LONG-RUN INCOME GROWTH AND WORLD GRAIN DEMAND:

AN ECONOMETRIC ANALYSIS

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William Henry Meyers

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TABLE OF CONTENTS

CHAPTER		PAGE
1	INTRODUCTION	1
	1.1 Statement of the Problem	1
	1.2 Historical Setting of the Problem	3
	1.3 Organization of the Thesis	8
2	METHODOLOGY	9
	2.1 Division of Research by Commodity	9
	2.2 Demand Projection Techniques	10
	2.3 Overview of the Analytical Approach	13
3	COARSE GRAIN DEMAND EQUATIONS AND PRICE LINKAGES	19
	3.1 Theoretical Basis for Estimation Model	19
	3.2 Specification and Empirical Results for Blocks 1 and 2	24
	3.3 Specification and Empirical Results for the USSR	49
	3.4 Specification and Empirical Results for Price Linkages	54
4	COARSE GRAIN PROJECTION MODEL	64
	4.1 Quantity Components and Quantity Equilibrium	64
	4.2 Price Linkages and Price Equilibrium	70
	4.3 Projection Assumptions	78
	4.4 Historical Performance of the Model	86
	4.5 Coarse Grain Demand and Price Projections	102
5	WHEAT PROJECTION MODEL	117
	5.1 Components of the Wheat Model	117
	5.2 Projection Assumptions	119
	5.3 Wheat Demand and Price Projections	122
6	WHEAT AND COARSE GRAINS SIMULTANEOUS MODEL	130
	6.1 Intersectoral Linkage	130
	6.2 Simultaneous Demand and Price Projections	133

CHAPTER		PAGE

7 SUMMARY AND CONCLUSIONS 146

BIBLIOGRAPHY 153

APPENDICES 157

1. Tables Supplementing Chapter 1 157
2. Regional Definitions and Data Sources 161
3. Tables Supplementing Chapter 3 166
4. Tables Supplementing Chapter 4 174
5. Tables Supplementing Chapter 6 178

LIST OF TABLES

TABLE		PAGE
1.1	Distribution of Growth in Consumption of Coarse Grains and Wheat from 1960/61-1962/63 to 1969/70-1971/72 Compared to Distribution of Population in 1970	5
1.2	Comparison of Per Capita Consumption of Coarse Grains, Wheat, Rice and Total Grain (1969/70-1971/72 Average)	6
3.1	Components of the Estimation Model for Coarse Grain Feed Demand	20
3.2	Coarse Grain Feed Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan	28
3.3	Coarse Grain Food Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan	29
3.4	A Comparison of Income Elasticities for Meat Consumption	32
3.5	Constrained Generalized Least Squares Estimates of Per Capita Coarse Grain Feed Demand from the Pooled Cross-Section Time-Series Model European Community, Double-log Form	41
3.6	Coarse Grain Feed Demand Estimates for Other West Europe, Semi-log (SL) and Log-inverse (LI) Forms . .	45-46
3.7	Regional Estimates of Food Demand for the European Community	50
3.8	Coarse Grain Consumption Relations for the USSR, Semi-log Form	52
3.9	Regression Estimates of Price Linkages Used in the Coarse Grain Model	60

TABLE | PAGE

4.1 Quantity Equilibrium in the Coarse Grain Model 65

4.2 Price Linkages in the Coarse Grain Model 72

4.3 Values of the Purchasing-Power Parity Parameters for Recent Years in Canada, Japan and the Netherlands . . 73

4.4 Assumed Rates of Growth of Population and Income for the Projection Period and Assumed Income Elasticities for Block 3 80

4.5 Assumed Rates of Growth of Population and Income for the Projection Period in Blocks 1 and 2 84

4.6 Percentage Changes in the Actual (ACT) and Estimated (EST) Values for Block 1 Demand and Prices in 1973 and 1974 and Percentage Error of the Estimates 95

4.7 Percentage Changes in the Actual (ACT) and Estimated (EST) Values for Demand in Blocks 2 and 3 and Percentage Error of the Estimates 100

4.8 Comparison of Actual Levels to the Simultaneous Solution Estimates for 1974 104

4.9 Projection of Coarse Grain Demand Assuming that Prices Remain at the 1974/75 Level 106

4.10 Projection of Coarse Grain Price and the Distribution of Consumption with Production Growth Constrained at Historical Rates 108

4.11 Impact of Changes in Projection Assumptions on the 1995 Base Solution 110

4.12 The Estimated "Impact" Elasticities of Coarse Grain Demand with Respect to the U.S. Price of Corn Based on 1995 Changes 114

5.1 Components of the Wheat Sector Model 118

TABLE		PAGE

5.2 The Assumed Ratios of Wheat to Coarse Grain Fed and the Income Elasticities for Wheat Food Demand 121

5.3 Projection of Wheat Demand Assuming that Prices Remain at the 1974/75 Level 123

5.4 Projection of Wheat Price and the Distribution of Consumption with Production Growth Constrained at Historical Levels 125

5.5 Impact of Changes in Projection Assumptions on the 1995 Base Solution 127

6.1 Wheat-Coarse Grain Feedback Linkage in the Simultaneous Model 132

6.2 Projections of Coarse Grain and Wheat Consumption Assuming Historical Rates of Production Growth and Recent Stock Rates in the Simultaneous Model 136

6.3 Projected Rate of Growth and Composition of Growth in Consumption of Coarse Grains and Wheat, 1974-1995 138

6.4 Projected Distribution of Consumption Growth for Coarse Grains and Wheat, 1974-1995 139

6.5 Impact of Changes in Projection Assumptions on the 1995 Base Solution of the Simultaneous Model . . 142

7.1 Effects on the 1995 Corn Export Price of a 10 Percent Increase in the Growth Rates of Income and Population 148

7.2 Comparison of Actual and Projected Levels of Per Capita Consumption of Coarse Grains plus Wheat . . . 150

LIST OF FIGURES

FIGURE		PAGE
2.1	Equilibrium in Year t for a Simple Projection Model	14
2.2	Equilibrium Price Determination in the Coarse Grain Model	16
4.1	The Summation of Coarse Grain Demand for Block 1 Illustrated for Two Countries	66
4.2	The Summation of Coarse Grain Demand for Block 2 Illustrated for Two Countries with Internal Prices P_{21} and P_{22}	68
4.3	The Interaction of the Three Demand Blocks in the World Market Equilibrium when Demands and Supply Shift to New Levels	71
4.4	Actual and Estimated Values for USA Coarse Grain Consumption	87
4.5	Actual and Estimated Values for Canada Coarse Grain Consumption	88
4.6	Actual and Estimated Values for Japan Coarse Grain Consumption	89
4.7	Actual and Estimated Values for USA Real Price of Corn	91
4.8	Actual and Estimated Values for Canada Real Price of Barley	92
4.9	Actual and Estimated Values for Canada Real Price of Wheat	93
4.10	Actual and Estimated Values for Japan Real Price of Corn	94
4.11	Actual and Estimated Values for Block 2 Coarse Grain Consumption	96

FIGURE PAGE

4.12 Actual and Estimated Values for EC9 Coarse Grain Consumption 97

4.13 Actual and Estimated Values for Other West Europe Coarse Grain Consumption 98

4.14 Actual and Estimated Values for USSR Coarse Grain Consumption 101

4.15 Actual and Estimated Values for Block 3 Coarse Grain Consumption 103

6.1 Solution of the Simultaneous Model when the Wheat-Corn Price Ratio is Above the Relative Feed Value . 134

6.2 Solution of the Simultaneous Model when the Wheat-Corn Price Ratio Equals the Relative Feed Value . . 135

6.3 Gulf Ports Prices of Wheat and Corn, Actual to 1974, Projected 1975 to 1995 141

Chapter 1

INTRODUCTION

This chapter presents the problem statement, the historical setting of the problem and a description of the thesis organization.

1.1 Statement of the Problem

There has been an increased concern about the future grain supply relative to demand ever since the events of the 1972/73 crop year initiated a rise in grain prices that was unprecedented in recent history. Although grain prices retreated in 1974 after supply conditions improved, there is little certainty about whether surplus, scarcity or neither will dominate the future. Discussions about surplus capacity and price supports that flourished in the post-World War II period have been replaced by debates over reserve stock programs and food security; and the Green Revolution optimism of the 1960's has given way to varying degrees of concern about world grain sufficiency and distribution in the decades just ahead.

As a basis for food policy decisions, it is important not only to anticipate the future level and composition of world grain demand relative to supply but to identify and understand the underlying forces that influence demand and supply. This study concentrates on the demand component, but the results should also provide some insight into the broader question of the long run potential for surplus or scarcity in grain markets.

The major factors which shift grain demand across time are population and income. It is expected that in high income countries the effect of income growth on demand for animal products is the primary shifter of grain demand; and in low income countries, both income and population may be important sources of demand growth.

Since the tightening of world food markets occurred, there has been considerable discussion about the relative importance of population and income effects on demand. At the extremes of this debate are certain members of affluent nations who place the entire burden for the food "crisis" on high rates of population growth in poor countries and certain members of poor nations who lay the entire blame on the high rates of meat consumption in affluent countries.

Clearly both population growth and increased meat consumption influence demand for grain. The effects of population growth on grain demand are rather straightforward and have seemed to get more attention in the discussion about future food availability. Less is known quantitatively about the more complex relationship between income growth, the changes in composition of diets and grain demand.

This study will focus on the effect of income growth on grain demand in the developed countries of the world. This is not an attempt to take sides in the population-vs-income debate, but rather to investigate the lesser known of the two effects. The income effect is expected to be most important in the high income economies, and these areas of the world have accounted for a major portion of both the demand and the growth in demand for wheat and coarse grains over the last decade.

The major question being asked in the study is to what extent future growth in grain consumption in developed countries will put pressure on prices and grain availability to the rest of the world. The income and population effects for the developed countries will be incorporated with third world income and population assumptions in a world projection model. This model will be used to project the probable consequences of income and population growth for grain demand and price trends over the next two decades, and the relative impacts of income and population effects in developed and third world areas will be compared.

1.2 Historical Setting of the Problem

The stated objective to focus on the income effects in developed countries is motivated not only by the dearth of attention given to this aspect of grain demand growth but also by its importance relative to other factors in explaining total growth in grain demand. Developed country demand is an especially important component of coarse grain demand, but its effect on wheat demand has also been substantial.

During the decade preceding the 1972/73 crop year, the developed countries as a whole accounted for 71 percent of the growth in coarse grain consumption and 60 percent of the growth in wheat consumption (Table 1.1). Feed consumption accounted for 74 percent of the growth in coarse grain consumption and 45 percent of the growth in wheat consumption. The developed market economies were the main source of growth in coarse grain feed demand and the developed central planned economies were the main source of wheat feed demand growth. The absolute change in total consumption of coarse grains and wheat was almost evenly distributed among the developed market economies, the developed central planned economies and the third world. However, it was far from equal on a per capita basis, since 66 percent of the total growth went to 30 percent of the world's population in the developed countries. Rice, on the other hand, is of little consequence in developed country consumption since more than 90 percent of the total is consumed in the third world (Appendix Table 1.3).

Similar patterns are likely to persist in the future if affluent consumers continue to increase the quantity and quality of animal products in their diets. This would be of little consequence to third world consumers if supplies were plentiful and grain prices were low. But if the limits to supply growth are such that prices remain high or increase, the potential for third world consumers to improve their diets would be directly threatened by increased developed country consumption.

It is well known that per capita grain consumption in the third world is far below that of the developed countries (Table 1.2),

Table 1.1. Distribution of Growth in Consumption of Coarse Grains and Wheat from 1960/61-1962/63 to 1969/70-1971/72 Compared to Distribution of Population in 1970[a]

Region	Coarse Grains Absolute Change	Coarse Grains Percent of Change	Wheat Absolute Change	Wheat Percent of Change	Total Absolute Change	Total Percent of Change	Population 1970	Population Percent of Total
	mil. mt	%	mil. mt	%	mil. mt	%	mil.	%
Developed Market[b]	62.0	48	13.4	15	75.4	34	706	20
(feed)	(52.7)	(41)	(11.4)	(12)	(64.1)	(29)		
Developed CPE[c]	29.3	23	41.5	45	70.8	32	368	10
(feed)	(31.0)	(24)	(29.5)	(32)	(60.6)	(27)		
Third World[d]	37.3	29	37.1	40	74.4	34	2543	70
(feed)	(11.9)	(9)	(0.8)	(1)	(12.7)	(6)		
Total	128.7	100	92.0	100	220.7	100	3617	100
(feed)	(95.6)	(74)	(41.7)	(45)	(137.3)	(62)		

[a]Computed in Appendix Tables 1.1 and 1.2.

[b]Australia, Canada, Japan, New Zealand, South Africa, United States, West Europe.

[c]East Europe, USSR.

[d]All countries not in (b) or (c).

Table 1.2. Comparison of Per Capita Consumption of Coarse Grains, Wheat, Rice and Total Grain (1969/70-1971/72 average)[a]

	Per Capita Consumption 1969/70-1971/72			
	Coarse Grains	Wheat	Rice	Total Grain
	kilograms			
Developed Market	386	124	21	531
Developed CPE	335	344	4	683
Third World	57	47	76	180
Total	149	92	58	299

[a]Computed from Appendix Tables 1.1 to 1.3.

and the importance of improving the inadequate nutritional levels is widely accepted.[1] There are basically two ways to increase grain consumption: increased internal production and increased imports. Although rates of production growth in the third world have equaled those in the developed countries over the last two decades, this was barely sufficient to keep pace with population growth. Thus, food imports have increased, and most future projections foresee a continuing growth in import requirements.[2]

Third world countries are faced in most cases with budget and foreign exchange constraints, so the price of grains is a crucial factor in their attempts to fight undernourishment and malnutrition. Although in theory, food aid and subsidized sales can offset higher price levels, one need only look at the rapid decline in the quantity of U.S. food aid in 1973 and 1974 to realize that scarcity and higher prices may well reduce food aid when it is needed most.[3]

Naturally, population and income effects on demand in all countries combine to influence world prices. However, if real

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[1]An FAO study of energy and protein supply in 1969-71 found the third world energy availability to be 5 percent below minimum requirements. FAO, Population, Food Supply and Agricultural Development, United Nations, Rome, 1975.

[2]U.S. Department of Agriculture, Economic Research Service, The World Food Situation and Prospects to 1980, FAER #98, December 1974.

[3]U.S. Department of Agriculture, Economic Research Service, Foreign Agricultural Trade of the United States, January 1977, Table 5.

grain prices of the future remain high or increase and developed country demand growth continues to be a major factor, the allocation of scarce grain supplies could well become a highly sensitive issue between developed and third world nations. On the other hand, if real prices continue the long-run downward trend that characterized much of the post World War II period prior to 1972, there probably would be little protest against increased grain feeding in developed countries. Thus, it is important to look at the question of developed country demand growth and long-run price trends simultaneously.

1.3 Organization of the Thesis

The division of the research by commodity and geographical region and an overview of the analytical approach to be used in the study will be presented in Chapter 2. The estimation models and estimation results for developed country demand equations and price linkages are presented in Chapter 3. In Chapter 4 the coarse grain projection model and the projection assumptions are described, the historical performance of the model is tested and the coarse grain demand and price projections are reported. A simple wheat model is developed in Chapter 5 and the partial equilibrium projections of that model are reported. In Chapter 6, the wheat and coarse grain models are integrated and the simultaneous demand and price projections are reported. Chapter 7 summarizes and evaluates the results of the study.

Chapter 2

METHODOLOGY

This chapter discusses the division of research by commodity and geographical region and presents a general description of the analytical approach used in the study.

2.1 Division of Research by Commodity

The objective here is to narrow the scope of the research so as to focus on the central questions posed in Chapter 1. Based on the historical patterns portrayed in Chapter 1, the future growth in income in developed countries is likely to have its greatest impact on feed demand in the coarse grains sector. Consequently, coarse grains demand is the major focus of this study.

Large quantities of wheat are consumed in the developed countries but the potential for future growth lies primarily in the third world. Although growth in wheat feeding in East and West Europe and the U.S.S.R. has a substantial impact on wheat demand growth during the 1961 to 1970 period, wheat never exceeded 18 percent of feed grain world wide and declined to about 14 percent in 1973 and 1974. In the European Community it was a subsidy in the form of the denaturing premium which motivated increased wheat feeding in the late 1960's and early 1970's. Even in the United States where relatively little wheat is fed, the proportion of wheat fed is affected by the wheat-corn price ratio. So the potential for increased wheat feed use in the future will depend in part upon relative price trends in wheat and coarse grains. A wheat sector is included in this study to analyze this potential substitution, but the analytical approach is greatly simplified compared to that of the more important coarse grain sector.

As noted in Chapter 1, rice is not a significant factor in overall developed country grain consumption. Only in Japan is it a significant factor in food use, and the potential substitution of rice for feed grains is very limited.[1] Thus, the exclusion of rice from this study helps to limit the scope but should not greatly influence the results.

To simplify the analysis, coarse grains--including barley, corn, oats, rye and sorghum are analyzed as an aggregate but separated by end use into two categories: feed and non-feed. Wheat is also separated into feed and non-feed categories for the projections.

2.2 Demand Projection Techniques

There are two basic approaches to making demand projections; the constant-price approach and the equilibrium approach. The first can be derived from a model where per capita consumption (q) is a function of per capita income (I).

$$(2.1)\quad q_t = f(I_t)$$

---

[1]The only recent example of significant substitution is in Japan in the early 1970's when excess rice stocks were "dumped" on the feed grain market.

Total consumption (Q) is population (N) times per capita consumption.

(2.2) $Q_t = N_t f(I_t)$

The rate of growth in consumption $(\hat{Q})$ can then be expressed in terms of the growth rates of population $(\hat{N})$ and per capita income $(\hat{I})$ and the income elasticity (η), and the projection takes the form:

(2.3) $Q_t = Q_0(1 + \hat{Q}_t)^t$

where $\hat{Q}_t = \hat{N}_t + \eta_t \hat{I}_t$

Q_0 = base year consumption

Q_t = projected consumption in year t.

This is the methodology used for the FAO projections[2] and it is widely used elsewhere because of its simplicity. For the same reason a modification of this method is employed in the coarse grain food and feed demand projections for the third world regions, East Europe and a few small developed market economies (see Appendix 2). This method is also utilized for the wheat food demand projections for all regions. A coarse grain consumption function is estimated for the U.S.S.R. to reflect the government's response to variation in internal production and is discussed in detail in Chapter 3.

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[2]FAO, Agricultural Commodity Projections, 1970-80, CCP 71/20, Rome, 1971.

The equilibrium approach to projections takes into account the effect of prices and the interaction of prices and quantities. Projections of this type can be derived from a model where per capita consumption (q) is a function of prices (P) and per capita income (I).

(2.4) $q_t = f(P_t, I_t)$

For a simple case of one grain, n countries, and a single world price with free trade and no transport costs, the projection model takes the form:

(2.5)	$q_{it} = f_i(P_t, I_{it}) \quad i = 1,2,\ldots,n$	i^{th} per capita demand
(2.6)	$Q_{it} = N_{it}\, q_{it}$	i^{th} total demand
(2.7)	$\sum_i Q_{it} = QS_t$	equilibrium condition
(2.8)	$QS_t = QS_0(1 + \hat{QS})^t$	supply projection
(2.9)	$N_{it} = N_{i0}(1 + \hat{N}_i)^t$	population projection
(2.10)	$I_{it} = I_{i0}(1 + \hat{I}_i)^t$	income projection

where I_i = per capita income in i^{th} country

N_i = population in i^{th} country

P = world price of grain

q_i = per capita grain demand in i^{th} country

Q_i = total grain demand in i^{th} country

QS = total supply of grain for all countries

Given assumed rates of growth in supply ($\hat{QS}$), population ($\hat{N}$) and per capita income ($\hat{I}$), this model simultaneously determines world price and the distribution of consumption among the n countries for each year t. One such equilibrium solution is illustrated in Figure 2.1. Constant-price projections can still be made with this type of model by suspending the equilibrium condition (2.7) and holding the price at some predetermined level over the projection period.

2.3 Overview of the Analytical Approach

The equilibrium approach is preferable to the constant price approach for the purposes of this study, since the projection of long-run trends in grain prices is one of the objectives. An equilibrium model is formulated for coarse grains by using empirical estimates of price response in the developed market economies and making reasonable assumptions about price elasticities for the rest of the world. The coarse grain model is divided into three demand blocks based on the assumptions about price formation.

Coarse grain food demand and feed demand equations are estimated for Canada, Japan, the United States and 16 countries of West Europe. Price linkages are also developed which take account of trade barriers and transport costs among these developed market economies.

Coarse grain prices in Canada and Japan are linked to the U.S. export price of corn with price linkage equations. These two countries and the United States form demand block 1. Coarse grain prices in West Europe are assumed to be policy determined

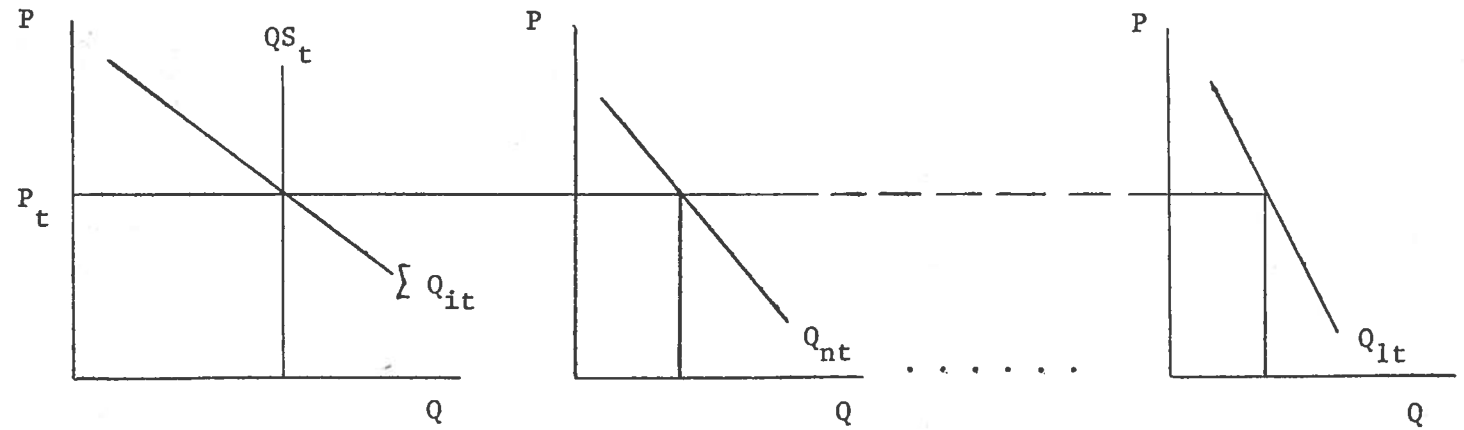

Figure 2.1. Equilibrium in Year t for a Simple Projection Model

unless the U.S. export price of corn exceeds a critical level. The West European countries form demand block 2, and a price linkage is developed in Chapter 4 which causes block 2 prices to be influenced by the U.S. export price of corn only when the latter exceeds a critical level.

The rest of the world is included in demand block 3 (see Appendix 2), where the constant price projections are modified by introducing price elasticity parameters. Since price elasticities are not estimated for these countries and regions, an elasticity representing the aggregate price response for block 3 is added to the system. This elasticity assumption integrates the block 3 projections into the equilibrium model and is discussed in Chapter 4.

The components of the coarse grain model are illustrated in Figure 2.2. Block 1 demand (D_1) is the horizontal summation of the individual country demands incorporating the price linkages. In block 2 internal prices are related to the threshold price of corn in the European Community, and demand (D_2) is perfectly inelastic with respect to the U.S. price unless the latter goes above a critical level. An aggregate elasticity with respect to the U.S. price is assumed for block 3 in order to make realistic adjustments to the constant price projection (D_3) when the price goes above or below the 1974 level. Without this elasticity assumption, block 3 demand would be perfectly inelastic as shown in the broken line in Figure 2.2(c).

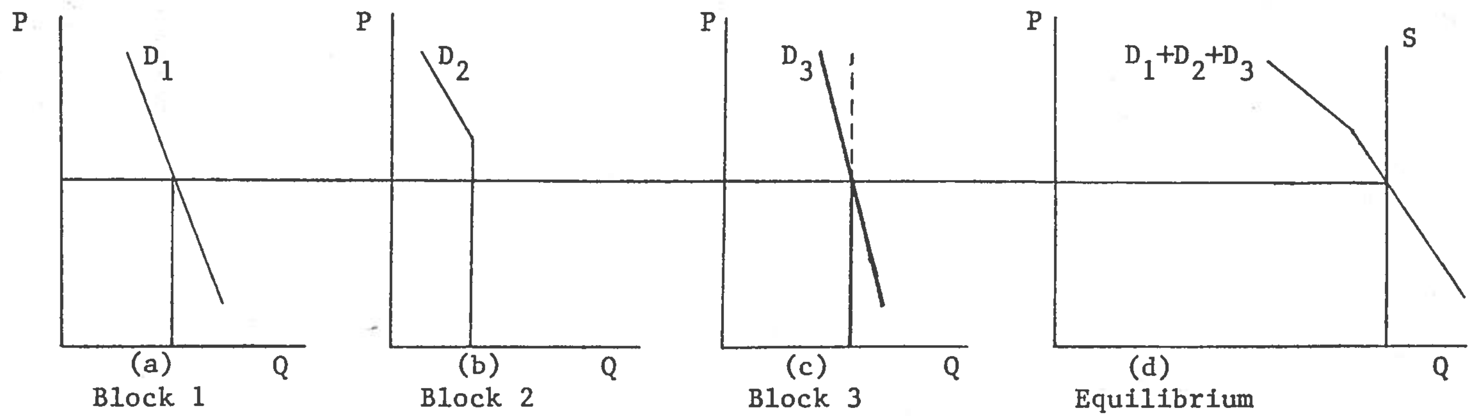

Figure 2.2. Equilibrium Price Determination in the Coarse Grain Model

The U.S. price of corn is determined in each year of the projection period by the equilibrium condition shown in Figure 2.2(d). Other prices and quantities linked to the U.S. corn price are determined simultaneously. Prices will move upward (downward) if the demand factors cause world demand to increase more (less) rapidly than world supply at current prices.

The supply projections for coarse grains and wheat assume a continuation of historical production trends from 1960 to 1975. Projections of population and income, the major demand shifters, are based on the United Nations medium variant growth rates for population and "trend" growth rates for income. Sensitivity tests of the projections are made by altering the assumed growth rates of income, population and production and the assumed price elasticities for block 3.

In Chapters 5 and 6 a simple wheat sub-model is developed and integrated into the equilibrium model. The objective of this expansion is to measure the maximum extent to which wheat substitution for coarse grains in feed rations could influence the projection results. Wheat food demand is projected utilizing the simple constant-price method, and a price response is incorporated through an assumed elasticity as in block 3 of the coarse grain model. If the wheat-corn price ratio remains constant, wheat feed demand is projected to grow in direct proportion to the growth in coarse grain feed demand. The response of wheat feed demand to changes in the wheat-corn price ratio is assumed to be inelastic if the price ratio is above the relative feeding value and elastic if the price ratio is equal to the relative feeding value. The wheat-corn price ratio is not permitted to fall below the relative feeding value.

Equilibrium solutions for the coarse grain model, the wheat sub-model and the interactive model of wheat and coarse grains are determined with a dampened Gauss-Seidel interactive program[3] on the University of Minnesota Cyber 74 computer.

The data requirements vary by country and region as will be evident in Chapters 3 and 4, but all the data sources are listed in Appendix 2.

[3]The algorithm, called General-Analytical-Simulation-Solution-Program (GASSP), was written by Rodney C. Kite, Economic Research Service, U.S.D.A.

Chapter 3

COARSE GRAIN DEMAND EQUATIONS AND PRICE LINKAGES

The coarse grain demand equations for the developed market economies are the core of the projection model. Therefore, the specification and estimation of these relations need to be discussed in some detail. This chapter presents the theoretical basis for the estimation model, the specifications and empirical results of the demand estimations for blocks 1 and 2 and the USSR and for the estimations of the block 1 price linkages.

3.1 Theoretical Basis for Estimation Model

An important part of this study is to quantify the income effects on demand for feed grains. Feed demand is a derived demand arising from the activities of the animal products industry. In general, growth in real income increases the demand for animal products, which tends to raise animal product prices and stimulate the demand for grains and other production inputs.

There are essentially two types of econometric models that could be employed to estimate the income effect. The first approach is to estimate the structural coefficients of final supply, final demand and derived input demand equations for the animal product industry. In the context of the simple aggregate model in Table 3.1, this would involve estimation of equations (1), (2) and (4) for each country. Solving these equations simultaneously with the appropriate equilibrium condition (3) would give the

Table 3.1. Components of the Estimation Model for Coarse Grain Feed Demand

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STRUCTURAL EQUATIONS

(1)	$QLS_t = f_1(PL_t, PG_t, PX_t, \varepsilon_{1t})$	supply
(2)	$QLD_t = f_2(PL_t, I_t, PO_t, \varepsilon_{2t})$	domestic demand
(3)	$QLS_t = QLD_t + QLX_t$	quantity equilibrium
(4)	$QGD_t = f_3(PG_t, PL_t, PX_t, \varepsilon_{3t})$	derived demand

REDUCED FORM (input prices constant)

(5)	$QGD_t = g(PG_t, I_t, PX_t, PO_t, QLX_t, u_t)$	country demand

WORLD EQUILIBRIUM (i = 1, 2, . . . , n countries)

(6)	$QGD_{it} = a_i + b_i PG_{it} + C_i I_{it} + d_i Z_{it} + u_{it}$	country demand
(7)	$PG_{it} = WPG_t + M_{it}$	price linkage
(8)	$\sum_i N_{it} \cdot QGD_{it} = WQP_t - WCST_t$	quantity equilibrium

where I = income per capita
M = market margin
N = population
PG = price of coarse grain
PL = price of animal products
PO = price of other goods
PX = price of other inputs
QGD = demand for coarse grain feed per capita
QLS = supply of animal products per capita
QLD = domestic demand for animal products per capita
QLX = net exports of animal products per capita (negative for imports)
WCST = world change in coarse grain stocks
WPG = world price of coarse grain
WQP = world production of coarse grain
Z = vector of exogenous variables
ε,u = stochastic disturbance

reduced-form equation (5) and the corresponding reduced-form coefficients.[1] These are referred to as the "derived" coefficients. The second approach is to estimate the reduced-form equation (5) directly to obtain the reduced-form coefficients on income and other exogenous variables. This method is referred to as unrestricted least-squares (ULS).

The first approach would usually be preferable for a country study focusing on the structural parameters. But the focus of this study is on projections, for which only the reduced-form coefficients are necessary. In terms of econometric properties, both the "derived" and the unrestricted least-squares estimators are consistent. The "derived" estimator is asymptotically more efficient, provided that consistent estimators (two-stage least-squares or three-stage least-squares, for example) are used for the structural equations.[2] In a study of the small sample properties of the ULS and "derived" estimators, Summers[3] found that the differences in efficiency were not very great and concluded that "economy in computation can safely supplant statistical efficiency as a basis for choosing" among these methods. Considering the broad scope of this study, the computational savings

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[1] Net exports (imports) of animal products is exogenous in this simple system.

[2] J. Johnston, Econometric Methods, 2nd ed. (New York: McGraw-Hill, 1972), pp. 408-420.

[3] R.M. Summers, "A Capital Intensive Approach to the Small Sample Properties of Various Simultaneous Equation Estimators," Econometrica 33 (January 1965), pp. 1-41.

associated with using the unrestricted least squares method are very substantial so that is the method used.

Implicit in this discussion has been the assumption of open economies, where the equilibrium constraint depends upon the world supply rather than the domestic supply of grain. A simplified world system for n countries, where all coarse grain is fed, is shown in equations (6), (7) and (8) of Table 3.1. In this context the possibility of simultaneous equations bias arises due to the simultaneous determination of all quantities QGD_{it}, all prices PG_{it} and world price WPG_t. However, in many of the developed market economies, grain prices have been determined by government policy and are therefore exogenous. Other countries are quite small relative to the rest of the world and can be considered price takers on the world market.[4] The United States is the most notable exception to both of these cases because it is relatively large and has had relatively less price control. Hence, two-stage least squares and ordinary least squares regressions are estimated for the United States.

Before proceeding to the estimation results, it is of interest to look briefly at the relationship between the reduced-form elasticities and those of the final product demand. Brandow[5]

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[4] L.R. Klein, "Single Equation vs. Equation System Methods of Estimation in Econometrics," Econometrica 28 (October 1960), pp. 866-871.

[5] G.E. Brandow, "Demand for Factor and Supply of Output in a Perfectly Competitive Industry," Journal of Farm Economics 44 (August 1962), pp. 895-899.

analyzed the reduced-form price elasticity assuming a linearly homogeneous Cobb-Douglas production function, a log-log final product demand and a perfectly competitive industry. He concluded that "demand for an input is elastic, unit elastic, or inelastic accordingly as demand for output is elastic, unit elastic or inelastic . . ." The cross price elasticity was found to be negative for an elastic output demand and positive for an inelastic output demand.

In Appendix Table 3.1, a slightly more general case is analyzed for three inputs. It is more general in that decreasing returns to scale are permitted, and income is added to the demand relation so that its reduced-form impact can be traced. For the price elasticities the magnitudes of the elasticities are affected, but the general conclusions are the same as those drawn by Brandow in the constant returns to scale case. The reduced-form income elasticity is equal to the final demand elasticity of income under constant returns to scale. Under decreasing returns to scale the reduced-form income elasticity is larger for an inelastic final demand and smaller for an elastic final demand. Finally, the results in Appendix Table 3.1 show that the reduced-form equation is homogeneous of degree zero in prices and income, provided that the same condition holds for the final product demand.

Since the final product is defined as aggregate animal products, it is reasonable to assume that final demand is inelastic in the developed market economies.[6] Therefore, it is expected that the reduced-form demand for fed coarse grains will be inelastic, the cross-price elasticities will be positive and the income elasticities will be no smaller than the final product income elasticities.[7]

3.2 Specification and Empirical Results for Blocks 1 and 2

The discussion of empirical results is divided into two sections. The first covers the United States, Canada and Japan (block 1), where separate country regressions are estimated. The second covers Western Europe (block 2), where a pooled cross-section time-series model is used. However, certain aspects of the specification which are common to both blocks are discussed first.

Demand and income variables are in per capita units, so population is assumed to have a simple multiplicative effect on demand. Prices and income for each country are deflated by the national consumer price index for all goods (1970=100), thereby imposing the homogeneity condition on demand and eliminating the "price of other goods" as a separate explanatory variable. Then,

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[6] Brandow (1961) and George and King (1971) calculated the retail price elasticities of "all meats" in the United States to be -.60 and -.35, respectively.

[7] The work of Allen (1968) shows that for the case of a general linearly homogeneous production function these conclusions on the price elasticities will not necessarily hold when the elasticity of substitution between factors is not equal to one. However, it can be shown that the result regarding income elasticity is not affected by the elasticity of substitution.

all prices and income are converted to 1970 U.S. dollars with the 1970 exchange rate in order to facilitate cross-country comparisons and, in the case of block 2, to facilitate the cross-section time-series analysis. The price linkages are made more tractable by using only prices of the two major coarse grains, barley and corn. For each country the price of dominant feed grain is selected as the price variable. Except for two countries, equations are estimated for the period 1960/61 to 1973/74, and 1974/75 is later used as the prediction interval.[8] Japan equations were estimated over the period 1960/61 to 1974/75.

Block one estimates. Separate country equations were estimated by ordinary least squares (OLS) for the U.S., Canada and Japan. A two-stage least squares (TSLS) estimator was also used for the U.S. due to the possible simultaneous equations bias as noted in section 3.1 above. The specification of the block 1 equations and the variable definitions are as follows:

UNITED STATES

(1) $QFEDC_t = f(UPC_t, I_t, UPM_t, UPFL_t, u_{1t})$

(2) $QFODC_t = f(UPC_t, I_t, u_{2t})$

CANADA

(3) $QFEDC_t = f(CPB_t, I_t, CPW_t, CED, u_{3t})$

(4) $QFODC_t = f(CPB_t, I_t, COD, u_{4t})$

[8] Price data for West European countries is not available beyond crop year 1974/75.

JAPAN

(5) $QFEDC_t = f(JPC_t, I_t, JQFE_t, T*JD, u_{5t})$

(6) $QFODC_t = f(JPC_t, I_t, u_{6t})$

Endogenous Variables

QFEDC = coarse grain demand for feed per capita, kg.

QFODC = coarse grain demand for food per capita, kg.

UPC = average price received by U.S. farmers for corn, $/cwt.

Exogenous Variables

CED = dummy variable, 1 (1967 to 1969), 0 (elsewhere)

COD = dummy variable, 1 (1971), 0 (elsewhere)

CPB - average Canadian Wheat Board selling price for No. 3 Canadian Western 6-row barley, $/100 kg.

CPW = average Canadian Wheat Board selling price for No. 2 Northern wheat (No. 1 Canadian Western Red Spring 14%), $/100 kg.

I = private consumption expenditure per capita, $

JD = dummy variable, 1 (1960 to 1966), 0 (elsewhere)

JPC = wholesale price index of imported corn, 1970=100 for calendar year index

JQFE = wheat and rice fed per capita, kg.

T = trend, 1960 = 1, . . .

UPM = average U.S. wholesale price of soybean meal at Decatur, $/cwt.

UPFL = index of prices paid for livestock inputs, 1910-14=100

The regression estimates are reported in Tables 3.2 and 3.3. The U.S. and Canadian feed and food demand income elasticities were below 1.0 at the historical means, and in a linear form of equation (Appendix Tables 3.2 and 3.3) these elasticities would tend to increase toward 1.0 in a long-run projection. Economic theory suggests that the income elasticities for feed or food grain products are not likely to increase for high income consumers, so a double-log, semi-log or log-inverse form of equation is more appropriate. The semi-log form is used for the U.S. and Canada because it permits income elasticities to decline as per capita consumption rises, but preserves the simplicity of the linear form for purposes of the world model solution routine.[9] The feed demand income elasticity for Japan was greater than 1.0 at the historical means so it will tend to decrease in a long-run projection using a linear form of equation.

The feed demand coefficients in Table 3.2 are all significant at the 5 percent level or better except for the U.S. meal price coefficient. The latter was retained in the equation since a t-statistic greater than 1.0 still improves the adjusted $\bar{R}^2$. The explanatory power of the estimated equations is good to excellent as evidenced by the $\bar{R}^2$ values, and the Durbin-Watson statistics indicate the absence of serial correlation in the disturbance.

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[9] In the semi-log specification the income variable is replaced by the natural log of income and the elasticity equals the estimated income coefficient divided by the dependent variable.

Table 3.2. Coarse Grain Feed Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan

USA	UPC	ln(I)	UPM	UPFL	CONST	$\bar{R}^2$	D.W.	CV d.f.
OLS	-60.007	137.28	4.095	0.7583	-704.10	.85	1.81	0.03
(t)	(4.22)	(3.05)	(1.36)	(5.05)	(2.07)			9
e	-.25	.23	.03	.58				
e*	-.36	.21	.04	.70				
TSLS	-72.514	129.85	4.181	0.8562	-659.49		2.10	0.02
(t)	(5.40)	(3.43)	(1.66)	(6.35)	(2.31)			9
e	-.30	.21	.03	.65				
e*	-.44	.20	.04	.79				
CANADA	**CPB**	**ln(I)**	**CPW**	**CED**	**CONST**	$\bar{R}^2$	**D.W.**	**CV d.f.**
OLS	-38.761	537.28	18.946	-64.207	-3441.3	.95	2.37	0.03
(t)	(3.60)	(12.87)	(2.76)	(5.44)	(10.62)			9
e	-.50	.97	.30					
e*	-.71	.82	.50					
JAPAN	**JPC**	**I**	**JQFE**	**T*JD**	**CONST**	$\bar{R}^2$	**D.W.**	**CV d.f.**
OLS	-0.2242	0.1162	-1.122	1.144	-7.926	.99	2.23	0.04
(t)	(3.55)	(27.45)	(6.20)	(3.52)	(0.84)			10
e	-.41	1.56						
e*	-.24	1.37						

t = t-statistic (absolute value)
e = elasticity at the means
e^* = elasticity for 1973
CV = standard error/mean
d.f. = degrees of freedom

Table 3.3. Coarse Grain Food Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan

USA	UPC	ln(I)		CONST	$\bar{R}^2$	D.W.	CV d.f.
OLS	-0.141	21.916		-102.32	.96	2.01	0.01
(t)	(0.48)	(17.83)		(10.62)			11
e	-.005	.31					
e*	-.007	.29					
TSLS	0.021	21.776		-101.61		1.95	0.01
(t)	(0.07)	(17.49)		(10.43)			11
e	.001	.31					
e*	.001	.29					
CANADA	CPB	ln(I)	COD	CONST	$\bar{R}^2$	D.W.	CV d.f.
OLS	-1.253	31.487	21.241	-145.13	.81	1.39	0.04
(t)	(1.75)	(3.20)	(4.47)	(1.96)			10
e	-.10	.35					
e*	-.17	.35					
JAPAN	JPC	I		CONST	$\bar{R}^2$	D.W.	CV d.f.
OLS	-0.0389	-0.0020		31.249	.15	1.98	0.16
(t)	(0.43)	(0.30)		(2.14)			12
e	-.17	-.06					
e*	-.15	-.08					

t = t-statistic (absolute value) e* = elasticity for 1973 d.f. = degrees of freedom
e = elasticity at the means CV = standard error/mean

As expected, the signs of the direct price coefficients are negative, income coefficients are positive and other input price coefficients are positive. The variable for other grain feed in Japan (JQFE) shows the effect of government policies to divert excess rice stocks to feed uses, primarily in the period 1971 to 1973. A ton of rice displaced slightly over one ton of coarse grains.

