10-12 quarters. It is also suggested that exchange rate variations affects feed grain exports within the first year of the change in the exchange rate.

Devadoss and Meyers (1987) revisited the dynamic responses of farm output prices and farm input or nonfarm output prices to a change in money supply. Bordo and Cairnes were the first to look at this problem, later followed by Bessler. Bessler’s results for the Brazilian economy were inconsistent with the results found earlier by Bordo and Cairnes for the United States and other countries. Devadoss and Meyers used the same approach - vector autoregression (VAR) - for the United States economy as Bessler did for the Brazilian economy. They also used the Monte-Carlo integration method, which generates standard errors of the impulse responses, to test the significance of the impulse responses generated by the VAR technique. The results strongly supported the Cairnes-Bordo theory that agricultural product prices respond faster to a change in money supply than manufactured product prices. Their findings were also consistent with earlier studies, with the exception of Bessler. Furthermore, the results were consistent with macroeconomic theory that positive money supply shocks affect relative prices in favor of producers of nondurable goods, such as agricultural commodities, traded in flex-price markets. Consequently, the authors concluded that the non-neutral effect of positive money supply shocks on relative prices benefited farmers because farm product prices increased relatively more than nonfarm product prices.

Orden and Fackler (1989) elaborated on and discussed the structural interpretation of VAR models used to evaluate macroeconomic impacts on agriculture. Their analysis was used to examine monetary impacts on agricultural prices. Generally, they found there were few good reasons to restrict attention to VAR models with a recursive structure and many good reasons not to do so. Specifically, they found reasons to be cautious about recursive models and derive more sensible results from a model with simultaneity in which behavioral shocks were not associated with the equations for specific variables, such as was done with recursive models. With respect to the impacts of monetary policy on agricultural prices, identifying policy shocks with the quantity of money variable, to them, seemed particularly inappropriate for their sample period. They thought if a recursive structure was imposed, it would be more reasonable to identify shocks to the interest rate with monetary policy.

Taylor and Spriggs, (1989) continued the work on exchange rates and studied the effects of the monetary macro-economy on Canadian agricultural prices. The authors defined two specific objectives for their paper. The first was to determine the relative importance of macro-economic variables in agricultural price instability. The variables were the U.S./world exchange rate, the Canada/U.S. exchange rate, and the domestic money supply. The second objective was in a Canadian context, and that was to test whether agricultural prices responded faster or slower to monetary shocks than manufacturers prices. After constructing a VAR model, the forecast error for each for variable was computed. From there, a decomposition of the forecast error variance was used to determine whether any of the instability in agricultural prices was due to random shocks occurring in the macro-economic variables. Additionally, it was used to indicate when macroeconomic variables had the greatest impact on the variability of agricultural prices and to what degree. The results of their study indicated that of the three monetary variables evaluated the variation in the status of the U.S. dollar against world currencies contributed the most to Canadian agricultural price instability. In answering their second objective Taylor and Spriggs gave supporting evidence of earlier work done by Bordo and Frankel. Taylor and Spriggs' analysis suggested that agricultural prices responded more rapidly to a monetary shock in the short run. However, this was offset by a more rapid response of manufacturer's responses in later periods. This analysis supported the hypothesis of long-run neutrality of money.

Robertson and Orden, (1990) on a common note with Taylor and Spriggs, were concerned with long-run money neutrality. They analyzed jointly, using a Vector Error Correction (VEC) model, the long-run and short-run empirical behavior of quarterly levels of money, agricultural prices, and manufacturing prices in New Zealand for the period 1963:1 – 1987:1. The authors hypothesized long-run money neutrality and believed it was empirically supported through their research. Supporting evidence included: (1) that tests for stationarity failed to reject a unit root in autoregressive models of the individual series for money, agricultural prices, and manufacturing prices, (2) that the money and price series also seemed to be cointegrated, with parameter estimates from unrestricted cointegration regressions close to unity, and (3) when proportionality among levels of money and prices was imposed on the cointegrating regressions, the evidence was weaker, but the restricted error-correction terms (residuals) also appeared stationary. The authors also found that monetary shocks raised the levels of prices in the long run. Agricultural prices responded more quickly than manufacturing prices, but there was no evidence that agricultural prices rose proportionately more than the money supply or that they overshoot their long-run levels in the short run. Shocks to manufacturing prices induced monetary expansions and placed agriculture in a short-run cost-price squeeze, while levels of the money supply and manufacturing prices had not responded to fluctuations in agricultural prices. No evidence was found that policy reforms had altered the dynamic patterns among money and prices through 1987:1.

Bradshaw and Orden (1990) extended the work of Bessler and Babula by conducting an in-sample and out-of-sample Granger causality test to determine whether or not the real trade-weighted agricultural exchange rate helped to predict monthly real prices and export sales for corn, wheat, and soybeans. For each variable they specified an ARIMA model, alternative univariate and bivariate autoregressive models, as well as a restricted bivariate autoregressive model based upon Hsiao's procedure. In their results they found that model specification (how the lag length was chosen) as well as the choice between in-sample and out-of-sample was important in determining whether or not Granger causality was detected from the exchange rate to export sales of wheat, corn, and soybeans. In using the Ashley, Granger, and Schmalensee (AGS) procedure for the in-sample to compare the best univariate and bivariate models Granger causality from the exchange rate to the variables was supported, with reasonable levels of significance. The authors did note, however, that the evidence from the comparison of the best forecasting models for Granger causality was less conclusive than when comparing the exchange rate to export sales. The out-of-sample Granger causality tests indicated an absence of short-run purchasing power parity where movements in the real exchange rate had real effects. Bradshaw and Orden's results overall indicated a place for the exchange rate in predicting agricultural prices.

In the Agricultural Outlook bulletin from October 1990 the Economic Research Service (ERS) of the United States Department of Agriculture (USDA) studied the relationship between oil and agricultural chemical and fertilizer prices. Using a VAR model it was estimated that agricultural chemical and fertilizer prices would rise by about one-fourth of the percentage increase in crude oil prices, and that the increases would be spread over 24 to 28 months. It was noted that oil, also affected by the exchange rate had an additional impact on agricultural oil-based inputs and their prices for lengthy time periods.

Unlike others, Carter, Gray, and Furtan (1990) examined the effect of the exchange rate on inputs and outputs that were both tradable. They used an ordinary least squares model to estimate exchange rate pass-through for Canadian agriculture. In the study they found that exchange rate pass-through was significant on major input variables in Canadian agriculture. However, they believed they could be explained by institutional factors. The major conclusion from the paper was that both input and commodity prices are affected by the exchange rate. It is believed that this may reduce the short-run effect of exchange rates (wheat producers in this case) or even reverse the impact (as in the case of feeder cattle). With the large pass-through rate that was found there was only a small impact on the quantity of grain produced. The small production impact reduced the impact of agricultural trade in determining exchange rates.

Fuller et al., (1991) in a slightly different light, researched the spring onion market, specifically developing a simultaneous equation model to analyze the forces affecting the onion producing sector in Texas. The research centered on factors affecting spring onion production and prices in Texas, imports of onions from Mexico, and onion production and prices in Mexico. In the model each country's excess demand and supply function and variables relating to the exchange rate, the real tariff, and a U.S. policy variable for the 1976-1985 period were included. The factors hypothesized to affect the variables were late summer onion production, exchange rates, onion exports from the United States, incomes of the Mexican and United States populations, tariffs, and the variety of onions marketed by Texas producers. Among their many conclusions they found that the devaluation of the peso encouraged onion imports from Mexico, especially after the peso was allowed to float relative to the dollar in 1982.

Policies are rarely directed towards the U.S. beef industry. Generally, policies designed for crops, then used as inputs into beef, influence the beef industry. Henry, Peterson, Bessler, and Farris (1993) used a time-series model to analyze the effects of agricultural policies on the U.S. beef cattle industry, including both direct policies, such as the beef import quota, and feed grain and dairy policies that may indirectly affect the beef industry. The authors did note that using a VAR Bayesian model had limitations, but still proved useful for research. In their first experiment, the Dairy Termination Program (DTP) was found to only have a modest affect on the beef industry. There was a substantial fall in prices at the onset of the program, but beef prices and production returned to levels suggested by the unconditioned forecasts almost immediately following the shock. They also found that the effect from varying the beef import quota was relatively small. On the other hand, differences in policies affecting corn prices not only lead to large changes in prices and cattle numbers, but also generated wide oscillations in the cyclical evolution of the variables.

Babula, Ruppel, and Bessler, (1995) following earlier work of Bessler and Babula, tried to discern whether exchange rates had elicited systematic responses in U.S. corn prices, sales and shipments, and whether the dynamic transmission mechanisms tying the variables together changed over time. A VAR model was used on monthly prices for real exchange rates, real corn prices, corn export sales, and corn export shipments for the U.S. No cointegration was found between exchange rates, prices, sales, and shipments of corn. However, any influences they found of these variables were only in the short-run. They believed if there was a change in the exchange rate it would affect prices and sales in the short-run, but the new price would not be able to support the sales level because there was no underlying equilibrium. The point being, that policy analysts who were looking to get the exchange rate for agriculture "right" would likely be continually frustrated.

In 1996 Dorfman and Lastrapes reinvestigated the issue of how agricultural prices responded to monetary policy relative to the general price level, while adding depth and robustness to earlier work done by Chambers, Chambers and Just, Orden, and Rausser et al. Dorfman and Lastrapes first identified the variables' responses to shocks, with the help of theoretically based, long-run economic restrictions. For this study in particular, the restriction was long-run money neutrality. Under this imposition, agriculture could neither gain nor suffer from the effects of long-run monetary policy. This was because farm prices were constrained not to be influenced by money-supply shocks for an infinite horizon. However, farm prices could respond to monetary policy at a different rate than the price index, in the short-run. This provided for a monetary expansion to produce a short-term cost/price expansion which could have been beneficial for the agricultural sector, or a cost/price squeeze that could have harmed agriculture. Second, Bayesian methods were taken to model specification, which allowed for derivation of a posterior distribution of impulse responses. This integrated model uncertainty and added robustness to the results. Third, agricultural prices were separated into crop and livestock subsets to examine their responses. Their results generally showed that in the short run agriculture benefited from expansionary monetary policies. Livestock prices exhibited a strong positive response to money-supply shocks on impact, while crop prices had a very small initial positive response. However, crop prices gradually rose and took longer to fully adjust than livestock prices.

