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Monetary policy, exchange rate, and effects on US wheat trade and domestic market in an imperfect competition framework

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Monetary policy, exchange rate, and effects on U.S. wheat trade and domestic market in an imperfect competition framework

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1 INTRODUCTION

1.1 The Problem

In the last decade, new developments have emerged from volatile changes in the multirelated economies and thus research in the field of agricultural trade and policy has been directed to studies of (1) the effects of exchange rate changes on agricultural trade, and (2) the interdependence between financial and agricultural markets, hence the effects of monetary factors on agriculture. The first has been extensively studied; however, the importance of the exchange rate continues to be the subject of debate. The second was gradually given attention, especially, since the exchange rate regime switched from fixed to flexible in 1973. However, quantitative studies in this development are few so far and the linkages between financial and agricultural markets are not well constructed yet so that conclusions obtained are still open to question.

Investigation on the effects of exchange rate changes on agricultural trade began in the mid-1970s. Pertinent events in the real world that caught the attention of economists in this investigation were the agricultural commodity boom and the two concurrent devaluations of the U.S. dollar in the early 1970s.[1] Some observers

[1]The first dollar devaluation (by almost 10 percent vis-a-vis the special drawing right, SDR) in 1971 was mainly because of the increasingly poor international payments (deficits) situation for the United States. This devaluation, however, was

and researchers explained the commodity boom with reasons such as the rise of incomes in developing countries, worldwide population growth, bad weather and the associated crop failures in many parts of the world (e.g., the Soviet Union), etc. In 1974, Schuh first suggested that the dollar devaluation was an omitted reason. Then, he directed attention to the link between exchange rate and agriculture, particularly agricultural trade.

In the early 1980s, a farm crisis occurred. The primary problem was declining agricultural product prices, hence lower income received by farmers relative to increasing costs of agricultural production. Similarly, many explanations were proposed but arguments had crucially attributed the problem to the declining foreign demand for U.S. agricultural products. The U.S. dollar appreciation, therefore, was blamed as the primary reason for declining foreign demand (e.g., Schuh, 1984). Apparently, along with the boom-and-bust of agricultural products exchange rate is always a focus of practical questions and of interest to economic researchers over time. Many trade theoreticians and empiricists question the effectiveness of exchange rate devaluation as a policy tool for agricultural trade: whether the effects of exchange rate changes on agricultural trade are significant or not?

Unfortunately, assessments of the effects of exchange rate changes result in divergent and perhaps contrary conclusions. Some argue that the exchange rate is less important because (1) the demand for and supply of agricultural products are inelastic (e.g., Kost, 1976; Vellianitis-Fidas, 1976), and (2) price insulation

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followed by continuous and deteriorating deficits. Consequently, the United States announced to unilaterly devaluate the dollar again in 1973. From that time on, all major currencies in the world including the U.S. dollar started to float and the fixed exchange rate system was broken.

policies in importing countries and trade policies in other exporting countries might offset and dominate exchange rate effects (e.g., Johnson et al., 1977; Grennes et al., 1980). However, another group of observers argue that (1) devaluation should raise the foreign demands for U.S. agricultural products because the cost of payments declines (e.g., Schuh, 1974), and (2) changes in exchange rate would cause all prices of traded goods to change, the cross-price effects coupled with the own-price effect should fluctuate exports and prices significantly (e.g., Chambers and Just, 1979, 1981, 1982), so that the role of exchange rate in trade is important. Divergence in the effectiveness of exchange rate, therefore, confuses the exchange rate as a policy tool in implementation.

Prior to 1973 the exchange rate could be regarded as a monetary instrument; however, this is no longer true since the dollar started to float. Theoretically and ideally, exchange rates are determined by the foreign exchange market under the flexible system. Therefore, the focus of studies on effects of exchange rate changes has been gradually turning to the investigation of effects of exchange rate determinants on agricultural trade. Among determinants of flexible exchange rate monetary factors have been strongly focused. Consequently, research is looking at the interdependence between financial and agricultural markets, and to measure the effects of monetary policy on agricultural commodity markets (e.g., Chambers, 1981, 1983, 1984; Chambers and Just, 1982). This has become a hot topic in recent years.

Not only the flexible exchange rate system but also the depressed agricultural sector and concurrent contractionary monetary policy in the 1980s enhanced the investigation of interdependence between financial and agricultural markets (Batten and Luttrell, 1982; Denbaly, 1984; Devadoss, 1985; Devadoss et al., 1987b; Frankel, 1984; Schuh, 1981, 1983; Schuh et al., 1980; Starleaf, 1982). Most of the studies pointed out that the contractionary monetary policy since 1979 aimed at lower inflation had adversely affected the agricultural sector, because the appreciation of the dollar value caused the foreign demand for U.S. agricultural products to decline and the higher interest rates raised the cost of production and then crucially hurt the supply of agricultural products. The lower prices due to declining demand on the one hand and the higher cost due to higher interest payment on the other jointly caused the farm crisis to explode in the 1980s.

Although the interdependence between financial and agricultural markets was emphasized, quantitative measurements of the impacts of monetary policy in empirical studies are few so far. Devadoss (1985) and Devadoss et al. (1987b) measured the impacts in a farm-nonfarm macrolinkage, general equilibrium model. Impacts on specific agricultural markets had been studied by Chambers and Just (1981, 1982) for wheat, corn, and soybeans, and by Denbaly for coarse grain markets. The adverse effects of a tight monetary policy on the agricultural sector was substantiated by Devadoss and Devadoss et al. Chambers and Just concluded that wheat and corn exports, and wheat and soybean prices are dramatically sensitive, while soybean exports and corn prices are less sensitive, to monetary policy. However, Denbaly's findings indicated that the effects of money supply changes on exports and prices of coarse grain market are small.

Theoretically, effects of exchange rate changes or monetary policy on agriculture can be substantiated with less doubt; however, the empirical assessment of these effects, as that obtained, seems divergent, inconsistent, and perhaps contrary. What factors may have caused such mixed results are numerous; however, the basic theoretical framework might be the primary one, particularly when a specific commodity market is investigated. The common theoretical framework of all previous studies is the competitive framework, that is, the market is assumed competitive, so that the law of one price is implied and the market power of big exporters or importers is neglected. Utilization of the competitive framework might be a big defect since, as several studies pointed out, many agricultural world markets (e.g., wheat) do not appear to follow the competitive market characteristics. Thus, for the theoretical assessment or empirical measurement of the effects of monetary policy the competitive framework might not be suitable, and by insisting on its use the biased results could be a priori expected if the market is actually imperfect competition.

If the agricultural world market is evidenced imperfectly competitive, as Thompson (1981) strongly suggested, it is very important and required to incorporate such behavior into a trade model. This will create an alternative way to investigate not only the trade theory but also the assessment of effects of exchange rate changes or monetary policy on agricultural commodity markets.

1.2 Objective of this Study

The objectives of this study are as follows:

1. To theoretically develop a new U.S. wheat model containing trade in the imperfect competition world market and the competitive domestic market. This breaks away from the conventional competitive model.
2. To connect the U.S. wheat model with the financial market via the linkages of exchange rate and interest rate determination, then to theoretically evaluate the impacts of U.S. monetary policy on wheat trade and domestic market.

3. To empirically estimate the theoretical new wheat model and examine the validation and stability of the model.

4. To empirically measure the impacts of U.S. monetary policy on the wheat sector using the newly developed model.

1.3 Organization of this Study

The present study is organized as follows:

Chapter 2 reviews the previous relevant literature, discusses controversies and limitations in the previous studies, and indicates the direction of this study.

Chapter 3 presents the duopoly world wheat trade model. The world wheat market structure is discussed first, and a duopoly wheat export pricing behavior is performed next.

Chapter 4 constructs a new U.S. wheat model, and connects this model with the financial market to theoretically assess the impacts of monetary policy. The U.S. wheat model consists of imperfect competition trade and a competitive domestic market. The connection is via the interest rate (the internal channel) and the exchange rate (the external channel) determination, where the portfolio equilibrium model is employed to determine these two rates in the financial market.

Chapter 5 empirically estimates the theoretical model, reports and interprets the results, and examines the validation and stability of the model.

Chapter 6 empirically analyzes the impacts of U.S. monetary policy on the wheat sector using dynamic simulation and multiplier analysis.

Chapter 7 includes a summary of this study, conclusions, and suggestions for further research.

2 REVIEW OF LITERATURE

Schuh (1974) was the first to direct attention to the effects of exchange rate on U.S. agriculture. He pointed out that analysis of trade and development problems of U.S. agriculture in the past neglected, for the most part, the role of the exchange rate. By using the induced technical change model, he indicated that exchange rate plays an important role in agricultural trade, the adoption of new production technology, and the distribution of benefits of technical change. Moreover, for agricultural price changes, he argued that even the exchange rate was not the only contributing factor, the overvaluation of the U.S. dollar has had an important role in the secular decline of agricultural prices from the mid-1950s through the 1960s. The rise of agricultural prices in 1973 in large part was a result of dollar devaluation in the same period.

From that time on, a series of studies on measuring the effects of exchange rate changes on agricultural trade followed. The new development of investigation is the impact of monetary policy on agriculture as described in the preceding chapter.

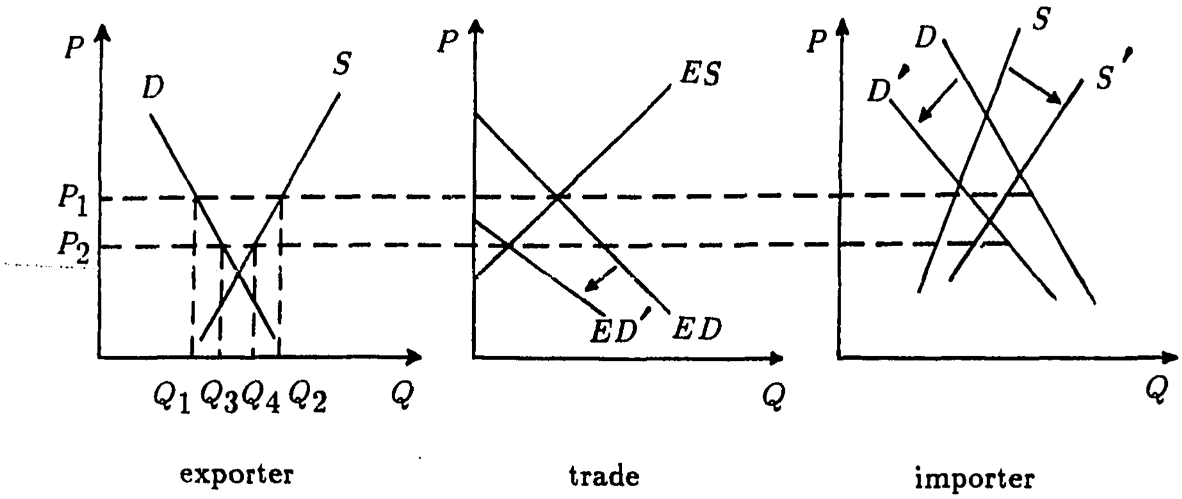


Figure 2.1: The competitive framework of trade

2.1 Effects of Exchange Rate Changes on Agricultural Trade

2.1.1 Theoretical framework

2.1.1.1 Graphical framework The effects of exchange rate changes on trade can be theoretically presented and perceived by a conventional one-commodity, two-country, partial equilibrium graph, Figure 2.1. However, one must bear in mind that there are two assumptions underpinning the use of Figure 2.1, (1) homogeneous traded good, and (2) free trade, so that the law of one price (LOP) holds. In other words, markets are assumed competitive and thus any trade participant is a market price taker. Change in the domestic price is, therefore, equal to change in the export price.

To stress the role of exchange rate in U.S. agricultural trade, Schuh used the exporter's graph of Figure 2.1 to interpret the influence of dollar overvaluation. P_1

is the equilibrium price without overvaluation. Impacts of overvaluation are that domestic price declines from P_1 to P_2, domestic demand increases from Q_1 to Q_3, domestic supply declines from Q_2 to Q_4 (because mobile resources are forced out of industry), and foreign demand decreases from the amount Q_1Q_2 to Q_3Q_4 (because U.S. products become more expensive as the dollar overvalued). Consequently, gross income to the agricultural sector is reduced and the sector becomes more dependent on the domestic market.

This graphical framework can help in understanding the theoretical impacts of changes in exchange rate; however, the specific impacts on price and quantity for a particular commodity market should depend upon (1) the elasticities of demand and supply curves in both countries, then the elasticities of excess demand and excess supply curves, and (2) demand and supply shifters besides exchange rate. Apparently, they are unclear in the framework.

Kost (1976) applied Figure 2.1 to assess the effects of changes in exchange rate. By carefully treating the scale changes in vertical axes to reflect the price in terms of a common currency as exchange rate changes, he demonstrated that the impacts of exchange rate changes on trade and price depend on (1) the magnitude of the exchange rate change and (2) the elasticities of the export supply and the import demand curves. For a devaluation by the exporting country, the maximum amount of change in price or quantity traded is the same in percentage as the amount of devaluation. The more inelastic the export supply curve, the more percentage change in price rather than in quantity. Therefore, for the inelastic demand and supply of U.S. agricultural products, he expected that the dollar devaluation would have a small impact on trade, and if it did "what effect there is will be primarily on price rather than quantity."

Kost incorporated the elasticities of demand and supply curves into consideration. However, other demand and supply shifters besides exchange rate were neglected. Demand and supply are implicitly assumed as functions of own price only. Exchange rate change can shift the demand and supply curve through its effect on the own price since the LOP holds.

2.1.1.2 Simple mathematical model The above simple two-country, one-commodity, partial equilibrium graphical framework can be mathematically expressed (Chambers and Just, 1979) as follows:

$$\begin{aligned} D_i &= f(v_i), \quad \partial f/\partial v_i < 0 \\ S_i &= g(p_i), \quad \partial g/\partial p_i > 0 \\ D_i &= S_i = Q_i \\ v_i &= p_i e \end{aligned} \tag{2.1}$$

where D_i is the excess (import) demand for commodity i of the importing country and is a function of the market price v_i in the importing country, S_i is the excess (export) supply of commodity i of the exporting country and is a function of the market price p_i in the exporting country, Q_i is the quantity of commodity i traded, e is the exchange rate evaluated in terms of the units of the importer's currency per unit of the exporter's currency. The LOP is assumed by the model to equilibrate prices.

In equilibrium, effects of exchange rate changes on price and quantity traded are (in terms of elasticities)

$$\zeta_i^p = \frac{dp_i}{de}\frac{e}{p_i} = \frac{-\eta_i}{\eta_i - \epsilon_i} < 0 \tag{2.2}$$

$$\zeta_i^Q = \frac{\partial Q_i}{\partial e}\frac{e}{Q_i} = (\frac{dp_i}{de}\frac{e}{p_i})(\frac{dS_i}{dp_i}\frac{p_i}{S_i}) = \zeta_i^p \epsilon_i < 0 \tag{2.3}$$

where ϵ_i (> 0) is the elasticity of excess supply with respect to p_i, and η_i (< 0) is the elasticity of excess demand with respect to v_i. Clearly, a devaluation of the exporting country's currency ($de < 0$) would result in increases of exporter's price and quantity traded. However, ζ_i^p is confined to the closed interval [0,-1] since $\eta_i < 0$ and $\epsilon_i > 0$. ζ_i^Q may be greater than ζ_i^p in absolute value dependent upon the magnitude of ϵ_i.

Kost's conclusion, therefore, can be clearly seen from equations (2.2) and (2.3). If $\epsilon_i = 0$, perfectly inelastic excess supply, ζ_i^p = -1 and $\zeta_i^Q = 0$, that is, the impacts of devaluation are fully on the export price and quantity traded is unchanged. If $\epsilon_i = \infty$, perfectly elastic, $\zeta_i^p = 0$ and the quantity traded will fully respond in percentage to the devaluation. In case of inelastic demand and supply of U.S. agricultural products, the percentage change in export price should exceed the percentage change in quantity in response to any percentage change in the dollar value. Thus, export price is more responsive to devaluation than the quantity traded.

2.1.1.3 A more general mathematical model The lack of consideration of other demand and supply shifters was patched up by Chambers and Just (1979). They criticized the simple model as being too restrictive on the specification of (excess) demand equation, and then argued that from the standard neoclassical demand theory the (excess) demand should be specified as a function of all prices and income. More strictly speaking, the cross-price effects as well as the own-price effect must be accounted for in the assessment of effects of exchange rate changes.

By assuming that all goods are traded for simplification and no influence on qualitative results (Chambers and Just, 1979, 1980), they extended the simple model as

$$\begin{aligned} D_i &= f(v, M) \\ S_i &= g(P, m) \\ Q_i &= D_i = S_i \\ v &= Pe \end{aligned} \tag{2.4}$$

where v is a vector containing all prices of n commodities in the importing country, M is the aggregate income of the importing country, P is a vector containing all prices of n commodities in the exporting country, m is the aggregate income of the exporting country. Similarly, in the absence of barriers to trade the LOP holds in equilibrium for all traded commodities.

The effect of exchange rate change on the price of ith commodity (p_i) can be derived by differentiating the equilibrium condition ($dM = dm = 0$) as

$$\tilde{\zeta}_i^p = \frac{dp_i}{de}\frac{e}{p_i} = \zeta_i^p + \frac{\zeta_i^p}{\eta_i}[(\eta_i^*)'(s + \zeta_i^*) - (\epsilon_i^*)'\zeta_i^*] \tag{2.5}$$

where ζ_i^p is the partial exchange rate elasticity defined by equation (2.2), $\tilde{\zeta}_i^p$ is the total exchange rate elasticity, η_i^* is an $n-1$ column vector of cross-price elasticities of demand, ζ_i^* is an $n-1$ column vector of exchange rate elasticities of the cross prices, s is an $n-1$ column vector of ones, and ϵ_i^* is an $n-1$ column vector of cross-price elasticities of supply. From equation (2.5), if, and only if, the term in bracket is negative the absolute value of $\tilde{\zeta}_i^p$ is greater than ζ_i^p. Therefore, Chambers and Just concluded that "there is no a priori reason to restrict ζ_i^p to the closed interval [0,-1]." The percentage change in price may be greater than the percentage change of devaluation, as long as the cross-price effects are accounted for.

Chambers and Just also criticized the simple model, (2.1), in that the specification of excess demand function forces a price change to have the same effect as an exchange rate change. This could be true, using their more general model, only when the cross-price elasticities are zero between the traded commodity i and all other goods, but it is hardly realized. To support the view that exchange rate changes are differentiated from market price movements, they cited Orcutt's (1950) hypothesis that economic agents react more quickly to exchange rate fluctuations than to market price changes in a world characterized by fixed exchange rate. Consequently, they argued that prior to any empirical investigation of effects of devaluation this hypothesis should be considered.

Above are the basic conventional theoretical frameworks that underpinned models in the assessment of the effects of exchange rate changes on agricultural trade. Various extensions or modifications in modeling had been made in empirical studies. In general, they are changes in the number of country and commodity included and can be classified as

A. two-country, one-commodity model. This is the simple graphical framework and the simple mathematical model.

B. two-country, multicommodity model. This is the Chambers and Just proposed model with cross-price effects in consideration.

C. multicountry, one-commodity model. This is the spatial or nonspatial model.[1]

D. multicountry, multicommodity model. This is, perhaps, the most complete model (spatial or nonspatial).

In addition to changes in the number of country or commodity included, various specifications and modifications had been made in empirical models such as (1) to have trade and/or domestic policies consideration or policy reaction functions, and (2) to formulate the price transmission equation instead of the price linkage between countries in model. Another simplified way which had been tried in several empirical studies is to simply estimate the import (excess) demand equations for, e.g., U.S. products.

2.1.2 Empirical findings

Since the theoretical evaluations are so controversial, effects of exchange rate changes have become an empirical rather than a theoretical issue. However, results of empirical measurements were also mixed. Rough groupings of those mixed results could be made up of "insignificant" and "significant" effects of exchange rate changes on trade. Various reasons have been proposed by proponents of each group to support their findings.

[1]Multicountry models are basically simultaneous systems of equations specified to reflect the behavior of trading countries and their interrelationships through the world market. According to Thompson's (1981) reviews and classifications, there are three multicountry models: spatial price equilibrium models, nonspatial price equilibrium models, and trade flow or market share models. These models generally include more domestic market detail, but the interrelationships among countries are introduced by means of net trades of countries in the nonspatial models, and by means of trade flows and/or market shares in the spatial models and in the trade flow and market share models.

Proponents of the insignificant effects argued that the exchange rate devaluation has relatively little impact on agricultural prices (domestic and export) and quantity traded. Kost (1976) and Vellianitis-Fidas (1976) based their findings for this stand on the inelastic demands and supplies of U.S. agricultural products, particularly in the short run. Vellianitis-Fidas also found that the long-term effects of exchange rate changes on exports are quite small and perhaps even zero. Kost's conclusion of insignificant effects was actually a theoretical assessment using Figure 2.1. Vellianitis-Fidas empirically tested the equation of U.S. agricultural exports by OLS regression using cross-sectional (a stepwise procedure) and time-series data.

Johnson et al. (1977) developed a short-run forecasting multicountry wheat model (a spatial equilibrium model with goods differentiated by country of origin) to examine the importance of exchange rate, tariffs, export taxes, and transport cost in the commodity boom of 1973. As a result, they argued that price insulation and trade policies by wheat importers and exporters had the largest impact on U.S. wheat prices, the dollar devaluation was of lesser important (a 10 percent devaluation of the dollar led to approximately a 7 percent increase in wheat domestic prices). Moreover, the U.S. shipping policy that raised transport cost almost offset the effect of devaluation on raising the wheat price. However, their conclusion was criticized by Chambers and Just (1979) who said, "the qualitative results of their analysis may well be correct, but the quantitative magnitudes are certainly open to question." This is because, as Chambers and Just pointed out, their multicountry export flows model is equivalent to the simple mathematical model without the cross-price effects, therefore, a priori restricts the exchange rate elasticity of export price to the closed interval [0,-1] and forces the exchange rate changes to have the same effects as export price changes on the import demand.

In contrast, proponents of significant effects of exchange rate changes argued that exchange rates had been an important determinant of agricultural exports and led to fluctuations of domestic price (Chambers and Just, 1979, 1981, 1982; Clark, 1974; Devadoss, 1985; Devadoss et al., 1987b; Fletcher et al., 1982). Schuh (1974) theoretically indicated the important role of exchange rate on trade. Clark, perhaps is the first one to empirically examine the effects of exchange rate changes, indicated that devaluations have a larger effect on agricultural goods than on manufactured goods. By focusing on a particular agricultural commodity trade and striking out the role of exchange rate, Fletcher et al. estimated the U.S. wheat export demand equation with the exchange rate as separate regressor (based on the Orcutt hypothesis). The significant results were evidenced.

To be more defensible for this stand, Chambers and Just (1979) developed a theoretical model, (2.4), and then made a critique to the argument of insignificant exchange rate effects. Their key proposition was that the cross-price effects due to exchange rate changes must be accounted for and thus the effects on exports and price might be significant. Their later studies (1981, 1982) supported the significant argument. Such argument was also evidenced by Devadoss, and Devadoss, Meyers, and Starleaf in a farm-nonfarm, macrolinkage model. Both in the simultaneous estimation and dynamic simulation the exchange rates did have large impacts on U.S. crop exports and price.

Not getting into groups, Collins et al. (1980) argued that exchange rate impacts on trade and prices are not being able to be announced as simply large or small. By decomposing the price changes into the divergence of inflation rates and changes in exchange rate between trading countries, they concluded that effects of exchange rate changes on real U.S. commodity prices are smallest under free trade and real commodity price insulation policies, but as nominal price insulation policies become more prevalent the effects will substantially rise.

2.2 Impacts of Monetary Policy on Agriculture

Since exchange rates started to float in 1973 and the farm crisis occurred in the 1980s, the attention of economists has been gradually directed to the investigation of impacts of monetary policy on agriculture. The associated change in modeling, primarily, is that exchange rate should be endogenized because it is no longer a policy instrument in the purest sense in implementation.

Shei (1978), perhaps, was the first to attempt to link and study the effects of monetary phenomena on U.S. agriculture. He constructed a compact, empirical, general equilibrium model of the U.S. economy, and thereby simulated the impacts of money supply and exchange rate on the agricultural sector. His results indicated that agricultural prices tend to rise more than nonagricultural prices when money supply expands. On the other hand, money supply has more important effects on U.S. agriculture than the exchange rate. However, a shortcoming of his model is that the exchange rate was treated as predetermined, so that the causal linkage between money supply and exchange rate was ignored.

In the 1980s, most studies on the effects of monetary policy on agriculture argued that the effects are substantive, a contractionary monetary policy tends to adversely affect the agricultural sector. However, the impact linkages between monetary factors and agricultural markets were diverse. It is likely that a complete, realistic, and generally acceptable model (theoretical or empirical) has not been constructed yet, especially for a specific agricultural commodity market, such as wheat.

Since U.S. agriculture is heavily dependent upon trade, most studies focused on the impact of monetary policy through the channel of exchange rate. However, the interdependence between financial and agricultural markets is not only through exchange rate, but also through other channels. To summarize recent studies, monetary factors can have impacts on agricultural commodity markets through the influence on (1) the exchange rate determination process (the external channel), hence impact on trade, and (2) the level of interest rate, inflation, and income (the internal channels), hence impacts on production and demands in the domestic market (e.g., Devadoss, 1985; Devadoss et al., 1987b; Starleaf, 1982).

Exchange rate effects have been reviewed in the previous section. However, for purposes of examining the effects of monetary factors through this channel, two crucial points must be considered: (1) the exchange rate variable must be endogenized, and (2) how the monetary factors influence the exchange rate determination under the flexible exchange rate system, that is, the formulation of exchange rate determination equation in model.

To meet these two requirements, Chambers and Just (1982) built a three-block recursive empirical model to examine the effects of monetary factors on agricultural markets of wheat, corn, and soybean. Their effort was to account for the cross-price effects, thus all goods were assumed tradeable (Chambers and Just, 1979). The results strongly suggested that effects are dramatically large. However, their formulation of exchange rate equation is ad hoc and, therefore, theoretically assailable. To attain theoretical underpinning, Chambers (1984) adopted the portfolio balance approach to exchange rate determination, and developed a short-run theoretical model to conduct the interdependence between financial and agricultural markets. His empirical results implied that the short-run effects of monetary policy (e.g., open market operation) are not neutral since agricultural prices fall relative to nonagricultural prices. Thus, a contractionary monetary policy would depress the agricultural sector and lead to lower relative prices, income, and returns to factors specific to agriculture.

Denbaly (1984) estimated the effects of money supply increase on the world coarse grain market. He adopted the simple monetary approach to exchange rate determination. As a result, he found that the excess supply of money created in the monetary sector tends to depreciate the value of the U.S. dollar; however, it leads to only a relative small increase in U.S. domestic price and exports. Thus, the contractionary monetary policy does not have dramatically adverse effects on U.S. coarse grain exports and domestic market.

In a macroeconomic, general equilibrium framework, Devadoss (1985) and Devadoss et al. (1987b) also formulated the exchange rate equation by the simple monetary approach. The adverse impacts of contractionary monetary policy on the farm sector was substantiated by their empirical findings, thus a loose monetary policy was suggested in the policy implication.

Turning to internal channels, the first to look at is the effect of monetary policy through the interest rate. The importance of changes in the domestic interest rate and its implications for the agricultural sector had been emphasized; however, there are only a few empirical studies that address the effect. In general, the interest rate can affect the agricultural markets in two ways (1) through the cost of borrowing production loans which, in turn, affect the cost of production, hence the supply (cost effect), and (2) through the storage cost of carrying commodity reserves, hence demand for inventories (stock effect) (Chambers, 1981, 1983; Devadoss, 1985; Devadoss and Meyers, 1986; Devadoss et al., 1987b; Frankel, 1984; Schuh et al., 1980).

Chambers (1981) derived the cost effect (interest rate effect through production) in a simple two-country, one-commodity trade model. His theoretical derivation indicated a negative interest rate effect on exports; whereas, the effect on price is ambiguous conditional on the combined effect of interest rate on exports of exporter and on imports of importer. Frankel (1984) described the short-run stock effect (interest rate effect through carrying inventories) using the overshooting concept. As the money supply change, demand for storable (agricultural) commodities will change associated with the short-run fluctuations of interest rate until the adjustments are long enough and sufficiently back toward the long-run equilibrium. Devadoss empirically estimated the interest rate effects on the agricultural sector in his dissertation, which appears to have been the first empirical study, and argued that the tight monetary policy and alarming budget deficit lend to higher interest rate, and hence "has an adverse effect on the farm sector since farmers pay higher interest on their production loan and other operating expenses." A consistent result was obtained by Devadoss and Meyers and Devadoss et al. when a sustained 3 percent decrease in money supply growth was simulated in their sectoral general equilibrium model.

The other internal channels through which monetary policy may have impact on agriculture are inflation and income (Devadoss, 1985). For example, an expansionary monetary policy might induce higher general price level and the growth of income. The higher general price level will increase the cost of nonfarm inputs, hence lead to a reduction in production (inflation, or cost, effect). On the other hand, increase in income may result in a higher demand for high-income-elasticity agricultural products (income, or demand, effect).

The inflation effect on the farm sector was debated in empirical studies. For example, Tweeten (1980, 1983) found that a rise in the general price levels tends to result in a loss to farmers in real income, because inflation raised prices paid by farmers (inputs) more than that it raised prices received by them (output). However, a later study by Starleaf et al. (1985) argued that farmers were benefited by an acceleration in the rate of inflation because the farm-output price inflation reacts quicker and sharper than farm-input price inflation in short-run movements. The empirical simulation results of a contractionary monetary policy by Devadoss (1985) and Devadoss et al. (1987b) indicated that lower inflation might benefit the farm sector, but the increases in the value of the dollar (exchange rate effect) and the domestic interest rate (interest rate effect) and the fall in income (income effect) might overwhelm the inflation effect and tend to hurt the farm sector. The income effect due to monetary policy is positive.

There is another area of study that has the same goal of examining the interrelationship between financial and agricultural sectors — using the Granger causality test (e.g., Barnett, 1980; Barnett et al. 1983; Chambers, 1981, 1984; and Devadoss et al., 1986). Some evidence has been detected on the causal relationship between financial and agricultural sectors. For example, the significant causal effect is found

(1) from money supply to agricultural exports and imports, food price, wheat price, and (2) from exchange rate to national trade deficits, hence to aggregate agricultural price and wheat price. The causal effect from interest rate to agricultural exports and imports, however, had been detected insignificant. These tests draw important policy implications from financial sector to agriculture.

2.3 Discussion of Controversy and Limitation

2.3.1 Free trade and the law of one price (LOP)

Agricultural commodities were conventionally and generally regarded as flex-price goods or auction goods; that is, prices are free to respond to fluctuations in demand in the short run (Frankel, 1984; Hicks, 1974; Okun, 1975). Consequently, most agricultural trade models were basically conceptualized and operated within the competitive (or free trade) framework, because this framework is tightly matched with the regardness.[2] Within this framework, products are marketed competitively, international commodity arbitrage is perfect and ensures that a product sold internationally will obey the law of one price (LOP) — in common currency units prices of a product sold in two markets will differ by no more than the transport cost between the two markets. In other words, by ignoring the transport cost, export price of the exporting country, import price of the importing country, and domestic prices in both countries are all equal (see Figure 2.1). As already seen in the foregoing review, all previous analyses (effects of exchange rate changes and/or monetary policy on agriculture) followed the competitive framework, and the LOP was assumed if no trade barriers were considered.

[2] For detailed survey of agricultural trade models see Thompson (1981).

Unfortunately, recent evidence suggests that the LOP did not hold during the 1960s and 1970s (e.g., Isard, 1977; Richardson, 1978). This finding implies that commodity arbitrage is never perfect, thus the standard competitive framework in empirical study is questionable, and so is the conclusion. The commonly perceived reasons for the failure of LOP are (1) imperfectly competitive market, (2) differentiated products, and (3) barriers to trade (Dunn, 1970; Isard, 1977; Richardson, 1978).

Regarding the world wheat market, first, most of individual country's markets are highly protected by exerting trade barriers in the importing side, such as variable levies in the European Community (EC), quotas in Japan. With little doubt, the LOP should not hold, at least on the importing side. Second, to use competitive framework is not realistic. While this framework was assumed and adopted by all previous studies, studies on the characteristic of the world wheat market pointed out that it is imperfectly rather than perfectly competitive (these studies will be reviewed and discussed in Chapter 3). Apparently, if the world wheat market is imperfectly competitive, the conventional competitive framework is incorrect, and hence the biased empirical results could be a priori expected.

As the strongest recommendation by Thompson (1981) for future agricultural trade modeling work, if the market is evidenced imperfectly competitive it is very important and required to incorporate this behavior into the trade model. Therefore, analysis for the world wheat market should be based on an imperfectly competitive framework and the LOP should not be assumed.

2.3.2 Cross-price effects

Chambers and Just (1979, 1981, 1982) emphasized the importance of cross-price effects in the assessment of the effects of exchange rate changes on trade. Omission of cross-price effects tends to force the exchange rate changes to have same effects as price changes, then, the exchange rate elasticity of exporter's price is confined to the closed interval [0, -1]. In supporting their argument that exchange rate changes are different from market price movements, so is the importance of cross-price effects, they quoted Orcutt's hypothesis that economic agents react more quickly to exchange rate fluctuations than to market price changes when exchange rates are fixed. The reason is because consumers perceive an exchange rate change as being more permanent than short-run price changes.

Theoretically, all prices and incomes should be incorporated for a more complete trade model without doubt. However, Chambers and Just's model itself and the model in empirical application may have problems, and the significant exchange rate effects are also questionable. First of all, their model, (2.4), does not intrinsically differ from the simple model, (2.1), except for the inclusion of other prices and incomes. This is clear because the treatment of the exchange rate variable in both models is via the LOP assumption. Moreover, if cross-price effects exist at the initial moment when devaluation occurs, there is no difference between exchange rate change and exporter's price change (through the LOP) except that change in exchange rate will far-reach all individual commodity markets. In the long run, exchange rate variations and exporter's price variations of equal magnitude are equivalent. This is because after all adjustments have taken place, the impact of both variations is identical. What difference may have is the response lags under a fixed exchange rate system (Reed, 1980).

Second, Orcutt's hypothesis actually was not embodied in their model, (2.4), and did not help their conclusion in interpretation. Under the fixed exchange rate system, if price is elastic in response to exchange rate change, it is due to the cross-price effects, not due to the consumer's response to devaluation, which was proposed larger than the response to price change. On the other hand, the exchange rates were experienced to change much quicker than the price change under the flexible exchange rate system since 1973. Therefore, it could be plausibly expected, due to the spirit of Orcutt's hypothesis, that consumers should react less quickly to exchange rate changes than to the exporter's price changes. The price in response to devaluation in a short run, accordingly, tends to be inelastic rather than elastic under the flexible exchange rate system.

The final problem in the empirical study is what prices (indices) should be included in order to account for the cross-price effects. Actually, there is no answer for this problem. The difficulty is the unavailability of data (Chambers and Just, 1979, 1981). Reed's (1980) suggestion, "the inclusion of prices for commodities which are close substitutes (complements) to the good studied," is more sound in practice.

Incorporation of possible cross-price effects to clarify the effects of all variables in the model is theoretically acceptable and should be attempted in empirical study. The exchange rate elasticity of the exporter's price may be theoretically elastic due to the cross-price effects, but the possibility in the real world is still open to question. Under the flexible exchange rate system and if the individual agricultural markets are highly protected, Orcutt's hypothesis and the exchange rate pass through problem (Jabara and Schwartz, 1987) might reduce the exchange rate effects on trade.

2.3.3 Trade and domestic policies

Johnson et al. (1977) questioned Schuh's (1974) emphasis on the importance of exchange rate in U.S. agricultural price changes; therefore, they tested the importance to the boom of the U.S. wheat export price in 1973 and concluded that the dollar devaluation was of lesser importance than the trade policies exercised by other major importers and exporters. Their conclusion was criticized by Chambers and Just (1979) who claimed that their multicountry model a priori restricts the effect of devaluation (omitting cross-price effects), so that the quantitative measure are open to question. In a reply to Chambers and Just's critique, Grennes et al. (1980) argued that, first, there is a theoretical reason to expect U.S. domestic prices to rise by no more than the devaluation, and second, whether devaluation is important or not depends on what it is compared with. Apparently, there appears a question: are trade policies in other countries important enough to lessen or offset the effects of exchange rate changes?

The importance of impacts of domestic and trade policies on price and quantity traded had been studied by a number of researches.[3] Grennes et al. (1978a) argued that price insulation policies (the EC and Japan) and the export taxes (Canada, Australia, and Argentina) tend to destabilize the U.S. wheat price. When price in-

[3] Various policies in world agricultural markets can see, for example, Bredahl, Meyers, and Collins (1979), de Gorter and Meilke (1987), Devadoss et al. (1987a), Enders and Lapan (1987), Krishna and Chhibber (1983), Mahama (1985), Runge and von Witzke (1987), and Spriggs (1981).

sulation is perfect in an importing country, the domestic price is perfectly insulated and the effective import demand becomes perfectly inelastic. More specifically, Bredahl, Meyers, and Collins (1979) incorporated the insulation policies in estimating the elasticities of foreign demand for U.S. agricultural products. The insulation policy was expressed in terms of "price transmission elasticity" (EP_i), which is usually bounded by zero and one. EP_i is one (perfect price transmission) only when a free trade with zero transport cost is undertaken or if the foreign price varies proportionally with the U.S. price. As a result of calculation, the price elasticity of foreign demand for U.S. wheat exports is zero if EP_i is assumed zero, while it is -5.50 if a free trade is assumed. However, they pointed out that the strong evidence in the world wheat market is that EP_i, with respect to U.S. price, approaches zero because most major importing countries insulated their internal consumption prices from the world price. Furthermore, they (Collins et al., 1980) assessed the effects of exchange rate changes on the real U.S. agricultural prices, and concluded that effects are smaller under real commodity price insulation policies. To couple the domestic policies on production and consumption with the trade policy, de Gorter and Meilke (1987) found that both the (domestic) intervention price and (import) threshold price in the EC had influence on its wheat trade.

It appears that the effects of the dollar devaluation should be in (large) part offset by price insulation policies exercised by other countries. If foreign domestic markets are perfectly insulated, the effects should be small, or even zero. Thus, in any of the assessment of exchange rate effects the omission of trade policy in modeling might result in upward biases.

2.3.4 Differentiation of commodity

With few exceptions, most of the previous studies on the exchange rate effects, as well as those of conventional agricultural trade models, presumed homogeneous trade commodity (Thompson, 1981). Grennes et al. (1978b) is one of the few exceptions that questioned this presumption. For wheat, they point out that it is not a homogeneous good. In the study of effects of devaluation on trade, Johnson et al. (1977) differentiated wheat by country of origin.

To differentiate commodity in trade model may be justified in two ways: (1) by physical characteristics of products, and (2) by country of origin (Johnson et al. 1979). Wheat is used for human food (primarily), livestock feeding, and industrial usage. The considerable varieties of wheat in physical characteristics (e.g., protein content) lead to that different types of wheat are often destined for different end uses. Thus, it may not be valid to assume that wheat is a homogeneous commodity (Gilmour and Fawcett, 1986). On the other hand, wheats in international trade might also be differentiated by country of origin in the eyes of each importing country in regard to the reliability of suppliers, information cost, and such. In terms of price, differentiation of wheat should be reflected in price differentiations. If wheats are differentiated by country of origin, the different spatial prices could be explained largely by transfer cost, such as transport, marketing margins, and governmental trade barriers (Johnson et al., 1977). As wheats are differentiated by physical characteristics, the original (export) prices themselves should be essentially different to reflect their quality.

As the LOP was evidenced being weakly supported and the fact that wheats in the world market are differentiated, the product differentiation should be presumed in modeling and in empirical content for better qualitative results. A few studies have been attempted to differentiate wheats in the trade model by country of origin,[4] the physical characteristics of wheat, however, are still assumed homogeneous. Further research which attempts for most realistic to see the price response to exogenous impact should also assume the differentiation in physical characteristics.

2.3.5 Financial market and the formulation of exchange rate equation

While the interdependence between financial and agricultural markets was recently emphasized and studied, the linkage via exchange rate determination is the most important one because U.S. agriculture is heavily dependent upon trade. Efforts have been made to formulate the exchange rate equation for this purpose; however, it has not yet been done well. The main difficulty is that the formulation has to be theoretically underlined and empirically capable, but limitations on either request usually exist. This is because approaches of the exchange rate determination that have been developed are mostly theoretical, few of them can be easily applied in empirical study, for example, econometric estimation.

Chambers (1981) theoretically formulated exchange rate as, the simplest asset approach to the exchange rate determination, a function of the relative domestic and foreign interest rate. The theoretical basis is that in a world where monetary assets can move across countries, an increase in the domestic interest rate will attract investment capital to inflow, hence improve the country's payments position. However, such a simplified formulation might be sound only when the

[4]For summaries of these studies see Johnson et al. (1979) and Thompson (1981).

interest rate instead of money supply is the policy instrument. Money supply as an instrument and then its role and effects are submerged with this formulation. Another misleading in specification is that this formulation ignores, for example, the speculative movements of capital across countries (hence the role of news in foreign exchange markets), and the influence of inflation on (spot) exchange rate determination (Frenkel, 1980, 1981b; Frenkel and Levich, 1975; Frenkel and Mussa, 1980).

The later effort by Chambers (1984) adopted the portfolio balance model to formulate the exchange rate equation. However, his model was essentially a short-run framework, not suitable for a long-run analysis. What it improved is that the effects of monetary policy (e.g., open market operation) on agriculture can be theoretically evaluated, but the role of interest rate and its determination were ignored in modeling.

Turing to the empirical application, Chambers and Just (1982) endogenized the exchange rate variable in their U.S. crops model. Nevertheless, formulation of the exchange rate equation is ad hoc, making it theoretically assailable. Their only rationale is that "the empirical model does not purport to be a 'monetarist' model of exchange rate determination. On the other hand, it should not be pictured as a 'nonmonetarist' model, either. Rather, it is an attempt to capture the effect of some important monetary variables as well as nonmonetary variable (through the balance on current account) on the exchange rate determination process..." (p. 236).

In fact of empirical application, among approaches of exchange rate determination the one that was widely adopted is the simple monetary approach (Frenkel, 1976, 1984). Denbaly (1984) and Devadoss (1985) successfully applied this approach in their doctoral theses. The shortcoming of this approach is that it was evidenced to be hardly successful in interpreting the unprecedentedly volatile exchange rate movements in the 1970s. Frenkel (1976), the pioneer of this approach, demonstrated it in a hyperinflationary economy (e.g., Germany in the early 1920s), however, if inflation is moderate (e.g., in the 1970s) this approach fails (Frankel, 1979). The key point is the collapse of purchasing power parity (PPP), which primarily underpins this approach (see, e.g., Dornbusch, 1980; Frenkel, 1981a, 1981b).