The price and income coefficients are best compared in terms of elasticities. The U.S. corn price elasticity can be compared to the own price elasticity of -.42 reported for corn feed demand in a recent study by Womack.[10] Aggregate coarse grain demand would tend to be more inelastic than corn demand and the reduced-form demand would tend to be more inelastic than the derived demand specification used in the Womack study, so the estimated elasticity of -.25 to -.30 is reasonable. Similarly, the barley price elasticity estimated for Canada compares favorably to the own price elasticity of -.78 reported for feed barley demand by Jolly.[11] The corn price elasticity for Japan falls within the range set by the U.S. and Canadian estimates.

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[10] A. Womack, "The U.S. Demand for Corn, Sorghum, Oats and Barley: An Econometric Analysis," Economic Report 76-5, University of Minnesota, August 1976.

[11] R.W. Jolly, "An Econometric Analysis of the Grain-Livestock Economy in Canada with a Special Emphasis on Commercial Agricultural Policy," Department of Agricultural and Applied Economics, University of Minnesota (unpublished Ph.D. dissertation), 1976.

It was shown in the previous section that the reduced-form income elasticity should be no smaller than the corresponding income elasticity with respect to final product demand. There is quite a range in the estimates of income elasticities for meat consumption in the developed market economies as seen in Table 3.4. However, there is a discernible pattern indicating that the elasticity is lowest for the U.S. The OECD estimates show Japan setting an upper bound with Canada and West Europe between the extremes. The other estimates show little difference in elasticities outside the U.S. The feed grain income elasticity estimates in Table 3.2 are consistent with the pattern of the OECD estimates.

In general, one would expect food demand for coarse grains to be more price inelastic and less income elastic than feed demand. This is the case for the food demand estimates (Table 3.3) except for the U.S. income elasticity. Since 1960 there has been a resurgence in the food demand for coarse grains in the U.S. primarily for industrial use. There may be some omitted variable bias if this resurgence is in part due to changes in taste, technology or other excluded variables that are positively correlated with income. This is not a serious problem if the relationship between income and these excluded variables continues over the projection period. Since food demand has only been about 11 percent of U.S. coarse grain consumption, further investigation of this relation is not considered necessary.

Table 3.4. A Comparison of Income Elasticities for Meat Consumption

	USA	CAN	JPN	EC9		OWE	
				range	average	range	average
<u>OECD</u>[a]							
Beef and veal	.4	.6	.9	.25; .70	.34	.30; .90	.47
Pig meat	-.18	.0	1.5	-.10; .70	.51	.10; .70	.41
Poultry meat	.4	.8	1.9	.60; 2.9	1.75	.80; 3.10	1.90
<u>GEORGE & KING</u>[b]							
Meat and poultry	.24						
<u>ERS</u>[c]							
All meat	.55	.60	.64		.70		.65
<u>FAO</u>[d]							
All meat	.19	.35	.33		.36		.35

[a] OECD, <u>Agricultural Projections for 1975 and 1985</u>, Paris, 1968, Annex III, Table 1.

[b] P.S. George and G.A. King, "Consumer Demand for Food Commodities in the United States with Projections to 1980," Giannini Foundation Monograph #26, March 1971. Calculated from Table 33 using expenditure weights in Table 2.

[c] ERS, <u>Growth in World Demand for Feed Grains</u>, FAER No. 63, USDA, July 1970, Table 47 (adjusted elasticities).

[d] FAO, <u>Agricultural Commodity Projections, 1970-1980</u>, Vol. 2, United Nations, Rome, 1971.

The price coefficient for food demand is significant only for Canada. In fact, neither price nor income coefficients are significant for Japan and the explanatory power of the equation is very low. For the projections, therefore, it will be assumed that per capita food demand for Japan remains constant.

Finally, the OLS and TSLS estimates for the U.S. do not differ substantially either in the feed or food demand equations. This would seem to indicate that simultaneity is not a serious problem in the context of the world model.

Block two estimates. West Europe is divided into two sub-regions. The first consists of the nine countries in the enlarged European Community[12] and the second includes the remaining eight continental countries in West Europe.[13] Since country data were available for each of the variables, three methods of estimation were considered. They were:

1. estimate separate country equations,
2. pool the data into two regional cross-section time-series models and estimate country equations in this framework, and
3. aggregate the data across each of the two sub-regions and estimate two regional equations.

The first and second approaches both utilize the "within country"

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[12] Since Belgium and Luxembourg are treated as one unit, there are actually eight separable country data units.

[13] Iceland and Malta are accounted for in block 3.

variation in the variables, and the second also permits the cross-country variation to affect the estimates. The third method simplifies the analysis by reducing the number of equations to be estimated, but there is an inevitable loss in information that occurs when some of the variation is submerged in the regional averages. The aggregate approach was used to estimate the coarse grain food demand equations; but due to its greater importance in the coarse grain sector, a regional cross-section time-series model was used for feed demand. There are several advantages to this method.

1. All available information is used in the estimation procedure.

2. In a pooled model it is possible to perform statistical tests for the equality of price and income coefficients across countries within a region and to impose equality constraints when justified by these tests. Such constraints reduce the number of coefficients to be estimated and thereby increase the degrees of freedom.

3. The traditional problem of multicollinearity between prices and income in time-series demand studies is minimized by pooling cross-section and time-series observations. The cross-sectional observations increase the variance of the independent variables and constraints on the coefficients have the same effect as increasing the sample size. Both of these effects tend to increase the

precision of the estimates.

There are some problems that are introduced by pooling the data. First, the stochastic component of the pooled model may not have all the good properties required in order that the ordinary least squares estimator be efficient. This will be addressed after the general model is presented. Second, the data must be in the same units of measurement across countries. Quantity units are usually standardized, but exchange rates must be used to standardize the monetary units. When all price and income data are deflated, they are in 1970 real currency units of respective countries. Therefore the 1970 exchange rate with respect to the U.S. dollar is used to transform all monetary data into 1970 U.S. dollars. Since this involves multiplication by a constant it only changes the estimated coefficients by a constant.[14]

A fully constrained[15] pooled model for n countries over T time periods is written

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[14]Consider an estimated equation in national currency units:

$$Q_t = \hat{\alpha} + \hat{\beta} P_t + u_t$$

If the 1970 exchange rate is r_{70} and prices are transformed to 1970 dollars the estimated equation will be

$$Q_t = \hat{\alpha} + \hat{\beta}^* (r_{70} P_t) + u_t$$

where $\hat{\beta}^* = \hat{\beta}/r_{70}$.

[15]Assumes that each coefficient is constant across all countries in the region.

$$(3.1)\quad Q_{it} = b_0 + b_1P_{it} + b_2I_{it} + b_3Z_{it} + e_{it} \qquad i=1,2,\ldots,n \quad t=1,2,\ldots,T$$

or in matrix notation as

$$(3.1)\quad Q = XB + e$$

where

$$Q = \begin{bmatrix} Q_{11} \\ Q_{12} \\ \cdot \\ Q_{1T} \\ Q_{21} \\ \cdot \\ Q_{2T} \\ \cdot \\ \cdot \\ Q_{nT} \end{bmatrix} \qquad XB = \begin{bmatrix} 1 & P_{11} & I_{11} & Z_{11} \\ 1 & P_{12} & I_{12} & Z_{12} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & P_{1T} & I_{1T} & Z_{1T} \\ \cdot & P_{21} & I_{21} & Z_{21} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & P_{2T} & I_{2T} & Z_{2T} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ 1 & P_{nT} & I_{nT} & Z_{nT} \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix} \qquad e = \begin{bmatrix} e_{11} \\ e_{12} \\ \cdot \\ e_{1T} \\ e_{21} \\ \cdot \\ e_{2T} \\ \cdot \\ \cdot \\ e_{nT} \end{bmatrix}$$

A fully unconstrained model includes n-1 country dummy variables for the intercept and each of the three independent variables. A pooled regression with these 4(n-1) added variables is equivalent to separate regressions for each country. The fully unconstrained model[16] is written

$$(3.3)\quad Q_{it} = b_{i0} + b_{i1}P_{it} + b_{i2}I_{it} + b_{i3}Z_{it} + e_{it} \qquad i=1,2,\ldots,n \quad t=1,2,\ldots,T$$

The test for the equality of all coefficients is an F-test of the

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[16] Assumes that each coefficient is different in each country of the region.

null hypothesis, H_0: $b_{i0} = b_{j0}$ all i,j

$b_{i1} = b_{j1}$ all i,j

$b_{i2} = b_{j2}$ all i,j

$b_{i3} = b_{j3}$ all i,j

where the alternative hypothesis is, H_a: no constraints. Fisher[17] has shown that the statistic

$$F = \frac{(u'u - v'v)/(4n - 4)}{v'v/(Tn - 4n)}$$

has an F distribution with 4n-4 and Tn-4n degrees of freedom, where

u'u = the sum of squared residuals under the null hypothesis (the constrained regression)

v'v = the sum of squared residuals under the alternative hypothesis (the unconstrained regression)

4n = the number of estimated coefficients in the unconstrained regression

4 = the number of estimated coefficients in the constrained regression

Tn = total number of observations in the pooled regression.

Of course, it is not very likely that all coefficients are equal, but the primary interest here is to test the equality of coarse grain price and income coefficients.

As noted, the stochastic component of the pooled model may

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[17] F. Fisher, "Tests of Equality between Sets of Coefficients," Econometrica 38 (March 1970), pp. 361-366.

problematic. Assuming that the explanatory variables are independent of the random disturbance term and there are no serious errors in specification or measurement, the OLS estimator is unbiased and consistent. The OLS estimator is also efficient if the disturbance e_{it} satisfies the following conditions (Kmenta):

(3.4) $E(e_{it}\ e_{jt}) = 0$ $\quad i \neq j$ cross-sectional independence

(3.5) $E(e_{it}\ e_{is}) = 0$ $\quad t \neq s$ non-autoregression

(3.6) $E(e_{it}^{2}) = \sigma^{2}$ $\quad$ homoscedasticity

Contemporaneous correlation in the disturbances is not likely to be a serious problem when the cross-sectional units are countries rather than regional units within a country, and there is no clear evidence of contemporaneous correlation in the results. Likewise the Durbin-Watson statistics from the unconstrained regressions were in the range of uncertainty, indicating no serious problems with autoregression (Appendix Tables 3.4 and 3.6). However, a comparison of error variances revealed the presence of heteroscedasticity, especially in the EC model (Appendix Table 3.5).

In the generalized least squares (GLS) regression for the European Community, cross-sectional independence and non-autoregression were assumed. To correct for heteroscedasticity, high variance and low variance countries were grouped, and the variance of disturbances for each group was estimated (Appendix Table 3.5). The GLS estimates are obtained by dividing all variables in the high variance group by the group standard error and all variables in the low variance group by the low variance group standard error. These weights are normalized so that the low variance group weight is 1.0 and the high variance group weight is 0.32575 (Appendix Table 3.5).

The specification of the block 2 feed demand equations and the variable definitions are as follows:

EUROPEAN COMMUNITY

(BELX) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, ANX_t, u_{it})$

(FRAN) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, FD, u_{2t})$

(ITAL) $QFEDC_t = f(PCG_t, I_t, ANX_t, ID, u_{3t})$

(NETH) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, LT_t, ND, u_{4t})$

(WGER) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, ANX, GD, u_{5t})$

(DENM) $QFEDC_t = f(PCG_t, I_t, PM_t, u_{6t})$

(IREL) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, u_{7t})$

(UKIN) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, u_{8t})$

OTHER WEST EUROPE

(ASTI) $QFEDC_t = f(PCG_t, I_t, PM_t, WFEDC_t, AD, u_{9t})$

(FINL) $QFEDC_t = f(PCG_t, I_t, u_{10t})$

(GREE) $QFEDC_t = f(PCG_t, I_t, PM_t, u_{11t})$

(NORW) $QFEDC_t = f(PCG_t, I_t, PM_t, u_{12t})$

(PORT) $QFEDC_t = f(PCG_t, I_t, PD, u_{13t})$

(SPAI) $QFEDC_t = f(PCX_t, I_t, WFEDC_t, u_{14t})$

(SWED) $QFEDC_t = f(PCG_t, I_t, u_{15t})$

(SWIT) $QFEDC_t = f(PCG_t, I_t, u_{16t})$

Endogenous Variables

QFEDC = coarse grain demand for feed per capita, kg.

Exogneous Variables

ANX = value of net exports of animal products per capita, $

I = private consumption expenditure per capita, $

PCG = average price paid by farmers for barley (corn for ITAL, NETH, PORT, SWIT), $/100 kg.

PCX = average U.S. corn price net of export subsidy adjusted for currency changes, $/100 kg.

PM = average U.S. wholesale price of soybean meal at Decatur adjusted for currency changes, $/short ton

WFEDC = quantity of wheat fed per capita, kg.

AD = dummy variable, 1 (1968), 0 (elsewhere)

FD = dummy variable, 1 (1967), 0 (elsewhere)

GD = dummy variable, 0 (1960 to 1966), 1 (elsewhere)

ID = dummy variable, 1 (1960 to 1962), 0 (elsewhere)

LT = log trend, 1957=ln(2), 1958=ln(3), etc.

ND = dummy variable, 0 (1960 to 1967), 1 (elsewhere)

PD = dummy variable, 1 (1969 to 1971), 0 (elsewhere)

The GLS estimates for the European Community (EC) are reported in Table 3.6. The linear, double-log, semi-log and log-inverse forms of equation were tried, and all gave similar results in the unconstrained regressions. However, the constrained regression (holding price and income coefficients constant) is acceptable only for the double-log form. Therefore the double-log form of

Table 3.5. Constrained Generalized Least Squares Estimates of Per Capita Coarse Grain Feed Demand from the Pooled Cross-Section Time-Series Model, European Community, Double-Log Form

COUNTRY	ln(PCG)	ln(I)	ln(PM)	WFEDC	ANX	Dummy	CONST
BELX	-0.2120	0.5565	--	-0.0055	0.0046	--	2.0383
(t)	(6.60)	(15.12)		(3.90)	(1.08)		(6.75)
FRAN	-0.2120	0.5565	--	-0.0024	--	0.0998	1.9300
(t)	(6.60)	(15.12)		(3.20)		(3.66)	(7.03)
ITAL	-0.2120	0.5565	--	--	0.0025	-0.2076	1.9003
(t)	(6.60)	(15.12)			(2.16)	(9.69)	(6.91)
NETH*	-0.2120	0.5565	--	-0.0036	--	-0.2382	3.5038
(t)	(6.60)	(15.12)		(2.32)		(2.61)	(9.98)
WGER	-0.2120	0.5565	--	-0.0037	0.0080	0.0701	1.8621
(t)	(6.60)	(15.12)		(2.66)	(1.44)	(1.70)	(6.13)
DENM	-0.2120	0.5565	0.0677	--	--	--	2.9473
(t)	(6.60)	(15.12)	(1.91)				(9.01)
IREL	-0.2120	0.5565	--	-0.0038	--	--	2.7317
(t)	(6.60)	(15.12)		(2.06)			(9.30)
UKIN	-0.2120	0.5565	--	-0.0023	--	--	1.7141
(t)	(6.60)	(15.12)		(3.15)			(6.05)

$\bar{R}^2$ = .99 D.W. = 1.94 d.f. = 87

*log trend term has coefficient = -0.5206
(t) = (5.05)

equation was selected for the EC. Price and income coefficients were constrained across all countries and other variables were unconstrained.[18] Variables with t-statistics below 1.0 were deleted.

The estimated price and income elasticities are in the range between the U.S. and Canada estimates. The only significant high protein price effect is for Denmark, and it is similar in magnitude to that of the U.S. The effect of wheat fed was significant in all countries but Italy and Denmark where wheat is less than 4 percent of total fed grain. As with rice feeding in Japan, wheat fed in the EC was strongly influenced by government policies which were better reflected in quantities than in wheat prices. The magnitudes of the coefficients on fed wheat are not as meaningful in the double-log equation as in the linear form, but as a comparison the Ireland coefficient of -.0038 is approximately equivalent to -1.0 in the linear form.

The effect of animal exports (or imports) was significant only in BELX, Italy and West Germany. The signs are correct--more exports or fewer imports increase domestic feed demand--but the magnitudes are again not easily interpreted. A comparison to the linear estimates for West Germany showed that the coefficient 0.008 was approximately equivalent to a coefficient of 1.0 in the

[18]The Fisher test shown on the lower part of Appendix Table 3.5 was applied to test the null hypothesis that the constraint caused no increase in the sum of squared errors. The null hypothesis could not be rejected at the 5 percent level of significance.

linear form. That is, a one-dollar increase in animal product exports increased demand for coarse grains by 1 kilogram. Actually the differences in the net export position of the EC countries is reflected mainly in the intercepts which were largest for the major exporters (Netherlands, Denmark and Ireland) and smallest for the major importers (Italy, West Germany and the U.K.).

Many of the dummy shift variables appear to be associated with the EC unified price policy that was adopted as of July 1, 1967. France apparently had a short-run glut in 1967/68 that was not reflected in the price level. In 1966, the West Germany requirement that mixed feed have a 50 percent animal protein content was removed, thereby shifting coarse grain demand upward. The sophisticated feed mixing industry of the Netherlands shifted rapidly to increased use of "other energy ingredients"[19] in 1968/69 thereby shifting coarse grain demand downward. The trend term in the Netherlands is associated with a long-run shift from other coarse grains to corn from the mid-fifties to the early seventies. Since corn has a greater feed value per quantity unit, substitution of corn for other grains, like a technological change, makes it possible to produce the same quantity of animal products with a smaller grain input.

The Italy dummy variable coincides with the adoption of the EC common agricultural policy (CAP) in 1962. Under the CAP, Italy

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[19] FAS, "Dutch Feed Mixtures Influenced by EC Grain Import Levies," Foreign Agriculture Circular, Grains, FG 3-76, March 1976.

changed from a state trading system to a private trading system. The upward shift in feed grain consumption after 1962 appears to be associated with this institutional change. One plausible explanation for the shift is that there were illegal private imports before the CAP which were not reflected in the national consumption statistics.

The unconstrained estimates for Other West Europe (OWE) shown in Appendix Table 3.6 have generally higher income and price elasticities than those of the EC and considerably more variability across countries. Perhaps the latter should not be surprising in view of the fact that the OWE is a more heterogeneous group of countries than the EC. In any case, attempts to impose cross-country constraints were unsuccessful and efforts were directed instead to separate country regressions. Since the estimated income elasticities are nearly twice those of the EC it seemed important to use a semi-log or log-inverse from of equation for the long-run projections. The semi-log form is selected whenever possible because it permits both the price and income elasticities to decline as consumption rises. In the cases of Norway and Switzerland the semi-log form does not perform well so the log-inverse form is used.[20]

The results given in Table 3.6 show estimated income

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[20]The double-log specification is changed to log-inverse form by replacing the log of income with the inverse of income, and the elasticity equals the estimated income coefficient times -1.0 over the income level.

Table 3.6. Coarse Grain Feed Demand Estimates for Other West Europe, Semi-Log (SL) and Log-Inverse (LI) Forms

COUNTRY (Form)	PCG	I	PM	WFEDC	Dummy	$\bar{R}^2$	D.W.	CV d.f.
ASTI(SL)	-10.090	210.59	-0.2616	-0.8513	27.430	.92	2.64	0.04
(t)	(0.91)	(2.44)	(2.29)	(1.75)	(2.14)			8
e	-.45	.94	-.11					
e*	-.28	.72	-.08					
FINL(SL)	-10.340	413.71	--	--	--	.92	2.30	0.08
(t)	(4.20)	(9.31)						11
e	-.41	1.30						
e*	-.27	.95						
GREE(SL)	-10.414	120.34	0.2706	--	--	.91	2.24	0.10
(t)	(1.45)	(6.27)	(1.74)					10
e	-.76	.91	.19					
e*	-.45	.56	.15					
NORW(LI)	-0.4598	-1038.26	-0.0942	--	--	.90	2.05	0.01
(t)	(1.62)	(2.00)	(1.17)					10
e	-.46	.73	-.09					
e*	-.46	.61	-.09					
PORT(SL)	-12.049	135.99	--	--	-37.196	.88	2.60	0.09
(t)	(1.66)	(3.60)			(3.05)			10
e	-1.04	1.14						
e*	-.59	.74						

(continued)

Table 3.6.--continued

COUNTRY (Form)	PCG	I	PM	WFEDC	Dummy	$\bar{R}^2$	D.W.	CV d.f.
SPAI(SL)	-10.322	252.19	--	-0.9787	--	.94	2.36	0.07
(t)	(1.45)	(11.93)		(1.27)				10
e	-.27	1.25						
e*	-.22	.85						
SWED(SL)	-8.7762	253.19	--	--	--	.78	1.83	0.06
(t)	(1.80)	(4.23)						11
e	-.34	.85						
e*	-.22	.71						
SWIT(LI)	-1.091	-1781.38	--	--	--	.86	2.42	0.02
(t)	(1.20)	(0.94)						11
e	-1.09	1.03						
e*	-1.09	0.82						

t = t-statistic (absolute value)
e = elasticity at means
e* = elasticity for 1973
CV = standard error/mean
d.f. = degrees of freedom

elasticities at historical means that are higher than those estimated for the EC and lower than the estimate for Japan. The income elasticities range from 1.30 for Finland to 0.73 for Norway and the price elasticities range from -.27 for Spain to -1.09 for Switzerland. In general, higher price elasticities are associated with higher income elasticities, which is consistent with the implications of the Slutsky equation.[21] Based on the log-inverse and semi-log coefficients it is not possible to associate the different income elasticities strictly with differences in income or per capita consumption.[22] There are many factors which influence these elasticities including the composition of final product consumption and the structure of the animal products industry,

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[21]The Slutsky equation is formulated in the context of final demand, but as shown in section 3.1 the reduced-form elasticities are closely related to final demand elasticities. The Slutsky equation expressed in elasticities is

$$\varepsilon_p = \varepsilon_c - \alpha\eta$$

where ε_p = price elasticity of demand
ε_c = compensated demand price elasticity (holding consumer utility constant)
α = proportion of expenditure spent on the product
η = income elasticity

Ceteris paribus, a higher income elasticity is associated with a higher ordinary price elasticity (see Henderson and Quandt, pp. 31, 32).

[22]For example, if the differences in income elasticity were related only to differences in income level, one would expect the log-inverse income coefficients to be similar in magnitude.

which differ across countries.[23] The 1973 elasticities for "Other West Europe" are approaching the levels of those in the EC.

The meal price coefficients are significant in Austria, Greece and Norway and the cross price elasticities are small. In Austria and Norway the cross price elasticities are negative, indicating either a weak substitution effect or a complementary relationship between coarse grains and high protein inputs.[24] Wheat fed is significant for Austria and Spain, and both coefficients are near -1.0, which is reasonable. The dummy variables for Austria and Portugal are to account for quirks in the data which were not found in comparable OECD data and could not be otherwise explained.

The specification of the block 2 coarse grain food demand equations and variable definitions are as follows:

<u>EUROPEAN COMMUNITY</u>

$QFOD_t = f(PFG_t, Y_t, ECD, u_{1t})$

<u>OTHER WEST EUROPE</u>

$QFOD_t = f(PFG_t, Y_t, u_{2t})$

<u>Endogenous Variables</u>

QFOD = coarse grain demand for food, 1000 metric tons

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[23] An industry with more fixed inputs will require a greater proprotionate increase in variable inputs to achieve a given percent growth in output. As demonstrated with the simple model in Appendix Table 3.1, this would result in larger reduced-form elasticities for price and income.

[24] R.G.D. Allen, <u>Mathematical Analysis for Economists</u> (New York: St. Martin's Press, 1938), pp. 373-374, 505-509.

Exogenous Variables

PFG = regional weighted average of coarse grain food prices, $/100 kg.

Y = regional private consumption expenditure, million dollars

ECD = dummy variable, 1 (1960 to 1970), 0 (elsewhere)

The results of these regressions are presented in Table 3.7. As expected, the food demand tends to be more price inelastic and less income elastic than feed demand. The price variable for the EC is not significant and is dropped from the equation. The dummy variable represents an unexplained upward shift in the food consumption series beginning in 1971. The price and income variables in the OWE equation are marginally significant and the explanatory power of the equation is low. This may be due to excluded variables that cause serial correlation in the residuals and reduce the efficiency of the estimates. Efforts to correct this using a two-stage Cochrane-Orcutt procedure were not successful, perhaps because of the limited degrees of freedom. Nevertheless, these estimates are unbiased and the elasticities have reasonable magnitudes, so they were considered adequate for the food demand projections.

3.3 Specification and Empirical Results for the USSR

The equation for the USSR is not a demand equation in the usual sense, but simply relates the quantity of coarse grain consumption to income and domestic production. The specification of the function is based on the hypothesis that livestock production

Table 3.7. Regional Estimates of Food Demand for the European Community

REGION	PFG	ln(Y)	Dummy	CONST	$\bar{R}^2$	D.W.	CV d.f.
EC9	--	6565.06	-2130.75	-68179.33	.97	2.56	0.03
(t)		(8.98)	(6.63)	(7.22)			11
e		.50					
e*		.39					
OWE	-163.43	1051.81	--	-6866.82	.76	0.78	0.07
(t)	(1.44)	(1.41)		(0.73)			11
e	-.59	.34					
e*	-.38	.26					

t = t-statistic (absolute value)
e = elasticity at means
e* = elasticity for 1973
CV = standard error/mean
d.f. = degrees of freedom

plans and food use are influenced by income growth and constrained by the level of domestic production. The retail price of meat was raised only in 1962 and a dummy variable is included to reflect the possible effects of that policy change. The quantity of wheat fed is also included in the specification for feed demand to account for the substitution effects. The specification of the USSR consumption relations and variable definitions are as follows:

FEED

$$QFED_t = f(INC_t, QPDN_t, WFED_t, UD, u_{1t})$$

FOOD

$$QFOD_t = f(INC_t, QPDN_t, u_{2t})$$

Endogenous Variables

QFED = coarse grain feed consumption, 1000 mt.

QFOD = coarse grain food consumption, 1000 mt.

Exogenous Variables

INC = wage and salary income, mil. rubles

QPDN = domestic coarse grain production, 1000 mt.

WFED = quantity of wheat fed, 1000 mt.

UD = dummy variable, 1 (1960 to 1962), 0 (elsewhere)

The results of the semi-log estimates are presented in Table 3.8. The income and production variables are significant at the 5 percent level or better in both equations, and the wheat fed and policy variables are marginally significant. The explanatory

Table 3.8. Coarse Grain Consumption Relations for the USSR, Semi-Log Form

DEPENDENT VARIABLE	ln(INC)	QPDN	WFED	UD	CONST	$\bar{R}^2$	D.W.	CV d.f.
QFED	40956.7	0.5307	-0.1490	3649.4	-400541	.99	2.54	0.04
(t)	(3.48)	(6.10)	(1.13)	(1.49)	(3.59)			10
e	.89							
e*	.53							
QFOD	-9832.0	0.2583			102434	.49	2.39	0.11
(t)	(2.20)	(3.61)			(2.47)			12
e	-.49							
e*	-.41							

t = t-statistic (absolute value)
e = elasticity at means
e* = elasticity for 1974
CV = standard error/mean
d.f. = degrees of freedom

power of the feed equation is excellent, while the food equation explains approximately 50 percent of the variation in food consumption. The Durbin-Watson statistics are in the inconclusive region so there is no strong evidence of serial correlation. More importantly, the coefficients have the correct signs and appear to have reasonable magnitudes. The income elasticity for feed demand is similar to those estimated for OWE, and the food demand income elasticity is negative, implying it is an inferior good. The wheat fed coefficient is negative, though not as large as might be expected. The dummy variable shows a higher feed consumption during the period of lower meat prices. This indicates that the retail price affects meat demand but not meat supply, which is plausible in a planned economy.

The coefficients on domestic production measure the extent to which shortfalls (or surpluses) in production are offset by increases (or decreases) in net imports. The coefficient 0.53 implies that roughly half of the shortfall in a poor year is made up in imports and the remainder is absorbed by a decline in consumption. The coefficient of 0.26 in the food equation indicates that food consumption is less sensitive to variation in production. If these results are combined in an import demand relation they are similar to results obtained in a recent study on import demands in Eastern Europe.[25]

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[25] M.E. Ryan and J.P. Houck, "Eastern Europe, a Growing Market for U.S. Feed Grains," Economic Report 76-7, Department of Agricultural and Applied Economics, University of Minnesota, Nov. 1976.

The import demand (QM_t) derived from the two estimated equations is

(3.7) $QM_t = (QFED_t + QFOD_t) - QPDN_t$.

Substituting the coefficients on the production variable and representing all other variables with Z_{it} we obtain:

(3.8) $QM_t = (\sum_i \alpha_i Z_{it} + .789\ QPDN_t) - QPDN_t$

(3.9) $QM_t = \sum_i \alpha_i Z_{it} - .211\ QPDN_t$.

By comparison, the import demand equations estimated by Ryan and Houck for Poland, Czechoslovakia and Hungary had significant coefficients on the respective production variables with magnitudes of -.18, -.26, and -.25. The implied coefficient of -.21 for the USSR is of the same order of magnitude.

3.4 Specification and Empirical Results for Block 1 Price Linkages

In order for the coarse grain sector model to have an equilibrium solution, price linkages must be established between the countries in block 1. The European countries in block 2 are assumed to have policy determined prices over the projection period, and those assumptions are discussed in Chapter 4. Canada has a complex system of pricing and marketing of grains operated by the Canadian Wheat Board, but their price quotations tend to be influenced by prices across the border in U.S. markets. In particular, barley price quotations are increasingly tied to U.S.

corn prices. The price variable for Japan is the price index of imported corn, and the U.S. share of these imports has exceeded 50 percent since 1963. The only major import restriction affecting coarse grains was a quota on sorghum imports which was lifted in 1964. It is reasonable therefore to link the Canadian barley price and the Japanese corn price index to the U.S. corn price for projection purposes.

The price series on the U.S. Gulf-port price of corn does not extend back beyond 1962, so an export price proxy (EXPC) was generated from the U.S. average farm price (UPC) and the average export subsidy (XSUB) as follows:

$$\text{(3.10)} \quad EXPC = 2.2046(UPC - XSUB) \quad .$$

This variable is in units of dollars per 100 kilograms and has a simple correlation coefficient of 0.994 with the Gulf-port price of corn for the period 1962 to 1974. An estimated linear relation between these variables is presented in Table 3.9.

Since all prices in the model are deflated, the desired linkages are between real price levels. However, spatial equilibrium is generally defined in terms of nominal prices, using annual exchange rates to convert to common currency units. This leads to a price linkage of the form

$$\text{(3.11)} \quad \frac{NP_{it}}{r_{it}} = M_{it} + NXPC_t$$

where M_i = price margin including fixed tariffs and transport costs in U.S. dollars

NP_i = nominal price of grain in ith country in local currency

NXPC = nominal U.S. export price of grain in U.S. dollars

r_i = exchange rate in local currency per U.S. dollar

An analogous relation can be formulated for real prices. Prices in this model are first deflated by the consumer price index (CPI) with base year 1970, then transformed to 1970 U.S. dollars with the 1970 exchange rate (r_{70}). This 1970 real dollar price (RDP) is

$$(3.12) \quad RDP_{it} = NP_{it}/(CPI_{it} \cdot r_{i70}) \quad .$$

By performing some algebraic operations to equation 3.11, the relationship linking real price (RDP) to the real U.S. price (EXPC) and a real margin (RM) is equivalent to deflating both sides of (3.11) by the U.S. CPI and can be written:

$$(3.13) \quad \frac{RDP_{it}}{K_{it}} = RM_{it} + EXPC_t$$

where

$$K_{it} = \frac{r_{it} \cdot USCPI_t}{r_{70} \cdot CPI_{it}} \quad .$$

Allowing for constant and marginal effects, a simple equation can be specified to estimate this relationship:

$$(3.14) \quad \frac{RDP_{it}}{K_{it}} = \hat{\alpha} + \hat{\beta}\, EXPC_t + u_t \quad .$$

For projection purposes then, assumptions need only be made about the level of K_{it} since the projection relation would be

$$(3.15)\quad RDP_{it} = K_{it}(\hat{\alpha} + \hat{\beta}\ EXPC_t) \quad .$$

The parameter K_{it} is related to the "purchasing-power parity hypothesis" of the international trade literature. The "relative version" of this hypothesis expressed in terms of the components of K_{it} is that the current equilibrium exchange rate is approximately equal to the base exchange rate times the relative current price levels:

$$(3.16)\quad r_{it} \simeq r_{i70} \frac{CPI_{it}}{USCPI_t} \quad .$$

That is, exchange rates adjust to compensate for differing rates of inflation. It is clear from (3.16) that if the "purchasing-power parity hypothesis" holds in practice, K_{it} would remain close to 1.0 over time. Caves and Jones[26] specify that the base period should be a "reasonably normal" year, which is hardly the case for the year just prior to the major currency readjustments of 1971 and 1972.

There are other reasons why the hypothesis may not hold up in practice, but Yeager found that it "performed reasonably well"[27] in predicting equilibrium exchange rates in the period

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[26] R.E. Caves and R.W. Jones, World Trade and Payments (Boston: Little, Brown and Co., 1973), pp. 335-339.

[27] L.B. Yeager, "A Rehabilitation of Purchasing-Power Parity," Journal of Political Economy 66 (December 1958), pp. 516-530.

1937 to 1957. To test the hypothesis with recent data, K_{it} was calculated for Canada, Japan and 16 West European countries using data from 1960 to 1973. The hypothesis that $\overline{K}_i = 1$ was tested and could not be rejected at the 5 percent level in 14 of the 18 countries. Out of the 252 cases, all but 36 (15 percent) were within 15 percent of 1.0; and half of these outliers occurred during the currency readjustment from 1971 to 1973. Due to the increased flexibility of exchange rates since 1971, the hypothesis should perform better in the period after 1973 than in the previous decade.

The purpose here is not to debate the merits or failures of the purchasing-power parity hypothesis, but rather to indicate that K_{it} is a relatively stable parameter over the long run and becomes more so as the flexibility of exchange rates increases. Certainly, long-run assumptions about any of its separate components would of necessity be more arbitrary than assumptions about K_{it}. The latter assumptions will be discussed in the next chapter and are based on recent values of K_{it} that reflect the currency readjustments of 1971 and 1972.

The most satisfactory specification for the Canada barley price relation includes a constant term only up to 1971, implying that the price relationship changed under the higher price regime of the last three years. Thus a dummy variable (CD71) is used, so the intercept is $\hat{\alpha}$ from 1960 to 1971 and zero from 1972 onward. The specification is

$$(3.17)\quad CPB_t/KC_t = \hat{\alpha}\ CD71 + \hat{\beta}\ EXPC_t + u_t$$

where CD71 = dummy variable, 1 (1960 to 1971), 0 (elsewhere)

CPB = average Canadian Wheat Board selling price for No. 3 Canadian Western 6-row barley (deflated by CPI)

EXPC = export price proxy as defined in (3.10) above (deflated by U.S. CPI)

KC = "purchasing-power parity parameter" for Canada as defined in (3.13) above.

The results in Table 3.9 show that the Canadian barley price has a 40 percent differential over the U.S. corn price in recent years and a smaller differential before 1972. Part of this differential is due to the fact that the U.S. price proxy is based on the farm price of corn rather than the export price.

The Canadian feed equation includes the price of wheat as an independent variable, so some assumption must be made about the formation of the Canadian wheat price over the projection period. Since the Canadian Wheat Board administers both prices, the historical relationship between wheat and barley prices is a reasonable behavioral assumption for the projection period. The relationship estimated is

$$(3.18)\quad CPW_t = \hat{\alpha} + \hat{\beta}\ CPB_t + \hat{\gamma}\ CD73 + u_t$$

where CD73 = dummy variable, 1 (1973), 0 (elsewhere)

CPB = average Canadian Wheat Board selling price for No. 3

Table 3.9. Regression Estimates of Price Linkages Used in the Coarse Grain Model

DEPENDENT VARIABLE	EXPC	CD71	CONST	$\bar{R}^2$	D.W.	CV d.f.
GULFPC (t)	1.0580 (29.59)		0.7437 (3.46)	.99	1.84	0.03 11
CPB/KC (t)	1.4012 (42.70)	-0.8559 (3.93)		.96	2.09	0.06 13
	CPB	CD73	CONST	$\bar{R}^2$	D.W.	CV d.f.
CPW (t)	1.1658 (20.33)	2.962 (6.22)	0.2137 (0.51)	.99	2.28	0.04 11
	ΔEXPC	$EXPC_{-1}$	CONST	$\bar{R}^2$	D.W.	CV d.f.
JPC/KJ (t)	11.055 (7.64)	16.719 (11.80)	14.175 (1.76)	.93	2.00	0.05 11

t = t-statistic (absolute value)
CV = standard error/mean
d.f. = degrees of freedom

Canadian Western 6-row barley (deflated by CPI)

CPW = average Canadian Wheat Board selling price for No. 2 Northern Wheat (deflated by CPI).

The 1973 observation was omitted because the Wheat Board's price policy that year was significantly different from that in 1974 and resulted in a substantially higher average price than would otherwise have obtained.[28]

The results in Table 3.9 show that the 1973 wheat price was \$2.96 above the prediction line. The constant is not significant and the wheat price is about 17 percent above the barley price over the historical period.

The Japan-U.S. price linkage is different from the Canadian linkage in two ways. One is that the Japanese "price" is an index. The other is that the Japanese crop year is April-March compared with July-June for the U.S., and prices like quantities are crop-year values. The first is not really a problem. Since a price index is formed by multiplying (or dividing) every price in the series by a single constant, it merely changes the units of the dependent variable and alters the estimated coefficients by the same constant factor. The second difference implies that the Japan April-March price may be more closely related to the April-March or even the March-February average U.S. price than to the July-June average. A simple approach which allows the

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[28] The Canadian Wheat Board Annual Report (Winnipeg, Canada, January 31, 1976), pp. 7, 20-24.

data to determine this time period relationship is shown in the specification below[29]:

$$(3.19)\quad JPC_t/KJ_t = a + b[\delta \cdot EXPC_t + (1-\delta)\ EXPC_{t-1}]$$

The corresponding estimation model is

$$(3.20)\quad JPC_t/KJ_t = \hat{\alpha} + \hat{\beta}(EXPC_t - EXPC_{t-1}) + \hat{\gamma}\ EXPC_{t-1} + u_t$$

where EXPC = export price proxy as defined in (3.10) above (deflated by U.S. CPI)

JPC = wholesale price index of imported corn in Japan (deflated by CPI)

KJ = "purchasing-power parity parameter" for Japan as defined in (3.13) above

$\hat{\beta}$ = the OLS estimate of $b \cdot \delta$

$\hat{\gamma}$ = the OLS estimate of b

δ = the time period parameter ($0 < \delta < 1$).

It is clear that $\hat{\beta}/\hat{\gamma}$ is an estimate of the time period parameter δ. The results of this regression in Table 3.9 show that $\hat{\delta}$ = 0.661 which corresponds to about 8 months.[30] This means that

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[29]This method was previously used by M. Bredahl and D. Tischendorf, "Price Formation of Soybeans and Soybean Meal: The U.S. and Germany," unpublished manuscript, University of Minnesota, February 1977.

[30]Since $\hat{\delta}$ is a nonlinear function of the unrestricted coefficients $\hat{\beta}$ and $\hat{\gamma}$, the variance of $\hat{\delta}$ must be approximated from a truncated Taylor expansion. The calculated result is a standard error of 0.099 and a t-statistic for $\hat{\delta}$ of 6.67.

the dependent variable is best explained by the March-February average of U.S. export prices[31], which is reasonable in view of possible lags in the market process.

These price linkages all have "good fit" as indicated by the high adjusted $\overline{R}^2$; and the hypothesis of no autocorrelation in the disturbance term cannot be rejected at the 5% level of significance, so serial correlation is not a problem.

[31] Of course, this weighted average of the July-June prices is an approximation of the March-February average and is not necessarily equal to the value that would be obtained from the monthly data.

Chapter 4

COARSE GRAINS PROJECTION MODEL

This chapter describes the components of the coarse grains projection model, its historical performance, the projection assumptions, and the projection results.