Espinoza, Fuller, and Malaga, (1998) similar to Fuller et al. in 1991, estimated a price equilibrium econometric simulation model representing the melon sectors of the U.S., Mexico, and Caribbean nations to analyze the primary economic forces influencing Mexico's competitiveness in the U.S. winter melon market. The economic variables were the peso/dollar exchange rate, relaxation of U.S. melon tariffs under provisions of the NAFTA, and accelerated growth rates in Mexico's per capita income, agricultural wages and melon yields. A three-stage least squares was used to estimate model parameters for the econometric model. They found, in the short-run, devaluation of the peso and an accelerated rate of growth in melon yields had the greatest impact on Mexico's export opportunities. However, in the long-run, these one-time devaluations tended to dissipate. For developing nations wishing to compete in U.S. horticulture markets, the adoption of yield-enhancing technology was the most important factor in increasing export opportunities.

Agricultural products produced in the U.S. are often exported, but before the products are ever produced a portion of the inputs for the commodity are imported.

According to Knutson, Penn, and Flinchbaugh (1988) before mechanical power was developed, purchased inputs accounted for less than 50 percent of cash receipts. Since 1980, nearly 75 percent of cash receipts have gone to purchased inputs. This has made agriculture more vulnerable with respect to inflation and to financial risk. Four macroeconomic variables have had a particularly pronounced impact on agriculture: (1) income growth, (2) inflation rate, (3) interest rate, and (4) value of the dollar.

Kapombe and Colyer (1999) examined the livestock sector; however, their study was not similar to the one done by Henry, Peterson, Bessler, and Farris. Kapombe and Colyer used a structural time series model to determine the dynamic characteristics, forecasting properties, and policy implications affecting the U.S. broiler export market with a specific look at how international markets responded. The analysis indicated that the broiler export market was very sensitive to changes in the real exchange rate and trade distortion policies. This suggested that the U.S. could increase boiler exports by extending efforts on international macroeconomic policy coordination, as opposed to depending strictly on domestic sectoral policies, and working toward elimination of trade distortion policies through NAFTA, GATT, and other trade negotiations.

In 2000, Barichello, unlike previous studies, evaluated the effect of currency depreciation on trade flows, specifically the depreciation that occurred in Indonesia during 1997 and 1998. Because there were so many factors working simultaneously it was hard to evaluate the change in trade flows. Barichello stated that a better data set would be needed to build an appropriate model. It was noted that the data appeared to show a gradual and extended decrease in import flows for agriculture, particularly wheat, until the end of 1998. The reason cited was agriculture had little demand for imported raw imports and was, therefore, able to have increased export production.

Lamb (2000), from the point of view of a producer and consumer, examined whether food crops or export crops in Africa were substitutes in production during the short run. A structural econometric method considering the demand for and supply of food and export crops was used. Lamb considered two cases: (1) the case of a farmer who chose between producing export crops or food crops to be consumed domestically and (2) a consumer who purchased both domestic and imported foods. The cross-price elasticities for food and export supply functions were found to be statistically significant. This indicated that food and export crops were substitutes in production for African agriculture. The evidence also proved that while aggregate agricultural output responded positively to increases in food prices, it responded negatively to increases in export prices, in the short run. Lamb believed an explanation for this was that increases in export prices lead farmers to shift resources into production of export crops, away from food crops. While the impact to food crops was immediate the impact to export crops was slow due to production lags occurring in export crops. Additionally, a persistent and robust negative relationship was found between the exchange rate and aggregate agricultural output, even when conditioned on export and food prices. This suggested a number of different things. The exchange rate may have acted as a proxy for other, unexplained macroeconomic variables, and the effects of adjustment on those variables were leading to a positive effect on agricultural output. Another was that changes in the exchange rate were not fully passed through to prices immediately.

In the Agricultural Outlook (USDA ERS, 2001) for January/February 2001 they asserted that historically, movements in exchange rates have accounted for approximately 25 percent of the change in U.S. agricultural export value. They also believed that in the previous five years the appreciation of the U.S. dollar had become a handicap for U.S. agricultural exports. The reason cited for the appreciation of the dollar was the international financial crisis that occurred from 1997-1999. In a closing note they stated that the "value" of the dollar became more complex when considering overall U.S. agricultural exports or even a single commodity because each commodity was generally exported to several countries.

In 2002, Xu and Orden replicated and extended the dynamic econometric analysis of Carter, Gray, and Furtan. The study was extended to evaluate short-run and long-run exchange rate pass-through and the Law of One Price (LOP) for five traded farm outputs (wheat, soybeans, corn, feeder steers, and slaughter steers) and four traded non-farm-produced inputs (fertilizer, pesticides, petroleum, and farm machinery) for the 1975-1999 period. Xu and Orden's findings generally confirmed the work done by Carter, Gray, and Furtan. The author's empirical findings confirmed that short-run adjustments to the LOP tended to occur for the five agricultural outputs and to a somewhat lesser extent for the three non-farm-produced intermediate inputs, while the LOP was refuted for farm machinery. Evidence that the LOP held more strongly for farm outputs than for non-farm-produced inputs suggested that an exchange rate depreciation did not have a full impact on agricultural input markets and affected output prices to a greater extent. Since the LOP did not hold for Canada or the U.S. for all traded non-farm-produced inputs either in the short-run or the long-run, the input price increases associated with a devaluation would not completely offset an increase in output price.

Cho, Sheldon, and McCorriston (2002) studied the effect of medium to long-run exchange rate uncertainty, which had not been evaluated, on agricultural trade and compared the impact on agricultural trade relative to other sectors. The data used were bilateral trade flows for ten developed countries between 1974 and 1995. The aggregate trade flow data was separated into trade in agricultural products, machinery, chemicals, and other manufacturing. A gravity model was applied to the data, allowing for cross-country determinants of trade including income, distance, membership of customs unions, common borders, and exchange rate uncertainty, among others. Additionally, they used panel data which allowed them to capture changes in variables over time such as income and changes in exchange rate uncertainty. The authors found a clear conclusion: compared to other sectors, agricultural trade has been more adversely affected by medium to long-run uncertainty in real exchange rates. The authors made note that short-run volatility could be hedged, and, therefore, it was long-run variability in exchange rates that mattered. This notion implied that if long-run variability was a function of the deviation of nominal exchange rates from underlying fundamentals, then macroeconomic policy may have a key role in influencing trade flows. The evidence they reported suggested that agricultural trade was more susceptible to exchange rate uncertainty than aggregate data would have suggested and that the negative effects on the growth of trade had a stronger effect on trade in agricultural goods than when compared with other sectors. It was shown that these results of trade flows are not just applicable to the U.S., but to other developed countries as well.

Taking on a new challenge in 2006, Shane, Roe, and Somwaru estimated the effect of trade partner income and real trade-weighted exchange rates on U.S. agricultural exports. The authors used a Ramsey style general equilibrium framework to derive the specification of the empirical model. The authors concluded that the real trade-weighted exchange rate and trade partner income were key determinants of U.S. agricultural exports. The trade data suggested that bulk commodities tended to be exported to lower income countries than did the higher valued commodities such as fresh fruit and red meat. For the 1972-2003 period, a one percent annual increase in trade partners' income was found to increase total agricultural exports by about 1.6 percent, while a one percent appreciation of the dollar relative to trade partners' real trade-weighted exchange rate decreased total agricultural exports by about 0.8 percent. The authors also found from a decomposition analysis that the negative effect of exchange rate appreciation on exports often dominated the positive effect from income growth. Most historical increases in agricultural exports were associated with income growth, whereas most of the declines in exports were associated with an appreciation of the U.S. trade-weighted exchange rate. The same analysis also showed that the income effect had tended to dampen over time. This dampening effect allowed the appreciation of the exchange rate to dominate the income effect, particularly for bulk commodities.

In an approach on imported inputs, rather than exports, Yeboah, Shaik, and Allen (2009) looked at the effects of the U.S. dollar versus Mexican peso exchange rate on the prices of four inputs, fertilizer, chemicals, farm machinery, and feed. Unit root tests and the four input price ratios supported the presence of unit roots with a trend model. However, after testing a first difference model the presence of unit roots was rejected. A vector autoregression (VAR) model in seemingly unrelated regression (SUR) framework was used to account for unit roots as well as to evaluate the importance of exchange rates on the inputs. Heteroskedasticity and autocorrelation were also tested in the model. It was concluded that even after five quarters short-run adjustments to the Law of One Price did not occur. This result was consistent with other conceptual frameworks that industrial prices are more likely to be unresponsive to the exchange rate than farm commodity prices.

Somewhat similar to the Agricultural Outlook bulletin of October 1990 Harri, Nalley, and Hudson (2009) examined the relationship of price throughout time of agricultural commodities, oil prices, and exchange rates. A Johansen model, which was a p-dimensional, k^{th} order VAR-model, was used to evaluate the relationships. Generally, it was found that commodity prices were linked to oil for corn, cotton, and soybeans, but not for wheat. Furthermore, it was found that exchange rates did play a role over time in the linkage of prices. The findings indicated that the strength of the relationship between corn and oil has increased over time, as well as the fact that they are interrelated. They believe conventional risk management strategies should be reevaluated as they may not work as well as before because of the change in the relationship between output (corn) prices and input prices (crude oil).

A consideration to take into account in this research is that it was conducted around the time the renewable fuel standard (RFS) became mandated. It is still too early to see, but in a few years it would interesting to see if the relationship still held for corn and crude oil when the RFS is either more or less binding, as Rosson also suggests.

In a discussion over this paper, Rosson (2009) commented that this research may indicate that as the constraints on corn use in the RFS in the 2007 Energy Bill become more binding, that the new linkage found between oil and corn will weaken. This in turn would lead to less upward pressure on corn prices and to less market volatility.

Again, looking at the short and long run, Baek and Koo (2009) studied how those effects played a role on changes in macroeconomic variables on U.S. farm income. Specifically they looked at interest rates, agricultural commodity prices, and exchange rates. In their study they used an autoregressive distributed lag (ARDL) approach to cointegration with quarterly data for the 1989-2008 time period. In the long run they found that the exchange rate has a negative relationship with farm income. This fit with the theory that a weaker dollar made U.S. agricultural commodities more competitive on the world market, therefore, the U.S. would export more. In turn, increased exports improved farm income. On the flip side, they found that in the short-run the exchange rate was not statistically significant, even at the 10% level. This indicated that the exchange rate had little effect in the short run on U.S. farm income.