In addition to the exchange rate determination, as reviewed in the previous section interest rate is another important impact channel from the financial market on agricultural markets. Almost all previous studies neglected this impact channel. For those few studies that had interest rate incorporated in the model, the interest rate determination theory was either lacking or misspecified. The portfolio equilibrium model (Branson et al. 1977; Kouri, 1976, 1980) will be used in this study. The advantage to use this model is that it simultaneously determines both exchange and interest rates. The theory of this model and the reduced form determination equations will be discussed in Chapter 4.

2.4 Direction of the Present Study

The U.S. wheat market has three properties, so is investigated in this study. First, the United States has been the biggest exporter in the world wheat market since the 1960s. Second, in value terms, wheat is the most important (the biggest) agricultural product exported by the United States. Third, in quantity terms, about half (55 percent on average) of domestic production is exported and the other half used domestically. As the biggest exporter in the world market (about 41 percent on average from 1960 to 1985), the United States can exercise its market power to influence the world wheat price. Thus, the United States is hardly the market price taker. Instead, it can price wheat exports like an oligopolist. As the biggest export product, wheat can be regarded as representative of U.S. agricultural trade. Moreover, U.S. wheat is destined half to trade and half to domestic market, so these two markets are almost equally important. This property provides a relatively balanced evaluation of the effects of monetary policy. For example, if a commodity is produced almost totally for domestic (foreign) uses, the effect of monetary policy through exchange rate should be less (extremely)important.

According to the foregoing review and discussion, construction of a theoretically sound model and assessment of the effects of monetary policy would require the incorporation of the following:

1. an oligopolistic behavior of the world wheat market
2. differentiation of wheat in the world market by country of origin and also by physical characteristics
3. inclusion of prices of commodities that are close substitutes (complements) to wheat and wheat products to account for the cross-price effects
4. implementation of trade and domestic agricultural policy
5. determination of exchange rate and interest rate in the financial market

A complete U.S. wheat model should consist of foreign trade and domestic market. A financial market could be independently constructed. Assessment of effects of monetary policy can be done by merging these three separate blocks together with the impact channels being linked and the commodity market cleared.

Note that the effects of monetary policy through inflation and income channels would not be incorporated into the study. This is because production of wheat is relatively capital-intensive, interest rate as a price of capital is more important than other nonfarm inputs. On the other hand, wheat products are staple foods in consumption, the price and income elasticities are small so they are less important. Certainly, if an aggregate model, for example, farm sector as a whole, is investigated, these two effects might be important and should be accounted for (e.g., Devadoss, 1985; Devadoss et al., 1987b). Thus, the monetary policy impacts incorporated in this study are through the exchange rate (the external channel) on wheat trade, and through the interest rate (the internal channel) on domestic market.

Since wheat trade and domestic market are just a small part relative to total trade or to the economy as a whole, it is justified to assume that both exchange and interest rates are determined in the financial market independent from changes in the wheat market. That is, there is no feedback impact from the wheat market to the financial market, hence to the determination of these two rates (Chambers, 1981). A schematic diagram in Figure 2.2 describes the impact channels of monetary policy on U.S. wheat trade and domestic market. This is the basic theoretical framework of this study.

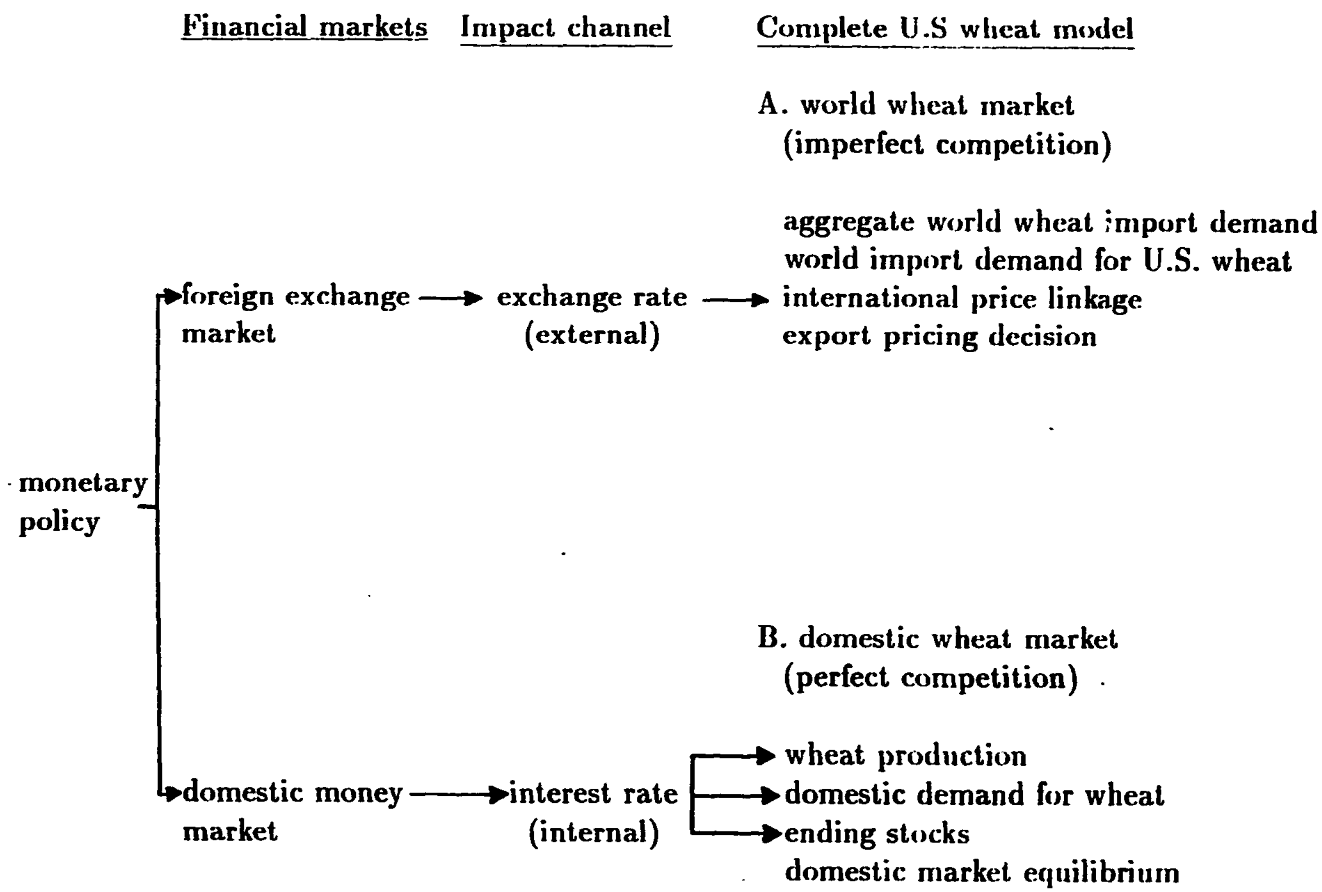


Figure 2.2: Impact channels of monetary policy on U.S. wheat trade and domestic market

3 DUOPOLY WORLD WHEAT MARKET

The main attempt of this chapter is to model an imperfect competition world wheat trade — a duopoly model. Such incorporation of imperfect competition behavior breaks away from the conventional competitive framework.

Before going on to discuss the structure of world wheat market and the determination of world prices, it is essential to discuss the basic theory of demand for and supply of wheat in the importing countries. Note that the competitive behavior is assumed for all domestic markets of trade participating countries. For example, the United States is an oligopolist in the world market, but its domestic market is assumed competitive. The reason is because both wheat producers and consumers are numerous, none can have influence on domestic price determination.

3.1 Demand for Wheat in the Importing Countries

Chambers and Just (1979) suggested that, according to the neoclassical demand theory, (excess) demand should be specified as a function of all prices and income. Such specification would account for cross-price and income effects in addition to the own-price effect. In the theoretical derivation of such neoclassical demand function, they suggested to explicitly assume the separability of the utility function.

However, an important characteristics of demand for wheat that was ignored is that demand for wheat is a derived demand, not directly the consumer's choice. Consumers demand the final wheat products; whereas, demand for wheat is a factor demand by the producers of wheat products, such as cereal and bread. Consumer's choice among goods is to maximize his profit, factor demand by a producer, however, is to maximize his profit. They are intrinsically different.

There are two main destinations of wheat: food use and feed use. Demand (derived demand) for wheat mainly results from these two uses. The theoretical procedure for obtaining the demand for wheat is, first, to obtain the consumer's demand for final wheat products, and second, according to the consumer's demand, to derive the demand for primary wheat, an input of production of final wheat products.

3.1.1 Individual demand for final wheat products and meat

Following the separability of utility function, a consumer can partition the set of n commodities available to him or her into S ($S < n$) mutually exclusive and collectively exhaustive groups, $[G_1, G_2, ...G_S]$. Each group l contains n_l commodities and $n = \sum_{l=1}^{s} n_l$. The commodities within a group are assumed to possess some common characteristics. Therefore, the consumer can make his or her consumption decision in two stages: (1) to budget income into groups, and (2) to allocate income within group. The necessary and sufficient condition for such budgeting process to be consistent with the theoretical one stage process is that the utility function is weakly separable and each of the group aggregator functions is homothetic (Armington, 1969; Blackorby et al., 1978; Gorman, 1959; Johnson et al., 1984).

Now, consider that the individual is budgeting his or her income (per capita) y over S groups. In the first stage of the optimization process expenditure functions of the following type are obtained:

$$y_l = y_l(P_1, P_2, ..., P_S, y) \quad \text{for } l = 1...S \tag{3.1}$$

where y_l is the expenditure on group l; P_1, P_2, ..., P_S are price indices for each budget category of the form

$$P_l = P_l(p_{l1}, ..., p_{ln_l}) \quad \text{for } l = 1...S \tag{3.2}$$

where p_{l1}, ...,p_{ln_l} are the prices of n_l commodities, which constitute group l. This budgeting is made under the income constraint $y = \sum_{l=1}^{s} y_l = \sum_{l=1}^{s} P_l G_l$.

The second stage of the optimization process consists of the determination of the quantity demand of each item $r \varepsilon l$ under the expenditure constraint $\sum_{r\varepsilon l} p_{lr} q_{lr} = y_l$. These quantities are determined in the second-stage within group decision,

$$q_{lr} = q_{lr}(p_{l1}, ..., p_{ln_l}, y_l), \quad r \varepsilon l \tag{3.3}$$

The demand equations in a such budgeting process are, hence, the two-stage demand equations,

$$q_{lr} = q_{lr}[p_{l1}, ..., p_{ln_l}; y_l(P_1, ..., P_S; y)], \quad r \varepsilon l \tag{3.4}$$

or a more general form, by substituting (3.1) into (3.4),

$$q_{lr} = q_{lr}[p_{l1}, ..., p_{ln_l}; P_1, P_2, ..., P_S; y], \quad r \varepsilon l \tag{3.5}$$

Thus, individual demand for a particular commodity depends on income, price indices of all groups, and prices of commodities within groups.

For convenience, let group one ($l = 1$) be grain and grain products and group two ($l = 2$) be meat and related products. Then, the individual's demand for any wheat product is

$$q_{1i} = q_{1i}[p_{11}, p_{12}, ..., p_{1n_1}; P_1, P_2, ..., P_S; y], \quad i\varepsilon 1 \tag{3.6}$$

and demand for any meat and related products is

$$q_{2j} = q_{2j}[p_{21}, p_{22}, ..., p_{2n_2}; P_1, P_2, ..., P_S; y], \quad j\varepsilon 2 \tag{3.7}$$

Note that the two-stage demand equations are not demands for wheat, they are demands for wheat products and meat and related products.

3.1.2 Country's demand for final wheat products and meat

For simplicity, assume that consumer preference is homogeneous in a country; therefore, the country's demand for each product can be obtained by a simple summation of all individuals' demands.

Suppose there are w wheat products and m meat and related products available in the market, where $w \leq n_1$ and $m \leq n_2$. The demand system can be written as

$$Q_{WP} = \begin{pmatrix} Q_{11} \\ Q_{12} \\ \cdot \\ \cdot \\ \cdot \\ Q_{1w} \end{pmatrix} = \begin{pmatrix} N \cdot q_{11} \\ N \cdot q_{12} \\ \cdot \\ \cdot \\ \cdot \\ N \cdot q_{1w} \end{pmatrix} = N \cdot q^w \tag{3.8}$$

$$Q_M = \begin{pmatrix} Q_{21} \\ Q_{22} \\ \cdot \\ \cdot \\ \cdot \\ Q_{2m} \end{pmatrix} = \begin{pmatrix} N \cdot q_{21} \\ N \cdot q_{22} \\ \cdot \\ \cdot \\ \cdot \\ N \cdot q_{2m} \end{pmatrix} = N \cdot q^m \tag{3.9}$$

where Q_{WP} and Q_M are column vectors of the country's demands for final wheat products and for meat and related products, respectively; q^w and q^m are column vectors of individual's demands for wheat products and for meat and related products, respectively; N is the population, and q_{1i}, $i = 1 \cdots w$, and q_{2j}, $j = 1 \cdots m$, are defined by (3.6) and (3.7).

3.1.3 The derived demand for wheat

Suppose competitive markets exist for both final products and primary factors of production in a country. Wheat is the primary input of its final products. Supply of wheat is not fixed because of trade. The aggregate derived food (feed) use demand for wheat can be obtained from wheat product (meat and related products) industries through the profit-maximization behavior.

Define the price and quantity vectors of the final wheat products as

$q^{w'} = (q_{11}, q_{12}, \cdots, q_{1w})$	vector of individual's demands for wheat products
$Q_1 = (Q_{11}, Q_{12}, \cdots, Q_{1w})$	vector of industry production of wheat products

$P_1^w = (p_{11}, p_{12}, \cdots, p_{1w})$ — vector of w prices of wheat products

$V_1 = (v_{11}, v_{12}, \cdots, v_{1k})$ — vector of k prices of primary factors for producing w wheat products, let v_{11} be the price of wheat

$X_1 = (x_{11}, x_{12}, \cdots, x_{1k})$ — vector of k primary factors for producing w wheat products

$0 = F(Q_1, X_1)$ — the implicitly joint production function

Then, the aggregate Marshallian factor demand function can be obtained by the profit-maximization process as

$$
\begin{aligned}
Max \quad \Pi &= P_1^w Q_1' - V_1 X_1' \\
s.t. \quad 0 &= F(Q_1, X_1) \\
Q_1' &= N \cdot q^w(P_1^w, p_{1\,w+1}, \cdots, p_{1\,n_1}; P_1, \cdots, P_S; y) = Q_{WP}
\end{aligned}
$$

Forming the Lagrangian function,

$$L(Q_1, X_1, \lambda_1, \lambda_2) = P_1^w Q_1' - V_1 X_1' - \lambda_1 F(Q_1, X_1) - \lambda_2 (Q_1' - N q^w)$$

where $\lambda_2 = (\lambda_{21}, \lambda_{22}, ..., \lambda_{2w})$. The first-order conditions (FOC) of equilibrium are

$$
\begin{aligned}
\frac{\partial L}{\partial Q_1} &= P_1^{w'} - \lambda_1 \frac{\partial F}{\partial Q_1} - \lambda_2' = 0 \\
\frac{\partial L}{\partial X_1} &= V_1' - \lambda_1 \frac{\partial F}{\partial X_1} = 0 \\
\frac{\partial L}{\partial \lambda_1} &= F(Q_1, X_1) = 0 \\
\frac{\partial L}{\partial \lambda_2} &= Q_1' - N\, q^w = 0
\end{aligned}
$$

A set of implicit functions can be obtained from FOC as

$$\begin{aligned} Q_1^{'} &= Q_1^{'}(V_1; P_1^w; p_{1\,w+1}, \cdots, p_{1\,n_1}; P_1, P_2, \cdots, P_S; y; N) \\ &= Q_1^{'}(v_{11}, v_{12}, \cdots, v_{1k}; p_{11}, p_{12}, \cdots, p_{1w}, p_{1\,w+1}, \cdots, p_{1\,n_1}; \\ &\quad P_1, \cdots, P_S; y; N), \end{aligned}$$

$$\begin{aligned} X_1^{'} &= X_1^{'}(V_1; P_1^w; p_{1\,w+1}, \cdots, p_{1\,n_1}; P_1, P_2, \cdots, P_S; y; N) \\ &= X_1^{'}(v_{11}, v_{12}, \cdots, v_{1k}; p_{11}, p_{12}, \cdots, p_{1w}, p_{1\,w+1}, \cdots, p_{1\,n_1}; \\ &\quad P_1, \cdots, P_S; y; N) \end{aligned}$$

where $Q_1^{'}$ is a set of final wheat products market equilibrium functions; $X_1^{'}$ is a set of derived demand functions for primary factors.

Let X_{11} in vector X_1 be wheat, so the functional form of derived demand for wheat can be written as

$$\begin{aligned} X_{11} &= X_{11}(v_{11}, v_{12}, \cdots, v_{1k}; p_{11}, p_{12}, \cdots, p_{1w}, p_{1\,w+1}, \cdots, p_{1\,n_1}; \\ &\quad P_1, \cdots, P_S; y; N). \end{aligned} \tag{3.10}$$

It is clear that variables to influence the demand for wheat are (1) population in the country, (2) income per capita, (3) price indices of all commodity groups, which will affect the income allocation into groups, (4) all prices of final grain products within group, and (5) all prices of primary factors used to produce final wheat products.

The same procedure can be applied to group 2, meat and related products. A similar derived feed use demand function for wheat can be written as

$$\begin{aligned} X_{21} &= X_{21}(v_{21}, v_{22}, \cdots, v_{2h}; p_{21}, p_{22}, \cdots, p_{2m}, p_{2\,m+1}, \cdots, p_{2\,n_2}; \\ &\quad P_1, \cdots, P_S; y; N). \end{aligned} \tag{3.11}$$

where v_{21} is referred to as wheat price. Note that v_{11} in equation (3.10) and v_{21} in equation (3.11) are wheat price and must be equivalent; let $v_{11} = v_{21} = v_1$.

The country's demand for wheat could be simply the summation of equation (3.10) and (3.11). A general functional form can be written as

$$\begin{aligned} D &= X_{11} + X_{21} \\ &= D(v_1, \cdots, v_{h+k}; p_{11}, \cdots, p_{1w}, p_{1\,w+1}, \cdots, p_{1\,n_1}; \\ &\quad p_{21}, \cdots, p_{2m}, p_{2\,m+1}, \cdots, p_{2\,n_2}; P_1, \cdots, P_S; y; N) \end{aligned} \tag{3.12}$$

where v_1 is the wheat price.

Chambers and Just (1979) emphasized that cross-price effects are important, one can more precisely find, (3.12), that cross-price effects may exist in three places: among all commodity groups, (P_1, P_2, ..., P_S); among all commodities within group, ($p_{11}, p_{12}, ..., p_{1n_1}$) and ($p_{21}, p_{22}, ...p_{2n_2}$); and among all primary factors, (v_1, ..., v_{k+h}).

The major problem of this approach in empirical study is the unavailability of data. In fact, there are no such detailed and well-grouped price indices, especially when time-series data are applied. However, the own-price and some close substitute (or complement) prices should be included in empirical study (Reed, 1980).

3.2 Production of Wheat in the Importing Country

Many previous studies specified the production of wheat simply as a function of current or lagged price. Nevertheless, a recent and more realistic specification is that it is a product of yield per acre and the wheat area (Devadoss et al., 1987a; Gallagher et al., 1981; Mahama, 1985; Spriggs, 1978, 1981). The reasoning is that the variability of wheat area is largely determined by economic factors, while yield variability is more subject to environmental factors and technology.

What are economic factors affecting the wheat area? Under the assumption of competitive domestic market, the individual wheat producer is a market price taker, so that his or her production is determined at the equilibrium condition of market price equal to marginal cost (P = MC). The economic factors, therefore, are wheat price received by producer and prices of inputs. An increase in wheat price and/or a decrease in production cost (prices of inputs) would increase the quantity produced.

However, most governments of the importing countries intervene in their domestic wheat markets. Domestic wheat producers receive payments from government. For example, the intervention prices in the EC, wheat support price in Japan, and so on. Prices received by wheat producers are always higher than the actual market price, where the difference is subsidized by governments. Therefore, price received by producers is relatively the most important economic factor that determines the area, other economic factors are relatively less important. In viewing the fact of government intervention, production of wheat in the importing country could be specified as

$$S_t = YA_t \cdot AH_t(FV_t) \tag{3.13}$$

where S_t is production of wheat, YA_t is wheat yield per acre, AH_t is wheat area, and FV_t is the government support price received by farmers.

In time horizon, the crop year (July 1 to June 30) was always used in agricultural research and will be used in this study. However, one must bear in mind that production of wheat is almost finished at the beginning of the crop year. Harvest takes place in June and July, so that supply of wheat can be regarded as fixed for the coming crop year. What can influence wheat supply is the area at planting time. It is a function of the government price and this price is always announced at the beginning of planting for the coming crop year production.

Another property of wheat production is its rigidity in adjustment in response to the market information. Unlike the manufacturing sector, once wheat is seeded production is almost determined, weather conditions aside. Thus, wheat area for crop year t is determined at the beginning of planting, which is in year $t-1$ in the time horizon. As the crop year starts, the supply of wheat is fixed. Clearly, current market price is mainly determined by market demand.

3.3 Demand for and Supply of Wheat in the Centrally Planned Economy (CPE)

The above specification of demand for and supply of wheat is primarily based on the price theory. However, it may not be applicable to the centrally planned economy (CPE), such as the USSR and China.

Distribution of wheat in the CPE is basically via two marketing systems: government-owned sale agencies and the free market. Wheat producers are requested by government to deliver and sell a fixed proportion of production to public agencies. This wheat is sold by the government sale agencies to demanders at the government price. The producers' self-left portion of production is for their self-consumption, seed use, and supply to the free market. The demanders of those nonproducers can buy wheat at government agencies at government price and/or at the free market at the market price. Most wheat is distributed through the government marketing system. The free market is relatively small and acts as a supplement in the national distribution system.

Under these two marketing systems, the actual demand for wheat of the producers is equal to their self-left wheat minus supply to the free market. On the other hand, the actual demand of nonproducers is the summation of demands in government and free marketing systems. The aggregate demand for wheat at crop year t, therefore, is the summation of demands of producers and nonproducers, and can be specified as

$$D_t^C = D(v_t^{cf}, v_t^{cg}, y_t^c, N_t^c, S_t^c) \qquad (3.14)$$

where v_t^{cf} is the free market price, and v_t^{cg} is the government price. Since wheat area in the CPE is usually centrally planned by government, production of wheat ($S_t^C = YA_t^C \cdot AH_t^C$) is considered exogenously determined.

3.4 Structure of World Wheat Market

The world wheat market behavior had been hypothesized as perfect competition and imperfect competition. The model of perfect competition, that is, the competitive framework, had been widely applied in the agricultural trade model, especially in studies of exchange rate effects on trade. However, if the market is imperfect competition, analysis based on the competitive framework should be biased, so the conclusion is meaningless and disappointed (Thompson, 1981).

3.4.1 Regularities of the world wheat market

Some regularities of the world wheat market are observed as follows:

Table 3.1: Supply shares of major exporting counties (average, %)[a]

Year	Total	U.S.	Canada	Australia	Argentina	EC	Others
1960 - 64	100.00	41.38	23.19	12.76	5.59	6.15	10.93
1965 - 69	100.00	36.89	21.39	12.57	6.38	8.79	13.99
1970 - 74	100.00	42.25	21.45	12.84	3.22	8.52	11.73
1975 - 79	100.00	44.18	19.46	13.81	5.51	9.26	7.79
1980 - 85	100.00	40.95	20.94	12.98	5.56	9.81	9.76
1960 - 85	100.00	40.95	20.94	12.98	5.56	9.81	9.76

[a]International Wheat Council. Various issues. World Wheat Statistics.

1. Wheat was supplied by five major exporting regions: the United States, Canada, Australia, Argentina, and the EC. These five regions supplied about 90 percent, where the United States and Canada shared more than 60 percent, of the world supply (Table 3.1).

2. There are more than 100 importing countries in the demand side. The relatively more important regions are the EC, Japan, and India in the free economies, and the USSR and China in the centrally planned economies. These five regions shared about 45 percent of the world wheat demand (Table 3.2).

3. The Canadian export prices were always higher than export prices of other exporting countries. Movements of all export prices were almost at the same steps except for the short-run, small adjustments in each country (Figures 3.1 and 3.2)

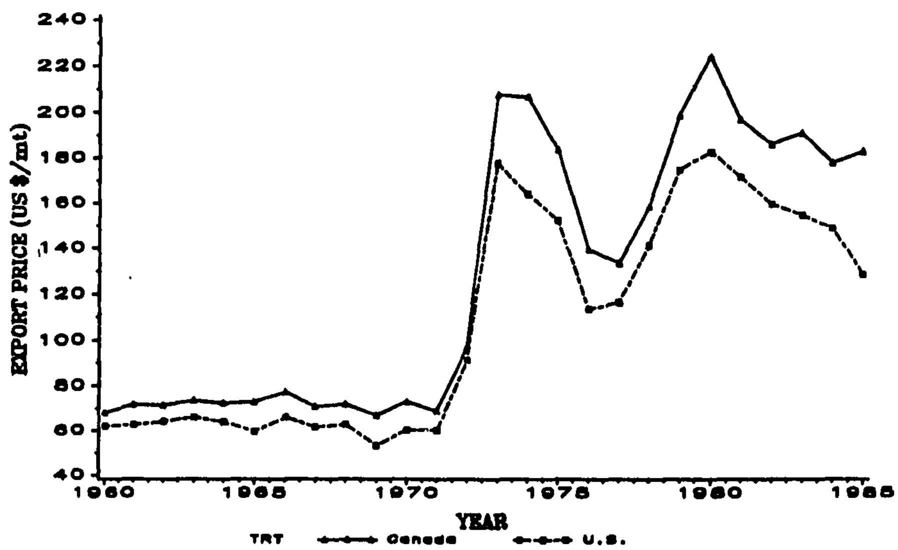
4. Export prices were relatively stable in the fixed exchange rates period (1960 - 72), while under the flexible exchange rate system (1973 - 85) fluctuant and unstable export prices were observed (Figures 3.1 and 3.2).

From the market shares in the supply and demand sides, it is apparent that the

Table 3.2: Demand shares of major importing countries (average, %)[a]

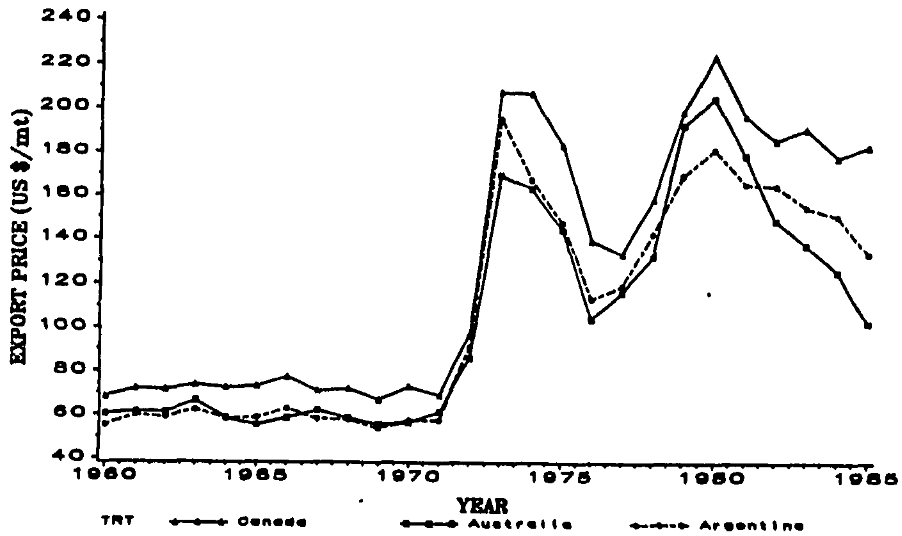
Year	Total	EC	Japan	India	USSR	China	Others
1960 - 64	100.00	19.62	6.66	9.20	4.62	9.17	50.74
1965 - 69	100.00	14.96	8.04	10.03	4.99	9.22	52.76
1970 - 74	100.00	11.40	8.68	4.86	8.38	7.65	59.04
1975 - 79	100.00	7.37	8.07	3.17	10.40	8.34	62.65
1980 - 85	100.00	3.56	6.00	1.68	20.71	11.09	56.96
1960 - 85	100.00	11.08	7.43	5.63	10.24	9.17	56.45

[a]International Wheat Council. Various issues. World Wheat Statistics.



Canadian export price, no. 1, CWRS, in store price, St. Lawrence .
U.S. export price, no. 2, Hard Winter, ordinary, fob, Gulf Port.
• Source: International Wheat Council. World Wheat Statistics.

Figure 3.1: Export prices of Canada and the United States



Canadian export price, no. 1, CWRS, in store price, St. Lawrence.
Australia export price, AWS selling price, fob.
Argentina export price, Trigo Pan.
• Source: International Wheat Council. World Wheat Statistics.

Figure 3.2: Export prices of Canada, Australia, and Argentina

world wheat market is hardly competitive. A trade theory and hence the empirical model should be able to capture and interpret the outcomes in price and quantity changes over time.

3.4.2 Previous studies on the world wheat market structure

Mendulson (1957) was among the earliest to study the world wheat market conduct. He argued that to consider international pricing in the framework of competitive trade theory for wheat is inappropriate, the world price was directly affected by monopolistic and monopsonistic forces exercised through the International Wheat Agreement (IWA).[1] As it followed, oligopolistic nature of pricing and

[1]IWA was replaced by the International Grains Arrangement (IGA) in July 1968.

structure of world wheat market were postulated.

McCalla (1966) conceptualized the world wheat market in a circumstance of stable prices as a model of cooperative duopoly between Canada and the United States.

> A duopoly approach rather than an oligopolistic approach is appropriate for two reason. First, Canada and the United States supply 60 percent of the market. Second, only these two countries have storage facilities in sufficient volume to permit holding, and ability essential to duopolistic or oligopolistic pricing. This storage capacity and the willingness of these countries to hold stocks support the duopoly concept (p. 713).

Other reasons contributing to the duopoly model are that Canada and the United States have lower production costs and huge volumes of production relative to other suppliers. The behavior of other smaller exporters, such as Australia and Argentina, was postulated more akin to follow the duopolists' price to clear their current crop. The demand side of the market was characterized as competitive because of the absence of market power.

Note that McCalla's postulation of a duopoly model was narrowly confined to the free world wheat market with sales to USSR and China excluded. In a broader world market including the centrally planned countries, he abandoned the duopoly model and argued that the market was an oligopoly on the exporting side and an oligopsony on the importing side (McCalla, 1970).

McCalla's cooperative duopoly model was followed by Taplin (1969) except for the specification in the wheat pricing behavior. Alaouze et al. (1978) extended McCalla's duopoly to a triopoly model with Australia as the third triopolist. They argued that a market-share triopoly model was appropriate after the price war in the 1968 season. Australia no longer pursued a policy of pricing to sell its exportable surplus. Evidence of the vast increase in carryover stocks in 1968 and increase in the storage capacity in the next season (1969) indicated that Australia was prepared to exercise restraint in its wheat marketing. This model was proposed to be appropriate until the 1972 season when the market was characterized by high, unstable prices and low carryover stocks. Instead, the market was postulated as competitive from that season on, but after the mid-1970s they further suggested that market was returning to some form of stable, oligopolistic structure because price had begun to fall and stocks were increasing.

In 1979, Carter and Schmitz refused the thus far generally accepted notion that world wheat prices were largely determined by major exporters (market of oligopoly). Instead, they evidenced that the market power on the part of major importers was perhaps greater than the power of major exporters (maker of oligopsony). A rather naive graphical "optimal tariff" model was performed to empirically examine the world wheat price formation. Their result showed that Japan and the EC, particularly Japan, were more likely the world price leader, because the world price (1966 to 1972, 1976) was approximately determined at the level Japan and the EC set an optimal or nearly optimal tariff (quota equivalent). The market power may temporarily revert from the major importers to exporters and the market is effectively an oligopolistic pricing only at the time of commodity booms from 1973 to 1975.

An implication about the market structure was drawn by Spriggs et al. (1982) from their results of test on leadership between Canadian and U.S. wheat prices. The oligopoly model suggested by Carter and Schmitz for the 1974 - 1975 period was supported because the U.S. acted as the price leader (price leadership will be discussed in the next section). The competitive market asserted by Grennes and Johnson (1979, 1980) to against either oligopoly or oligopsony model was evidenced inappropriate. The market may have been temporarily competitive at the time of 1972 to 1973, but that is not likely the case for all time.

Following the sequence of arguments but lack of agreement on the world wheat market structure, Kolstad and Burris (1986) formally tested the hypotheses: Canada-U.S. duopoly, Canada-U.S.-Australia triopoly, Japan-EC duopsony, and perfect competition. A spatial equilibria world wheat trade model was applied to the 1972 season, and they concluded "Nasy duopsony conduct assumption is a very poor explainer of trade. The duopoly and triopoly models performed considerably better, with the duopoly model forecasts being slightly closer to the actual values than the tripoloy model" (p. 35). Since they were the first to conduct a formal test, the finding provides a very important direction for the previous mixture on world wheat market structure. Table 3.3 summarizes all previous market structure hypotheses associated with the noticeable market outcomes and events of the dollar.

3.4.3 World wheat market of duopoly

From the regularities and previous studies, the world wheat market is, at least most of the time, more realistically imperfect rather than perfect competition.

> But should the duopoly arrangement disintegrate, it is certain that it will be replaced by another imperfectly competitive market structure .... It will not be replaced by an international market approaching pure competition ... (McCalla, 1966, p.727).

Table 3.3: The hypothesized world wheat market structures

Crop year	Hypothesis (proponents)	Outcomes and the dollar events
1. 1960 - 63	Duopoly (McCalla, Taplin)	Stable price
2. 1964 - 65	Triopoly or U.S. dominant (McCalla)	Price war (↓17% in 1964, historical low in 1965)
3. 1966 - 67	Duopoly (Taplin) Duopsony (Carter and Schmitz)	Price recovery and stable
4. 1968 - 71	Triopoly (Alaouze et al.) Duopsony (Carter and Schmitz)	Price war (↓12% in 1968, historical low in 1969) Gold window closed in 1971 First dollar devaluation (about 7%) at Dec. 1971
5. 1972	Duopoly (or triopoly) (Kolstad and Burris) Duopsony (Carter and Schmitz) Competitive(Alaouze et al.)	High and increasing price (↑41%) Second dollar devaluation in the early 1973 (flexible system started)
6. 1973	Oligopoly (Carter and Schmitz) Competitive (Alaouze et al.)	High and increasing price (historical high)
7. 1974 - 75	Oligopoly (Carter and Schmitz; Spriggs et al.) Competitive (Alaouze et al.)	High but decreasing price (↓14%)
8. 1976	Duopsony (Carter and Schmitz) Oligopoly(Alaouze et al.)	Price drop down (↓29%)
9. 1977 –	Oligopoly(Alaouze et al.)	Stable price

Whereas, what structure can the market be best fitted? None of the previous findings can provide a firm direction. A general recognition is that there are structure changes, and that the changing structure creates major difficulties in modeling world wheat trade (Alaouze et al., 1978; Spriggs et al., 1982). Thus, it is not surprising that studies on exchange rate effects, as well as on trade and policy, were always undertaken with the competitive framework. However, the previous studies have already pictured the world wheat market. Even though it is not strongly underpinned unless a formal test is done, a duopoly model might be the best characterization of the world wheat market. This model has been recently applied by Gilmour and Fawcett (1986) and Schwartz (1986).

From Table 3.3, disregarding the more complicated postulation that market is oligopoly in the supply side and oligopsony in the importing side, Carter and Schmitz's postulation is the only one to characterize the world wheat market as duopsony. Oligopoly (triopoly or duopoly) is most often postulated in the past. This is conceivable from the regularities of the world wheat market.

Carter and Schmitz's rather naive graphical analysis is the conventional analysis of commercial policy in trade theory, which assumes firms are perfectly competitive in the world market. The optimal tariff argument they applied in analysis is simply a restatement for a country the monopoly or monopsony argument for firms. An importing country whose import is large enough to influence the world price can exert a tariff to improve its terms of trade and, hence, to increase its domestic welfare. The tariff that increases domestic welfare the most is called the optimal tariff (Enders and Lapan, 1987). However, there are two things that must be noticed in the optimal tariff argument. First, the market is a priori assumed competitive.

Second, the country to exert an optimal tariff should be large enough in import (or export) to influence the world price.

Regarding the market structure, Carter and Schmitz's analysis, like the conventional analysis, a priori assumed a competitive world wheat market. That is, the world price is determined by the equilibrium of world (excess) demand and supply even if the large (importing) country exerts its market power. A lower world price is because of a lower demand due to the exercise of tariff, but the competitive framework containing demand and supply schedules is unchanged. However, according to the firm theory in the microeconomic theory (see, e.g., Henderson and Quant, 1980), there is no supply schedule for a monopolist (or oligopolist). The monopolist decides the market price (or quantity) to maximize its profit (MR = MC), given the market demand facing it. Similarly, there is no demand schedule for a monopsonist (or oligopsonist). The market price (or quantity) is decided by profit-maximization behavior given the supply schedule. Thus, the optimal tariff analysis per se is an argument about a country's welfare from trade rather than market structure. It appears that if a country has market power to influence world price determination, market should easily be imperfectly competitive and result in a market failure. The presumption of competitive character is infeasible. This is, perhaps, a shortcoming of the conventional trade theory, so that "very recent research has refocused attention on the role of commercial policy in the presence of imperfect competition"(Enders and Lapan, 1987, p. 177). Carter and Schmitz's finding, therefore, is hardly an implication of duopsony structure for the world wheat market. Indeed, market is characterized as competitive.

The second important necessity of the optimal tariff argument is that an importing country that can exert optimal tariff should be large enough in import to influence the world price. Carter and Schmitz argued that "one of the major importers of wheat (e.g., Japan or the EC) acts as a price leader in setting an optimal or nearly optimal tariff." Their optimal import tariff solution (1966 to 1972, 1975) of the estimated and actual price per ton are (p. 519)

	Estimated	Actual
Export price	$70	$72 (average)
Price in the importing countries	$198	$193 (Japan)
		$113 (EC)

As they pointed out, relative to Japan the EC "is not taking full advantage of its position as major wheat importer." Actually, one fact was neglected in their paper that the EC is also a major wheat exporter and is a net exporter since 1974. Therefore, in the optimal tariff argument the EC is hardly to be identified as a major importer to exert optimal tariff. Indeed, their results already entirely deny the position of the EC as a major importer to exert optimal tariff, because the actual price in the EC ($113) is closer to the estimated export price ($70) rather than the estimated price in importing countries ($198). The country that seems likely to exert optimal tariff is Japan, because the actual price in Japan ($193) is very close to the estimated price in the importing countries ($198). However, in the period of their optimal tariff solution, Japan shared only 8 percent (Table 3.2) of the world wheat imports. It is hardly believable that Japan in that period acted as a world price leader in setting an optimal or nearly optimal tariff with, for example, the United States or Canada kept tacit (the United States shared about 40 percent and Canada shared about 21 percent of the world supply). While the optimal tariff argument requires a country should be large enough to exert optimal tariff, Japan seems not likely the one in the world wheat market to do so.

Neither market is characterized as imperfectly competitive nor Japan is big enough in imports to influence the world wheat price, Carter and Schmitz's duopsony (or oligopsony) argument, therefore, is weakly supportable. The only possibility their conclusion is plausible is that all major importing countries (they mentioned Japan, the EC, the USSR, and China) explicitly worked together (a collusive arrangement). They conceived this only possibility, so argued that "the major importers of wheat could be acting in a fashion similar to tacit collusive behavior and that they are effectively imposing close to an optimal import tariff on wheat" (p. 519). However, first, the EC is already evidenced by their result not to exert an optimal tariff, and second, even if the EC cooperated with other major importing countries these four major importers only shared about 35 percent of the world wheat demand. Neither the possibility nor the effectiveness of collusion is acceptable according to their evidence.

A direct, strong rejection to Carter and Schmitz's conclusion was Kolstad and Burris' (1986) test result. Carter and Schmitz argued a structure of duopsony for the 1972 season, but it was examined to be a very poor explainer compared with any other market structure hypothesis. Rather, duopoly appeared to be the best characterization of the world wheat market.

As the duopsony fails to be plausible, postulations left are the conventional oligopoly structure except the one of perfect competition for the period 1973 - 75. Note that the competitive character in the demand side thus far is uniformly accepted. Among oligopoly postulations, duopoly and triopoly are the two that were more often postulated to characterize the market.

Alaouze et al. (1978) evidenced a triopoly structure for the 1968 - 71 period. Australia was asserted the third triopolist associated with the United States and Canada. The primary reasons are the outcome of a price war started in 1968, and the associated increases in carryover stocks and production in Australia. The price war in 1968 was argued to be a result of the emergence of triopoly, where the increase in carryover stocks in Australia implies its ability and willingness to exert market power in preserving market shares.

However, a statement about those outcomes by Gilmour and Fawcett (1986) sounds like a disagreement.

> The last few years have seen the American building up large stocks of wheat .... Theoretically the Americans could 'dump' all of their present wheat stocks on the world wheat market at prices sufficiently low .... Luckily for other exporting market participants, the Americans have seldom seen fit to carry over this threat out to the extreme until recently. However, there have been occasions in the past when the Americans have exercised some market muscle by deliberately decreasing their traditional wheat stocks position until the smaller wheat exporters fell in line with American desires. For example, in the late sixties when Australian wheat production almost doubled, the Australian initially refused to increase their wheat stocks as well. An international wheat price war started – largely by the Americans 'dumping' stocks – and continued until the Australians greatly expanded their stock holding capacity and willingly held stocks when the Americans and Canadians held stocks (pp. 36 - 37).

What have been stressed in the above statement are that the price war in 1968 was started by the U.S. dumping, and increase in Australian carryover stocks was resulted from the pressure of the United States and the lower world price. Regarding the oligopoly market structure, the United States was implied to be the most powerful supplier and Australia was forced to fall in line with its desire. If Gilmour and Fawcett's statement is more realistic, the world wheat market should be more plausibly characterized as duopoly.