4.1 Quantity Components and Quantity Equilibrium

The model for coarse grains has three demand blocks, as outlined in Chapter 2 above. The first is composed of demand in Canada, Japan and the U.S., where prices are linked to the U.S. price of corn. The second block includes the countries of West Europe, where prices are assumed to be policy determined. The third includes the USSR, Eastern Europe and all remaining countries and regions of the world, where the price response is based on elasticity assumptions.

In the block 1 countries it is assumed that internal prices are determined by the supply and demand equilibrium in the world model. All prices are tied to the U.S. export price of corn through the price linkages which were discussed in Chapter 3. The per capita demand relations presented in Chapter 3 are combined to determine total coarse grain demand for each country as seen in (1) of Table 4.1. The horizontal summation of the three country demands to determine total block 1 demand is illustrated in Figure 4.1.

In the block 2 countries of West Europe it is assumed that

Table 4.1. Quantity Equilibrium in the Coarse Grains Model

BLOCK 1 (USA, CAN, JPN)

(1) $QD_{it} = N_{it}(QFEDC_{it} + QFODC_{it})$ $\quad i = 1, 3$

BLOCK 2 (West Europe except Iceland and Malta)

(2) $N_{jt}(QFEDC_{jt})$ $\quad j = 1, 16$ (jth country)

(3) $QFOD_{it}$ $\quad i = 4, 5$ (ith region)

(4) $QD_{4t} = QFOD_{4t} + \sum_{j=1}^{8} N_{jt}(QFEDC_{jt})$

(5) $QD_{5t} = QFOD_{5t} + \sum_{j=9}^{16} N_{jt}(QFEDC_{jt})$

BLOCK 3 (18 regions)

(6) $QD_{it} = QFOD_{it} + QFED_{it}$ $\quad i = 6, 23$

EQUILIBRIUM

(7) $QM_{it} = QD_{it} + CST_{it} - QP_{it}$ $\quad i = 1, 23$ import demand

(8) $\Sigma QM_{it} = 0$ trade identity

(9) $\Sigma QD_{it} = \Sigma QS_{it} - \Sigma CST_{it}$

(10) $\Sigma QD_{it} = WQP_t - WCST_t$ equilibrium condition

where CST = change in coarse grain stocks (end-beginning)
N = population
QD = total coarse grain demand
QFED = total coarse grain fed
QFOD = total coarse grain not fed
QFEDC = per capita coarse grain fed
QFODC = per capita coarse grain not fed
QM = coarse grain imports (negative for exports)
QP = coarse grain production
WCST = world change in coarse grain stocks
WQP = world coarse grain production

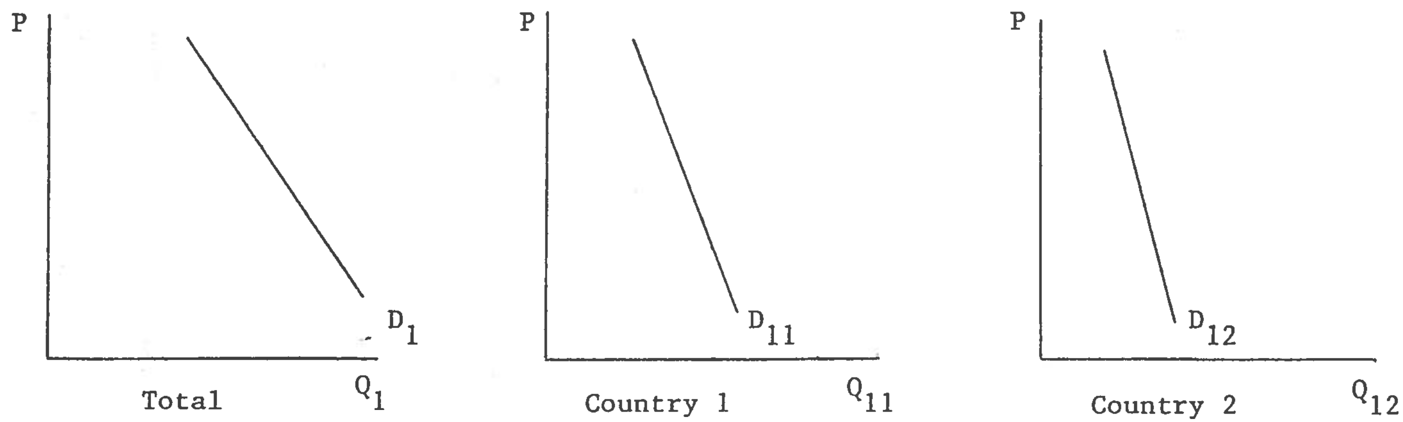

Figure 4.1. The Summation of Coarse Grain Demand for Block 1 Illustrated for Two Countries.

internal prices are determined by government policy and are not affected by world price unless the latter goes above a critical level. This conditional linkage is described in the next section. The per capita feed demand and regional food demand relations presented in Chapter 3 are combined, as seen in (2) to (5) of Table 4.1, to determine total coarse grain demand for the EC-9 (4) and the "other-8" (5). Since internal prices are exogenous, the summation (Figure 4.2) generates a kinked demand curve for block 2 which is perfectly inelastic up to the lowest internal price level.

Block 3 includes the central planned economies, the third world regions and small developed countries not included in blocks 1 and 2. Except for the USSR, demand projections in this block are based on assumed levels of population growth, income growth and income elasticities. From consumption in the base year, the projection of demand in year t is calculated with the relations:

$$(4.1)\quad QFOD_{it} = QFOD_{i0}(1 + \hat{N}_i + \eta_{i1}\hat{I}_i)^t$$

$$(4.2)\quad QFED_{it} = QFED_{i0}(1 + \hat{N}_i + \eta_{i2}\hat{I}_i)^t$$

where $\hat{I}$ = annual rate of growth in per capita private consumption expenditures

$\hat{N}$ = annual rate of population growth

η_{i1} = income elasticity of coarse grain food demand

η_{i2} = income elasticity of coarse grain feed demand

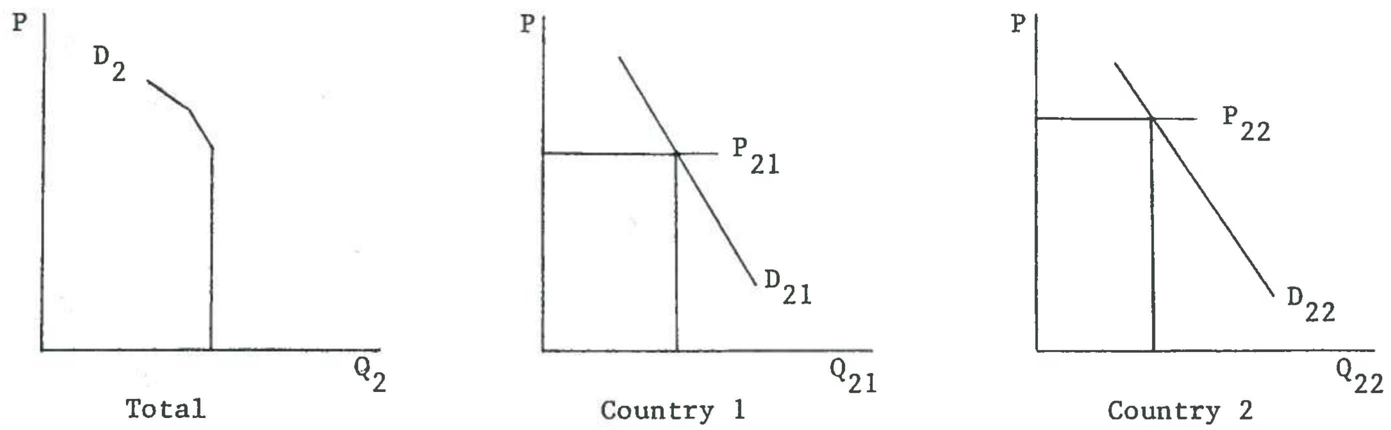

Figure 4.2. The Summation of Coarse Grain Demand for Block 2 Illustrated for Two Countries with Internal Prices P_{21} and P_{22}.

QFED = total coarse grain fed

QFOD = total coarse grain not fed

Since the base year may not be a "normal" year, the base year consumption selected in all but a few cases is a trend line value from a logarithmic trend.[1]

For the USSR, food and feed demand projections are based on the estimated equations reported in Chapter 3. For each of the 18 countries and regions in block 3, total coarse grain demand is the simple sum of food and feed demands as seen in (6) of Table 4.1. Since price elasticities were not estimated for block 3 regions, an aggregate price elasticity is assumed for block 3 in order to allow a reasonable price response.

The quantity equilibrium condition is derived in (7) to (10) of Table 4.1. The import demand (or negative export supply) for each region or country (7) is domestic consumption plus change in stocks minus domestic supply. The trade identity (8) imposes the condition that total imports equal total exports and leads to the equilibrium condition (10) that world demand must equal world production minus change in stocks. The solution of the model, therefore, does not require assumptions about production or stocks in any single country or region but only for the world as a whole.

---

[1]The exceptions are very minor consuming regions. For total coarse grain these are ICEMAL and ROW. For fed coarse grain these include SEASIA, EAF, and VEN (see Appendix 2 for region definitions).

The equilibrium solution is illustrated in Figure 4.3, where S is production minus change in stocks. The broken lines illustrate the dynamics of the model when demands and supply shift. Price is determined by the intersection of world demand with world supply. In this case, the equilibrium price is too low to affect demand in block 2, so the entire price adjustment occurs in blocks 1 and 3.

4.2 Price Linkages and Price Equilibrium

The price linkages for block 1 were estimated and discussed in Chapter 3. These tie the internal prices of Canada and Japan to the U.S. average farm price of corn through the export price as shown in (1) to (3) of Table 4.2. The U.S. export subsidy which has not been used since 1962 is assumed to be zero over the projection period. The purchasing-power parity parameters calculated for Canada (KC) and Japan (KJ) declined during the currency adjustments that began in 1971. In the case of Japan it declined dramatically from 1.0 to about 0.7 in 1973 to 1975 (Table 4.3). The leveling off in the latter three years suggests that these may be stabilizing at a new equilibrium. It would be desirable to have more observations, but these are not yet available. Therefore, the averages of the last three years are used as approximations of KC and KJ for the projection. An adjustment coefficient is also included to test the sensitivity of the model to alternative assumptions.

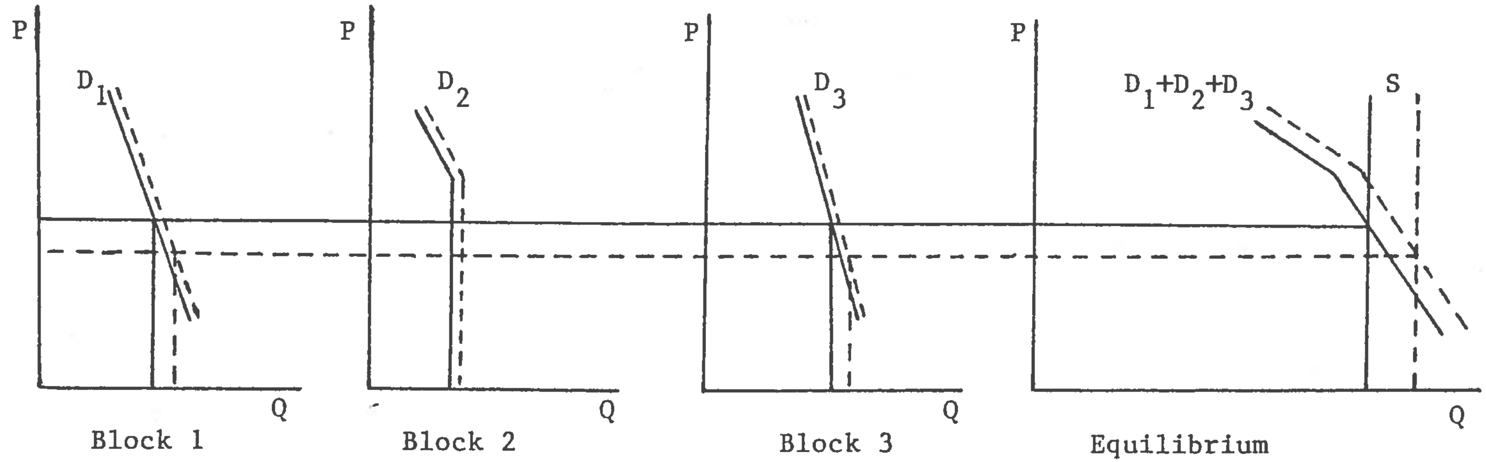

Figure 4.3. The Interaction of the Three Demand Blocks in the World Market Equilibrium When Demands and Supply Shift to New Levels*

*The new levels are indicated by broken lines.

Table 4.2. Price Linkages in the Coarse Grain Model[a]

BLOCK 1 (USA, CAN, JPN)

(1) $EXPC_t = f(UPC_t, XSUB)$

(2) $JPC_t = KJ \cdot f(EXPC_t, EXPC_{t-1})$

(3) $CPB_t = KC \cdot f(EXPC_t)$

BLOCK 2 (West Europe except Iceland and Malta)

(4) $MPC_t = KN(EXPC_t + M)$

(5) If $[MPC_t \leq NTPC_{t-1}(1 + PR)]$ $R = PR$

(6) If $[MPC_t > NTPC_{t-1}(1 + PR)]$ $R = (MPC_t - MPC_{t-1})/MPC_{t-1}$

(7) $PCG_{jt} = PCG_{j,t-1}(1 + R)$ $j = 1, 16$

BLOCK 3 (18 regions)

(8) $QD^*_{it} = QD_{it}(EXPC_t/EXPC_{74})^{\varepsilon}$ $i = 6, 23$

where CPB = internal price of barley, Canada
EXPC = export price of corn, U.S.
JPC = internal price of corn, Japan
KC,KJ,KN = purchasing power parity parameters (see Chapter 3)
M = marketing margin
MPC = minimum export price U.S. corn at Rotterdam
NTPC = threshold price of corn, Rotterdam
PCG_j = internal price of coarse grain, jth country
PR = policy rate of growth in real price of coarse grain
QD = projected coarse grain demand (ith region)
QD^* = price-adjusted coarse grain demand (ith region)
R = rate of growth in real price of coarse grain
UPC = average farm price of corn, U.S.
XSUB = average export subsidy on U.S. corn
ε = price elasticity of demand

[a]All prices and M are in 1970 U.S. dollars. The K parameters and rates R and PR do not have units of measure, QD and QD^* are quantities.

TABLE OF CONTENTS

CHAPTER		PAGE
1	INTRODUCTION	1
	1.1 Statement of the Problem	1
	1.2 Historical Setting of the Problem	3
	1.3 Organization of the Thesis	8
2	METHODOLOGY	9
	2.1 Division of Research by Commodity	9
	2.2 Demand Projection Techniques	10
	2.3 Overview of the Analytical Approach	13
3	COARSE GRAIN DEMAND EQUATIONS AND PRICE LINKAGES	19
	3.1 Theoretical Basis for Estimation Model	19
	3.2 Specification and Empirical Results for Blocks 1 and 2	24
	3.3 Specification and Empirical Results for the USSR	49
	3.4 Specification and Empirical Results for Price Linkages	54
4	COARSE GRAIN PROJECTION MODEL	64
	4.1 Quantity Components and Quantity Equilibrium	64
	4.2 Price Linkages and Price Equilibrium	70
	4.3 Projection Assumptions	78
	4.4 Historical Performance of the Model	86
	4.5 Coarse Grain Demand and Price Projections	102
5	WHEAT PROJECTION MODEL	117
	5.1 Components of the Wheat Model	117
	5.2 Projection Assumptions	119
	5.3 Wheat Demand and Price Projections	122
6	WHEAT AND COARSE GRAINS SIMULTANEOUS MODEL	130
	6.1 Intersectoral Linkage	130
	6.2 Simultaneous Demand and Price Projections	133

CHAPTER		PAGE
7	SUMMARY AND CONCLUSIONS	146
	BIBLIOGRAPHY	153
	APPENDICES	157
	1. Tables Supplementing Chapter 1	157
	2. Regional Definitions and Data Sources	161
	3. Tables Supplementing Chapter 3	166
	4. Tables Supplementing Chapter 4	174
	5. Tables Supplementing Chapter 6	178

LIST OF TABLES

TABLE		PAGE
1.1	Distribution of Growth in Consumption of Coarse Grains and Wheat from 1960/61-1962/63 to 1969/70-1971/72 Compared to Distribution of Population in 1970	5
1.2	Comparison of Per Capita Consumption of Coarse Grains, Wheat, Rice and Total Grain (1969/70-1971/72 Average)	6
3.1	Components of the Estimation Model for Coarse Grain Feed Demand	20
3.2	Coarse Grain Feed Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan	28
3.3	Coarse Grain Food Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan	29
3.4	A Comparison of Income Elasticities for Meat Consumption	32
3.5	Constrained Generalized Least Squares Estimates of Per Capita Coarse Grain Feed Demand from the Pooled Cross-Section Time-Series Model European Community, Double-log Form	41
3.6	Coarse Grain Feed Demand Estimates for Other West Europe, Semi-log (SL) and Log-inverse (LI) Forms . .	45-46
3.7	Regional Estimates of Food Demand for the European Community	50
3.8	Coarse Grain Consumption Relations for the USSR, Semi-log Form	52
3.9	Regression Estimates of Price Linkages Used in the Coarse Grain Model	60

TABLE | PAGE

4.1 Quantity Equilibrium in the Coarse Grain Model 65

4.2 Price Linkages in the Coarse Grain Model 72

4.3 Values of the Purchasing-Power Parity Parameters for Recent Years in Canada, Japan and the Netherlands . . 73

4.4 Assumed Rates of Growth of Population and Income for the Projection Period and Assumed Income Elasticities for Block 3 80

4.5 Assumed Rates of Growth of Population and Income for the Projection Period in Blocks 1 and 2 84

4.6 Percentage Changes in the Actual (ACT) and Estimated (EST) Values for Block 1 Demand and Prices in 1973 and 1974 and Percentage Error of the Estimates 95

4.7 Percentage Changes in the Actual (ACT) and Estimated (EST) Values for Demand in Blocks 2 and 3 and Percentage Error of the Estimates 100

4.8 Comparison of Actual Levels to the Simultaneous Solution Estimates for 1974 104

4.9 Projection of Coarse Grain Demand Assuming that Prices Remain at the 1974/75 Level 106

4.10 Projection of Coarse Grain Price and the Distribution of Consumption with Production Growth Constrained at Historical Rates 108

4.11 Impact of Changes in Projection Assumptions on the 1995 Base Solution 110

4.12 The Estimated "Impact" Elasticities of Coarse Grain Demand with Respect to the U.S. Price of Corn Based on 1995 Changes 114

5.1 Components of the Wheat Sector Model 118

TABLE		PAGE

5.2 The Assumed Ratios of Wheat to Coarse Grain Fed and the Income Elasticities for Wheat Food Demand 121

5.3 Projection of Wheat Demand Assuming that Prices Remain at the 1974/75 Level 123

5.4 Projection of Wheat Price and the Distribution of Consumption with Production Growth Constrained at Historical Levels 125

5.5 Impact of Changes in Projection Assumptions on the 1995 Base Solution 127

6.1 Wheat-Coarse Grain Feedback Linkage in the Simultaneous Model 132

6.2 Projections of Coarse Grain and Wheat Consumption Assuming Historical Rates of Production Growth and Recent Stock Rates in the Simultaneous Model 136

6.3 Projected Rate of Growth and Composition of Growth in Consumption of Coarse Grains and Wheat, 1974-1995 138

6.4 Projected Distribution of Consumption Growth for Coarse Grains and Wheat, 1974-1995 139

6.5 Impact of Changes in Projection Assumptions on the 1995 Base Solution of the Simultaneous Model . . 142

7.1 Effects on the 1995 Corn Export Price of a 10 Percent Increase in the Growth Rates of Income and Population 148

7.2 Comparison of Actual and Projected Levels of Per Capita Consumption of Coarse Grains plus Wheat . . . 150

LIST OF FIGURES

FIGURE		PAGE
2.1	Equilibrium in Year t for a Simple Projection Model	14
2.2	Equilibrium Price Determination in the Coarse Grain Model	16
4.1	The Summation of Coarse Grain Demand for Block 1 Illustrated for Two Countries	66
4.2	The Summation of Coarse Grain Demand for Block 2 Illustrated for Two Countries with Internal Prices P_{21} and P_{22}	68
4.3	The Interaction of the Three Demand Blocks in the World Market Equilibrium when Demands and Supply Shift to New Levels	71
4.4	Actual and Estimated Values for USA Coarse Grain Consumption	87
4.5	Actual and Estimated Values for Canada Coarse Grain Consumption	88
4.6	Actual and Estimated Values for Japan Coarse Grain Consumption	89
4.7	Actual and Estimated Values for USA Real Price of Corn	91
4.8	Actual and Estimated Values for Canada Real Price of Barley	92
4.9	Actual and Estimated Values for Canada Real Price of Wheat	93
4.10	Actual and Estimated Values for Japan Real Price of Corn	94
4.11	Actual and Estimated Values for Block 2 Coarse Grain Consumption	96

FIGURE PAGE

4.12 Actual and Estimated Values for EC9 Coarse Grain Consumption 97

4.13 Actual and Estimated Values for Other West Europe Coarse Grain Consumption 98

4.14 Actual and Estimated Values for USSR Coarse Grain Consumption 101

4.15 Actual and Estimated Values for Block 3 Coarse Grain Consumption 103

6.1 Solution of the Simultaneous Model when the Wheat-Corn Price Ratio is Above the Relative Feed Value . 134

6.2 Solution of the Simultaneous Model when the Wheat-Corn Price Ratio Equals the Relative Feed Value . . 135

6.3 Gulf Ports Prices of Wheat and Corn, Actual to 1974, Projected 1975 to 1995 141

Chapter 1

INTRODUCTION

This chapter presents the problem statement, the historical setting of the problem and a description of the thesis organization.

1.1 Statement of the Problem

There has been an increased concern about the future grain supply relative to demand ever since the events of the 1972/73 crop year initiated a rise in grain prices that was unprecedented in recent history. Although grain prices retreated in 1974 after supply conditions improved, there is little certainty about whether surplus, scarcity or neither will dominate the future. Discussions about surplus capacity and price supports that flourished in the post-World War II period have been replaced by debates over reserve stock programs and food security; and the Green Revolution optimism of the 1960's has given way to varying degrees of concern about world grain sufficiency and distribution in the decades just ahead.

As a basis for food policy decisions, it is important not only to anticipate the future level and composition of world grain demand relative to supply but to identify and understand the underlying forces that influence demand and supply. This study concentrates on the demand component, but the results should also provide some insight into the broader question of the long run potential for surplus or scarcity in grain markets.

The major factors which shift grain demand across time are population and income. It is expected that in high income countries the effect of income growth on demand for animal products is the primary shifter of grain demand; and in low income countries, both income and population may be important sources of demand growth.

Since the tightening of world food markets occurred, there has been considerable discussion about the relative importance of population and income effects on demand. At the extremes of this debate are certain members of affluent nations who place the entire burden for the food "crisis" on high rates of population growth in poor countries and certain members of poor nations who lay the entire blame on the high rates of meat consumption in affluent countries.

Clearly both population growth and increased meat consumption influence demand for grain. The effects of population growth on grain demand are rather straightforward and have seemed to get more attention in the discussion about future food availability. Less is known quantitatively about the more complex relationship between income growth, the changes in composition of diets and grain demand.

This study will focus on the effect of income growth on grain demand in the developed countries of the world. This is not an attempt to take sides in the population-vs-income debate, but rather to investigate the lesser known of the two effects. The income effect is expected to be most important in the high income economies, and these areas of the world have accounted for a major portion of both the demand and the growth in demand for wheat and coarse grains over the last decade.

The major question being asked in the study is to what extent future growth in grain consumption in developed countries will put pressure on prices and grain availability to the rest of the world. The income and population effects for the developed countries will be incorporated with third world income and population assumptions in a world projection model. This model will be used to project the probable consequences of income and population growth for grain demand and price trends over the next two decades, and the relative impacts of income and population effects in developed and third world areas will be compared.

1.2 Historical Setting of the Problem

The stated objective to focus on the income effects in developed countries is motivated not only by the dearth of attention given to this aspect of grain demand growth but also by its importance relative to other factors in explaining total growth in grain demand. Developed country demand is an especially important component of coarse grain demand, but its effect on wheat demand has also been substantial.

During the decade preceding the 1972/73 crop year, the developed countries as a whole accounted for 71 percent of the growth in coarse grain consumption and 60 percent of the growth in wheat consumption (Table 1.1). Feed consumption accounted for 74 percent of the growth in coarse grain consumption and 45 percent of the growth in wheat consumption. The developed market economies were the main source of growth in coarse grain feed demand and the developed central planned economies were the main source of wheat feed demand growth. The absolute change in total consumption of coarse grains and wheat was almost evenly distributed among the developed market economies, the developed central planned economies and the third world. However, it was far from equal on a per capita basis, since 66 percent of the total growth went to 30 percent of the world's population in the developed countries. Rice, on the other hand, is of little consequence in developed country consumption since more than 90 percent of the total is consumed in the third world (Appendix Table 1.3).

Similar patterns are likely to persist in the future if affluent consumers continue to increase the quantity and quality of animal products in their diets. This would be of little consequence to third world consumers if supplies were plentiful and grain prices were low. But if the limits to supply growth are such that prices remain high or increase, the potential for third world consumers to improve their diets would be directly threatened by increased developed country consumption.

It is well known that per capita grain consumption in the third world is far below that of the developed countries (Table 1.2),

Table 1.1. Distribution of Growth in Consumption of Coarse Grains and Wheat from 1960/61-1962/63 to 1969/70-1971/72 Compared to Distribution of Population in 1970[a]

Region	Coarse Grains Absolute Change	Coarse Grains Percent of Change	Wheat Absolute Change	Wheat Percent of Change	Total Absolute Change	Total Percent of Change	Population 1970	Population Percent of Total
	mil. mt	%	mil. mt	%	mil. mt	%	mil.	%
Developed Market[b]	62.0	48	13.4	15	75.4	34	706	20
(feed)	(52.7)	(41)	(11.4)	(12)	(64.1)	(29)		
Developed CPE[c]	29.3	23	41.5	45	70.8	32	368	10
(feed)	(31.0)	(24)	(29.5)	(32)	(60.6)	(27)		
Third World[d]	37.3	29	37.1	40	74.4	34	2543	70
(feed)	(11.9)	(9)	(0.8)	(1)	(12.7)	(6)		
Total	128.7	100	92.0	100	220.7	100	3617	100
(feed)	(95.6)	(74)	(41.7)	(45)	(137.3)	(62)		

[a]Computed in Appendix Tables 1.1 and 1.2.

[b]Australia, Canada, Japan, New Zealand, South Africa, United States, West Europe.

[c]East Europe, USSR.

[d]All countries not in (b) or (c).

Table 1.2. Comparison of Per Capita Consumption of Coarse Grains, Wheat, Rice and Total Grain (1969/70-1971/72 average)[a]

	Per Capita Consumption 1969/70-1971/72			
	Coarse Grains	Wheat	Rice	Total Grain
	kilograms			
Developed Market	386	124	21	531
Developed CPE	335	344	4	683
Third World	57	47	76	180
Total	149	92	58	299

[a]Computed from Appendix Tables 1.1 to 1.3.

and the importance of improving the inadequate nutritional levels is widely accepted.[1] There are basically two ways to increase grain consumption: increased internal production and increased imports. Although rates of production growth in the third world have equaled those in the developed countries over the last two decades, this was barely sufficient to keep pace with population growth. Thus, food imports have increased, and most future projections foresee a continuing growth in import requirements.[2]

Third world countries are faced in most cases with budget and foreign exchange constraints, so the price of grains is a crucial factor in their attempts to fight undernourishment and malnutrition. Although in theory, food aid and subsidized sales can offset higher price levels, one need only look at the rapid decline in the quantity of U.S. food aid in 1973 and 1974 to realize that scarcity and higher prices may well reduce food aid when it is needed most.[3]

Naturally, population and income effects on demand in all countries combine to influence world prices. However, if real

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[1]An FAO study of energy and protein supply in 1969-71 found the third world energy availability to be 5 percent below minimum requirements. FAO, Population, Food Supply and Agricultural Development, United Nations, Rome, 1975.

[2]U.S. Department of Agriculture, Economic Research Service, The World Food Situation and Prospects to 1980, FAER #98, December 1974.

[3]U.S. Department of Agriculture, Economic Research Service, Foreign Agricultural Trade of the United States, January 1977, Table 5.

grain prices of the future remain high or increase and developed country demand growth continues to be a major factor, the allocation of scarce grain supplies could well become a highly sensitive issue between developed and third world nations. On the other hand, if real prices continue the long-run downward trend that characterized much of the post World War II period prior to 1972, there probably would be little protest against increased grain feeding in developed countries. Thus, it is important to look at the question of developed country demand growth and long-run price trends simultaneously.

1.3 Organization of the Thesis

The division of the research by commodity and geographical region and an overview of the analytical approach to be used in the study will be presented in Chapter 2. The estimation models and estimation results for developed country demand equations and price linkages are presented in Chapter 3. In Chapter 4 the coarse grain projection model and the projection assumptions are described, the historical performance of the model is tested and the coarse grain demand and price projections are reported. A simple wheat model is developed in Chapter 5 and the partial equilibrium projections of that model are reported. In Chapter 6, the wheat and coarse grain models are integrated and the simultaneous demand and price projections are reported. Chapter 7 summarizes and evaluates the results of the study.

Chapter 2

METHODOLOGY

This chapter discusses the division of research by commodity and geographical region and presents a general description of the analytical approach used in the study.

2.1 Division of Research by Commodity

The objective here is to narrow the scope of the research so as to focus on the central questions posed in Chapter 1. Based on the historical patterns portrayed in Chapter 1, the future growth in income in developed countries is likely to have its greatest impact on feed demand in the coarse grains sector. Consequently, coarse grains demand is the major focus of this study.

Large quantities of wheat are consumed in the developed countries but the potential for future growth lies primarily in the third world. Although growth in wheat feeding in East and West Europe and the U.S.S.R. has a substantial impact on wheat demand growth during the 1961 to 1970 period, wheat never exceeded 18 percent of feed grain world wide and declined to about 14 percent in 1973 and 1974. In the European Community it was a subsidy in the form of the denaturing premium which motivated increased wheat feeding in the late 1960's and early 1970's. Even in the United States where relatively little wheat is fed, the proportion of wheat fed is affected by the wheat-corn price ratio. So the potential for increased wheat feed use in the future will depend in part upon relative price trends in wheat and coarse grains. A wheat sector is included in this study to analyze this potential substitution, but the analytical approach is greatly simplified compared to that of the more important coarse grain sector.

As noted in Chapter 1, rice is not a significant factor in overall developed country grain consumption. Only in Japan is it a significant factor in food use, and the potential substitution of rice for feed grains is very limited.[1] Thus, the exclusion of rice from this study helps to limit the scope but should not greatly influence the results.

To simplify the analysis, coarse grains--including barley, corn, oats, rye and sorghum are analyzed as an aggregate but separated by end use into two categories: feed and non-feed. Wheat is also separated into feed and non-feed categories for the projections.

2.2 Demand Projection Techniques

There are two basic approaches to making demand projections; the constant-price approach and the equilibrium approach. The first can be derived from a model where per capita consumption (q) is a function of per capita income (I).

$$(2.1) \quad q_t = f(I_t)$$

---

[1] The only recent example of significant substitution is in Japan in the early 1970's when excess rice stocks were "dumped" on the feed grain market.

Total consumption (Q) is population (N) times per capita consumption.

$$(2.2) \quad Q_t = N_t f(I_t)$$

The rate of growth in consumption $(\hat{Q})$ can then be expressed in terms of the growth rates of population $(\hat{N})$ and per capita income $(\hat{I})$ and the income elasticity (η), and the projection takes the form:

$$(2.3) \quad Q_t = Q_0(1 + \hat{Q}_t)^t$$

where $\hat{Q}_t = \hat{N}_t + \eta_t \hat{I}_t$

Q_0 = base year consumption

Q_t = projected consumption in year t.

This is the methodology used for the FAO projections[2] and it is widely used elsewhere because of its simplicity. For the same reason a modification of this method is employed in the coarse grain food and feed demand projections for the third world regions, East Europe and a few small developed market economies (see Appendix 2). This method is also utilized for the wheat food demand projections for all regions. A coarse grain consumption function is estimated for the U.S.S.R. to reflect the government's response to variation in internal production and is discussed in detail in Chapter 3.

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[2] FAO, Agricultural Commodity Projections, 1970-80, CCP 71/20, Rome, 1971.

The equilibrium approach to projections takes into account the effect of prices and the interaction of prices and quantities. Projections of this type can be derived from a model where per capita consumption (q) is a function of prices (P) and per capita income (I).

(2.4) $q_t = f(P_t, I_t)$

For a simple case of one grain, n countries, and a single world price with free trade and no transport costs, the projection model takes the form:

(2.5) $q_{it} = f_i(P_t, I_{it}) \quad i = 1,2,...,n$ — i^{th} per capita demand

(2.6) $Q_{it} = N_{it}\, q_{it}$ — i^{th} total demand

(2.7) $\sum_i Q_{it} = QS_t$ — equilibrium condition

(2.8) $QS_t = QS_0(1 + \hat{QS})^t$ — supply projection

(2.9) $N_{it} = N_{i0}(1 + \hat{N}_i)^t$ — population projection

(2.10) $I_{it} = I_{i0}(1 + \hat{I}_i)^t$ — income projection

where I_i = per capita income in i^{th} country

N_i = population in i^{th} country

P = world price of grain

q_i = per capita grain demand in i^{th} country

Q_i = total grain demand in i^{th} country

QS = total supply of grain for all countries

Given assumed rates of growth in supply ($\hat{QS}$), population ($\hat{N}$) and per capita income ($\hat{I}$), this model simultaneously determines world price and the distribution of consumption among the n countries for each year t. One such equilibrium solution is illustrated in Figure 2.1. Constant-price projections can still be made with this type of model by suspending the equilibrium condition (2.7) and holding the price at some predetermined level over the projection period.

2.3 Overview of the Analytical Approach

The equilibrium approach is preferable to the constant price approach for the purposes of this study, since the projection of long-run trends in grain prices is one of the objectives. An equilibrium model is formulated for coarse grains by using empirical estimates of price response in the developed market economies and making reasonable assumptions about price elasticities for the rest of the world. The coarse grain model is divided into three demand blocks based on the assumptions about price formation.

Coarse grain food demand and feed demand equations are estimated for Canada, Japan, the United States and 16 countries of West Europe. Price linkages are also developed which take account of trade barriers and transport costs among these developed market economies.

Coarse grain prices in Canada and Japan are linked to the U.S. export price of corn with price linkage equations. These two countries and the United States form demand block 1. Coarse grain prices in West Europe are assumed to be policy determined

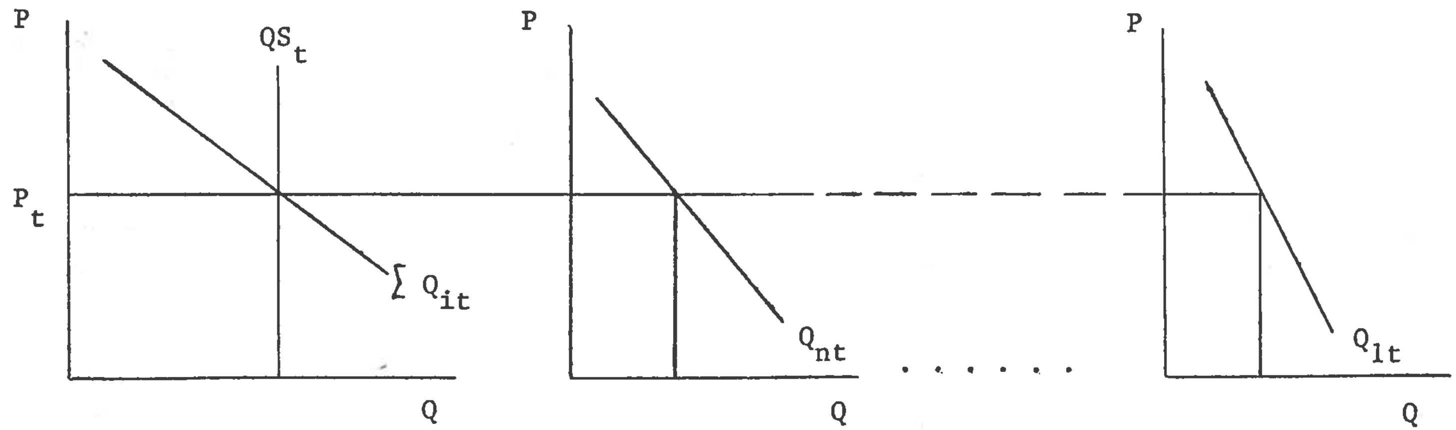

Figure 2.1. Equilibrium in Year t for a Simple Projection Model

unless the U.S. export price of corn exceeds a critical level. The West European countries form demand block 2, and a price linkage is developed in Chapter 4 which causes block 2 prices to be influenced by the U.S. export price of corn only when the latter exceeds a critical level.

The rest of the world is included in demand block 3 (see Appendix 2), where the constant price projections are modified by introducing price elasticity parameters. Since price elasticities are not estimated for these countries and regions, an elasticity representing the aggregate price response for block 3 is added to the system. This elasticity assumption integrates the block 3 projections into the equilibrium model and is discussed in Chapter 4.

The components of the coarse grain model are illustrated in Figure 2.2. Block 1 demand (D_1) is the horizontal summation of the individual country demands incorporating the price linkages. In block 2 internal prices are related to the threshold price of corn in the European Community, and demand (D_2) is perfectly inelastic with respect to the U.S. price unless the latter goes above a critical level. An aggregate elasticity with respect to the U.S. price is assumed for block 3 in order to make realistic adjustments to the constant price projection (D_3) when the price goes above or below the 1974 level. Without this elasticity assumption, block 3 demand would be perfectly inelastic as shown in the broken line in Figure 2.2(c).

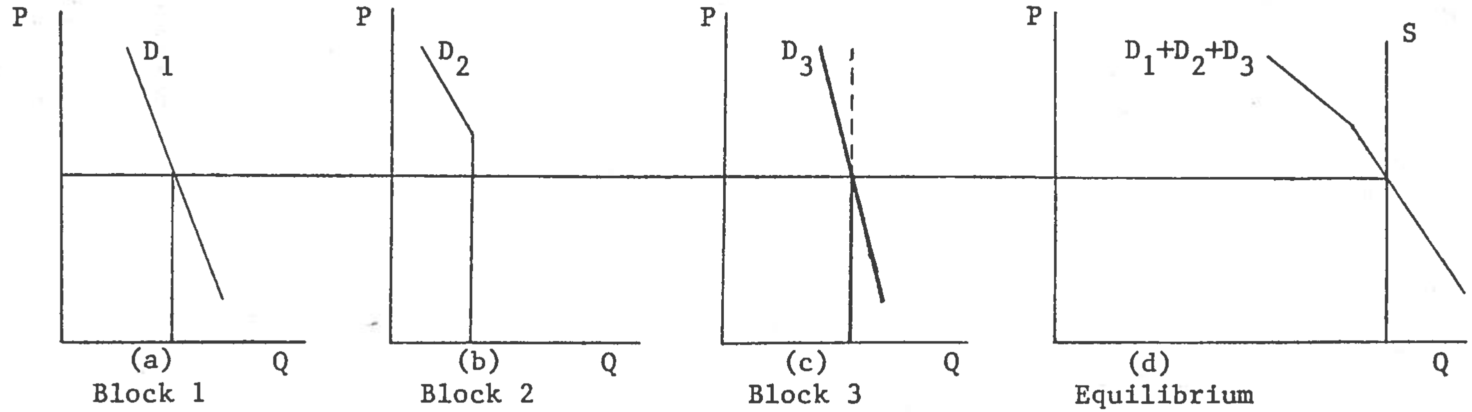

Figure 2.2. Equilibrium Price Determination in the Coarse Grain Model

The U.S. price of corn is determined in each year of the projection period by the equilibrium condition shown in Figure 2.2(d). Other prices and quantities linked to the U.S. corn price are determined simultaneously. Prices will move upward (downward) if the demand factors cause world demand to increase more (less) rapidly than world supply at current prices.

The supply projections for coarse grains and wheat assume a continuation of historical production trends from 1960 to 1975. Projections of population and income, the major demand shifters, are based on the United Nations medium variant growth rates for population and "trend" growth rates for income. Sensitivity tests of the projections are made by altering the assumed growth rates of income, population and production and the assumed price elasticities for block 3.

In Chapters 5 and 6 a simple wheat sub-model is developed and integrated into the equilibrium model. The objective of this expansion is to measure the maximum extent to which wheat substitution for coarse grains in feed rations could influence the projection results. Wheat food demand is projected utilizing the simple constant-price method, and a price response is incorporated through an assumed elasticity as in block 3 of the coarse grain model. If the wheat-corn price ratio remains constant, wheat feed demand is projected to grow in direct proportion to the growth in coarse grain feed demand. The response of wheat feed demand to changes in the wheat-corn price ratio is assumed to be inelastic if the price ratio is above the relative feeding value and elastic if the price ratio is equal to the relative feeding value. The wheat-corn price ratio is not permitted to fall below the relative feeding value.