Exchange Rate Pass-Through

In 1990, Kim studied the historical response of the price of U.S. non-oil merchandise imports to the exchange rate using quarterly data from 1968 through 1986. A varying-parameter model was used to estimate the import-price function. There was no strong evidence that the short-run direct effect of exchange rate changes on the U.S. import price declined in the 1980s. However, the results suggested that the import price became relatively more sensitive to exchange rate changes when industrial countries were included in weighting exchange rates and costs. Also, a dollar appreciation tended to cause a smaller decline in U.S. import prices due to a larger associated increase in foreign costs. The article confirmed the general notion that international price linkage would become more loosened with exchange rate floating and the degree of exchange rate fluctuations.

In 1996, Gron and Swenson stated that many people had been interested in the extent to which product prices responded to exchange-rate-induced changes in cost. However, they pointed out that some past empirical facts may have reflected the sale of products whose production occurred in multiple locations. In addition, it was noted that when firms were able to shift their production across borders or alter their location of sourcing, their costs did not change one-for-one with exchange rate movements. Therefore, in their study, they estimated exchange rate pass-through while controlling for local production in destination markets. While they focused on the U.S. automobile market there may also be implications for the fertilizer and petroleum industries where companies have production in both the U.S. and abroad. Gron and Swenson's results showed that while accounting for local production increases the estimate of exchange-rate pass-through, incomplete pass-through still remains. Additionally, prices responded similarly to cost changes for inputs from the country's home country and for input costs from other countries. Lastly, the results indicated that the ability to produce in multiple locations gave firms more flexibility to adjust to changes in input prices, which resulted in a smaller price response.

Looking at the base of it all, Kardasz and Stollery (2001) examined the determinants of the pass-through of exchange rate changes into both domestic and import prices for a broad sample of Canadian manufacturing industries, as well as the industries' responses to exchange rate changes. Their study was based on a Cournot model that allowed for product differentiation between domestic and imported goods. Their data set covered the 1972-1989 time period. The results showed that, on average, a 10 percent depreciation of the Canadian dollar raised the price of imports by 2.55 percent and the price of domestically produced goods by about half that amount. They also found that domestic production costs and the Canadian dollar price of Canadian exports were important channels through which the exchange rate affected the prices of domestically produced goods. Furthermore, they found industry values of the pass-through elasticities for domestic goods increased with the elasticity of substitution between imports and these domestic goods and with the advertising intensity of domestic producers, but not with both at the same time. The exchange rate pass-through elasticity for imports tended to be high in industries where the elasticity of substitution between imports and domestic goods and the rate of price protection were high and where the advertising intensity of domestic producers was low. Lastly, the authors noted that while these results held for Canadian manufacturing industries that they do not necessarily match economic theory.

Comparisons with other, earlier empirical studies suggested that the results may not generalize across time or with different countries.

Campa and Goldberg (2005) was another pair who took up the issue of exchange rate pass-through. Using quarterly data from 1975 through 2003 they estimated pass-through elasticities and their effects on import prices for 23 Organization for Economic Cooperation and Development (OECD) countries. For their estimation a log linear regression specification was used. The authors found, as an average across the OECD countries, that import prices in local currencies reflect 46% of exchange rate fluctuations in the short run and 64% over the longer term. The U.S. had among the lowest pass-through rates to import prices in the OECD, at approximately 23% in the short-run and 42% over the longer run. It was noted that pass-through into import prices is lower for countries with low average inflation and low exchange rate variability. Also, the pass-through of exchange rate changes into food and agricultural products was not statistically different from that into manufacturing.

Sekine, in 2006, took a different approach than others in his study and looked at the issue of exchange-rate pass-through to domestic prices and whether and why it has declined. The author estimated the development of pass-through coefficients for six major industrial nations (the United States, Japan, Germany, the United Kingdom, France, and Italy) by taking into account their time-varying natures. This was not frequently done in earlier studies, instead rolling regressions were often used which were based on the assumption that the underlying parameters did not change within the sample periods. In this study pass-through was divided into two stages. The first was the effect of the exchange rate on import prices ("first-stage" pass-through) and the second was the effect of import price movements on consumer price ("second-stage" pass-through). To estimate the pass-throughs a simple specification, single equation analysis, no cointegration relationship, symmetric linear model, was used. These standard specifications were derived from a partial equilibrium setup. For first-stage pass-through it was confirmed that not only long-run exchange rate pass-through, but also impacts of commodity prices fluctuation have become smaller. This implied that import prices of industrial countries have become more resilient to external shocks of foreign exchange rates and commodity prices. Also, a decline in the volatility seemed to reflect the fact that in the past decade there was no major shock comparable to those observed with the two oil crises. Since this study was done in 2006 it does not include the oil crisis of 2008. It would be interesting to see how that oil crisis affected volatility and if levels returned to those seen in previous oil crises.

In second-stage pass-through it was shown that consumer prices have become less responsive to movement in import prices in major industrial countries. Simultaneously, the level and volatility of consumer prices inflation have declined. Both the first- and second-stage pass-throughs changes were statistically significant and economically non-negligible. For example, with the U.S., when the two pass-throughs were combined, the long-run responsiveness of consumer prices to a 10% exchange rate fluctuation declined from 0.4 percentage points to almost zilch.

In 2007, Marazzi and Sheets studied to what extent movements in the exchange rate and in foreign firms' production costs are reflected in changes in U.S. import prices.

To do this, they used the framework of an empirical analog of a traditional mark-up pricing model. The authors asserted they had provided new evidence documenting a decline in exchange rate pass-through to U.S. import prices, from well above 0.5 in the 1970s and 1980s to somewhere around 0.2 over the past decade. The work done pointed to a number of corresponding explanations for the decline in exchange rate pass-through. They first found evidence that the reduced import share of material-intensive goods, the prices of which are more sensitive to exchange rates (once indirect effects through commodity prices are taken into account) – explains a portion of the fall in the aggregate exchange rate pass-through decline. Second, they believed, foreign exporters could increasingly be setting their prices while keeping a close watch on the behavior of U.S. domestic prices, which is consistent with "pricing to market". Third, was their belief that China's rising prominence in the U.S. market, as direct competition, as well as the threat of potential competition, had affected the pricing behavior of foreign exporters. This evidence, along with the author's observation of the pass-through coefficients stepping down around the time of the Asian financial crisis, brought to light a new hypothesis linking the decline in pass-through to the evolving nature of competition in global markets and structural changes in international patterns of production.

While the authors found a decline in exchange rate pass-through to U.S. import prices, consideration should be given to the results of the material-intensive goods industry, as it is more applicable to agricultural production. Material-intensive goods refer to non-oil industrial supplies and food and beverages.

In the material-intensive goods industry the pass-through estimates depended on whether or not the model controlled for commodity prices in the regressions. The estimates for pass-through fell rapidly when controls for commodity prices were included. On the other hand, when the controls were not included, the pass-through estimates were much higher and, if anything, increased in the years leading up to the study. Results such as those indicate that the exchange rate's effects on the prices of imported industrial supplies and foods and beverages have come principally through its indirect effect on commodity prices. Those findings are also consistent with the commodity-intensive nature of the goods. Agriculture remains a commodity-intensive industry so concern should be given to the relationship between it and the exchange rate, even if pass-through estimates appear to have declined overall for all imports.

In 2008, Goldberg and Hellerstein also picked up the subject of exchange rate pass-through. In their study they attempted to better understand the structural determinants of exchange rate pass-through. The authors used a static partial-equilibrium structural model. This exploited marginal and markup costs by examining the variation in the price data, which they believed to be caused by exchange rates, a source of large and plausibly exogenous price variation. The authors noted that several other studies had used a similar approach and applied it to several other industries, with general patterns emerging. The most notable one was that all studies found a large role for non-traded costs/imported inputs. Those two factors are estimated to contribute 50 to 78 percent to incomplete pass-through. Goldberg and Hellerstein also found that marginal costs (expressed in producer currency) strongly co-vary with exchange rates. This suggested that those marginal costs contain either imported inputs (denominated in a currency other than producer currency) or non-traded costs. Without multi-destinational data, however, they could not distinguish between imported inputs or non-traded costs. The authors did point out that recent work done by Gita Gopinath, Oleg Itskhoki, and Roberto Rigobon in 2007 documented low exchange rate pass-through at the dock in the U.S. Since prices at the dock did not contain non-traded costs the finding could be explained only by variable markups or imported inputs. The data used by Gopinath, Itskhoki, and Rigobon did not allow for distinction between the two explanations, but given the relatively small role attributed to markup adjustment in structural studies, the descriptive results were strongly suggestive of the importance of imported inputs. Lastly, Goldberg and Hellerstein stated that it would be desirable to integrate insights from the partial-equilibrium literature to general-equilibrium models that would inform monetary policy.

Engel (2009), in providing a discussion about exchange rate flexibility, commented on the relationship between exchange rates, imported inputs, and exports. He believed that the idea that a country with a large trade deficit experiencing a normal depreciation would play a significant role in equilibrating the trade balance was not supported. Engel pointed to two main problems. The first was that supposed economic behavior was not consistent with actual economic behavior. Secondly, the underlying presumption that exchange rates move to eliminate trade balances was not well grounded in theory and defies common sense observation. He cited three differences between traditional “models” and reality. The first was the well understood notion that short-run elasticities of import demand could be low. The second was that there is now a large body of empirical evidence of pricing to market and low pass-through of exchange rates to prices. The third consideration he believed might explain why current account balances overall, rather than imports, are not very responsive to exchange rates was that many export goods are produced using intermediate goods. Engel stated that a depreciation may increase the price of imported goods, but if those goods were inputs into the export sector, the country's competitiveness may not be strongly affected. He noted, putting together these three elements – low short-run elasticities, low pass-through, and imported intermediate goods – into a macroeconomic model calibrated to match Asian economies, concluding that a depreciation of the currency would have little effect (and possibly perverse effects) on the current account balance.

Summary

In the 1970's a significant debate started when Edward Schuh stated that the exchange rate played a large role in agriculture. Abundant theoretical arguments have been made along with empirical analyses, but there seems to be no absolute answer as to what role, magnitude or importance versus other factors, the exchange rate plays in agriculture. In large part, the research done with exchange rates and agriculture has been on prices and the effects on exports. The other relevant research has been on exchange rate pass-through in conjunction with many different industries.