MaCalla defines market power as the capacity and willingness to hold stocks, an ability essential to oligopolistic pricing. This definition was adopted by Alaouze et al. to justify the Australia position in the world wheat market as the third triopolist. The fact that Australia increased its storage capacity in 1968 - 71 is true; however, the key point is whether or not the increases in carryover stocks indicates the willingness of Australia to act as the third triopolist? Australian production in 1968 and 1969 were almost double the level in 1967. However, production in 1970 fell back to the level in 1967, that is, almost the original level before increases. For the ending stocks, there were vast increases in 1968 and 1969, but they sharply fell down in 1970. The sharp fall in both production and stocks in 1970 make the willingness of Australia to hold stocks questionable.

According to the postulation made by researchers and the real world evidence, the market structure for the 1968 - 71 period might be more realistically described as follows. At the outset in 1968, Australia may have intented to act as the third triopolist in the world market. Its intent resulted in increases in production and exports, so was its market share in the world market. However, after the United States detected the emergence of Australia and the loss of its market share in the world market, it deliberately dumped the market when Australia refused to hold more stocks and to export less. Consequently, the price war started. A formal and special meeting, therefore, was arranged in July 1969 (the beginning of the 1969 season) at Washington, D.C. to avoid the further deterioration of the world wheat market (Alaouze et al., 1978). An agreement was made to increase the market share for Australia but Australia also have to hold the surplus of production (so increased its silo system in 1969). Eventually, Australia reduced its production, hence the ending stocks, in 1970 and returned to its original position from that season on. Apparently, even if Australia had intent to be the third triopoly, it failed. The increase in carryover stocks in 1968 - 69 was not due to Australian willingness; otherwise, it is not necessary to reduce production and stocks holding in 1970 and beyond. This implies that the world wheat market was actually dominated by the United States. The triopoly postulation is thus inappropriate.

Turning to the market structure for the 1973 - 75 period, both oligopoly (Carter and Schmitz, 1979; Spriggs et al., 1982) and competitive (Alaouze et al., 1978) were postulated. It is necessary to discuss the plausibility of a duopoly assumption for the period. The primary reason Alaouze et al. postulated the competitive structure is the outcome of high and unstable prices, which is very straightforward a departure from imperfect competition. However, no evidence was provided to support this postulation, so it is hardly plausible. Indeed, their competitive postulation entirely ignored the events in the international financial market, that is, the dollar devaluation (see Table 3.3). Instead, Carter and Schmitz's optimal tariff analysis, although it is weak as a market structure argument, indicated that the major wheat exporters rather than major importers owned the market power in this period. Moreover, Spriggs et al.'s causality test showed that the United States was leading the world price in 1974 - 75. These more precisely statistical examinations imply an oligopoly rather than a competitive structure for these three seasons.

From the above discussion, a duopoly structure is assumed for the world wheat market in this study. The United States is the most powerful exporting country and Canada is the second largest exporting country. These two countries are the duopolists with other relatively smaller exporting countries acting as their followers. The demand side of the market is assumed competitive because of the absence of market power.

3.5 A Model of Duopoly Pricing

The standard trade theory is conventionally based on the competitive framework. There is no general trade model of oligopoly. The difficulties in developing a general oligopoly trade model are, for example, how to predict the action of small numbers of firms (e.g., explicit or tacit collusion, or noncollusive action), outcome of competition (prices or outputs), the nature of conjectures about other firms' responses, and so on. So, it is not possible to provide any sort of general analysis of oligopoly trade (Helpman and Krugman, 1986). Therefore, some specific structural and behavioral assumptions are needed for the following duopoly pricing analysis.

3.5.1 Two basic assumptions

1. Each world wheat trade participating country is assumed an appropriate market unit.
2. Wheats are differentiated in the world market, but the elasticity of substitution is high.

The first assumption validates the standard microeconomic duopoly theory in application by replacing a country for a firm. In the world wheat market, this assumption coincides very closely with the real world situation because on the supply side the ability to set price (or quantity exported) in the five major exporting regions is directly or indirectly vested in one government or quasi-government agency, so are the wheat imports on the demand side.[2]

The second assumption breaks away from the general one of homogeneous products. Differentiation of wheat can be justified by country of origin and by physical characteristics (see Chapter 2).

3.5.2 Structural assumptions

1. The supply side of the world wheat market is dominated by two large exporters (the United States and Canada) and a fringe of smaller exporters (Australia, Argentina, the EC, and others).
2. The demand side of the world wheat market is characterized as competitive.

Under these two basic and two structural assumptions, the standard duopoly theory with differentiated products could be utilized as long as the small exporters' behavior is accounted for. The United States and Canada are the two duopolists in the world wheat market.

3.5.3 Behavioral assumptions

1. Profit-maximization behavior.
2. Canada is the price leader with the United States acting as the price follower.

[2]For example, Canadian Wheat Board (CWB), U.S. Department of Agriculture (USDA), Australia Wheat Board (AWB), Argentina Grain Board (AGB), Common Agricultural Policy (CAP) in the EC, Food Agency (FA) in Japan.

3. Other smaller exporters are either to sell what they can at the duopolists' price or to cut price to sell their predetermined quantities of wheat to the world market.

There are three maximization behaviors had been assumed in the previous studies : sales-maximization (McCalla, 1966), revenuc-maximization (Alaouze et al., 1978; Taplin, 1969), and profit-maximization (Kolstad and Burris, 1986). McCalla assumed the sales-maximization for Canada, the price leader, because he argued that the Canadian Wheat Board (CWB) as a sales agency operating at cost has no incentive to maximize profit. The CWB might shift from sales- to profit-maximization policy only in years of short supply. This postulation was criticized by Taplin. Because the incomes of Canadian wheat farmers are determined largely by export prices, the Canadian export policy must principally concern the returns of wheat farmers. Instead, Taplin postulated that Canada generally acts as a pure monoplist and sets export prices to maximize farmers' revenue. Since the United States was assumed to be a price follower, both duopolists eventually maximize their revenue from exports. The revenue-maximization was also assumed by Alaouze et al. for Canada. Kolstad and Burris adopted the standard profit-maximization assumption in testing hypotheses of the world wheat market structure.

Indeed, revenue-maximization and profit-maximization are equivalent with respect to a crop-year pricing behavior. Recall the fact mentioned before that wheat production is almost finished at the beginning of the crop year, therefore, at the point in time when the sales decision is made in a crop year, the total cost is already spent and could be considered fixed. Theoretically, this implies that the marginal cost cannot be adjusted by changing the quantity to produce. Thus, the two behavior assumptions of revenue- and profit-maximization would be simultaneously reached at the condition of marginal revenue equals zero. In other words, once the revenue is maximized, the profit is also maximized.

Profit- (or revenue-) maximization behavior is assumed in this study. In addition to Taplin's postulation, the main reason is because more than 50 percent of production is exported in the United States and Canada, it is hardly believable that these two countries just tend to maximize sales without attempting to make earnings from exports over time. The sales-maximization assumption may be plausible only in years when domestic production much exceeds the aggregate demand and the storage facilities.

The price leadership between Canada and the United States in the world market was much debated in the past. Conventionally, Canada was taken as the price leader with the United States (and Australia in a triopoly model) as its follower(s) (Alaouze et al., 1978; McCalla, 1966; Taplin, 1969). In recent years, this leadership was more specifically examined (Gilmour and Fawcett, 1986; Spriggs et al., 1982).

The representative assertion of the Canadian price leadership was made by McCalla (1966), "Canadian price leadership arises primarily because the United States is willing to let Canada lead." His assertion is basically in regard to U.S. domestic and foreign agricultural policies. The U.S. domestic wheat policy of support price, which is usually higher than the world price, necessitates the payment of export subsidies. Since the CWB has direct control over export price and USDA's control is indirect, the United States can simplify its position by taking Canadian export price as a reference and determining the export subsidy. On the aspect of foreign policy, the United states has attempted to avoid serious disruption in the world wheat trade; for example, the implementation of Public Law (P.L.) 480, which aimed to dispose the worrisome supplies without breaking the market. Such attempt curtails U.S. behavior in the world wheat market. In addition, the United States may prefer not to dominate the world market overtly because of the undesirable image of a large country dominating small countries. Other explanation that had been proposed and quoted by McCalla for the Canadian price leadership are (1) Canada had been the largest exporter from the 1920s to the late 1950s, (2) Canadian wheat in quality is superior to U.S. wheat, and (3) barometric price leadership exists for Canada because Canada has greater ability to react to changing world condition.

Taplin argued that because the U.S. farm incomes had little relationship to export revenue, the U.S. export policy could be regarded as being much more flexible than that of Canada; therefore, Canada generally acted as a pure monopolist to set export price with the United States as its follower. Alaouze et al. argued that Canadian price leadership is primarily because of its attempts to maximize revenue from exports.

Spriggs et al. appear to have been the first to formally test the price leadership between Canadian and U.S. price. The Granger causality test was conducted on the daily data, CWB quotations for wheat delivered to Thunder Bay and U.S. Minneapolis cash closing price,[3] for sixteen crop years (1964 - 78). The leadership was presented in terms of the significant nonzero-lag cross-correlation coefficient. Their test result shows (1) price leadership by Canada in no years, (2) price leadership by the United States in 1974 and 1975, and (3) instantaneous causality in eight out of the sixteen years.

[3]The weak point is the use of U.S. domestic price not export price (usually the Gulf Port price), which is mostly concerned by this study.

Gilmour and Fawcett conducted the regression analysis (quarterly data) to more completely investigate the relationship between American and Canadian wheat prices. The tested regression equations included the price linkages between (1) the CWB asking price for Canadian Western Red Spring (CWRS) and the USDA calculated farm price, and (2) Canadian unit value export price and the U.S. Gulf Port price. Either reaction function of Canadian price to U.S. price or the inverse was examined (so there are four sorts of reaction function). Alternative (linear and logarithmic) specifications and fittings were presented for any sort of reaction function, and formal and rigorous model selection procedures (parsimony and simplicity principle) were made to choose the relatively best equation.

Regarding price leadership in the world wheat market, their chosen overall best specifications of export price reaction functions indicated that (1) neither in linear nor in logarithmic specification did the Canadian unit value export price respond to the U.S. Gulf Port price in terms of the Canadian dollar, and (2) both in linear and in logarithmic specifications the U.S. Gulf Port price did significantly and instantaneously respond to the Canadian unit value export price in terms of the U.S. dollar. Their findings imply that the CWB does take domestic supply condition into consideration to determine the export price. On the other hand, market information is generally disseminated quickly in the American market and since the American wheat is less preponderant in the premium quality wheat market, some adjustment on the U.S. price is made in response to the CWB price. Thus, the Canadian price leadership and the product heterogeniety assumption sound realistic.

The third behavioral assumption addresses the behavior of other smaller exporting countries in the world market. This assumption was made by McCalla (1966) and is accepted in this study. The price movements (see Figures 3.1 and 3.2) appear to be evidence to support this assumption. Once this assumption is made the standard duopoly solution, thereafter, can be directly utilized to analyze the world wheat trade under imperfect competition.

3.5.4 World demand facing duopolists

By adopting the duopoly characterization for the world wheat market, the world price, therefore, is not determined by the equilibrium of excess supply and demand schedules as under the competitive framework. Instead, world prices are decided by duopolists pricing decisions.

According to the above assumptions, the leader-follower relationship (because of the price leadership assumption) with differentiated products (because of the product heterogeniety assumption) Stackelberg solution (see, e.g., Henderson and Quandt, 1980) appears to be the best fitted one to solve the duopoly world wheat market. This the so-called Stackelberg determinate equilibrium solution. Note that the decision variable in the Stackelberg solution could be either price or quantity. Duopolists can decide price and let the market demand schedule determine the quantity, or vice versa. Price is taken as the decision variable in this study because the world wheat market seems more price competitive from the regularities.

Canada is taken as the price leader and the United States is the price follower. Since wheats are assumed differentiated, each duopolist would face its own distinct demand curve and thereby to maximize profit. However, the demand facing any duopolist should be affected by the other's price decision because wheats are close substitutes. In pricing decision, the follower would obey its reaction function in response to the leader's price. The leader would act as a pure monopolist in maximizing its profit and deciding the price level, given the follower's price reaction function (i.e., the leader is aware of the follower's price reaction function).

The first step to go for the following analysis is to derive the demand schedule facing duopolists, and the second is to link the price of exporter's price and the domestic price in the importing country. The exchange rate variable, therefore, is incorporated into the model through the international price linkage.

Since the demand side of the world wheat market and also all domestic markets are assumed competitive, import demand for wheat of any importing country is defined, like that in the competitive framework, as the excess demand of its domestic market. Countries on the demand side of world market is divided into "free economies" and "centrally planned economies." This is because, as mentioned earlier, the specification of demand and supply functions for the free economies is based on the price theory, but it is hardly applicable to the centrally planned economies. In addition, since the inventories in the importing countries are relatively small and stable, stock demand is not specified and not considered in modeling for simplicity (Mahama, 1985).

Import demand of a free economy i at crop year t can be simply obtained by subtracting equations (3.13) from (3.12),

$$\begin{aligned} ED_{ti} &= D_{ti} - S_{ti} \\ &= ED[v_{ti}, FV_{ti}, y_{ti}, N_{ti}, Z_{ti}] \end{aligned} \tag{3.15}$$

where Z_{ti} is a vector containing YA_{ti} and all prices (indices) except wheat price,

v_{ti}. The aggregate import demand of free economies at crop year t is the summation of equation (3.15) for all participants,

$$\begin{aligned} Q_t^F &= \sum_i ED_{ti} \\ &= F(v_t, FV_t, y_t^f, N_t^f, Z_t) \end{aligned} \tag{3.16}$$

where all arguments in equation (3.16) are defined in a manner of integration of all free economies. Similarly, aggregate import demand of centrally planned economies at crop year t, from equation (3.14) and the exogenous wheat production, is

$$\begin{aligned} Q_t^C &= \sum_j (D_{tj}^C - S_{tj}^C) \\ &= G(v_t^{cf}, v_t^{cg}, y_t^c, N_t^c, S_t^c) \end{aligned} \tag{3.17}$$

The aggregate world demand (Q_t^W) can be defined as aggregate import demand of free economies plus aggregate import demand of centrally planned economies.

$$Q_t^W = Q_t^F + Q_t^C \tag{3.18}$$

The world demand facing duopolists, therefore, is the aggregate world demand minus aggregate export supply of other smaller exporters,

$$Q_t^D = Q_t^W - Q_t^S \tag{3.19}$$

where Q_t^D is the world demand facing duopolists, and Q_t^S is the aggregate export supply of smaller exporters. According to the behavioral assumption, Q_t^S is considered as exogenously determined by the smaller exporters. Equation (3.19) is actually the residual demand facing duopolists as defined by Alaouze et al. (1978), McCalla (1966), and Taplin (1969).

3.5.5 International price linkage

The law of one price (LOP) was usually assumed for the linkage, for example, model (2.1) and (2.4). However, it had been evidenced not to hold in the real world (see Chapter 2). In this study, the duopolists' export prices and the domestic market price of the importing countries are linked as

$$v_t^{CA} = (P_t^{CA} + t_t^{CA})e_t^{US}(1+\tau_t) + M \tag{3.20}$$

$$v_t^{US} = (P_t^{US} + t_t^{US})e_t^{US}(1+\tau_t) + M \tag{3.21}$$

where P_t^{CA} and P_t^{US} are Canada and U.S. export prices in terms of the U.S. dollar,[4] respectively; e_t^{US} is exchange rate evaluated in terms of the units of importers' currencies per unit of the U.S. dollar; t_t^{CA} and t_t^{US} are transport cost in terms of the U.S. dollar per unit (e.g., metric ton) of wheat delivered from Canada and the United States, respectively; τ_t is tariff exercised by importing countries and assumed the same against Canada and the United States; M is the market margin in the importing country.

The price linkages explicitly embody the assumption that Canadian and American wheats are differentiated by country of origin and by physical characteristics. P_t^{CA} is not necessarily equal to P_t^{US} (always higher) presenting the differentiation by physical characteristics, where t_t^{CA} is not necessarily equal to t_t^{US} presenting the differentiation by country of origin (Gilmour and Fawcett, 1986; Johnson et al., 1977, 1979). By means of the price linkage, the exchange rate is incorporated into the model. A decrease in e_t^{US} means a devaluation of the U.S. dollar.

[4]The price quotation of the Canadian Wheat Board (CWB) is in both the Canadian dollar and the U.S. dollar. Importers can pay for trade in either currency.

3.5.6 Duopoly pricing – the Stackelberg determinate equilibrium solution

Since Canadian and American wheats are assumed differentiated, any importer, therefore, can buy wheat in the world market with a choice between price and quality. Accordingly, each duopolist will face its own distinct demand curve (see, e.g., Henderson and Quandt, 1980). The quantity each duopolist can sell would depend upon not only the world demand facing duopolists, but also upon the other duopolist's price decision. The world demand facing duopolists in the world market then is decomposed into two distinct demand functions,

$$Q_t^D = Q_t^W - Q_t^S = Q_t^{US} + Q_t^{CA} \tag{3.22}$$

and in general forms Q_t^{US} and Q_t^{CA} could be written as

$$Q_t^{US} = f[(P_t^{US} + t_t^{US}), (P_t^{CA} + t_t^{CA}), Q_t^W, Q_t^S] \tag{3.23}$$

$$\frac{\partial f}{\partial (P_t^{US} + t_t^{US})} < 0, \quad \frac{\partial f}{\partial (P_t^{CA} + t_t^{CA})} > 0$$
$$\frac{\partial f}{\partial Q_t^W} > 0, \quad \frac{\partial f}{\partial Q_t^S} < 0$$

$$Q_t^{CA} = g[(P_t^{US} + t_t^{US}), (P_t^{CA} + t_t^{CA}), Q_t^W, Q_t^S] \tag{3.24}$$

$$\frac{\partial g}{\partial (P_t^{US} + t_t^{US})} > 0, \quad \frac{\partial g}{\partial (P_t^{CA} + t_t^{CA})} < 0$$
$$\frac{\partial g}{\partial Q_t^W} > 0, \quad \frac{\partial g}{\partial Q_t^S} < 0$$

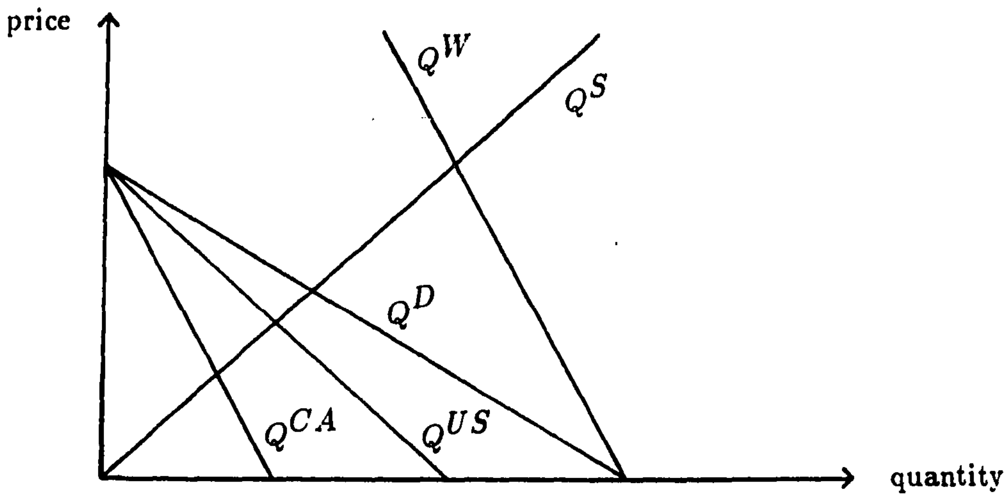


Figure 3.3: Demand schedules in the world wheat market

where $Q_t^{US}(Q_t^{CA})$ is world import demand for U.S. (Canada) wheat, and $(P_t^{CA} + t_t^{CA})$ and $(P_t^{US} + t_t^{US})$ are import prices ($c.i.f.$) in terms of the U.S. dollar resulting from imports from Canada and U.S., respectively. The demand schedules can be presented graphically as Figure 3.3, where Q^W represents the aggregate world demand schedule, Q^S is the aggregate export supply schedule of other smaller exporters, and Q^D is the world demand schedule facing duopolists.

From equations (3.23) and (3.24), it is noticeable that an increase in Canada (U.S.) price with U.S. (Canada) price unchanged would result in a reduction of demand for Canada (U.S.) export. Because classes of wheat are close substitutes change in the relative price will affect the sources of purchases, some customers of Canada (U.S.) would turn to U.S. (Canada). In Figure 3.3, the relative price change will rotate $Q^{CA}(Q^{US})$ schedule to left (right) or right (left). Thus, export quantity change due to a price change is not only along the demand schedule but also dependent upon the rotation of schedules. Any shift of the Q^S schedule will shift the schedule of world demand facing duopolists (Q^D), hence the schedules Q_{CA} and Q_{US} .

For simplicity and without loss of generality, linear form demand equations are assumed for (3.23) and (3.24). The two distinct import demand equations facing the United States and Canada at crop year t could be rewritten as

$$Q_t^{US} = a_0 - a_1(P_t^{US} + t_t^{US}) + a_2(P_t^{CA} + t_t^{CA}) + a_3 Q_t^W - a_4 Q_t^S \quad (3.25)$$
$$Q_t^{CA} = b_0 + b_1(P_t^{US} + t_t^{US}) - b_2(P_t^{CA} + t_t^{CA}) + b_3 Q_t^W - b_4 Q_t^S \quad (3.26)$$

where $a_i > 0, \ b_j > 0, \ i\, j = 1, \ ..., \ 4.$

According to the Stackelberg leader-follower determinate equilibrium solution, the United States (price follower) will price its wheat by obeying the price reaction function, given Canadian export price. Canada (price leader) will act as a pure monopolist in pricing its wheat export to maximize profit, given U.S. price reaction function. The U.S. price reaction function is obtained by maximizing its profit function.

$$\Pi_t^{US} = P_t^{US} Q_t^{US} - TC_t^{US}$$

The first-order condition of optimization with respect to P_t^{US} is

$$\frac{\partial \Pi_t^{US}}{\partial P_t^{US}} = Q_t^{US} - a_1 P_t^{US} = 0$$

where Q_t^{US} is given by equation (3.25). Note that because total cost of production, as mentioned earlier, is already spent and fixed at the point in time of decision making, the first-order condition of profit maximization shows that the marginal

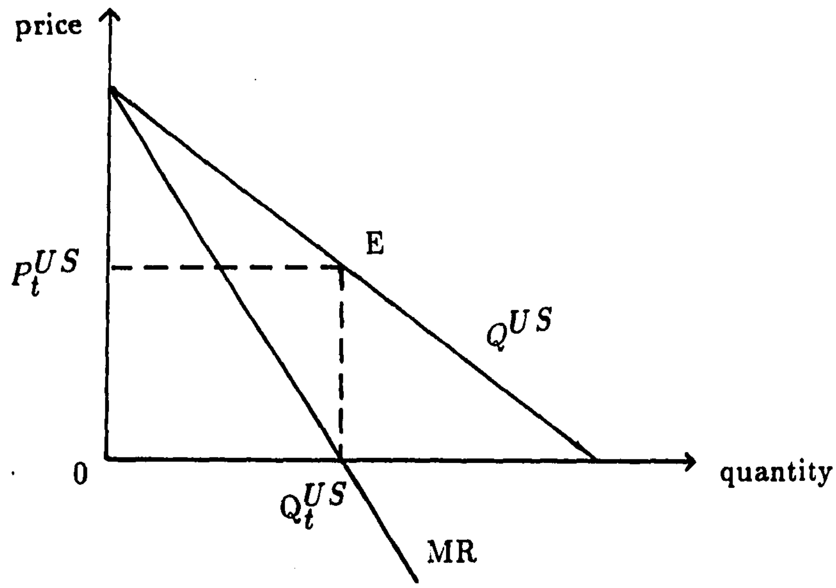


Figure 3.4: U.S. wheat export price and quantity decision

revenue equals zero (MR = MC = 0). This condition is also true for revenue-maximization behavioral assumption, so that these two behavioral assumptions are actually equivalent. The U.S. export price reaction function, therefore, is

$$P_t^{US} = \frac{1}{2a_1}\left(a_0 + a_2 P_t^{CA} - a_1 t_t^{US} + a_2 t_t^{CA} + a_3 Q_t^{W} - a_4 Q_t^{S}\right) \qquad (3.27)$$

Graphically, the U.S. export price and quantity decision can be presented as Figure 3.4, given the Q^{US} schedule and Canadian export price (P_t^{CA}). P_t^{US} is decided at point E and the demand schedule will determine the quantity Q_t^{US} at which MR = 0.

Given the U.S. price reaction function, Canada (price leader) will act as a monopolist and price its wheat export to maximize profit

$$\Pi_t^{CA} = P_t^{CA} Q_t^{CA} - TC_t^{CA}$$

Substituting equations (3.26) and (3.27) into profit function, the first-order condition gives the Canada export price decision as

$$P_t^{CA} = c_0 + c_1 t_t^{US} - c_2 t_t^{CA} + c_3 Q_t^W - c_4 Q_t^S \tag{3.28}$$

where (assume $2b_2a_1 - b_1a_2 > 0$)

$$c_1 = \frac{b_1 a_1}{2a_1(2b_2a_1 - b_1a_2)} > 0 \qquad c_2 = \frac{1}{2a_1} > 0$$

$$c_3 = \frac{2b_3a_1 + b_1a_3}{2a_1(2b_2a_1 - b_1a_2)} > 0 \qquad c_4 = \frac{2b_4a_1 + b_1a_4}{2a_1(2b_2a_1 - b_1a_2)} > 0$$

From the price equations (3.27) and (3.28), it is clear that both Canada and the United States in pricing their wheat exports respond to the aggregate world demand and the action of other smaller exporters. Canada acts as a monopolist in pricing, while the United States adjusts its price in response to the Canadian price. The transport cost (freight rate) can also influence the duopolist's price because it changes the import price of the importing countries.

The world wheat trade, therefore, can be described as follows. The importing countries' import demands are originated from the excess demands of their domestic markets. These excess demands sum to the aggregate world demand into the international market. Most of the world demand is supplied by the United States and Canada. These two duopolists are able to price their exports to maximize earnings according to the demand facing them. Other relatively smaller exporters tend to follow the duopolists' prices. However, actions of these smaller exporters in the international market can shift the world demand facing duopolists, hence their pricing decision.

Impacts of the exchange rate changes can be seen from the price linkages. A devaluation of the U.S. dollar will lower the domestic price in the importing countries if import tariffs are fixed. The lower prices tend to increase the import demands of the importing countries, hence the aggregate world demand. Duopolists, therefore, can price their exports higher due to the strong world demand. However, if tariffs are variable in response to the exchange rate changes to insulate the domestic price changes, the excess demands will not change, so the aggregate world demand and the duopolists exports are unchanged.

4 U.S. WHEAT MODEL AND IMPACTS OF MONETARY POLICY

In keeping with the objective of this study to assess the impacts of monetary policy on U.S. wheat trade and domestic market, this chapter would first construct the complete U.S. wheat model and then connect this model with the financial market. The connection, the impact channels, is via the exchange rate (the external channel) and the interest rate (the internal channel) determination. Finally, the theoretical impacts of monetary policy will be graphically evaluated.

4.1 U.S. Wheat Model

The complete U.S. wheat model contains the U.S. domestic market and foreign trade. Regarding wheat demands, the domestic and world markets are almost equally important because the domestic production is almost equally absorbed by domestic and foreign demands. However, the characteristics of domestic and foreign markets is much different. As already seen in Chapter 3, the world wheat market more realistically is characterized as duopoly, the United States acts as a duopolist to price its wheat exports according to the world demand facing it. On the domestic side, the market is more realistically characterized as competitive because both wheat producers and demanders are numerous, and none can influence the domestic price determination. The domestic price, therefore, is determined by the equilibrium of aggregate domestic demand and supply available to the domestic market.

4.1.1 Foreign demand for U.S. wheat and U.S. export pricing

The foreign demand for U.S. wheat is originated from the world wheat market. For modeling this demand, parts of the world wheat trade model developed in the preceding chapter are carried over here to construct the structural U.S. wheat model. They are the aggregate world import demand, world import demand facing the United States, international price linkage, and the U.S. export pricing equation.

$$Q_t^W = Q_t^F + Q_t^C \tag{4.1}$$

$$v_t^{US} = (P_t^{US} + t_t^{US})e_t^{US}(1 + \tau_t) \tag{4.2}$$

$$Q_t^{US} = a_0 - a_1 \frac{P_t^{US} + t_t^{US}}{P_t^{CA} + t_t^{CA}} + a_2 Q_t^W - a_3 Q_t^S \tag{4.3}$$

$$P_t^{US} = \alpha_0 + \alpha_1 P_t^{CA} - \alpha_2 t_t^{US} + \alpha_3 t_t^{CA} + \alpha_4 Q_t^W - \alpha_5 Q_t^S \tag{4.4}$$

Note that the import demand for U.S. wheat is respecified as a function of the relative import price of the importing country.

4.1.2 Domestic wheat use demands

The domestic wheat use demands are partitioned into three components: food use, feed use, and seed use. Note that the price affecting the demand for wheat more realistically should be the price prevailing in the domestic market. Under the competitive framework, the domestic price is inferred to equal to the export price due to the LOP. However, the LOP had been evidenced not to hold and the competitive framework can not characterize the world wheat market. The domestic price, therefore, is not necessarily equal to the export price.

4.1.2.1 Food use and feed use demands for wheat The specification of food use and feed use demands for wheat, equations (3.10) and (3.11), in the importing country is also applicable for the United States. With changed notations and expressed in linear forms, the domestic food and feed use demand equations are

$$D_t^F = d_0 - d_1 P_t^D + d_2 y_t^{US} + d_3 N_t^{US} - d_4 i_t + \tilde{d}_5 P\tilde{W}P_t' \quad (4.5)$$

$$D_t^L = k_0 - k_1 P_t^D + k_2 y_t^{US} + k_3 N_t^{US} - k_4 i_t + \tilde{k}_5 P\tilde{M}P_t' \quad (4.6)$$

where $d_i > 0$ $k_j > 0$, i $j = 1,...,4$; D_t^F is food use demand; D_t^L is feed use demand; P_t^D is the U.S. domestic wheat price; y_t^{US} is income (per capita); N_t^{US} is population; i_t is the interest rate; $P\tilde{W}P_t$ is a row vector containing prices (indices) of wheat substitutes (complements) in producing final wheat products, all grain products, and all commodity groups; and $P\tilde{W}P_t$ is a row vector containing prices (indices) of wheat substitutes (complements) in livestock feeding, meat, and all commodity groups. Note that the interest rate is here explicitly expressed in equations because it is the cost of capital (investment) in the industries of final wheat products and livestock.

4.1.2.2 Seed use demand Seed use demand for wheat is specified as a function of wheat area for the next season and the time trend.

$$D_t^S = r_0 + r_1 AH_{t+1} + r_2 T \quad (4.7)$$

where $r_1 > 0$. The time trend variable is included to capture the variability in, for example, technology over time.

4.1.3 Wheat ending stocks

Unlike that the importing countries do not hold significant levels of wheat stocks and the levels are relatively stable, wheat ending stocks in the United States absorbs a noticeable percentage of production and the stocks levels fluctuate over time associated with market fluctuations. Thus, to model the stock equation for the U.S. wheat model is necessitated. The U.S. wheat stocks (I_t) are partitioned into government (public) stocks (I_t^G) and commercial (free) stocks (I_t^F).

$$I_t = I_t^G + I_t^F \tag{4.8}$$

4.1.3.1 Government stocks The government stock holding is regarded as a device for price stabilization and food security (Grennes et al., 1978a). The level of this stock is specified as a function of government production loan rate, domestic price, current production, and the export.

$$I_t^G = g_0 + g_1 GL_t - g_2 P_t^D + g_3 S_t - g_4 Q_t^{US} \tag{4.9}$$

where $g_i > 0,\ \ i = 1, ..., 4$, and GL_t is the government production loan rate. In the real world, the government ending stocks could be regarded as the market residual. Quantity exported reflects foreign demand, while domestic price reflects demand in the domestic market. A depressed market or an overproduction will result in increase in the government stocks. A government program participant can sell wheat to the government at the loan rate. The higher the loan rate, the more the stocks tend to be.

4.1.3.2 Commercial stocks The commercial stocks are held by wheat producers (or the equivalents) and the intent of this holding is assumed to make more future earnings, that is, a motivation of commodity speculation. For simplicity, a two-periods case is specified to see the possible explanatory variables and their effects on commercial stock holdings. A wheat producer might simply arrange an expected earnings equation for this stocks holding decision as

$$EE_{t+1} = (EP_{t+1} - P_t)\, I_t - P_t\, I_t\, i_t = I_t[EP_{t+1} - P_t(1 + i_t)]$$

where EE_{t+1} is the expected extra earnings from stock holdings, EP_{t+1} is the expected future price, P_t is the current price (domestic price, export price, or government support price), i_t is interest rate, and I_t is level of stocks to hold. The stock holder can make extra earnings if he or she expects $EP_{t+1} > P_t$, but , on the other hand, he or she also burdens the opportunity cost evaluated by the interest loss $(P_t I_t i_t)$. The stock holding decision can be seen from the derivatives of EE_{t+1} with respect to I_t, that is, the expected extra earnings per additional stocks holding

$$\frac{dEE_t}{dI_t} = EP_{t+1} - P_t(1 + i_t) \gtreqless 0$$

or

$$E\dot{P}_{t+1} \gtreqless i_t$$

where $E\dot{P}_{t+1} = (EP_{t+1}/P_t) - 1$, the expected inflation rate of wheat. Apparently, if $E\dot{P}_{t+1} < i_t$, the wheat producer should tend to sell all his or her current crop and deplete previous stocks. The producer can sell wheat to either government stock holding agents at loan rate or wheat markets at market prices. Inversely, if $E\dot{P}_{t+1} > i_t$, he or she should tend to hold inventories as much as possible limited by the current capacity of silo system to hold inventories. Thus, the commercial stock demand for wheat could be specified as a function of expected price (positive), current market prices (negative), government price (negative), capacity of stock holdings (positive), and interest rate (negative). By employing a linear form, the commercial stocks equation (I_t^F) at year t can be written as

$$I_t^F = s_0 - s_1 P_t^D - s_2 P_t^{US} - s_3 GP_t + s_4 EMP_{t+1} + s_5 \bar{I}_t^C - s_6 i_t \qquad (4.10)$$

where GP_t is government price (target price or loan rate), EMP_{t+1} is the expected market price, $\bar{I}_t^C$ is the capacity of stock holdings, and $s_i > 0, i = 1, ..., 6$. Both P_t^D and P_t^{US} are included because wheat producers can sell wheat to either domestic or foreign market.

4.1.4 Wheat production

As defined in Chapter 3, wheat production is the product of yield and wheat area. Since the domestic wheat market is assumed competitive, the wheat area is determined by price received by farmers and the costs of production, that is, the marginal equilibrium condition P = MC. Note that because of the properties of wheat production, all factors except climate and technology affecting the wheat planting area should be considered by farmers in decisions at planting time. These factors are, for example, (1) prices to be received in the coming crop year, (2) costs, and (3) kind of crops to plant. However, these factors in the real world are much related to government programs.

Indeed, the acreage planted has been widely investigated in agricultural economics, which is the so-call acreage response function. The particular interest of such investigation is to see how the acreage planted responds to the government agricultural programs (see, e.g., Garst and Miller, 1975; Langley, 1983; Lidman and

Bawden, 1974; Morzuch et al., 1980). Because agricultural production can not be adjusted instantaneously in response to market information, acreage planted actually determines the production. However, since what the market price will be in the coming crop year is unknown at planting time, the government announced support prices tend to provide an important reference for the planting decision. Almost all empirical findings indicate that government programs historically exert significant influence on the wheat area.

The main purpose of government wheat programs is to raise income of wheat farmers, and two instruments are employed — the direct price support and acreage control (Heid, 1979). The direct price support program is to guarantee the minimum price received by farmers, while the acreage control program is designed to restrict the acreage planted for wheat, thereby to control the wheat production. In the real world, these two programs are exercised by manner of "the nonrecourse loan or the guaranteed target price" and "the land diversion payments." A wheat grower who participates in government programs can obtain diversion payments if he or she takes land out of wheat production, and, on the other hand, he or she can receive the guaranteed price if the market price is lower than this price.

The price support program has been exercised since the 1930s. Prior to 1974, the nonrecourse loan to farmers was exercised. The loan rates were regarded as the price at which the government stands ready to purchase the output of program participators, or to loan funds to the farmer with his or her output as collateral. The target price was zero prior to 1974, but always exceeds the loan rate since it was exercised at the time. The acreage control programs, relative to the price support programs, changed frequently over time. Since the 1960s programs can be separated into quota years (1960 to 1964) and land diversion years (1965 to 1985) (Garst and Miller, 1975; Morzuch et al., 1980). In the quota years, the programs was referred to as an allotment system and the program participation was nearly mandatory with penalties if violations occurred. After wheat farmers rejected the wheat allotment system for supply control in 1963, acreage set-aside and the land diversion programs had tended more towards a voluntary paid diversion approach. Apparently, the effects of government programs could be perceived as (1) for the price support programs, the higher the loan rate or the guarantee target price, the larger the acreage planted, (2) for the acreage control program, the larger the allotment in the quota years and the lower the rates of diversion payments in the land diversion years, the larger the acreage planted will be.

In addition to government programs, a rational wheat farmer may also tend to question what the market price will be and if the market price is lower or higher than the government support price? The aggregate acreage response equation is conceptualized in a linear form as,[1]

$$\begin{aligned} AH_t &= h_0 + h_1 EMP_{wt} - h_2 EMP_{ot} + h_3 GP_t - h_4 DP_t \\ &\quad + h_5 WAL_t - h_6 FC_t \end{aligned} \tag{4.11}$$

where $h_i > 0, i = 1, ..., 6$, EMP_{wt} is the expected wheat market price received by farmers, EMP_{ot} is the expected market price received by farmers of other

[1]Because government programs changed almost every three to five years and each change exerted a significant influence on the acreage response, to conceptualize all alternative program changes in one equation might result in approximate rather than strict measurements of the responses. For example, degree of freedom is a problem in estimation, and relevant variables and structural parameters may change over time.

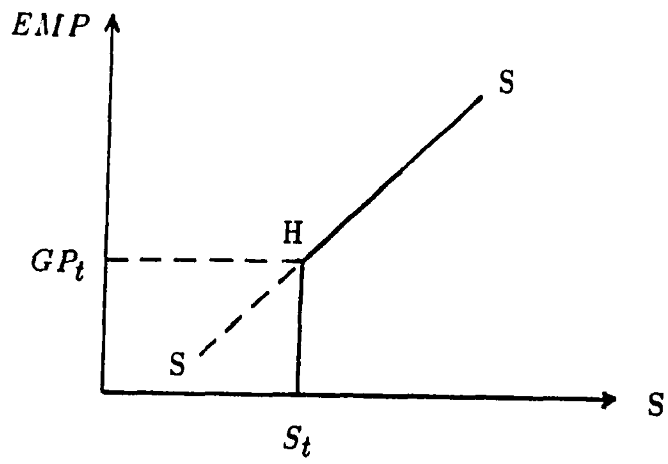


Figure 4.1: U.S. wheat supply curve

competing crops, DP_t is the diversion payments per acre, WAL_t is the wheat acreage allotment, and FC_t is factor prices. Note that if the expected market prices are lower than the government announced support price (GP_t) due to a depressed market, the government price will dominate the wheat area decision.

Following the definition, wheat production at crop year t is

$$S_t = YA_t \cdot AH_t \tag{4.12}$$

where YA_t is yield per acre. The wheat supply curve, therefore, can be graphically presented as Figure 4.1. If there is no government support price, the wheat supply curve will be along SS curve where supply of wheat is a function of the expected market price, ceteris paribus. The government support price will kink the supply curve at point H, where the supply curve becomes vertical because this price is announced and fixed. Changes in other variables will shift the supply curve with the kinked point (H) pegging at GP_t level.

Finally, because the domestic market is competitive, a market equilibrium condition is needed to determine the domestic price and close the system.

$$S_t + I_{t-1} - Q_t^{US} = D_t^F + D_t^L + D_t^S + I_t \tag{4.13}$$

The left-hand side denotes the total supply available to the domestic market. The right-hand side is the aggregate domestic demand (D_t^D).

So far, the complete U.S. wheat model is already constructed and all equations are theoretically embodied. The exchange rate variable appears at the international price linkages. The interest rate enters the domestic demand and the wheat commercial ending stock equations, (4.5), (4.6), and (4.10). As mentioned earlier, these two rates have to be endogenized for the assessment of impacts of monetary policy. Therefore, the next ongoing step is to formulate the exchange rate and interest rate determination equations, and thereby the monetary policy, in terms of money supply (M_t^S), is incorporated into the model.

4.2 U.S. Financial Market

The financial market consists of the foreign exchange market and money market. In general, the exchange rate is determined in the foreign exchange market, where the money market determines the domestic interest rate.

4.2.1 Portfolio equilibrium model – the exchange rate and interest rate determination

The portfolio equilibrium model (Branson et al., 1977; Kouri, 1976, 1980) is adopted by this study to determine the exchange and interest rates. The advantage of using this model is that it can simultaneously determine these two rates and can be easily applied to evaluate the effects of monetary policy.

Assume that there are three assets (money, bonds, and foreign assets) and that all assets but money are not perfect substitutes, the portfolio equilibrium model can be presented as

$$\frac{M^S}{P} = L(i,\, y), \quad L_i = \frac{\partial L}{\partial i} < 0 \quad L_y = \frac{\partial L}{\partial y} > 0 \tag{4.14}$$

$$\frac{B^S + M^S}{P} = D(i,\, i^* + \pi) \cdot \frac{A}{P}, \; D_i = \frac{\partial D}{\partial i} > 0, \; D_{i^*} = \frac{\partial D}{\partial (i^* + \pi)} < 0 \tag{4.15}$$

$$\frac{eF^S}{P} = F(i,\, i^* + \pi) \cdot \frac{A}{P}, \; F_i = \frac{\partial F}{\partial i} < 0, \; F_{i^*} = \frac{\partial F}{\partial (i^* + \pi)} > 0 \tag{4.16}$$

$$\frac{A}{P} = \frac{M^S + B^S + eF^S}{P} \tag{4.17}$$

where M^S is supply of money, B^S is supply of domestic-currency-denominated bonds, F^S is supply of foreign assets, y is domestic real income, P is domestic price deflator, e is exchange rate evaluated as units of domestic currency per unit of foreign currency, i^* is foreign nominal interest rate, π is the expected rate of depreciation of the domestic currency, A is value of marketable wealth in domestic currency, $L(\cdot)$ is demand for money, $D(\cdot)$ is proportion of total demand for domestic assets, and $F(\cdot)$ is proportion of total demand for foreign assets. The equation (4.14) is the conventional domestic money market equilibrium, where the demand for money function is assumed the standard "liquidity preference" form. The equations

(4.15) and (4.16) are the equilibrium condition for domestic assets (money and bonds) and foreign assets, respectively. The private sector in the portfolio choice at each point in time must satisfy the wealth constraint (4.17).