Equilibrium solutions for the coarse grain model, the wheat sub-model and the interactive model of wheat and coarse grains are determined with a dampened Gauss-Seidel interactive program[3] on the University of Minnesota Cyber 74 computer.

The data requirements vary by country and region as will be evident in Chapters 3 and 4, but all the data sources are listed in Appendix 2.

[3] The algorithm, called General-Analytical-Simulation-Solution-Program (GASSP), was written by Rodney C. Kite, Economic Research Service, U.S.D.A.

Chapter 3

COARSE GRAIN DEMAND EQUATIONS AND PRICE LINKAGES

The coarse grain demand equations for the developed market economies are the core of the projection model. Therefore, the specification and estimation of these relations need to be discussed in some detail. This chapter presents the theoretical basis for the estimation model, the specifications and empirical results of the demand estimations for blocks 1 and 2 and the USSR and for the estimations of the block 1 price linkages.

3.1 Theoretical Basis for Estimation Model

An important part of this study is to quantify the income effects on demand for feed grains. Feed demand is a derived demand arising from the activities of the animal products industry. In general, growth in real income increases the demand for animal products, which tends to raise animal product prices and stimulate the demand for grains and other production inputs.

There are essentially two types of econometric models that could be employed to estimate the income effect. The first approach is to estimate the structural coefficients of final supply, final demand and derived input demand equations for the animal product industry. In the context of the simple aggregate model in Table 3.1, this would involve estimation of equations (1), (2) and (4) for each country. Solving these equations simultaneously with the appropriate equilibrium condition (3) would give the

Table 3.1. Components of the Estimation Model for Coarse Grain Feed Demand

STRUCTURAL EQUATIONS

(1)	$QLS_t = f_1(PL_t, PG_t, PX_t, \varepsilon_{1t})$	supply
(2)	$QLD_t = f_2(PL_t, I_t, PO_t, \varepsilon_{2t})$	domestic demand
(3)	$QLS_t = QLD_t + QLX_t$	quantity equilibrium
(4)	$QGD_t = f_3(PG_t, PL_t, PX_t, \varepsilon_{3t})$	derived demand

REDUCED FORM (input prices constant)

(5)	$QGD_t = g(PG_t, I_t, PX_t, PO_t, QLX_t, u_t)$	country demand

WORLD EQUILIBRIUM (i = 1, 2, . . . , n countries)

(6)	$QGD_{it} = a_i + b_i PG_{it} + C_i I_{it} + d_i Z_{it} + u_{it}$	country demand
(7)	$PG_{it} = WPG_t + M_{it}$	price linkage
(8)	$\sum_i N_{it} \cdot QGD_{it} = WQP_t - WCST_t$	quantity equilibrium

where I = income per capita
M = market margin
N = population
PG = price of coarse grain
PL = price of animal products
PO = price of other goods
PX = price of other inputs
QGD = demand for coarse grain feed per capita
QLS = supply of animal products per capita
QLD = domestic demand for animal products per capita
QLX = net exports of animal products per capita (negative for imports)
WCST = world change in coarse grain stocks
WPG = world price of coarse grain
WQP = world production of coarse grain
Z = vector of exogenous variables
ε,u = stochastic disturbance

reduced-form equation (5) and the corresponding reduced-form coefficients.[1] These are referred to as the "derived" coefficients. The second approach is to estimate the reduced-form equation (5) directly to obtain the reduced-form coefficients on income and other exogenous variables. This method is referred to as unrestricted least-squares (ULS).

The first approach would usually be preferable for a country study focusing on the structural parameters. But the focus of this study is on projections, for which only the reduced-form coefficients are necessary. In terms of econometric properties, both the "derived" and the unrestricted least-squares estimators are consistent. The "derived" estimator is asymptotically more efficient, provided that consistent estimators (two-stage least-squares or three-stage least-squares, for example) are used for the structural equations.[2] In a study of the small sample properties of the ULS and "derived" estimators, Summers[3] found that the differences in efficiency were not very great and concluded that "economy in computation can safely supplant statistical efficiency as a basis for choosing" among these methods. Considering the broad scope of this study, the computational savings

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[1]Net exports (imports) of animal products is exogenous in this simple system.

[2]J. Johnston, Econometric Methods, 2nd ed. (New York: McGraw-Hill, 1972), pp. 408-420.

[3]R.M. Summers, "A Capital Intensive Approach to the Small Sample Properties of Various Simultaneous Equation Estimators," Econometrica 33 (January 1965), pp. 1-41.

associated with using the unrestricted least squares method are very substantial so that is the method used.

Implicit in this discussion has been the assumption of open economies, where the equilibrium constraint depends upon the world supply rather than the domestic supply of grain. A simplified world system for n countries, where all coarse grain is fed, is shown in equations (6), (7) and (8) of Table 3.1. In this context the possibility of simultaneous equations bias arises due to the simultaneous determination of all quantities QGD_{it}, all prices PG_{it} and world price WPG_t. However, in many of the developed market economies, grain prices have been determined by government policy and are therefore exogenous. Other countries are quite small relative to the rest of the world and can be considered price takers on the world market.[4] The United States is the most notable exception to both of these cases because it is relatively large and has had relatively less price control. Hence, two-stage least squares and ordinary least squares regressions are estimated for the United States.

Before proceeding to the estimation results, it is of interest to look briefly at the relationship between the reduced-form elasticities and those of the final product demand. Brandow[5]

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[4] L.R. Klein, "Single Equation vs. Equation System Methods of Estimation in Econometrics," Econometrica 28 (October 1960), pp. 866-871.

[5] G.E. Brandow, "Demand for Factor and Supply of Output in a Perfectly Competitive Industry," Journal of Farm Economics 44 (August 1962), pp. 895-899.

analyzed the reduced-form price elasticity assuming a linearly homogeneous Cobb-Douglas production function, a log-log final product demand and a perfectly competitive industry. He concluded that "demand for an input is elastic, unit elastic, or inelastic accordingly as demand for output is elastic, unit elastic or inelastic . . ." The cross price elasticity was found to be negative for an elastic output demand and positive for an inelastic output demand.

In Appendix Table 3.1, a slightly more general case is analyzed for three inputs. It is more general in that decreasing returns to scale are permitted, and income is added to the demand relation so that its reduced-form impact can be traced. For the price elasticities the magnitudes of the elasticities are affected, but the general conclusions are the same as those drawn by Brandow in the constant returns to scale case. The reduced-form income elasticity is equal to the final demand elasticity of income under constant returns to scale. Under decreasing returns to scale the reduced-form income elasticity is larger for an inelastic final demand and smaller for an elastic final demand. Finally, the results in Appendix Table 3.1 show that the reduced-form equation is homogeneous of degree zero in prices and income, provided that the same condition holds for the final product demand.

Since the final product is defined as aggregate animal products, it is reasonable to assume that final demand is inelastic in the developed market economies.[6] Therefore, it is expected that the reduced-form demand for fed coarse grains will be inelastic, the cross-price elasticities will be positive and the income elasticities will be no smaller than the final product income elasticities.[7]

3.2 Specification and Empirical Results for Blocks 1 and 2

The discussion of empirical results is divided into two sections. The first covers the United States, Canada and Japan (block 1), where separate country regressions are estimated. The second covers Western Europe (block 2), where a pooled cross-section time-series model is used. However, certain aspects of the specification which are common to both blocks are discussed first.

Demand and income variables are in per capita units, so population is assumed to have a simple multiplicative effect on demand. Prices and income for each country are deflated by the national consumer price index for all goods (1970=100), thereby imposing the homogeneity condition on demand and eliminating the "price of other goods" as a separate explanatory variable. Then,

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[6] Brandow (1961) and George and King (1971) calculated the retail price elasticities of "all meats" in the United States to be -.60 and -.35, respectively.

[7] The work of Allen (1968) shows that for the case of a general linearly homogeneous production function these conclusions on the price elasticities will not necessarily hold when the elasticity of substitution between factors is not equal to one. However, it can be shown that the result regarding income elasticity is not affected by the elasticity of substitution.

all prices and income are converted to 1970 U.S. dollars with the 1970 exchange rate in order to facilitate cross-country comparisons and, in the case of block 2, to facilitate the cross-section time-series analysis. The price linkages are made more tractable by using only prices of the two major coarse grains, barley and corn. For each country the price of dominant feed grain is selected as the price variable. Except for two countries, equations are estimated for the period 1960/61 to 1973/74, and 1974/75 is later used as the prediction interval.[8] Japan equations were estimated over the period 1960/61 to 1974/75.

Block one estimates. Separate country equations were estimated by ordinary least squares (OLS) for the U.S., Canada and Japan. A two-stage least squares (TSLS) estimator was also used for the U.S. due to the possible simultaneous equations bias as noted in section 3.1 above. The specification of the block 1 equations and the variable definitions are as follows:

UNITED STATES

(1) $QFEDC_t = f(UPC_t, I_t, UPM_t, UPFL_t, u_{1t})$

(2) $QFODC_t = f(UPC_t, I_t, u_{2t})$

CANADA

(3) $QFEDC_t = f(CPB_t, I_t, CPW_t, CED, u_{3t})$

(4) $QFODC_t = f(CPB_t, I_t, COD, u_{4t})$

[8] Price data for West European countries is not available beyond crop year 1974/75.

JAPAN

(5) $QFEDC_t = f(JPC_t, I_t, JQFE_t, T*JD, u_{5t})$

(6) $QFODC_t = f(JPC_t, I_t, u_{6t})$

Endogenous Variables

QFEDC = coarse grain demand for feed per capita, kg.

QFODC = coarse grain demand for food per capita, kg.

UPC = average price received by U.S. farmers for corn, \$/cwt.

Exogenous Variables

CED = dummy variable, 1 (1967 to 1969), 0 (elsewhere)

COD = dummy variable, 1 (1971), 0 (elsewhere)

CPB - average Canadian Wheat Board selling price for No. 3 Canadian Western 6-row barley, \$/100 kg.

CPW = average Canadian Wheat Board selling price for No. 2 Northern wheat (No. 1 Canadian Western Red Spring 14%), \$/100 kg.

I = private consumption expenditure per capita, \$

JD = dummy variable, 1 (1960 to 1966), 0 (elsewhere)

JPC = wholesale price index of imported corn, 1970=100 for calendar year index

JQFE = wheat and rice fed per capita, kg.

T = trend, 1960 = 1, . . .

UPM = average U.S. wholesale price of soybean meal at Decatur, \$/cwt.

UPFL = index of prices paid for livestock inputs, 1910-14=100

The regression estimates are reported in Tables 3.2 and 3.3. The U.S. and Canadian feed and food demand income elasticities were below 1.0 at the historical means, and in a linear form of equation (Appendix Tables 3.2 and 3.3) these elasticities would tend to increase toward 1.0 in a long-run projection. Economic theory suggests that the income elasticities for feed or food grain products are not likely to increase for high income consumers, so a double-log, semi-log or log-inverse form of equation is more appropriate. The semi-log form is used for the U.S. and Canada because it permits income elasticities to decline as per capita consumption rises, but preserves the simplicity of the linear form for purposes of the world model solution routine.[9] The feed demand income elasticity for Japan was greater than 1.0 at the historical means so it will tend to decrease in a long-run projection using a linear form of equation.

The feed demand coefficients in Table 3.2 are all significant at the 5 percent level or better except for the U.S. meal price coefficient. The latter was retained in the equation since a t-statistic greater than 1.0 still improves the adjusted $\bar{R}^2$. The explanatory power of the estimated equations is good to excellent as evidenced by the $\bar{R}^2$ values, and the Durbin-Watson statistics indicate the absence of serial correlation in the disturbance.

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[9] In the semi-log specification the income variable is replaced by the natural log of income and the elasticity equals the estimated income coefficient divided by the dependent variable.

Table 3.2. Coarse Grain Feed Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan

USA	UPC	ln(I)	UPM	UPFL	CONST	$\bar{R}^2$	D.W.	CV d.f.
OLS	-60.007	137.28	4.095	0.7583	-704.10	.85	1.81	0.03
(t)	(4.22)	(3.05)	(1.36)	(5.05)	(2.07)			9
e	-.25	.23	.03	.58				
e*	-.36	.21	.04	.70				
TSLS	-72.514	129.85	4.181	0.8562	-659.49		2.10	0.02
(t)	(5.40)	(3.43)	(1.66)	(6.35)	(2.31)			9
e	-.30	.21	.03	.65				
e*	-.44	.20	.04	.79				
CANADA	**CPB**	**ln(I)**	**CPW**	**CED**	**CONST**	$\bar{R}^2$	**D.W.**	**CV d.f.**
OLS	-38.761	537.28	18.946	-64.207	-3441.3	.95	2.37	0.03
(t)	(3.60)	(12.87)	(2.76)	(5.44)	(10.62)			9
e	-.50	.97	.30					
e*	-.71	.82	.50					
JAPAN	**JPC**	**I**	**JQFE**	**T*JD**	**CONST**	$\bar{R}^2$	**D.W.**	**CV d.f.**
OLS	-0.2242	0.1162	-1.122	1.144	-7.926	.99	2.23	0.04
(t)	(3.55)	(27.45)	(6.20)	(3.52)	(0.84)			10
e	-.41	1.56						
e*	-.24	1.37						

t = t-statistic (absolute value)
e = elasticity at the means
e^* = elasticity for 1973
CV = standard error/mean
d.f. = degrees of freedom

Table 3.3. Coarse Grain Food Demand Semi-log Estimates for the United States and Canada and Linear Estimate for Japan

USA	UPC	ln(I)		CONST	$\bar{R}^2$	D.W.	CV d.f.
OLS	-0.141	21.916		-102.32	.96	2.01	0.01
(t)	(0.48)	(17.83)		(10.62)			11
e	-.005	.31					
e*	-.007	.29					
TSLS	0.021	21.776		-101.61		1.95	0.01
(t)	(0.07)	(17.49)		(10.43)			11
e	.001	.31					
e*	.001	.29					
CANADA	**CPB**	**ln(I)**	**COD**	**CONST**	**$\bar{R}^2$**	**D.W.**	**CV d.f.**
OLS	-1.253	31.487	21.241	-145.13	.81	1.39	0.04
(t)	(1.75)	(3.20)	(4.47)	(1.96)			10
e	-.10	.35					
e*	-.17	.35					
JAPAN	**JPC**	**I**		**CONST**	**$\bar{R}^2$**	**D.W.**	**CV d.f.**
OLS	-0.0389	-0.0020		31.249	.15	1.98	0.16
(t)	(0.43)	(0.30)		(2.14)			12
e	-.17	-.06					
e*	-.15	-.08					

t = t-statistic (absolute value) e* = elasticity for 1973 d.f. = degrees of freedom
e = elasticity at the means CV = standard error/mean

As expected, the signs of the direct price coefficients are negative, income coefficients are positive and other input price coefficients are positive. The variable for other grain feed in Japan (JQFE) shows the effect of government policies to divert excess rice stocks to feed uses, primarily in the period 1971 to 1973. A ton of rice displaced slightly over one ton of coarse grains.

The price and income coefficients are best compared in terms of elasticities. The U.S. corn price elasticity can be compared to the own price elasticity of -.42 reported for corn feed demand in a recent study by Womack.[10] Aggregate coarse grain demand would tend to be more inelastic than corn demand and the reduced-form demand would tend to be more inelastic than the derived demand specification used in the Womack study, so the estimated elasticity of -.25 to -.30 is reasonable. Similarly, the barley price elasticity estimated for Canada compares favorably to the own price elasticity of -.78 reported for feed barley demand by Jolly.[11] The corn price elasticity for Japan falls within the range set by the U.S. and Canadian estimates.

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[10] A. Womack, "The U.S. Demand for Corn, Sorghum, Oats and Barley: An Econometric Analysis," Economic Report 76-5, University of Minnesota, August 1976.

[11] R.W. Jolly, "An Econometric Analysis of the Grain-Livestock Economy in Canada with a Special Emphasis on Commercial Agricultural Policy," Department of Agricultural and Applied Economics, University of Minnesota (unpublished Ph.D. dissertation), 1976.

It was shown in the previous section that the reduced-form income elasticity should be no smaller than the corresponding income elasticity with respect to final product demand. There is quite a range in the estimates of income elasticities for meat consumption in the developed market economies as seen in Table 3.4. However, there is a discernible pattern indicating that the elasticity is lowest for the U.S. The OECD estimates show Japan setting an upper bound with Canada and West Europe between the extremes. The other estimates show little difference in elasticities outside the U.S. The feed grain income elasticity estimates in Table 3.2 are consistent with the pattern of the OECD estimates.

In general, one would expect food demand for coarse grains to be more price inelastic and less income elastic than feed demand. This is the case for the food demand estimates (Table 3.3) except for the U.S. income elasticity. Since 1960 there has been a resurgence in the food demand for coarse grains in the U.S. primarily for industrial use. There may be some omitted variable bias if this resurgence is in part due to changes in taste, technology or other excluded variables that are positively correlated with income. This is not a serious problem if the relationship between income and these excluded variables continues over the projection period. Since food demand has only been about 11 percent of U.S. coarse grain consumption, further investigation of this relation is not considered necessary.

Table 3.4. A Comparison of Income Elasticities for Meat Consumption

	USA	CAN	JPN	EC9		OWE	
				range	average	range	average
<u>OECD</u>[a]							
Beef and veal	.4	.6	.9	.25; .70	.34	.30; .90	.47
Pig meat	-.18	.0	1.5	-.10; .70	.51	.10; .70	.41
Poultry meat	.4	.8	1.9	.60; 2.9	1.75	.80; 3.10	1.90
<u>GEORGE & KING</u>[b]							
Meat and poultry	.24						
<u>ERS</u>[c]							
All meat	.55	.60	.64		.70		.65
<u>FAO</u>[d]							
All meat	.19	.35	.33		.36		.35

[a] OECD, Agricultural Projections for 1975 and 1985, Paris, 1968, Annex III, Table 1.

[b] P.S. George and G.A. King, "Consumer Demand for Food Commodities in the United States with Projections to 1980," Giannini Foundation Monograph #26, March 1971. Calculated from Table 33 using expenditure weights in Table 2.

[c] ERS, Growth in World Demand for Feed Grains, FAER No. 63, USDA, July 1970, Table 47 (adjusted elasticities).

[d] FAO, Agricultural Commodity Projections, 1970-1980, Vol. 2, United Nations, Rome, 1971.

The price coefficient for food demand is significant only for Canada. In fact, neither price nor income coefficients are significant for Japan and the explanatory power of the equation is very low. For the projections, therefore, it will be assumed that per capita food demand for Japan remains constant.

Finally, the OLS and TSLS estimates for the U.S. do not differ substantially either in the feed or food demand equations. This would seem to indicate that simultaneity is not a serious problem in the context of the world model.

Block two estimates. West Europe is divided into two subregions. The first consists of the nine countries in the enlarged European Community[12] and the second includes the remaining eight continental countries in West Europe.[13] Since country data were available for each of the variables, three methods of estimation were considered. They were:

1. estimate separate country equations,
2. pool the data into two regional cross-section time-series models and estimate country equations in this framework, and
3. aggregate the data across each of the two sub-regions and estimate two regional equations.

The first and second approaches both utilize the "within country"

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[12]Since Belgium and Luxembourg are treated as one unit, there are actually eight separable country data units.

[13]Iceland and Malta are accounted for in block 3.

variation in the variables, and the second also permits the cross-country variation to affect the estimates. The third method simplifies the analysis by reducing the number of equations to be estimated, but there is an inevitable loss in information that occurs when some of the variation is submerged in the regional averages. The aggregate approach was used to estimate the coarse grain food demand equations; but due to its greater importance in the coarse grain sector, a regional cross-section time-series model was used for feed demand. There are several advantages to this method.

1. All available information is used in the estimation procedure.
2. In a pooled model it is possible to perform statistical tests for the equality of price and income coefficients across countries within a region and to impose equality constraints when justified by these tests. Such constraints reduce the number of coefficients to be estimated and thereby increase the degrees of freedom.
3. The traditional problem of multicollinearity between prices and income in time-series demand studies is minimized by pooling cross-section and time-series observations. The cross-sectional observations increase the variance of the independent variables and constraints on the coefficients have the same effect as increasing the sample size. Both of these effects tend to increase the

precision of the estimates.

There are some problems that are introduced by pooling the data. First, the stochastic component of the pooled model may not have all the good properties required in order that the ordinary least squares estimator be efficient. This will be addressed after the general model is presented. Second, the data must be in the same units of measurement across countries. Quantity units are usually standardized, but exchange rates must be used to standardize the monetary units. When all price and income data are deflated, they are in 1970 real currency units of respective countries. Therefore the 1970 exchange rate with respect to the U.S. dollar is used to transform all monetary data into 1970 U.S. dollars. Since this involves multiplication by a constant it only changes the estimated coefficients by a constant.[14]

A fully constrained[15] pooled model for n countries over T time periods is written

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[14]Consider an estimated equation in national currency units:

$$Q_t = \hat{\alpha} + \hat{\beta} P_t + u_t$$

If the 1970 exchange rate is r_{70} and prices are transformed to 1970 dollars the estimated equation will be

$$Q_t = \hat{\alpha} + \hat{\beta}^* (r_{70} P_t) + u_t$$

where $\hat{\beta}^* = \hat{\beta}/r_{70}$.

[15]Assumes that each coefficient is constant across all countries in the region.

(3.1) $Q_{it} = b_0 + b_1 P_{it} + b_2 I_{it} + b_3 Z_{it} + e_{it}$ $\quad i=1,2,\ldots,n$

$t=1,2,\ldots,T$

or in matrix notation as

(3.1) $Q = XB + e$

where

$$Q = \begin{bmatrix} Q_{11} \\ Q_{12} \\ \cdot \\ Q_{1T} \\ Q_{21} \\ \cdot \\ Q_{2T} \\ \cdot \\ \cdot \\ Q_{nT} \end{bmatrix} \qquad XB = \begin{bmatrix} 1 & P_{11} & I_{11} & Z_{11} \\ 1 & P_{12} & I_{12} & Z_{12} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & P_{1T} & I_{1T} & Z_{1T} \\ \cdot & P_{21} & I_{21} & Z_{21} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & P_{2T} & I_{2T} & Z_{2T} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ 1 & P_{nT} & I_{nT} & Z_{nT} \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \end{bmatrix} \qquad e = \begin{bmatrix} e_{11} \\ e_{12} \\ \cdot \\ e_{1T} \\ e_{21} \\ \cdot \\ e_{2T} \\ \cdot \\ \cdot \\ e_{nT} \end{bmatrix}$$

A fully unconstrained model includes n-1 country dummy variables for the intercept and each of the three independent variables. A pooled regression with these 4(n-1) added variables is equivalent to separate regressions for each country. The fully unconstrained model[16] is written

(3.3) $Q_{it} = b_{i0} + b_{i1} P_{it} + b_{i2} I_{it} + b_{i3} Z_{it} + e_{it}$ $\quad i=1,2,\ldots,n$

$t=1,2,\ldots,T$

The test for the equality of all coefficients is an F-test of the

[16] Assumes that each coefficient is different in each country of the region.

null hypothesis, H_0: $b_{i0} = b_{j0}$ all i,j

$b_{i1} = b_{j1}$ all i,j

$b_{i2} = b_{j2}$ all i,j

$b_{i3} = b_{j3}$ all i,j

where the alternative hypothesis is, H_a: no constraints. Fisher[17] has shown that the statistic

$$F = \frac{(u'u - v'v)/(4n - 4)}{v'v/(Tn - 4n)}$$

has an F distribution with 4n-4 and Tn-4n degrees of freedom, where

u'u = the sum of squared residuals under the null hypothesis (the constrained regression)

v'v = the sum of squared residuals under the alternative hypothesis (the unconstrained regression)

4n = the number of estimated coefficients in the unconstrained regression

4 = the number of estimated coefficients in the constrained regression

Tn = total number of observations in the pooled regression.

Of course, it is not very likely that all coefficients are equal, but the primary interest here is to test the equality of coarse grain price and income coefficients.

As noted, the stochastic component of the pooled model may

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[17] F. Fisher, "Tests of Equality between Sets of Coefficients," Econometrica 38 (March 1970), pp. 361-366.

problematic. Assuming that the explanatory variables are independent of the random disturbance term and there are no serious errors in specification or measurement, the OLS estimator is unbiased and consistent. The OLS estimator is also efficient if the disturbance e_{it} satisfies the following conditions (Kmenta):

(3.4) $E(e_{it}\ e_{jt}) = 0$ $\quad i \neq j$ cross-sectional independence

(3.5) $E(e_{it}\ e_{is}) = 0$ $\quad t \neq s$ non-autoregression

(3.6) $E(e_{it}^{\ 2}) = \sigma^2$ $\quad$ homoscedasticity

Contemporaneous correlation in the disturbances is not likely to be a serious problem when the cross-sectional units are countries rather than regional units within a country, and there is no clear evidence of contemporaneous correlation in the results. Likewise the Durbin-Watson statistics from the unconstrained regressions were in the range of uncertainty, indicating no serious problems with autoregression (Appendix Tables 3.4 and 3.6). However, a comparison of error variances revealed the presence of heteroscedasticity, especially in the EC model (Appendix Table 3.5).

In the generalized least squares (GLS) regression for the European Community, cross-sectional independence and non-autoregression were assumed. To correct for heteroscedasticity, high variance and low variance countries were grouped, and the variance of disturbances for each group was estimated (Appendix Table 3.5). The GLS estimates are obtained by dividing all variables in the high variance group by the group standard error and all variables in the low variance group by the low variance group standard error. These weights are normalized so that the low variance group weight is 1.0 and the high variance group weight is 0.32575 (Appendix Table 3.5).

The specification of the block 2 feed demand equations and the variable definitions are as follows:

EUROPEAN COMMUNITY

(BELX) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, ANX_t, u_{it})$

(FRAN) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, FD, u_{2t})$

(ITAL) $QFEDC_t = f(PCG_t, I_t, ANX_t, ID, u_{3t})$

(NETH) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, LT_t, ND, u_{4t})$

(WGER) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, ANX, GD, u_{5t})$

(DENM) $QFEDC_t = f(PCG_t, I_t, PM_t, u_{6t})$

(IREL) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, u_{7t})$

(UKIN) $QFEDC_t = f(PCG_t, I_t, WFEDC_t, u_{8t})$

OTHER WEST EUROPE

(ASTI) $QFEDC_t = f(PCG_t, I_t, PM_t, WFEDC_t, AD, u_{9t})$

(FINL) $QFEDC_t = f(PCG_t, I_t, u_{10t})$

(GREE) $QFEDC_t = f(PCG_t, I_t, PM_t, u_{11t})$

(NORW) $QFEDC_t = f(PCG_t, I_t, PM_t, u_{12t})$

(PORT) $QFEDC_t = f(PCG_t, I_t, PD, u_{13t})$

(SPAI) $QFEDC_t = f(PCX_t, I_t, WFEDC_t, u_{14t})$

(SWED) $QFEDC_t = f(PCG_t, I_t, u_{15t})$

(SWIT) $QFEDC_t = f(PCG_t, I_t, u_{16t})$

Endogenous Variables

QFEDC = coarse grain demand for feed per capita, kg.

Exogneous Variables

ANX = value of net exports of animal products per capita, $

I = private consumption expenditure per capita, $

PCG = average price paid by farmers for barley (corn for ITAL, NETH, PORT, SWIT), $/100 kg.

PCX = average U.S. corn price net of export subsidy adjusted for currency changes, $/100 kg.

PM = average U.S. wholesale price of soybean meal at Decatur adjusted for currency changes, $/short ton

WFEDC = quantity of wheat fed per capita, kg.

AD = dummy variable, 1 (1968), 0 (elsewhere)

FD = dummy variable, 1 (1967), 0 (elsewhere)

GD = dummy variable, 0 (1960 to 1966), 1 (elsewhere)

ID = dummy variable, 1 (1960 to 1962), 0 (elsewhere)

LT = log trend, 1957=ln(2), 1958=ln(3), etc.

ND = dummy variable, 0 (1960 to 1967), 1 (elsewhere)

PD = dummy variable, 1 (1969 to 1971), 0 (elsewhere)

The GLS estimates for the European Community (EC) are reported in Table 3.6. The linear, double-log, semi-log and log-inverse forms of equation were tried, and all gave similar results in the unconstrained regressions. However, the constrained regression (holding price and income coefficients constant) is acceptable only for the double-log form. Therefore the double-log form of

Table 3.5. Constrained Generalized Least Squares Estimates of Per Capita Coarse Grain Feed Demand from the Pooled Cross-Section Time-Series Model, European Community, Double-Log Form

COUNTRY	ln(PCG)	ln(I)	ln(PM)	WFEDC	ANX	Dummy	CONST
BELX	-0.2120	0.5565	--	-0.0055	0.0046	--	2.0383
(t)	(6.60)	(15.12)		(3.90)	(1.08)		(6.75)
FRAN	-0.2120	0.5565	--	-0.0024	--	0.0998	1.9300
(t)	(6.60)	(15.12)		(3.20)		(3.66)	(7.03)
ITAL	-0.2120	0.5565	--	--	0.0025	-0.2076	1.9003
(t)	(6.60)	(15.12)			(2.16)	(9.69)	(6.91)
NETH*	-0.2120	0.5565	--	-0.0036	--	-0.2382	3.5038
(t)	(6.60)	(15.12)		(2.32)		(2.61)	(9.98)
WGER	-0.2120	0.5565	--	-0.0037	0.0080	0.0701	1.8621
(t)	(6.60)	(15.12)		(2.66)	(1.44)	(1.70)	(6.13)
DENM	-0.2120	0.5565	0.0677	--	--	--	2.9473
(t)	(6.60)	(15.12)	(1.91)				(9.01)
IREL	-0.2120	0.5565	--	-0.0038	--	--	2.7317
(t)	(6.60)	(15.12)		(2.06)			(9.30)
UKIN	-0.2120	0.5565	--	-0.0023	--	--	1.7141
(t)	(6.60)	(15.12)		(3.15)			(6.05)

$\bar{R}^2$ = .99 D.W. = 1.94 d.f. = 87

*log trend term has coefficient = -0.5206
(t) = (5.05)

equation was selected for the EC. Price and income coefficients were constrained across all countries and other variables were unconstrained.[18] Variables with t-statistics below 1.0 were deleted.

The estimated price and income elasticities are in the range between the U.S. and Canada estimates. The only significant high protein price effect is for Denmark, and it is similar in magnitude to that of the U.S. The effect of wheat fed was significant in all countries but Italy and Denmark where wheat is less than 4 percent of total fed grain. As with rice feeding in Japan, wheat fed in the EC was strongly influenced by government policies which were better reflected in quantities than in wheat prices. The magnitudes of the coefficients on fed wheat are not as meaningful in the double-log equation as in the linear form, but as a comparison the Ireland coefficient of -.0038 is approximately equivalent to -1.0 in the linear form.

The effect of animal exports (or imports) was significant only in BELX, Italy and West Germany. The signs are correct--more exports or fewer imports increase domestic feed demand--but the magnitudes are again not easily interpreted. A comparison to the linear estimates for West Germany showed that the coefficient 0.008 was approximately equivalent to a coefficient of 1.0 in the

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[18]The Fisher test shown on the lower part of Appendix Table 3.5 was applied to test the null hypothesis that the constraint caused no increase in the sum of squared errors. The null hypothesis could not be rejected at the 5 percent level of significance.

linear form. That is, a one-dollar increase in animal product exports increased demand for coarse grains by 1 kilogram. Actually the differences in the net export position of the EC countries is reflected mainly in the intercepts which were largest for the major exporters (Netherlands, Denmark and Ireland) and smallest for the major importers (Italy, West Germany and the U.K.).

Many of the dummy shift variables appear to be associated with the EC unified price policy that was adopted as of July 1, 1967. France apparently had a short-run glut in 1967/68 that was not reflected in the price level. In 1966, the West Germany requirement that mixed feed have a 50 percent animal protein content was removed, thereby shifting coarse grain demand upward. The sophisticated feed mixing industry of the Netherlands shifted rapidly to increased use of "other energy ingredients"[19] in 1968/69 thereby shifting coarse grain demand downward. The trend term in the Netherlands is associated with a long-run shift from other coarse grains to corn from the mid-fifties to the early seventies. Since corn has a greater feed value per quantity unit, substitution of corn for other grains, like a technological change, makes it possible to produce the same quantity of animal products with a smaller grain input.

The Italy dummy variable coincides with the adoption of the EC common agricultural policy (CAP) in 1962. Under the CAP, Italy

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[19] FAS, "Dutch Feed Mixtures Influenced by EC Grain Import Levies," Foreign Agriculture Circular, Grains, FG 3-76, March 1976.

changed from a state trading system to a private trading system. The upward shift in feed grain consumption after 1962 appears to be associated with this institutional change. One plausible explanation for the shift is that there were illegal private imports before the CAP which were not reflected in the national consumption statistics.

The unconstrained estimates for Other West Europe (OWE) shown in Appendix Table 3.6 have generally higher income and price elasticities than those of the EC and considerably more variability across countries. Perhaps the latter should not be surprising in view of the fact that the OWE is a more heterogeneous group of countries than the EC. In any case, attempts to impose cross-country constraints were unsuccessful and efforts were directed instead to separate country regressions. Since the estimated income elasticities are nearly twice those of the EC it seemed important to use a semi-log or log-inverse from of equation for the long-run projections. The semi-log form is selected whenever possible because it permits both the price and income elasticities to decline as consumption rises. In the cases of Norway and Switzerland the semi-log form does not perform well so the log-inverse form is used.[20]

The results given in Table 3.6 show estimated income

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[20]The double-log specification is changed to log-inverse form by replacing the log of income with the inverse of income, and the elasticity equals the estimated income coefficient times -1.0 over the income level.

Table 3.6. Coarse Grain Feed Demand Estimates for Other West Europe, Semi-Log (SL) and Log-Inverse (LI) Forms

COUNTRY (Form)	PCG	I	PM	WFEDC	Dummy	$\bar{R}^2$	D.W.	CV d.f.
ASTI(SL)	-10.090	210.59	-0.2616	-0.8513	27.430	.92	2.64	0.04
(t)	(0.91)	(2.44)	(2.29)	(1.75)	(2.14)			8
e	-.45	.94	-.11					
e*	-.28	.72	-.08					
FINL(SL)	-10.340	413.71	--	--	--	.92	2.30	0.08
(t)	(4.20)	(9.31)						11
e	-.41	1.30						
e*	-.27	.95						
GREE(SL)	-10.414	120.34	0.2706	--	--	.91	2.24	0.10
(t)	(1.45)	(6.27)	(1.74)					10
e	-.76	.91	.19					
e*	-.45	.56	.15					
NORW(LI)	-0.4598	-1038.26	-0.0942	--	--	.90	2.05	0.01
(t)	(1.62)	(2.00)	(1.17)					10
e	-.46	.73	-.09					
e*	-.46	.61	-.09					
PORT(SL)	-12.049	135.99	--	--	-37.196	.88	2.60	0.09
(t)	(1.66)	(3.60)			(3.05)			10
e	-1.04	1.14						
e*	-.59	.74						

(continued)

Table 3.6.--continued

COUNTRY (Form)	PCG	I	PM	WFEDC	Dummy	$\bar{R}^2$	D.W.	CV d.f.
SPAI(SL)	-10.322	252.19	--	-0.9787	--	.94	2.36	0.07
(t)	(1.45)	(11.93)		(1.27)				10
e	-.27	1.25						
e*	-.22	.85						
SWED(SL)	-8.7762	253.19	--	--	--	.78	1.83	0.06
(t)	(1.80)	(4.23)						11
e	-.34	.85						
e*	-.22	.71						
SWIT(LI)	-1.091	-1781.38	--	--	--	.86	2.42	0.02
(t)	(1.20)	(0.94)						11
e	-1.09	1.03						
e*	-1.09	0.82						

t = t-statistic (absolute value)
e = elasticity at means
e* = elasticity for 1973
CV = standard error/mean
d.f. = degrees of freedom

elasticities at historical means that are higher than those estimated for the EC and lower than the estimate for Japan. The income elasticities range from 1.30 for Finland to 0.73 for Norway and the price elasticities range from -.27 for Spain to -1.09 for Switzerland. In general, higher price elasticities are associated with higher income elasticities, which is consistent with the implications of the Slutsky equation.[21] Based on the log-inverse and semi-log coefficients it is not possible to associate the different income elasticities strictly with differences in income or per capita consumption.[22] There are many factors which influence these elasticities including the composition of final product consumption and the structure of the animal products industry,

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[21] The Slutsky equation is formulated in the context of final demand, but as shown in section 3.1 the reduced-form elasticities are closely related to final demand elasticities. The Slutsky equation expressed in elasticities is

$$\varepsilon_p = \varepsilon_c - \alpha\eta$$

where ε_p = price elasticity of demand
ε_c = compensated demand price elasticity (holding consumer utility constant)
α = proportion of expenditure spent on the product
η = income elasticity

Ceteris paribus, a higher income elasticity is associated with a higher ordinary price elasticity (see Henderson and Quandt, pp. 31, 32).

[22] For example, if the differences in income elasticity were related only to differences in income level, one would expect the log-inverse income coefficients to be similar in magnitude.

which differ across countries.[23] The 1973 elasticities for "Other West Europe" are approaching the levels of those in the EC.

The meal price coefficients are significant in Austria, Greece and Norway and the cross price elasticities are small. In Austria and Norway the cross price elasticities are negative, indicating either a weak substitution effect or a complementary relationship between coarse grains and high protein inputs.[24] Wheat fed is significant for Austria and Spain, and both coefficients are near -1.0, which is reasonable. The dummy variables for Austria and Portugal are to account for quirks in the data which were not found in comparable OECD data and could not be otherwise explained.

The specification of the block 2 coarse grain food demand equations and variable definitions are as follows:

EUROPEAN COMMUNITY

$QFOD_t = f(PFG_t, Y_t, ECD, u_{1t})$

OTHER WEST EUROPE

$QFOD_t = f(PFG_t, Y_t, u_{2t})$

Endogenous Variables

QFOD = coarse grain demand for food, 1000 metric tons

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[23] An industry with more fixed inputs will require a greater proprotionate increase in variable inputs to achieve a given percent growth in output. As demonstrated with the simple model in Appendix Table 3.1, this would result in larger reduced-form elasticities for price and income.

[24] R.G.D. Allen, Mathematical Analysis for Economists (New York: St. Martin's Press, 1938), pp. 373-374, 505-509.

Exogenous Variables

PFG = regional weighted average of coarse grain food prices, \$/100 kg.

Y = regional private consumption expenditure, million dollars

ECD = dummy variable, 1 (1960 to 1970), 0 (elsewhere)

The results of these regressions are presented in Table 3.7. As expected, the food demand tends to be more price inelastic and less income elastic than feed demand. The price variable for the EC is not significant and is dropped from the equation. The dummy variable represents an unexplained upward shift in the food consumption series beginning in 1971. The price and income variables in the OWE equation are marginally significant and the explanatory power of the equation is low. This may be due to excluded variables that cause serial correlation in the residuals and reduce the efficiency of the estimates. Efforts to correct this using a two-stage Cochrane-Orcutt procedure were not successful, perhaps because of the limited degrees of freedom. Nevertheless, these estimates are unbiased and the elasticities have reasonable magnitudes, so they were considered adequate for the food demand projections.

3.3 Specification and Empirical Results for the USSR

The equation for the USSR is not a demand equation in the usual sense, but simply relates the quantity of coarse grain consumption to income and domestic production. The specification of the function is based on the hypothesis that livestock production

Table 3.7. Regional Estimates of Food Demand for the European Community

REGION	PFG	ln(Y)	Dummy	CONST	$\bar{R}^2$	D.W.	CV d.f.
EC9	--	6565.06	-2130.75	-68179.33	.97	2.56	0.03
(t)		(8.98)	(6.63)	(7.22)			11
e		.50					
e*		.39					
OWE	-163.43	1051.81	--	-6866.82	.76	0.78	0.07
(t)	(1.44)	(1.41)		(0.73)			11
e	-.59	.34					
e*	-.38	.26					

t = t-statistic (absolute value)
e = elasticity at means
e* = elasticity for 1973
CV = standard error/mean
d.f. = degrees of freedom

plans and food use are influenced by income growth and constrained by the level of domestic production. The retail price of meat was raised only in 1962 and a dummy variable is included to reflect the possible effects of that policy change. The quantity of wheat fed is also included in the specification for feed demand to account for the substitution effects. The specification of the USSR consumption relations and variable definitions are as follows:

FEED

$QFED_t = f(INC_t, QPDN_t, WFED_t, UD, u_{1t})$

FOOD

$QFOD_t = f(INC_t, QPDN_t, u_{2t})$

Endogenous Variables

QFED = coarse grain feed consumption, 1000 mt.

QFOD = coarse grain food consumption, 1000 mt.

Exogenous Variables

INC = wage and salary income, mil. rubles

QPDN = domestic coarse grain production, 1000 mt.

WFED = quantity of wheat fed, 1000 mt.