The vector autoregression (VAR) model has been widely used for determining the impact of the exchange rate on a number of variables. For this research, a VAR model will be used. The use of a VAR model allows the variables to dictate the relationship between them. Additionally, it does not impose a possibly incorrect structure. The VAR will also allow for several different variables, in this case price variables, to be evaluated. Additionally, a VAR model is not as restrictive, which is good for this research since it has not been done before.

In the past ten years, 2001-2011, the landscape of agriculture has changed. The year 2008 brought record commodity prices, along with increased consumer concern. Renewable fuel standard mandates have changed, along with increases in quantity of imported inputs. These changes give increasing reason to take up the issue of the exchange rate and its effects again. Especially now, on how it passes from imported inputs through to exported products in the agricultural industry. Specifically, this has not been done before and will shed new light for policy making, as well as for producers. This research will combine the knowledge gained from research done on exchange rates and agriculture, as well as exchange rate pass-through to determine the effect of the exchange rate, at the producer level, on the corn, wheat, and beef cattle production systems.

CHAPTER III

METHODOLOGY

This thesis begins with the theoretical foundations used in the development of the empirical model. In this chapter, the theoretical underpinnings of the research and method of analysis are explained, while an empirical model for testing the hypothesis is developed.

Theoretical Model

The theoretical model for this thesis is illustrated by the four-panel diagram demonstrating the impacts of changes in exchange rates in Figure 6. Economic theory indicates that an appreciation (depreciation) in the exporter's currency or a depreciation (appreciation) in the importer's currency will have the same effect. A shift to the left (right) of the excess demand curve occurs, decreasing (increasing) quantity traded and price in the exporting country and increasing (decreasing) price in the importing country.

Price is the mechanism that causes industries to adjust to changes in exchange rates. However, multiple industries that eventually funnel into the agricultural sector and even different sectors of the agricultural industry, face changing exchange rates and prices. The critical question is: are some of these industries better or worse off with a weaker dollar?

The literature in Chapter II presents important variables for calculating the impact of exchange rates on exports and imports. They are: price of good imported, price of good exported, and the exchange rate.

This study examines the relationship between several commodities: corn, wheat, feeder steers, ethanol, diesel, ammonia, urea, di-ammonium phosphate, and exchange rates. All formulas are comprised of the price variables lagged one period through *k* periods. Corn price is represented by *Pc*, wheat by *Pw*, feeder steers by *Pb*, ethanol by *Pe*, diesel by *Pd*, ammonia by *Pa*, urea by *Pu*, and di-ammonium phosphate by *Pdap*. Exchange rate is represented by *R* which is an index of the exchange rate(s) between the U.S. and the currencies of major trading partners. The price of corn is modeled by:

$$Pc=f(R_{t-1}, R_{t-k}, Pd_{t-1}, Pd_{t-k}, Pu_{t-1}, Pu_{t-k}, Pe_{t-1}, Pe_{t-k}, Pa_{t-1}, Pa_{t-k}, Pdap_{t-1}, Pdap_{t-k}, Pc_{t-1}, Pc_{t-k})$$

Wheat price is modeled by:

$$Pw=f(R_{t-1}, R_{t-k}, Pd_{t-1}, Pd_{t-k}, Pa_{t-1}, Pa_{t-k}, Pdap_{t-1}, Pdap_{t-k}, Pu_{t-1}, Pu_{t-k}, Pw_{t-1}, Pw_{t-k})$$

The feeder cattle price is modeled by:

$$Pb=f(R_{t-1}, R_{t-k}, Pd_{t-1}, Pd_{t-k}, Pw_{t-1}, Pw_{t-k}, Pc_{t-1}, Pc_{t-k}, Pb_{t-1}, Pb_{t-k})$$

Empirical Model

Many of the studies presented in Chapter II used either an equilibrium displacement or time series model to determine the effect of exchange rate changes. Time series models have received criticism for their lack of economic structure. For example, constraints based on economic theory are not imposed on the model. Instead, time series techniques allow the data to describe the relationship between the variables. Regardless, time series and structural models are still related in economics research. This is because economic theory dictates what variables should be included in the model. This thesis will follow the basic premise of a time series model with the model estimation derived from economic theory.

Based on the literature, an appropriate method to estimate the effect of exchange rates on imported inputs and exports of the feeder cattle, corn, and wheat sectors is to use a vector autoregressive time series model with quarterly or monthly data. Bessler and Babula used a VAR model to study wheat price, sales, and shipments. They found total dollars of sales and volume of shipments did not respond to exchange rate changes because exchange rates adjust real purchasing power, having no real effect. However, under an unrestricted vector autoregression wheat prices responded substantially to shocks in the real exchange rate. Similarly, Babula, Ruppel, and Bessler used a combination of both time series and structural models to find that exchange rates do not influence corn exports, but do play a role in price. Bradshaw and Orden used a time series model to study the effectiveness of using the exchange rate in forecasting and found that it did have a place in predicting agricultural prices.

The basic procedure was to estimate the above equations as a standard vector autoregression (VAR) model. First, we tested for stationarity using the Dickey-Fuller test. It is important that the data are stationary because this indicates that the data return to its mean after a shock. If the data did not return to its mean then it would represent a "random walk" and we would run the risk of inferring spurious relationships among variables. The independent variable of a stationary series can be expressed as a linear function of its past and the weights of past coefficients. Additionally, the data's autocorrelation function declines as *k*, the number of lags, becomes large, tending towards zero. Lastly, if stationarity was not corrected for, statistical tests and inferences from the model estimation would be biased because the variances associated with the estimation would be inflated and the variance would go to infinity.

In general, if after the first differencing the data are still not stationary then they must continue to be adjusted in differences and lag lengths until stationarity is achieved. A standard T-test statistic was calculated and compared to the distributions tabulated by Dickey and Fuller to test whether the restrictions held. After testing for stationarity the data was transformed by the natural log. This was done so the results could be interpreted as an elasticity. For example, if there is a one standard deviation shock to the exchange rate we have a percentage response from the price of the commodity.

Next, the residuals for each price series were plotted. The graphs were evaluated and for variables with outliers the corresponding dates were examined to see if there was an event to cause the outlier to occur. For unusual events affecting the market, such as abnormal weather, a dummy variable was created. After creating dummy variables, a seasonal harmonic variable was created. In agriculture, cycles of a regular nature often occur. To account for both yearly and quarterly seasonal price cycles harmonic variables were created. They are represented by:

$$x=p*\cos(wt-\Theta) \tag{1}$$

$$x=p*\sin(wt-\Theta) \tag{2}$$

where: p = 1, the amplitude

Θ = 0, the phase displacement

T = the proportion of the year that has passed

w = how many cycles per period there are

The annual cycle is given by the formula:

(3) $$w(a)=(2\Pi)$$

With the quarterly cycle given by the formula:

(4) $$w(q)=(4*2\Pi)$$

The dummy variables were placed in with the price series data and used as a deterministic component in estimating the models. This was done to account for the outliers in the data, which if left in, would have unduly influenced the results.

Three different VAR models were estimated for corn, wheat, and feeder steers each. The first model used the annual and quarterly harmonic variables, accounting for a time trend in the data as a deterministic component. The second model used only annual harmonic variables while the third model did not incorporate harmonic variables. After estimating the models, the “best” model for corn, wheat, and feeder steers was chosen based on the Schwarz Bayesian Criterion (SBC) and the idea of parsimony. The idea of a parsimonious model is to use the smallest number of lags possible for adequate representation of the data. According to Enders, “the SBC will select a more parsimonious model than the AIC (Akaike Information Criterion)”(2010, 217). Therefore, it was decided that the SBC selection of a lag length structure would be used for this research. The multivariate generalization of this test statistic is represented by:

(5) $$\text{SBC: } (-2\ln(L))/T + (n\ln(T))/T$$

where: n = number of parameters estimated

T = number of usable observations

L = maximized value of the multivariate log likelihood function.

Between different models the more parsimonious model can also be selected by choosing the model that has the smallest SBC value. Upon the selection of the "best" model the SBC values were compared across lag lengths, selecting the lag that had the smallest value. The VAR model was also tested for the use of a constant in the deterministic component. A constant would account for a time trend in the data, if needed.

Upon choosing lag lengths block exogeneity was tested on diesel and the exchange rate together, as well as separately. A likelihood ratio test was used for testing block exogeneity in the three systems, corn, wheat, and feeder steers. Block-exogeneity tests are used for deciding whether to incorporate an additional variable into a VAR. It determines whether lags of one variable Granger cause any of the other variables in the system. The idea of Granger causality is a limited notion of causality where past values of one series (x_t) are useful for predicting future values of another series (y_t), after past values of y_t have been controlled for. For example, in a three-variable case with w_t, y_t, and z_t, the test is whether lags of one variable, say w_t, Granger cause either y_t or z_t to be equal to zero. Basically, the block exogeneity test restricts all lags of w_t in the y_t and z_t to be equal to zero. This cross-equation restriction is then tested using the likelihood ratio test, which is given by the formula:

(6) $$(T-c)(\ln|\Sigma_r| - \ln|\Sigma_u|)$$

where: T = number of observations

C = number of parameters estimated in each equation of the unrestricted system

$\text{Ln}|\Sigma_r|$ = the natural logarithm of the determinant of Σ_r, the restricted system

$\text{Ln}|\Sigma_u|$ = the natural logarithm of the determinant of Σ_u, the unrestricted system

Σ_u is calculated by estimating the *yt* and *zt* equations using lagged values of $\{y_t\}$, $\{z_t\}$, and $\{w_t\}$. To calculate Σ_r the equations must be estimated again excluding the lagged values of $\{w_t\}$. The statistic has a chi-squared distribution with degrees of freedom equal to the number of restrictions in the system. If the calculated value of the statistic is less than the chi-squared distribution at a ten percent significance level, we will not be able to reject the null hypothesis. The null hypothesis is that the exchange rate and diesel variables, jointly or separately, are exogeneous with respect to the price of the corn, wheat, or feeder steers systems.

With the completion and results of these tests the best VAR model was estimated. It was then decided that the data for each system should be evaluated over two different time periods. The decision to do this was based upon the idea that a structural change in the commodity markets had occurred. A rapid rise in commodity prices, especially corn, had been observed in late 2006. Therefore, the data were split into two sections, the first from the beginning of the data in 1997 through 2006 and the other from 2007 until the end of the data in March 2011. Possible reasons for the change in market structure could be due to the increase of contracts traded in the commodities futures markets. Also, increased fuel costs could be driving the prices of commodities upward. The demand for food and higher valued crops by developing countries could also contribute to the new observed level of commodity prices. If the effect of the exchange rate was different over the two different time periods there will be implications for not only farmers and ranchers, but agribusinesses and policy makers as well. The role of the exchange rate could possibly play a larger role in the profitability of producers and agribusinesses if it is increasing in influence on prices through time. Additionally, if the role of the exchange rate on commodity prices is changing it may affect the way the next farm bill is written, as well as how interest groups lobby for policy changes.