Theoretically, the exchange rate is freely determined by the foreign exchange market. Therefore, assuming no intervention in the foreign exchange market, the central bank can change the supply of money discretely at any time through intervention in the domestic bond market, that is, the open market operation (OMO).

$$M^S = M_o + (B^{cb} - B_o^{cb}) \tag{4.18}$$

where M_o is stock of money at the initial moment, and $(B^{cb} - B_o^{cb})$ is the central bank's purchase of domestic bonds. The net supply of domestic bonds to be held by the private sector is equal to the total stock of government securities minus holdings of the central bank.

$$B^S = B^T - B^{cb} \tag{4.19}$$

where B^T is the total stock of government debt. The supply of foreign assets is equal to the total stock of foreign assets acquired through past surpluses in the current account.

$$F^S = F^T \tag{4.20}$$

where F^T is the cumulative sum of past current account surpluses or deficits.

Now, the wealth constraint for the private sector and for the central bank together implies the Walras' law for financial markets.

$$\frac{(M^D - M^S)}{P} + \frac{(B^D - B^S)}{P} + \frac{e(F^D - F^S)}{P} = 0 \tag{4.21}$$

There are thus only two independent equilibrium conditions sufficient to determine the exchange rate and the interest rate in the model. Suppose the money market and the foreign exchange market are in equilibrium to determine these two rates, the domestic bond market will therefore be in equilibrium according to the Walras' law.

4.2.1.1 Money market equilibrium By employing the purchasing power parity (PPP) condition,

$$P = eP^*$$

where P^* is the foreign price, the money market equilibrium condition can be rewritten as

$$M^S = eP^* L(i, y) \tag{4.22}$$

Total differential, equation (4.22) can be rewritten as

$$di = \frac{1}{eP^* L_i} dM^S - \frac{L_y}{L_i} dy - \frac{L}{P^* L_i} dP^* - \frac{L}{eL_i} de \tag{4.23}$$

This equilibrium condition can be graphically presented as the positively sloped MM schedule in Figure 4.2 ($dM^S = dy = dP^* = 0$ in equilibrium).

$$\frac{di}{de} = -\frac{L}{eL_i} > 0 \tag{4.24}$$

Thus, an increase in the price of foreign currency ($de > 0$) increases the domestic price level and therefore the demand for money, this requires an offsetting increase in the domestic interest rate ($di > 0$). From equation (4.23), it is apparent that an increase in money supply or decrease in real income and/or foreign price will shift MM curve down and lower the domestic interest rate.

4.2.1.2 Foreign exchange market equilibrium It follows from the Walras' law, (4.21), that when the foreign exchange market is in equilibrium, the total demand for domestic assets equals the total supply of domestic assets, equation (4.15). Therefore, the equilibrium condition for the foreign exchange market can be written in the form

$$\frac{eF^S}{D^S} = \frac{eF^S}{B^S + M^S} = \frac{F(i,\, i^* + \pi)}{D(i,\, i^* + \pi)} = f(i, i^* + \pi) \tag{4.25}$$

and

$$f_i = \frac{\partial f}{\partial i} < 0, \quad f_{i^*} = \frac{\partial f}{\partial (i^* + \pi)} > 0$$

Assuming that π is a regressive around the expected long-run equilibrium value of the exchange rate($\bar{e}$)

$$\pi = \theta(e,\, \bar{e}), \quad \theta_e = \frac{\partial \theta}{\partial e} < 0, \quad \theta_{\bar{e}} = \frac{\partial \theta}{\partial \bar{e}} > 0 \tag{4.26}$$

then, by total differential the equilibrium condition (4.25) can be written as,

$$de = \frac{1}{\frac{F^S}{D^S} - f_i * \theta_e}[f_i d_i + f_i * di^* + f_i * \theta_{\bar{e}} d\bar{e} - e\, d(\frac{F^S}{D^S})] \tag{4.27}$$

This equilibrium condition can be graphically presented as the negatively sloped FF schedule in Figure 4.2 ($di^* = d\bar{e} = d(F^S/D^S) = 0$ in equilibrium).

$$\frac{di}{de} = \frac{\frac{F^S}{D^S} - f_i * \theta_e}{f_i} < 0 \tag{4.28}$$

Thus, an increase in the price of foreign currency ($de > 0$) reduces the expected rate of depreciation ($d\pi < 0$) and therefore the demand for foreign asset ($df < 0$), this requires an offsetting decrease in the domestic interest rate ($di < 0$) to keep the market in equilibrium.

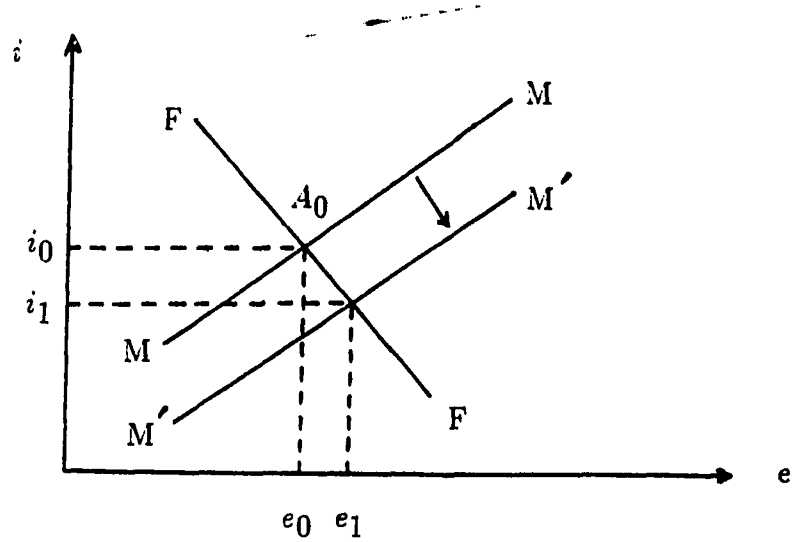


Figure 4.2: Simultaneous determination of the exchange rate and the interest rate

4.2.1.3 Determination of exchange rate and interest rate The portfolio equilibrium model, therefore, can solve the exchange rate and interest rate determination simultaneously by the two equilibrium conditions (4.23) and (4.27). Graphically, the equilibrium values of the interest rate (i_0) and exchange rate (e_0) are determined by the intersection of the FF and MM schedules at A_0 in Figure 4.2.

The reduced forms of the determination of these two rates also can be mathematically obtained by solving the two equilibrium conditions, (4.23) and (4.27).

$$\begin{aligned} di &= \left(\frac{L_i eE}{L_i eE + Lf_i}\right)\left[\left(\frac{1}{eP^* L_i}\right)dM^S - \left(\frac{Ly}{L_i}\right)dy - \left(\frac{L}{P^* L_i}\right)dP^*\right. \\ &\quad \left. -\left(\frac{Lf_{i^*}}{L_i}eE\right)di^* + \left(\frac{L}{L_i E}\right)d\left(\frac{F^T}{M_o + B^T}\right)\right] \end{aligned} \tag{4.29}$$

$$de = \left(\frac{L_i eE}{L_i eE + Lf_i}\right)\left[\left(\frac{f_i}{eP^* L_i E}\right)dM^S - \left(\frac{f_i Ly}{L_i E}\right)dy\right.$$

$$-(\frac{f_i L}{P^* L_i E})dP^* + \frac{f_i *}{E}di^* - \frac{e}{E}d(\frac{F^T}{M_o + B^T})] \quad (4.30)$$

where $E = \frac{F^S}{D^S} - f_i * \theta_e > 0$.

This model can be applied to evaluate the effects of change in money supply on the exchange rate and the interest rate. Under the pure flexible exchange rate regime, the central bank can change money supply by traditional open market operation. The effects of an increase in the money supply can be seen from Figure 4.2. The MM schedule will shift down with no change in the location of the FF schedule. The domestic interest rate declines from i_0 to i_1, while the domestic currency depreciates from e_0 to e_1. Such impacts can also be seen from the reduced forms (4.29) and (4.30). Changes in the exchange rate and the interest rate due to change in money supply, therefore, can pass through to domestic market and trade. This provides a pertinent way to evaluate the impacts of monetary policy on the commodity market.

4.3 U.S. Wheat Model and Impacts of Monetary Policy

To connect the U.S. wheat model with the financial market, the graphical equilibrium structural model of this study can be shown as Figure 4.3 for crop year t. The foreign demand panel shows that the United States acts as a duopolist in the world wheat market and prices its wheat export according to the demand facing it (Q^{US}). The production panel presents the kinked U.S. supply schedule. Production (S_t) for crop year t is determined by the expected market price ($EMPt$) if this price is higher than the government support price (GPt). Total supply is the summation of production and beginning stocks ($S_t + I_{t-1}$) and is fixed for the current crop

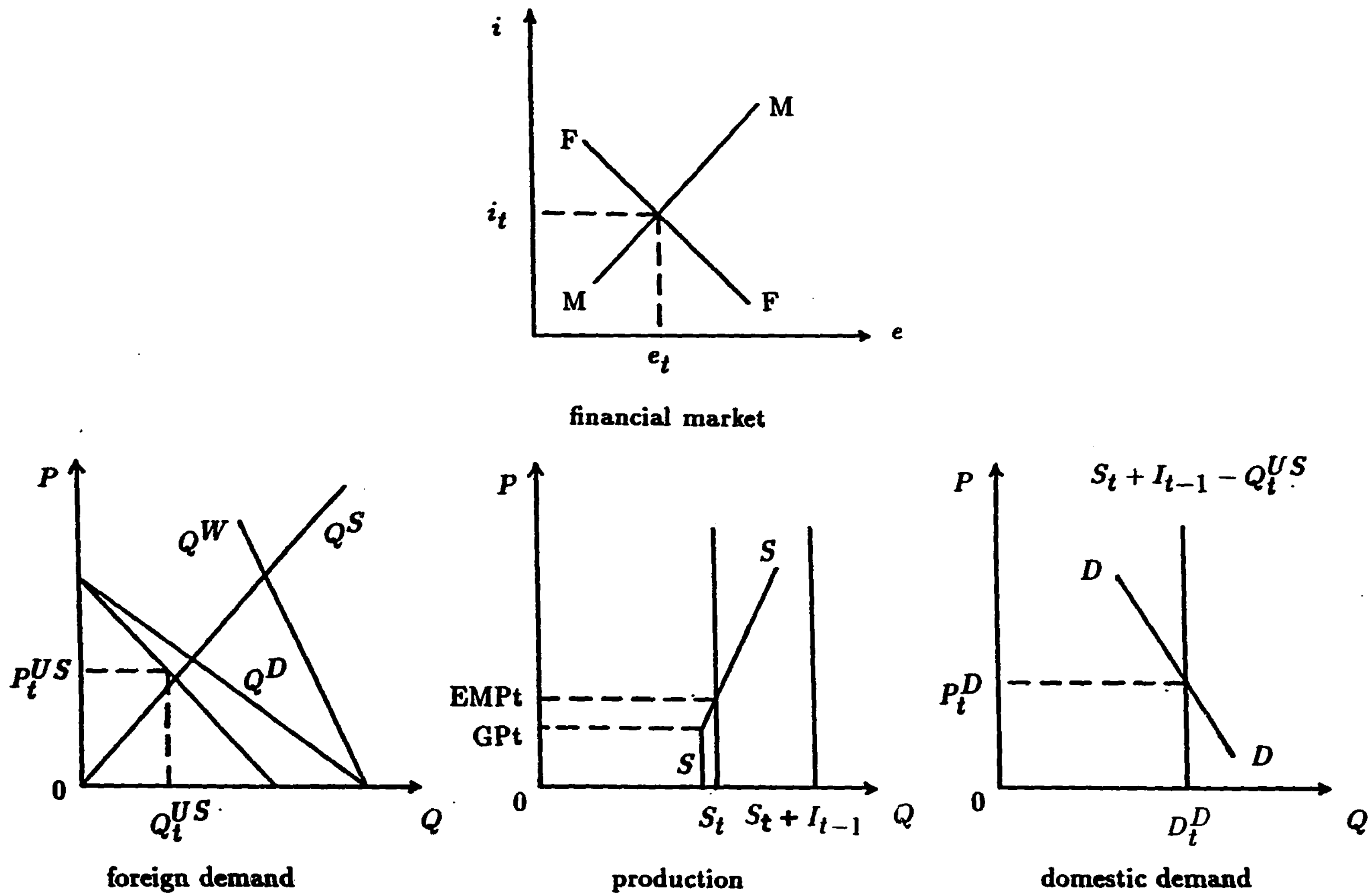


Figure 4.3: U.S. wheat model and price determination

year t. The domestic demand panel shows the competitive domestic wheat market, where the domestic price (P_t^D) is determined by the equilibrium of domestic demand (D_t^D) and supply available to the domestic market ($S_t + I_{t-1} - Q_t^{US}$). Note that the domestic demand schedule (DD) in this panel is the summation of all domestic demands and ending stocks. The financial market panel presents the determination of exchange rate and domestic interest rate.

Because the market characteristics of the world wheat market and the U.S. domestic wheat market are different, the price determination processes in these two markets are different. Therefore, it is clear from Figure 4.3 that the U.S. export price (P_t^{US}) is not necessarily equal to the domestic market price (P_t^D). The U.S. export prices were evidenced historically higher than its domestic prices.

4.3.1 Impacts on U.S. wheat trade and domestic market

Various exogenous impacts on the U.S. wheat sector can be evaluated by using Figure 4.3. The domestic monetary policy impacts are shown in Figure 4.4, while Figure 4.5 shows the exogenous external impacts. The impacts on the U.S. wheat sector in the real world might be the combination of these two.

From Figure 4.4, an increase in the domestic money supply will shift down the MM schedule in the financial market panel. This will result in decline in domestic interest rate and dollar depreciation. Then, through the external impact channel the dollar devaluation will rotate the demand for U.S. wheat schedule (Q^{US}) upward due to impact on aggregate world import demand (Q^W). Also, because of the change of the duopolists' relative export price resulting from the devaluation effect on Q^W, Q^{US} schedule will shift outward or inward. The upward rotation will raise

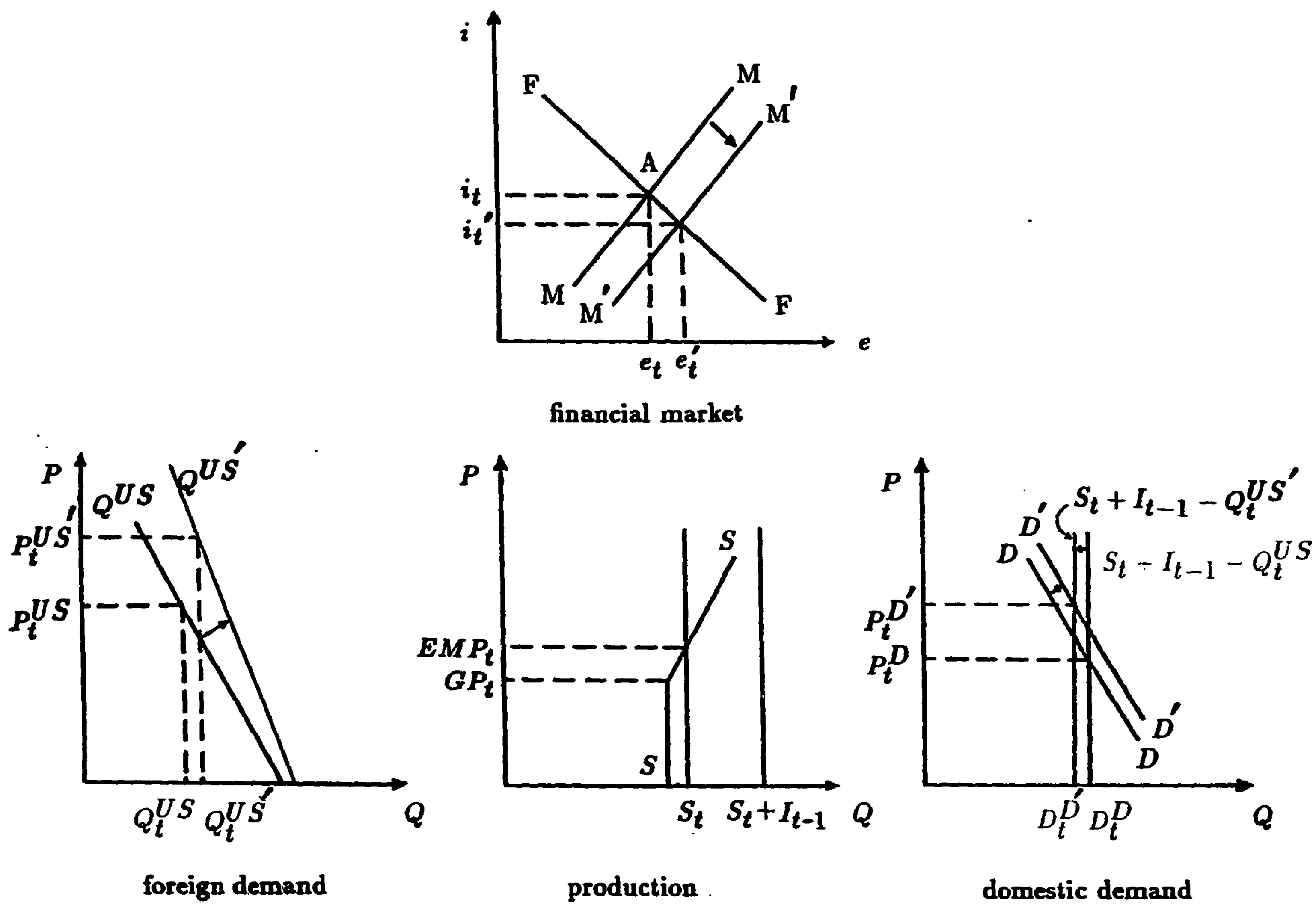


Figure 4.4: Impacts of monetary policy on U.S. wheat trade and domestic market

export price (P_t^{US}) because of the profit-maximization decision; whereas, change in wheat export (increase or decrease) depends upon the shift (outward or inward) of Q^{US} schedule. The empirical results of this study evidenced small increase in export, that is, an outward but small shift on Q^{US} schedule. Change in export and export price will have backward effects on the domestic market.

Through the internal impact channel, the lower interest rate will induce increases in domestic demands and commercial ending stocks. The interest rate effects coupled with changes in export and export price due to the exchange rate effects on trade will result in an upward shift in the domestic demand (DD) schedule and a leftward shift (if export increases) in the supply to domestic market. The domestic price (P_t^D) ultimately will be pulled up. Apparently, both export and domestic prices go up due to the money supply increase. However, the magnitude of price increases depends upon the elasticities of demand schedules, the exchange rate effect on trade, and interest rate effect on the domestic market. Change in wheat export is theoretically ambiguous dependent upon the relative price change of duopolists in response to the dollar devaluation.

Figure 4.5 shows the impacts on the U.S. wheat sector resulting from an exogenous external increase in world import demand. This is presented by an outward shift in the foreign demand panel. U.S. exports increase and export prices rise. The increase in exports reduces the current supply available to the domestic market, and thereafter rises the domestic price and decreases the total domestic demand in the domestic demand panel. The increase in export and export price depends upon the amount the foreign demand schedule shifts and its elasticity. The decrease in domestic demand and rise in domestic price depend upon the elasticity of domestic

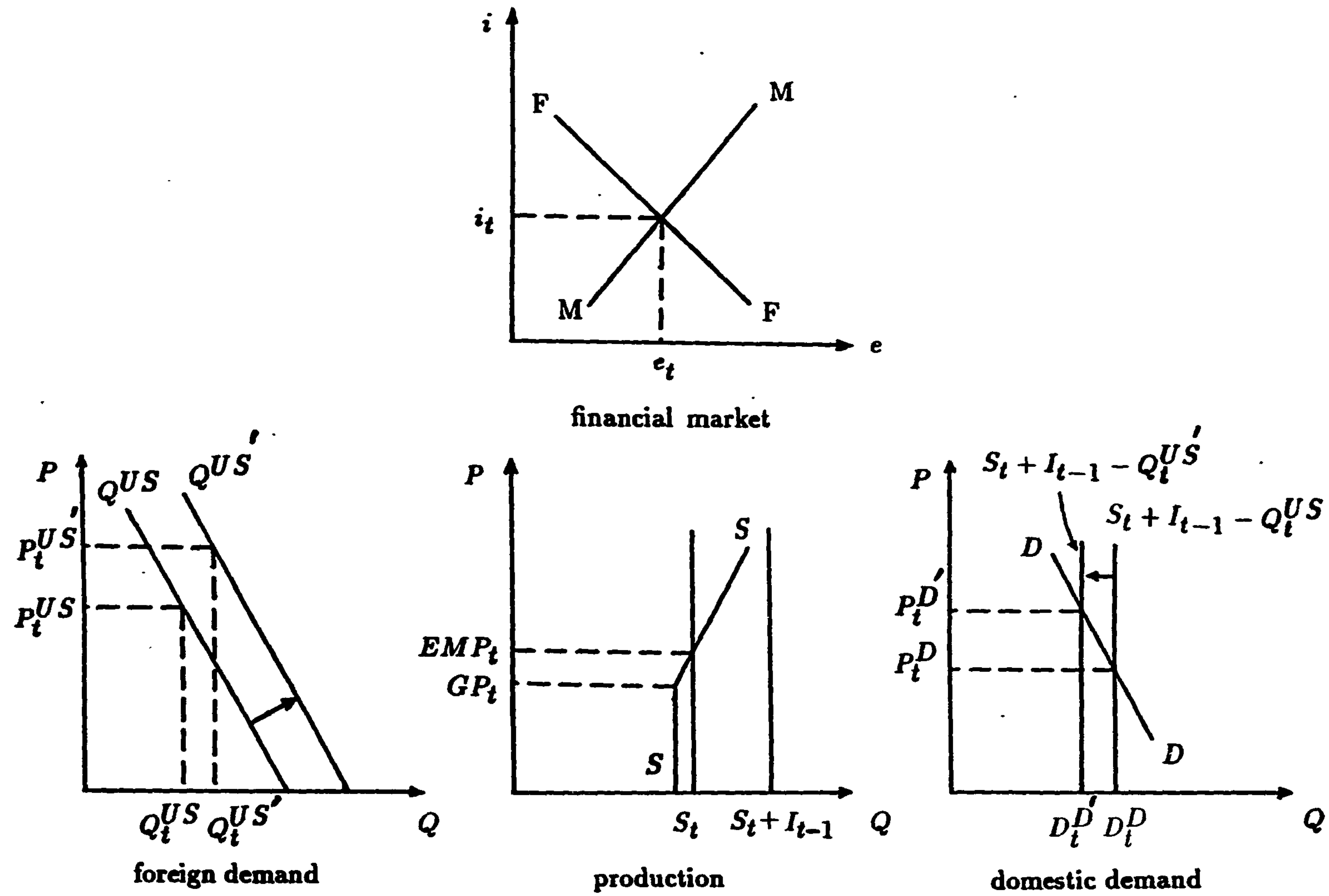


Figure 4.5: Exogenous external impacts on U.S. wheat trade and domestic market

demand schedule and the amount the exports increased.

4.4 Features of the Model

In contrast to the conventional competitive model, this model in the part of U.S. foreign demand is imperfectly competitive. Some features of this model are as follows.

First, determination of wheat export and export price. Under the competitive framework, the country's export is defined as the excess supply of domestic market. In other worlds, it is treated as to sell the domestic wheat surplus. The world price is determined by the equilibrium of world (excess) demand and (excess) supply. The United States, therefore, in a sense is inferred as a world price taker. Instead of such treatment, the U.S. wheat export in this model depends upon the world demand facing it and its export pricing. As a duopolist in the world wheat market, the United States can price its wheat export to maximize profit. It is not trying to sell its domestic wheat surplus but to make profit from the world market. Rather, by exerting its market power, the United States can influence the world wheat price.

Second, the component to clear market. Since export is treated as a residual of domestic market under the competitive framework, it must absorb all domestic surplus and clear the world market. However, this might not be realistic. For example, if all importing countries do not want to import any more wheat even if the world price is sufficiently low, where can the domestic surplus go? Instead of export, the domestic government demand is taken as the component to absorb all domestic surplus in the model. As specified in equation (4.9), if a depressed market wheat producers tend to sell to the government. In addition, government agents tend to store inventory for price stabilization. Such specification and treatment appears more plausible.

Third, failure of the law of one price (LOP). As mentioned before, most of previous competitive models assumed the LOP; however, it was evidenced to fail in the real world. Although few studies within the competitive framework treated the export price and domestic price as unequal, determination of these two prices is quite unclear and implausible. This is because they have to obey the equilibrium condition, the only condition for price determination, of aggregate demand equals aggregate supply. In this model, it is very clear that the U.S. export price (P_t^{US}) is not necessarily equal to the domestic price (P_t^D). The export price is determined by export pricing equation (4.4), while the domestic price is determined by the equilibrium condition of aggregate domestic demand equal to supply available to domestic market, that is, the market clearing condition (4.13). All reasons of imperfect competition world market, barriers to trade, and product differentiations to break the LOP are incorporated into the model.

Fourth, the interrelationship between trade and domestic market. This model can fully embody the general issue, especially for the 1980s, that the depressed domestic price is resulted from the depressed foreign demand for U.S. wheat. This is quite clear from the market clearing condition (4.13) and the graphical analysis, Figures (4.4) or (4.5). Obviously, a decrease in foreign demand (Q_t^{US}) will increase wheat supply available to the domestic market, hence depress domestic price. Conversely, if a boom in the world market occurs, domestic price should be bid up because more wheat are sold to the world market.

Fifth, different market characteristics and the associated different price determination processes. This model contains the competitive domestic market and trade in the duopoly world market in a model. The different determination processes of export and domestic price associated with different market characteristics are also explicitly presented.

Sixth, the linkage between wheat model and financial market. As reviewed in Chapter 2, the linkage between agricultural market and financial market are so far not well constructed. This model connects the wheat model with the financial market via the most important linkages of exchange rate and interest rate determination. These two rates are pertinently embodied in the model. Furthermore, for the purpose to evaluate the impacts of monetary policy on the wheat sector, these two rates are endogenized. The portfolio equilibrium model is employed to simultaneously determine these two rates. It provides the theoretical basis.

5 EMPIRICAL ANALYSIS AND MODEL EXAMINATION

This chapter provides the empirical estimation results of the theoretical model developed in the previous chapters, and the interpretation of results. Also, validation and stability of this model are examined.

5.1 Estimation

Since the relative prices in equations, and identities and possible autocorrelated error terms can lead the model to be nonlinear, the nonlinear three-stage least squares (3SLS) was used for the final estimation of the model. The principal component technique was applied in estimation because the number of exogenous variables exceeds the number of observations. Seventeen principal components were calculated from all exogenous variables and then used as the instrument variables in estimation. The computer program used for the estimation was SYSNLIN of SAS/ETS (SAS, 1984). Table 5.1 presents the final form of the estimated model.

As described in the theoretical model, the empirical model consists of three parts: foreign demands for U.S. wheat, U.S. domestic wheat market, and the financial market. In part 1, the theoretical foreign demand was extended to include six regions: EC, Japan, India, USSR, China, and the rest of the world (ROW). This is because (1) these importing countries were relatively big in the world wheat market,

(2) these countries exerted different and various domestic and trade policies that resulted in different impacts on their wheat import demands, and (3) the theoretical specifications on the import demands are different because the USSR and China are the centrally planned economies and the others are free economies.

For each importing country, the total wheat import demand equation and import demand for U.S. wheat equation were estimated. The total import demand equation is originated from the definition of domestic excess demand in which the trade and domestic agricultural policy are important. The import demand for U.S. wheat equation stresses the country's action in the duopolistic international wheat market, especially the demand for U.S. wheat in response to the duopolists' relative price. The international price linkage was introduced into the model if the importing country's tariff is fixed. However, if the tariff is variable it is evaluated instead of the price linkage. In both the international price linkage and the evaluation of variable tariff, price in the importing country was connected to the U.S. export price, that is, the U.S. export price was referred to the world price. Such treatment is because the United States was the biggest world wheat supplier. The U.S. export pricing equation was estimated to present its determination. In addition, the Canadian wheat export pricing equation was estimated and included in the model. To include the Canadian export price in the model was important because Canada was the price leader. Any change in Canadian price in response to, e.g., the dollar devaluation would result in change in the U.S. export price (the price follower). Moreover, the excellent estimation results in Canadian export pricing can evidence the theoretical behavioral assumption of price leadership.

Part 2 is the U.S. domestic market, which is basically that developed in Chapter

4. Part 3 is the financial market containing the interest rate and exchange rate determination equations. These two equations are actually the theoretical reduced forms (4.29) and (4.30). Since in the foreign demand part there are six separated regions, this implies that six exchange rates should be included and estimated in the model to capture the exchange rate effects in different regions. However, to include all exchange rates tends to complicate the model and estimation. For simplicity, assume that the world monetary system is efficient, international arbitrages equate the exchange rate of a currency against the U.S. dollar (e.g., US $/Yen) to the product of this currency against SDR and the SDR against the U.S. dollar (US $/Yen = (SDR/Yen)(US $/SDR). Therefore, only the exchange rate of the U.S. dollar against SDR was estimated and the exchange rates of other currencies against SDR are assumed exogenously determined.

An empirical problem was encountered in estimating the exchange rate and interest rate determination equations. Since the theoretical determination of these two rates as specified in Chapter 4 is suitable only for the period of flexible exchange rate regime, one should not be able to estimate the reduced forms (4.29) and (4.30) if data period used includes the fixed exchange rate regime. Techniques to solve this problem will be discussed later in this chapter.

Only the final form of the model estimated is reported in Table 5.1. This model consists of 36 equations, including 21 behavior equations and 15 identities. For each equation, the estimated coefficients, t-statistics (parentheses), and elasticities of major variables (brackets) are reported.

5.1.1 The data base

Annual data for the period 1965-85 were used for estimation. Table 5.2 shows the complete list of variable names, descriptions, and data sources. However, since the foreign demands were separated into six regions, numerous problems were encountered in obtaining the appropriate data for each region. For example, according to the neoclassical demand theory, demand for wheat should be specified as a function of all prices and income. However, the detailed commodity prices (indices) are not always available. Even the wheat price data it is not available in the CPE.

In a few cases, because of the unavailabiltiy of data, appropriate proxy variables were used in estimation. For example, the region of the rest of the world (ROW) in estimation was treated as the developing countries as a whole. This is because most of the wheat importing countries in the ROW region are developing countries according to the United Nation's classification. Since there was no series available for tariffs for countries in the ROW region, the producer, or wholesale wheat prices in Morocco, South Africa, Tunisia, Austria, Brazil, and Pakistan were used to calculate the average tariff for the region. These countries were relatively bigger wheat importers in the ROW region.

In the estimation of exchange rate and interest rate determination, the exchange rate of the U.S. dollar against SDR was used because no other consistent exchange rate series is available for the study period 1965–85. Since there is no single series available for the world interest rate, an average of the interest rates of West Germany, Japan, Canada, United Kingdom, France, and Italy (see Table 5.2) was used as proxy of world interest rate excluding the United States. For the world price index, the consumer price index of the industrial countries was used. Since the data for the theoretical definition of the U.S. accumulative sum of current account surplus was not available, holding of the foreign assets in the commercial banks was used instead. However, this will change the sign for the coefficient because this data means a demand for rather than a supply of foreign assets.

Table 5.1: The estimated structural model

Part 1. Foreign demands for U.S. Wheat

EC total wheat import demand

$$\text{WHIMTEC} = 14125.90 - \underset{\substack{(-2.19)\\ [-0.21]}}{5.11} * \text{WHPTHEC} + \underset{(0.75)}{0.033} * \text{WHEXTEC}$$

$$- \underset{(-9.55)}{2026.13} * \text{WHYAEC} + \underset{(4.12)}{1096.71} * \text{D68} + \underset{(8.77)}{2429.39}$$

$$* \text{D70} - \underset{(-4.49)}{1304.69} * \text{D76} \quad (5.1)$$

$R^2 = 0.95, \quad \text{DW} = 2.12$

EC import demand for U.S. wheat

$$\text{WHIM1EC} = \text{E} * \text{WHIMTEC} \quad (5.2)$$

EC import variable levy

$$\text{TAFEC} = [\text{WHPTHEC}/(\text{WHEXPUS} + \text{FRUSEC})$$

$$* \text{ERSDREC}/\text{ERSDR}] - 1 \quad (5.3)$$

Japan total wheat import demand

$$\text{WHIMTJA} = - 17009.12 - \underset{\substack{(-4.56)\\ [-0.23]}}{0.01} * \text{WHSPJA} - \underset{\substack{(-6.19)\\ [-0.40]}}{0.044} * \text{WHRSPJA}$$

$$+ \underset{(16.02)}{236.22} * \text{POPJA} - \underset{(-3.61)}{332.03} * \text{WHYAJA}$$

$$+ \underset{(5.33)}{551.60} * \text{SHIFT75} - \underset{(-2.50)}{250.10} * \text{D70} + \underset{(4.22)}{448.26}$$

Table 5.1 (Continued)

$$* D80 - 350.34 * D85 \quad (5.4)$$
$$(-3.03)$$

$R^2 = 0.96$, DW = 2.37

Japan import demand for U.S. wheat

$$WHIM1JA = 214.38 - 1165.99 * (WHEXPUS + FRUSJA)/$$
$$(-3.42)$$
$$[-0.35]$$

$$(WHEXP1CA + FRCAJA) + 0.81 * WHIMTJA$$
$$(28.63)$$

$$- 0.50 * WHIMOJA - 334.40 * D71 \quad (5.5)$$
$$(-7.81) \qquad (-7.43)$$

$R^2 = 0.95$, DW = 2.76

Japan import tariff (quota equivalent)

$$TAFJA = [WHRSPJA/(WHEXPUS + FRUSJA)$$

$$* ERSDRJA1/ERSDR] - 1 \quad (5.6)$$

India total wheat import demand

$$WHIMTIN = 8036.80 + 6.29 * WHPFMIN + 4.15 * RIPWHIN$$
$$(10.68) \qquad (1.21)$$
$$[2.42] \qquad [0.24]$$

$$- 8391.78 * WHYAIN - 0.21 * LAG(WHCOTIN)$$
$$(-18.22) \qquad (-6.46)$$

$$* 1000 - 1762.38 * D7780 + 3503.42 * D65$$
$$(-5.78) \qquad (11.89)$$

Table 5.1 (Continued)

$$- 2034.47 * D80 + 1904.17 * D82 \quad (5.7)$$
$$(-5.15) \quad (5.46)$$

$R^2 = 0.97$, DW = 2.17

India import demand for U.S. wheat

$$WHIM1IN = 2579.45 - 3072.28 + (WHEXPUS + FRUSIN)/$$
$$(-2.69)$$
$$[-1.27]$$

$$(WHEXP1CA + FRCAIN) + 0.90 * WHIMTIN$$
$$(37.38)$$

$$- 0.84 * WHIMOIN \quad (5.8)$$
$$(-8.99)$$

$R^2 = 0.97$, DW = 2.47

India wheat import tariff/subsidy

$$TAFIN = [WHPFMIN/(WHEXPUS + FRUSIN)$$

$$* ERSDRIN1/ERSDR] - 1 \quad (5.9)$$

USSR total wheat import demand

$$WHIMTSR = 11866.46 - 0.26 * (WHPODSR + LAG$$
$$(-19.23)$$

$$(WHESTSR)) + 83.26 * NANPDSR - 89.43$$
$$(21.68) \quad (-9.59)$$

$$* CHTAXSR - 10524.21 * SHIFT73 - 6175.91$$
$$(-12.90) \quad (-9.02)$$

Table 5.1 (Continued)

$$* \text{ D70 } -7039.57 * \text{D71} - 6315.23 * \text{D85} \quad (5.10)$$
$$\quad\quad (-9.70) \quad\quad (-6.58)$$

$R^2 = 0.98$, DW = 1.55

USSR import demand for U.S. wheat

WHIM1SR = -30.67 - 196.09 * DSR *(WHEXPUS/
(-1.07)

WHEXP1CA) + 0.75 * DSR * WHIMTSR
(52.70)

- 1.03 * DSR * WHIMOSR + 1651.32
(-39.31) (11.28)

* D79 - 1548.25 * D82 (5.11)
(-9.40)

$R^2 = 0.99$, DW = 2.78

USSR percentage change in wheat import price

CHTAXSR = -[WHEXPUS/LAG(WHEXPUS) + ERSDRSR1/

LAG(ERSDRSR1) - ERSDR/LAG(ERSDR)-1]

* 100 (5.12)

China total wheat import demand

WHIMTCH = -21416.00 - 0.28 * WHPODCH + 20.99 * POPCH
(-12.66) (5.25)

+72.56 * GPPCH + 3582.81 * SHIFT77 + 2812.93
(11.34) (6.15) (-4.39)

Table 5.1 (Continued)

```
* D65 - 2986.13 * D71 -2805.88 * D85                    (5.13)
           (-5.53)           (-3.88)
```

$R^2 = 0.94$ DW = 2.73

China import demand for U.S. wheat

```
WHIM1CH =  34.27 - 900.79 * DCH * (WHEXPUS/
                  (-2.91)

           WHEXPICA) + 0.87 * DCH * WHIMTCH -1.35
                      (35.41)             (-24.34)

           * DCH * WHIMOCH - 2833.81 * D72              (5.14)
                            (-11.48)
```

$R^2 = 0.98$ DW = 1.97

ROW total wheat import demand

```
WHIMTRW =  22527.28 - 60.51 * WHIMPRW + 13.87
                     (-2.08)           (2.73)
                     [-0.19]           [0.11]

           * RIIMPRW + 831.70 * GDPINDGC - 0.50
                      (11.03)           (-6.95)
                      [1.58]

           * WHPODRW + 3616.16 * SHIFT79
                      (2.58)

           + 8823.31 * D84                              (5.15)
             (7.53)
```

$R^2 = 0.96$ DW = 2.61

Table 5.1 (Continued)

ROW import demand for U.S. wheat

$$WHIM1RW = \underset{}{532.44} + \underset{(3.35)}{638.03} * (LAG(WHEST) + WHPOD)$$

$$* 0.0272155/(LAG(WHCOTCA) + WHPODCA/$$

$$1000) + \underset{(45.33)}{0.73} * WHIMTRW - \underset{(-24.19)}{0.76} * WHIMORW \quad (5.16)$$

$R^2 = 0.99$ DW = 1.89

ROW international price linkage

$$WHIMPRW = (WHEXPUS/ERSDR) * (1 + TAFRW) \quad (5.17)$$

Aggregate world wheat import demand

$$WHIMTWL = WHIMTEC + WHIMTJA + WHIMTIN + WHIMTSR + WHIMTCH + WHIMTRW \quad (5.18)$$

Total import demand for U.S. wheat

$$WHEXT2 = WHIM1EC + WHIM1JA + WHIM1IN + WHIM1SR + WHIM1CH + WHIM1RW \quad (5.19)$$

Canada wheat export pricing

$$WHEXP2CA = -24.22 + \underset{(6.67)}{7.53} * FRUS - \underset{(-4.36)}{6.17} * FRCA$$

$$+ \underset{(9.54)}{0.0013} * WHIMTWL + \underset{(11.13)}{59.26} * SHIFT73$$

$$+ \underset{(5.29)}{38.43} * D85 \quad (5.20)$$

Table 5.1 (Continued)

$R^2 = 0.98$ DW = 1.41

Canada wheat export price in terms of the U.S. dollar

$$WHEXP1CA = WHEXP2CA * ERSDRCA1 * ERSDR \quad (5.21)$$

U.S. wheat export pricing

$$\begin{aligned} WHEXPUS = \; & 2.71 + \underset{\substack{(36.53) \\ [0.85]}}{0.71} * WHEXP1CA - \underset{(-4.53)}{1.83} * FRUS \\ & + \underset{(5.86)}{2.90} * FRCA + \underset{(9.35)}{0.00068} * WHIMTWL \\ & - \underset{(-9.56)}{0.0015} * WHIMOWL \end{aligned} \quad (5.22)$$

$R^2 = 0.99$ DW = 1.95

Part 2. U.S. domestic wheat market

Wheat area planted for next season

$$\begin{aligned} USWHEAPF = \; & 10.01 + \underset{\substack{(7.21) \\ [0.62]}}{16.59} * WHFPFOC + \underset{\substack{(4.44) \\ [0.20]}}{5.27} * WHSPFOC \\ & - \underset{\substack{(-4.02) \\ [-0.46]}}{28.56} * OAFOCP - \underset{(-2.74)}{0.18} * WHSAAFOC + \underset{(6.57)}{0.65} \\ & * WHALTFOC + \underset{(6.57)}{35.90} * X7185 - \underset{(-1.39)}{2.91} * D73 \end{aligned} \quad (5.23)$$

$R^2 = 0.96$ DW = 1.68

Table 5.1 (Continued)

Wheat area harvested

$$WHAH = H * LAG(USWHEAPF) \quad (5.24)$$

Wheat production

$$WHPOD = WHYA * WHAH \quad (5.25)$$

Expected wheat export price (3-year moving average)

$$WHEXPFC1 = [WHEXPUS + LAG(WHEXPUS) + LAG(LAG(WHEXPUS))] * 0.0272155/3 \quad (5.26)$$

Expected farm price (3-year moving average)

$$WHFPFOC = [WHFP + LAG(WHFP) + LAG(LAG(WHFP))]/3 \quad (5.27)$$

Food use demand

$$\begin{aligned} WHFOU = \; & 568.57 - \underset{\substack{(-5.55)\\ [-0.04]}}{1542.00} * (WHFP/USPWJM) \\ & + \underset{\substack{(11.13)\\ [0.46]}}{274.17} * (PIBACE/USPWJM) - \underset{\substack{(-10.30)\\ [-0.67]}}{426.72} \\ & * (PIDP/USPWJM) + \underset{\substack{(9.57)\\ [0.27]}}{0.088} * USCE \\ & - \underset{\substack{(-2.60)\\ [-0.02]}}{1.52} * IR1 \end{aligned} \quad (5.28)$$

Table 5.1 (Continued)

$R^2 = 0.98$ DW = 2.13

Feed use demand

$$\text{WHFP} = [-0.04 \underset{(-3.81)}{-0.0000052} * \text{WHFEU} + \underset{(17.92)}{1.39}$$

$$* (\text{COFP}/\text{USPWJM}) + \underset{(6.27)}{0.0000075} * \text{USCE}$$

$$+ \underset{(7.31)}{0.028} * (\text{PIMP}/\text{USPWJM})] * \text{USPWJM} \quad (5.29)$$

$R^2 = 0.95$ DW = 2.32

Seed use demand

$$\text{WHSEU} = -846.66 + \underset{(68.89)}{1.33} * \text{USWHEAPF} + \underset{(9.01)}{0.42} * \text{TREND} \quad (5.30)$$

$R^2 = 0.99$ DW = 1.36

Commercial (free) ending stocks

$$\text{WHFRS1} = 325.41 - \underset{\substack{(-5.24)\\ [-0.91]}}{88.33} * (\text{WHEXPUS} * 0.0272155)$$

$$- \underset{\substack{(-2.80)\\ [-0.58]}}{55.27} * \text{WHTP1} + \underset{\substack{(9.16)\\ [1.53]}}{152.60} * \text{WHEXPFC1}$$

$$- \underset{(-8.72)}{0.29} * \text{WHGVS1} + \underset{(9.34)}{0.62} * \text{MAXFRS1}$$

Table 5.1 (Continued)

$$- 25.63 * IR1 \quad (5.31)$$
(-6.02)
[-0.59]

$R^2 = 0.94$ DW = 1.71

Government ending stocks

WHGVS1 = 51.20 + 526.13 * WHLR - 199.54 * WHFP
(12.94) (-6.27)

+ 0.56 * WHPOD - 0.036 * WHEXT2 + 506.31
(6.37) (-8.58) (7.18)

* D73 - 489.55 * D76 (5.32)
(-6.47)

$R^2 = 0.92$ DW = 1.56

Total ending stocks

WHEST = WHFRS1 + WHGVS1 (5.33)

Domestic market clearing condition

WHPOD + LAG(WHEST) - WHEXT2

= WHFOU + WHFEU + WHSEU + WHEST (5.34)

Table 5.1 (Continued)

Part 3. U.S. financial market

Interest rate determination

$$\text{IR1} = \underset{}{-13.24} - \underset{(-7.23)}{0.046} * \text{M1} + \underset{(8.99)}{0.95} * (\text{NI/GNPDF})$$

$$+ \underset{(5.70)}{0.14} * \text{DI} * \text{CPIIDC} + \underset{(13.79)}{0.25} * (1 - \text{DI})$$

$$* \text{CPIUS} + \underset{(8.67)}{0.58} * \text{DI} * \text{IRWOL} - \underset{(-8.12)}{2.89}$$

$$* \text{D76} - \underset{(-9.17)}{3.32} * \text{D77} \qquad (5.35)$$

$R^2 = 0.97$ DW $= 2.13$

Exchange rate determination

$$\text{ERSDR} = 1.01 - \underset{(-5.51)}{0.21} * \text{X} + \underset{(11.75)}{0.0017} * \text{X} * \text{M1}$$

$$- \underset{(-12.79)}{0.0079} * \text{X} * \text{CPIIDC} + \underset{(6.39)}{0.18} * \text{X} * \text{LAG(ERSDR)}$$

$$+ \underset{(9.73)}{0.75} * \text{X} * \text{ASRATO} \qquad (5.36)$$

$R^2 = 0.94$ DW $= 1.93$

Table 5.2: Description, unit, and data source of variables

Variable	Description	Unit	Source
Endogenous			
CHTAXSR	USSR, change in wheat import price	Percent	Calculated
E	EC, proportion of wheat imports from U.S.	Percent	Calculated
ERSDR	U.S., exchange rate, end of year	US $/SDR	IMF, IFS[a]
IR1	U.S., interest rate, treasury bill rate	Percent	IMF, IFS
TAFEC	EC, wheat import variable levy	Percent	Calculated
TAFIN	India, wheat import tariff/subsidy	Percent	Calculated
TAFJA	Japan, wheat import tariff (quota equivalent)	Percent	Calculated
USWHEAPF	U.S., wheat area planted, next year	Million acres	USDA,[b] ASCS
WHAH	U.S., wheat area harvested	Million bushels	USDA, ASCS

[a]International Monetary Fund. Various issues. International Financial Statistics.