UD = dummy variable, 1 (1960 to 1962), 0 (elsewhere)

The results of the semi-log estimates are presented in Table 3.8. The income and production variables are significant at the 5 percent level or better in both equations, and the wheat fed and policy variables are marginally significant. The explanatory

Table 3.8. Coarse Grain Consumption Relations for the USSR, Semi-Log Form

DEPENDENT VARIABLE	ln(INC)	QPDN	WFED	UD	CONST	$\bar{R}^2$	D.W.	CV d.f.
QFED	40956.7	0.5307	-0.1490	3649.4	-400541	.99	2.54	0.04
(t)	(3.48)	(6.10)	(1.13)	(1.49)	(3.59)			10
e	.89							
e*	.53							
QFOD	-9832.0	0.2583			102434	.49	2.39	0.11
(t)	(2.20)	(3.61)			(2.47)			12
e	-.49							
e*	-.41							

t = t-statistic (absolute value)
e = elasticity at means
e* = elasticity for 1974
CV = standard error/mean
d.f. = degrees of freedom

power of the feed equation is excellent, while the food equation explains approximately 50 percent of the variation in food consumption. The Durbin-Watson statistics are in the inconclusive region so there is no strong evidence of serial correlation. More importantly, the coefficients have the correct signs and appear to have reasonable magnitudes. The income elasticity for feed demand is similar to those estimated for OWE, and the food demand income elasticity is negative, implying it is an inferior good. The wheat fed coefficient is negative, though not as large as might be expected. The dummy variable shows a higher feed consumption during the period of lower meat prices. This indicates that the retail price affects meat demand but not meat supply, which is plausible in a planned economy.

The coefficients on domestic production measure the extent to which shortfalls (or surpluses) in production are offset by increases (or decreases) in net imports. The coefficient 0.53 implies that roughly half of the shortfall in a poor year is made up in imports and the remainder is absorbed by a decline in consumption. The coefficient of 0.26 in the food equation indicates that food consumption is less sensitive to variation in production. If these results are combined in an import demand relation they are similar to results obtained in a recent study on import demands in Eastern Europe.[25]

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[25] M.E. Ryan and J.P. Houck, "Eastern Europe, a Growing Market for U.S. Feed Grains," Economic Report 76-7, Department of Agricultural and Applied Economics, University of Minnesota, Nov. 1976.

The import demand (QM_t) derived from the two estimated equations is

$$(3.7) \quad QM_t = (QFED_t + QFOD_t) - QPDN_t \quad .$$

Substituting the coefficients on the production variable and representing all other variables with Z_{it} we obtain:

$$(3.8) \quad QM_t = (\sum_i \alpha_i Z_{it} + .789 \; QPDN_t) - QPDN_t$$

$$(3.9) \quad QM_t = \sum_i \alpha_i Z_{it} - .211 \; QPDN_t \quad .$$

By comparison, the import demand equations estimated by Ryan and Houck for Poland, Czechoslovakia and Hungary had significant coefficients on the respective production variables with magnitudes of -.18, -.26, and -.25. The implied coefficient of -.21 for the USSR is of the same order of magnitude.

3.4 Specification and Empirical Results for Block 1 Price Linkages

In order for the coarse grain sector model to have an equilibrium solution, price linkages must be established between the countries in block 1. The European countries in block 2 are assumed to have policy determined prices over the projection period, and those assumptions are discussed in Chapter 4. Canada has a complex system of pricing and marketing of grains operated by the Canadian Wheat Board, but their price quotations tend to be influenced by prices across the border in U.S. markets. In particular, barley price quotations are increasingly tied to U.S.

corn prices. The price variable for Japan is the price index of imported corn, and the U.S. share of these imports has exceeded 50 percent since 1963. The only major import restriction affecting coarse grains was a quota on sorghum imports which was lifted in 1964. It is reasonable therefore to link the Canadian barley price and the Japanese corn price index to the U.S. corn price for projection purposes.

The price series on the U.S. Gulf-port price of corn does not extend back beyond 1962, so an export price proxy (EXPC) was generated from the U.S. average farm price (UPC) and the average export subsidy (XSUB) as follows:

$$(3.10)\quad EXPC = 2.2046(UPC - XSUB)\quad .$$

This variable is in units of dollars per 100 kilograms and has a simple correlation coefficient of 0.994 with the Gulf-port price of corn for the period 1962 to 1974. An estimated linear relation between these variables is presented in Table 3.9.

Since all prices in the model are deflated, the desired linkages are between real price levels. However, spatial equilibrium is generally defined in terms of nominal prices, using annual exchange rates to convert to common currency units. This leads to a price linkage of the form

$$(3.11)\quad \frac{NP_{it}}{r_{it}} = M_{it} + NXPC_t$$

where M_i = price margin including fixed tariffs and transport costs in U.S. dollars

NP_i = nominal price of grain in ith country in local currency

NXPC = nominal U.S. export price of grain in U.S. dollars

r_i = exchange rate in local currency per U.S. dollar

An analogous relation can be formulated for real prices. Prices in this model are first deflated by the consumer price index (CPI) with base year 1970, then transformed to 1970 U.S. dollars with the 1970 exchange rate (r_{70}). This 1970 real dollar price (RDP) is

$$(3.12) \quad RDP_{it} = NP_{it}/(CPI_{it} \cdot r_{i70}) \quad .$$

By performing some algebraic operations to equation 3.11, the relationship linking real price (RDP) to the real U.S. price (EXPC) and a real margin (RM) is equivalent to deflating both sides of (3.11) by the U.S. CPI and can be written:

$$(3.13) \quad \frac{RDP_{it}}{K_{it}} = RM_{it} + EXPC_t$$

where

$$K_{it} = \frac{r_{it} \cdot USCPI_t}{r_{70} \cdot CPI_{it}} \quad .$$

Allowing for constant and marginal effects, a simple equation can be specified to estimate this relationship:

$$(3.14) \quad \frac{RDP_{it}}{K_{it}} = \hat{\alpha} + \hat{\beta}\, EXPC_t + u_t \quad .$$

For projection purposes then, assumptions need only be made about the level of K_{it} since the projection relation would be

$$(3.15)\quad RDP_{it} = K_{it}(\hat{\alpha} + \hat{\beta}\ EXPC_t)\quad .$$

The parameter K_{it} is related to the "purchasing-power parity hypothesis" of the international trade literature. The "relative version" of this hypothesis expressed in terms of the components of K_{it} is that the current equilibrium exchange rate is approximately equal to the base exchange rate times the relative current price levels:

$$(3.16)\quad r_{it} \simeq r_{i70} \frac{CPI_{it}}{USCPI_t}\quad .$$

That is, exchange rates adjust to compensate for differing rates of inflation. It is clear from (3.16) that if the "purchasing-power parity hypothesis" holds in practice, K_{it} would remain close to 1.0 over time. Caves and Jones[26] specify that the base period should be a "reasonably normal" year, which is hardly the case for the year just prior to the major currency readjustments of 1971 and 1972.

There are other reasons why the hypothesis may not hold up in practice, but Yeager found that it "performed reasonably well"[27] in predicting equilibrium exchange rates in the period

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[26] R.E. Caves and R.W. Jones, World Trade and Payments (Boston: Little, Brown and Co., 1973), pp. 335-339.

[27] L.B. Yeager, "A Rehabilitation of Purchasing-Power Parity," Journal of Political Economy 66 (December 1958), pp. 516-530.

1937 to 1957. To test the hypothesis with recent data, K_{it} was calculated for Canada, Japan and 16 West European countries using data from 1960 to 1973. The hypothesis that $\overline{K}_i = 1$ was tested and could not be rejected at the 5 percent level in 14 of the 18 countries. Out of the 252 cases, all but 36 (15 percent) were within 15 percent of 1.0; and half of these outliers occurred during the currency readjustment from 1971 to 1973. Due to the increased flexibility of exchange rates since 1971, the hypothesis should perform better in the period after 1973 than in the previous decade.

The purpose here is not to debate the merits or failures of the purchasing-power parity hypothesis, but rather to indicate that K_{it} is a relatively stable parameter over the long run and becomes more so as the flexibility of exchange rates increases. Certainly, long-run assumptions about any of its separate components would of necessity be more arbitrary than assumptions about K_{it}. The latter assumptions will be discussed in the next chapter and are based on recent values of K_{it} that reflect the currency readjustments of 1971 and 1972.

The most satisfactory specification for the Canada barley price relation includes a constant term only up to 1971, implying that the price relationship changed under the higher price regime of the last three years. Thus a dummy variable (CD71) is used, so the intercept is $\hat{\alpha}$ from 1960 to 1971 and zero from 1972 onward. The specification is

$$(3.17)\quad CPB_t/KC_t = \hat{\alpha}\, CD71 + \hat{\beta}\, EXPC_t + u_t$$

where CD71 = dummy variable, 1 (1960 to 1971), 0 (elsewhere)

CPB = average Canadian Wheat Board selling price for No. 3 Canadian Western 6-row barley (deflated by CPI)

EXPC = export price proxy as defined in (3.10) above (deflated by U.S. CPI)

KC = "purchasing-power parity parameter" for Canada as defined in (3.13) above.

The results in Table 3.9 show that the Canadian barley price has a 40 percent differential over the U.S. corn price in recent years and a smaller differential before 1972. Part of this differential is due to the fact that the U.S. price proxy is based on the farm price of corn rather than the export price.

The Canadian feed equation includes the price of wheat as an independent variable, so some assumption must be made about the formation of the Canadian wheat price over the projection period. Since the Canadian Wheat Board administers both prices, the historical relationship between wheat and barley prices is a reasonable behavioral assumption for the projection period. The relationship estimated is

$$(3.18)\quad CPW_t = \hat{\alpha} + \hat{\beta}\, CPB_t + \hat{\gamma}\, CD73 + u_t$$

where CD73 = dummy variable, 1 (1973), 0 (elsewhere)

CPB = average Canadian Wheat Board selling price for No. 3

Table 3.9. Regression Estimates of Price Linkages Used in the Coarse Grain Model

DEPENDENT VARIABLE	EXPC	CD71	CONST	$\bar{R}^2$	D.W.	CV d.f.
GULFPC (t)	1.0580 (29.59)		0.7437 (3.46)	.99	1.84	0.03 11
CPB/KC (t)	1.4012 (42.70)	-0.8559 (3.93)		.96	2.09	0.06 13
	CPB	CD73	CONST	$\bar{R}^2$	D.W.	CV d.f.
CPW (t)	1.1658 (20.33)	2.962 (6.22)	0.2137 (0.51)	.99	2.28	0.04 11
	ΔEXPC	$EXPC_{-1}$	CONST	$\bar{R}^2$	D.W.	CV d.f.
JPC/KJ (t)	11.055 (7.64)	16.719 (11.80)	14.175 (1.76)	.93	2.00	0.05 11

t = t-statistic (absolute value)
CV = standard error/mean
d.f. = degrees of freedom

Canadian Western 6-row barley (deflated by CPI)

CPW = average Canadian Wheat Board selling price for No. 2 Northern Wheat (deflated by CPI).

The 1973 observation was omitted because the Wheat Board's price policy that year was significantly different from that in 1974 and resulted in a substantially higher average price than would otherwise have obtained.[28]

The results in Table 3.9 show that the 1973 wheat price was $2.96 above the prediction line. The constant is not significant and the wheat price is about 17 percent above the barley price over the historical period.

The Japan-U.S. price linkage is different from the Canadian linkage in two ways. One is that the Japanese "price" is an index. The other is that the Japanese crop year is April-March compared with July-June for the U.S., and prices like quantities are crop-year values. The first is not really a problem. Since a price index is formed by multiplying (or dividing) every price in the series by a single constant, it merely changes the units of the dependent variable and alters the estimated coefficients by the same constant factor. The second difference implies that the Japan April-March price may be more closely related to the April-March or even the March-February average U.S. price than to the July-June average. A simple approach which allows the

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[28] The Canadian Wheat Board Annual Report (Winnipeg, Canada, January 31, 1976), pp. 7, 20-24.

data to determine this time period relationship is shown in the specification below[29]:

$$(3.19)\quad JPC_t/KJ_t = a + b[\delta \cdot EXPC_t + (1-\delta)\ EXPC_{t-1}]$$

The corresponding estimation model is

$$(3.20)\quad JPC_t/KJ_t = \hat{\alpha} + \hat{\beta}(EXPC_t - EXPC_{t-1}) + \hat{\gamma}\ EXPC_{t-1} + u_t$$

where EXPC = export price proxy as defined in (3.10) above (deflated by U.S. CPI)

JPC = wholesale price index of imported corn in Japan (deflated by CPI)

KJ = "purchasing-power parity parameter" for Japan as defined in (3.13) above

$\hat{\beta}$ = the OLS estimate of $b \cdot \delta$

$\hat{\gamma}$ = the OLS estimate of b

δ = the time period parameter ($0 < \delta < 1$).

It is clear that $\hat{\beta}/\hat{\gamma}$ is an estimate of the time period parameter δ. The results of this regression in Table 3.9 show that $\hat{\delta}$ = 0.661 which corresponds to about 8 months.[30] This means that

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[29] This method was previously used by M. Bredahl and D. Tischendorf, "Price Formation of Soybeans and Soybean Meal: The U.S. and Germany," unpublished manuscript, University of Minnesota, February 1977.

[30] Since $\hat{\delta}$ is a nonlinear function of the unrestricted coefficients $\hat{\beta}$ and $\hat{\gamma}$, the variance of $\hat{\delta}$ must be approximated from a truncated Taylor expansion. The calculated result is a standard error of 0.099 and a t-statistic for $\hat{\delta}$ of 6.67.

the dependent variable is best explained by the March-February average of U.S. export prices[31], which is reasonable in view of possible lags in the market process.

These price linkages all have "good fit" as indicated by the high adjusted $\bar{R}^2$; and the hypothesis of no autocorrelation in the disturbance term cannot be rejected at the 5% level of significance, so serial correlation is not a problem.

[31] Of course, this weighted average of the July-June prices is an approximation of the March-February average and is not necessarily equal to the value that would be obtained from the monthly data.

Chapter 4

COARSE GRAINS PROJECTION MODEL

This chapter describes the components of the coarse grains projection model, its historical performance, the projection assumptions, and the projection results.

4.1 Quantity Components and Quantity Equilibrium

The model for coarse grains has three demand blocks, as outlined in Chapter 2 above. The first is composed of demand in Canada, Japan and the U.S., where prices are linked to the U.S. price of corn. The second block includes the countries of West Europe, where prices are assumed to be policy determined. The third includes the USSR, Eastern Europe and all remaining countries and regions of the world, where the price response is based on elasticity assumptions.

In the block 1 countries it is assumed that internal prices are determined by the supply and demand equilibrium in the world model. All prices are tied to the U.S. export price of corn through the price linkages which were discussed in Chapter 3. The per capita demand relations presented in Chapter 3 are combined to determine total coarse grain demand for each country as seen in (1) of Table 4.1. The horizontal summation of the three country demands to determine total block 1 demand is illustrated in Figure 4.1.

In the block 2 countries of West Europe it is assumed that

Table 4.1. Quantity Equilibrium in the Coarse Grains Model

BLOCK 1 (USA, CAN, JPN)

(1) $QD_{it} = N_{it}(QFEDC_{it} + QFODC_{it})$ $\quad i = 1, 3$

BLOCK 2 (West Europe except Iceland and Malta)

(2) $N_{jt}(QFEDC_{jt})$ $\quad j = 1, 16$ (jth country)

(3) $QFOD_{it}$ $\quad i = 4, 5$ (ith region)

(4) $QD_{4t} = QFOD_{4t} + \sum_{j=1}^{8} N_{jt}(QFEDC_{jt})$

(5) $QD_{5t} = QFOD_{5t} + \sum_{j=9}^{16} N_{jt}(QFEDC_{jt})$

BLOCK 3 (18 regions)

(6) $QD_{it} = QFOD_{it} + QFED_{it}$ $\quad i = 6, 23$

EQUILIBRIUM

(7) $QM_{it} = QD_{it} + CST_{it} - QP_{it}$ $\quad i = 1, 23$ import demand

(8) $\Sigma QM_{it} = 0$ trade identity

(9) $\Sigma QD_{it} = \Sigma QS_{it} - \Sigma CST_{it}$

(10) $\Sigma QD_{it} = WQP_t - WCST_t$ equilibrium condition

where CST = change in coarse grain stocks (end-beginning)
N = population
QD = total coarse grain demand
QFED = total coarse grain fed
QFOD = total coarse grain not fed
QFEDC = per capita coarse grain fed
QFODC = per capita coarse grain not fed
QM = coarse grain imports (negative for exports)
QP = coarse grain production
WCST = world change in coarse grain stocks
WQP = world coarse grain production

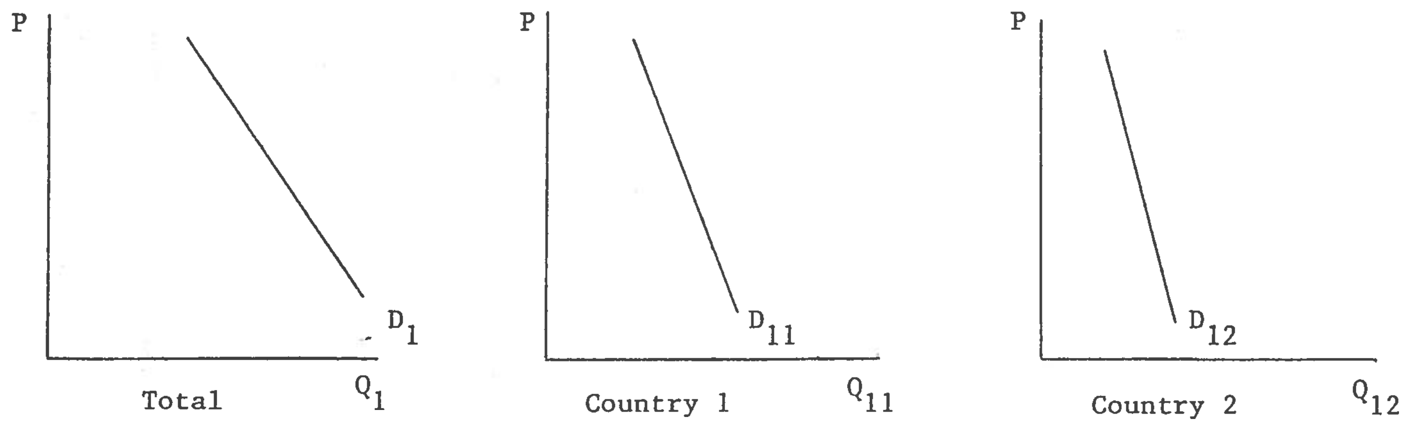

Figure 4.1. The Summation of Coarse Grain Demand for Block 1 Illustrated for Two Countries.

internal prices are determined by government policy and are not affected by world price unless the latter goes above a critical level. This conditional linkage is described in the next section. The per capita feed demand and regional food demand relations presented in Chapter 3 are combined, as seen in (2) to (5) of Table 4.1, to determine total coarse grain demand for the EC-9 (4) and the "other-8" (5). Since internal prices are exogenous, the summation (Figure 4.2) generates a kinked demand curve for block 2 which is perfectly inelastic up to the lowest internal price level.

Block 3 includes the central planned economies, the third world regions and small developed countries not included in blocks 1 and 2. Except for the USSR, demand projections in this block are based on assumed levels of population growth, income growth and income elasticities. From consumption in the base year, the projection of demand in year t is calculated with the relations:

$$(4.1) \quad QFOD_{it} = QFOD_{i0}(1 + \hat{N}_i + \eta_{i1}\hat{I}_i)^t$$

$$(4.2) \quad QFED_{it} = QFED_{i0}(1 + \hat{N}_i + \eta_{i2}\hat{I}_i)^t$$

where $\hat{I}$ = annual rate of growth in per capita private consumption expenditures

$\hat{N}$ = annual rate of population growth

η_{i1} = income elasticity of coarse grain food demand

η_{i2} = income elasticity of coarse grain feed demand

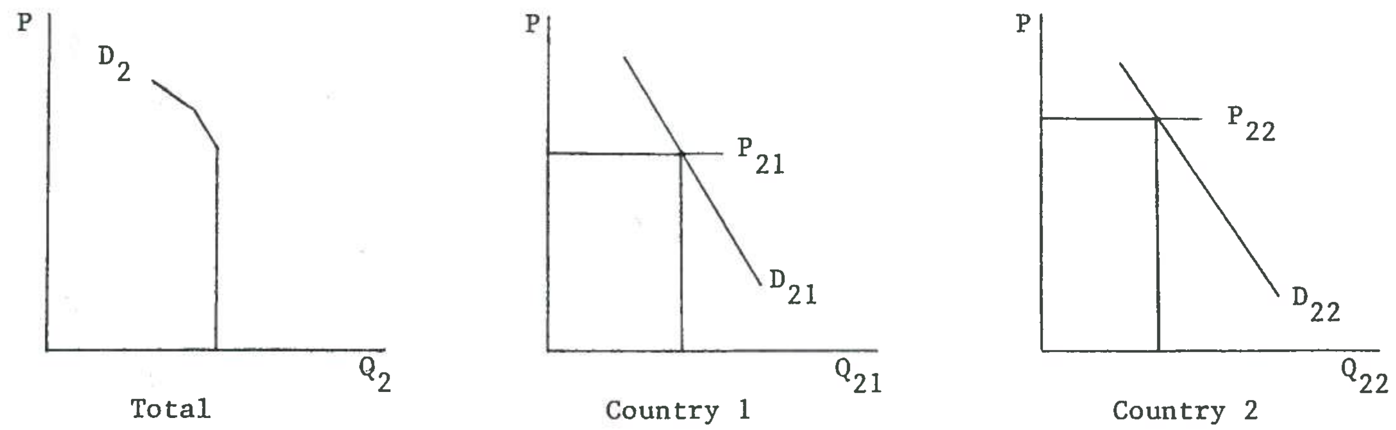

Figure 4.2. The Summation of Coarse Grain Demand for Block 2 Illustrated for Two Countries with Internal Prices P_{21} and P_{22}.

QFED = total coarse grain fed

QFOD = total coarse grain not fed

Since the base year may not be a "normal" year, the base year consumption selected in all but a few cases is a trend line value from a logarithmic trend.[1]

For the USSR, food and feed demand projections are based on the estimated equations reported in Chapter 3. For each of the 18 countries and regions in block 3, total coarse grain demand is the simple sum of food and feed demands as seen in (6) of Table 4.1. Since price elasticities were not estimated for block 3 regions, an aggregate price elasticity is assumed for block 3 in order to allow a reasonable price response.

The quantity equilibrium condition is derived in (7) to (10) of Table 4.1. The import demand (or negative export supply) for each region or country (7) is domestic consumption plus change in stocks minus domestic supply. The trade identity (8) imposes the condition that total imports equal total exports and leads to the equilibrium condition (10) that world demand must equal world production minus change in stocks. The solution of the model, therefore, does not require assumptions about production or stocks in any single country or region but only for the world as a whole.

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[1]The exceptions are very minor consuming regions. For total coarse grain these are ICEMAL and ROW. For fed coarse grain these include SEASIA, EAF, and VEN (see Appendix 2 for region definitions).

The equilibrium solution is illustrated in Figure 4.3, where S is production minus change in stocks. The broken lines illustrate the dynamics of the model when demands and supply shift. Price is determined by the intersection of world demand with world supply. In this case, the equilibrium price is too low to affect demand in block 2, so the entire price adjustment occurs in blocks 1 and 3.

4.2 Price Linkages and Price Equilibrium

The price linkages for block 1 were estimated and discussed in Chapter 3. These tie the internal prices of Canada and Japan to the U.S. average farm price of corn through the export price as shown in (1) to (3) of Table 4.2. The U.S. export subsidy which has not been used since 1962 is assumed to be zero over the projection period. The purchasing-power parity parameters calculated for Canada (KC) and Japan (KJ) declined during the currency adjustments that began in 1971. In the case of Japan it declined dramatically from 1.0 to about 0.7 in 1973 to 1975 (Table 4.3). The leveling off in the latter three years suggests that these may be stabilizing at a new equilibrium. It would be desirable to have more observations, but these are not yet available. Therefore, the averages of the last three years are used as approximations of KC and KJ for the projection. An adjustment coefficient is also included to test the sensitivity of the model to alternative assumptions.

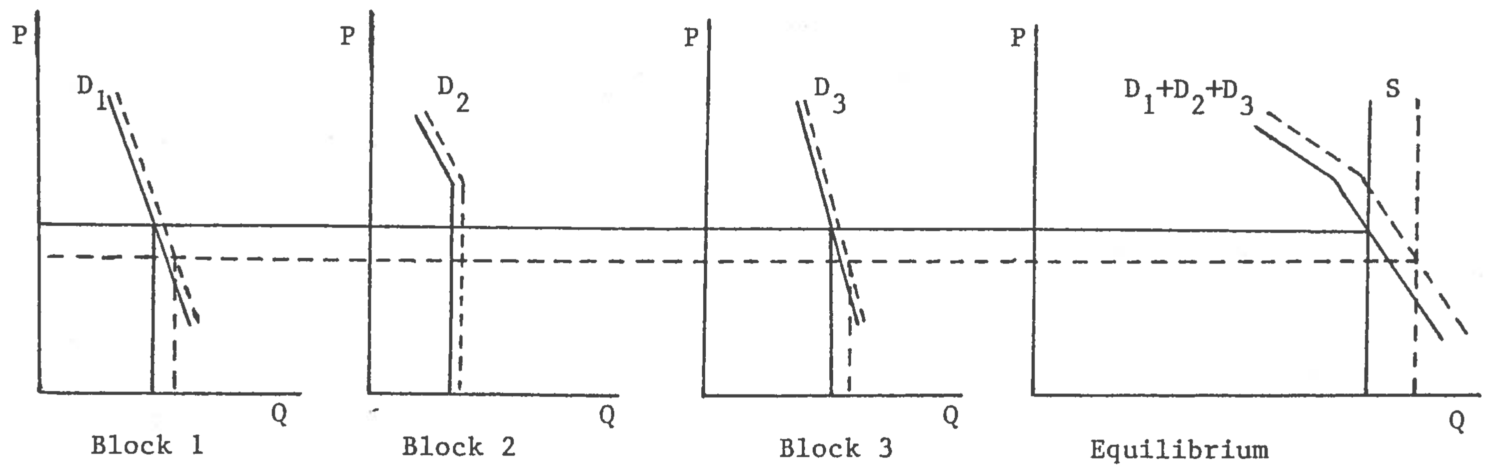

Figure 4.3. The Interaction of the Three Demand Blocks in the World Market Equilibrium When Demands and Supply Shift to New Levels*

*The new levels are indicated by broken lines.

Table 4.2. Price Linkages in the Coarse Grain Model[a]

BLOCK 1 (USA, CAN, JPN)

(1) $EXPC_t = f(UPC_t, XSUB)$

(2) $JPC_t = KJ \cdot f(EXPC_t, EXPC_{t-1})$

(3) $CPB_t = KC \cdot f(EXPC_t)$

BLOCK 2 (West Europe except Iceland and Malta)

(4) $MPC_t = KN(EXPC_t + M)$

(5) If $[MPC_t \leq NTPC_{t-1}(1 + PR)]$ $R = PR$

(6) If $[MPC_t > NTPC_{t-1}(1 + PR)]$ $R = (MPC_t - MPC_{t-1})/MPC_{t-1}$

(7) $PCG_{jt} = PCG_{j,t-1}(1 + R)$ $j = 1, 16$

BLOCK 3 (18 regions)

(8) $QD^*_{it} = QD_{it}(EXPC_t/EXPC_{74})^{\varepsilon}$ $i = 6, 23$

where CPB = internal price of barley, Canada
EXPC = export price of corn, U.S.
JPC = internal price of corn, Japan
KC,KJ,KN = purchasing power parity parameters (see Chapter 3)
M = marketing margin
MPC = minimum export price U.S. corn at Rotterdam
NTPC = threshold price of corn, Rotterdam
PCG_j = internal price of coarse grain, jth country
PR = policy rate of growth in real price of coarse grain
QD = projected coarse grain demand (ith region)
QD^* = price-adjusted coarse grain demand (ith region)
R = rate of growth in real price of coarse grain
UPC = average farm price of corn, U.S.
XSUB = average export subsidy on U.S. corn
ε = price elasticity of demand

[a]All prices and M are in 1970 U.S. dollars. The K parameters and rates R and PR do not have units of measure, QD and QD^* are quantities.

Table 4.3. Values of the Purchasing-Power Parity Parameters for Recent Years in Canada, Japan and the Netherlands

Year	Canada	Japan	Netherlands
1970	1.000	1.000	1.000
1971	1.006	0.864	0.878
1972	0.985	0.816	0.833
1973	0.972	0.719	0.717
1974	0.969	0.700	0.644
1975	0.980	0.691	0.684

In block 2, as already noted, internal prices are exogenous unless world price goes above some critical level. So it is necessary to define such a critical level and to establish the manner in which a world price above that level affects European prices.

The West European grain market is dominated by the European Community (EC), and some of the countries still outside are already aligning their price policies with the EC in preparation for possible future integration. Therefore, with relatively little loss in accuracy this analysis can be simplified by assuming that all 16 countries follow a single policy with regard to the rate of increase in grain prices. This is referred to as the policy rate (PR) in (5) of Table 4.2, and it is used to generate internal coarse grain prices as illustrated by (7), where current price is higher than last year's price by the factor (1 + PR).

The policy-determined rate of growth remains in force as long as the policy price of grain exceeds the world price. It is necessary to establish a minimum price (MPC) at which U.S. corn can be offered to the EC and to compare this to an equivalent threshold price set by the EC. A complete model of the EC pricing system would be far too complex for the purposes of this study. Such a model developed by Bredahl[2] shows that the internal corn prices of each member country can be linked to the

[2] Maury E. Bredahl, "Price Formation in the European Community," CED Working Paper, ERS/USDA, 1977.

threshold price of corn in Rotterdam. The same relationship is expected to hold for barley. Therefore, the approach here is to key on the Netherlands threshold price of corn (NTPC) and assume that if the price of U.S. corn at Rotterdam (MPC) becomes greater than the threshold price, all European coarse grain prices rise at a rate equivalent to the growth rate of MPC. This is shown in (6) of Table 4.2.

What remains is to link MPC to the U.S. export price of corn (EXPC). Based on the price linkage discussion in Chapter 3, the relationship between the threshold price (NTPC) and the U.S. export price can be expressed as

$$(4.3) \quad NTPC_t - VL_t = KN_t(EXPC_t + M_t)$$

where M is the marketing margin, VL the variable levy, KN is the purchasing power parity parameter, and all values are in U.S. dollars. The marketing margin for recent years can be calculated from equation (4.3), since all the other variables are known. These calculations are shown in Appendix Table 4.1. There is no strong trend in the margin from 1971 to 1974, so the average of these is taken as an approximation of the marketing margin for the projection period. It is not unreasonable to assume that the margin rises just enough to keep pace with inflation, but an adjustment coefficient is included to test the sensitivity of the model to alternative assumptions.

As with the case of Canada and Japan, the purchasing power parity parameter KN appears to stabilize from 1973 to 1975 (Table 4.3), so the average of these three years is taken as an approximation of KN for the projection period. Again an adjustment coefficient is included for sensitivity testing. Having set these parameters, the minimum price of U.S. corn in Rotterdam can be calculated from the U.S. export price as shown in (4) of Table 4.2. Relations (5) to (7) show how the threshold price always grows at the policy rate PR, and internal prices increase at the policy rate except when MPC exceeds the threshold price. In the latter case, internal prices increase at the world market rate. This is a very simplified model of the European price system, but it captures the salient features of the system and its relationship to the world market.

Finally, in the absence of estimated price elasticities for block 3, a crude price relation is imposed to permit some price response to occur. This is shown in (8) of Table 4.2. Simply stated, if the U.S. export price of corn goes above or below the 1974 level, projected demand will decrease or increase, respectively. The magnitude of the adjustment depends upon the assumed price elasticity ε, which represents the aggregate response for block 3.

Any assumption made about the price elasticity for block 3 is bound to be somewhat arbitrary, since it applies to feed and non-feed uses and to developed as well as third world areas. The developed country demand in block 3 is dominated by the central planned economies. East European grain trade has exhibited a response to world prices in recent years[3], and the same should be expected of the USSR for recent years. If imports are the only component of consumption that responds to world prices, the price elasticity with respect to total demand would be quite small. For example, Ryan and Houck estimated the corn import price elasticity for East Germany to be -0.76, but imports account for only about 20 percent of coarse grain consumption. If world price has no effect on domestic coarse grain supply, the total demand elasticity with respect to world price is about -0.15.[4] East Europe and the USSR combined have imported somewhat less than 20 percent of their total coarse grain consumption, so the overall price elasticity is not likely to be much different from the East German case.

One would expect the price elasticity for fed coarse grains to be much higher in the third world; but unlike East Europe and the USSR, food rather than feed uses dominate third world consumption.

Moreover, the internal supplies of some third world regions

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[3]Mary E. Ryan and J.P. Houck, "Eastern Europe, a Growing Market for U.S. Feed Grains," Economic Report 76-7, Department of Agricultural and Applied Economics, University of Minnesota, November 1976.

[4]Consider $E_Q = E_M \cdot \frac{M}{Q} + E_{Q-M} \cdot \frac{Q-M}{Q}$ where Q is total demand, M is imports, and E is elasticity. If domestic supply is inelastic with respect to world price, $E_{Q-M} = 0$ and $E = E_M \cdot M/Q = (-0.76) \times (.2) = -.15$.

are also protected from world price influence. The most notable of these is China, which accounts for over 30 percent of third world coarse grain consumption. Therefore, the total third world demand would also be rather inelastic with respect to world price. The block 3 elasticity is initially set at -0.2 and an adjustment coefficient is included to test the sensitivity of the model to alternative elasticity levels.

4.3 Projection Assumptions

All of the exogenous variables in the model must be assigned values over the projection period, and assumptions must be made regarding the income elasticities used in the block 3 projections. Most of the exogenous variables are assumed to change at a constant rate over time, and this section discusses the choice of these growth rates as well as the choice of income elasticities.

Income elasticities. The block 3 income elasticities for coarse grain food demand are based on estimates from three sources. First, constant growth rates in coarse grain food demand were estimated for each region for the 1960 to 1974 period. Then income elasticities implied by these rates were calculated[5]

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[5]Using the notation of equation (4.1) above, let the growth rate of demand be $\hat{R}$. Then

$$\hat{R} = \hat{N} + \eta \cdot \hat{I} \quad \text{and} \quad \eta = (\hat{R} - \hat{N})/\hat{I}$$

So the implied elasticity η is derived from the growth rates of demand $(\hat{R})$, population $(\hat{N})$ and income $(\hat{I})$.

and compared to estimated FAO[6] elasticities for coarse grain food demand and ERS[7] elasticities for total coarse grain demand. These are shown in Appendix Table 4.2. The criteria used to choose elasticities for the projection model were as follows:

1. Use the "trend" elasticity if it is not outside the range of the FAO and ERS estimates.
2. If the "trend" elasticity is outside the range of the other two, use the estimated elasticity that is closer to the "trend" value.
3. If the "trend" elasticity is negative and the other two are both positive, use an elasticity of zero.

For Iceland, Malta and the "rest of the world" feed and food uses were not separated and an elasticity of 0.3 was assumed. These assumptions are summarized in Table 4.4.

The approach used for food demand could not be used for feed demand. The "trend" elasticities for the third world regions were very erratic, perhaps due to less reliable data for feed use. However, FAO has reported income elasticities for livestock products. It is necessary, therefore, to look to economic theory for the relationship between the direct income effect on

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[6] FAO, Agricultural Commodity Projections, 1970-1980, Volume 2, United Nations, Rome, 1971.

[7] Economic Research Service, World Demand Prospects for Grain in 1980, Foreign Agricultural Economic Report No. 75, U.S. Department of Agriculture, December 1971, Table 11.

Table 4.4. Assumed Rates of Growth of Population and Income for the Projection Period and Assumed Income Elasticities for Block 3

Region[a]	Population Rate	Income Rate	Income Elasticity Food	Feed
ICEMAL	0.72	5.20	0.30[b]	
ANZ	1.75	2.91	0.0	0.05
SAFR	3.10	2.38	0.15	0.41
EEUR	0.72	4.47	-0.07	0.48
USSR	1.08	4.78	EQN	EQN
CHIN	1.48	2.39	0.20	1.22
EASIA	2.54	3.11	0.0	0.90
SEASIA	2.70	3.21	0.50	0.90
SOASIA	2.76	1.09	-0.16	1.20
NAFRME	2.48	4.66	-0.08	0.59
CAFR	2.91	2.22	0.0	0.80
EAFR	3.12	1.58	0.0	0.74
MAMER	3.07	2.95	0.26	0.61
VEN	2.79	2.69	0.45	0.48
BRZ	2.86	5.89	0.20	0.48
ARG	1.19	3.12	0.0	0.18
OSA	2.76	1.92	0.0	0.70
ROW	2.20	1.67	0.30[b]	

[a] See Appendix 2 for region definitions

[b] Elasticity for food and feed combined

final product demand and the derived income effect on input demand.

It was shown in the theoretical discussion of Chapter 3 that in a Cobb-Douglas framework, the reduced form elasticity of income with respect to feed demand is no smaller than the income elasticity of the final product.[8] Therefore, the FAO estimated elasticities for "all meat" were taken as reasonable estimates of the income elasticities for feed demand.[9] These assumed elasticities are given in Table 4.4.

Population growth rates. The population growth assumptions used in the projections are based on the United Nations medium variant as assessed in 1974. The medium variant rates were used by ERS to calculate the 1985 population projections by region. From these projections, the implied compound rates of regional population growth for the 1975-85 period were calculated (Appendix Table 4.3). The UN country population growth rates for the 1975-85 period were used for countries in blocks 1 and 2. For the "rest of the world" region, the historical growth rate for the 1970-75 period was used. The assumed rates of population growth for 1975-95 are presented in Table 4.4 for block 3 and in Table 4.5 for blocks 1 and 2. There are adjustment

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[8] It can also be shown that for any linearly homogeneous production function, the reduced-form elasticity of income is identical to the final product income elasticity.

[9] In Appendix Table 4.2 these are compared to equivalent elasticities estimated by ERS which are of the same order of magnitude.

coefficients in the model which permit sensitivity testing by changing all developed country or all third world population growth rates by a fixed proportion.

Income growth rates. The income growth assumptions are based on the United Nations "trend" projections of real per capita private consumption expenditures as assessed in 1974. The assumed income growth rates for block 3 regions are those calculated by the ERS from UN country projections for the period 1970 to 1985 (Appendix Table 4.3). For Iceland, Malta and blocks 1 and 2, the UN country growth rates for the period 1975-1985 are used. These assumed rates are presented in Table 4.4 for block 3 and in Table 4.5 for blocks 1 and 2. Adjustment coefficients are used to test the sensitivity of the model by changing all developed or all third world income growth rates by a fixed proportion.

Supply growth and stocks. The quantity equilibrium condition in Table 4.1 above sets total demand equal to total production minus change in stocks. In this model supply and stocks are taken as exogenous but the impact of differing assumptions will be measured. For the base solution, the rate of growth in production is set equal to the historical growth in world production from the 1960-1962 average to the 1973-1975 average. The rate for the entire period was 2.7 percent per annum[10], though

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[10] Calculated from world total production of coarse grain in World Agricultural Situation, WAS-11, ERS, U.S. Department of Agriculture, October 1976, Table 15.

it was higher in the 61-70 period and lower in the 70-74 period.

Coarse grain stocks in the U.S. and the world have declined in recent years due principally to policy changes and higher prices. Future stocks are also likely to be subject to price and policy influence, so different stock assumptions are tested. For the base solution, it is assumed that the percent of world production held as stock remains constant and equal to the average percent held from 1971 to 1974. Although world stock data is not complete, it is apparently consistent and it shows that coarse grain stocks averaged 10 percent of world production from 1971-74 compared with 15 to 20 percent in the 1960's. A 10 percent stock level may not be much above what is required to meet transactions demand. Under this assumption 10 percent of the increment to production each year goes into stocks. Therefore, the projection of production net of change in stocks takes the form

$$(4.4) \quad QS_t = QP_{t-1}(1 + \hat{QP} - \alpha \cdot \hat{QP})$$

where QS_t = current production minus change in stocks

QP_{t-1} = previous year's production

$\hat{QP}$ = rate of growth in production

α = proportion of production held as stock

If $\alpha = 0$, the absolute stock level remains constant as production increases and the growth rate in available supply (QS) equals the growth rate in production.

Table 4.5. Assumed Rates of Growth of Population and Income for the Projection Period in Blocks 1 and 2

Country	Population Rate	Income Rate
BLOCK 1		
Canada	1.50	2.85
Japan	0.95	6.10
United States	0.95	2.95
BLOCK 2		
Belilux	0.50	3.00
France	0.90	3.80
Italy	0.45	3.90
Netherlands	0.70	3.90
W. Germany	0.25	3.60
Denmark	0.30	3.75
Ireland	1.20	3.05
United Kingdom	0.40	2.00
Austria	0.20	4.05
Finland	0.10	3.45
Greece	0.15	6.30
Norway	0.55	3.55
Portugal	0.25	5.60
Spain	1.00	5.45
Sweden	0.55	2.55
Switzerland	0.35	3.95

Since production in 1974 was below trend, the average production for 1973 to 1975 was used as the initial level for the supply projection.