After the estimation of the VAR model a likelihood ratio test was computed to select the best model based upon lag length. This was done to investigate whether it was consistent with the SBC, indicating the same lag length structure. The null hypothesis was that the beta coefficient of the longer lag model was equal to zero. Sequential lag lengths, starting at one, were paired against each other and tested until the null hypothesis was not rejected; indicating that the smaller lag length should be selected.

Finally, a Bayesian Averaging of Classical Estimates (BACE) approach would be followed. The BACE approach comes from the idea that there is not a "true" model. It attaches probabilities to different possible models. Inferences are made by considering estimates from all models, with the importance of each being determined by model probabilities. Several references for Bayesian model averaging exist, however, here Hoeting et al. (1999) and Bryant and Davis (2008) are followed, providing the details needed to understand the Sala-i-martin, Doppelhofer, and Miller (2004) approach.

Let M_i denote a specific model. The model space considered can be defined as M = $\{M_1, M_2, \ldots, M_n\}$ and the sample of data with T observations as y. Let Θ_i denote the k_i parameter vector associated with M_i, $p(\Theta_i | M_i)$ the prior density for Θ_i under M_i, $L(Y, \Theta_i)$ the likelihood function for model M_i, and $p(M_i)$ the prior probability on the ith model. By Bayes theorem, the posterior probability for the ith model is

(7)
$$p(Mi \mid y) = \frac{p(Mi)\,p(y \mid Mi)}{\sum_{j=1}^{N} p(Mj)\,p(y \mid Mj)}$$

where

(8)
$$p(y \mid Mj) = \int L(y, \Theta j)\,p(\Theta j \mid Mj)\,d\Theta j$$

is the integrated likelihood of model *j*. The first equation is a measure of support for model M_i relative to all other models in the model space. A computational difficulty in implementing (7) is evaluating (8). Sala-i-martin, Doppelhofer, and Miller (2004) addressed this problem by using the Schwarz 1978 approximation to (8), which in log form is

(9)
$$\log p(y \mid M_j) = \log L(y, \hat{\Theta}_j) - 0.5 k_j \log T$$

where $\log L(y, \hat{\Theta}_j)$ is the estimated log likelihood function with the estimated parameter vector $\hat{\Theta}_j$ for model M_j. The right-hand side is the Bayesian information criterion (BIC_j).

Using equation (8), the mean of a quantity of interest across models can be calculated by taking expectations over all models,

(10)
$$E[\eta(\hat{\Theta}) \mid y] = \sum_{i=1}^{2^K} p(M_i \mid y)\,\eta_i(\hat{\Theta}_i \mid y, M_i)$$

where $\eta_i(\hat{\Theta}_i \mid y, M_i)$ is the quantity of interest calculated from the estimated parameter vector $\hat{\Theta}_i$ emanating from model *i*.

One of the difficulties in Bayesian model averaging is assigning the prior probabilities *p*(M_i) for each model. The most simple approach, as indicated by Sala-i-martin, Doppelhofer, and Miller (2004), is to assign equal prior probability to each model, which is equivalent to an implicit prior belief that the expected number of included explanatory variables, $\bar{k}$, should be half of the total number of explanatory variables *K*. A problem occurs if *K* is large because in particular this implies a very strong prior belief that the number of included variables should be large. Sala-i-martin, Doppelhofer, and Miller (2004) overcame this difficulty by directly specifying the prior mean model size $\bar{k}$, and then specifying the prior for a single model that includes *k* explanatory variables of the form $p(k) = (\bar{k}/K)^k (1-\bar{k}/K)^{K-k}$, so models of the same size have the same prior. This research assigned an equal prior probability to each model. After estimating the posterior probabilities, evaluating them over the models and finding the mean of the quantity of interest, the results were interpreted. Upon interpretation of the results the net effect of the exchange rate was evaluated on the systems.

Data

The models are estimated using daily and weekly price data over the 1997-2011 time period. The price data are from Thompson Reuters DataStream (2011a, b, c, d, e, f), Livestock Marketing Information Center (LMIC 2010), Hart's Oxy-Fuel News and Bloomberg (2011a, b, c). The exchange rate index is expressed in foreign currency per U.S. dollar and was obtained from the Federal Reserve (U.S. Fed). Figure 5 graphically displays the value of the exchange rate index from 1997-2011.

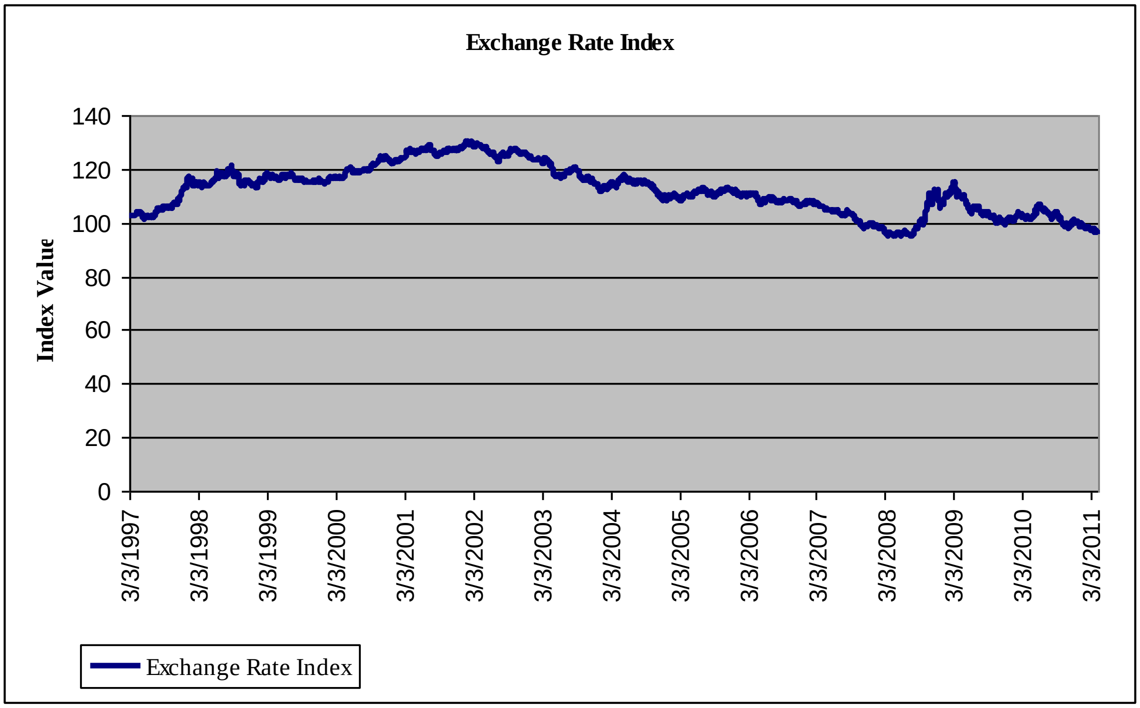

Figure 7. Exchange Rate Index Value 1997-2011.

An increase in this index value corresponds to a strengthening of the U.S. dollar. The U.S. dollar generally strengthened in value through 2002 before weakening through 2008. The relatively weaker dollar from 2005 through 2008 lent itself to the commodity boom that also occurred during that time period.

Descriptive statistics for the data are provided in Table 1. They include minimum, maximum, mean, standard deviation, and coefficient of variation. The minimum is the smallest number for that data series and the maximum is the largest. The mean is the average, or the sum of all data points divided by the number of points. The standard deviation is the square root of the variance. The variance is the sum of squared deviations from the mean divided by the number of observations minus one. The coefficient of variation is the relative variability in the data, calculated by dividing the standard deviation by the absolute value of the mean.

Table 1. Descriptive Statistics for Corn, Wheat, and Feeder Steers Output and Input Prices

Variable	Mean	Standard Deviation	Minimum	Maximum	Coefficient of Variation
Corn, $/bu	2.73	1.08	1.45	7.11	0.39
Wheat, $/bu	4.60	1.83	2.38	14.07	0.39
Feeder Steers, $/cwt	107.44	17.01	69.89	155.81	15.83
Exchange Rate Index Value	112.28	8.89	94.78	130.23	7.92
Diesel, $/gal	1.30	0.80	0.29	4.06	0.61
Ammonia, $/Ton	251.32	128.92	91.50	880.00	51.30
Urea, $/Ton	218.00	131.54	75.50	810.00	60.34
DAP, $/Ton	301.78	225.20	132.00	1225.00	74.63
Ethanol, $/gal	1.67	0.54	0.93	3.78	32.52

The average price of corn for number 2 yellow was $2.73 per bushel over the study period, while the average price of wheat, number 2 hard (Kansas), was $4.60 per bushel. The minimum prices of corn and wheat were $1.45 and $2.38 per bushel, respectively, while the maximum prices were $7.11 and $14.07. Average price for 500-600 pound feeder steers was $107.44 per cwt, with a minimum of $69.99 and a maximum of $155.81 per cwt. The exchange rate index value had an average of 112.28. Diesel and ethanol had an average price of $1.30 and $1.67, respectively, per gallon. Average prices per ton for ammonia, urea, and di-ammonium phosphate were $251.32, $218.00, and $301.78, respectively.

CHAPTER IV

ANALYSIS AND RESULTS

Model estimation and statistics were calculated using RATS, a comprehensive time series analysis and econometrics software package, and Excel. After the original VAR was estimated, using SBC to indicate a lag length structure, a likelihood ratio test was performed to see if it indicated the same lag length model as the SBC. The results from the likelihood ratio were incongruous with those from the SBC. Given the different lag lengths indicated by each test, it was decided that a BACE approach model would be followed. The results from the BACE modeling indicated quite convincingly that the model should be estimated with each variable lagged only one period.