[b]United States Department of Agriculture. Sept. 1988. Supply and Use Typing Data. ASCS.

Table 5.2 (Continued)

Variable	Description	Unit	Source
WHEST	U.S., wheat ending stocks	Million bushels	USDA, ASCS
WHEXPFC1	U.S., expected wheat export price (3-year moving average)	US $/bu	Calculated
WHEXPUS	U.S., wheat export price, no. 2, Hard Winter, fob, Gulf Port	US $/mt	IWC, WWS[c]
WHEXP1CA	Canada, wheat export price, no. 1, in store, CWRS, St. Lawrence	US $/mt	IWC, WWS
WHEXP2CA	Canada, wheat export price, no. 1, in store, CWRS, St. Lawrence	CA $/mt	IWC, WWS
WHEXT2	U.S., wheat export	1000 mt	Wheat Sit.[d] & Outlook
WHFEU	U.S., wheat feed use	Million bushels	USDA, ASCS
WHFOU	U.S., wheat food use	Million bushels	USDA, ASCS
WHFP	U.S., wheat domestic farm price	US $/bu	USDA, ASCS

[c]International Wheat Council. Various issues. World Wheat Statistics.

[d]United States Department of Agriculture. Various issues. Wheat Situation and Outlook.

Table 5.2 (Continued)

Variable	Description	Unit	Source
WHFPFOC	U.S., expected wheat farm price (3-year moving average)	US $/bu	Calculated
WHFRS1	U.S., commercial (free) ending stocks (= WHEST-WHGVS1)	Million bushels	Calculated
WHGVS1	U.S., government ending stock (CCC, FOR, 9-month Loan)	Million bushels	CARD,[e] wheat model
WHIMTCH	China, total wheat imports	1000 mt	IWC, WWS
WHIMTEC	EC, total wheat imports	1000 mt	IWC, WWS
WHIMTIN	India, total wheat imports	1000 mt	IWC, WWS
WHIMTJA	Japan, total wheat imports	1000 mt	IWC, WWS
WHIMTRW	ROW, total wheat imports	1000 mt	Calculated
WHIMTSR	USSR, total wheat imports	1000 mt	IWC, WWS
WHIMTWL	World, total wheat imports	1000 mt	IWC, WWS
WHIMPRW	ROW, domestic wheat price	SDR/mt	Calculated
WHIM1CH	China, wheat import from U.S.	1000 mt	IWC, WWS
WHIM1EC	EC, wheat imports from U.S.	1000 mt	IWC, WWS
WHIM1IN	India, wheat imports from U.S.	1000 mt	IWC, WWS
WHIM1JA	Japan, wheat imports from U.S.	1000 mt	IWC, WWS
WHIM1RW	ROW, wheat imports from U.S.	1000 mt	IWC, WWS

[e]Devadoss et al. 1987a.

Table 5.2 (Continued)

Variable	Description	Unit	Source
WHIM1SR	USSR, wheat imports from U.S.	1000 mt	IWC, WWS
WHPOD	U.S., wheat production	Million bushels	USDA, ASCS
WHSEU	U.S., wheat seed use	Million bushels	USDA, ASCS
Exogenous			
ASRATO	U.S., ratio of foreign assets in commercial banks and total government debt	Percent	IMF, IFS
COFP	U.S., corn farm price	US $/bu	USDA, ASCS
CPIIDC	Industrial countries, Consumer Price Index	Index 1980=100	IMF, IFS
CPIUS	U.S., Consumer Price Index	Index 1980=100	IMF, IFS
DCH	China, dummy variable for years no wheat imports from U.S.	(1965-71)=0 (1975-76)=0 else=1	
DI	U.S., dummy variable for years of fixed exchange rate regime	(1965-70)=0 else=1	
DSR	USSR, dummy variable for years no wheat imports from U.S.	(1965-71)=0 else=1	

Table 5.2 (Continued)

Variable	Description	Unit	Source
D7780	India, dummy variable to reflect wheat import decrease	(1977-80)=0 else=1	
ERSDRCA1	Canada exchange rate, end of year	SDR/CA $	IMF, IFS
ERSDREC1	EC, exchange rate, end of year[=($/SDR)/($/ECU)]	ECU/SDR	Calculated
ERSDRIN1	India, exchange rate, end of year	Rupees/SDR	IMF, IFS
ERSDRJA1	Japan, exchange rate, end of year	Yen/SDR	IMF, IFS
ERSDRSR1	USSR, exchange rate, end of year[=($/SDR)/($/Rouble)]	Rouble/SDR	Calculated
FRCA	Canada, average freight rate	US $/mt	Calculated
FRCAIN	Canada, freight rate to India	US $/mt	IWC, WWS
FRCAJA	Canada, freight rate to Japan	US $/mt	IWC, WWS
FRUS	U.S., average freight rate	US $/mt	Calculated
FRUSEC	U.S., freight rate to EC (Rotterdam and UK)	US $/mt	IWC, WWS
FRUSIN	U.S., freight rate to India	US $/mt	IWC, WWS
FRUSJA	U.S., freight rate to Japan	US $/mt	IWC, WWS
GDPDF	U.S., GDP deflator	Index 1980=100	IWC, WWS

Table 5.2 (Continued)

Variable	Description	Unit	Source
GDPINDGC	Developing Countries, real GDP Index	Index 1980=100	IMF, IFS
GPPCH	China, grain procurement price	Yuan/mt	USDA, Agric.[f] Stat. of PRC
H	U.S., proportion of wheat area harvested to area planted	percent	Calculated
IRWOL	World, average of interest rates in West Germany (money market rates), UK (treasury bill rate), Canada(treasury bill rate), Japan (money market rate), France (money market rate), and Italy (government bond yield rate)	Percent	IMF, IFS
MAXFRS1	U.S., maximum capacity of free ending stocks = max(WHFRS1$_{t-i}$, i=1...)	Million bushels	
M1	U.S., nominal money supply (M1)	Billion dollars	IMF, IFS
NANPDSR	USSR, nominal net material products	Billion roubles	UN, MBS[g]
NI	U.S., nominal national income	Billion dollar	IMF, IFS

[f]United States Department of Agriculture. 1987.

[g]United Nations. Various issues. Monthly Bulletin of Statistics.

Table 5.2 (Continued)

Variable	Description	Unit	Source
OAFOCP	U.S., oat forecast price (3-year moving average)	US $/bu	USDA, ASCS
PIBACE	U.S., price index of bakery and cereal products, retail cost	Index 1967=100	USDA,[h] Agric. Stat.
PIDP	U.S., price index of dairy products, retail cost	Index 1967=100	ASDA, Agric. Stat.
PIMP	U.S., price index of meat products, retail cost	Index 1967=100	USDA, Agric. Stat.
POPCH	China, population	Million	IMF, IFS
POPJA	Japan, population	Million	IMF, IFS
RIIMPRW	ROW, world rice price (Thailand export price)	SDR/mt	CARD, Rice model
RIPWHIN	India, rice wholesale price	Rupees/mt	CARD, wheat model
SHIFT72	Dummy variable	(1972-85)=1 else=0	
SHIFT73	Dummy variable	(1973-85)=1 else=0	
SHIFT75	Dummy variable	(1975-85)=1 else=0	
SHIFT77	Dummy variable	(1977-85)=1 else=0	

[h]United States Department of Agriculture. Various issues. Agricultural Statistics.

Table 5.2 (Continued)

Variable	Description	Unit	Source
SHIFT97	Dummy variable	(1979-85)=1 else=0	
TAFRW	ROW, wheat import tariff	Percent	Calculated
TREND	Trend variable	Year	
USCE	U.S., real personal consumption expenditures	Billion dollar	Econ. Report of President
USPWJM	U.S., Producer Price Index	Index 1967=100	CARD, wheat model
WHALTFOC	U.S., wheat area allotment, next season	Million acres	USDA, ASCS
WHCOTCA	Canada, wheat ending stocks	Million mt	CARD, wheat model
WHCOTIN	India, wheat ending stocks	Million mt	CARD, wheat model
WHESTSR	USSR, wheat ending stocks	1000 mt	CARD, wheat model
WHEXTEC	EC, total wheat export	1000 mt	IWC, WWS
WHIM	U.S., wheat import	Million bushels	USDA, ASCS
WHIMOCH	China, wheat imports from other exporters	1000 mt	IWC, WWS
WHIMOEC	EC, wheat imports from other exporters	1000 mt	IWC, WWS

Table 5.2 (Continued)

Variable	Description	Unit	Source
WHIMOIN	India, wheat imports from other exporters	1000 mt	IWC, WWS
WHIMOJA	Japan, wheat imports from other exporters	1000 mt	IWC, WWS
WHIMORW	ROW, wheat imports from other exporters	1000 mt	IWC, WWS
WHIMOSR	USSR, wheat imports from other exporters	1000 mt	IWC, WWS
WHIMOWL	World, wheat imports from other exporters	1000 mt	IWC, WWS
WHLR	U.S., wheat production loan rate	US $/bu	USDA, ASCS
WHPFMIN	India, wheat farm price	Rupees/mt	CARD, wheat model
WHPODCA	Canada, wheat production	1000 mt	IWC, WWS
WHPODCH	China wheat production	1000 mt	IWC, WWS
WHPODRW	ROW, wheat production	1000 mt	IWC, WWS
WHPODSR	USSR, wheat production	1000 mt	IWC, WWS
WHPTHEC	EC, wheat import threshold price	ECU/mt	CARD, wheat model

Table 5.2 (Continued)

Variable	Description	Unit	Source
WHRSPJA	Japan, domestic wheat resale price	Yen/mt	Japan, ASAFF[i]
WHSAAFOC	U.S., wheat set-aside areas	Million acres	USDA, ASCS
WHSPFOC	U.S., government support price[=max(WHTP1, WHLR)]	US $/bu	USDA, ASCS
WHSPJA	Japan, government wheat purchase price	Yen/mt	Japan, ASAFF
WHTP1	U.S., wheat target price	US $/bu	USDA, ASCS
WHYA	U.S., wheat yield per acre	Bushel/ac	USDA, ASCS
WHYAEC	EC, wheat yield per hectare	mt/hec	IWC, WWS
WHYAIN	India, wheat yield per hectare	mt/hec	IWC, WWS
WHYAJA	Japan, wheat yield per hectare	mt/hec	IWC, WWS
X	Grafted polynomial variable to connect the fixed and flexible exchange rate system	(1965-71)=0 1972=1 1973=2 (1974-85)=3	
X7186	U.S., dummy variable to reflect the government program participation from mandatory to voluntary	(1971-86)=1 else=0	

[i]Ministry of Agriculture, Forestry, and Fisheries. Various issues Abstract of Stat. on Agric., Forestry, and Fisheries.

5.2 The Model

5.2.1 Part 1. Foreign import demands and U.S. export pricing

5.2.1.1 The European Communities (EC) wheat imports The principal agricultural policies in the EC are via the setting of a target price, an intervention price, and a threshold price. The target price reflects the desired price for farm outputs, the intervention price represents a minimum (or guaranteed) price for farmers, and the threshold price is the minimum price at which products are allowed to be imported into the EC. The actual domestic price will vary between the target price and the intervention price. In general, the intervention price is about 90 % of the target price, and these three policy prices moved at the same steps. Figure 5.1 shows these three prices for wheat, as well as the world (U.S.) wheat price from 1965 to 1985.

For wheat imports, the threshold price maintains a high and relatively stable level of price for domestic consumers and producers. Since the world price vary, this price is supported by the operation of a variable levy on imports. When world price rises (falls), the tariff increases (decreases). The operation of variable levy, therefore, insulated domestic price from changes in the world price (Enders and Lapan 1987; Sampson and Snape, 1980).

According to the definition that import demand is the excess demand of domestic market, effect of the threshold price can be presented as Figure 5.2, where P_t^{TH} is the threshold price and is fixed, P_t^W and $P_t^{W'}$ are world price (EC import

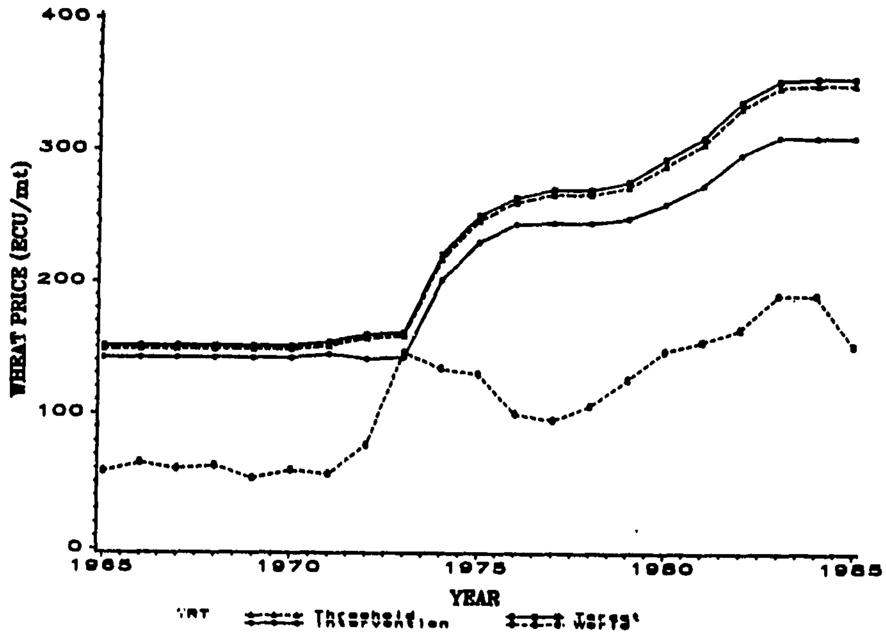


Figure 5.1: EC wheat policy prices and the world (U.S.) price

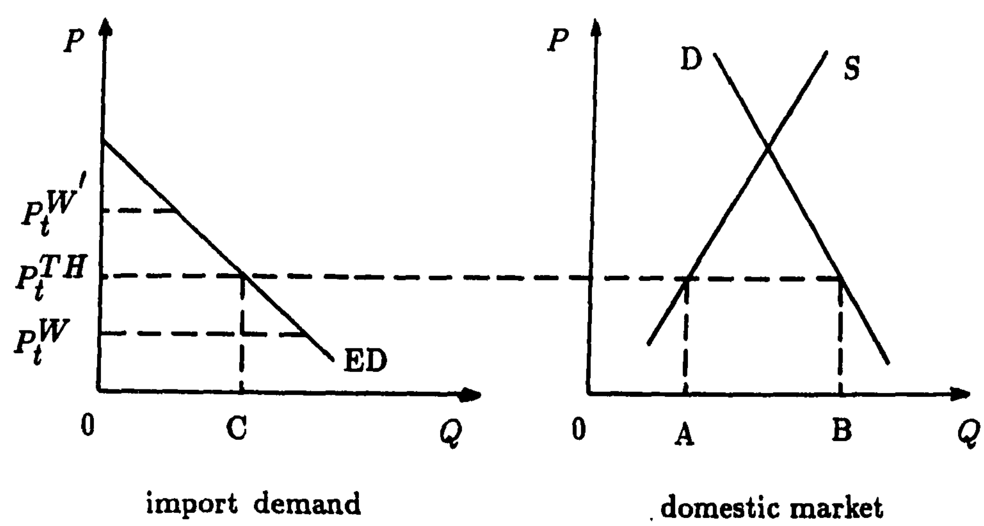


Figure 5.2: Effect of threshold price on wheat import in EC

price, *c.i.f.*), D and S represent the demand and supply schedules in the domestic market, and ED is the excess demand schedule. Once the P_t^{TH} is set and fixed, the quantity to import is equal to AB in the domestic market panel, which is equal to 0C in the import demand panel. Changes in the world price (P_t^W or $P_t^{W'}$) would not change the quantity imported. An import tariff is imposed to raise P_t^W, or to lower $P_t^{W'}$ (import subsidy) to P_t^{TH}. The variable levy can be calculated equal to $(P_t^{TH} - P_t^W)/P_t^W$ as an *ad valorem* tariff. The domestic price hence is completely insulated from the world price. Such price insulation is evidenced by the price movements in Figure 5.1 in which the domestic prices moved together and are relatively more stable than the movement of world price.

The EC total wheat import demand, therefore, depends upon the location of D and S schedules and the threshold price. The domestic wheat production is determined by the government support price and yield. However, since the target price and the intervention price moved at the same steps as the movement of the threshold price (Figure 5.1), the threshold price alone can reflect the price effect on production. This price can also represent the domestic market price movement because the actual price will be between the target and the intervention prices. Thus, the EC total wheat import demand, (5.1), was specified as a function of the threshold price, yield, and exports. All signs are correct as expected. The threshold price elasticity of EC import demand is -0.21. The negative effect of the threshold price reflects its negative effect on import and also negative effect on domestic demand and positive effect on production. The yield might reflect the technology progress over time and the harvest situation. Wheat export was included because EC is also a major exporter in the world market. Dummy variables for 1969, 1970, and 1976 reflect the extreme drop and rise of import demand in these years. The equation (5.3) is the calculated variable levy.

Turing to the purchase of wheat in the world market, the cost of import for wheat importers is exactly the threshold price, no matter where wheat is bought. The only effect is the distribution of this import cost between exporters and the EC governments. If a higher world price, the importers would pay more to the exporters and less to the EC government. Thus, countries of imports are determined by other nonprice factors, e.g., quality of wheat, risk, etc. The import demand for U.S. wheat, (5.2), is expressed as a proportion of the total import demand, where the proportion was assumed exogenously determined.

5.2.1.2 Japan wheat imports Japan agricultural policy for wheat contains the domestic price policy and the import policy. The domestic government prices include the purchase price for wheat producers and the wheat selling price for demanders in the domestic market. The import policy is the well known "quota" system[1]. The government policy devices are aimed to stabilize domestic price and guarantee the farm income. Under the government control, the domestic price is insulated from the price fluctuations in the world market. Figure 5.3 shows the movements of the purchase price, selling price, and the world (U.S.) price.

The policy effects on the wheat import demand are shown as Figure 5.4, where P_t^S is the purchase price, P_t^{SL} is the selling price, D and S are domestic demand and supply schedules, respectively, and ED is the excess demand schedule. If there

[1]The Japan government policy for wheat can be found in Japan Economic Yearbook and Abstract of Statistics on Agriculture, Forestry, and Fisheries published by the government of Japan.

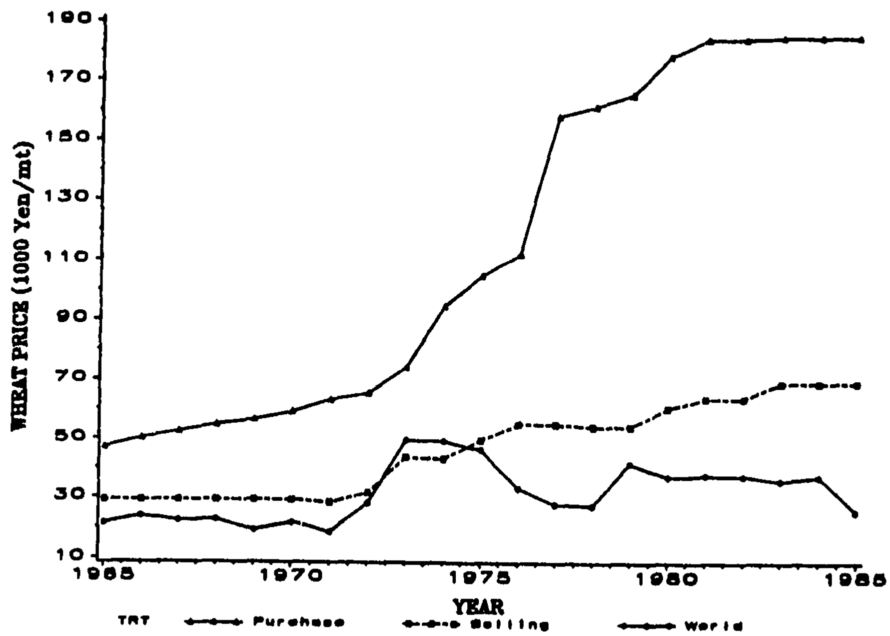


Figure 5.3: Japan domestic price and the world (U.S.) price

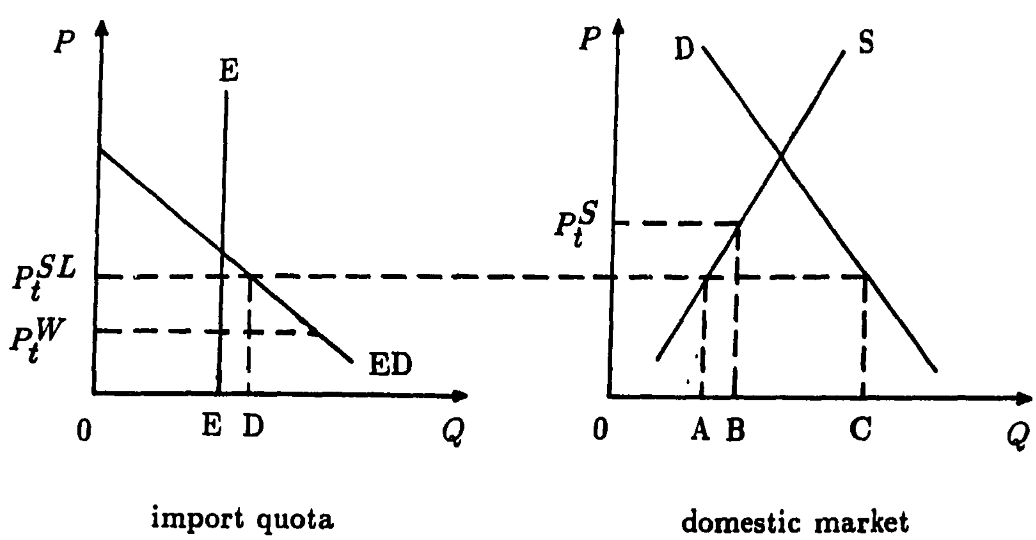


Figure 5.4: Domestic government prices and import quota in Japan

is no purchase price, the government sets both the selling price P_t^{SL} and import quota AC (= 0D in the import demand schedule) to make the domestic market in equilibrium. However, the Japan program also sets the purchase price P_t^S, which results in an overproduction AB. The actual import quota needed for the market equilibrium at P_t^{SL}, therefore, is reduced to BC, which is equal to 0E in the excess demand schedule. A vertical line EE represents the actual import quota. So the actual import quota can be decided by government at the same time the desired purchase and selling prices are being set, given S and D schedules. The higher these two prices, the less the import quota will be. The world price (P_t^W) has no impact on either import quota or domestic price because both are set by government.

Japan wheat import demand, the import quota, was estimated as equation (5.4). Both the purchase price (WHSPJA) and selling price (WHRSPJA) effects were very significant, the estimated elasticities are -0.23 and -0.40, respectivity. The purchase price had less effect than the selling price because of the land limit. Because domestic price was set by government and stable, population (POPJA) appeared an important factor to shift the domestic demand schedule, hence the import demand. Similarly, wheat yield had significant negative effect. The SHIFT75 variable reflected the Japan policy change in imports. After the high world price in the early 1970s, the increasing import quota turned to keep constant. The increased excess demands for wheat in large part were supplied by domestic production. This can be evidenced by the sharp increased in the purchase price and by the self-sufficiency ratio, which was about 5% in 1970s and about 12% since the late 1970s.

Unlike the EC by setting the threshold price on imports so that the private importers are indifferent about countries of origin of buyings, wheat imports are undertaken by the government Food Agency (FA) in Japan and by setting the domestic selling price rather than the import price so that the cost of imports is important. Therefore, under the product differentiation assumption Japan in the duopoly world wheat market would buy wheat with the choice on price and quality. Since the substitution elasticity of wheat is high, if the import price (*c.i.f.*) from the United States is higher relative to the import price from Canada, more wheat will be imported from Canada. Conversely, more wheat will be imported from the United States if the relative import price is lower. The Japan import demand for U.S. wheat , therefore, was estimated as a function of the relative import price from U.S. and Canada, total import demand, and import from other smaller exporters, equation (5.5). This equation indeed is the theoretical equation (4.3). All signs are correct and all estimates are very significant. The Japan import demand for U.S. wheat is less elastic (-0.35) with respect ot the relative import price from U.S. and Canada.

The approximate import tariff (quota equivalent) was calculated by using the domestic selling price in equation (5.6). However, such a calculated import tariff might be underestimated or overestimated because the selling prices were not the actual market prices. This implies that the Japan government subsidized the domestic consumption, if it is underestimated.

5.2.1.3 India wheat imports The main feature of the Indian grain market is its segmentation into concessional and commercial markets – a dual market. For the concessional market, the government buys grain from producers, monopolizes imports, and together with stocks to sell to the low-income consumers at a

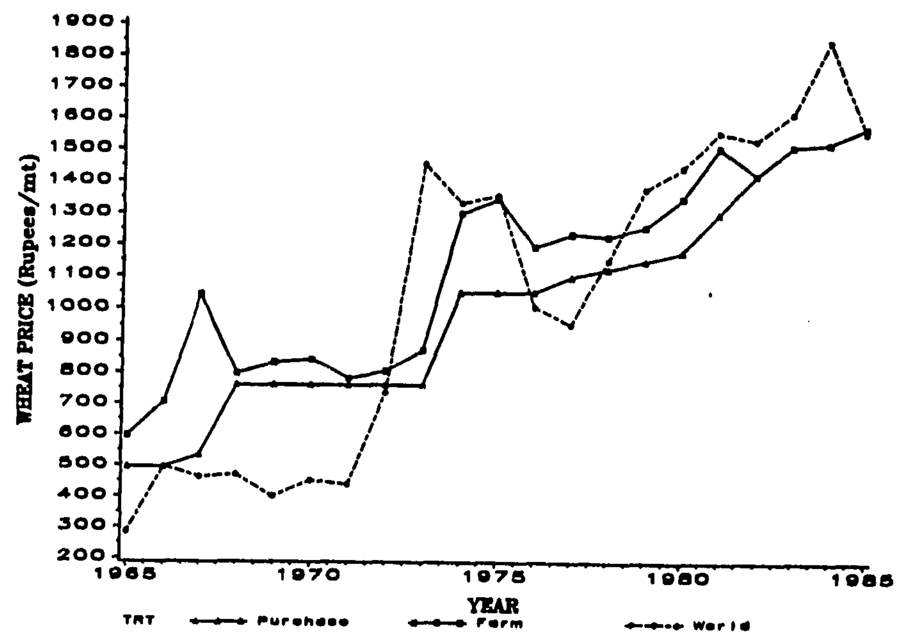


Figure 5.5: India domestic wheat price and the world (U.S.) price

subsidized price. On the supply side, the government handled about 10 percent of total grain available for consumption since the late 1970s. This system provided an average of about 29 percent of wheat consumption on the demand side during the period 1961 to 1978. The two government policy prices, therefore, are the procurement (purchase) price and the resale price (Mahama, 1985).

For wheat, imports were the main source for the concessional sales. However, the Indian Green Revolution program between 1967 and 1972 enabled government to procure enough domestic wheat, increase stocks, and hence eliminate imports as the main source. Since the concessional market is relative small and the dependence on imports is diminishing, the Indian agricultural policy seems to be focusing on the stabilization of domestic price. This can be evidenced from the movement of farm price in Figure 5.5. The farm prices can be separated into two segments at 1974. Prices were relativlye stable in each segment except in a few years. Compared

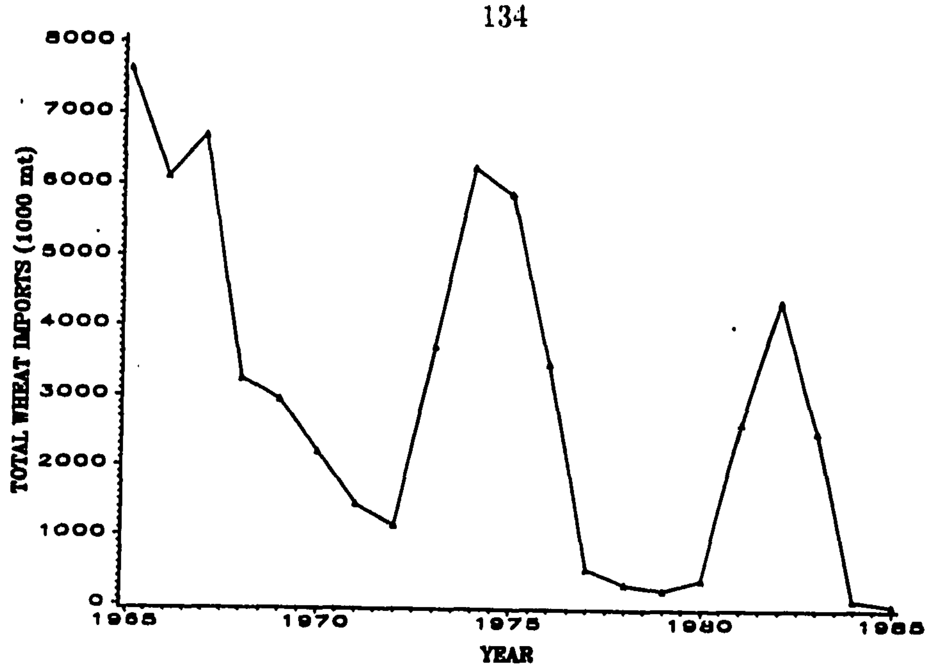


Figure 5.6: India total wheat imports

to the relatively unstable world price, it turns out that the domestic prices were stabilized and insulated from the world price changes.

The wheat import demand, therefore, can be fully specified by the Indian agricultural programs. The Green Revelation program resulted in almost sufficient production for domestic consumption, and thereafter the secular declines of wheat imports since 1967. The occasional sharp increases in wheat imports were occurred because of domestic price inflation. Government tended to import enough wheat from the world market to stabilize domestic price inflation. This is evidenced by the concurrent rise in domestic farm price and import demands in 1967, 1974-75, and 1981-82 (Figures 5.5 and 5.6).

India total wheat import demand was estimated as equation (5.7). The positive and very significant coefficient for domestic farm price (WHPFMIN) consists with the price stabilization policy. The estimated farm-price elasticity of import demand is 2.42, which is very elastic. Rice (RIPWHIN) was an important substitute for wheat in consumption, the cross-price elasticity is 0.24. Wheat yield had negative effect on imports as expected. The beginning stock was also an important factor in determining imports from abroad. Note that the government purchase price for the concessional market was not significant and was ruled out. This implies that the government purchase system had little significance. Farmers did not face a dual market as consumers did.

Most India wheat imports were from the United States. However, in the duopoly world wheat market India did significantly respond to the relative import price of the United States and Canada. The equation (5.8) presents import demands for U.S. wheat. The negative coefficient for the relative price of two duopolists is very significant and elastic (-1.27). This implies that the cost of import is matter to India in choosing the wheat supplier in the world market.

The equation (5.9) calculates the India wheat import tariffs or subsidies. The U.S. export price was used as the world price for this purpose. From Figure 5.5, it is clear that India government taxed wheat imports until 1972, and thereafter subsidized the imports most of the time to stabilize the domestic price.

5.2.1.4 The Soviet Union (USSR) wheat imports As specified in Chapter 3 for the centrally planned economies, the USSR total wheat import demand (WHIMTSR), (5.10), was estimated as a function of total domestic supply (production plus beginning stocks), income, and changes in import cost. Since the domestic price of food grains were always under the government control through the distribution system, internal price may be meaningless in the CPE. However, external price can be important (Chambers and Just, 1981). The import price is thus included in specification. Because of lack of domestic price data, the percentage changes in import cost (CHTAXSR) was calculated to reflect the price effect on import demand. The equation (5.12) presents the formula, which was derived from the international price linkage. Similarly, U.S. export price was used as the world price for the calculation. Since food consumption in the CPE is mostly arranged and controlled by government for food security, the domestic wheat price was assumed constant in the calculation.

The import demand for U.S. wheat (WHIM1SR) was estimated as equation (5.11). All signs are correct as expected. However, the relative export price of the United States and Canada was not very significant for the USSR. This implies that in choosing the exporter in the duopoly world market other nonprice factors, (e.g., political factors) were important (Chambers and Just, 1981). For example, the USSR did not import wheat from the United States until 1971. This might be based on nonprice factors consideration in decision. A dummy variable (DSR) was set to reflect the zero import from U.S. and to restrict the estimation.

5.2.1.5 China wheat imports The total wheat imports, (5.13), was estimated as a function of domestic production, population, and the government grain procurement price index. Since income per capita in China was stable and low until the 1980s, income effect was insignificant. The government flour price is constant at 0.326 Yuan/kg over time, so is meaningless. Both income and domestic consumption price were thus ruled out in specification. Instead, population appeared an important demand shifter for wheat consumption. This is realistic because food consumption is under government control by the ration system. However, change in the world price had no effect on the total import demand either, so was ruled out. A positive and very significant coefficient was obtained for the domestic grain procurement price index. This is an aggregate grain price index. A rise in this price might imply a supply shortage; therefore, more wheat was imported from the world market to secure the domestic supply and stabilize the potential price inflation. The SHIFT77 variable was included to reflect the structural changes due to the economic reform in China.

In the duopoly world wheat market, equation (5.14) shows that import demand for U.S. wheat did significantly respond to the relative export price of the United States and Canada. Since China did not import wheat from the United States until 1971 and in 1975 and 1976, a dummy variable DCH was set to restrict the estimation.

5.2.1.6 The rest of the world (ROW) wheat imports All other wheat importing countries were aggregated as the ROW region in this study. Total wheat import, (5.15), was specified as a function of wheat price (WHIMPRW) in the ROW, rice price (RIIMPRW) in the ROW, income, and wheat production (WHPODRW). The estimated coefficients are consistent with theoretical expectations and are statistically significant. The wheat price elasticity of import was estimated at -0.19, which is inelastic. Rice appeared as an important substitute of wheat in the world market, the cross-price elasticity is 0.11. Since most of countries in this region are developing countries, increase in income tended to result in more wheat consumption, hence more wheat imports from the world market. The income elasticity was estimated at 1.58 for the ROW region. Wheat production in the ROW was also an important determinant of imports.

Import demand for U.S. wheat, (5.16), in the duopoly world market, however, did not respond to the relative price of the United States and Canada. Instead, the relative supply of the United States and Canada was more important. This is because the United States is the biggest wheat producer in the world, to secure supply for imports most countries bought wheat from the United States. A positive and significant coefficient was obtained for the relative supply ratio. Since each country in the region is small in imports, fixed tariff trade policy was assumed. The equation (5.17) links the wheat price in the ROW with the world price, where the U.S. export price was taken as the world price.

5.2.1.7 Total import demand for U.S. wheat and U.S. export pricing

The aggregate world wheat import demand, (5.18), is the summation of total wheat imports of all regions. Similarly, total import demand for U.S. wheat is the sum of all import demands for U.S. wheat, (5.19). The equations (5.20) and (5.22) present the export pricing decision of Canada and the United States, respectively. All estimated coefficients for the pricing equations have correct signs as expected and are very significant. These evidence the duopoly world wheat market characteristics and the Canada price leadership assumption.

In the pricing decision, Canada acts as a monopolist, even the action of other smaller exporters had no influence on its pricing decision. The United States acts as the price follower and also significantly responds to the action of smaller exporters in the world market. As discussed in Chapter 3, this is because the United States tries to maintain its market share in the world market; whereas, Canada concerned more with the domestic supply conditions (Gilmour and Fawcett, 1986). The estimated elasticity of U.S. export price with respect to Canadian export price is 0.85. The freight rates would fluctuate the import prices of the importers, therefore, in the backward had significant influence on the duopolists' pricing decision. They are in some respects like export taxes to offset the effects of changes in export price or exchange rates (Johnson et al., 1977).

5.2.2 Part 2. U.S. domestic wheat market

5.2.2.1 U.S. wheat production The U.S. wheat production expressed by equations (5.23), (5.24), and (5.25). Since wheat area harvested was not exactly equal to the area planted, the area planted was estimated, and then area harvested was expressed as a proportion of the area planted, (5.24). As defined in previous chapters, wheat production, (5.25), is the product of yield and area harvested.

Wheat area planted (USWHEAPF) was estimated for the next season, (5.23), and was specified as a function of the expected price received by farmers, the government announced support price for next season, expected price received by farmers for the competing oat crop, the set-aside area of wheat, the allotment area for the next season, and a structural change variable. All estimated coefficients are statistically significant and have correct signs as the theoretical expectation. The expected price received by farmers (WHFPFOC) turned out to be the most important factor for the area planting decision, with elasticity 0.62. Oat appeared as the most important competing crop for wheat. The estimated cross-price elasticity is -0.46. This is consistent with Langley's (1983) findings in testing the acreage responses to government programs in different wheat production regions. The government programs, support price (WHSPFOC), set-aside program (WHSAAFOC), and allotment (WHALTFOC), had significant impacts on the area planting decision, where the support price elasticity of area planted is 0.20. The mandatory allotment program was accounted for in the planting decision until 1970. Then, the program participation became voluntary. The WHALTFOC variable, therefore, was restricted equal to zero since 1971, and a structural change variable X7185 was included to reflect the change in program participation (Garst and Miller, 1975). The area harvested for the current crop year was expressed as a proportion the one-year lag value of the area planted for next season, (5.24).

5.2.2.2 The expected wheat market prices The equations (5.26) and (5.27) express the expectations of wheat market prices. Since U.S. wheat production was almost equally absorbed by domestic market and world market, both the expected export price (WHEXPFC1) and the expected farm price (WHFPFOC) were formulated. For simplicity, the expected prices were formulated as a simple 3-year moving average.[2] Such formulation, however, was satisfactory in the estimation of this model.

5.2.2.3 Domestic demands for wheat Three domestic demands were estimated as equations (5.28), (5.29), and (5.30). Domestic food use demand for

[2]In the literature there have been six major approaches to the measurement of the expected price: naive expectations, weighted expectations, extrapolative expectations, adaptive expectations, rational expectations, and future market price. However, no firm conclusions as to the best technique has been determined for agricultural prices (Langley, 1983).

wheat, (5.28), was specified as a function of real domestic wheat price, real price index of bakery and cereal products, real price index of dairy price, real consumption expenditure, and the interest rate. The domestic wheat price elasticity of food use demand is as expected inelastic at -0.04. Since demand for wheat is a derived demand, increase in the real price of bakery and cereal products (PIBACE/USPWJM) would derive more demand for wheat; however, the estimated elasticity is inelastic (0.46). The dairy products turned out to be complements of the final wheat products. A negative coefficient was obtained and the cross-price elasticity is -0.67. The standard positive income effect was also obtained and the estimated income elasticity is 0.27. As the price of capital investment in the industry of final wheat product, the interest rate had negative effect (interest rate effect) on the industry, hence on the demand for primary wheat. However, even the estimated coefficient is statistically significant the estimated interest rate elasticity is very low at -0.02.

The equation (5.29) expresses the feed use demand for wheat.[3] Corn was an important substitute of wheat in the livestock industry. A positive coefficient was obtained for the real price index of meat products (PIMP/USPWJM). This is consistent with the theoretical specification of derived demand for wheat. Income effect was positive as prior expectation. However, the interest rate effect was insignificant, so was ruled out in the equation.