A rate of production growth for the USSR is required to project the production variable in the USSR equation. The historical rate of production growth was estimated for this purpose. Taking the major land expansion program of 1973 as a supply shifter[11], the trend rate of production is 2.8 percent per annum.

European price policy. It is not possible, of course, to penetrate the intentions of policymakers in Europe. As indicated in Section 4.2 above, it is assumed that the policies of the European Community with regard to grain prices will be followed by all of Europe. It is reasonable to assume that the European Community will increase the threshold price of grain at a rate sufficient to keep pace with inflation. Thus, the policy rate of growth for the real price grain in Europe is assumed to be zero initially but is changed for sensitivity tests.

Other endogenous variables. The quantity of wheat fed in the USSR and West European countries is assumed to remain a constant proportion of coarse grain fed. The proportion in each country is the ratio of wheat fed to coarse grain fed in 1974.

The price of soybean meal in the U.S. and West Europe is

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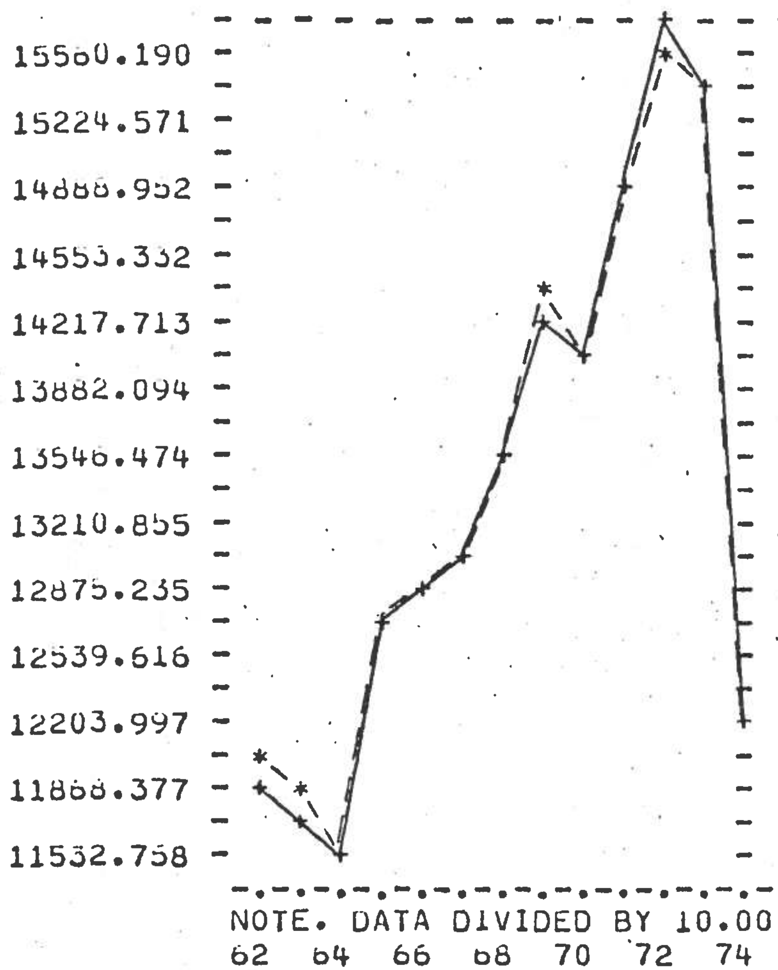
[11] See David M. Schoonover, "The Soviet Feed-Livestock Economy: Preliminary Findings on Performance and Trade Implications," Prospects for Agricultural Trade with the USSR, ERS-Foreign 356, U.S. Department of Agriculture, April 1974, p. 36.

assumed to keep pace with inflation, so the real price remains constant at the 1974 level. The same assumption is made with regard to the price of feeder livestock in the U.S. The value of net exports of annual products in Belgium, Germany and Italy is also assumed to remain constant in real terms. These assumptions are of necessity rather arbitrary but they do not seem unreasonable.

4.4 Historical Performance of the Model

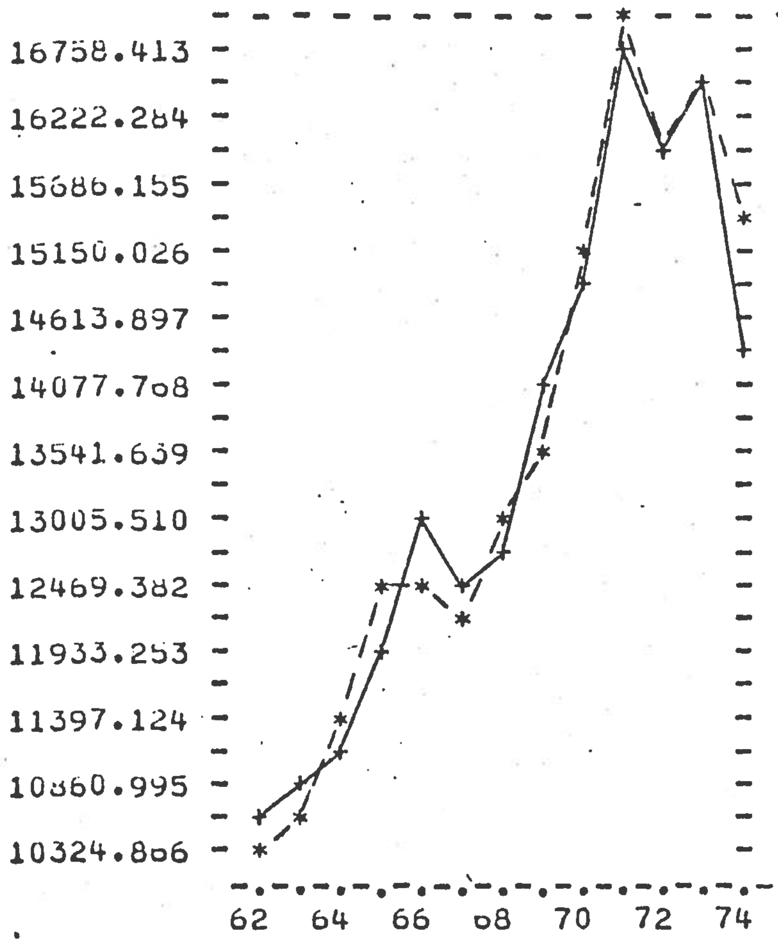
Before proceeding to the projections generated by the coarse grains model, it is important to demonstrate how the model performs over the historical period. With the exception of Japan and the USSR, the demand relations were estimated over the 1960-73 period and 1974 serves as the prediction interval.

The first test is the performance of the equations estimated for the three block 1 countries. A simultaneous solution for the historical period 1962 to 1974 was obtained using the estimated demand equations and price linkages and setting exogenous variables equal to their historical values. The equilibrium prices and quantities were determined by equating total block 1 demand to world supply net of actual demand levels in blocks 2 and 3. The estimated and actual values of total coarse grain consumption by country and the relevant prices are plotted in Figures 4.4 to 4.10. The consumption estimates (Figures 4.4 to 4.6) trace the historical pattern quite well and pick up most of the turning points. Coarse grain demand estimates for the U.S., which



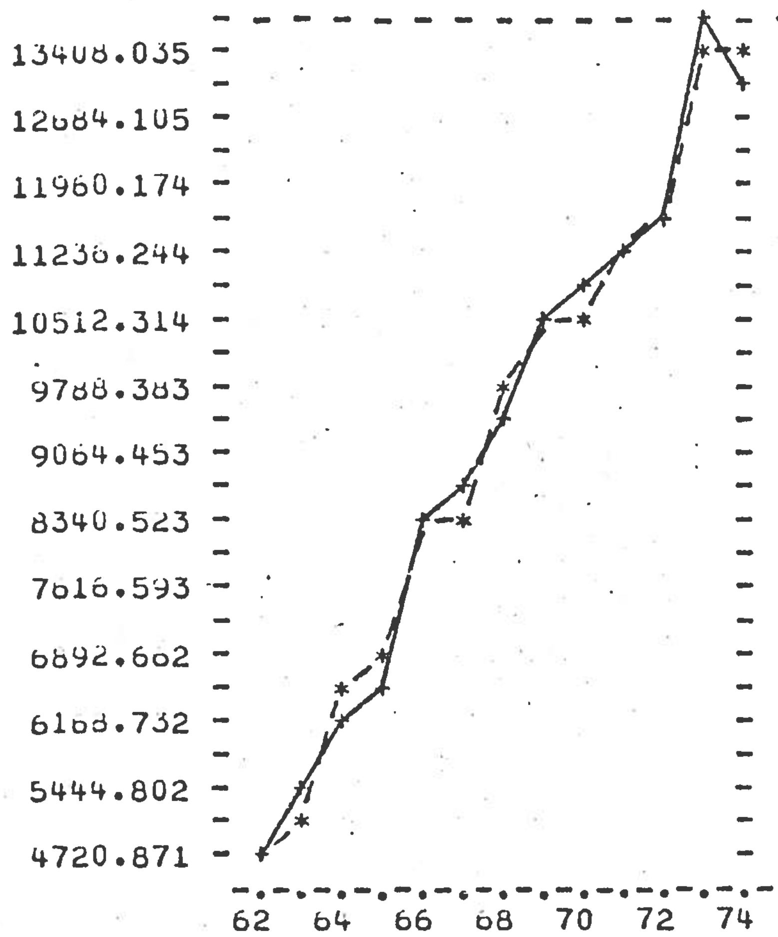
YEAR	LEVELS(10,000 mt) (+)	(*)
1962	12026.000	12080.126
1963	11838.000	11881.248
1964	11568.000	11532.758
1965	12873.000	12779.139
1966	12907.000	12979.720
1967	13132.000	13189.369
1968	13677.000	13625.801
1969	14364.000	14427.286
1970	14087.000	14113.186
1971	15023.000	14975.425
1972	15728.000	15722.997
1973	15498.000	15507.125
1974	12369.000	12207.787
FORECAST		

Figure 4.4 Actual(+) and Estimated(*) Values for USA Coarse Grain Consumption



YEAR	LEVELS (1,000mt) (+)	(*)
1962	10811.000	10324.866
1963	11041.000	10797.966
1964	11343.000	11587.618
1965	12068.000	12631.660
1966	13232.000	12654.322
1967	12640.000	12321.574
1968	12856.000	13121.460
1969	14339.000	13772.346
1970	15125.000	15309.940
1971	16773.000	17026.478
1972	16025.000	16053.422
1973	16563.000	16529.091
1974	14383.000	15656.029
FORECAST		

Figure 4.5 Actual(+) and Estimated(*) Values for Canada Coarse Grain Consumption



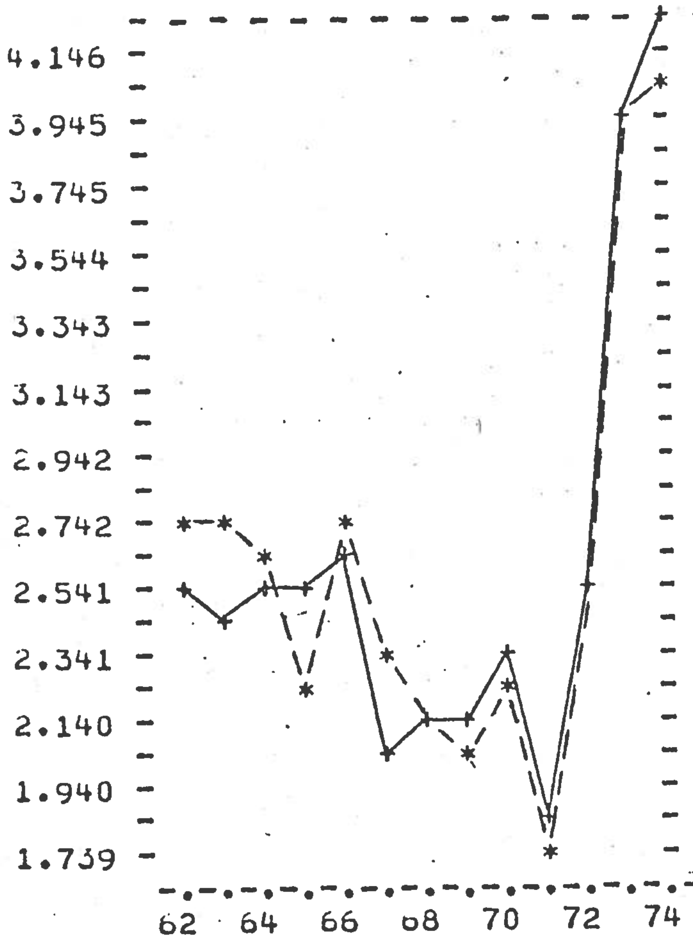
YEAR	LEVELS (1,000mt) (+)	(*)
1962	4976.000	4720.871
1963	5579.000	5389.554
1964	6474.000	6561.802
1965	6569.000	6943.947
1966	8529.000	8379.478
1967	8782.000	8526.739
1968	9584.000	9830.528
1969	10754.000	10687.796
1970	11105.000	10658.201
1971	11296.000	11518.269
1972	11908.000	11929.607
1973	13770.000	13712.659
1974	13382.000	13721.100
FORECAST		

Figure 4.6 Actual(+) and Estimated(*) Values for Japan Coarse Grain Consumption

average about 85 percent of block 1 demand, tracked particularly well even in the 1974 prediction interval. The estimate of the U.S. price of corn (Figure 4.7) picks up the major turning points after 1965, though it does not track well in the earlier period. Since the Canadian and Japanese prices are linked to the U.S. corn price it is not surprising that a similar pattern is reflected in the behavior of those estimates (Figures 4.8 to 4.10).

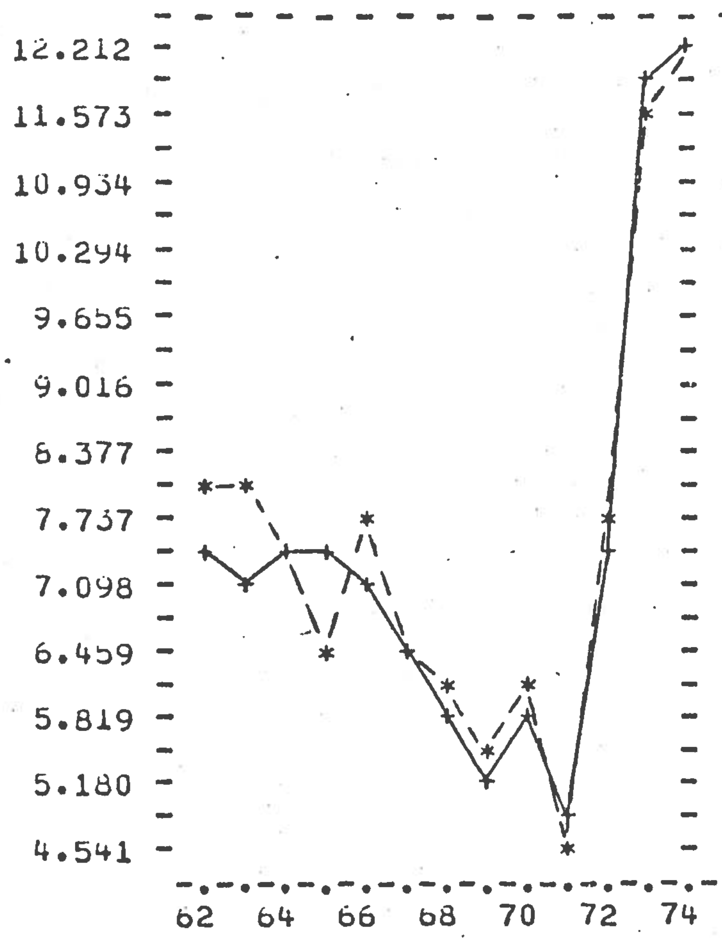
The prediction interval test is presented in greater detail in Table 4.6 where the percentage changes in actual and estimated values are compared for 1973 and 1974. This test is valid primarily for the U.S. and Canada, since the estimation interval for Japan included 1974. The comparison of 1974 actual and estimated percent changes in demand and prices for the U.S. and Canada show that the direction of change was correctly predicted in all cases. The actual and estimated changes in U.S. demand and Canadian barley and wheat prices for 1974 were also similar in magnitude. The error in 1974 prediction as a percent of the actual value was less than 3.5 percent except for the Canadian demand estimate which was 8.85 percent above the actual.

The historical performance of the block 2 estimates is shown in Figures 4.11 to 4.13. The first of these plots actual and estimated quantities of aggregate coarse grain demand for all of West Europe, the second plots the same quantities for the (enlarged) European Community (EC9) and the third includes the rest of West Europe (OWE) excluding Iceland and Malta. The EC9



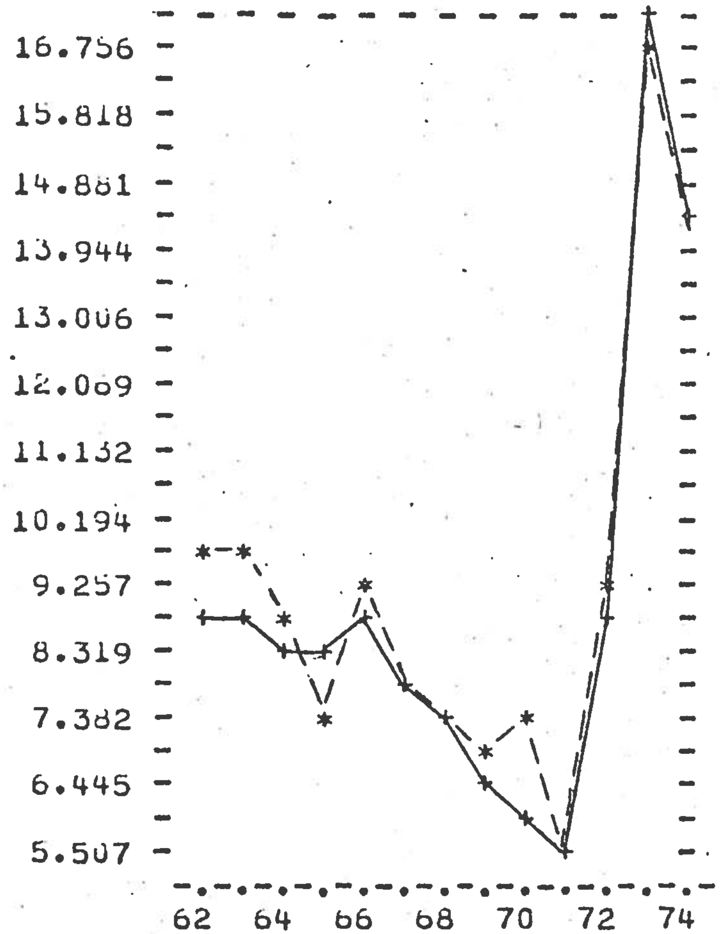
YEAR	LEVELS($/cwt) (+)	(*)
1962	2.566	2.790
1963	2.514	2.801
1964	2.613	2.652
1965	2.549	2.290
1966	2.644	2.744
1967	2.137	2.397
1968	2.151	2.235
1969	2.174	2.080
1970	2.374	2.284
1971	1.850	1.739
1972	2.600	2.586
1973	3.977	3.957
1974 FORECAST	4.246	4.110

Figure 4.7 Actual(+) and Estimated(*) Values for USA Real Price of Corn



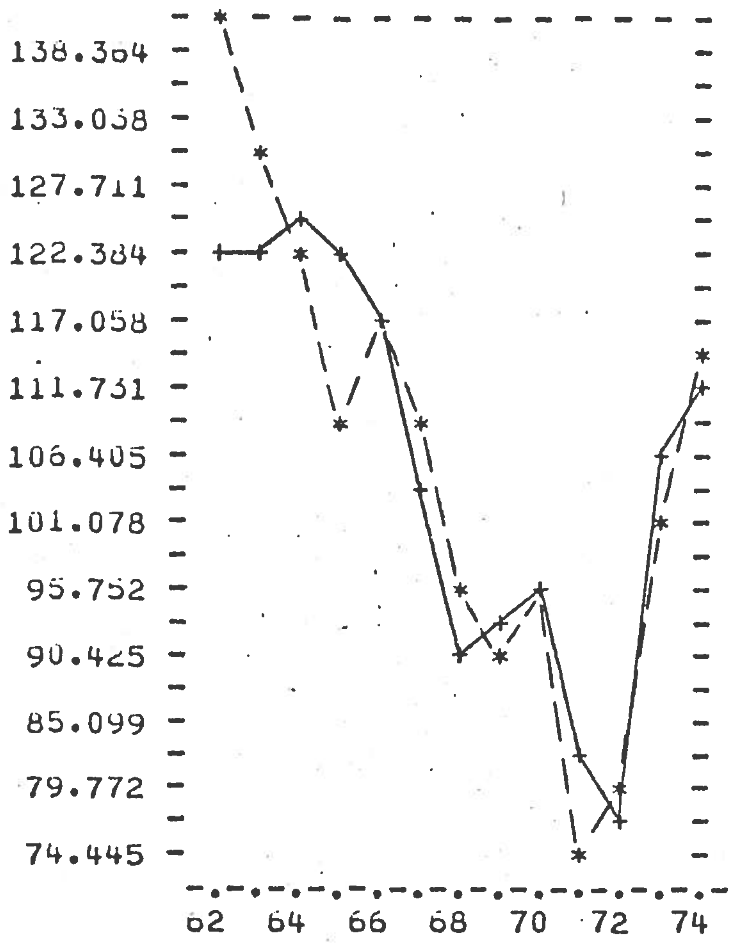
YEAR	LEVELS (CAN$/cwt) (+)	(*)
1962	7.635	8.271
1963	7.100	8.277
1964	7.483	7.711
1965	7.577	6.489
1966	7.250	7.966
1967	6.691	6.769
1968	5.891	6.214
1969	5.260	5.708
1970	5.955	6.199
1971	5.032	4.541
1972	7.532	7.865
1973	12.051	11.882
1974	12.532	12.301
FORECAST		

Figure 4.8 Actual(+) and Estimated(*) Values for Canada Real Price of Barley



YEAR	LEVELS(CAN$/cwt) (+)	(*)
1962	9.092	9.856
1963	9.161	9.863
1964	8.777	9.203
1965	8.653	7.778
1966	8.848	9.500
1967	7.886	8.105
1968	7.462	7.458
1969	6.687	6.938
1970	6.437	7.440
1971	5.955	5.507
1972	8.860	9.383
1973	17.224	17.028
1974	14.875	14.554
FORECAST		

Figure 4.9 Actual(+) and Estimated(*) Values for Canada Real Price of Wheat



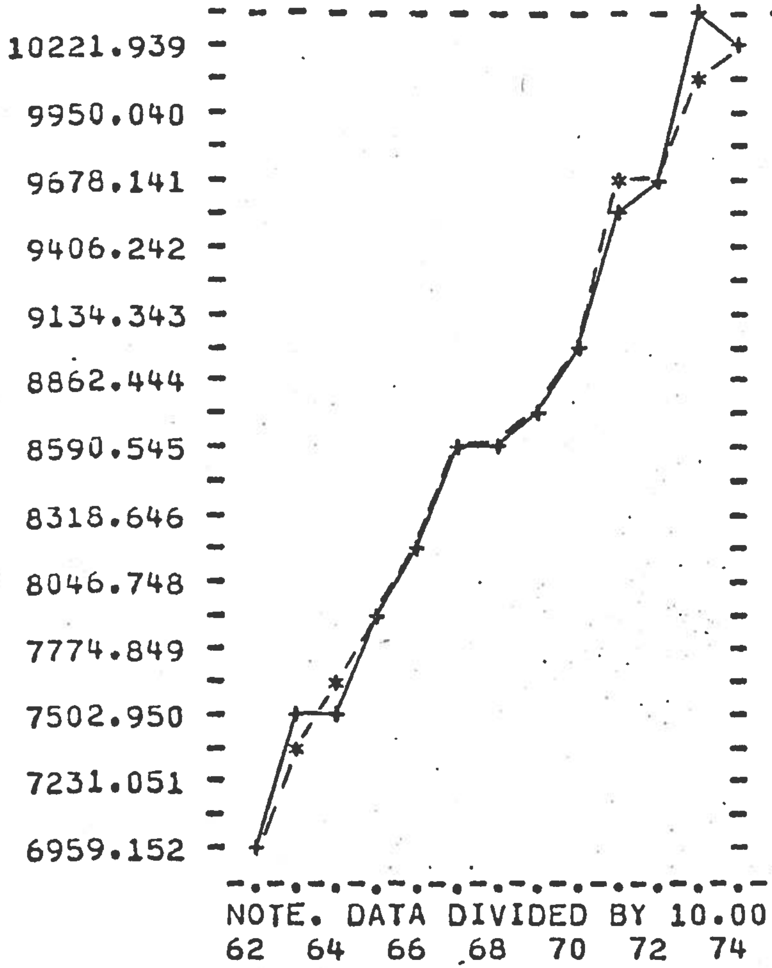
YEAR	LEVELS(INDEX) (+)	(*)
1962	124.920	141.027
1963	122.850	132.899
1964	125.660	123.356
1965	123.700	109.627
1966	118.000	119.113
1967	105.970	109.805
1968	91.733	96.749
1969	93.596	92.835
1970	98.225	96.975
1971	83.349	74.445
1972	78.187	81.889
1973	108.780	102.930
1974 FORECAST	112.880	114.773

Figure 4.10 Actual(+) and Estimated(*) Values for Japan Real Price of Corn

Table 4.6. Percentage Changes in the Actual (ACT) and Estimated (EST) Values for Block 1 Demand and Prices in 1973 and 1974 and Percentage Error of the Estimates

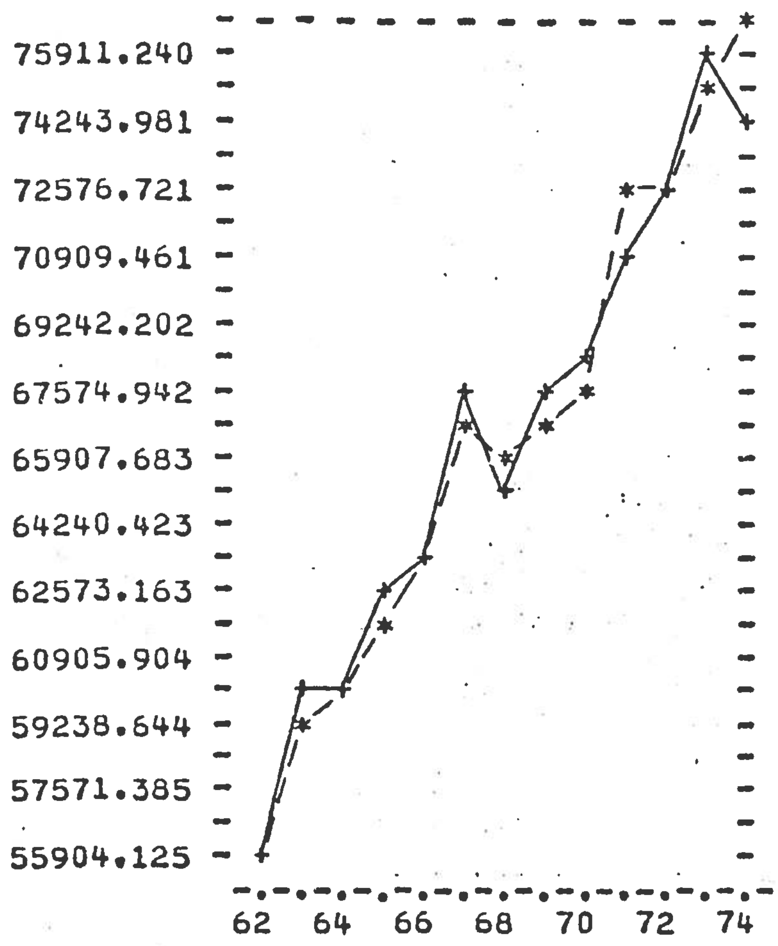
	Percent Change				Percent Error	
	1973		1974		1973	1974
	ACT	EST[a]	ACT	EST[a]		
QCGTC						
USA	-1.46	-1.37	-20.19	-21.28	0.06	-1.30
CAN	3.36	2.96	-13.16	-5.28	-0.21	8.85
JPN	15.64	14.95	-2.82	0.62	-0.42	2.53
RPC USA	52.99	53.00	6.76	3.86	-0.51	-3.21
RPB CAN	60.00	51.07	3.99	3.52	-1.40	-1.85
RPW CAN	94.42	81.48	-13.64	-14.53	-1.14	-2.16
RPC JPN	39.13	25.70	3.77	11.51	-5.38	1.68

[a] $100 \times (EST_t - EST_{t-1})/EST_{t-1}$



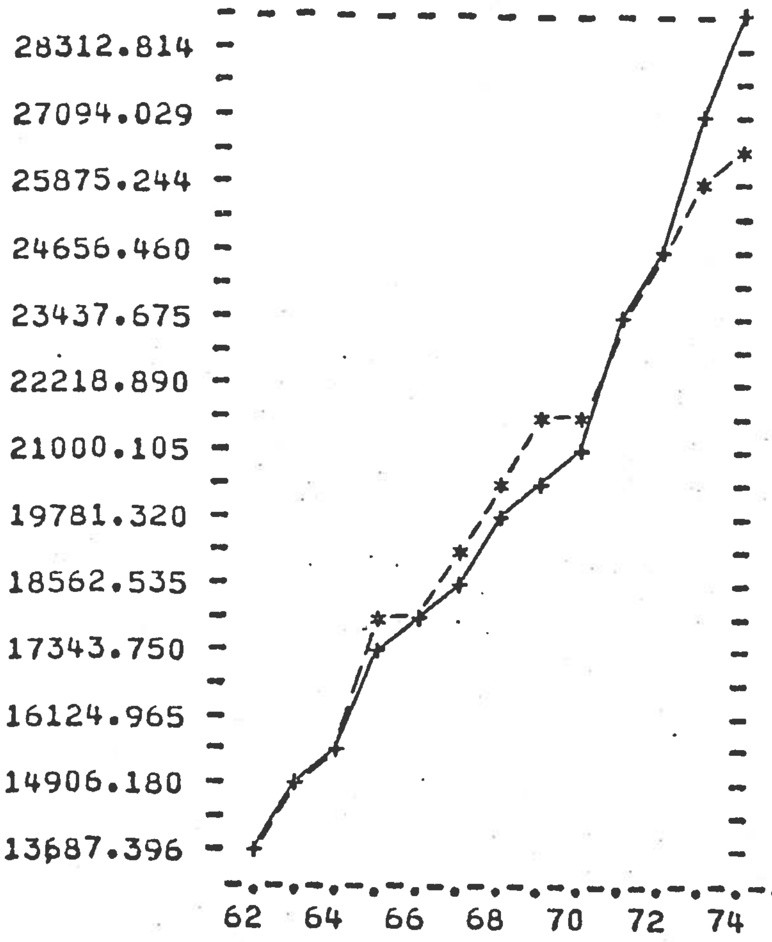
YEAR	LEVELS(10,000mt) (+)	(*)
1962	7033.433	6959.152
1963	7554.901	7491.092
1964	7613.518	7678.445
1965	8015.860	8000.511
1966	8198.811	8256.335
1967	8696.538	8654.513
1968	8600.780	8645.234
1969	8841.429	8840.439
1970	9037.208	9023.179
1971	9556.029	9709.510
1972	9764.262	9793.759
1973	10357.888	10153.612
1974	10326.135	10345.261
FORECAST		

Figure 4.11 Actual(+) and Estimated(*) Values for Block 2 Coarse Grain Consumption



YEAR	LEVELS(1000mt) (+)	(*)
1962	56354.243	55904.125
1963	60122.837	59609.785
1964	60524.318	60746.722
1965	62695.786	61974.056
1966	63799.292	64141.165
1967	68143.319	67299.677
1968	65681.896	66050.810
1969	67579.218	66792.768
1970	68778.944	68400.001
1971	71627.400	73394.430
1972	72819.565	72839.119
1973	76178.008	75475.785
1974 FORECAST	74339.139	76744.870

Figure 4.12 Actual(+) and Estimated(*) Values for EC9 Coarse Grain Consumption



YEAR	LEVELS (1000mt) (+)	(*)
1962	13980.086	13687.396
1963	15426.173	15301.138
1964	15610.863	16037.733
1965	17462.809	18031.057
1966	18188.822	18422.187
1967	18822.061	19245.458
1968	20325.901	20401.532
1969	20835.067	21611.620
1970	21593.134	21831.786
1971	23932.889	23700.675
1972	24823.051	25098.468
1973	27400.873	26060.331
1974 FORECAST	28922.207	26707.737

Figure 4.13 Actual(+) and Estimated(*) Values for Other West Europe Coarse Grain Consumption

estimates track better than the OWE estimates and the aggregates track best of all due to compensating errors in the two sub-regions. What looks like serial correlation in the estimated total errors for OWE is at least partially due to the semi-log form of function that was used, since this pattern was not evident for the double-log estimates. However, given the relatively high income elasticities in OWE, it did not seem advisable to abandon the declining elasticity assumption.

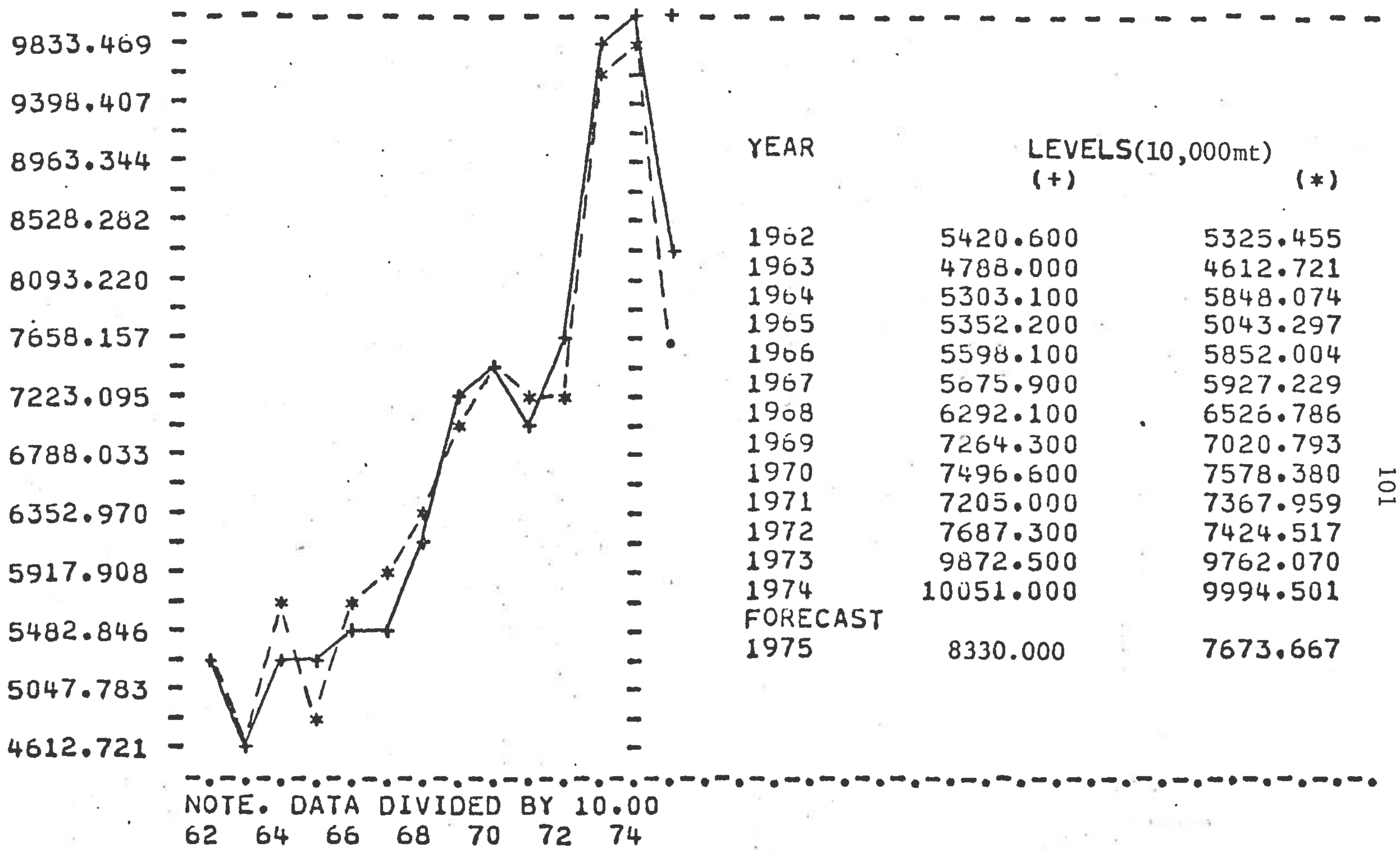
The prediction interval tests are presented in more detail in Table 4.7. The EC9 estimates did not pick up the downturn in feed demand that occurred in 1974. This was at least in part due to a short-run decline in animal units which is not reflected in these estimates. The percent change in the 1974 OWE estimate had the correct sign but was not as large in magnitude as the actual percent change. The percent errors in the estimates were 3.2 percent and -7.7 percent for the EC9 and OWE, respectively. Since these were compensating errors, the estimate of total block 2 demand was in error by only 0.2 percent.

The historical performance of the USSR estimates is shown in Figure 4.14. The estimates pick up the major turning points over the historical period and in the prediction interval. Since the estimation interval included 1974, recent ERS estimates of 1975 income, production and consumption were used for the prediction interval. As seen in Table 4.7, the 1975 downturn was correctly predicted by the model, though the magnitude of

Table 4.7. Percentage Changes in the Actual (ACT) and Estimated (EST) Values for Demand in Blocks 2 and 3 and Percentage Error of the Estimates

	Percent Change						Percent Error		
	1973		1974		1975		1973	1974	1975
	ACT	EST[a]	ACT	EST[a]	ACT	EST[a]			
Block 2	6.08	3.67	-0.31	1.89			-1.97	0.19	
EC9	4.61	3.62	-2.41	1.68			-0.92	3.24	
OWE	10.39	3.83	5.55	2.49			-4.89	-7.66	
Block 3	8.25	10.13	3.51	3.14			0.79	0.43	
USSR	28.43	31.48	1.81	2.38	-17.12	-23.22	-1.12	-0.56	-7.88

[a] $100\times(EST_t - EST_{t-1})/EST_{t-1}$



YEAR	LEVELS(10,000mt) (+)	(*)
1962	5420.600	5325.455
1963	4788.000	4612.721
1964	5303.100	5848.074
1965	5352.200	5043.297
1966	5598.100	5852.004
1967	5675.900	5927.229
1968	6292.100	6526.786
1969	7264.300	7020.793
1970	7496.600	7578.380
1971	7205.000	7367.959
1972	7687.300	7424.517
1973	9872.500	9762.070
1974	10051.000	9994.501
FORECAST		
1975	8330.000	7673.667

Figure 4.14 Actual(+) and Estimated(*) Values for USSR Coarse Grain Consumption

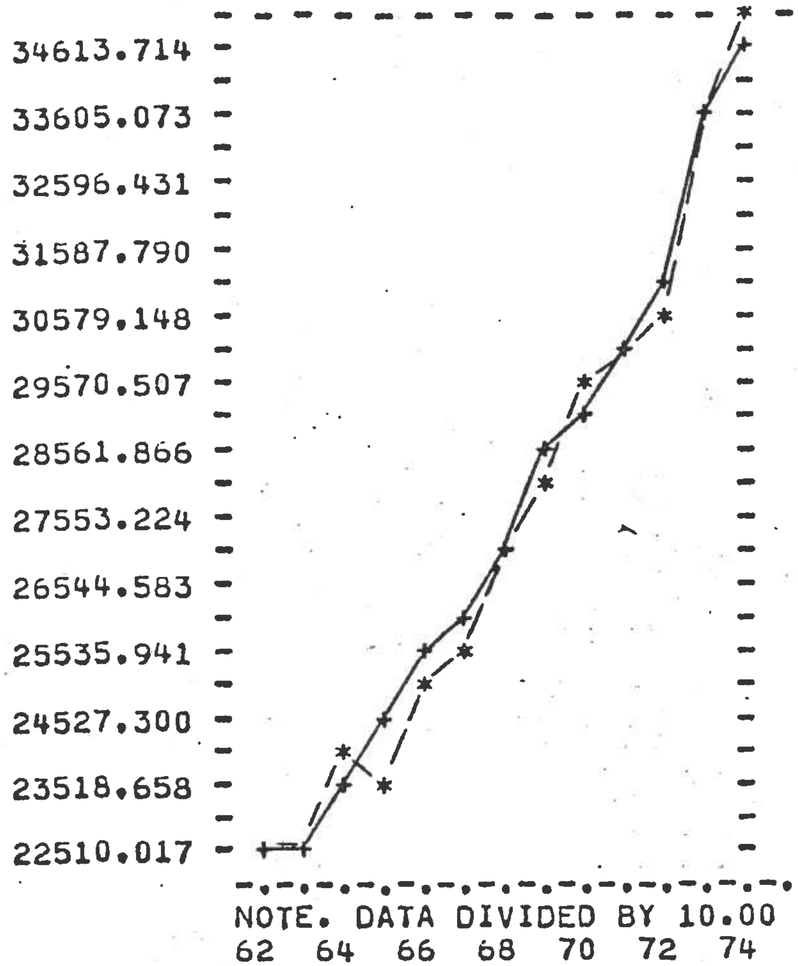
the change was slightly higher for the estimate. As a result, the 1975 prediction was 7.9 percent below the ERS estimate.