The following general equations were estimated for corn, wheat, and feeder steers, respectively:

$$Pc=\beta_{1t}Rt_{-1}+\beta_{2t}Pd_{t-1}+\beta_{3t}Pu_{t}\text{-}1+\beta_{4t}Pet_{-1}+\beta_{5t}Pa_{t-1}+\beta_{6t}Pdap_{t-1}+\beta_{7t}Pc_{t-1}$$

$$Pw=\beta_{1t}R_{t-1}+\beta_{2t}Pd_{t-1}+\beta_{3t}Pa_{t-1}+\beta_{4t}Pdap_{t-1}+\beta_{5t}Pu_{t-1}+\beta_{6t}Pw_{t-1}$$

$$Pb=\beta_{1t}R_{t-1}+\beta_{2t}Pd_{t-1}+\beta_{3t}Pw_{t-1}+\beta_{4t}Pc_{t}\text{-}1+\beta_{5t}Pb_{t-1}$$

where β is the coefficient of the variable estimated in time t for all models.

After collecting the data, a Dickey Fuller test was performed to determine if the data were stationary. Stationarity is an important characteristic to observe because if the data are not stationary, it could not be used for forecasting. This is because there would be a risk of inferring spurious relationships among variables. The Dickey Fuller test was performed using a drift, or constant term, and without. Generally, we failed to reject the null hypothesis that the data were non-stationary. In the case of ethanol, di-ammonium phosphate, urea, and ammonia, however, the t-statistic values were greater than the critical t-values (Table 2) when a constant was not included. Therefore, the data were differenced once. The test for stationarity was not performed again because generally the price data were stationary after differencing once.

Table 2. Dickey Fuller T-Statistic and Critical Values for Model of Commodity Prices and Exchange Rates

Price Series	T-Statistic	T-Critical at 10%
Without Drift Term (Constant)		
Diesel	-2.658	-3.131
Ethanol	-3.934	-3.131
DAP	-3.273	-3.131
Urea	-4.112	-3.131
Ammonia	-4.306	-3.131
Corn	-1.544	-3.131
Wheat	-2.596	-3.131
Feeder Steers	-2.270	-3.131
Exchange Rate	-2.654	-3.131
With Drift Term (Constant)		
Diesel	-0.946	-2.569
Ethanol	-2.458	-2.569
DAP	-2.285	-2.569
Urea	-2.144	-2.569
Ammonia	-2.339	-2.569
Corn	0.046	-2.569
Wheat	-1.072	-2.569
Feeder Steers	-0.885	-2.569
Exchange Rate	-0.963	-2.569

Next, the residuals of each price series were plotted. Those price series with outliers were researched to see if there was a specific event causing the outliers. For diesel price, Hurricane Rita, in 2005, caused power outages and damages at refineries, causing a large spike in the price that could be easily seen as an outlier in the residuals of the diesel price data. During November, 2008 several factors combined to cause a large drop in the di-ammonium phosphate price. These factors included a general decline in crop prices creating soft fertilizer demand, a shortened application window caused by wet weather, an increase in supplies from overseas, tighter credit markets, and a congested distribution system. For urea in June, 2005 there was a large price drop due to continued low demand and commodity prices. Additionally, adverse weather conditions affected urea use areas. Investigation of the residuals allowed a rationale for the inclusion of dummy variables to be added to the deterministic component in the model for these three price series; urea, dap, and diesel. When the dummy variables were added the residual graphs of these commodities residuals returned to a more “normal” level.

The natural logs of each price series were computed for further use in the model. This was done because the results are easier to interpret, in that the parameter estimates can be interpreted similar to elasticities, i.e. a one percent change in a price variable has a percent impact on the overall system. Quarterly and yearly seasonal harmonic variables were also added at this point.

Three models were estimated each for the corn, wheat, and feeder steers systems. One system contained no seasonal component, the other two included seasonal harmonic variables, one accounting for a yearly cycle and the other, a yearly and quarterly cycle. Each of the models was evaluated using the Schwarz Bayesian Criterion (SBC). The lag length structure that returned the smallest SBC value was the model that best fit the data.

Comparing the lag length structure that returned the smallest information criterion value between the three models, no seasonal component, yearly cycle, and yearly and quarterly cycle, the selected lag length structure with the smallest information criterion value was chosen as the best overall model. Table 3 contains the SBC values for each model.

Table 3. VAR Model SBC Values Testing for Use of a Harmonic Variable

Lag	SBC Values		
	Corn	Wheat	Feeder Steers
With Yearly & Quarterly Harmonic Variable			
1	-49.361	-42.182	-37.234
2	-49.188	-42.086	-37.069
3	-48.982	-41.946	-36.909
4	-48.727	-41.794	-36.723
5	-48.382	-41.547	-36.525
6	-48.059	-41.321	-36.351
7	-47.740	-41.102	-36.147
8	-47.400	-40.847	-35.952
9	-47.044	-40.608	-35.759
10	-46.691	-40.348	-35.567
11	-46.363	-40.123	-35.369
12	-46.039	-39.870	-35.178
With Yearly Harmonic Variable			
1	-49.447	-42.276	-37.273
2	-49.273	-42.178	-37.106
3	-49.069	-42.038	-37.941
4	-48.814	-41.885	-36.751
5	-48.467	-41.885	-36.550
6	-48.142	-41.413	-36.375
7	-47.820	-41.193	-36.171
8	-47.478	-40.937	-35.979
9	-47.123	-40.700	-35.787
10	-46.769	-40.438	-35.594
11	-46.440	-40.215	-35.397
12	-46.112	-39.960	-35.202
With No Harmonic Variable			
1	-49.562	-42.367	-37.342
2	-49.390	-42.269	-37.174
3	-49.184	-42.129	-37.010
4	-48.929	-41.977	-36.819
5	-48.583	-41.729	-36.620
6	-48.257	-41.505	-36.444
7	-47.934	-41.285	-36.243
8	-47.591	-41.029	-36.052
9	-47.235	-40.790	-35.862
10	-46.879	-40.526	-36.667
11	-46.551	-40.301	-35.472
12	-46.222	-40.049	-35.275

For the three models, corn, wheat, and feeder steers, the SBC indicated a lag length of one. The model with no seasonal harmonic variable was found to be the simplest model that adequately represented the data across the corn, wheat, and feeder steers models. Then, the VAR systems were estimated again, this time testing for whether a constant was needed in the deterministic component. Once again, this was done by using the SBC to select the simplest, most adequate representation of the data for the models. The SBC selected the model with no constant in the deterministic component for all three systems. Table 4 contains the SBC values for each model.

Table 4. VAR Model SBC Values Testing for Use of a Constant

Lag	SBC Values		
	Corn	Wheat	Feeder Steers
With Constant			
1	-49.501	-42.315	-37.230
2	-49.328	-42.217	-37.062
3	-49.123	-42.076	-36.898
4	-48.867	-41.925	-36.710
5	-48.521	-41.677	-36.509
6	-48.195	-41.453	-36.333
7	-47.873	-41.233	-36.132
8	-47.529	-40.977	-35.940
9	-47.173	-40.738	-35.751
10	-46.818	-40.474	-35.555
11	-46.489	-40.249	-35.361
12	-46.161	-39.997	-35.165
Without Constant			
1	-49.562	-42.367	-37.273
2	-49.390	-42.269	-37.104
3	-49.184	-42.129	-36.940
4	-48.929	-41.977	-36.752
5	-48.583	-41.729	-36.551
6	-48.257	-41.505	-36.375
7	-47.934	-41.285	-36.174
8	-47.591	-41.029	-35.982
9	-47.235	-40.790	-35.793
10	-46.879	-40.526	-35.598
11	-46.551	-40.301	-35.404
12	-46.222	-40.049	-35.208

Next, a block exogeneity test was performed jointly, as well as separately, on the diesel and exchange rate variables. This was done by using a likelihood ratio test for the three systems, corn, wheat, and feeder steers. The block exogeneity test was conducted to test whether or not a particular variable in the model is actually exogenous and can therefore be excluded from the model. For example, if the diesel and exchange rate variables were exogenous then they could be excluded from the VAR model and listed as a deterministic component. These p-values are contained in Table 5:

Table 5. Block Exogeniety P-Values for Exchange Rate and Diesel, Tested Jointly and Separately

	P-Value
Exchange Rate and Diesel	
Corn	0.00000288
Wheat	0.00000647
Feeder Steers	0.16727811
Exchange Rate	
Corn	0.00208457
Wheat	0.00228295
Feeder Steers	0.30939962
Diesel	
Corn	0.00000000
Wheat	0.00000000
Feeder Steers	0.00000000

The null hypothesis was that the beta coefficient was equal to zero, meaning the exchange rate and diesel variables were exogenous with respect to the price of the system being tested, corn, wheat, or feeder steers. Using a 10% significance level, if the p-value was less than 0.10, then the null hypothesis was rejected. For both the corn and wheat systems, the null hypothesis was rejected, meaning that diesel and exchange rates were not exogenous, jointly or separately, and that they should be included in the model. However, the null hypothesis was not rejected for the feeder steers system when evaluated for the exchange rate and diesel jointly, as well as for the exchange rate individually. The null hypothesis was rejected for the feeder steers system with respect to the diesel variable, meaning the diesel variable should be included in the model. For the sake of consistent modeling moving forward, the exchange rate and diesel variables were not considered exogenous in the feeder steers system.

At this point, the data were then segmented into two different periods. The first starting at the beginning of the data in 1997 and going through the end of 2006, while the second started at the beginning of 2007 and went through the end of the data in 2011. This was done to evaluate whether or not there had been a structural change in the markets. This particular time break was chosen due to the rapid rise in commodity prices in late 2006, especially corn prices. Additionally, corresponding to increasing corn prices, there was an increase in ethanol production. By breaking the data into two periods the hypothesis was that there was a changing relationship between commodity prices and exchange rates during the study period. The correlations are contained in Table 6.

Table 6. Correlation Values Between the Exchange Rate and Studied Variable by Time Period

Variable	Early	Late
Corn	-0.145	-0.368
Wheat	-0.059	-0.398
Feeder Steers	-0.017	-0.029

* The early period means 1997-2006.
The late period is 2007-2011.

In each system the absolute value of the correlation between the evaluated variable and the other variables in the equation increased from the early time period to the later time period. This indicated that the exchange rate effect has had an increasing role in the corn, wheat, and feeder steers production systems. Additionally, it indicated that the prices of the inputs in the corn, wheat, and feeder steers systems move together more with the output prices now than they did in the past. The relative magnitudes are also interesting in that there is more correlation between exchange rates and corn and wheat than in feeder steers. That may be because corn and wheat are closer to the form exported. Feeder steers must still go through a number of production stages before the final exported product is derived.