Seed use demand for wheat, (5.30), depended upon the wheat area planted for the next season (USWHEAPF). A positive and statistically significant coefficient for

[3]Since the SAS program requires each endogenous variable appears only once on the left hand side of the equation system, the feed use demand equation was estimated with the domestic price (WHFP) as the dependent variable, so was it simulated in the model examination and policy analysis.

the time trend variable (TREND) might imply a progess in the seeding technology or more domestic wheat used as seed in planting over time.

5.2.2.4 Domestic ending stocks In light of past historical difficulty in estimating stocks equations, the statistical properties of equations (5.31)and (5.32) are excellent. As the theoretical specification in Chapter 4, the commercial (free) stocks (WHFRS1) were held for speculative motivation, especially boom and bust in the world market. A rise in the current export price (WHEXPUS) or a depressed expected export price (WHEXPFC1) would deplete the commercial stock holding. In respone to the domestic market condition, a higher target price (WHTP1) would lower the holding because farmers can receive more subsidy from government. Sales to government stocks holding because of the borrowing of production loan can reduce the level of commercial stock holding. The capacity of the silo system for holding stocks was significant in restricting the holding. The opportunity cost (interest rate effect) appeared very significant and important in the commercial stocks holding decision. The estimated interest rate elasticity is -0.59.

The government stock holding was commonly treated as an exogenous component in the past; however, the successful estimation of equation (5.32) implies that it indeed was like the barometer of the market. The government loan rate (WHLR) had a positive effect on government stocks because of the borrowing of production loan with wheat as collateral. Besides, the government stocks level reflected the production and market demand situation. Strong demand in domestic market (rise in WHFP) and/or in world market (increase in WHEXT2) would absorb more wheat production, hence reduce the government stocks. However, if depressing demands in both markets and high production, more wheat were sold to government and stacked the government stocks. The government stock, therefore, was actually a component to absorb the market surplus. Total ending stocks, (5.33), were simply the sum of commercial stocks and government stocks.

5.2.3 Part 3. U.S. financial market

5.2.3.1 The interest rate determination The estimated results of the interest rate determination are presented in equation (5.35). This equation is actually the reduced form of interest rate determination equation (4.29) in Chapter 4. However, the theoretical determination equation is derived under the flexible exchange rate system, so is appropriate only for the periods since 1973.

Under the fixed exchange rate regime, the interest rate determination could be derived from the domestic money market equilibrium condition (4.14), keeping the assumption of exogenous real domestic income, as

$$di = \frac{1}{PL_i}(dM^S - PL_y\,dy - L\,dP), \quad \text{for 1965 to 1972} \qquad (5.37)$$

Since the data used in this study (1965 to 1985) include both fixed and flexible exchange rate regimes, the approximate interest rate estimation equation for the whole period, therefore, can be formulated by connecting (5.37) and (4.29). Note that the domestic money supply (M^S) and real income (y) are the determinants of interest rates in both fixed and flexible exchange rage regimes, other determinants appear only once in each regime. A dummy variable (DI), therefore, was defined to restrict other determinants in estimation.

The estimation results are satisfactory. All estimated coefficients are statistically significant and all signs are correct as prior expectation. However, the explanatory variable the ratio of foreign assets and total government debt (ASRATO) was insignificant and ruled out in this equation.

5.2.3.2 The exchange rate determination Similarly, the theoretical reduced form (4.30) of exchange rate determination equation was estimated. This equation, however, is appropriate only for the flexible exchange rate regime. The explanatory variables had no effect on the exchange rate under the fixed exchange rate system.

To solve this problem and estimate the exchange rate determination equation for the whole period (1965 to 1985), the grafted polynomial technique developed by Fuller (1976) was used to connect the fixed and flexible regimes in estimation. This technique had been used by Denbaly (1984), Devadoss (1985), Devadoss et al. (1987b), and Liu et al. (1986).

To illustrate the use of grafted polynomial in the estimation, the exchange rate time series was divided into three segments: (1) fixed exchange rate (1965-71), (2) transition period (1971-73), and (3) flexible exchange rates (1973-85). The exchange rate (US $/SDR) was fixed under the fixed regime. In the transition period, even though the flexible regime was officially adopted in 1973, many countries started to revalue their currencies against the U.S. dollar, thereby breaking away from the fixed exchange rate system. The U.S. dollar, therefore, depreciated against SDR. Under the flexible exchange rate regime since 1973, the exchange rates are determined by the determinants as equation (4.30).

A grafted polynomial variable (X), therefore, is defined as below to join these three segments together.

$$
\begin{aligned}
X &= 0 && \text{year} \leq 1970 \\
&= \text{year - 1970} && 1971 \leq \text{year} \leq 1972 \\
&= 3 && \text{year} \geq 1973
\end{aligned}
$$

By multiplying this variable to all explanatory variables, the exchange rate equation (4.30) became a single, continuous, and estimable equation for the whole period including fixed and flexible exchange rate system. This variable was also includes as a separate regressor to capture the exchange rate movements in the transition period.

The estimated results of the exchange rate equation is presented in equation (5.36). Because of the autocorrelation problem, a one-year lag exchange rate was included as explanatory variable. The estimated dependent variable, the current year exchange rate, therefore, is more appropriate specified as a predicted value. However, the theoretical explanatory variables based on the portfolio equilibrium model are also important exchange rate determinants except the foreign interest rate variable. All estimated coefficients are very significant and have the anticipated signs.

To summarize these econometric results, the estimated coefficients in all equations conform to the theoretical expectations and the real world evidence. The impact channels of monetary policy are also captured well (refer to Figure 2.2). The exchange rate effects through the international price linkage (the external channel) is well explained in the USSR and the ROW regions, see equations (5.12) and (5.17). In all other regions, the exchange rate has no impact on their import demands because of domestic and trade policies implemented by these regions. The interest rate effects (the internal channel) on the domestic food use demand and the commercial ending stock holdings are very significant, see equations (5.28) and (5.31). Since wheat is primarily for food use and the commercial stock holding reflects commodity speculation on the wheat market, it is very important to account for interest rate effects in the model.

The duopoly world wheat market is evidenced by the model. Except for the EC, import demands for U.S. wheat in all other regions do significantly respond to the relative price of the United States and Canada, or the relative wheat supply of these two duopolists. The Canada and U.S. wheat export pricing equations strongly support the duopoly market characteristics and behavioral assumptions, especially the Canada price leadership assumption. Once the duopolists' prices are decided, the import demands for U.S. wheat are determined by the import demands facing the United States. Such a determination process is fully captured by this model. The equation (5.19) sums all import demands for U.S. wheat. It is equivalent to total U.S. wheat exports.

In the interest rate and exchange rate equations (5.35) and (5.36), the U.S. money supply (M1) has very significant influence on the determination of these two rates. The portfolio equilibrium model provides the theoretical basis for these two equations, and the excellent estimated results enable this model to precisely assess the impacts of the U.S. monetary policy on wheat trade and domestic market.

Finally, this empirical model appears to be the first one to present the different market characteristics of world market and U.S. domestic market, and then the different determination processes of the export price and domestic price, (5.22) and (5.29). The interaction of these two markets is also captured. The domestic market clearing condition, (5.34), fully expresses the external impact (WHEXT2) on the domestic wheat supply, hence on the domestic price. Export price is also linked to domestic market to reflect its effect on domestic market. A strong foreign demand, therefore, can raise both the export price and domestic price. Figures (4.3) – (4.5) in the preceding chapter graphically show the different price determination processes and the interaction of these two markets due to exogenous shocks.

5.3 Validation and Stability of the Model

Since the model is to be used for dynamic simulation analysis of the effects of monetary policy, the validation and the stability of the model must be first examined. Validation of the model is its overall ability to reproduce the actual data of the endogenous variables, while stability of the model is its response to an exogenous shock over time. The estimated structural equations and identities were used for the examinations.

5.3.1 Validation of the model

In order to measure this model's ability to reproduce the actual data, the structural form of the model was simulated over the entire period (1965 to 1985). The simulation results are then compared with the actual data. A dynamic simulation procedure – the solved values rather than the actual values are used for lagged values of endogenous variables – was run because it allows the researcher to study the evolutionary character of the model over time. Since the model is nonlinear, the nonlinear simulation procedure was used for the solution. The computer program used for the purpose is SIMNLIN (DYNAMIC) of SAS/ETS (SAS, 1984).

The statistics to measure the model's simulation performance include root mean square error (RMSE), root mean square percentage error (RMSPE), and Theil's forecast statistics. The RMSE is a measure of the deviation of the simulated value from the actual value. The RMSPE expresses RMSE in terms of percentage. Theil's statistics are also often used to measure simulation performance of a model. There are three different components decomposed from the mean square error (MSE): bias error (UM), regression error (UR), and disturbance error (UD). The UM is an indication of systematic error, since it measures the extent to which the average values of the simulated and actual series deviate from each other. The UR indicates the ability of the model to replicate the degree of variability in the variable of interest. The UD measures the error remaining after deviations from average values and average variabilities have been accounted for. The perfect correlation of the simulated values with actual values would imply the ideal distribution of MSE over these three sources as UM = UR = 0 and UD = 0 (Pindyck and Rubinfeld, 1981)

Table 5.3 presents the overall goodness of fit of the model from dynamic simultaneous simulation run. In general, for a large model an RMSPE of less than 25 percent is considered to be good. Most endogenous variables of this model have very low RMSPE. Out of 21 estimated endogenous variables 14 variables have RMSPE less than 20 percent. Variables with high RMSPE are WHIMTIN, WHIM1IN, WHIMTSR, WHIM1SR, WHIM1CH, WHFEU, WHFRS1, and WHGVS1. The reason of high RMSPE for these variables is because in some years their actual values are equal to or close to zero. For example, WHIM1SR equals zero from 1965 to 1971, and WHIM1CH equals zero from 1965 to 1971 and from 1975 to 1976. Thus, any small error of prediction creates a high proportion of error when error is compared to the small actual values, especially the zero actual values. In addition to the reason of small magnitude, the high RMSPE of domestic feed use (WHFEU) is because this variable was estimated and simulated by moving it to the left-hand side of market clearing condition (5.34). Therefore, simulation errors from all foreign demands and domestic demands accumulate and are transferred to this variable. In general, the model performs very well in tracking the observed values. Figures 5.7 to 5.15 plot the predicted versus actual values of 9 key endogenous variables.

Theil's forecast error statistics of the dynamic simulation are presented in Table 5.4. As described above, for a good fit of the model the values of UM and UR should be close to zero and UD should be close to one. For UM, all variables have zero values UM. This indicates that for all variables there is no systematic error, the actual and the simulated series on average fitted very well. The regression error (UR) is also almost perfect except for variables WHIM1SR and WHFEU. This implies that these two variables were not specified well, and a revision might be necessary. However, since the unavailability of data for the USSR and the fact that the USSR had no import from the United States for 1965 to 1971 because of nonprice factors, estimation for WHIM1SR was restricted. The reason for WHFEU has high simulation regression error, as mentioned earlier, is because of the small magnitude in years and the accumulation of errors from all foreign and domestic demands. In general, Theil's forecast errors of most simulation variables are from disturbance terms (UD) rather than others. This model performs satisfactorily.

Table 5.3: Root mean square error (RMSE) and root mean square percentage error (RMSPE) from the dynamic simulation (N=21)

Variable	RMSE	RMSPE
EC total wheat import (WHIMTEC)	423.989	11.73
EC wheat imports from U.S. (WHIM1EC)	170.65	11.72
Japan total wheat imports (WHIMTJA)	143.36	2.84
Japan wheat import from U.S. (WHIM1JA)	118.30	4.09
India total wheat imports (WHIMTIN)	566.39	726.84
India wheat imports from U.S. (WHIM1IN)	502.60	1356.73
USSR total wheat imports (WHIMTSR)	2804.28	400.20
USSR wheat imports from U.S. (WHIM1SR)	1706.57	55990149.00
China total wheat imports (WHIMTCH)	813.15	20.04
China wheat imports from U.S. (WHIM1CH)	386.38	70935749.00
ROW total wheat imports (WHIMTRW)	2158.76	5.74
ROW wheat import from U.S. (WHIM1RW)	1513.72	10.24
ROW domestic wheat price (WHIMPRW)	12.72	11.63
World total wheat imports (WHIMTWL)	3597.69	5.71
U.S. wheat export (WHEXT2)	2242.68	8.57

Table 5.3 (Continued)

Variable	RMSE	RMSPE
Canada wheat export price (WHEXP2CA)	10.76	9.34
U.S. wheat export price (WHEXPUS)	9.84	11.99
U.S. wheat area planted, next year (USWHEAPF)	3.47	4.74
U.S. wheat production (WHPOD)	98.42	4.47
U.S. wheat food use (WHFOU)	6.80	1.18
U.S. wheat feed use (WHFEU)	134.48	125.84
U.S. wheat seed use (WHSEU)	4.71	5.31
U.S. free ending stocks (WHFRS1)	67.55	37.59
U.S. government ending stocks (WHGVS1)	177.57	115.65
U.S. total ending stocks (WHEST)	135.69	19.51
U.S. wheat domestic farm price (WHFP)	0.24	9.28
U.S. domestic interest rate (IR1)	0.49	7.62
U.S. exchange rate (ERSDR)	0.03	2.73

Table 5.4: Theil forecast error statistics (N=21)

Variable	MSE	MSE decomposition Bias UM	Reg. UR	Dist. UD	Accuracy U1
WHIMTEC	179683.00	0.00	0.00	1.00	0.07
WHIM1EC	29121.48	0.01	0.05	0.94	0.08
WHIMTJA	20550.77	0.00	0.01	0.99	0.03
WHIM1JA	13995.41	0.00	0.00	1.00	0.04
WHIMTIN	320794.00	0.00	0.04	0.96	0.15
WHIM1IN	252602.00	0.00	0.02	0.98	0.17
WHIMTSR	7863972.00	0.00	0.21	0.79	0.23
WHIM1SR	2912383.00	0.02	0.60	0.38	0.47
WHIMTCH	661206.00	0.00	0.01	0.99	0.11
WHIM1CH	149291.00	0.03	0.00	0.97	0.13
WHIMTRW	4660264.00	0.00	0.02	0.98	0.05
WHIM1RW	2291355.00	0.00	0.04	0.96	0.08
WHIMPRW	161.67	0.01	0.17	0.82	0.10
WHIMTWL	12943404.00	0.00	0.04	0.96	0.05
WHEXT2	5029631.00	0.00	0.00	1.00	0.07

Table 5.4 (Continued)

Variable	MSE	MSE decomposition Bias UM	Reg. UR	Dist. UD	Accuracy U1
WHEXP2CA	115.69	0.00	0.00	1.00	0.06
WHEXPUS	96.77	0.01	0.01	0.98	0.08
USWHEAPF	12.03	0.00	0.03	0.97	0.05
WHPOD	9685.88	0.00	0.00	1.00	0.05
WHFOU	46.18	0.00	0.00	1.00	0.01
WHFEU	18084.86	0.00	0.55	0.45	0.71
WHSEU	22.22	0.00	0.03	0.97	0.05
WHFRS1	4563.04	0.00	0.02	0.98	0.19
WHGVS1	31532.04	0.00	0.00	1.00	0.23
WHEST	18410.77	0.00	0.00	1.00	0.13
WHFP	0.06	0.00	0.03	0.97	0.08
IR1	0.24	0.00	0.00	1.00	0.06
ERSDR	0.00	0.00	0.03	0.97	0.03

Another important examination on the validation of the model is the model's ability to duplicate turning points or rapid changes in the actual data. As Figures 5.7 to 5.15 illustrate, the simulated series do seem to reproduce the general long-run behavior of the actual series, although a few short-run fluctuations in the actual series are not reproduced very well.

For the aggregate world wheat imports (Figure 5.7), even it accumulates the import demands of all regions, there are only 3 turning point errors out of 21 simulated years, and the sharp increase in 1972 and the sharp decrease in 1985 were predicted very well. Similarly, the U.S. wheat export (Figure 5.8) is the accumulative sum of all import demands for U.S. wheat, but has only 3 turning point errors. All sharp rises and falls were also predicted well. The sharp fluctuations in U.S. export price (Figure 5.9) and domestic price (Figure 5.10) after the commodity booms in the early 1970s were simulated very close to the actual data. Turning to the financial market, both the interest rate (Figure 5.14) and exchange rate (Figure 5.15) were predicated accurately. There are only 2 turning point errors for the interest rate and 1 for the exchange rate. By such comparison of predicated and actual values, this model shows a good ability to trace upward and downward movements in the data.

5.3.2 Stability of the model

The stability of the model is examined by its response to a one-period exogenous shock. If changes in endogenous variables in response to the shock are decreasing as time passes, and simulation values with shock move back to base values (simulation values without shock), the model is stable. The faster the adjustment back toward the base values, the more stable the model.

In this study, the money supply growth rate in 1973 was exogenously increased by 3 percent to test the stability of the model. The year 1973 was chosen because the flexible exchange rate regime officially started in that year. Given this shock, the expected immediate effects are the U.S. dollar depreciation and a decrease in the domestic interest rate. Then, through the external channel the exchange rate via the international price linkage would have impacts on foreign wheat import demands. Through the internal channel, the lower interest rate would increase the domestic food use demand for wheat and the commercial (free) ending stocks. Also, change in foreign demands for U.S. wheat would have impact on the domestic market. Eventually, U.S. wheat exports, export price, domestic demands, and domestic price would change (refer to Figure 2.2, Figure 4.4, and the structural model in Table 5.1). The consequent changes in all endogenous variables in the following years depend upon the lagged endogenous variables and the price expectations. However, they are expected to diminish as time passes.

Table 5.5 reports the dynamic simulation results for the key endogenous variables: the base values, changes from the base values caused by money supply growth in 1973, and the percentage changes. As the theoretical expectation, the percentage change of all variables decreases as time passes, and all simulated results eventually approach the base values. For the immediate effects, a 3 % increase in money supply caused a 3.29 % depreciation in the U.S. dollar and a 5.77 % decrease in the interest rate in 1973. Because of the one-year lag autocorrelation, the exchange rates in the following years steadily decreased and back toward the base value from 1973 to 1984. However, the domestic interest rate moved back to its base values quickly in

1974. Impacts of the money supply shock were spread out via the exchange rate changes on the world market and via the interest rate decrease on the domestic market. However, the exchange rate effect was zero on the total wheat imports of the EC, Japan India, and China because of the domestic and trade policies exercised in these regions. On the domestic side, the current year (1973) wheat production was unchanged because wheat was planted in the last crop year. A detailed analysis of those changes will be discussed in the next chapter. The important point here, as shown in Table 5.5, is that all changes in endogenous variables in response to the money supply shock decreased over time. Since all variables moved back to their base values after the shock, this model can be judged stable.

According to the above examinations, this model's performance is satisfactory and the model is stable. They suggest that the model developed in this study provides a good foundation for further empirical analysis.

Table 5.5: Dynamic impacts of an increase in the U.S. money supply growth rate by 3 percent in 1973

Variable	Year	1973	1974	1975	1976	1977
WHIMTEC	Base	6056	5360	6016	4711	5522
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1EC	Base	2766	2218	3373	1342	2215
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIMTJA	Base	5091	5214	5746	5781	5483
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1JA	Base	3067	2992	3347	3391	3073
(1000 mt)	Change	5.33	1.82	1.53	0.67	0.48
	% change	0.17	0.06	0.05	0.02	0.02
WHIMTIN	Base	2533	6773	5434	3027	573
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1IN	Base	678	4948	3803	1664	311
(1000 mt)	Change	14.31	5.14	4.09	1.77	1.22
	% change	2.11	0.10	0.11	0.11	0.39
WHIMTSR	Base	2494	1440	9807	6743	9027
(1000 mt)	Change	103.03	40.76	-1.53	11.62	-0.48
	% change	4.13	2.83	-0.02	0.17	-0.01
WHIM1SR	Base	1611	-689	4052	4362	5177
(1000 mt)	Change	78.34	30.92	-0.91	8.62	-0.48
	% change	4.86	-4.49	-0.02	0.20	-0.01

Table 5.5 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
4532	4871	4247	4377	3578	3693	1575	2798
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2206	2489	2140	2495	1494	1459	610	907
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5554	5626	6073	5776	5754	5774	5901	5543
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3136	3164	3666	3385	3370	3394	3493	3262
0.22	0.17	0.06	0.05	0.03	0.01	0.01	0.00
0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
123	127	19	3830	4470	1690	668	235
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-10	-69	-147	2563	3900	1021	644	376
0.55	0.35	0.18	0.13	0.06	0.02	0.01	0.00
-5.30	-0.51	-0.12	0.01	0.00	0.00	0.00	0.00
3165	11029	12294	18606	19832	23185	27590	17213
2.98	-1.64	0.61	-0.07	0.22	0.10	0.00	0.05
0.12	-0.02	0.01	-0.00	0.00	0.00	0.00	0.00
2022	3595	1375	5553	2701	6485	5713	749
2.98	-1.64	0.61	-0.07	0.22	0.09	0.00	0.05
0.15	-0.05	0.04	-0.00	0.01	0.00	0.00	0.01

Table 5.5 (Continued)

Variable	Year	1973	1974	1975	1976	1977
WHIMTCH	Base	5782	4406	3653	2580	9126
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1CH	Base	2560	933	34	34	458
(1000 mt)	Change	3.54	1.05	0.00	0.00	0.34
	% change	0.14	0.11	0.00	0.00	0.07
WHIMTRW	BASE	39101	37556	39892	36390	44977
(1000 mt)	Change	21.73	7.62	10.36	4.46	4.31
	% change	0.06	0.02	0.03	0.01	0.01
WHIM1RW	Base	19853	15566	19945	14844	21394
(1000 mt)	Change	15.84	6.60	10.58	9.01	6.20
	% change	0.08	0.04	0.05	0.06	0.03
WHIMTWL	Base	61057	60748	70549	59232	74708
(1000 mt)	Change	124.76	48.39	8.83	15.77	3.57
	% change	0.20	0.08	0.01	0.03	0.00
WHEXT2	Base	30534	25969	34554	25637	32628
(1000 mt)	Change	117.36	45.53	15.29	20.07	7.76
	% change	0.38	0.18	0.04	0.08	0.02
WHEXP2CA	Base	205.34	187.48	172.34	150.89	174.90
(CA $/mt)	Change	0.16	0.06	0.01	0.02	0.00
	% change	0.08	0.03	0.01	0.01	0.00
WHEXPUS	Base	178.11	155.86	147.02	126.90	135.35
(US $/mt)	Change	5.16	2.52	1.23	0.62	0.33
	% change	2.90	1.62	0.83	0.49	0.25

Table 5.5 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
6287	8929	13467	14033	12625	9194	7766	7272
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1684	1393	7988	8450	4113	3487	3094	801
0.12	0.12	0.04	0.04	0.02	0.01	0.00	0.00
0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
46072	55823	53518	56785	52436	53781	60235	52805
1.06	1.48	0.48	0.48	0.20	0.06	0.04	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19115	25924	22353	26406	26538	22224	26084	22358
1.95	0.86	-0.02	0.03	0.36	0.25	0.10	-0.05
0.01	0.00	-0.00	0.00	0.00	0.00	0.00	-0.00
65733	86405	89618	103408	98695	97317	103735	85867
4.99	-0.74	1.28	0.38	0.49	0.18	0.04	0.07
0.01	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
28153	36497	37374	48851	42117	38070	39638	28454
5.81	-0.13	0.87	0.47	0.68	0.38	0.13	0.01
0.02	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
186.94	230.38	270.87	246.30	225.90	224.20	233.52	247.36
0.01	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
127.35	167.34	182.19	177.11	156.11	152.90	144.04	137.34
0.17	0.10	0.07	0.04	0.02	0.01	0.01	0.00
0.13	0.06	0.04	0.02	0.01	0.01	0.00	0.00

Table 5.5 (Continued)

Variable	Year	1973	1974	1975	1976	1977
USWHEAPF	Base	71.59	80.69	82.89	75.24	71.03
(mil. ace)	Change	0.02	0.04	0.07	0.02	-0.01
	% change	0.03	0.05	0.08	0.02	-0.02
WHPOD	Base	1721	1800	2291	2215	2043
(mil. bu.)	Change	0.00	0.59	1.14	1.76	0.51
	% change	0.00	0.03	0.05	0.08	0.02
WHFOU	Base	534.69	554.87	592.36	577.83	590.91
(mil. bu.)	Change	0.53	-0.03	-0.04	0.03	0.02
	% change	0.10	-0.01	-0.01	0.01	0.00
WHFEU	Base	-165.43	109.78	137.67	175.47	32.31
(mil. bu.)	Change	-5.69	-3.52	-5.03	4.41	2.92
	% change	3.44	-3.21	-3.65	2.51	9.04
WHSEU	Base	86.56	99.06	102.40	92.68	87.51
(mil. bu.)	Change	0.03	0.05	0.09	0.02	-0.02
	% change	0.04	0.05	0.09	0.03	-0.02
WHFRS1	Base	158.23	464.33	578.21	617.83	530.45
(mil. bu.)	Change	5.84	5.12	9.62	4.23	2.03
	% change	3.69	1.10	1.66	0.68	0.38
WHGVS1	Base	260.32	40.11	117.72	507.74	730.88
(mil. bu.)	Change	-5.02	-1.89	-0.83	1.11	0.61
	% change	-1.93	-4.72	-0.71	0.02	0.08
WHEST	Base	418.54	504.43	695.93	1125.57	1261.33
(mil. bu.)	Change	0.82	3.23	8.79	5.34	2.64
	% change	0.19	0.64	1.26	0.47	0.21

Table 5.5 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
70.72	80.76	83.31	78.15	74.05	78.44	81.24	77.43
-0.05	-0.02	0.00	0.01	0.01	-0.00	-0.00	-0.00
-0.07	-0.03	0.00	0.01	0.01	-0.00	-0.01	-0.00
1909	2117	2381	2624	2507	2345	2571	2607
-0.40	-1.41	-0.62	0.01	0.39	0.17	-0.04	-0.13
-0.02	-0.07	-0.03	0.00	0.01	0.01	-0.00	-0.01
597.17	595.89	598.82	610.37	621.72	635.94	656.34	672.77
0.01	-0.00	-0.00	-0.00	0.00	0.00	0.00	-0.00
0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	-0.00
299.65	314.32	139.72	75.05	-7.02	217.35	369.70	415.88
1.07	-0.34	-0.59	-0.24	0.15	0.24	0.10	-0.05
0.36	-0.11	-0.42	-0.31	-2.08	0.10	0.03	-0.01
87.52	101.27	105.08	98.66	93.64	99.89	104.03	99.40
-0.06	-0.03	0.00	0.01	0.01	-0.00	-0.01	-0.00
-0.07	-0.03	0.00	0.01	0.01	-0.00	-0.01	-0.00
391.86	374.65	268.39	296.71	299.94	302.84	235.50	136.52
1.20	0.85	0.47	0.23	0.07	0.02	0.03	0.05
0.31	0.23	0.17	0.08	0.02	0.01	0.01	0.03
761.95	545.78	818.40	837.39	1093.15	1086.92	1147.99	1636.41
-0.18	-0.86	-0.54	-0.08	0.18	0.16	0.00	-0.10
-0.02	-0.16	-0.07	-0.01	0.02	0.01	0.00	-0.01
1153.81	920.43	1086.79	1134.10	1393.09	1389.77	1383.45	1772.93
1.01	-0.02	-0.08	0.15	0.26	0.18	0.04	-0.04
0.09	-0.00	-0.01	0.01	0.02	0.01	0.00	-0.00

Table 5.5 (Continued)

Variable	Year	1973	1974	1975	1976	1977
WHFP	Base	4.13	4.05	3.50	2.79	2.40
(US $/mt)	Change	0.00	0.00	0.00	-0.00	-0.00
	% change	0.10	0.07	0.13	-0.15	-0.13
IR1	Base	6.51	8.10	6.74	4.84	4.69
(%)	Change	-0.38	0.00	0.00	0.00	0.00
	% change	-5.77	0.00	0.00	0.00	0.00
ERSDR	Base	1.24	1.26	1.21	1.18	1.17
(US $/SDR)	Change	0.04	0.02	0.01	0.01	0.00
	% change	3.29	1.73	0.89	0.54	0.29

Table 5.5 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
2.93	3.50	4.03	3.09	3.61	4.18	3.30	2.95
-0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00
-0.04	0.01	0.02	0.01	-0.01	-0.01	-0.00	0.00
8.35	9.93	11.60	13.05	10.85	8.98	9.78	7.67
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.24	1.26	1.23	1.14	1.10	1.10	0.98	1.11
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.15	0.08	0.04	0.02	0.01	0.01	0.00	0.00