When the USSR equations are combined with logarithmic time trends for the remaining regions of block 3, the historical consumption pattern is traced reasonably well as seen in Figure 4.15. In Table 4.7 the percent error of this aggregate is 0.8 and 0.4 in 1973 and 1974, respectively. The historical performance of this aggregate is not very important here, but the 1974 level represents the starting point for the projection model.

Since the projection values are obtained from the simultaneous solution of blocks 1, 2 and 3, the projection results are best compared to the corresponding simultaneous solution for 1974 rather than the actual 1974 levels. A comparison of the simultaneous solution estimates and the actual levels for 1974 in Table 4.8 indicates that these starting point levels are quite similar to the actual levels.

4.5 Coarse Grain Demand and Price Projections

Two types of projections for the period 1974 to 1995 are discussed in this section. The first is a constant-price projection from 1974 to 1995, holding prices at the 1974 levels. The second is a projection of equilibrium solutions where a world supply constraint is imposed and equilibrium prices and quantities are determined by the simultaneous model. In all projections in this section it is assumed that wheat feeding practices do not deviate significantly from historical patterns.



YEAR	LEVELS (10,000mt) (+)	(*)
1962	22761.700	22711.979
1963	22794.300	22510.017
1964	23765.100	24260.245
1965	24591.800	23992.261
1966	25598.100	25370.202
1967	26202.100	26033.756
1968	27221.100	27247.870
1969	28828.400	28396.518
1970	29426.300	29658.573
1971	30514.700	30141.107
1972	31208.100	30918.615
1973	33781.400	34049.408
1974 FORECAST	34966.700	35118.035

Figure 4.15 Actual(+) and Estimated(*) Values for Block 3 Coarse Grain Consumption

Table 4.8. Comparison of Actual Levels to the Simultaneous Solution Estimates for 1974

	Actual	Estimates	Percent Error
	million metric tons		percent
World Consumption	604.4	604.4	0.0
Block 1[a]	151.5	149.8	-1.1
Block 2[b]	103.3	103.5	0.2
Block 3	349.7	351.2	0.4
(Dev CPE)[c]	(160.2)	(157.5)	-1.7
(Other Dev)[d]	(9.6)	(10.0)	4.2
(Third World)	(179.9)	(183.7)	2.1
Feed	384.4	383.0	-0.4
Food	220.0	221.4	0.6
	1970 U.S. dollars/cwt		
U.S. Corn Price	4.246	4.228	-0.4

[a]Includes USA, Canada and Japan

[b]Includes West Europe except for Iceland and Malta

[c]Includes USSR and East Europe

[d]Includes Australia, New Zealand, South Africa, Iceland and Malta

A simple wheat model is developed in Chapter 5, and the wheat feeding assumptions are relaxed in the interactive model of Chapter 6.

For the constant-price projections the price linkages and supply growth assumptions are set aside in order to determine the rate and distribution of demand growth when prices are held at the 1974 level. These projection results are presented in Table 4.9. The average rate of demand growth for the 21-year period is 2.86 percent per annum and is increasing slowly over time. The total absolute increase in demand is 489.3 million metric tons or an 81 percent increase over the 1974 level. Of this absolute increase, 65 percent is due to increased demand in all the developed countries, while the third world accounts for only 35 percent. In terms of end use, 74 percent of the absolute increase is for feed purposes.

There are two major observations that can be made about the constant-price projections before looking in greater detail at the "equilibrium" projections. The first is that the rates of growth projected here are higher than the historical rates of production growth, so some upward pressure on prices should be expected in the "equilibrium" projections. Second, these growth rates are somewhat higher than those obtained by FAO under a constant-price assumption. For total coarse grains the FAO projected a growth rate of 2.6 percent per annum for the 1970-85

Table 4.9. Projection of Coarse Grain Demand Assuming that Prices Remain at the 1974/75 Level

	W. Europe	Other Dev Mkt[a]	Dev CPE[b]	Third World	Feed	Food	Total
			million metric tons				
Absolute Level							
1974	103.5	159.7	157.5	183.7	383.0	221.4	604.4
1985	134.2	213.1	218.7	257.5	544.7	278.7	823.4
1995	167.4	284.3	286.9	355.1	745.5	348.2	1093.7
Absolute Change							
1974-95	63.9	124.6	129.4	171.4	362.5	126.8	489.3
Percent of Change							
1974-95	13	26	26	35	74	26	100
Growth rate			percent per annum				
1974-85	2.39	2.66	3.03	3.12	3.42	2.11	2.85
1985-95	2.24	2.92	2.75	3.27	3.00	2.25	2.88
1974-95	2.32	2.78	2.90	3.19	3.22	2.18	2.86

[a] Includes Australia, Canada, Iceland, Japan, Malta, New Zealand, South Africa, and the United States

[b] Includes East Europe and the USSR

period and 2.5 percent per annum for the 1970-90 period.[12] Also, in the FAO projections only 53 percent of the absolute increase from 1970-85 came from the developed countries compared to about 65 percent in this study. The prominence of developed country demand evidenced in this study is quite plausible, since this is the pattern observed in Chapter 1 as typical of the last decade. It is not likely that this pattern would shift abruptly.

The base solution for the "equilibrium" projection is presented in Table 4.10 and incorporates all of the initial assumptions discussed in section 4.3 above. The production and stock assumptions combine to limit world consumption growth to 2.43 percent per annum.[13] As a result, all equilibrium consumption projections are below the constant-price projections and the equilibrium real price of corn increases from $4.23 to $5.94 per hundredweight over the projection period. The overall distribution of consumption growth does not differ substantially from the constant-price case. Developed countries account for 64 percent of the absolute increase, and 74 percent of the increase is for feed purposes. However, the block 1 countries of Canada, Japan and the U.S. bear a greater part of the price adjustment burden so their portion of the absolute increase drops from 26

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[12] FAO, <u>Population, Food Supply and Agricultural Development</u> (United Nations, Rome, 1975), Tables 16, 22.

[13] The apparent growth rate is actually somewhat higher (2.54) for the 1974-85 period because the production base is the 1973-75 average rather than the abnormally low 1974 level.

Table 4.10. Projection of Coarse Grain Price and the Distribution of Consumption with Production Growth Constrained at Historical Rates[a]

	Coarse Grain Consumption							
	W. Europe	Other Dev Mkt[b]	Dev CPE[c]	Third World	Feed	Food	Total	Corn Price[d]
	million metric tons							$/cwt
Absolute Level								
1974	103.5	159.7	157.5	183.7	383.0	221.4	604.4	4.23
1985	132.2	201.8	212.4	249.9	524.5	271.8	796.3	4.89
1995	160.3	252.2	268.3	331.5	684.2	328.1	1012.3	5.94
Absolute Change								
1974-95	56.8	92.5	110.8	147.8	301.2	106.7	407.9	
Percent of Change								
1974-95	14	23	27	36	74	26	100	
Growth Rate								
1974-85	2.25	2.15	2.76	2.84	2.90	1.88	2.54	1.33
1985-95	1.95	2.25	2.36	2.87	2.69	1.90	2.43	1.96

[a]Assumed coarse grain production growth of 2.7 percent per annum and carryover stock proportion of 10 percent

[b]Includes Australia, Canada, Iceland, Japan, Malta, New Zealand, South Africa and United States

[c]Includes USSR and East Europe

[d]Average price received by U.S. farmers for corn in $/cwt, deflated by CPI

percent to 23 percent.

The most important new information from Table 4.10 is the effect of the supply constraint on prices. The real price of U.S. corn, to which all other prices are linked, increases at an average annual rate of 1.33 percent from 1974-85 and 1.96 percent from 1985-95. In 1980 the world price overtakes the European threshold price, and thereafter the European prices are determined by world market forces rather than by internal policies. Given these price trends, real food costs would not only fail to return to the relatively low levels of the 1960's but would rise above the relatively high levels set in 1973 and 1974.

A greater insight into the characteristics of the model and the relative importance of various assumptions that went into these projections is obtained by testing the sensitivity of the results to changes in the base assumptions. The impact analysis presented in Table 4.11 shows the effects of increasing the assumed growth rates of income, population and production by 10 percent and changes in other key parameters. The effects of 10 percent reductions in assumed growth rates are opposite in sign and approximately equal in magnitude to those recorded in Table 4.11, so these figures can be used to look at impacts in either direction.

The major demand shifters, population and income, are analyzed for all developed and all third world countries. Among these factors, income growth in the developed countries had the

Table 4.11. Impact of Changes in Projection Assumptions on the 1995 Base Solution[a]

	Consumption							Price	
	W. Europe	Other Dev Mkt	Dev CPE	Third World	Feed	Food	Total	U.S. Corn	Eur. Price Equality
		million metric tons						$/cwt	year
1995 Base	160.3	252.2	268.3	331.5	684.2	328.1	1012.3	5.94	1980
10 Percent Increase in Growth Rate of:									
Income									
Dev Country	3.3	1.4	1.1	-5.8	5.0	-5.0	0	0.55	1979
Third World	-0.7	-3.0	-1.4	5.2	0.3	-0.3	0	0.17	1979
Population									
Dev Country	0.7	1.8	-0.1	-2.5	0.9	-0.9	0	0.23	1979
Third World	-1.6	-7.0	-3.2	11.7	-7.2	7.2	0	0.38	1979
Production									
World	5.1	21.0	11.2	14.3	39.4	12.3	51.7	-1.13	1987
USSR	-0.7	-3.2	5.7	-1.9	-0.8	0.8	0	0.17	1979
Parameters									
Stock rate = .05	2.8	11.9	6.0	7.7	21.8	6.6	28.4	-0.64	1982
Elas. = -.30	1.7	6.6	-3.6	-4.6	3.6	-3.6	0	-0.38	1980
PRATE = .01	0	0	0	0	0	0	0	0	1990

[a]To illustrate the use of this table, consider the second row of numbers. If the assumed growth rates of income for developed countries are multiplied by 1.1, the new equilibrium solution for 1995 redistributes the fixed supply and raises price. Feed consumption increases by 5 million mt and food use decreases by the same amount. Third world consumption declines by 5.8 million mt and the developed countries consume 5.8 million mt more. The increased demand causes the equilibrium price in 1995 to increase by 55 cents. The variable levy for Europe would decline to zero by 1979.

greatest impact on price, and population growth in the third world was second in importance. Although this pattern would not be expected to hold for wheat or rice, it clearly indicates that third world population growth cannot be singled out as the major factor contributing to the projected rise in coarse grain prices. As expected, income growth in the third world and population growth in the developed countries are less important factors. The latter has a significant influence because the low rates of population growth are offset by the high rates of per capita consumption. In terms of the distribution of consumption, an increase in developed country income or population growth shifts consumption from third world food use to developed country feed use when world supply is fixed. The reverse distribution effects occur as a result of increased income or population growth in the third world.

These results can also be used to evaluate alternative scenarios and answer "what if" questions. For example, what if developed country incomes grow at a 10 percent lower rate over the next two decades? The projected 1995 price would be 55 cents lower and the corresponding distribution changes would be opposite in sign from those for the 10 percent increase. An approximation of multiple effects can be obtained by adding the impacts of two or more changes. For example, what if developed country incomes and the third world population both grow at a 10 percent lower rate over the next two decades? The projected 1995 price would be approximately 93 cents lower, 2.2 million metric tons of coarse grain would shift from food to feed use and 5.9 million metric tons from third world to developed country consumption. The overall impact would benefit the developed countries, but even this combination of events would not eliminate the rising price trend.

A 10 percent increase in the rate of production growth also increases the rate of growth in available supply (and consumption) by 10 percent, since the stock carryover is a constant proportion of production.[14] The result is a 5.1 percent increase in 1995 consumption (51.7 million metric tons) and a drop of $1.13 in the projected corn price. The world price still overtakes the European threshold price but not until 1987. Seventy-two percent of the increased consumption is in the developed countries and 77 percent of the increase is for feed purposes. Should the rate of growth in world production be 10 percent lower than the base assumption, the effects would be opposite in direction and approximately equal in magnitude.

Because of the effect of Soviet production on internal consumption, the USSR production assumption is a separate parameter. If the growth rates of USSR production and world production are

[14] From the supply growth assumptions in section 4.3 it follows that:

$$S_t = Q_{t-1}(1 + 1.1\hat{Q} - 1.1\hat{Q}\alpha)$$

$$= Q_{t-1}[1 + 1.1(\hat{Q} - \hat{Q}\alpha)]$$

both increased by 10 percent, the distribution of consumption changes slightly in favor of the USSR; and due to the increased demand, the projected 1995 price has a net decline of $.96 instead of $1.13. But the USSR assumption does not have a major impact on the solution.

The relatively large price effect of the production assumption derives from the inelastic nature of world demand. An approximation of the "impact" elasticity of demand[15] with respect to the U.S. price of corn can be obtained by dividing the percent change in equilibrium quantity by the percent change in equilibrium price. The overall elasticity (Table 4.12) is -.27 and the regional estimates range from -.17 in West Europe to -.44 in the other developed market economies. These extremes are reasonable, since West European demand does not respond at all to changes in the market price until the 1980's while Canada, Japan and the U.S. are the countries most responsive to the market price. The elasticities for the developed central planned economies and the third world (block 3) were assumed to be -.2 and the calculated "impact" elasticities are close to that level.

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[15] These are termed "impact" elasticities because they are based on the equilibrium quantities and prices of the model and are not to be confused with the elasticities of the estimated equations. Also these represent a lower limit on the price elasticities, since they are estimated by taking the inverse of the price flexibility. See J.P. Houck, "The Relationship of Direct Price Flexibilities to Direct Price Elasticities," Journal of Farm Economics 47 (August 1965): 789-792.

Table 4.12. The Estimated "Impact" Elasticities of Coarse Grain Demand with Respect to the U.S. Price of Corn Based on 1995 Changes[a]

	Percent Change in		
	Quantity (1)	Price (2)	Estimated Elasticity (1)/(2)
World	5.1	-19.0	-.27
West Europe	3.2	-19.0	-.17
Other Dev Mkt	8.3	-19.0	-.44
Dev CPE	3.9	-19.0	-.21
Third World	4.3	-19.0	-.23
Feed	5.8	-19.0	-.31
Food	3.7	-19.0	-.19

[a]These estimates represent lower limits on the price elasticities since they are estimated by taking the inverse of the price flexibilities.

It is reasonable that these should be between the two extremes and perhaps closer to the elasticity of West Europe, since many of these regions are also partially protected from world market influences. The sensitivity of the solution to the block 3 elasticity assumption was tested by using an alternative elasticity of -.3. The result (Table 4.11) was a slightly lower U.S. price and a shift in consumption from block 3 to blocks 1 and 2.

It might be argues that the stock carryover proportions would decline at higher price levels. To test the effect of such a change the assumed stock carryover proportion was reduced from 10 percent to 5 percent, which would immediately reduce to 5 percent the proportion of <u>incremental</u> production placed in stocks and gradually reduce the total stock proportion from 10 percent of production toward 5 percent of production. The effect of this change is approximately equal to a 5 percent increase in the rate of production growth.

Finally the assumption regarding the policy rate of growth in the European threshold price was tested. Instead of holding real prices constant, the new policy rate increases real prices at the rate of 1 percent per year. As a result, West European consumption is reduced slightly and the rest of the world enjoys slightly lower prices until 1990 when the market price overtakes the threshold price. From that point to the end of the projection period there is no change from the base solution.

It is clear from this analysis that in this partial equilibrium framework, the upward pressure on coarse grain prices is very strong and only a fortuitous combination of favorable events would succeed in holding prices near the 1974 level. Since the major component of demand growth is feed demand, the obvious question is to what extent these high prices would attract increased substitution of wheat for coarse grains in feeding rations. The answer depends upon the strength of demand relative to supply in the wheat sector and what this implies for the price of wheat relative to coarse grains. The simple wheat model developed in Chapter 5 and the interactive model of Chapter 6 is an attempt to establish an upper bound on the wheat substitution potential and thereby a lower bound on the projected price of coarse grains.

Chapter 5

WHEAT PROJECTION MODEL

A very simplified model of the world wheat sector is developed in this chapter in order to look at the interaction of the wheat and coarse grain sectors. Because the coarse grain model projections indicated a strong upward pressure on coarse grain prices, it seems especially important to determine whether developments in the wheat sector would have a tendency to exacerbate or to alleviate that pressure. The components of the wheat model, the projection assumptions, and the wheat demand and price projections are presented in this chapter. The interaction of the wheat and coarse grain models is discussed in Chapter 6.

5.1 Components of the Wheat Model

The feed portion of wheat demand is the primary linkage between the wheat and coarse grain sectors. It is assumed that wheat substitution for coarse grains in food use is not a significant factor in the interaction of these sectors. Initially it is assumed that feed demand follows traditional patterns with some adjustment for changes in the wheat-corn price ratio. This behavior is illustrated in (1) and (2) of Table 5.1. Wheat fed remains a fixed proportion of coarse grain fed unless the price ratio changes. If the corn price rises relative to wheat, the proportion of wheat fed and the quantity of wheat fed rise.

Wheat food demand is projected by the same method that was

Table 5.1. Components of the Wheat Sector Model

(1) $RATIO_t = PW_t/PC_t$

(2) $WFED_{it} = QFED_{it} \cdot \gamma_i \cdot (RATIO_t/RATIO_{74})^{\varepsilon_{wg}}$

(3) $WFOD_{it} = WFOD_{i74} \cdot (1 + \hat{N}_i + \eta_{wi} \hat{I}_i)^t \cdot (PW_t/PW_{74})^{\varepsilon_w}$

(4) $WD_{it} = WFOD_{it} + WFED_{it}$

EQUILIBRIUM

(5) $\Sigma WD_{it} = WWP_t - WCWST_t$ $\quad i = 1, 2, . . . , 23$ regions

where $\hat{I}$ = annual rate of growth in per capita private consumption expenditures
$\hat{N}$ = annual rate of population growth
PC = U.S. export price of corn
PW = U.S. export price of wheat
QFED = quantity of coarse grain feed demand
RATIO = U.S. export price ratio of wheat to corn
WCWST = world change in wheat stocks
WD = quantity of total wheat demand
WFED = quantity of wheat feed demand
WFOD = quantity of wheat food demand
WWP = world wheat production
γ = historical ratio of wheat fed to coarse grain fed
ε_{wg} = price ratio elasticity for wheat feed demand
ε_w = price elasticity for wheat food demand
η_w = income elasticity for wheat food demand

used for block 3 in the coarse grain model. As illustrated in (3) of Table 5.1, food demand is projected from the base year consumption with the rate of growth determined by growth in population and income and the income elasticity of demand for wheat. Food demand is not affected by the corn price but will rise or fall is the wheat price declines or increases, respectively, from its 1974 level.

The equilibrium condition in (5) of Table 5.1 is analogous to the coarse grain model equilibrium. World demand is set equal to world wheat production minus the change in world stocks. At this stage the wheat model is a recursive extension of the coarse grain model, since the latter generates the price of corn and the quantity of coarse grain fed, but the resulting wheat price and quantities do not affect the coarse grain solution. In Chapter 6 this simultaneity will be incorporated in the interactive model.

5.2 Projection Assumptions

The population and income growth rates are the same as those in the coarse grains model except that regional rates of growth for the European Community and "Other West Europe" were substituted for the individual country rates. The income elasticities for food demand are those estimated by the FAO[1], and the ratio of wheat to coarse grain fed for 1974 was calculated from the data.

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[1]Agricultural Commodity Projections, 1970-1980.

These are listed in Table 5.2.

There is a price elasticity of total fed wheat with respect to the wheat-corn price ratio and a price elasticity of total wheat food demand with respect to the wheat price. As in the case of the block 3 coarse grain price elasticity, these are of necessity somewhat arbitrary. The price ratio elasticity could also be interpreted as the cross-price elasticity of fed wheat with respect to the corn price. As such it should be no greater than the coarse grain price elasticity (-0.2) of Chapter 4. Therefore, the ratio elasticity for fed wheat is initially set at -0.2 and the price elasticity for food wheat is set slightly lower at -0.15. It is not unrealistic for these to be quite inelastic, since they reflect the response of domestic consumption to world market prices rather than to internal prices.

The projection of wheat supply net of stock changes is based on the same method used for coarse grain supply and demonstrated in equation (5.1) below.

$$(5.1) \quad QS_t = QP_{t-1}(1 + \hat{QP} - \alpha \cdot \hat{QP})$$

where QS_t = current production minus change in stocks

QP_{t-1} = previous year's production

$\hat{QP}$ = rate of growth in production

α = proportion of production held as stock.

The base rate of growth in world wheat production is set equal to the historical growth in production from the 1960-62

Table 5.2. The Assumed Ratios of Wheat to Coarse Grain Fed and the Income Elasticities for Wheat Food Demand

Region	γ^a	η^b
BLOCK 1		
Canada	0.160	-0.25
Japan	0.004	0.09
United States	0.018	-0.20
BLOCK 2		
European Community	0.214	-0.17
Other West Europe	0.060	-0.20
BLOCK 3		
Australia, N. Zealand	0.676	-0.06
South Africa	0.0	0.18
East Europe	0.302	-0.10
USSR	0.390	-0.14
China	0.0	0.50
East Asia	0.027	0.66
Southeast Asia	0.0	0.66
South Asia	0.208	0.36
N. Africa, Mid-East	0.080	0.02
Central Africa	0.0	0.96
East Africa	0.0	0.39
Middle America	0.028	0.32
Venezuela	0.0	0.26
Brazil	0.0	0.29
Argentina	0.011	-0.10
Other South America	0.023	0.29
Rest of the World	0.0	0.44

[a]Ratio of wheat fed to coarse grain fed in 1974

[b]Price elasticity of demand for wheat estimated by FAO, Agricultural Commodity Projections, 1970-1980, Vol. 2, United Nations, Rome, 1971

average to the 1973-1975 average[2]. The rate was 3.1 percent per annum for the period, though like coarse grain production, the growth was lower in the last four years of the period. It is also assumed that the proportion of production held as stock remains constant at 18 percent, which is the average for the 1971 to 1974 period. The 1973 to 1975 average production was used as the initial level for the supply projection.

5.3 Wheat Demand and Price Projections

As with the coarse grain model, the constant-price projections for 1974 to 1995 are presented first, followed by projections of the equilibrium solutions for the wheat sector. The constant-price assumptions project wheat feed demand as a fixed proportion of the constant-price coarse grain feed demand, and the prices of corn and wheat are held at the 1974 levels. Under these assumptions (Table 5.3) the average annual rate of demand growth for the 21-year period is 3.01 percent for feed demand, 1.82 percent for food demand and 2.06 percent for total demand. The absolute increase is 187 million metric tons of which 65 percent is due to third world demand and 71 percent is for food purposes. This is understandably in contrast to the coarse grain pattern of demand growth which was heavily weighted in favor of feed demand in developed countries.

These results are very similar to the constant-price

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[2]Calculated from world total production of wheat in World Agricultural Situation, WAS-11, ERS, U.S. Department of Agriculture, October 1976, Table 13.

Table 5.3. Projection of Wheat Demand Assuming that Prices Remain at the 1974/75 Level

	Feed Demand			Food Demand			Total Demand		
	Developed Countries[a]	Third World	Total	Developed Countries[a]	Third World	Total	Developed Countries	Third World	Total
				million metric tons					
Absolute Level									
1974	62.5	0.9	63.4	148.6	137.3	285.9	211.1	138.2	349.2
1985	88.1	1.5	89.6	154.9	190.0	344.9	243.0	191.5	434.4
1995	115.8	2.4	118.2	161.3	256.6	417.9	277.1	259.0	536.1
Absolute Change									
1974-95	53.3	1.5	54.8	12.7	119.3	132.0	66.0	120.8	186.9
Percent of Change									
1974-95	28	1	29	7	64	71	35	65	100
Growth Rate									
1974-85	3.17	4.75	3.19	0.38	3.00	1.72	1.29	3.01	2.00
1985-95	2.77	4.81	2.81	0.41	3.05	1.94	1.32	3.07	2.13
1974-95	2.98	4.78	3.01	0.39	3.02	1.82	1.30	3.04	2.06

[a]Includes developed market economies, the USSR and East Europe

projection results of the FAO which predicted a 2.0 percent annual rate of growth for world wheat demand for 1970-85 and 1970-90.[3] The FAO projected that 70 percent of the absolute increase would be due to third world demand and 66 percent would be for food purposes. This similarity is not surprising, since FAO estimates of income elasticities and rates of income and population growth were used for the food demand projections.

The clear implication of these projections is that projected demand growth in the wheat sector is weak relative to potential supply growth, so wheat prices should decline in a projection of partial equilibrium solutions for wheat. The base solution for the "equilibrium" projection (Table 5.4) incorporates the supply and price assumptions discussed in section 5.2 above. In these projections the coarse grain model solution affects the wheat solution, but there is no feedback from the wheat solution to the coarse grain model. The wheat production and stock assumptions combine to permit a rate of consumption growth of 2.54 percent per annum.[4] As a result all equilibrium consumption projections are above the constant-price projections and the projected real price of wheat declines from $129 to $67 per ton over the

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[3]FAO, Population, Food Supply and Agricultural Development, Tables 16, 22.

[4]The apparent growth rate is actually somewhat higher (2.66) for the 1974-85 period because the production base is the 1973-75 average rather than the lower 1974 level.

Table 5.4. Projection of Wheat Price and the Distribution of Consumption with Production Growth Constrained at Historical Levels[a]

	Feed Consumption			Food Consumption					
	Developed Countries[b]	Third World	Total	Developed Countries[b]	Third World	Total	Total Wheat	Wheat Price[c]	Corn Price[d]
	million metric tons							$/mt	
Absolute Level									
1974	62.5	0.9	63.4	148.6	137.3	285.9	349.2	128.8	106.1
1985	97.5	1.6	99.1	164.8	202.3	367.1	466.2	84.9	121.6
1995	135.7	2.7	138.4	177.9	283.0	460.9	599.2	67.0	146.0
Absolute Change									
1974-95	73.2	1.8	75.0	29.3	145.7	175.0	250.0		
Percent of Change	percent								
1974-95	29	1	30	12	58	70	100		
Growth Rate	percent per annum								
1974-85	4.13	5.37	4.14	0.95	3.28	2.15	2.66		
1985-95	3.36	5.37	3.40	0.77	3.41	2.30	2.54		

[a]Assumed wheat production growth of 3.1 percent per annum and carryover stock proportion of 18 percent.

[b]Includes the developed market economies, East Europe and the USSR.

[c]U.S. price No. 2 Hard Winter Ordinary Protein Wheat, FOB Gulf ports, deflated by CPI.

[d]U.S. price No. 2 Yellow Corn, FOB Gulf ports, deflated by CPI.

projection period. The distribution of consumption does not change substantially from the constant-price case.

When the projected Gulf ports price of wheat is compared to the projected Gulf ports price of corn derived from the coarse grain model, it is clear that this is not a realistic outcome. Since the feeding value of wheat is slightly higher than that of an equivalent measure of coarse grain[5] it is not likely that the wheat price could remain below the corn price over the long run. It is more likely that the substitution of wheat for coarse grains in feed rations would increase dramatically until the wheat-corn price ratio reached a level approximately equal to the relative feeding value. This would doubtless mean wheat feeding rates well above historical levels, since this relative price situation has not existed over any extended historical period. This behavioral assumption is incorporated in the interactive model of Chapter 6. However, before exploring that alternative, the wheat model is subjected to sensitivity tests similar to those reported for the coarse grain model.

The sensitivity tests in Table 5.5 show the impact of changed assumptions on the wheat price and the distribution of consumption. The effects on the export price of corn are generated by the coarse grain model and are equivalent to the impacts on corn price reported in Table 4.10. The last column in Table

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[5]Relative feeding value: corn 1.00; wheat 1.05; barley .90; sorghum .95. See Economic Research Service, Wheat Situation, WS-236, USDA, May 1976, Table 11.

Table 5.5. Impact of Changes in Projection Assumptions on the 1995 Base Solution

	Consumption					Export Price		Year When PW < PC
	Developed Countries	Third World	Feed	Food	Total	Wheat	Corn	
	million metric tons					$/metric ton		
1995 Base	313.6	285.7	138.4	460.9	599.2	67.0	146.0	1978
10 Percent Increase in Growth Rate of								
Income								
Dev Country	0.8	-0.8	3.3	-3.3	0	1.4	12.8	1978
Third World	-2.4	2.4	-1.1	1.1	0	3.0	3.9	1978
Population								
Dev Country	2.1	-2.1	-0.1	0.1	0	3.4	5.3	1978
Third World	-7.7	7.7	-3.9	3.9	0	10.2	8.8	1978
Wheat Production	17.8	14.2	9.2	22.8	32.0	-18.4	0	1977
Parameters								
Stock rate = .13	10.8	8.6	5.5	13.8	19.3	-12.0	0	1977
Cross-elas = -.3	5.1	-5.1	8.6	-8.6	0	9.0	0	1978
Food elas = -.25	-3.4	3.4	-5.7	5.7	0	15.8	0	1979

5.6 reports the year in which the wheat export price falls below the corn export price. Because this is a recursive solution with the coarse grain results affecting wheat feed demand, the demand shifters influence wheat demand in two ways. First, through the coarse grain equilibrium price and quantities fed, and then directly through the demand shifts in the wheat model. In the case of wheat production and parameter changes, the coarse grain solutions are not affected so only the direct impact applies.

The increase in developed country income growth has the least impact among all the demand shifters in contrast to the coarse grain model. There is a small shift from food to feed consumption, an even smaller shift from third world to developed country consumption and a 2 percent increase in the 1995 projected wheat price. The third world income shift has about twice the impact in the opposite direction. As should be expected, the increase in third world population growth has the greatest impact among the demand shifters. It causes a 15 percent increase in the 1995 wheat price and has a greater impact on the reallocation of consumption than the other demand factors. The year of price inversion was not affected by any of these shifts in demand. The increased rate of wheat production and the reduction of the stock carryover proportion from 18 percent to 13 percent have the effect of increasing available supply and reducing the equilibrium price. The gains in consumption are nearly proportional to the base distribution of consumption. Feed has the greatest percentage gain due to a more elastic demand, so the developed countries gain slightly more than the third world.

Imposing more elastic behavior on wheat demand would, of course, moderate the price decline over the projection period. Changing the feed and food price elasticities by -0.1 increases the 1995 wheat price by $9.00 and $15.80, respectively, and delays the price inversion by about one year. By experimenting with more elastic assumptions one could no doubt arrive at a combination that would keep the wheat price above the corn price, but such a procedure would be quite arbitrary and would not provide much information on the maximum impact of wheat on the coarse grain sector.

The main purpose of integrating the wheat sector with the coarse grain model is to determine the maximum amount of impact the wheat surplus could have on the projected coarse grain scarcity. This is accomplished in the next chapter by postulating that the assumed elasticity for wheat feed demand applies only to "traditional" demand for feed wheat. When the long-run price of wheat relative to corn falls below a critical level, a more elastic demand for feed wheat obtains.

Chapter 6

WHEAT AND COARSE GRAIN SIMULTANEOUS MODEL

The results of Chapters 4 and 5 project an excess demand situation for coarse grains (prices rising) and an excess supply situation for wheat (price falling). Clearly there is a point beyond which this divergence of price trends cannot continue, because at some point wheat substitution for coarse grains would increase dramatically. This chapter introduces a feedback mechanism from the wheat sector to the coarse grain sector which is designed to measure the maximum impact of the excess wheat supply on coarse grain prices and quantities.

6.1 Intersectoral Linkage

The wheat model in Chapter 5 permits food demand to increase as the wheat price falls and feed demand to increase as the wheat price falls relative to the corn price. However, the wheat price still falls to a level below the corn price by 1978. Imposing more elastic demand assumptions would postpone but not prevent this result. The price elasticity of feed demand in Chapter 5 represents the responsiveness to world price of "traditional" feed wheat demand, which is dominated by East and West Europe and the USSR. If the wheat-corn price ratio falls to the relative feed value of these two grains, one would expect greatly increased wheat feeding in places like the United States and Japan, which traditionally have fed little wheat.

To develop a model that will measure the maximum impact of the excess wheat supply, two assumptions are made. First, the relative price can never go below the relative feed value of wheat with respect to corn. Second, when the relative price equals the relative feed value, all excess wheat supply is added to the coarse grain supply in corn equivalents. This makes wheat a perfect substitute for corn in feed value equivalents.

This feedback linkage is summarized in Table 6.1. The feed value of wheat relative to corn in 1.05[1], so the feedback linkage comes into play if the price of wheat falls below 1.05 times the corn price. When that occurs the new equilibrium conditions (1), (2) and (3) of Table 6.1 take effect. Condition (1) prevents the wheat-corn price ratio from falling below the relative feed value. Condition (2) measures the excess wheat supply available at the equilibrium level of prices and replaces the wheat quantity equilibrium. Condition (3) establishes a new quantity equilibrium for the coarse grain sector by adding the excess wheat supply (in corn equivalents) to the total supply of coarse grains.

This interactive model is illustrated in Figures 6.1 and 6.2. Figure 6.1 shows the case where the wheat-corn price ratio is greater than 1.05 and there is no feedback from the wheat sector. This solution is recursive; the price and quantities from the coarse grain sector affect the wheat demand (WD) through feed

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[1]U.S. Department of Agriculture, Economic Research Service, Wheat Situation, WS-236, May 1976, Table 11.

Table 6.1. Wheat-Coarse Grain Feedback Linkage in the Simultaneous Model

IF ($PW_t < 1.05 \cdot PC_t$)

(1) $PW_t = 1.05 \cdot PC_t$

(2) $EWS_t = WWP_t - WCWST_t - \Sigma WD_{it}$

(3) $\Sigma QD_{it} = WQP_t - WCST_t + 1.05 \cdot WES_t$

where PW = U.S. export price of wheat

PC = U.S. export price of corn

WD = wheat demand

QD = coarse grain demand

EWS = excess supply of wheat

WWP = world wheat production

WQP = world coarse grain production

WCWST = world change in wheat stocks

WCST = world change in coarse grain stocks demand, but wheat does not affect the coarse grain solution. As seen in Figure 6.1, the price ratio in this case is greater than the relative feed value, and the excess supply of wheat in corn equivalents (EWS) does not intersect the excess demand for coarse grains (ECGD). This represents the situation at the beginning of the projection period.

The broken lines in Figure 6.2 represent the projection results obtained in Chapters 4 and 5 without the feedback linkage. The price of wheat (PW_0^*) fell below the price of corn (PC_0). When the lower bound is imposed on the price ratio along with the other new equilibrium conditions, a simultaneous solution is obtained. The simultaneous solution, shown in solid lines on Figure 6.2, results in additional wheat feeding, higher wheat prices and lower corn prices. The magnitude of these effects is discussed below.

6.2 Simultaneous Demand and Price Projections

The base solution for the simultaneous system (Table 6.2) shows total coarse grain and wheat consumption growing at the same rates found in the separate (partial) equilibrium projections of Chapters 4 and 5 (Tables 4.9 and 5.4), because total consumption is constrained by supply growth. However, wheat feeding is nearly 30 percent higher in this solution and as a result the rise in corn price is moderated and the wheat price decline is halted. The wheat price declines for three years until 1978, when it reaches the minimum price ratio with corn of

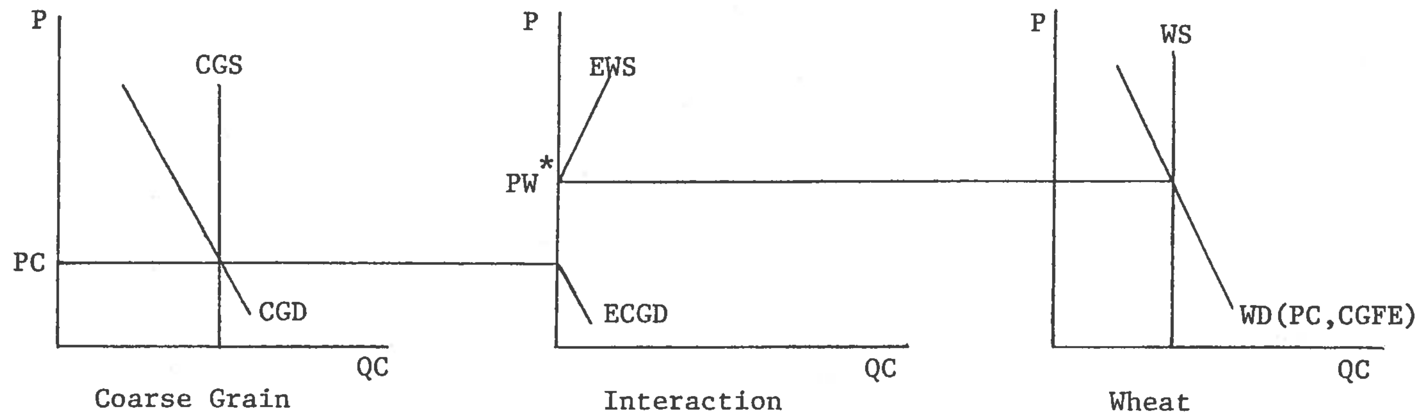

Figure 6.1. Solution of the Simultaneous Model When the Wheat-Corn Price Ratio is Above the Relative Feed Value

Note: The illustration is simplified by expressing all quantities in corn equivalents (QC). Wheat demand (WD) is increased if the price of corn (PC) or the quantity of fed coarse grain (CGFE) increases. Wheat supply (WS) and coarse grain supply (CGS) are predetermined. The excess supply of wheat (EWS) does not intersect the excess demand for coarse grain (ECGD) so there is no further interaction between sectors. The equilibrium wheat price (PW^*) is above the corn price (PC).

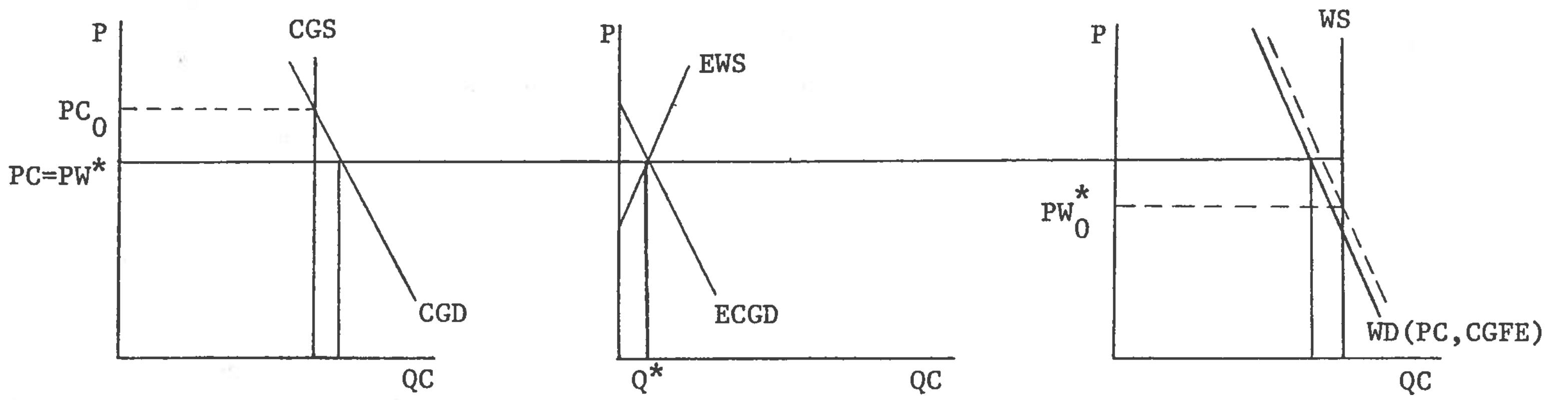

Figure 6.2. Solution of the Simultaneous Model When the Wheat-Corn Price Ratio Equals the Relative Feed Value

Note: The partial equilibrium results of Chapters 4 and 5 are illustrated with broken lines and result in a wheat price (PW_0^*) below the corn price (PC_0) after 1978.

In the simultaneous model the intersection of excess wheat supply (EWS) and excess coarse grain demand (ECGD) results from the price ratio constraint, and Q^* is the corn equivalent quantity of wheat which is added to feed supplies. The prices of wheat and corn are equal on a corn equivalent basis. The actual wheat price is higher ($PW = 1.05\ PW^*$).