Next, a likelihood ratio test was performed. The likelihood ratio test indicated a lag length structure of four for both the corn and wheat systems in the early and late periods. The indicated lag length structure of four was inconsistent with the lag length structure selected by the SBC. In Table 7, a p-value exceeding 0.10 indicates that the tested lag length is insignificant, meaning that a shorter lag length should be used. In this case, the p-values 0.8846, 0.1409, 0.3577, and 0.2051 all exceed 0.10 for early corn, late corn, early wheat, and late wheat, respectively, indicating a lag length structure of four in each case.

Table 7. Likelihood Ratio Test for Lag Length on Early* and Late Period Corn and Wheat

Test of Lags	P-Value
Early Corn	
2 vs. 1	0.0001
3 vs. 2	0.0896
4 vs. 3	0.0006
5 vs. 4	0.8846
Late Corn	
2 vs. 1	0.0000
3 vs. 2	0.0000
4 vs. 3	0.0197
5 vs. 4	0.1409
Early Wheat	
2 vs. 1	0.0001
3 vs. 2	0.0512
4 vs. 3	0.0003
5 vs. 4	0.3577
Late Wheat	
2 vs. 1	0.0000
3 vs. 2	0.0000
4 vs. 3	0.0009
5 vs. 4	0.2051

* The early period means 1997-2006. The late period is 2007-2011.

Due to the ambiguity between the Schwarz Bayesian Criterion test and the likelihood ratio test it was decided that a Bayesian Averaging of Classical Estimates (BACE) approach should be used.

Bayesian modeling means that we (or the model) “learn” from each model outcome and then use that information to adjust our model, finally arriving at the most likely, or best, most probable model. The first step in estimating the posterior probability piece of the BACE model was to assign prior probabilities to each lag length structure of the model. It was decided that an equal probability would be assigned to each of the corn, wheat, and feeder steers models, with models ranging in lag length structure from one to 12. To calculate the prior density under the prior probability the integrated likelihood of the models was calculated. This was done using the Schwarz 1978 approximation, which uses the log likelihood function. This also happens to be equal to the SBC. However, the SBC that was computed by RATS, the econometric software, was of a different form than that found with the original Schwarz formulation. Therefore, the original Schwarz formulation was applied to the data to derive the correct form of the SBC that could be used in the figuring of the BACE posterior probability. The numbers were then used in the estimation of the posterior probability for each lag length structure of the corn, wheat, and feeder steers models. The results in estimating the posterior probabilities heavily favored the lag length structure of one. Due to limitations in exponentiating large, positive numbers a posterior probability could not be estimated for some of the larger lag length structures. The calculated posterior probabilities for each system and lag length are shown in Table 8. For all systems, the probability for a lag length structure of one is very close to one. The probability for longer lag length structures quickly trails off to very small numbers, going towards a probability of zero. Posterior probabilities for larger numbers of lags could not be calculated due to machine limitations.

Table 8. BACE Posterior Probabilities for the Early* and Late Periods of the Corn, Wheat, and Feeder Steers Systems

Lags	Early Corn	Late Corn	Early Wheat	Late Wheat	Early Feeder Steers	Late Feeder Steers
1	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00
2	3.479E-45	1.260E-33	3.379E-32	1.618E-23	1.666E-25	7.991E-22
3	4.360E-97	1.040E-61	2.590E-69	7.017E-42	5.496E-51	3.013E-43
4	4.320E-143	4.717E-101	2.365E-101	3.859E-67	4.312E-79	1.608E-66
5	1.712E-200	8.776E-143	4.706E-141	2.125E-98	7.242E-109	7.513E-91
6	8.119E-256	5.453E-181	8.222E-183	1.424E-122	7.827E-139	1.595E-110
7	2.192E-307	1.836E-222	3.152E-221	2.225E-149	1.260E-167	4.447E-134
8		1.397E-265	1.550E-280	1.296E-181	7.286E-209	1.908E-157
9		5.432E-300		2.336E-206	1.678E-235	1.252E-177
10				1.263E-231	3.814E-280	2.590E-195
11				1.215E-259	2.425E-308	4.661E-219
12				4.398E-291		6.843E-240

* The early period means 1997-2006. The late period is 2007-2011.

The estimated posterior probabilities were then used to estimate the mean of the quantity of interest. Because the posterior probability heavily favored the models with a lag length structure of one the mean of the quantity of interest was equal to the cumulative response to the exchange rate shock of one standard deviation in the exchange rate. These results were normalized to a one percent shock in the exchange rate. Table 9 contains the BACE means of the effect of a one percent shock (increase) in exchange rates on the various prices of interest. The early (1997-2006) and late (2007-2011) periods are estimated. Using the figures from Table 9 the result for early corn, for example, can be interpreted as, for a one percent increase in the value of the exchange rate the price of corn declined by 2.29% in the early time period.

Table 9. BACE Mean Response (% change) of prices to a 1% Increase in Exchange Rate, 1997-2009

	Early	Late
Corn	-2.29	-4.50
Wheat	-1.85	-4.48
Feeder Steer	0.05	-0.56
Diesel	-2.18	-8.24
Ammonia	-2.08	-5.28
DAP	-0.59	-1.84
Urea	-1.12	-4.89
Ethanol	0.40	-1.75

* The early period means 1997-2006. The late period is 2007-2011.

The signs of the response to the exchange rate shock were generally as expected for corn, wheat, and feeder steers. By and large, it was found that, although small, the impact of the exchange rate on the commodities is getting increasing over time.

An increase in the exchange rate led to a decrease in the prices of the three commodities for both time periods modeled, except for the early period of the feeder steers. Between the late and early periods the effect of the exchange rate increased on corn, wheat, and feeder steers. From these results, the conclusion can be drawn that the exchange rate is increasingly having a larger effect on the prices of corn, wheat, and feeder steers. In the case of corn and wheat a one percent increase in exchange rate led to a greater than one percent decrease in corn and wheat price. In the case of feeder steers, the one percent shock in exchange rate led to a less than one percent change in price. However, in terms of the magnitude of change, the impact of the exchange rate on feeder steers price is 10 times greater in the later period than it was in the early period. This suggests that the impact of the exchange rate is increasing much more quickly on feeder steers than it is on the other commodities evaluated. It is also interesting to note that the sign, or direction of change, differed between the early and late time periods for feeder steers.

Based upon the results from the BACE model, the price response for the remaining variables, diesel, ammonia, urea, di-ammonium phosphate, and ethanol was only estimated for VAR models with a lag length structure of one. The input commodities had the sign expected, negative, for a percent increase in the exchange rate, meaning that as the value of the dollar strengthens the prices of the inputs decline. Ethanol displayed a positive price response to an increase in the exchange rate during the early period, but a negative response for the same effect in the later period. Like corn, wheat, and feeder steers, the effect of the exchange rate on ethanol and the inputs grew from the early to late time periods. Here it is interesting to note the increasing effect of the exchange rate between the two time periods. One hypothesized reason could be that expected effects of exchange rates might be more quickly incorporated by commodity market traders. The growth of speculative (hedge, index, and other) funds in the market couples with conversion to electronic exchanges has allowed for faster incorporation of "expected" effects of exchange rates. Another hypothesis, perhaps more importantly, is that agricultural and energy markets are more entangled. Also, the increasing effect may be due to the increasing use of imported inputs in agricultural production.

The objective of this research has been to determine the net effect of the exchange rates on agricultural outputs and inputs. The following paragraphs discuss the individual and net effects on each commodity. All results have been normalized to a one percent change in the exchange rate.

Corn

A positive change in the exchange rate, which indicates a strengthening dollar, has a negative impact on corn prices in both time periods. The effect of the exchange rate increased from the early period to the late time period. A corn producer in the early period would observe a 2.29% decline in the price of corn (Table 9). At the same time, the sum cost per bushel of their inputs, diesel, ammonia, urea, and di-ammonium phosphate, would decrease by 4.84% or 3.88%, respective to whether the producer used ammonia or urea as their nitrogen source.

A corn producer in the later period would experience a 4.50% decrease in corn price, while the sum cost per bushel of their inputs decreases by 15.36% using ammonia and by 14.97% using urea. The effect of the exchange rate on commodity prices is clearly much larger during the later time period, emphasizing the fact that the exchange rate has had an increasing effect on the prices of agricultural commodities throughout the time period studied. In the corn production system there is one last factor to consider in evaluating the net effect of the exchange rate. Ethanol, a by-product of corn, is also affected by the exchange rate. In the early period, a one percent increase in the value of the dollar lead to a 0.40% increase in the ethanol price. However, in the late period, an increase in the exchange rate would lead to a 1.74% decline in the ethanol price. The price decline during the later period is expected because if the dollar strengthens that makes the cost of imported goods relatively cheaper. From the early to the late period ethanol transitioned from being a fuel additive to a competitor with petroleum-based fuels, which oil, the raw material, is largely imported into the U.S. A stronger dollar would allow the U.S. to import more petroleum based fuel, relatively cheaper. Therefore, in order for ethanol to remain competitive the price would need to decline. In the case of the early period, where the sign is not as expected there are some hypothesized reasons as to why this may have occurred. The first is that the ethanol industry was relatively small at the beginning of the time period studied, meaning that prices remained more independent of foreign markets. A second hypothesis is that other possible market effects muted the effect of the exchange rate, such as the increase of total corn exports (ERS 2011c) over the early time period.

Wheat

Wheat producers experience observations very similar to that of corn. In the early period, an increase in the exchange rate led to a 1.84% decline in the wheat price. For the same time period the sum cost per bushel of the inputs, diesel, ammonia (or urea), and di-ammonium phosphate decreased by 4.84% (or 3.88%). For the later period there was a 4.48% decrease in price for wheat and a 15.36% (or 14.97%) decrease in the sum cost per bushel of the inputs. The direction of the price responses was as expected and increased in magnitude from the early period to the late period.

Feeder Steers

The net effect on feeder steers is somewhat different than that observed in the corn and wheat systems. In the early period, an increase in the exchange rate gave feeder steers prices a boost of 0.05%. However, in the later period, this effect was a decline by 0.56%

in the feeder steers price. The input for the feeder steers system is diesel and could possibly include winter wheat if the feeder steers grazed on it, but winter wheat price would be evaluated differently than the wheat in this model. Therefore, diesel will be the only input considered. In both periods there was a decline in the price of diesel, 2.17% and 8.24%, for early and late periods, respectively.