Figure 5.7: Predicted versus actual values of aggregate world wheat import

Figure 5.8: Predicted versus actual values of U.S. wheat exports

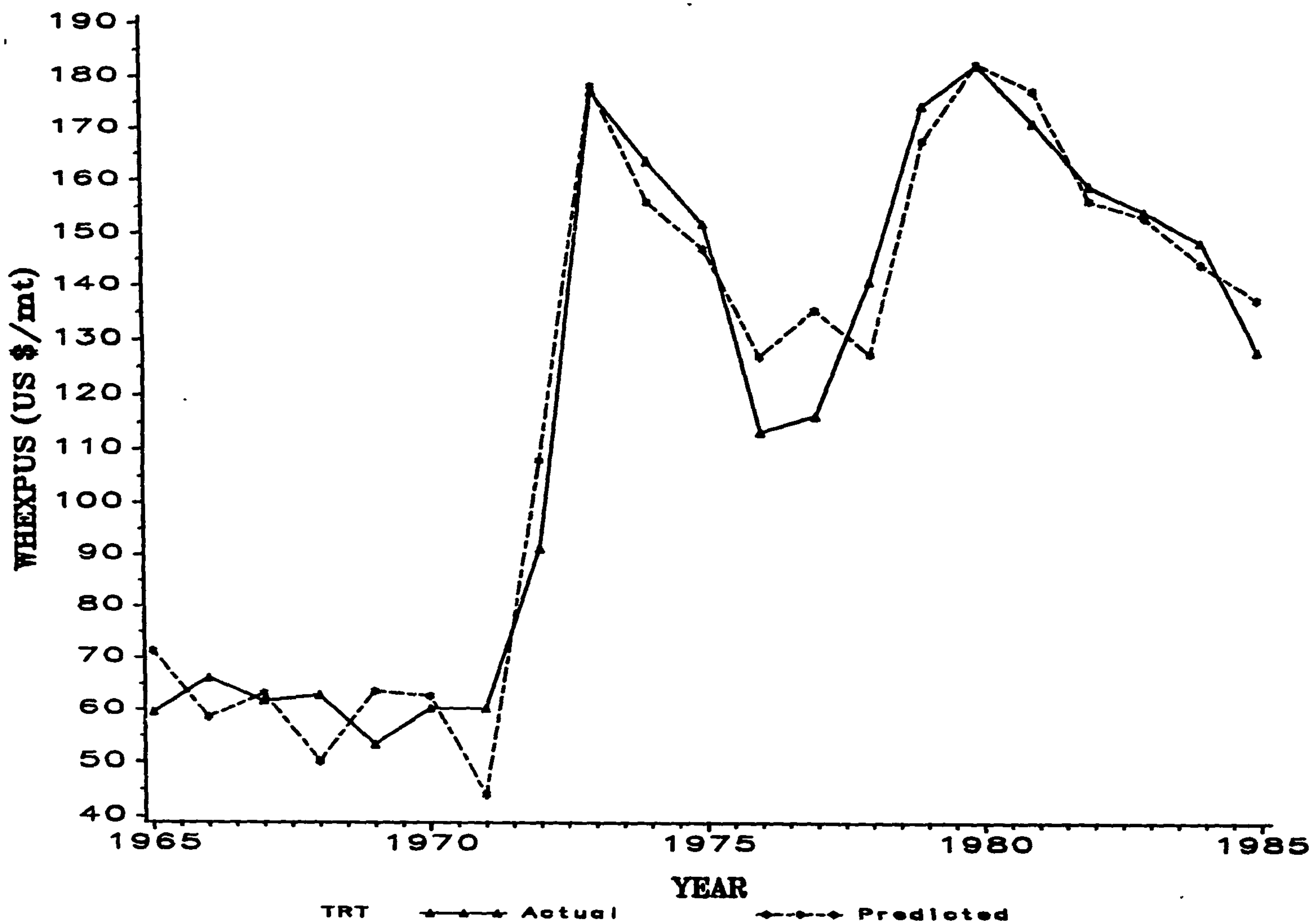


Figure 5.9: Predicted versus actual values of U.S. wheat export price

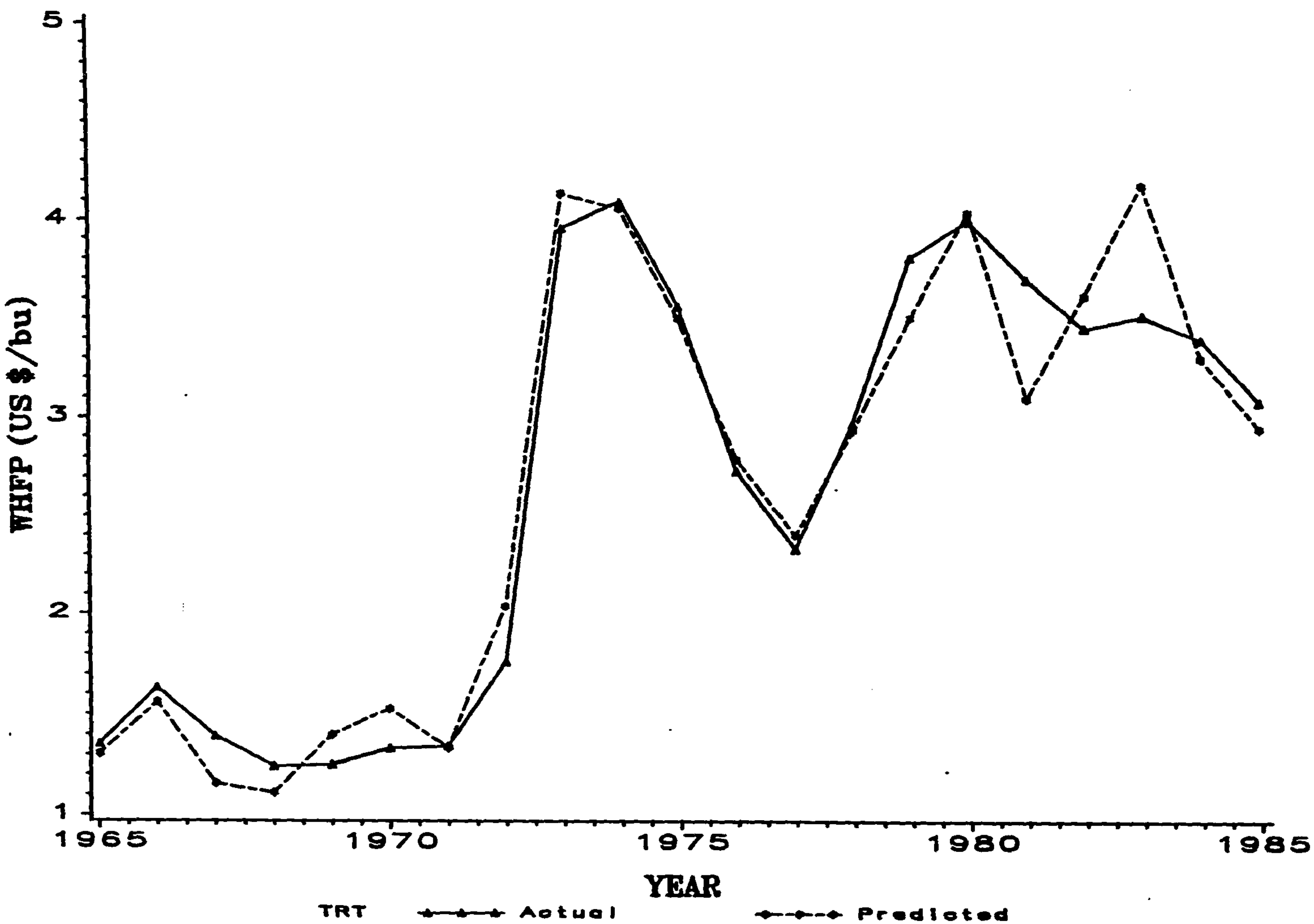


Figure 5.10: Predicted versus actual values of U.S. wheat farm price

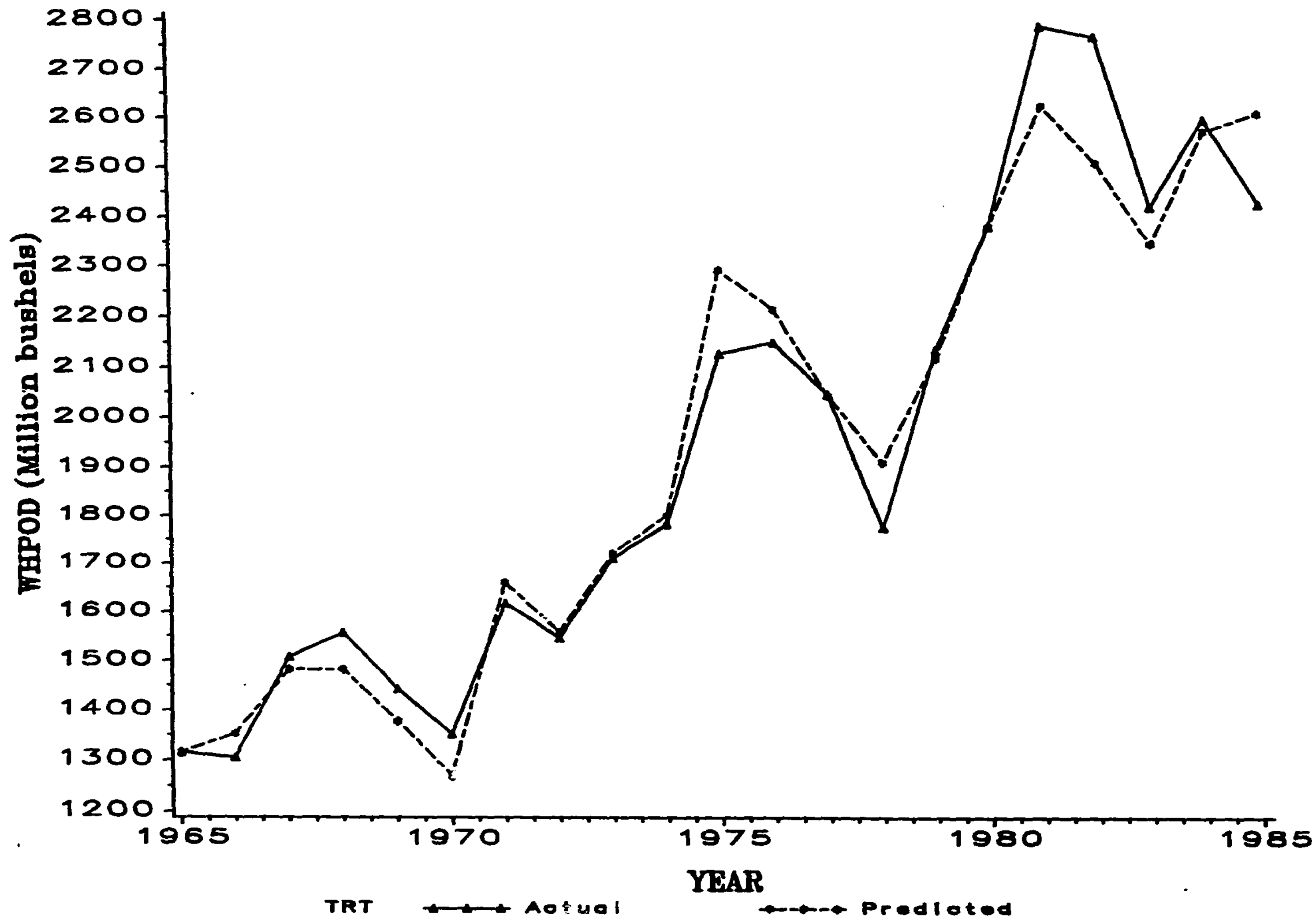


Figure 5.11: Predicted versus actual values of U.S. wheat production

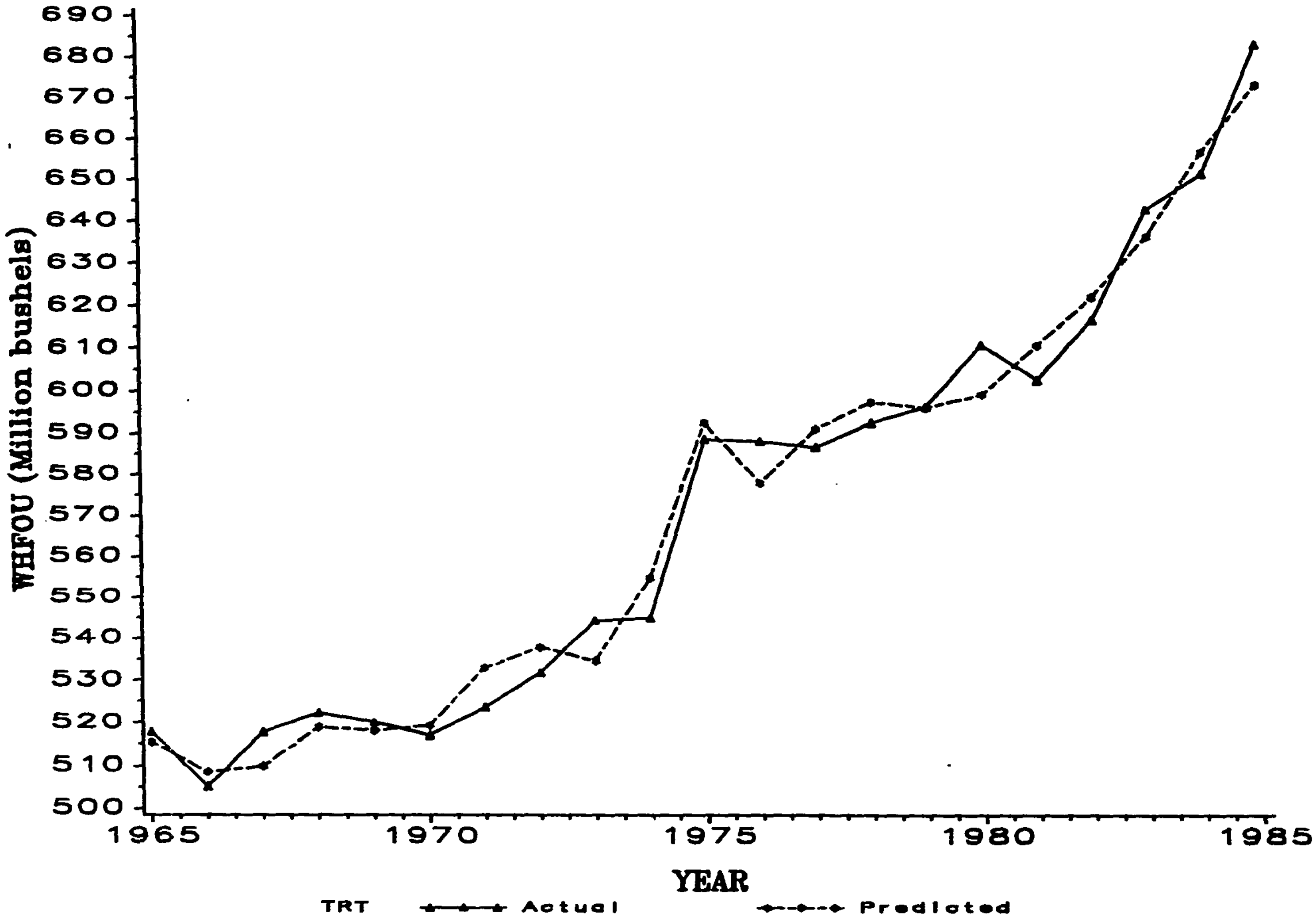


Figure 5.12: Predicted versus actual values of U.S. food use demand for wheat

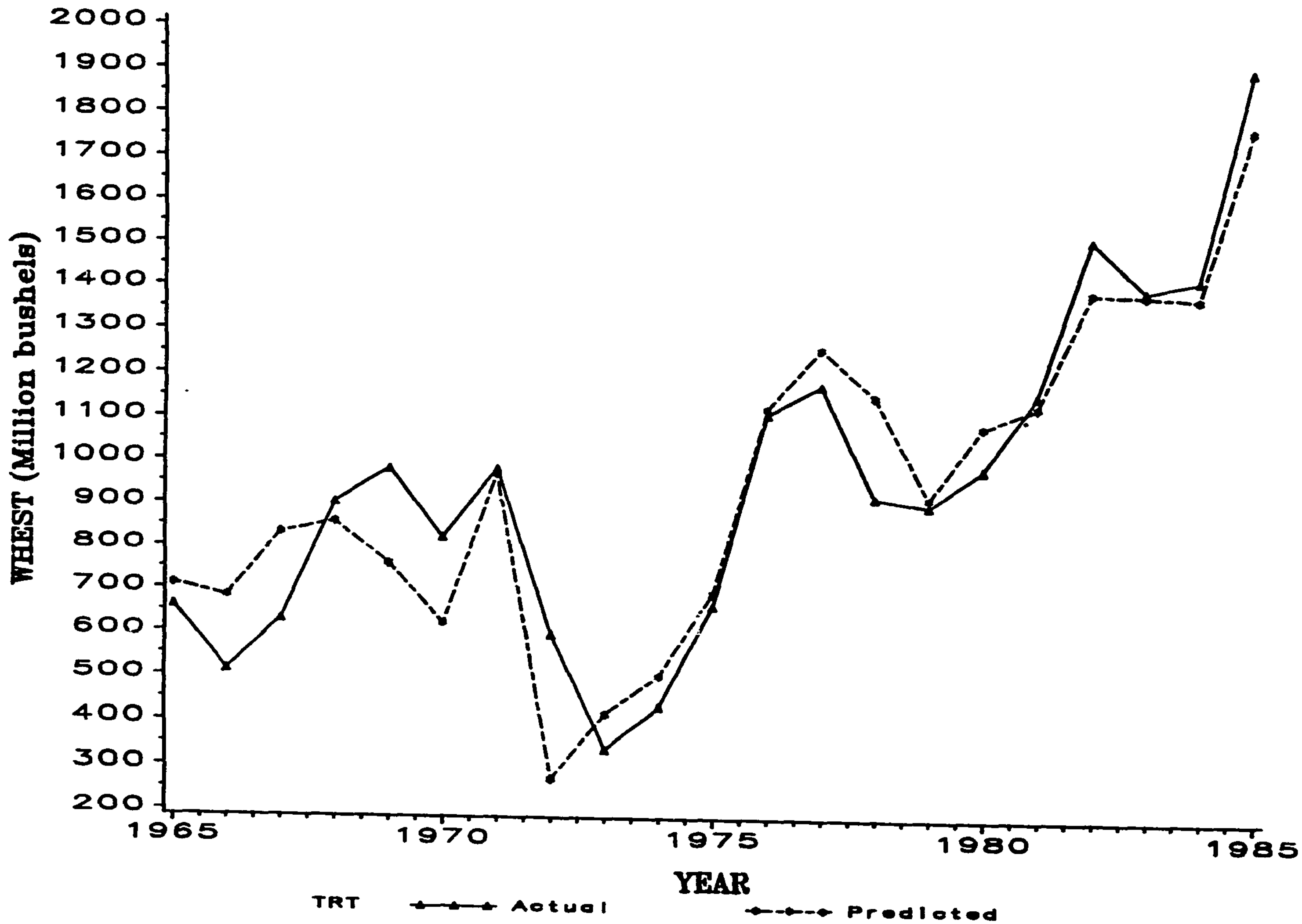


Figure 5.13: Predicted versus actual values of U.S. wheat ending stocks

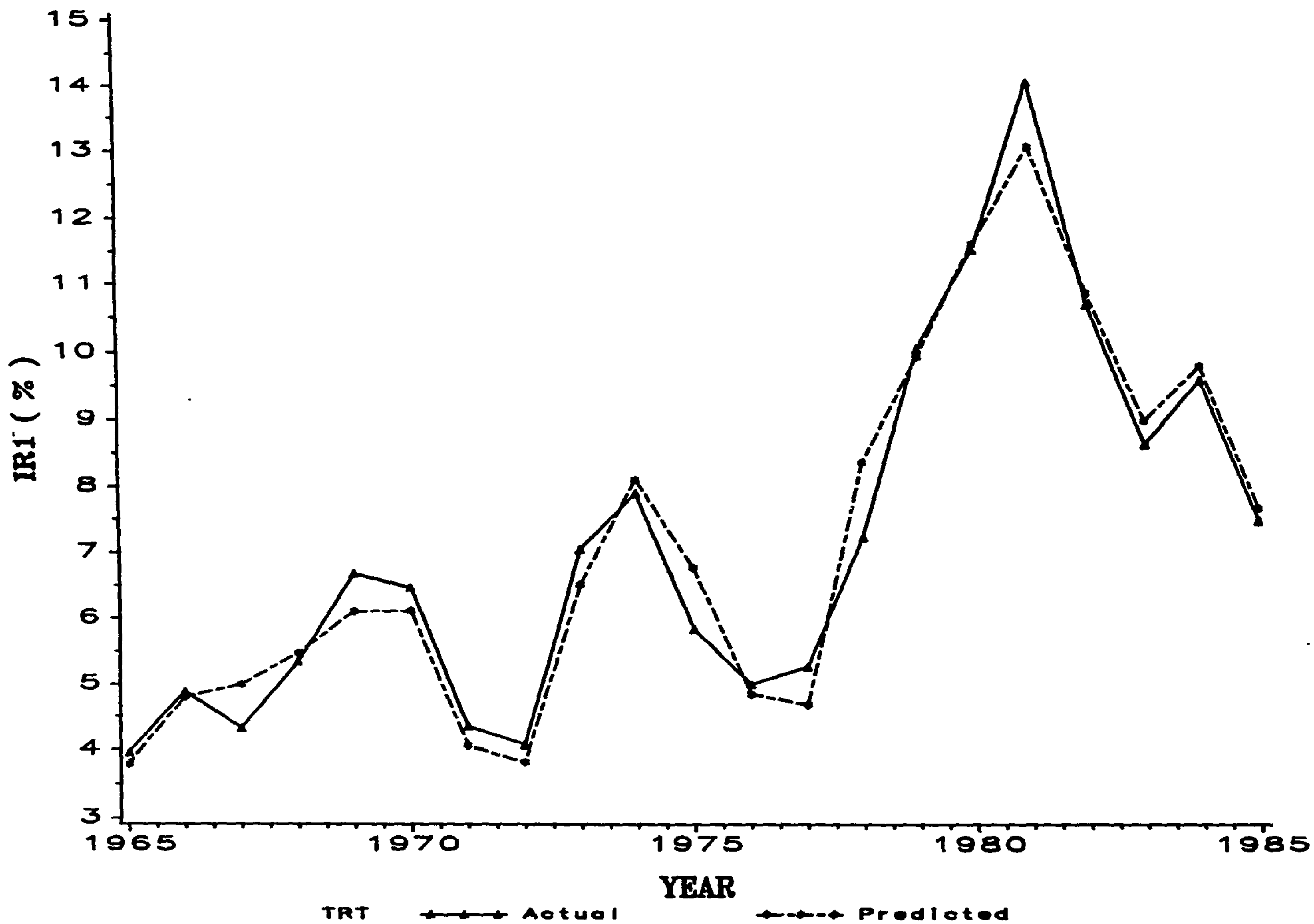


Figure 5.14: Predicted versus actual values of U.S. interest rate

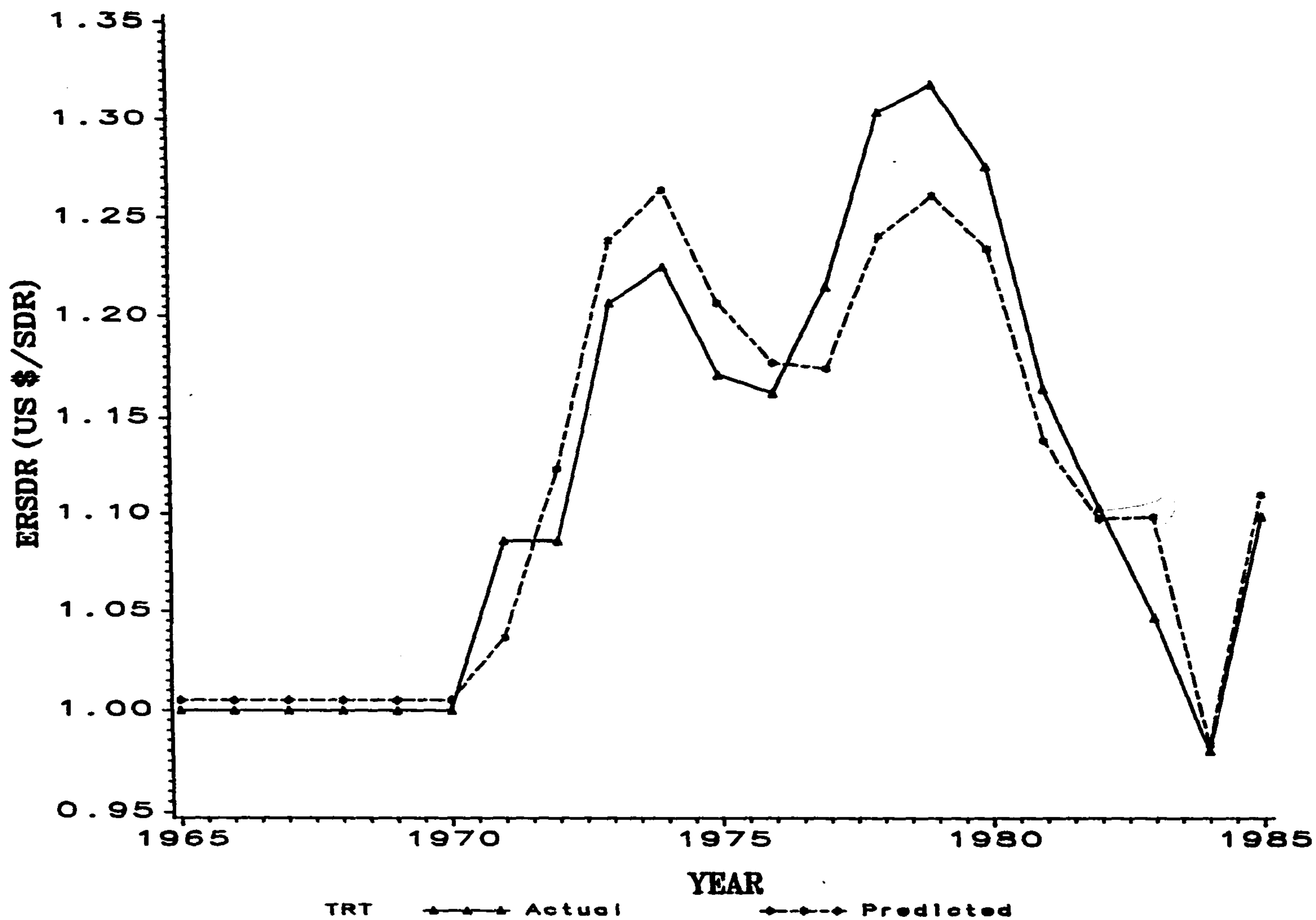


Figure 5.15: Predicted versus actual values of U.S. exchange rate

6 DYNAMIC ANALYSIS OF MONETARY POLICY IMPACTS

For the main objective of this study, to assessment of the impacts of monetary policy on U.S. wheat trade and domestic market, this chapter investigates the impacts of different monetary policies using dynamic simulation of the model developed in the preceding chapter.

Two monetary policy scenarios are analyzed for the period 1973 to 1985: first, an expansionary policy of a sustained increase in the money supply growth rate by 3 percent; and second, a contractionary policy of a sustained decrease in the growth rate, also by 3 percent. The period 1973 to 1985 was chosen because the monetary policy had no direct influence on the exchange rate determination under the fixed exchange rate regime prior to 1973. A sustained increase or decrease in money supply growth rate was assumed and undertaken because it did not seem reasonable that the monetary authority would alter money supply growth in only one year. Moreover, which year could be chosen for the money supply to grow is a question if only one year growth was assumed. The money supply level corresponding to the increase (decrease) in the growth rate, therefore, was incorporated into the model to analyze the impacts. By comparing the dynamic simulation results with and without the shock, it turns out the impacts of monetary policy on wheat trade and domestic market.

Note that because the money supply growth rate is sustainedly increased (decreased) every year since 1973, the consequent changes in the endogenous variables in any period include the dynamic effects of money supply changes of all previous periods. That is, the effects on endogenous variables from the dynamic simulation are compound effects. The later the year, the more the compound effects.

6.1 Impacts of Expansionary Monetary Policy

The theoretical immediate impacts of expansionary monetary policy, as described in Chapter 4 and graphically explained in Figure 4.4, are the U.S. dollar depreciation and lower domestic interest rate in the financial market. Then, through the external channel the exchange rate change would have impacts on foreign wheat import demands, and through the internal channel the lower interest rate would affect the domestic market (refer to Figure 2.2 for impact channels). The final net effects of the expansionary monetary policy would also include the interactions of world market and domestic market. These effects are compounded when the money supply increases are sustained.

Table 6.1 reports the dynamic simulation results of sustained money supply increases from 1973 to 1985 for 27 important endogenous variables. In the financial market, the value of exchange rate (US $/SDR) depreciated continuously from 3.29 % in 1973 to 16.90 % in 1985, while the interest rate (IR1) declined by -5.77 % in 1973 to -11.52 % in 1985. In the world market, changes in the exchange rate, however, had no impact on the total wheat import demand of the EC, Japan, India, and China as expected because these domestic markets were isolated. The total wheat import demand of the USSR (WHIMTSR) and ROW (WHIMTRW) had responses to the exchange rate changes. However, the final results indicated that changes in the USSR total import demand were various from year to year and small except in 1973 and 1974, and changes in the ROW total import demand were less responsive. The aggregate world wheat demand (WHIMTWL) increased by only 0.20 % in 1973 to 0.16 % in 1985. The small increases in world demand, therefore, resulted in Canada (the price leader) to raising its export price (WHEXP2CA) by only 0.08 % in 1973 to 0.07 % in 1985 in terms of Canadian currency. However, in terms of the U.S. dollar, the dollar depreciation raised the U.S. export price (WHEXPUS) from 2.90 % in 1973 to 16.17 % in 1985. Changes in two duopolists' relative price coupled with changes in the world import demand resulted in increases in U.S. wheat export (WHEXT2) to the duopoly world market. However, these increases in export were small, by 0.38 % in 1973 to 0.62 % in 1985.

In the domestic market, wheat production (WHPOD) had no change in 1973 as expected because wheat was planted in the last season and could not be changed. Production increased after 1974, but only by 0.03 % in 1974 to 0.22 % in 1985. For domestic demands, food use demand (WHFOU) increased by 0.10 % in 1973 to 0.19 % in 1985. Note that increases in food use demands were caused by the net effect of interest rate effect (to increase due to lower interest rates) and domestic price effect (to decrease due to higher prices). Also, since wheat products are staple food in consumption, food use demand was inelastic with respect to changes in both interest rate and price (the estimated elasticities are -0.02 and -0.04, respectively). Domestic feed use demand (WHFEU) appeared more sensitive to the price changes, and decreased over the simulation periods. Since wheat area planted increased (USWHEAPF), domestic seed use demand (WHSEU) also increased over time. For ending stocks, commercial stocks (WHFRS1) dramatically increased in response to the increasing export prices (so do to the increasing expected export prices) and the decreasing interest rates; whereas, government stocks (WHGVS1) were depleted over time. Total ending stocks (WHEST) increased from 0.19 % in 1973 to 3.08 % in 1985, which were mainly resulted from the increases in commercial ending stocks. Since the exchange rate effects caused only small increases in the foreign demand for U.S. wheat and the interest rate effects on the domestic demands were also small in aggregate, the domestic price (WHFP) increased by only 0.10 % in 1973 to 0.52 % in 1985.

6.2 Impacts of Contractionary Monetary Policy

In contrast to the expansionay monetary policy, impacts of a contractionary monetary policy were examined. The dynamic simulation results of this policy are reported in Table 6.2. All effects on the world market and domestic market are the same as the expansionary monetary policy but in an inverse direction.

In the financial market, decreases in money supply appreciated the U.S. dollar against SDR (ERSDR) from -3.29 % in 1973 to -16.91 % in 1985, and raised the domestic interest rate (IR1) from 5.77 % in 1973 to 11.52 % in 1985. Similarly, the monetary policy impacts were spread out via the exchange rate on the world market and via the interest rate on the domestic market. As a result, the U.S. wheat export price (WHEXPUS) declined from -2.89 % in 1973 to -16.19 % in 1985 and wheat export (WHEXT2) reduced from -0.39 % in 1973 to -0.82 % in 1985. The export prices were more responsive than the quantity exported. Changes in the exchange rate had no impact on total import demands of EC, Japan, India, and China.

Table 6.1: Dynamic impacts of a sustained increase in the U.S. money supply growth rate by 3 percent from 1973 to 1985

Variable	Year	1973	1974	1975	1976	1977
WHIMTEC	Base	6056	5360	6016	4711	5522
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1EC	Base	2766	2218	3373	1342	2215
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIMTJA	Base	5091	5214	5746	5781	5483
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1JA	Base	3067	2992	3347	3391	3073
(1000 mt)	Change	5.33	5.58	9.91	9.44	13.03
	% change	0.17	0.19	0.30	0.28	0.42
WHIMTIN	Base	2533	6773	5434	3027	573
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1IN	Base	678	4948	3803	1664	311
(1000 mt)	Change	14.31	15.62	26.50	24.99	33.49
	% change	2.11	0.32	0.70	1.50	10.76
WHIMTSR	Base	2494	1440	9807	6743	9027
(1000 mt)	Change	103.03	-29.35	-41.15	-4.26	-24.06
	% change	4.13	-2.04	-0.42	-0.06	-0.27
WHIM1SR	Base	1611	-689	4052	4362	5177
(1000 mt)	Change	78.35	-21.37	-29.41	-1.74	-16.08
	% change	4.86	3.10	-0.73	-0.04	-0.31

Table 6.1 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
4532	4871	4247	4377	3578	3693	1575	2798
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2206	2489	2140	2495	1494	1459	610	907
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5554	5626	6073	5776	5754	5774	5901	5543
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3136	3164	3666	3385	3370	3394	3493	3262
12.64	18.77	14.39	20.30	22.56	17.68	21.62	14.56
0.40	0.59	0.39	0.60	0.67	0.52	0.62	0.45
123	127	19	3830	4470	1690	668	235
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-10	-69	-147	2563	3900	1021	644	376
32.32	38.30	40.47	57.32	53.86	37.52	44.37	27.41
-311.89	-55.85	-27.45	2.24	1.38	3.68	6.89	7.28
3165	11029	12294	18606	19832	23185	27590	17213
16.88	-70.36	69.26	-76.35	4.41	48.14	-13.35	80.36
0.53	-0.64	0.56	-0.41	0.02	0.21	-0.05	0.47
2022	3595	1375	5553	2701	6485	5713	749
14.28	-50.07	53.90	-54.01	6.48	38.31	-7.61	61.54
0.71	-1.39	3.92	-0.97	0.24	0.59	-0.13	8.21

Table 6.1 (Continued)

Variable	Year	1973	1974	1975	1976	1977
WHIMTCH	Base	5782	4406	3653	2580	9126
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1CH	Base	2560	933	34	34	458
(1000 mt)	Change	3.54	3.33	0.00	0.00	9.33
	% change	0.14	0.36	0.00	0.00	2.04
WHIMTRW	BASE	39101	37556	39892	36390	44977
(1000 mt)	Change	21.73	31.46	68.52	75.53	117.90
	% change	0.06	0.08	0.17	0.21	0.26
WHIM1RW	Base	19853	15566	19945	14844	21394
(1000 mt)	Change	15.85	23.99	57.02	66.07	99.09
	% change	0.08	0.15	0.29	0.45	0.46
WHIMTWL	Base	61057	60748	70549	59232	74708
(1000 mt)	Change	124.76	2.12	27.37	71.27	93.84
	% change	0.20	0.00	0.04	0.12	0.13
WHEXT2	Base	30534	25969	34554	25637	32628
(1000 mt)	Change	117.36	27.15	64.02	98.76	138.86
	% change	0.38	0.10	0.19	0.39	0.43
WHEXP2CA	Base	205.34	187.48	172.34	150.89	174.90
(CA $/mt)	Change	0.16	0.00	0.04	0.09	0.12
	% change	0.08	0.00	0.02	0.06	0.07
WHEXPUS	Base	178.11	155.86	147.02	126.90	135.35
(US $/mt)	Change	5.16	7.18	8.20	8.56	9.82
	% change	2.90	4.61	5.58	6.74	7.26

Table 6.1 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
6287	8929	13467	14033	12625	9194	7766	7272
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1684	1393	7988	8450	4113	3487	3094	801
7.23	13.34	8.06	15.98	14.53	9.49	11.22	4.76
0.43	0.96	0.10	0.19	0.35	0.27	0.36	0.59
46072	55823	53518	56785	52436	53781	60235	52805
76.39	150.12	114.89	209.30	197.39	123.95	136.27	55.46
0.17	0.27	0.21	0.37	0.38	0.23	0.23	0.11
19115	25924	22353	26406	26538	22224	26084	22358
68.96	124.54	99.81	166.70	162.07	113.13	129.32	69.29
0.36	0.48	0.45	0.63	0.61	0.51	0.50	0.31
65733	86405	89618	103408	98695	97317	103735	85867
93.27	79.77	184.15	132.95	201.79	172.09	122.93	135.82
0.14	0.09	0.21	0.13	0.20	0.18	0.12	0.16
28153	36497	37374	48851	42117	38070	39638	28454
135.42	144.87	216.62	206.30	259.51	216.13	198.93	177.56
0.48	0.40	0.58	0.42	0.62	0.57	0.50	0.62
186.94	230.38	270.87	246.30	225.90	224.20	233.52	247.36
0.12	0.11	0.24	0.18	0.27	0.23	0.16	0.18
0.07	0.05	0.09	0.07	0.12	0.10	0.07	0.07
127.35	167.34	182.19	177.11	156.11	152.90	144.04	137.34
9.96	12.71	16.71	17.27	17.69	20.04	22.51	22.20
7.82	7.60	9.17	9.75	11.33	13.10	15.65	16.17

Table 6.1 (Continued)

Variable	Year	1973	1974	1975	1976	1977
USWHEAPF	Base	71.59	80.69	82.89	75.24	71.03
(mil. ace)	Change	0.02	0.06	0.11	0.12	0.10
	% change	0.03	0.08	0.14	0.16	0.14
WHPOD	Base	1721	1800	2291	2215	2043
(mil. bu.)	Change	0.00	0.59	1.82	3.06	3.34
	% change	0.00	0.03	0.08	0.14	0.16
WHFOU	Base	534.69	554.87	592.36	577.83	590.91
(mil. bu.)	Change	0.53	0.53	0.55	0.62	0.69
	% change	0.10	0.10	0.09	0.11	0.12
WHFEU	Base	-165.43	109.78	137.67	175.47	32.31
(mil. bu.)	Change	-5.69	-8.58	-9.93	-5.99	-3.51
	% change	3.44	-7.81	-7.21	-3.41	-10.87
WHSEU	Base	86.56	99.06	102.40	92.68	87.51
(mil. bu.)	Change	0.03	0.09	0.15	0.16	0.14
	% change	0.04	0.09	0.15	0.18	0.16
WHFRS1	Base	158.23	464.33	578.21	617.83	530.45
(mil. bu.)	Change	5.84	10.47	20.16	24.68	26.44
	% change	3.69	2.26	3.49	3.99	4.98
WHGVS1	Base	260.32	40.11	117.72	507.74	730.88
(mil. bu.)	Change	-5.02	-2.10	-3.08	-2.97	-3.81
	% change	-1.93	-5.24	-2.62	-0.58	-0.52
WHEST	Base	418.54	504.43	695.93	1125.57	1261.33
(mil. bu.)	Change	0.82	8.37	17.07	21.71	22.63
	% change	0.19	1.66	2.45	1.93	1.79

Table 6.1 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
70.72	80.76	83.31	78.15	74.05	78.44	81.24	77.43
0.09	0.08	0.10	0.18	0.26	0.27	0.18	0.16
0.12	0.10	0.12	0.23	0.35	0.34	0.22	0.21
1909	2117	2381	2624	2507	2345	2571	2607
2.75	2.62	2.39	3.21	5.87	8.31	8.76	5.80
0.14	0.12	0.10	0.12	0.23	0.35	0.34	0.22
597.13	595.89	598.82	610.37	621.72	635.94	656.34	672.77
0.74	0.80	0.85	0.84	0.93	1.09	1.17	1.27
0.12	0.13	0.14	0.14	0.15	0.17	0.18	0.19
299.65	314.32	139.72	75.05	-7.02	217.35	369.70	415.88
-5.66	-3.59	-5.15	-13.85	-12.24	-5.26	-3.41	-9.69
-1.89	-1.14	-3.69	-18.46	174.19	-2.42	-0.92	-2.33
87.52	101.27	105.08	98.66	93.64	99.89	104.03	99.40
0.12	0.11	0.14	0.24	0.35	0.35	0.24	0.21
0.13	0.11	0.13	0.25	0.37	0.35	0.23	0.21
391.86	374.65	268.39	296.71	299.94	302.84	235.50	136.52
29.78	29.80	31.63	41.94	49.21	48.37	50.39	60.71
7.60	7.95	11.79	14.13	16.41	15.97	21.40	44.47
761.95	545.78	818.40	837.39	1093.15	1086.92	1147.99	1636.41
-4.57	-4.62	-7.86	-9.77	-9.75	-4.73	-3.29	-6.13
-0.60	-0.85	-0.96	-1.17	-0.89	-0.43	-0.29	-0.37
1153.81	920.43	1086.79	1134.10	1393.09	1389.77	1383.45	1772.93
25.21	25.18	23.78	32.17	39.46	43.65	47.09	54.58
2.19	2.74	2.19	2.84	2.83	3.14	3.40	3.08

Table 6.1 (Continued)

Variable	Year	1973	1974	1975	1976	1977
WHFP	Base	4.13	4.05	3.50	2.79	2.40
(US $/mt)	Change	0.00	0.01	0.01	0.01	0.01
	% change	0.10	0.18	0.26	0.21	0.15
IR1	Base	6.51	8.10	6.74	4.84	4.69
(%)	Change	-0.38	-0.39	-0.41	-0.44	-0.47
	% change	-5.77	-4.84	-6.08	-9.06	-10.11
ERSDR	Base	1.24	1.26	1.21	1.18	1.17
(US $/SDR)	Change	0.04	0.06	0.08	0.09	0.10
	% change	3.29	5.10	6.57	7.66	8.51

Table 6.1 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
2.93	3.50	4.03	3.09	3.61	4.18	3.30	2.95
0.01	0.00	0.01	0.02	0.02	0.01	0.01	0.02
0.22	0.13	0.18	0.68	0.52	0.20	0.16	0.52
8.35	9.93	11.60	13.05	10.85	8.98	9.78	7.67
-0.51	-0.55	-0.58	-0.62	-0.68	-0.74	-0.79	-0.88
-6.15	-5.51	-5.04	-4.77	-6.24	-8.26	-8.04	-11.52
1.24	1.26	1.23	1.14	1.10	1.10	0.98	1.11
0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.19
8.82	9.37	10.29	11.93	13.34	14.50	17.38	16.90

Table 6.2: Dynamic impacts of a sustained decrease in the U.S. money supply growth rate by 3 percent from 1973 to 1985

Variable	Year	1973	1974	1975	1976	1977
WHIMTEC	Base	6056	5360	6016	4711	5522
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1EC	Base	2766	2218	3373	1342	2215
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIMTJA	Base	5091	5214	5746	5781	5483
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1JA	Base	3067	2992	3347	3391	3073
(1000 mt)	Change	-5.65	-6.01	-11.18	-10.82	-15.18
	% change	-0.18	-0.20	-0.33	-0.32	-0.49
WHIMTIN	Base	2533	6773	5434	3027	573
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1IN	Base	678	4948	3803	1664	311
(1000 mt)	Change	-15.11	-17.02	-29.73	-28.44	-38.71
	% change	-2.23	-0.34	-0.78	-1.71	-12.44
WHIMTSR	Base	2494	1440	9807	6743	9027
(1000 mt)	Change	-102.53	32.15	46.26	6.65	28.63
	% change	-4.11	2.23	0.47	0.10	0.32
WHIM1SR	Base	1611	-689	4052	4362	5177
(1000 mt)	Change	-78.02	23.40	33.04	3.30	19.16
	% change	-4.84	-3.40	0.82	0.08	0.37

Table 6.2 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
4532	4871	4247	4377	3578	3693	1575	2798
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2206	2489	2140	2495	1494	1459	610	907
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5554	5626	6073	5776	5754	5774	5901	5543
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3136	3164	3666	3385	3370	3394	3493	3262
-14.75	-22.03	-17.17	-24.98	-28.64	-22.92	-29.50	-19.66
-0.47	-0.70	-0.47	-0.74	-0.85	-0.68	-0.84	-0.60
123	127	19	3830	4470	1690	668	235
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-10	-69	-147	2563	3900	1021	644	376
-37.36	-44.18	-47.64	-69.68	-67.51	-47.85	-59.49	-36.18
360.57	64.42	32.32	-2.72	-1.73	-4.69	-9.24	-9.61
3165	11029	12294	18606	19832	23185	27590	17213
-18.69	83.39	-77.76	94.64	0.09	-55.33	24.74	-112.93
-0.59	0.76	-0.63	0.51	0.00	-0.24	0.09	-0.66
2022	3595	1375	5553	2701	6485	5713	749
-15.94	59.30	-60.69	66.85	-4.03	-44.39	15.19	-86.45
-0.79	1.65	-4.41	1.20	-0.15	-0.69	0.27	-11.54

Table 6.2 (Continued)

Variable	Year	1973	1974	1975	1976	1977
WHIMTCH	Base	5782	4406	3653	2580	9126
(1000 mt)	Change	0.00	0.00	0.00	0.00	0.00
	% change	0.00	0.00	0.00	0.00	0.00
WHIM1CH	Base	2560	933	34	34	458
(1000 mt)	Change	-3.78	-3.69	0.00	0.00	-11.02
	% change	-0.15	-0.04	0.00	0.00	-2.41
WHIMTRW	BASE	39101	37556	39892	36390	44977
(1000 mt)	Change	-23.40	-34.81	-77.97	-87.70	-138.96
	% change	-0.06	-0.09	-0.20	-0.24	-0.31
WHIM1RW	Base	19853	15566	19945	14844	21394
(1000 mt)	Change	-17.07	-26.39	-63.86	-74.84	-114.31
	% change	-0.09	-0.17	-0.32	-0.50	-0.53
WHIMTWL	Base	61057	60748	70549	59232	74708
(1000 mt)	Change	-125.93	-2.66	-31.71	-81.04	-110.33
	% change	-0.21	-0.00	-0.04	-0.14	-0.15
WHEXT2	Base	30534	25969	34554	25637	32628
(1000 mt)	Change	-5.15	-7.18	-8.20	-8.56	-9.83
	% change	-0.39	-0.11	-0.21	-0.43	-0.49
WHEXP2CA	Base	205.34	187.48	172.34	150.89	174.90
(CA $/mt)	Change	-0.17	-0.00	-0.04	-0.11	-0.15
	% change	-0.08	-0.00	-0.02	-0.07	-0.08
WHEXPUS	Base	178.11	155.86	147.02	126.90	135.35
(US $/mt)	Change	-5.15	-7.18	-8.20	-8.56	-9.83
	% change	-2.89	-4.61	-5.58	-6.75	-7.27

Table 6.2 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
6287	8929	13467	14033	12625	9194	7766	7272
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1684	1393	7988	8450	4113	3487	3094	801
-8.57	-16.05	-9.82	-20.22	-18.84	-12.55	-15.78	-6.50
-0.51	-1.15	-0.12	-0.24	-0.46	-0.36	-0.51	-0.81
46072	55823	53518	56785	52436	53781	60235	52805
-90.49	-180.42	-140.06	-264.22	-255.59	-164.05	-191.64	-75.38
-0.20	-0.32	-0.26	-0.47	-0.49	-0.31	-0.32	-0.14
19115	25924	22353	26406	26538	22224	26084	22358
-79.01	-146.47	-117.99	-206.49	-204.20	-141.98	-169.58	-83.72
-0.41	-0.56	-0.53	-0.78	-0.77	-0.64	-0.65	-0.37
65733	86405	89618	103408	98695	97317	103735	85867
-109.18	-97.02	-217.82	-169.58	-255.50	-219.39	-166.90	-188.32
-0.17	-0.11	-0.24	-0.16	-0.26	-0.23	-0.16	-0.22
28153	36497	37374	48851	42117	38070	39638	28454
-9.97	-12.73	-16.73	-17.30	-17.72	-20.06	-22.54	-22.24
-0.55	-0.46	-0.68	-0.52	-0.77	-0.71	-0.65	-0.82
186.94	230.38	270.87	246.30	225.90	224.20	233.52	247.36
-0.14	-0.13	-0.29	-0.22	-0.34	-0.29	-0.22	-0.25
-0.08	-0.06	-0.11	-0.09	-0.15	-0.13	-0.09	-0.10
127.35	167.34	182.19	177.11	156.11	152.90	144.04	137.34
-9.97	-12.73	-16.73	-17.30	-17.72	-20.06	-22.54	-22.24
-7.83	-7.61	-9.18	-9.77	-11.35	-13.12	-15.65	-16.19

Table 6.2 (Continued)

Variable	Year	1973	1974	1975	1976	1977
USWHEAPF	Base	71.59	80.69	82.89	75.24	71.03
(mil. ace)	Change	-0.02	-0.06	-0.12	-0.13	-0.11
	% change	-0.03	-0.08	-0.14	-0.17	-0.15
WHPOD	Base	1721	1800	2291	2215	2043
(mil. bu.)	Change	0.00	-0.59	-1.83	-3.09	-3.41
	% change	0.00	-0.03	-0.08	-0.14	-0.17
WHFOU	Base	534.69	554.87	592.36	577.83	590.91
(mil. bu.)	Change	-0.53	-0.53	-0.55	-0.62	-0.69
	% change	-0.10	-0.10	-0.09	-0.11	-0.12
WHFEU	Base	-165.43	109.78	137.67	175.47	32.31
(mil. bu.)	Change	5.71	8.64	10.07	6.29	3.98
	% change	-3.45	7.87	7.31	3.58	12.33
WHSEU	Base	86.56	99.06	102.40	92.68	87.51
(mil. bu.)	Change	-0.03	-0.09	-0.15	-0.17	-0.14
	% change	-0.04	-0.09	-0.15	-0.18	-0.16
WHFRS1	Base	158.23	464.33	578.21	617.83	530.45
(mil. bu.)	Change	-5.87	-10.50	-20.23	-24.82	-26.68
	% change	-3.71	-2.26	-3.50	-4.02	-5.03
WHGVS1	Base	260.32	40.11	117.72	507.74	730.88
(mil. bu.)	Change	5.11	2.21	3.38	3.44	4.62
	% change	1.96	5.50	2.87	0.68	0.63
WHEST	Base	418.54	504.43	695.93	1125.57	1261.33
(mil. bu.)	Change	-0.76	-8.29	-16.86	-21.38	-22.06
	% change	-0.18	-1.64	-2.42	-1.90	-1.75

Table 6.2 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
70.72	80.76	83.31	78.15	74.05	78.44	81.24	77.43
-0.10	-0.09	-0.12	-0.20	-0.29	-0.30	-0.22	-0.19
-0.14	-0.11	-0.14	-0.26	-0.39	-0.38	-0.27	-0.25
1909	2117	2381	2624	2507	2345	2571	2607
-2.89	-2.87	-2.71	-3.65	-6.47	-9.13	-9.86	-6.93
-0.15	-0.14	-0.11	-0.14	-0.26	-0.39	-0.38	-0.27
597.17	595.89	598.82	610.37	621.72	635.94	656.34	672.77
-0.73	-0.80	-0.84	-0.83	-0.92	-1.08	-1.16	-1.26
-0.12	-0.13	-0.14	-0.14	-0.15	-0.17	-0.18	-0.19
299.65	314.32	139.72	75.05	-7.02	217.35	369.70	415.88
6.30	4.18	5.87	14.88	13.61	6.77	4.57	10.77
2.10	1.33	4.20	19.83	-193.73	3.11	1.24	2.59
87.52	101.27	105.08	98.66	93.64	99.89	104.03	99.40
-0.13	-0.12	-0.15	-0.27	-0.38	-0.40	-0.29	-0.26
-0.15	-0.12	-0.15	-0.27	-0.41	-0.40	-0.28	-0.26
391.86	374.65	268.39	296.71	299.94	302.84	235.50	136.52
-30.03	-30.08	-32.04	-42.48	-49.93	-48.99	-51.00	-61.24
-7.66	-8.03	-11.94	-14.32	-16.65	-16.18	-21.66	-44.86
761.95	545.78	818.40	837.39	1093.15	1086.92	1147.99	1636.41
5.36	5.50	9.19	11.55	12.11	6.65	5.19	7.80
0.70	1.01	1.12	1.38	1.11	0.61	0.45	0.48
1153.81	920.43	1086.79	1134.10	1393.09	1389.77	1383.45	1772.93
-24.67	-24.58	-22.85	-30.93	-37.82	-42.34	-45.80	-53.44
-2.14	-2.67	-2.10	-2.73	-2.72	-3.05	-3.31	-3.01

Table 6.2 (Continued)

Variable	Year	1973	1974	1975	1976	1977
WHFP	Base	4.13	4.05	3.50	2.79	2.40
(US $/mt)	Change	-0.00	-0.01	-0.01	-0.00	-0.01
	% change	-0.10	-0.18	-0.26	-0.22	-0.17
IR1	Base	6.51	8.10	6.74	4.84	4.69
(%)	Change	0.38	0.39	0.41	0.44	0.47
	% change	5.77	4.84	6.08	9.06	10.11
ERSDR	Base	1.24	1.26	1.21	1.18	1.17
(US $/SDR)	Change	-0.04	-0.06	-0.08	-0.09	-0.10
	% change	-3.29	-5.10	-6.57	-7.66	-8.51

Table 6.2 (Continued)

1978	1979	1980	1981	1982	1983	1984	1985
2.93	3.50	4.03	3.09	3.61	4.18	3.30	2.95
-0.01	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	-0.02
-0.24	-0.15	-0.21	-0.73	-0.58	-0.26	-0.22	-0.57
8.35	9.93	11.60	13.05	10.85	8.98	9.78	7.67
0.51	0.55	0.58	0.62	0.68	0.74	0.79	0.88
6.15	5.51	5.04	4.77	6.24	8.26	8.04	11.52
1.24	1.26	1.23	1.14	1.10	1.10	0.98	1.11
-0.11	-0.12	-0.13	-0.14	-0.15	-0.16	-0.17	-0.19
-8.82	-9.37	-10.29	-11.93	-13.34	-14.50	-17.38	-16.91

In the domestic market, production (WHPOD) was unchanged in 1973 and decreased from 1974 to 1985. Food use demand (WHFOU) for wheat decreased over time because of the higher interest rates. The decreasing wheat area planted (USWHEAPF) due to lower farm prices resulted in decreases in the seed use demand (WHSEU) over time. However, feed use demand (WHFEU) increased in response to the lower domestic prices. The decreasing export price coupled with the higher interest rate depleted the commercial stock holdings (WHFRS1); whereas, the government stocks (WHGVS1) were stacked up because farmers tended to sell more wheat to government agents rather than to the depressed markets. The domestic price reflected the contractionary monetary policy and decreased by -0.10 % in 1973 to -0.57 % in 1985.

6.3 Analysis of Impacts of Monetary Policy

The impacts of monetary policy on U.S. wheat trade and domestic market, therefore, can be analyzed using above two dynamic simulation results. Table 6.3 reports the calculated exchange rate effects on U.S. wheat trade and interest rate effect on the domestic price in terms of the long-run average elasticity. For wheat trade, the average elasticity of export and export price are 0.05 and 0.88, respectively. Export price is more responsive than quantity; however, both are inelastic in response to exchange rate changes. Thus, in the duopoly world wheat market a 1 % U.S. dollar devaluation would result in 0.88 % increase in export price, but the increase of quantity exported is limited at 0.05 %.