Table 6.2. Projections of Coarse Grain and Wheat Consumption Assuming Historical Rates of Production Growth and Recent Stock Rates in the Simultaneous Model[a]

	Coarse Grains[b]			Wheat			Corn	Wheat	Weighted
	Feed	Food	Total	Feed	Food	Total	Price[c]	Price[d]	Price[e]
	million metric tons						1970 U.S. dollars/metric ton		
Absolute Level									
1974	383.0	221.4	604.4	63.4	285.9	349.2	106.1	128.8	114.5
1985	518.9	277.4	796.3	115.0	351.2	466.2	108.6	114.1	110.7
1995	670.4	341.9	1012.3	178.3	421.0	599.2	116.7	122.5	118.9
Growth Rate	percent per annum								
1974-85	2.80	2.07	2.54	5.57	1.89	2.66	0.21	-1.11	-0.31
1985-95	2.59	2.11	2.43	4.48	1.83	2.54	0.72	0.71	0.72

[a]Coarse grain production growth 1960-1962 to 1973-1975 was 2.7 percent per annum; average stocks 1971 to 1974 were 10 percent of production. Wheat production growth 1960-1962 to 1973-1975 was 3.1 percent per annum; average stocks 1971 to 1974 were 18 percent of production.

[b]Coarse grains included are barley, corn, oats, rye and sorghum.

[c]U.S. price No. 2 Yellow Corn, FOB Gulf Ports deflated by CPI (1974/75 nominal price was $133.42).

[d]U.S. price No. 2 Hard Winter Ordinary Wheat, FOB Gulf Ports, deflated by CPI (1974/75 nominal price was $163.51).

[e]Weighted average of corn and wheat prices.

1.05. Thereafter, it rises over time at the same rate as the corn price. The strength of feed demand is sufficient to absorb the excess supply in the wheat sector and still keep both wheat and coarse grain prices on a slight upward long-run trend. Due to the slower rate of price increase, the market price does not overtake the European threshold price until 1988 in this solution.

The importance of the feed demand component is seen more clearly in Table 6.3, which shows the composition of consumption growth. For coarse grains, 70 percent of the absolute increase is for feeding purposes compared to 74 percent in the partial equilibrium projection (Table 4.9). For wheat, 46 percent is due to feed demand compared to only 30 percent in the partial equilibrium projection (Table 5.4). Overall, feed demand growth explains 61 percent of the projected increase in wheat and coarse grain consumption.

The relative importance of developed country and third world consumption growth is highlighted in Table 6.4. Since the "new" feed wheat is not distinguishable from corn in the regional projections, it is aggregated with coarse grains for the purposes of these computations (Appendix Tables 6.1 to 6.3). The distribution of growth in these projections is nearly identical to that found in the partial equilibrium cases, with the developed countries accounting for about two-thirds of the wheat growth. Increased feed consumption in the developed countries

Table 6.3. Projected Rate of Growth and Composition of Growth in Consumption of Coarse Grains and Wheat, 1974-1995

	Absolute Change	Percent of Change	Growth Rate of Consumption
	mil. m.t.	%	% per annum
Coarse Grains			
Feed	287.4	70	2.70
Food	120.5	30	2.09
(Total)	(407.9)	(100)	(2.49)
Wheat			
Feed	114.9	46	5.05
Food	135.1	54	1.86
(Total)	(250.0)	(100)	(2.60)
Coarse Grain and Wheat			
Feed	402.3	61	3.11
Food	255.6	39	1.96
(Total)	(657.9)	(100)	(2.52)

Table 6.4. Projected Distribution of Consumption Growth for Coarse Grains and Wheat, 1974-1995[a]

	Coarse Grains[b]	Wheat[c]	Total
		percent	
Developed Countries			
Feed	59	30	50
Food	6	7	6
(Total)	(65)	(37)	(57)
Third World			
Feed	15	1	11
Food	20	62	32
(Total)	(35)	(63)	(43)
World			
Feed	74	31	61
Food	26	69	39
(Total)	(100)	(100)	(100)

[a]These were calculated from Appendix Tables 5.1 to 5.3.

[b]Includes "new" feed wheat in corn equivalents.

[c]Excludes "new" feed wheat.

alone explains 50 percent of the total growth in wheat and coarse grain consumption and the third world accounts for only 43 percent of the total.

The long-run price projections for 1975 to 1995 and the corresponding historical values are plotted in Figure 6.3. The sharply rising price trend (PC_0) is the projected corn export price from the partial equilibrium projection in Chapter 4. The slowly rising trends for corn export price (PC_1) and wheat export price (PW_1) are projected by the simultaneous model. Since the interactive model was designed so as to allow the maximum impact of wheat substitution, PC_1 represents a lower bound on the corn export price. Given the base level assumptions, the projections of PC_0 and PC_1 set upper and lower bounds on the corn export price. For the same reason that PC_1 is a lower bound, PW_1 represents an upper bound on the projected wheat export price. If the critical price ratio were set at 1.0 or 0.9 rather than 1.05, there would be less wheat fed and PW_1 would be lower and PC_1 higher. Comparing the projected to the historical real price levels, it is apparent that while the projected prices do not increase at a rapid rate, they establish a new plateau well above the levels experienced in the 1960's.

The final test of these results is to look at the impact of changes in the key assumptions presented in Table 6.5. A change in the income growth assumption for the developed countries has a smaller impact on corn price and a much greater impact on

FIGURE 6.3
U.S. GULF PORTS REAL PRICE OF WHEAT (PW) AND CORN (PC), ACTUAL TO 1974, PROJECTED 1975 TO 1995 (1970 U.S. DOLLARS)

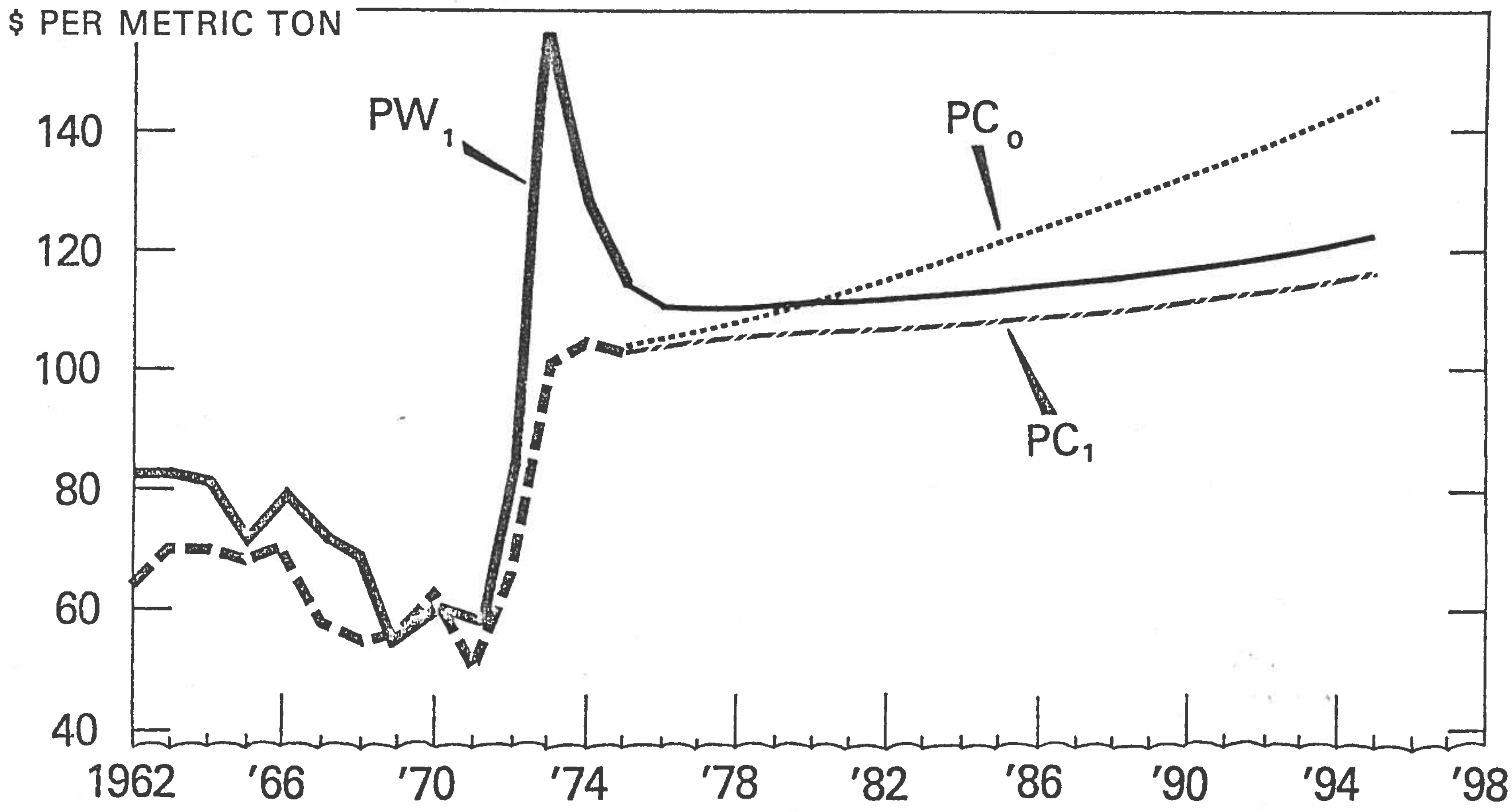

Table 6.5. Impact of Changes in Projection Assumptions on the 1995 Base Solution of the Simultaneous Model

Assumption	Coarse Grains Feed	Coarse Grains Food	Coarse Grains Total	Wheat Feed	Wheat Food	Wheat Total	Corn Price Farm	Corn Price Export	Wheat Price
			million metric tons				$/cwt	$/mt	$/mt
1995 Base	670.4	341.9	1012.3	178.2	421.0	599.2	4.68	116.7	122.5
10 Percent Increase in Growth Rate of									
Income									
Dev Country	4.5	-4.5	0	6.3	-6.3	0	.38	8.8	9.2
Third World	0.7	-0.7	0	-1.7	1.7	0	.17	4.0	4.2
Population									
Dev Country	0.4	-0.4	0	-0.5	0.5	0	.22	5.1	5.4
Third World	-5.8	5.8	0	-7.1	7.1	0	.45	10.4	11.0
Production									
Coarse Grains	41.5	10.2	51.7	-10.2	10.2	0	-.74	-17.2	-18.1
Wheat	-6.5	6.5	0	25.5	6.5	32.0	-.48	-11.3	-11.9
Parameters									
Elas = -.30	1.2	-1.2	0	-1.1	1.1	0	-.09	-2.0	-2.2
Cross-elas = -.30	0.4	-0.4	0	0.4	-0.4	0	.03	0.7	0.7
Food elas = -.25	0.4	-0.4	0	-1.5	1.5	0	.03	0.7	0.7
PR = .01	-0.8	0.8	0	-1.1	1.1	0	-.08	-1.9	-2.0

wheat price than was the case in the partial equilibrium solutions (Tables 4.10 and 5.5). This is due to the greater substitutability of wheat for coarse grains in the simultaneous model. For the same reason the third world population growth assumption now has a greater impact on corn price and a smaller relative impact on wheat price. A 1 percent decline in the growth rates of either developed country income or third world population would reduce the projected 1995 real price of corn to approximately the 1974 level. As before, the other two demand shifters have less impact on price levels and the projected distribution of consumption.

In the base solution the critical wheat-corn price ratio is reached in 1977 and this never changes more than one year in all of the sensitivity tests. However, the year when the market price reaches the European threshold price is very sensitive to changing assumptions. The base year is 1988; it drops to 1982 when the third world population rate is increases, and under the two high production rate assumptions the market price never reaches the threshold price.

As in the partial equilibrium projections, changes in the production growth assumptions have the greatest impact on prices and the levels of consumption. When the coarse grain production growth is increased, 80 percent of the 1995 increase is used for feed but this allows more wheat to be used for food. Similarly, when wheat production increases, 80 percent of the 1995 increase is fed but some coarse grain is diverted to food use. In both cases the net allocation is about 60 percent for feed and 40 percent for food.

The increased substitutability of wheat for corn in the simultaneous model leads to lower price flexibilities which are reflected in the production growth impacts. A 10 percent increase (decrease) in the rate of growth of coarse grain production decreases (increases) the projected 1995 real price of corn by \$.74 and the real export price of wheat by \$18.10. An equivalent change in the growth rate of wheat production changes the real price of corn by \$.48 and the real export price of wheat by \$11.90. Because of the high implicit price elasticity for the "new" fed wheat the price flexibility for wheat is lower than that for corn, but still it is clear that the rate of production growth has a critical impact on future price trends.

The model does not appear to be very sensitive to the elasticity assumptions. Neither prices nor the distribution of consumption are significantly affected by an increase of -.1 in any of these assumptions. An increase in the assumed rate of growth in the European threshold price also has little impact on the projection results. Their higher prices reduce world demand pressure only slightly and the resulting price effect is not significant.

Overall the simultaneous equilibrium projections offer a less dismal outlook for consumers because a favorable shift in any one of several factors could keep coarse grain prices near 1974 levels. However, the assumptions were chosen to reflect normal conditions, so the probabilities of favorable and unfavorable deviations from these assumptions should be about equal. Moreover, while the 1974 price levels may appear attractive in comparison to the partial equilibrium price projections in Chapter 4, they were certainly not considered attractive by consumers in 1974.

Chapter 7

SUMMARY AND CONCLUSIONS

Two major issues were the focus of this study. The first of these is the importance of income growth in developed countries as a shifter of the total world demand for grain. The second is the overall effect of demand growth on the future prices of grains given a continuation of historical trends in production. As noted in Chapter 1, the two issues are interrelated from a policy viewpoint because third world sensitivities to apparent inequities in grain distribution would surely intensify as grain prices increased. In an increasingly interdependent world this potential conflict cannot fail to concern farsighted policy-makers in the developed world.

The impact of developed country demand was measured in two ways--the total effect and the marginal effect. The total effect is seen in the projected distribution of the total increase in supply. Over the 21-year projection period about two-thirds of the increase in the supply of coarse grains and more than half of the combined increase in the supplies of wheat and coarse grains is consumed in the developed countries even though their projected population is less than one-fourth of world population by 1995.

The marginal effect is evaluated by comparing the impact on grain prices of increasing (or decreasing) the growth rate of income in developed countries to the impact of equivalent changes in the other major demand shifters. In the simultaneous model, the marginal effect of population growth in the third world on price is slightly greater than that of income growth in the developed countries (Table 7.1). However, when the distribution of population is considered, the importance of the demand shifters in developed countries is magnified. For example, the marginal effect of income growth per million inhabitants in developed countries dominates all the other demand factors (Table 7.1). Even population growth in the developed countries has a greater marginal effect per million inhabitants than population growth in the third world. Although this contradicts popular notions, it is true because the average person in a developed country consumes more wheat and coarse grains than five average persons in the third world.

Whether measured by the total effect or the marginal effect, these results indicate that the effects of the high income level and the income growth in the developed countries will continue to dominate the growth in the demand for grains well into the future.

The question of long-run price trends cannot be fully addressed without thorough analyses of wheat demand and the supply side for wheat and coarse grains. However, the coarse grain model projections based on historical levels of supply growth show a strong upward pressure on the long-run real prices of coarse

Table 7.1. Effects on the 1995 Corn Export Price of a 10 Percent Increase in the Growth Rates of Income and Population

Increased Growth Rate of	Overall Price Effect[a]	Price Effect per Million Inhabitants
	$/mt	cents/mt
Income		
Developed Countries	8.8	0.72
Third World	4.0	0.11
Population		
Developed Countries	5.1	0.42
Third World	10.4	0.29

[a]Taken from Table 6.5

grains. The real price of corn rises at an increasing rate over the projection period and by 1995 is 40 percent above the "crisis" level of 1974. In the simultaneous model projections, the maximum impact of wheat feeding was assumed and coarse grain demand pressure was still strong enough to bring about a slight upward trend in coarse grain prices and to establish a "floor" for the declining real wheat price. The implication with regard to wheat is that over the long run, feed grain demand could well be a price support mechanism for the wheat sector.

These projections do not bode well for the third world nations and give cause for concern among policymakers in the developed world. The projected growth in third world wheat and coarse grain consumption would limit per capita consumption growth (Table 7.2) to less than 1 percent per year. Moreover, at the projected real price levels, the third world deficit areas would have increasing difficulty in financing grain imports.

The policy questions suggested by these results fall into two general categories:

1. What changes in food, agricultural and foreign policies would be desirable under conditions of prolonged scarcity in world grain markets?
2. What changes in food, agricultural and foreign policies could effectively prevent the outcome which these projections imply?

Table 7.2. Comparison of Actual and Projected Levels of Per Capita Consumption of Coarse Grains plus Wheat

Region	Actual 1974	Projected 1985	Projected 1995	Annual Rate of Growth
	kilograms			percent
Developed Countries	569	663	748	1.31
Third World	116	125	133	0.65
Total	246	262	273	0.50

These questions are suitable issues for further research and cannot be adequately treated here. As with most policy issues, political as well as economic criteria must be considered. Producers are not likely to object to a long-run upward trend in grain prices, but consumers certainly would not be pleased. Exporting countries may not be threatened by rising prices but importers would be, especially those with limited foreign exchange resources. Such conflicts of interest must be resolved in the political arena, but a range of policy alternatives should be analyzed in anticipation of these conflicts.

The impact analysis conducted in this study gives some indication of the relative "benefits" of various supply and demand shifts, but the relative costs also need to be determined. For example, a 10 percent decline in the growth rate of population in the third world reduces the 1995 corn export price by $10.40 while a 10 percent increase in the growth rate of coarse grain production reduces the same price by $17.20. If the objective were to reduce grain prices and if these two alternatives had the same cost, the production increase would clearly provide more impact per dollar expended. No one has seriously advocated reducing developed country income growth rates as a means of moderating growth in grain demand, but measures to reduce per capita grain consumption in the developed countries would merit serious consideration. The dominant role of developed country demand in these projections suggests that policies designed to reduce grain consumption in the developed countries should be high on the list of alternatives.

It is important that research on these policy alternatives take account of the distribution effects as well as the overall effect on the price level. This study has not attempted to project trade flows, but other studies predict that the food deficits in the third world will continue to increase in future years. Investment in research and technical assistance to support agricultural development in the third world could reduce simultaneously the overall pressure on grain prices and the level of future food deficits in the third world. One choice which may confront the developed countries is to assist the third world in increasing these investments or face the prospect of later--and possibly larger--expenditures to help finance food imports. In a world of increasing interdependence, it is not likely that the developed countries can ignore the distribution problem indefinitely.

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APPENDIX 1

Tables Supplementing Chapter 1

Appendix Table 1.1. Distribution of Growth in the Consumption of Coarse Grains (1960/61-1962/63 average to 1969/70-1971/72 average) Compared to the Distribution of Growth in Population (1961 to 1970)

Region	Coarse Grain Consumption						Population	
	1960/61-1962/63	1969/70-1971/72	Absolute Change	Percent of Change	Rate of Growth	Per Capita Consp. 1969-71	Rate of Growth 61-70	1970
	million metric tons			%	% per annum	kg.	% per annum	mil.
Developed Market	210.7	272.7	62.0	48	2.91	386	1.07	706
(feed)	(177.9)	(230.6)	(52.7)	(41)	(2.92)	(327)		
Developed CPE	94.0	123.3	29.3	23	3.06	335	1.02	368
(feed)	(59.1)	(90.1)	(31.0)	(24)	(4.80)	(245)		
Third World	107.2	144.5	37.3	29	3.37	57	2.29	2543
(feed)	(22.0)	(33.9)	(11.9)	(9)	(4.92)	(13)		
World	411.9	540.6	128.7	100	3.07	149	1.91	3617
(feed)	(259.0)	(354.6)	(95.6)	(74)	(3.55)	(98)		

Data Source: Economic Research Service, World Agricultural Situation, WAS-7, USDA, June 1975; and unpublished data.

Appendix Table 1.2. Distribution of Growth in the Consumption of Wheat (1960/61-1962/63 average to 1969/70-1971/72 average)

Region	Wheat Consumption					
	1960/61-1962/63	1969/70-1971/72	Absolute Change	Percent of Change	Rate of Growth	Per Capita Consp. 1969-71
	million metric tons			%	% per annum	kg.
Developed Market	74.2	87.6	13.4	15	1.86	124
(feed)	(11.8)	(23.2)	(11.4)	(12)	(3.32)	(33)
Developed CPE	85.2	126.7	41.5	45	4.51	344
(feed)	(15.8)	(45.3)	(29.5)	(32)	(12.4)	(123)
Third World	82.9	120.0	37.1	40	4.20	47
(feed)	(0.3)	(1.1)	(0.8)	(1)	(15.5)	(0.4)
World	242.3	334.3	92.0	100	3.64	92
(feed)	(27.9)	(69.6)	(41.7)	(45)	(10.7)	(19)

Data Sources: Economic Research Service, World Agricultural Situation, WAS-7, USDA, June 1975; and unpublished data.

Appendix Table 1.3. Distribution of Growth in the Consumption of Rice (1960/61-1962/63 average to 1969/70-1971/72 average)

Region	Rice Consumption					
	1960/61-1962/63	1969/70 1971/72	Absolute Change	Percent of Change	Rate of Growth	Per Capita Consp. 1969-71
	million metric tons			%	% per annum	kg.
Developed Market	14.2	14.5	0.3	1	0.2	21
Developed CPE	0.7	1.6	0.9	2	9.6	4
Third World	140.5	193.4	52.9	98	3.6	76
World	155.4	209.5	54.1	100	3.4	58

Data Source: Economic Research Service, World Agricultural Situation, WAS-7, USDA, June 1975; and unpublished data.

APPENDIX 2

Regional Definitions and Data Sources

BLOCK THREE REGIONS

Code	Region	No.	Composition
DEV	Developed		
ICEMAL	(Europe)	1.	Iceland, Malta
ANZ	Oceania	2.	Australia, New Zealand
SAFR	South Africa	3.	Rep. of South Africa, Botswana, Namibia, Swaziland
EEUR	East Europe	4.	Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, Yugoslavia
USSR	Soviet Union	5.	Soviet Union
TW	Third World		
CHIN	China	6.	People's Republic of China
EASIA	East Asia	7.	Brunei, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan
SEASIA	Southeast Asia	8.	Burma, Khmer, Laos, South Vietnam, Thailand
SOASIA	South Asia	9.	Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka
NAFRME	North Africa and Middle East	10.	Algeria, Bahrain, Cyprus, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, Yemen (Sana), Yemen (Aden)
CAFR	Central Africa	11.	Angola, Burundi, Cameroon, Central African Rep., Chad, Congo, Dahomey, Ethiopia, French Territory of Afars and Issas, Gabon, Gambia, Ghana, Guinea, Equatorial Guinea,

(continued)

Code	Region	No.	Composition
			Portuguese Guinea, Ivory Coast, Liberia, Mali, Mauritania, Mauritius, Niger, Nigeria, Reunion, Rwanda, Senegal, Sierra Leone, Somalia, Spanish Sahara, Togo, Upper Volta, Zaire
EAFR	East Africa	12.	Kenya, Malagasy Rep., Malawi, Mozambique, Rhodesia, Tanzania, Uganda, Zambia
MAMER	Middle America	13.	Mexico, Bahamas, Bermuda, Costa Rica, Dominican Rep., El Salvador, Guatemala, Haiti, Honduras, British Honduras, Jamaica, Nicaragua, Panama, Trinidad and Tobago, Other Caribbean Isles
VEN	Venezuela	14.	Venezuela
BRZ	Brazil	15.	Brazil
ARG	Argentina	16.	Argentina
OSA	Other South America	17.	Bolivia, Chile, Columbia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Surinam, Uruguay
ROW	Rest of World	18.	North Korea, North Vietnam, Mongolia, Cuba, Pacific Islands, Papua-New Guinea--but also serving as a residual comprised of those regions not yet explicitly modeled

DATA SOURCES

1. Quantity Data

Data on production and utilization of coarse grains and wheat were obtained from the Economic Research Service (ERS) and the Foreign Agriculture Service (FAS) of the U.S. Department of Agriculture. The feed use data were not complete for some East European countries and China, so estimates of the missing data were made using available data from ERS publications and the FAO Food Balance Sheets.

2. Population, and Economic Indicators

Data on private consumption expenditures, population, consumer price indices and exchange rates for the developed market economies were obtained from International Financial Statistics. Population data for the central planned economies and the third world and wage income data for the USSR were obtained from ERS.

3. Prices

The U.S. farm price of corn was obtained from the ERS, the Gulf ports export price from the Grain Market News, and the Gulf ports wheat price from the Review of the World Wheat Situation. The soybean meal price is from the ERS and the livestock input price index is from the Annual Price Summary, Statistical Reporting Service.

Canadian prices were obtained from Grain Trade of Canada and the ERS. The Japan corn price index was provided by ERS from

Bank of Japan sources. West European coarse grain prices were from various issues of Prices of Agricultural Products and Selected Inputs in Europe.

4. Value of Animal Product Exports

The value of net exports of animal products was calculated from data in various issues of the FAO Trade Yearbook. The 1974 values were calculated from data in the U.N. Commodity Trade Statistics.

APPENDIX 3

Tables Supplementing Chapter 3

Appendix Table 3.1. Reduced-Form Elasticities in a Perfectly Competitive Industry[a]

STRUCTURAL EQUATIONS

(1) $Y = a\, X_1^{b_1} X_2^{b_2} X_3^{b_3}$	$a, b_i > 0$ $\gamma = 1 - \Sigma b_i \geq 0$	industry production
(2) $P_i = P_y\, b_i (Y/X_i)$	$i = 1, 2, 3$	1st order conditions
(3) $Y = d\, P_y^e\, I^\eta$	$e < 0;\ d, \eta > 0$ $e + \eta = 0$	final product demand

REDUCED-FORM EQUATION FOR X_1 (other input prices constant)

(4) $X_1 = A\, P_1^{\beta_1} P_2^{\beta_2} P_3^{\beta_3} I^{\beta_4}$

	decr. returns ($\gamma > 0$)	const. returns ($\gamma = 0$)
$\beta_1 =$	$\frac{b_1(1+e)}{w} - 1$	$b_1(1+e) - 1$
$\beta_2 =$	$\frac{b_2(1+e)}{w}$	$b_2(1+e)$
$\beta_3 =$	$\frac{b_3(1+e)}{w}$	$b_3(1+e)$
$\beta_4 =$	$\frac{\eta}{w}$	η

$$w = 1 - \gamma(1 + e) = \Sigma b_i(1 + e) - e > 0$$

[a]To facilitate comparison with the Brandow analysis the same notation is used whenever possible.

Appendix Table 3.1 continued

$w < 1$ if $-e < 1$
> 1 if $-e > 1$

Y = aggregate animal products
P_y = price of Y
I = income
X_i = production inputs
P_i = price of X_i

Appendix Table 3.2. Coarse Grain Feed Demand Linear Estimates for the United States and Canada

USA	UPC	I	UPM	UPFL	CONST	$\bar{R}^2$	D.W.	S.D. (d.f.)
OLS	-59.477	0.0512	3.959	0.7389	249.619	.86	1.81	15.27
t	(4.23)	(3.13)	(1.33)	(4.93)	(5.17)			(9)
e	-.25	.24	.03	.56				
e*	-.36	.26	.04	.68				
TSLS	-71.787	0.0481	4.075	0.8367	243.378		2.11	12.90
t	(5.36)	(3.47)	(1.62)	(6.16)	(5.95)			(9)
e	-.30	.22	.03	.64				
e*	-.43	.24	.04	.77				

CANADA	CPB	I	CPW	CED	CONST	$\bar{R}^2$	D.W.	S.D. (d.f.)
OLS	-39.256	0.2470	18.420	-61.710	154.279	.95	2.29	15.66
t	(3.61)	(12.71)	(2.64)	(5.17)	(2.98)			(9)
e	-.51	.96	.29					
e*	-.72	1.00	.48					

t = t-statistic (absolute value)
e = elasticity at the means
e*= elasticity in 1973

S.D. = standard deviation of residuals
d.f. = degrees of freedom

Appendix Table 3.3. Coarse Grain Food Demand Linear Estimates for the United States and Canada

USA	UPC	I		CONST	$\bar{R}^2$	D.W.	S.D. (d.f.)
OLS	-0.295	0.0079		49.721	.96	2.05	0.48
t	(1.04)	(18.45)		(39.51)			(11)
e	-.010	.31					
e*	-.016	.35					
TSLS	-0.135	0.0079		49.479		1.91	0.50
t	(0.44)	(17.58)		(37.63)			(11)
e	-.005	.31					
e*	-.007	.35					

CANADA	CPB	I	COD	CONST	$\bar{R}^2$	D.W.	S.D. (d.f.)
OLS	-1.368	0.0148	20.926	65.275	.81	1.45	3.94
t	(1.92)	(3.31)	(4.46)	(6.84)			(10)
e	-.11	.36					
e*	-.18	.44					

t = t-statistic (absolute value)
e = elasticity at the means
e* = elasticity for 1973

S.D. = standard deviation of residuals
d.f. = degrees of freedom

Appendix Table 3.4. Unconstrained Estimates of Coarse Grain Feed Demand

COUNTRY	ln(PCG)	ln(I)	ln(PM)	WFEDC	ANX	Dummy	$\bar{R}^2$	D.W.	SSE d.f.
BELX	−0.3792	0.4654	0.0069	−0.0056	0.0047	--	.48	1.66	.04501
(t)	(0.62)	(1.10)	(0.06)	(3.79)	(0.78)				(8)
FRAN	0.0346	0.5574	−0.0000	−0.0023	−0.0020	0.0953	.93	2.08	.00441
(t)	(0.18)	(8.17)	(0.00)	(1.96)	(0.37)	(3.55)			(7)
ITAL	−0.2058	0.6549	0.0170	--	0.0046	−0.2010	.97	2.49	.00649
(t)	(1.21)	(4.42)	(0.35)		(1.51)	(5.81)			(8)
NETH*	−0.4639	−0.9782	−0.2452	−0.0032	0.0024	−0.2336	.90	1.90	.06664
(t)	(0.45)	(0.30)	(0.11)	(0.83)	(0.17)	(1.08)			(6)
WGER	0.0438	0.5101	0.0008	−0.0016	0.0087	0.1121	.92	1.87	.00795
(t)	(0.09)	(1.26)	(0.01)	(0.72)	(1.07)	(1.34)			(7)
DENM	−0.2574	0.7573	0.0738	--	0.0009	--	.93	2.24	.00636
(t)	(2.32)	(5.37)	(1.71)		(1.04)				(9)
IREL	−0.3874	0.3986	0.0423	−0.0032	0.0021	--	.66	1.52	.05304
(t)	(1.07)	(0.82)	(0.37)	(1.57)	(0.61)				(8)
UKIN	−0.2752	0.5530	0.0325	−0.0029	0.0026	--	.77	1.40	.00577
(t)	(4.75)	(3.02)	(0.83)	(3.03)	(0.53)				(8)

*log trend term has coefficient = 0.0923 (t) (0.07)

SSE = sum of squared error
d.f. = degrees of freedom

Appendix Table 3.5. Tests for Homoscedasticity and the Constrained Regression, European Community

	SSE	d.f.	$\hat{\sigma}^2$	$1/\hat{\sigma}$	WEIGHTS
High SSE					
BELX	.04501	8			
NETH	.06664	6			
IREL	.05304	8			
High sum	.16469	22	0.007486	11.5579	0.32575
Low SSE					
FRAN	.00441	7			
ITAL	.00649	8			
WGER	.00795	7			
DENM	.00636	9			
UKIN	.00577	8			
Low sum	.03098	39	0.00794	35.4807	1.0
Unconstrained SSE_u	.19567	61			
Constrained SSE_c	.20740	74			
TEST HOMOSCEDASTICITY	$F = \frac{\text{High } \hat{\sigma}^2}{\text{Low } \hat{\sigma}^2} = 9.428$			$F_{20,40,.01} = 2.37$	
TEST CONSTRAINT	$F = \frac{(SSE_c - SSE_u)/(df_c - df_u)}{SSE_u/df_u} = 0.281$			$F_{14,60,.05} = 1.80$	

Appendix Table 3.6. Unconstrained Estimates of Coarse Grain Feed Demand for Other West Europe, Double-log Form

COUNTRY	ln(PCG)	ln(I)	ln(PM)	WFEDC	Dummy	$\bar{R}^2$	D.W.	SSE d.f.
ASTI	-0.3612	0.9153	-0.1309	-0.0033	0.117	.93	2.77	.00975
(t)	(0.90)	(2.74)	(2.21)	(1.67)	(2.26)			8
FINL	-0.4858	1.3236	-0.0414	--	--	.85	2.04	.11135
(t)	(3.49)	(5.63)	(0.29)					10
GREE	-0.7682	0.9424	0.2136	-0.0014	--	.92	2.79	.07215
(t)	(1.66)	(6.77)	(1.31)	(0.27)				10
NORW	-0.3895	0.8287	-0.1032	-0.0015	--	.89	2.28	.03082
(t)	(1.17)	(1.90)	(1.16)	(0.36)				9
PORT	-0.8909	1.0644	0.1215	--	-0.290	.85	2.59	.08725
(t)	(1.29)	(2.94)	(0.69)		(2.60)			9
SPAI	-0.4036	1.3070	-0.0571	-0.0060	--	.94	2.53	.03103
(t)	(2.47)	(14.04)	(0.70)	(1.77)				9
SWED	-0.2477	0.9508	0.0191	--	--	.75	1.84	.05382
(t)	(1.12)	(4.18)	(0.17)					10
SWIT	-1.0680	1.0780	-0.0490	--	--	.86	2.42	.15239
(t)	(1.14)	(0.95)	(0.28)					10

SSE = sum of squared error   d.f. = degrees of freedom

APPENDIX 4

Tables Supplementing Chapter 4

Appendix Table 4.1. Calculations of the Marketing Margin for U.S. Corn C.I.F. Rotterdam

Year	NTPC[a]	VL[b]	KN	NTPC-VL	EXPC	M[c]
	guilders/100 kg			- 1970 US dollars/100 kg -		
1967/68	32.99	13.32	0.993	6.315	4.712	1.647
1968/69	34.73	15.21	0.999	6.036	4.714	1.328
1969/70	35.00	13.04	0.986	6.327	4.792	1.624
1970/71	35.00	10.18	1.000	6.900	5.234	1.666
1971/72	35.50	15.29	0.878	5.227	4.079	1.874
1972/73	37.37	11.17	0.833	6.285	5.732	1.813
1973/74	37.77	1.14	0.717	8.134	8.768	2.576
1974/75	39.71	4.42	0.644	7.146	9.362	1.734

Source: [a]Maury E. Bredahl, "Price Formation in the European Community," CED Working Paper, ERS, USDA.

[b]Simple average of monthly corn import levies from Agricultural Markets, Vegetable Product Prices, Directorate-General Agriculture, European Community, Brussels, various issues.

[c]From equation (4.3) it can be seen that

$$M = \frac{NTPC - VL}{KN} - EXPC \quad .$$

Appendix Table 4.2. The Choice of Income Elasticities for Block 3 Projections

Region	Food Demand				Feed Demand	
	FAO[a]	ERS[b]	"Trend"[c]	Assumed	ERS[d]	FAO[a]
ANZ	-0.01	0.0	0.33	0.0	0.0	0.05
SAFR	-0.20	0.15	0.25	0.15	0.63	0.41
EEUR	-0.31	0.10	-0.07	-0.07	0.63	0.48
USSR	-0.32	0.30	-0.05	EQN	0.69	0.50
CHIN	0.20	0.0	0.44	0.20	1.00	1.22
EASIA	0.10	0.40	-0.11	0.0	1.00	0.90
SEASIA	0.10	0.50	2.09	0.50	1.00	0.90
SOASIA	-0.16	0.10	-1.52	-.16	1.00	1.20
NAFRME	-0.08	0.30	-0.15	-.08	--	0.59
CAFR	0.25	0.20	-0.62	0.0	--	0.80
EAFR	0.29	0.40	-0.09	0.0	1.00	0.74
MAMER	-0.25	0.40	0.26	0.26	0.56	0.61
VEN	0.09	0.45	0.45	0.45	--	0.48
BRZ	-0.30	0.25	0.20	0.20	--	0.48
ARG	0.0	0.0	1.68	0.0	--	0.18
OSA	0.30	0.45	-0.35	0.0	--	0.70

[a]FAO, Agricultural Commodity Projections, 1970-1980, Volume 2, United Nations.

[b]Elasticity for total demand for ERS, World Demand Prospects for Grain in 1980, FAER 75, U.S.D.A., Table 11.

[c]Elasticity implied by trend rates of growth in food demand.

[d]Elasticity for meat demand from ERS, Growth in Demand for Feed Grains, FAER 63, U.S. Department of Agriculture, Table 47.

Appendix Table 4.3. Basis for the Assumed Rate of Growth in Population and Private Consumption Expenditure in Block 3[a]

Region	Population			Private Consumption Expenditure per capita		
	Estimated 1975	Projected 1985	Assume PRT	Estimated 1970[b]	Projected 1985	Assume YRT
	million		%	1970 US dollars		%
ICEMAL	.536	0.576	0.72	990.	2118.	5.20
ANZ	16.616	19.929	1.75	1596.	2455.	2.91
SAFR	27.564	37.386	3.10	502.	715.	2.38
EEUR	129.787	139.486	0.72	1024.	1973.	4.47
USSR	254.300	283.011	1.08	1202.	2422.	4.78
CHIN	826.830	957.590	1.48	113.	161.	2.39
EASIA	252.114	324.028	2.54	156.	247.	3.11
SEASIA	107.220	139.963	2.70	102.	163.	3.21
SOASIA	825.444	1083.455	2.76	78.	92.	1.09
NAFRME	208.133	266.025	2.48	214.	423.	4.66
CAFR	202.878	270.383	2.91	96.	133.	2.22
EAFR	66.228	90.029	3.12	117.	148.	1.58
MAMER	92.571	125.258	3.07	434.	671.	2.95
VEN	12.670	16.681	2.79	535.	796.	2.69
BRZ	108.800	144.246	2.86	268.	633.	5.89
ARG	25.910	29.173	1.19	724.	1149.	3.12
OSA	70.807	92.941	2.76	311.	414.	1.92
ROW	49.087	(61.038)	2.20	181.	232.	1.67

[a]Population and income figures are unpublished data of the ERS, U.S. Department of Agriculture.

[b]Average for the period 1969/70 to 1971/72.

APPENDIX 5

Tables Supplementing Chapter 6

Appendix Table 5.1. Simultaneous Projection of Wheat Consumption without "New" Fed Wheat

	Developed Countries		Third World		Feed	Food	Total	"New"	Wheat
	Total	Food	Total	Food	(trad.)			Feed	Price
	million metric tons								$/mt
Consumption									
1974	211.0	148.6	138.1	137.3	63.4	285.9	349.2	0.0	128.8
1985	249.7	157.7	195.0	193.5	93.5	351.2	444.7	21.5	114.1
1995	283.1	162.5	260.8	258.5	123.0	421.0	543.9	55.3	122.5
Absolute Change									
1974-95	72.1	13.9	122.7	121.2	59.6	135.1	194.8		
Percent of Change	percent								
1974-95	37	7	63	62	31	69	100		
Growth Rate of Consumption	percent per annum								
1974-85	1.54	0.54	3.19	3.17	3.59	1.89	2.22		-1.11
1985-95	1.26	0.30	2.95	2.94	2.78	1.83	2.03		0.71
1974-95	1.41	0.43	3.07	3.06	3.21	1.86	2.13		-0.24

Appendix Table 5.2. Simultaneous Projection of Coarse Grain Consumption Including "New" Wheat Fed in Corn Equivalents

	Dev. Countries		Third World					Corn Price	
	Total	Feed	Total	Feed	Feed	Food	Total	Farm	Export
	million metric tons							\$/cwt	\$/mt
Consumption									
1974	420.7	336.5	183.7	46.5	383.0	221.4	604.4	4.23	106.1
1985	562.8	465.7	256.0	75.7	541.5	277.3	818.8	4.34	108.6
1995	722.7	610.7	347.7	117.8	728.5	341.9	1070.4	4.68	116.7
Absolute Change									
1974-95	302.0	274.2	164.0	71.3	345.5	120.5	466.0		
Percent of Change	percent								
1974-95	65	59	35	15	74	26	100		
Growth Rate of Consumption	percent per annum								
1974-85	2.68	3.00	3.06	4.53	3.20	2.07	2.80	0.23	0.21
1985-95	2.53	2.75	3.11	4.52	3.01	2.12	2.72	0.76	0.72
1974-95	2.61	2.88	3.08	4.53	3.11	2.09	2.76	0.48	0.45

Appendix Table 5.3. Projected Distribution of Coarse Grains plus Wheat

	Developed Countries			Third World			Total		
	Feed	Food	Total	Feed	Food	Total	Feed	Food	Total
					million metric tons				
Consumption									
1974	398.9	232.8	631.7	47.3	274.5	321.8	446.4	507.3	953.6
1985	557.7	254.8	812.5	77.2	373.8	451.0	635.0	628.5	1263.5
1995	731.3	274.5	1005.8	120.1	488.4	608.5	851.5	762.9	1614.3
Absolute Change									
1974-95	332.4	41.7	374.1	72.9	213.9	286.7	405.1	255.6	660.7
Percent of Change					percent				
1974-95	50.3	6.3	56.6	11.0	32.4	43.4	61.3	38.7	100.0