The direction of the change in feeder steers price was as expected for the later period, but not for the early period. Similar to the ethanol price, we hypothesize that there were market effects that dominated the effect of the exchange rate during the early time period. Throughout the early time period there was an overall trend of higher cattle prices and smaller supplies. At the end of 2003 there was an incident with Bovine Spongiform Encephalopathy (BSE) or “mad-cow disease” that greatly curtailed exports of beef in 2004 and even after. Additionally, there were policy changes that allowed more beef to be imported into Asia. Economic growth also occurred during this time period, bringing with it changing diets that created a demand for higher valued sources of protein. Mexico, Canada, South Korea, and Japan are four large importers of U.S. beef. All of these countries experienced the economic growth that took place during the early time period. Lastly, the effect on feeder steers may be small because they are a few steps removed from the exported product of boxed beef, where the effect of the exchange rate may be more prominent.

Net Effect Examples

In December, 1999, the average price received (ERS 2011a) for corn by U.S. producers was $1.82/bushel. In December, 2009, that average price was $3.60/bu. Similarly, the price of wheat (ERS 2011b) in July 1999 was $2.22/bu. In July 2009 this price was $5.17/bu. For feeder steers the average price received (LMIC 2010) in March 1999 was $96.16/cwt and $113.93/cwt in March 2009.

Texas AgriLife Extension Service (2011a, b, c) cost of production budgets are used in the estimation of these examples. Corn cost of production figures are for irrigated corn in District 1, the High Plains or Texas Panhandle area. Wheat and feeder steers cost of production figures are for dryland and winter stockers, respectively, in District 3, the Rolling Plains area of Texas, Northwest of Central Texas. Fertilizer costs were not split into single products for wheat. Therefore, for this example the cost of fertilizer will be assumed to be ammonia. In the corn cost of production tables from Texas Agrilife Extension the following three fertilizers were listed: nitrogen fertilizer – ANH3, phosphorus fertilizer – liquid, and nitrogen fertilizer – liquid. Ammonia, di-ammonium phosphate, and urea will proxy for the three descriptions, respectively. The 1999 cost of production budgets for both corn and wheat calculate fuel and lubrication as one lump cost. For the purpose of this example the lump sum will be used as a fuel cost. The cost of lubrication would be quite small and should not greatly affect the results of this example.

The examples will be as follows, the prices of the corn, wheat, and feeder steers systems will experience the effect of a one percent increase in the exchange rate. An approximate profit per bushel or cwt will be calculated and compared to an approximate profit before the increase in the exchange rate to demonstrate the net effect that a one percent increase in the exchange rate has on profit. The before exchange rate shock data was taken directly from the Agrilife Extension budgets. This is estimated for 1999 and 2009. The results are contained in Table 10:

Table 10. The Net Effect of Exchange Rate Shocks on Corn, Wheat, and Feeder Cattle Production Profits

	Before Shock	After Shock	Change in Price
1999 Corn			
Corn	$1.82	$1.78	-$0.04
Ammonia	-$0.12	-$0.11	$0.01
DAP	-$0.07	-$0.07	$0.00
Urea	-$0.08	-$0.08	$0.00
Diesel	-$0.02	-$0.02	$0.00
Net Effect ($/bu)	**$1.52**	**$1.48**	**-$0.04**
2009 Corn			
Corn	$3.60	$3.44	-$0.16
Ammonia	-$0.24	-$0.23	$0.01
DAP	-$0.42	-$0.41	$0.01
Urea	-$0.28	-$0.27	$0.01
Diesel	-$0.02	-$0.02	$0.00
Net Effect ($/bu)	**$2.63**	**$2.50**	**-$0.13**
1999 Wheat			
Wheat	$2.22	$2.18	-$0.04
Ammonia	-$0.42	-$0.41	$0.01
Diesel	-$0.18	-$0.18	$0.00
Net Effect ($/bu)	**$1.61**	**$1.59**	**-$0.02**
2009 Wheat			
Wheat	$5.17	$4.94	-$0.23
Ammonia	-$3.46	-$3.28	$0.18
Diesel	-$0.38	-$0.35	$0.03
Net Effect ($/bu)	**$1.33**	**$1.31**	**-$0.02**
1999 Feeder Steers			
Feeder Steers	$96.16	$96.21	$0.05
Diesel	-$0.30	-$0.29	$0.01
Net Effect ($/cwt)	**$95.86**	**$95.92**	**$0.06**
2009 Feeder Steers			
Feeder Steers	$113.93	$113.29	-$0.64
Diesel	-$0.91	-$0.83	$0.08
Net Effect ($/cwt)	**$113.02**	**$112.46**	**-$0.56**

These examples demonstrate the effect of a one percent increase in the value of the exchange rate. In 1999, a one percent change caused a decrease of $0.04/bu in profitability for corn and in 2009 the decrease in profitability was $0.13/bu. For a producer who harvests 10,000 bushels of corn the decrease in profit is $400 and $1,300 in the two time periods. In wheat, the one percent change caused a $0.02/bu decrease in profitability for both the early and late time period. There was an increase of $0.06/cwt in the feeder steers system in 1999, with a decrease of $0.56/cwt in 2009. A producer selling a 550 pound feeder steer would realize a decrease in profitability of $3.08 per head, which on a truckload of steers would sum to a decrease in profit of $215.60. These examples demonstrate the claim that has been made for many years; a stronger U.S. dollar hurts agricultural producers. Even after incorporating the effects of exchange rates on inputs, the one percent exchange rate shock or the dollar strengthening, resulted in reduced profitability. The opposite effect is reached if the exchange rate shock is negative, the value of the dollar declines and the net effect on producers is positive.

Summary

In this research, the point has been to understand how the exchange rate affects the prices of corn, wheat, and feeder steers, and the inputs into those systems. The estimated VAR and BACE models indicate that the exchange rate has had an increasing effect on the prices of commodities. Additionally, the results were as expected; a negative effect on prices was observed with the strengthening of the exchange rate, except in the case of the feeder steers in the early time period. However, the positive effect observed is very small, with several hypotheses for this observation. This research indicates that an increase in the value of the dollar generally has a negative effect on the profitability of corn, wheat, and feeder steers producers. Declines in profitability ranged from $0.02/bu in wheat to $0.56/cwt in feeder steers. The evidence of this study continues to support the notion that a stronger dollar is bad for the U.S. agricultural producer.

CHAPTER V

SUMMARY AND CONCLUSIONS

The debate over the level of impact that the exchange rate has on agriculture and its production systems has been ongoing for decades with little or no agreement on the significance of the role that the exchange rate plays. A close review of the literature indicates a general line of results: the effect of exchange rates on quantities tends to be short term in effect, exchange rates tend to be reflected in changing relation prices, and that the effect of exchange rates can be significant.

This research examined whether some agricultural industries were better or worse off with a weaker dollar. U.S. policy makers, producers, and agricultural economists alike are all concerned about the impact of exchange rates on U.S. agriculture. Some believe that a weaker U.S. dollar is hurting the profitability of producers as we become increasingly independent on imported inputs such as fuel and fertilizer. However, others believe that the value we gain from exports negates any effect felt on the input side. As we continue to increase the volume of imported inputs it is important to understand the role that the exchange rate plays. This knowledge is important for policy makers and university personnel, but most importantly for the farmers and ranchers of the U.S., who continually work to remain competitive and profitable in the growing, interconnected world market.

Chapter II provided a snapshot of the numerous research that has been done on exchange rates and its impact on agriculture. As the world becomes more interdependent it is important to continue research on the impact of exchange rates in order to have a more accurate representation of how the value of the dollar affects different aspects of the agricultural production system. Research on the topic will continue to be relevant as the market undergoes structural changes.

The major goal of this research was to better understand the impact of the exchange rate on the corn, wheat, and feeder steers production systems and the inputs into those systems. Specifically, the objective was to determine the net effect of exchange rates on agricultural inputs and outputs. This research found that a positive increase in the value of the exchange rate generally lead to a negative net effect on the profit levels of the corn, wheat, and feeder steers systems. However, further methodological work needs to be done on this particular research to extend it to extend it to include tests for statistical significance. To do that requires some complex programming that was beyond the scope of this thesis.

The example given for the net effect of the exchange rate was a one percent change in the value of the dollar. It is important to consider, however, the amount by which the exchange rate varies over time. Over the 14 year period, there was a 37% change in the exchange rate from the minimum to the maximum value. Although, the amount by which the exchange rate changes every day is slight. The average percentage change in the index value was 0.2%, with only 27 changes with a value greater than one percent out of 3,679 observations. Over time the effect of the exchange rate disseminates slowly through the production systems so, day to day the effect is minimal. It should be kept in mind, though, that most producers are not buying and selling their final products and inputs everyday. More often, only a few times a year. The change in the exchange rate between those points could be much larger then.

Several important research findings result from this work. One is a higher correlation in the later time period was found between all variable's prices and the exchange rate as compared to the early time period. This is especially apparent between the 1997-2006 and 2007-2011 periods. Exchange rate shocks have a larger effect today than they did only a few years ago. Additionally, it was found that the effect of a stronger dollar on corn, wheat, and feeder steer's net returns is negative. However, due to the effect of the closer exchange rate-commodity price relationship, the effect is stronger post-2006. Also, the increasing dependence on imported inputs has not reached a level where the positive effects of exchange rate shocks on output price are overwhelmed by the negative effect on input prices. A weaker dollar still results in increased net returns and a stronger dollar results in weaker net returns.

An opportunity for further research exists here in determining the causes of the increased correlation between exchange rates and prices. Is it simply a function of technology or is it the result of increased trading? Are these, potentially, unwanted consequences of this increased correlation? This research could also be extended to include how the futures commodity markets influence exchange rates and commodity prices. The impact of increased bio-fuel mandates and use could be evaluated as well. Additionally, it would be interesting to determine whether the increase in trading volume in futures commodities has influenced the correlation between the exchange rate and commodity prices. Lastly, for a better picture of effects on cattle this work could be extended to fed cattle and boxed beef.

The role of exchange rates will continue to be debated and examined, especially as the world market grows. With expansion of global markets and the occurrence of structural changes, this is a topic that may never be fully understood. However, from this research agricultural producers of corn, wheat, and feeder steers should take away the knowledge that the exchange rate does affect their profitability. In the future, they should not be overly concerned about a lower valued dollar from the perspective of their agricultural business. This information, along with all other research done on the influence of the exchange rate is of vital importance to agricultural producers, policy makers, and agribusinesses.

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