The simulation results consist with the duopoly world market characteristics and the theoretical explanation of exchange rate effects. In Figure 4.4, the dollar

Table 6.3: Exchange rate effect on U.S. wheat exports and interest rate effect on domestic market

Year	exchange rate elasticity[a] export	exchange rate elasticity[a] export price	interest rate elasticity[a] domestic price
1973	0.12	0.88	-0.03
1974	0.02	0.90	-0.04
1975	0.03	0.85	-0.04
1976	0.05	0.88	-0.03
1977	0.05	0.85	-0.02
1978	0.05	0.89	-0.02
1979	0.04	0.81	-0.01
1980	0.06	0.89	-0.02
1981	0.04	0.82	-0.06
1982	0.05	0.85	-0.04
1983	0.04	0.90	-0.01
1984	0.03	0.90	-0.01
1985	0.04	0.96	-0.03
average	0.05	0.88	-0.03

[a]Calculated as the percentage change of variable in interest divided by percentage change of exchange rate (interest rate) from base value.

devaluation would rotate the demand schedule facing the United States upward and result in a rise in export price, but change in quantity exported is quite small dependent upon the relative price change of two duopolists in response to the dollar devaluation. This is exactly as the simulation results. The inelastic export price with respect to the dollar devaluation is because most major importing countries (e.g., the EC, Japan, India, and China) isolated their domestic market so that the rotation of the world demand schedule and hence the demand schedule facing the United States in percentage are less than the devaluation. In addition to the isolation of domestic markets in the major importing countries, the quite small change in quantity exported is also because both duopolists in pricing their wheat exports tend to maximize profit. Effect of devaluation, therefore, is offset by increase in export prices.

It is interesting to compare the exchange rate effects of those study with that obtained in previous studies within the competitive framework. A comparison of exchange rate elasticities for wheat is given below.

	export	export price
This study	0.05	0.88
Vellianities-Fidas (1976)	small (perhaps zero)	
Johnson et al. (1977)		0.69
Chambers and Just (1981)	1.48	0.79

For wheat export, Vellianitis-Fidas concluded that the long-run effect of exchange rate change on export is quite small and perhaps even zero. This is consistent with the simulated result of this study. Chambers and Just assumed the exchange rate as an exogenous variable to study the effects on U.S. wheat, corn, and soybean markets. The exchange rate elasticity of wheat export obtained is elastic, with elasticity 1.48. Since the exchange rate elasticity had been proved must lie in the interval (0, -1) if all goods are net gross substitutes and all income elasticities are positive, in their interpretation for the elastic wheat export they attributed the plausibility to the negative income effects on corn and soybean as obtained in their empirical estimation. However, this implies that corn and soybean are inferior goods, but it is hardly true.

The exchange rate elasticity of export price obtained in this study is close to two other results, all are inelastic. Johnson et al. simulated a 10 % devaluation of the U.S. dollar against all currency in 1973 and obtain a 6.9 % increase in U.S. wheat export price. This short-run elasticity is 0.19 lower than the 0.88 of this study. Chambers and Just's long-run elasticity 0.79 is closer to the elasticity of this study. The estimated elasticities in previous studies are lower because they assumed the export price is equal to the domestic price within the competitive framework. However, as shown in the simulation results in Tables 6.1 and 6.2, show the domestic price was less influenced by exchanges in exchange rate due to money supply changes. Thus, to assume the export price equal to domestic price would underestimate the exchange rate elasticity of export price. Since the market characteristics of domestic market and world market are different, the export price and domestic price should be separated, so is the exchange rate effect on these two prices.

Since the exchange rate elasticity of wheat exports is small, changes in domestic market due to the money supply changes principally result from the interest rate effects. Table 6.3 also reports the net effect of interest rate on the domestic price. The interest rate effect on food use demand and commercial ending stocks was not calculated because changes in domestic price also had backward impact on food use demand and the commercial ending stocks were also influenced by the export price changes. The approximate net interest rate effect on domestic price is quite small. Such less responsive domestic price is because (1) the final wheat products are staple food in consumption so that foods use demand for wheat would not change dramatically even though the interest rate effect is significant, and (2) the government stocks stabilize the domestic price fluctuation. The function of government stocks in price stabilization can be seen from the dynamic simulation results in Table 6.1 and Table 6.2. For example, when domestic prices decrease, farmers tend to sell wheat to government at loan rate. The government stocks, therefore, increase and prevent a further decrease in domestic price.

Turning to the dynamic effects of monetary policy on wheat trade and domestic market, Table 6.4 reports impacts and long-run elasticities with respect to money supply increases for the key variables. As analyzed earlier, the expansionary monetary policy will depreciate the U.S. dollar and lower the domestic interest rate, with long-run elasticities 4.80 and -2.33, respectively. The eventual effects on wheat export price, domestic feed use, and commercial stocks are elastic, with elasticities of 4.12, -1.15, and 6.37, respectively. As expected, wheat export is less responsive to the monetary policy. Domestic disappearance decreases in response to increase in money supply. The decrease in disappearance mainly results from the decrease in feed use demand, which is elastic in response to rise in domestic price. Total ending stock has almost unitary elasticity in response to the money supply change. Increase in total ending stock is mainly from increase in the commercial stocks which overwhelms the decrease in government stocks. Since the increase in total ending stock is more than the decrease in domestic disappearance, the aggregate domestic demand increases. Domestic production also increases, but less than the increase in aggregate domestic demand. Consequently, domestic price is pulled up, but is inelastic (0.85) with respect to money supply change.

Chambers and Just (1982) included only the exchange rate channel in analyzing the effect of money supply changes on wheat, corn, and soybean markets. They estimated the long-run elasticities, with respect to money supply, of wheat export, price, domestic disappearance, and inventories at 2.03, 1.76, -0.02, and -0.18, respectively. Similarly, the elasticity of export was overestimated because in their result soybean is implied an inferior good with negative income effect. Their elasticity of export price (1.76) is between the elasticities of export price (4.12) and domestic price (0.85) of this study. As mentioned earlier, this is because they assume the domestic price and export price are equal within the competitive framework, so that the elasticity of export price tends to be underestimated and elasticity of domestic price is overestimated. Elasticity of ending stock (-0.18) is very close to the elasticity of government stock (-0.20) of this study. They did not estimate the commercialending stock, so that the commodity speculation was not incorporated into their model. The elasticity of domestic disappearance (-0.21) of this study is higher than the elasticity (-0.02) they obtained. This is because in estimating the demand for wheat they ignored (1) prices of the final wheat product, (2) interest rate effects, and (3) cross-price effects.

Chambers and Just (1982) argued that U.S. monetary policy has dramatic

Table 6.4: Dynamic effect of a sustained increase in the money supply growth rate by 3 percent

Variable	Average impacts[a] of money supply increase	Long-run[b] elasticity
Exchange rate (US $/SDR)	0.16	4.80
Domestic interest rate (%)	-0.72	-2.33
Export (1000 mt)	212.51	0.18
Export price (US $/mt)	19.40	4.12
Domestic price (US $/bu.)	0.09	0.85
Domestic production (mil. bu.)	5.72	0.07
Domestic disappearance (mil. bu.)	-6.98	-0.24
Food use (mil. bu.)	1.03	0.05
Feed use (mil. bu.)	-8.27	-1.15
Seed use (mil. bu.)	0.26	0.09
Total ending stocks (mil. bu.)	40.12	0.96
Free stocks (mil. bu.)	47.04	6.37
Government stocks (mil. bu.)	-6.92	-0.20

[a]Calculated as average changes of simulated values from the base values. The period 1980-85 is considered for the purpose of long-run analysis.

[b]Calculated as the percentage change from mean (1980 to 1985) divided by percentage change (3 percent) of the money supply.

effects on U.S. exports and prices. They estimated the long-run elasticity of wheat export and export price with respect to money supply at 2.03 and 1.76, respectively. The wheat export is more elastic than export price. However, within the competitive framework as they used, dramatic effect on export price requires a price-inelastic export (excess) supply schedule. Therefore, even the exchange rate can be treated as a separate regressor to affect the export as they did and a dollar devaluation can shift the demand schedule facing the United States outward to result in an increase in export and rise in export price, the percentage change in export price should be larger than the percentage change in export (see Chapter 2). Then, with respect to a specific money supply growth rate the export price should be more elastic than the quantity exported, not the inverse case as they obtained. Moreover, since most major wheat importing countries isolated their domestic markets by domestic and trade policies as discussed earlier, the outward shift of the demand schedule facing the United States due to the dollar devaluation is limited as evidenced by this study and other studies reviewed in Chapter 2. Change in export, therefore, is hardly to be expected elastic or more elastic than the export price. Not only the competitive framework misspecified the world wheat market but also the unreasonable results let their empirical conclusions questionable.

From the dynamic simulation results and above analysis, several findings were obtained about the impacts of monetary policy on U.S. wheat trade and domestic market.

First, the monetary policy in the financial market does significantly influence the exchange rate and interest rate determination. An expansionary (contractionary) monetary policy would depreciate (appreciate) the value of the U.S. dollar and lower (raise) the domestic interest rate. These two rates, therefore, spread the impacts of monetary policy on U.S. wheat trade and domestic market.

Second, in the duopoly world wheat market, changes in the value of the U.S. dollar due to U.S. monetary policy change have significant effect on U.S. wheat export price. Since the domestic market in most major importing countries are isolated, changes in the U.S. export price in percentage is less than changes in the exchange rate. However, with respect to the money supply change the U.S. export price does positively and significantly change and is very elastic. For quantity exported, since the exchange rate elasticity of export is very small, the effect of monetary policy is insignificant. To increase U.S. wheat exports, accordingly, should depend upon other factors, not the monetary policy (refer to Figure 4.5).

Third, in the U.S. domestic wheat market, the interest rate has significant effect on food use demand and commercial ending stocks. Since wheat products are staple foods in consumption, change in food use demand due to monetary policy is very small even through the interest rate effect is significant. In addition to the interest rate effect, the commercial ending stock is also influenced by the export (current and expected) price, which is significant in response to changes in the exchange rate. Thus, the holding of commercial stocks with speculative motivation does very elastically respond to the monetary policy. Feed use demand for wheat originated from the livestock sector appears more sensitive to wheat price rather the interest rate. The monetary policy, therefore, has no direct impact on feed use demand for wheat. In aggregate, an expansionary monetary policy tends to decrease the domestic disappearance and increase the total ending stocks. The net effect on aggregate domestic demand for wheat (disappearance plus total ending stocks) is positive, but inelastic.

Fourth, because of the government program, domestic wheat production does not directly respond to the monetary policy. Also, the property of wheat production of that wheat was planted in the last season in the time horizon would restrict production in response to the current year monetary policy. Government programs and the expected price received by farmers, therefore, dominate the planting decision, hence production. Wheat production appears very inelastic with respect to monetary policy. Under the competitive domestic market framework, the expansionary monetary policy eventually results in an increase in aggregate domestic demand which, is more than an increase in production, so the domestic price is pulled up but less elastic.

7 SUMMARY AND CONCLUSIONS

7.1 Summary of the Study

The two main objectives of this study are to develop a new U.S. wheat model that consists of wheat trade in the imperfect competition world market and competitive domestic market, and to measure the impacts of monetary policy on wheat trade and domestic market. A model was theoretically constructed and empirical studies were performed to estimate the theoretical model and to measure the monetary policy impacts. Both the theoretical development and empirical study for these two objectives are highly successful.

The theoretical U.S. wheat model was constructed in Chapters 3 and 4. The duopoly market characteristic was adopted from previous studies and was judged suitable for the world wheat market. World import demand facing the United States and U.S. export pricing decision, therefore, were solved by the Stackelberg determinate equilibrium solution. In the solution, Canadian wheat and U.S. wheat were assumed differentiated, Canada was taken as the price leader in the world market, and both duopolists tended to maximize profit (revenue) from wheat exports. The exchange rate variable was incorporated into the model via the international price linkage, whereas the law of one price (LOP) was not assumed. Incorporation of the duopoly characteristic for trade made this model different from the conventional competitive framework.

Structure of the competitive U.S. domestic market was similar to the conventional model, including wheat production, domestic disappearance, and ending stocks. However, each structural equation of the conventional model was respecified to be theoretical embodied, or extended to be more realistic and avoid the left-out explanatory variables. In the more important ones, all government programs in different time segments were captured to specify wheat area planting decision, the interest rate effects were accounted for to determine demand for wheat and commercial ending stocks, government ending stock was endogenized to present its function in price stabilization, and commercial ending stocks was endogenized and incorporated into the model to reflect the commodity speculation behavior. In addition, the separability of the utility function was assumed and thereby the two-stage budgeting procedure was performed to provide the theoretical basis for demand for final wheat products. Furthermore, the derived demand for primary wheat was obtained by the profit-maximization behavior of producers of final wheat products.

The complete U.S. wheat model, therefore, was constructed by combining the imperfect competition trade and competitive domestic market structural equation together. This model bears some important features that are the weakness of the conventional competitive model. First, it contains the world market and domestic market with different market characteristics in a model. Second, the different determination processes of export price and domestic price associated with the different market characteristics are explicitly presented, and thus these two prices are not necessarily equivalent. Third, a very important feature in structure for the purpose of assessing the impacts of monetary policy, the financial market originated variables exchange rate and interest rate are pertinently and distinctly embodied in the model. This model and its features provide a theoretical foundation for a precise measurement of impacts of monetary policy.

For the second main objective of assessing the impacts of monetary policy on U.S. wheat trade and domestic market, the U.S. wheat model was connected with the financial market via the linkages of exchange rate and interest rate determination. These two rates were endogenized in this study and the portfolio equilibrium model was employed as the theoretical basis to simultaneously determine these two rates. Therefore, U.S. monetary policy, in terms of money supply, can influence the determination of exchange rate and interest rate, and thereby has impact on wheat trade and domestic market. Such impacts, as well as the impacts of external shock, were theoretically evaluated.

The theoretical model was empirically estimated using annual data for the 1965 - 85 period. The estimation technique utilized to derive the structural coefficients was nonlinear, three-stage least squares (3SLS) with principal components as instrument variables. Foreign import demand in empirical estimation was extended to include six regions: the EC, Japan, India, USSR, China, and the rest of the world (ROW). Each region contained total import demand and import demand for U.S. wheat. Domestic and trade policies in each region were specified to present their influence on import demand. The final estimated model contained 36 equations, including 21 estimated equations and 15 identities. Almost all estimated coefficient were highly significant and had correct signs as theoretical expectations. The validation and stability of the estimated model were examined through the entire estimation period. All statistics indicated that this model performed satisfactorily.

This model, therefore, was utilized to empirically analyze the impacts of monetary policy on U.S. wheat trade and domestic market for the period 1973 to 1985 using the approach of dynamic simulation and thereafter the dynamic multiplier analysis.

7.2 Conclusions

The empirical estimation of the U.S. wheat model and findings from the dynamic simulation for effects of U.S. monetary policy on wheat trade and domestic market can be summarized as follows.

1. The U.S. wheat model developed in this study consists of imperfect competition trade and competitive domestic market, and then presents two different determination processes for export price and domestic price. The highly successful estimation and model examinations provide evidence for the theoretical development. Although the evidence is not fully conclusive, the estimation results indicate that the U.S. wheat industry do face two almost equally important markets which have different market characteristics. Because none of producers and demanders has market power, the domestic price is determined by market equilibrium. However, by taking Canadian export price as a reference price and making adjustment with world demand and freight rates, the United States in the world market can price exports to make profit.

2. The wheat model was connected with the financial market via the linkages of exchange rate and interest rate determination. These two rates were theoretically embodied in the structural equations as the impact channels of monetary policy. The highly significant estimated coefficients and the dynamic simula-

tion results indicated that these two rates are very important to the U.S. wheat sector and such linkages are pertinent. Furthermore, the exchange rate and interest rate were endogenized and estimated using the portfolio equilibrium approach. The excellent estimation results on the determination equations of these two rates lend support to this approach.

3. The simulation analysis indicated that in the duopoly world market the effects of monetary policy through the exchange rate channel on trade are dramatically significant on export price, but on quantity exported are quite small. The real world evidence that most major wheat importing countries isolated their domestic markets supports this conclusion. The dramatic effect on export price implies that the two major exporting countries, the United States and Canada, in pricing wheat exports tend to maximize profit, then to compensate export price for, e.g., the dollar devaluation. However, the simulation results also showed that the U.S. export price is not fully compensated for the dollar devaluation, that is, the export price with respect to exchange rate is inelastic.

4. Effects of monetary policy on the domestic market are principally through the interest rate channel on domestic food use demand and commercial ending stocks. In addition, the exchange rate effects on trade spill over to the domestic market by (1) change in export, hence change in supply to domestic market and in government ending stocks, and (2) change in export price, hence change in commercial ending stocks. The commercial ending stocks dramatically respond to the monetary policy. However, since final wheat products

are staple foods in consumption and the function of government stocks for price stabilization, change in the aggregate domestic demand (disappearance plus ending stocks) in response to monetary policy is small. Change in supply available for the domestic market is also small because of the insignificant effect of monetary policy on export. Thus, as determined by domestic market equilibrium, the eventual effect of monetary policy on domestic price is inelastic, with elasticity of 0.85.

5. In terms of change in prices, the dramatic increase in export price and the relative smaller rise in domestic price due to a money supply increase imply that the domestic market is more stable than trade in response to monetary policy. Since the U.S. wheat sector is heavily dependent on exports, an expansionary monetary policy would tend to have a positive impact on the sector.

7.3 Implications and Suggestions for Further Research

As mentioned in Chapter 3, the standard trade theory is conventionally based on the competitive framework. There is no general trade model of imperfect competition. In the recent development, more studies are concerned about trade in the presence of imperfect competition because many international markets do not appear to follow the competitive market characteristics, for instance the wheat trade. The duopoly wheat trade model developed by this study, therefore, provides a good example in the new development and model construction.

Moreover, U.S. wheat is sold about half to the domestic market and half to the foreign market. These two markets are almost equally important, but bear different market characteristics. The associated price determination, therefore, is different. The complete U.S. wheat model developed in this study fully captures these differences in market characteristics and price determination and also the interaction of domestic and foreign markets. Any study on a particular commodity market like wheat, therefore, should be able to present and capture those difference in consideration for model building, and should not be based on the competitive framework.

The exchange rate and interest rate variables were endogenized and estimated in this study using the portfolio equilibrium approach. There are only a few empirical studies, not so explicit and complete as this study, that have been done to evidence this approach so far. The excellent estimation results on the reduced form determination equations of these two rates lend support to this approach. Therefore, whenever both of these two rates have to be endogenized in a model and have to be related with the monetary policy to evaluate policy impacts, the portfolio equilibrium approach provides a good theoretical basis and the estimation results of this study can be a guide for empirical study. Furthermore, if the data used for empirical estimation includes both fixed and flexible exchange rate regimes, the techniques of this study can be applied in estimating these two rates.

This study concerns only the impacts of U.S. monetary policy on U.S. wheat trade and domestic market. However, the model developed can also be utilized for analyses of impacts of other policies or external shocks. For example, U.S. agricultural programs in setting target price, loan rate, and set-aside diversion payment, any importing country's trade and domestic policies, bad harvest due to bad weather, and so on.

Finally, the structural model of this study can be easily extended to become a nonspatial world trade model with imperfect competition. For such purpose, a detailed domestic market for each country should be constructed like the U.S. domestic market in this study. Import demand can be formulated by following the definition of excess demand of domestic market. Wheat trade in the duopoly world market is similar to the model of this study with Canada as the world price leader. Other exporting countries can be taken as the duopolists' price followers. In comparing to the competitive nonspatial model, such a model with imperfect competition should be more realistic in modeling the world wheat trade and policy analysis.

8 BIBLIOGRAPHY

Alaouze, C. M., A. S. Watson, and N. H. Sturgess. 1978. "Oligopoly Pricing in the World Wheat Market." *American Journal of Agricultural Economics* 60: 173–85.

Alaouze, C. M., A. S. Watson, and N. H. Sturgess. 1979. "Oligopoly Pricing in the World Wheat Market: Reply." *American Journal of Agricultural Economics* 61: 578–80.

Armington, Paul S. 1969. "Theory of Demand for Products Distinguished by Place of Production." *International Monetary Fund Staff Papers* 16: 159–78.

Barnett, Richard C. 1980. "The Relation between Domestic and International Liquidity and Nominal Agricultural Price – A Time–Series Analysis." M.S. Thesis. Purdue University.

Barnett, Richard C., D. A. Bessler, and R. L. Thompson. 1983. "The Money Supply and Nominal Agricultural Prices." *American Journal of Agricultural Economics* 65(2): 303–7.

Batten, D. S., and M. T. Belongia. 1984. "The Recent Decline in Agricultural Exports: Is the Exchange Rate the Culprit?" *Review*, Federal Reserve Bank of St. Louis 66(8): 5–14.

Batten, D. S., and M. T. Belongia. 1986. "Monetary Policy, Real Exchange Rates, and U.S. Agricultural Exports." *American Journal of Agricultural Economics* 66(2): 422–27.

Batten, D. S., and C. B. Luttrell. 1982. "Does Tight Monetary Policy Hurt U.S. Exports?" *Review*, Federal Reserve Bank of St. Louis 64(7): 24–27.

Bjarnson, H. F., M. J. McGarry, and A. Schmitz. 1969. "Converting Price Series of Internationally Traded Commodities to a Common Currency Prior to

Estimating National Supply and Demand Equations." *American Journal of Agricultural Economics* 51: 189–97.

Blackorby, C., D. Primont, and R. R. Russell. 1970. "Homothetic Separability and Consumer Budgeting." *Econometrica* 38: 468–72.

Blackorby, C., D. Primont, and R. R. Russell. 1978. *Duality, Separability and Functional Structure: Theory and Economic Applications*. New York: American Elsevier.

Branson, W. H., H. Halttunen, and P. Masson. 1977. "Exchange Rates in the Short Run." *European Economic Review* 10: 303-24.

Bredahl, M. E., W. H. Meyers, and K. J. Collins. 1979. "The Elasticity of Foreign Demand for U.S. Agricultural Products: The Importance of the Price Transmission Elasticity." *American Journal of Agricultural Economics* 61: 58–63.

Carter, Colin, and A. Schmitz. 1979. "Import Tariffs and Price Formation in the World Wheat Market." *American Journal of Agricultural Economics* 61: 517–22.

Carter, Colin, and A. Schmitz. 1980. "Import Tariffs and Price Formation in the World Wheat Market: Reply." *American Journal of Agricultural Economics* 62: 823–25.

Chambers, Robert G. 1981. "Interrelationships between Monetary Instruments and Agricultural Commodity Trade." *American Journal of Agricultural Economics* 63: 934–41.

Chambers, Robert G. 1983. "Discussion: Impact of Federal Fiscal–Monetary Policy on Farm Structure." *Southern Journal of Agricultural Economics* 15: 69–71.

Chambers, Robert G. 1984. "Agricultural and Financial Market Interdependence in the Short Run." *American Journal of Agricultural Economics* 66: 12–24.

Chambers, Robert G., and R. E. Just. 1979. "A Critique of Exchange Rate Treatment in Agricultural Trade Models." *American Journal of Agricultural Economics* 61: 249–57.

Chambers, Robert G., and R. E. Just. 1980. "A Critique of Exchange Rate Treatment in Agricultural Trade Models: Reply." *American Journal of Agricultural Economics* 62: 255–59.

Chambers, Robert G., and R. E. Just. 1981. "Effects of Exchange Rate Changes on U.S. Agriculture: A Dynamic Analysis." *American Journal of Agricultural Economics* 63: 32–46.

Chambers, Robert G., and R. E. Just. 1982. "An Investigation of the Effect of Monetary Factors on Agriculture." *Journal of Monetary Economics* 9: 235–47.

Chambers, Robert G., and R. E. Just. 1986. "A Critique of Exchange Rate Treatment on Agricultural Trade Model: Reply." *American Journal of Agricultural Economics* 68: 994–97.

Clark, Peter B. 1974. "The Effects of Recent Exchange Rate Changes on the U.S. Trade Balance." In P. B. Clark et al., eds. *The Effects of Exchange Rate Adjustments.* Proceedings of a conference sponsored by OASIA Research, U.S. Department of Treasury, Washington, D.C.

Collins, K. J., W. H. Meyers, and M. E. Bredahl. 1980. "Multiple Exchange Rate Changes and U.S. Agricultural Commodity Prices." *American Journal of Agricultural Economics* 62: 656–65.

de Gorter, H., and K. D. Meilke. 1987. "The EEC's Wheat Price Policies and International Trade in Differentiated Products." *American Journal of Agricultural Economics* 69: 223–29.

de Janvry, A., J. Bieri, and A. Nuez. 1972. "Estimation of Demand Parameters under Consumer Budgeting: An Application to Argentina." *American Journal of Agricultural Economics* 54(3): 422–30.

Denbaly, Massoud S. M. 1984. "U.S. Monetary Policy and the Exchange Rate: Effects on the World Coarse Grain Market." Ph.D. Dissertation. Iowa State University, Ames, Iowa.

Devadoss, S. 1985. "The Impacts of Monetary Policies on U.S. Agriculture." Ph.D. Dissertation. Iowa State University, Ames, Iowa.

Devadoss, S., and W. H. Meyers. 1986. "Monetary Policies, Interest Rates, and

U.S. Agriculture: An Economic Simulation Analysis." Working Paper 86–WP5. CARD, Iowa State University, Ames, Iowa.

Devadoss, S., W. H. Meyers, and S. R. Johnson. 1986. "Exchange Rates, Trade Deficits, and U.S. Prices." Paper presented at AAEA Annual Meeting, Reno, Nevada. Also Working Paper 86–WP10. CARD, Iowa State University, Ames, Iowa.

Devadoss, S., M. Helmar, and W. H. Meyers. 1987a. "FAPRI Trade Model for the Wheat Sector: Specification, Estimation, and Validation." Staff Report 86–SR3, Revision 2. CARD, Iowa State University, Ames, Iowa.

Devadoss, S., W. H. Meyers, and D. R. Starleaf. 1987b. "The Macrolinkages between the Nonfarm and Farm Sectors and the Impact of Monetary Policy Decisions." Monograph 87–M1. CARD, Iowa State University, Ames, Iowa.

Dohner, Robert S. 1984. "Export Pricing, Flexible Exchanges, and Divergence in the Prices of Traded Goods." *Journal of International Economics* 16: 79–101.

Dornbusch, Rudiger. 1980. "Exchange Rate Economics: Where Do We Stand?" *Brookings Papers on Economic Activity* No. 1: 143–85.

Dunn, Robert M., Jr. 1970. "Flexible Exchange Rates and Oligopoly Pricing: A Study of Canadian Markets." *Journal of Political Economy* 78: 140–51.

Enders, W., and H. Lapan. 1987. *International Economics: Theory and Policy.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Fletcher, S. M., R. E. Just, and A. Schmitz. 1982. "The Impact of Exchange Rates and Other Factors on North American Wheat Export Demand." In Gorden C. Rausser, eds. *World Food Crisis: Issues and Policy Alternatives.* Amsterdam: North–Holland Publishing Co.

Frankel, Feffery A. 1979. "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials." *American Economic Review* 69(4): 610–22.

Frankel, Feffery A. 1984. "Commodity Prices and Money: Lessons from International Finance." *American Journal of Agricultural Economics* 66(5): 560–66.

Frenkel, Jacob A. 1976. "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence." *Scandinavian Journal of Economics* 78(2): 200–24.

Frenkel, Jacob A. 1980. "Exchange Rates, Prices, and Money: Lessons from the 1920s." *American Economic Review* 70: 235–42.

Frenkel, Jacob A. 1981a. "The Collapse of Purchasing Power Parities during the 1970s." *European Economic Review* 16: 145–65.

Frenkel, Jacob A. 1981b. "Flexible Exchange Rate, Prices, and the Role of the News: Lessons from the 1970s." *Journal of Political Economy* 89(1): 665–705.

Frenkel, Jacob A. 1984. "Tests of Monetary and Portfolio Balance Models of Exchange Rate Determination." In J. F. O. Bilson and R. C. Marston, eds. *Exchange Rate Theory and Practice.* Chicago: National Bureau of Economic Research, The University of Chicago Press.

Frenkel, Jacob A., and R. M. Levich. 1975. "Covered Interest Arbitrage: Unexploited Profit?" *Journal of Political Economy* 83(2): 325–38.

Frenkel, Jacob A., and M. L. Mussa. 1980. "The Efficiency of Foreign Exchange Markets and Measures of Turbulence." *American Economic Review* 70: 374–81.

Friedman, Milton. 1976. *Price Theory.* Second edition. Chicago: Aldine Publishing Co.

Fuller, Wayne A. 1976. *Introduction to Statistical Time Series.* New York: John Wiley & Sons.

Gallagher, P., L. Michael, M. Bredahl, and T. J. Ryan. 1981. *The U.S. Wheat Economy in an International Setting: An Econometric Investigation.* U.S. Department of Agriculture, Economics and Statistics Service, Technical Bulletin No. 1644.

Gardner, B. L. 1975. "The Farm–retail Price Spread in a Competitive Food Industry." *American Journal of Agricultural Economics* 57(3): 399–409.

Garst, G. D., and T. A. Miller. 1975. "Impact of the Set–Aside Program on U.S. Wheat Acreages." *Agricultural Economic Research* 27(2): 30–37.

Gilmour, B., and P. Fawcett. 1986. "A Relationship between American and Canadian Wheat Prices." Working Paper 9/86. Commodity Market Analysis Division, Marketing and Economics Branch, Agriculture Canada.

Gorman, W. M. 1959. "Separable Utility and Aggregation." *Econometrica* 27(3): 469–81.

Government of Japan. Various issues. *Japan Economic Yearbook.* Japan.

Grennes, Tomas. 1975. "The Exchange Rate and U.S. Agriculture: Comment." *American Journal of Agricultural Economics* 57: 134–35.

Grennes, Tomas, and P. R. Johnson. 1979. "Oligopoly Pricing in the World Wheat Market: Comment." *American Journal of Agricultural Economics* 61: 574–77.

Grennes, Tomas, and P. R. Johnson. 1980. "Import Tariffs and Price Formation in the World Wheat Market: Comment." *American Journal of Agricultural Economics* 62: 819–21.

Grennes, Tomas, P. R. Johnson, and M. Thursby. 1978a. "Insulating Trade Policies, Inventories, and Wheat Price Stability." *American Journal of Agricultural Economics* 60(1): 132–34.

Grennes, Tomas, P. R. Johnson, and M. Thursby. 1978b. "Some Evidence on the Nebulous Law of One Price." Paper presented at the annual meeting of the Southern Economics Association, Washington, D.C.

Grennes, Tomas, P. R. Johnson, and M. Thursby. 1980. "A Critique of Exchange Rate Treatment in Agricultural Trade Models: Comments." *American Journal of Agricultural Economics* 62: 249–52.

Heid, Walter G., Jr. 1979. *U.S. Wheat Industry.* U.S. Department of Agriculture, Economics, Statistics, and Cooperative Services, Agricultural Economic Report No. 432.

Helpman, E., and P. R. Krugman. 1986. *Market Structure and Foreign Trade.* Cambridge, MA: The MIT Press.

Henderson, J. M., and R. E. Quandt. 1980. *Microeconomic Theory: A Mathematical Approach,* Third edition. New York: McGraw–Hill Book Co.

Hicks, John R. 1974. *The Critics in Keynesian Economics.* Oxford: Basil Blackwell.

International Monetary Fund. Various issues. *International Financial Statistics.* Washington, D.C.

International wheat Council. Various issues. *World Wheat Statistics.* London.

Isard, P. 1977. "How Far Can We Push the Law of One Price?" *American Economic Review* 67: 942–48.

Jabara, C. L., and N. E. Schwartz. 1987. "Flexible Exchange Rates and Commodity Price Changes: The Case of Japan." *American Journal of Agricultural Economics* 69: 580–590.

Johnson, D. G. 1984. "Domestic Agricultural Policy in an International Environment: Effects of Other Countries' Policies on the United States." *American Journal of Agricultural Economics* 66(5): 735–44.

Johnson, Paul R. 1977. "The Elasticity of Foreign Demand for U.S. Agricultural Products." *American Journal of Agricultural Economics* 59(3): 735–36.

Johnson, Paul R., T. Grennes, and M. Thursby. 1977. "Devaluation, Foreign Trade Controls, and Domestic Wheat Prices."*American Journal of Agricultural Economics* 59(4): 619–27.

Johnson, Paul R., T. Grennes, and M. Thursby. 1979. "Trade Models with Differentiated Products." *American Journal of Agricultural Economics* 61(1): 120–27.

Johnson, Stanley R., Z. A. Hassan, and R. D. Green. 1984. *Demand Systems Estimation: Methods and Applications.* Ames, Iowa: Iowa State University Press.

Johnston, J. 1984. *Econometric Methods.* Third Edition. New York: McGraw–Hill Book Co.

Judge, G. G., R. C. Hill, W. Griffiths, H. Lutkepohl, and T. C. Lee. 1982. *Introduction to the Theory and Practice of Econometrics.* New York: John Wiley & Sons.

Kolstad, C. D., and A. E. Burris. 1986. "Imperfectly Competitive Equilibria in International Commodity Markets." *American Journal of Agricultural Economics* 68(1): 27–36.

Konandreas, P., P. Bushnell, and R. Green. 1978. "Estimation of Export Demand Functions for U.S. Wheat." *Western Journal of Agricultural Economics* 3: 39–49.

Kost, William. 1976. "Effects of an Exchange Rate Change on Agricultural Trade." *Agricultural Economic Research* 28(3): 99–106.

Kouri, Pentti J. K. 1976. "The Exchange Rate and Balance of Payments in the Short Run and in the Long Run: A Monetary Approach." *Scandinavian Journal of Economics* 2: 280–304.

Kouri, Pentti J. K. 1980. " Monetary Policy, the Balance of Payments, and the Exchange Rate." In D. Bigman and T. Taya, eds. *The Functioning of Floating Exchange Rates: Theory, Evidence and Policy Implications.* Cambridge, MA: Ballinger.

Kreinin, Mordecai. 1977. "The Effect of Exchange Rate Change on Prices and Volume of Foreign Trade." *International Monetary Fund Staff Papers* 24: 297–329.

Krishna, R., and A. Chhibber. 1983. *Policy Modeling of a Dual Grain Market: The Case of Wheat in India.* Washington, D.C.: International Food Policy Research Institute.

Krueger, Anne O. 1983. *Exchange-Rate Determination.* New York: Cambridge University Press.

Langley, James A. 1983. "Regional Acreage Response Functions for Major field Crops: Estimation and Policy Implication." Ph.D. Dissertation. Iowa State University, Ames, Iowa.

Lau, L. J., and P. A. Yotopoulos. 1972. "Profit, Supply, and Factor Demand Functions." *American Journal of Agricultural Economics* 54: 11–18.

Lidman, R., and D. L. Bawden. 1974. "The Impact of Government Programs on Wheat Acreage." *Land Economics* 50(4): 327–35.

Liu, Zong-Shin, S. Devadoss, and W. H. Meyers. 1986. "Incorporation of Fixed-Flexible Exchange Rates in Econometric Trade Models: A Grafted Polynomial Approach." Paper presented at AAEA Annual Meeting, Reno, Nevada. Also Working Paper 86-WP6. CARD, Iowa State University, Ames, Iowa.

Longmire, Jim, and A. Morey. 1983. *Strong Dollar Dampens Demand for U.S. Farm Exports*. U.S. Department of Agriculture, Econ. Res. Serv., Agric. Econ. Report No. 193.

Mahama, R. 1985. "A Stochastic Simulation of the Impact of Price Insulation Policies on World Wheat Market Stability." Ph.D. Dissertation. Iowa State University, Ames, Iowa.

McCalla, A. F. 1966. "A Duopoly Model of World Wheat Pricing." *Journal of Farm Economics* 48: 711–27.

McCalla, A. F. 1970. "Wheat and the Price Mechanism: Or Duopoly Revisited and Abandoned." Paper presented at Seminar on Wheat, University of Manitoba, Winnipeg.

Mendulson, C. 1957. "Approaches to International Trade under Nonprice Competition." *Journal of Farm Economics* 39: 1724–31.

Meyers, W. H. 1979. "Exchange Rates in International Commodity Models: The Common Currency Question." *Agricultural Economic Research* 31: 40–43.

Ministry of Agriculture, Forestry, and Fisheries. Various issues. *Abstract of Statistics on Agriculture, Forestry, and Fisheries*. Government of Japan. Japan.

Morzuch, B. J., R. D. Weaver, and P. G. Helmberger. 1980. "Wheat Acreage Supply Response under Changing Farm Programs." *American Journal of Agricultural Economics* 62: 29–37.

Mustard, A. P., and S. C. Schmidt. 1983. "Short-Term Impact of the 1980–81 Partial U.S. Grain Embargo on Grain Trade." *North Central Journal of Agricultural Economics* 5(2): 111–21.

Okun, Arthur. 1975. "Inflation: Its Mechanics and Welfare Costs." *Brookings Papers on Economic Activity* No. 2: 351–90.

Orcutt, Guy H. 1950. "Measurement of Price Elasticities in International Trade." *Review of Economics and Statistics* 32: 117–32.

Pindyck, R. S., and D. L. Rubinfeld. 1981. *Econometric Models and Economic Forecasts*. New York: McGraw-Hill Book Company.

Reed, M. R. 1980. "A Critique of Exchange Rate Treatment on Agricultural Trade Models: Comment." *American Journal of Agricultural Economics* 62(2): 253–54.

Richardson, J. D. 1978. "Some Empirical Evidence on the Law of One Price." *Journal of International Economics* 8(2): 341–51.

Runge, C. F., and H. von Witzke. 1987. "Institutional Change in the Common Agricultural Policy of the European Community." *American Journal of Agricultural Economics* 69(2): 213–22.

Sampson, G. P., and R. H. Snape. 1980. "Effects of EEC's Variable Import Levies." *Journal of Political Economy* 88(5): 1026–1040.

Sarris, A. H., and J. Freebairn. 1983. "Endogenous Price Policies and International Wheat Prices." *American Journal of Agricultural Economics* 65(2): 214–24.

Sarris, A. H., and A. Schmitz. 1981. "Toward a U.S. Agricultural Export Policy for the 1980s." *American Journal of Agricultural Economics* 63(5): 832–39.

SAS Institute Inc. 1984. 738 pp. *SAS/ETS User's Guide, Version 5 Edition*. Cary, NC: SAS Institute Inc.

Schuh, G. E. 1974. "The Exchange Rate and U.S. Agriculture." *American Journal of Agricultural Economics* 56(1): 1–13.

Schuh, G. E. 1975a. "The Exchange Rate and U.S. Agriculture: Reply." *American Journal of Agricultural Economics* 57: 136–37.

Schuh, G. E. 1975b. "The Exchange Rate and U.S. Agriculture: Reply." *American Journal of Agricultural Economics* 57: 696–700.

Schuh, G. E. 1981. "The Foreign Trade Linkages." In *Modeling Agriculture for Policy Analysis in the 1980s*. Report of a Symposium sponsored by the

Federal Reserve Bank of Kansas City, Sept. 24–25.

Schuh, G. E. 1983. "U.S. Agricultural Policy in an Open World Economy." Testimony presented before the Joint Economic Committee of the U.S. Congress, Washington, D.C.

Schuh, G. E. 1984. "Future Directions for Food and Agricultural Trade Policy." *American Journal of Agricultural Economics* 66(2): 242–47.

Schuh, G. E., C. Hodge, and D. Orden. 1980. "Monetary Aspects of International Agricultural Trade." Presented at meeting of Research Consortium on Agricultural Trade, Tucson, Arizona.

Schwartz, N. E. 1986. "The Consequences of a Floating Exchange Rate for the U.S. Wheat Market." *American Journal of Agricultural Economics* 68(2): 428–33.

Shei, Shun-Yi. 1978. "The Exchange Rate and United States Agricultural Product Markets: A General Equilibrium Approach." Ph.D. Dissertation. Purdue University, West Lafayette, Indiana.

Silberberg, E. 1978. *The Structure of Economics – A Mathematical Analysis.* New York: McGraw–Hill Book Co.

Sorenson, V. L., and G. E. Rossmiller. 1983. "Future Options for U.S. Agricultural Trade Policy." *American Journal of Agricultural Economics* 65(5): 893–900.

Spitze, R. G. F. 1983. "The Agriculture and Food Act of 1981: Continued Policy Evolution." *North Central Journal of Agricultural Economics* 5(2): 65–75.

Spriggs, J. 1978. *An Econometric Analysis of Export Supply of Grains in Australia.* U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, FAER No. 150.

Spriggs, J. 1981. *An Econometric Analysis of Canadian Grains and Oilseeds.* U.S. Department of Agriculture, Econ. Res. Serv., Technical Bulletin No. 1662.

Spriggs, J., M. Kaylen, and D. Bessler. 1982. "The Lead–Lag Relationship between Canada and U.S. Wheat Prices." *American Journal of Agricultural Economics* 64(3): 569–72.

Starleaf, Dennis R. 1982. "Macroeconomic Policies and Their Impact upon the Farm Sector." *American Journal of Agricultural Economics* 64(5): 854–60.

Starleaf, Dennis R., W. H. Meyers, and A. Womack. 1985. "The Impact of Inflation on the Real Income of U.S. Farmers." *American Journal of Agricultural Economics* 67(2): 384–89.

Taplin, John H. E. 1969. "Demand in the World Wheat Market and the Export Policies of the United States, Canada, and Australia." Ph.D. Dissertation. Cornell University.

Thompson, R. L. 1981. "A Survey of Recent U.S. Developments in International Agricultural Trade Models." U.S. Department of Agriculture, Econ. Res. Serv., Biblio. and Lit. of Agriculture No. 21.

Tweeten, Luther. 1977. "The Elasticity of Foreign Demand for U.S. Agricultural Products: Comment." *American Journal of Agricultural Economics* 59(3): 737–38.

Tweeten, Luther. 1980. "An Economic Investigation of Inflation Pass–through to the Farm Sector." *Western Journal of Agricultural Economics* 5: 89–106.

Tweeten, Luther. 1983. "Impact of Federal Fiscal–Monetary Policy on Farm Structure." *Southern Journal of Agricultural Economics* 15(1): 61–68.

United Nations. Various issues. *Monthly Bulletin of Statistics.* New York, N.Y.: United Nations.

United States Department of Agriculture. Various issues. *Agricultural Statistics.* Washington, D.C.

United States Department of Agriculture. 1987. *Agricultural Statistics of People's Republic of China.* USDA, ERS. Stat. Bulletin No. 764.

United States Department of Agriculture. Sept. 1988. *Supply and Use Typing Data.* Agricultural Stabilization and Conservation Service. Washington, D.C.

United States Department of Agriculture. Various issues. *Wheat Situation and Outlook.* USDA, ERS. Washington, D.C.

United States Government Printing Office. 1987. *Economic Report of the*

President. Washington, D.C.

Vellianitis-Fidas, A. 1975. "The Exchange Rate and U.S. Agriculture: Comment." *American Journal of Agricultural Economics* 57: 691–95.

Vellianitis-Fidas, A. 1976. "The Impact of Devaluation on U.S. Agricultural Exports." *Agricultural Economic Research* 28(3): 107–16.

Winter, J. R., and J. K. Whittaker. 1979. "Estimation of Wheat Acreage Response Functions for the Northwest." *Western Journal of Agricultural Economics* 4(2): 83–87.

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