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M.S. degree in Agricultural Econ.

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OPTIMAL CARRYOVER POLICY FOR THE UNITED STATES NAVY BEAN INDUSTRY

By

Ross Owen Love

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

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ABSTRACT

OPTIMAL CARRYOVER POLICY FOR THE UNITED STATES NAVY BEAN INDUSTRY

By

Ross Owen Love

Michigan growers produce about 64 percent of the world's supply of navy (pea) beans. Price paid for navy beans ranged from about $8.00 per hundredweight to over $46.00 per hundredweight from 1966 to 1975. That same period was marked by declining yields, the end of government loan programs and increased competition in export markets. Concern over these attributes lead to the question of optimal carryover levels for navy beans.

Optimal levels were estimated for sets of specific assumptions through employment of the Gustafson carryover stocks model. This study went beyond previous applications and added: export demand, stochastic demand, econometric estimation of production mean and distribution and computer program. A data base and econometric model were established to facilitate the carryover model.

Optimal carryover was particularly sensitive to marginal cost and elasticity of demand. More generally, it would appear that in years of relatively good production insufficient crop is carried over.

DEDICATION

To Aunt Di and Poppy.
Their support of and belief in
my educational goals never faltered.

ACKNOWLEDGEMENTS

I deeply appreciate the time and energy Dr. John Brake gave as my major professor and thesis advisor. His encouragement and counsel were essential to the completion of this research.

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CHAPTER 1

Introduction

The United States produces about 65 percent of the world's supply of navy (pea) beans and most of the United States production comes from the State of Michigan. Michigan has produced from 93 to 100 percent of the annual domestic production over the last 20 years. Occasionally very limited production occurs in other states, primarily in Minnesota. Navy beans and the broader category of all dry edible beans are important crops in the agricultural areas of Michigan. Navy beans made up about 80 percent of all dry beans produced in Michigan over the ten year period 1966 to 1975. The value of production of all dry beans ranks high among the state's major agricultural commodities. A total value of $129,146,000 in 1975 made dry beans the fourth most important agricultural commodity produced in Michigan (see Table 1-1).

The industry is concentrated in the Saginaw Valley and "Thumb" regions of Michigan. This is largely due to the peculiar soil and climatic conditions necessary to produce the crop. Because of this geographic concentration, weather abnormalities in a small region can cause large fluctuations in production. Wide variations in production and price of navy beans have become common occurrences over the decade from 1966 to 1975, with production varying as much as 40

Table 1-1 Michigan Cash Receipts From Marketings: Top 8 Agricultural Products For 1975

Product	Cash Receipts (1,000 Dollars)
Dairy	376,314
Corn	202,890
Cattle and Calves	163,042
Dry Edible Beans	129,146
Wheat	128,452
Hogs	104,801
Vegetables	83,202
Soybeans	65,821

Source: Michigan Agricultural Statistics, 1976.

percent from one year to the next. Price has ranged from about $8.00 per hundredweight to over $46.00 per hundredweight during the same time period. Such variation has led to much concern among producers, processors, and inevitably final users. In the past few years there has been renewed interest in adjusting carrover stocks or reserves of agricultural commodities as a method of reducing supply variation. Objectives of reserve programs can include: price stability, producer welfare, and the facilitation of emergency reserves. Such carryover adjustment may be one method of reducing the adverse effects of wide variability of production (and price) of navy beans.

1.1 Research Objectives

The objectives of this study are:

Primary

1. Develop optimal carryover stocks rules, based on differing sets of specific assumptions, for the U.S. navy bean industry.

Supportive

2. Estimate U.S. supply and demand relationships for navy beans: a. To supply the necessary input data to the stocks model. b. To establish a workable base for econometric estimation with respect to navy beans.
3. Collect and summarize selected time series data on the production and marketing functions of the navy bean industry.

1.2 Research Approach to Fulfilling the Objectives

Objective one will involve the employment of a navy bean storage model based on the grain storage model developed by Robert Gustafson [1958]. As the model is used for this study many of the restrictive assumptions made in earlier applications will be revised to improve estimation and risk handling capabilities. Implementation of this model will require the use of the supply and demand relationships developed in objective two. The model output will indicate a set of optimal carryover stocks corresponding to various annual production possibilities. The model will be tested for sensitivity to specified changes in the predetermined conditions.

Objective two will involve estimation of an econometric model of U.S. supply and demand for navy beans. Ordinary least squares procedure is used to estimate structural equations for acres planted and yields on acres planted for the supply analysis. Two stage least squares procedure will be used to estimate the demand structure, consisting of a simultaneous system of two estimated equations (domestic and export) and an identity. Data collected in objective three will be employed in the fulfillment of this objective.

Objective three will involve the extensive collection and recording of time series data concerning the production and marketing processes of the industry for the twenty-five years from 1951 to 1975. Particular trends and recent developments will also be noted.

1.3 Format of the Study

This study will be arranged in the following manner. Chapter one is an introduction. Chapter two will be a short description of the navy bean industry in Michigan and the various problems faced by that industry today. Chapter three specifies the storage model, along with a review of its historical background and a discussion of the basic economic framework. Chapter four presents the supply and demand analysis, including the theoretical basis for the econometric model, estimation of the model and an analysis of the results.

Chapter five includes the estimation of the carryover model for navy beans and an analysis of the results. Chapter six is a summary and discussion of possible future research.

CHAPTER 2

The U.S. Navy Bean Industry

2.1 Introduction

Production of navy beans in the United States is highly concentrated in the State of Michigan. In the period of 1966 to 1975, an average of 98 percent of the navy beans grown in the U.S. were grown in the Saginaw Valley and "Thumb" regions of Michigan. During the same period of time, 80 percent of all dry edible beans produced in Michigan were navy beans. Dry beans are an important agricultural commodity in Michigan. Dry beans ranked fourth in value among all agricultural commodities in 1975 in the state, with a total value of $129,146,000. A distribution of dry bean acreage by county in Michigan is shown in Figure 2-1.

Weather has likely been a major factor in the concentration of the industry into such a small geographic area. Hayenga [1968] reported that, "since the navy bean plant appears especially sensitive to temperature, about 75°F during particular stages of plant growth, the resulting lower yields and profitability in some of the warmer areas of the state have likely been a major factor leading to production concentrations in the cooler northern 'thumb' area of Michigan."

Rather and Pettigrove [1944] stated "there is good

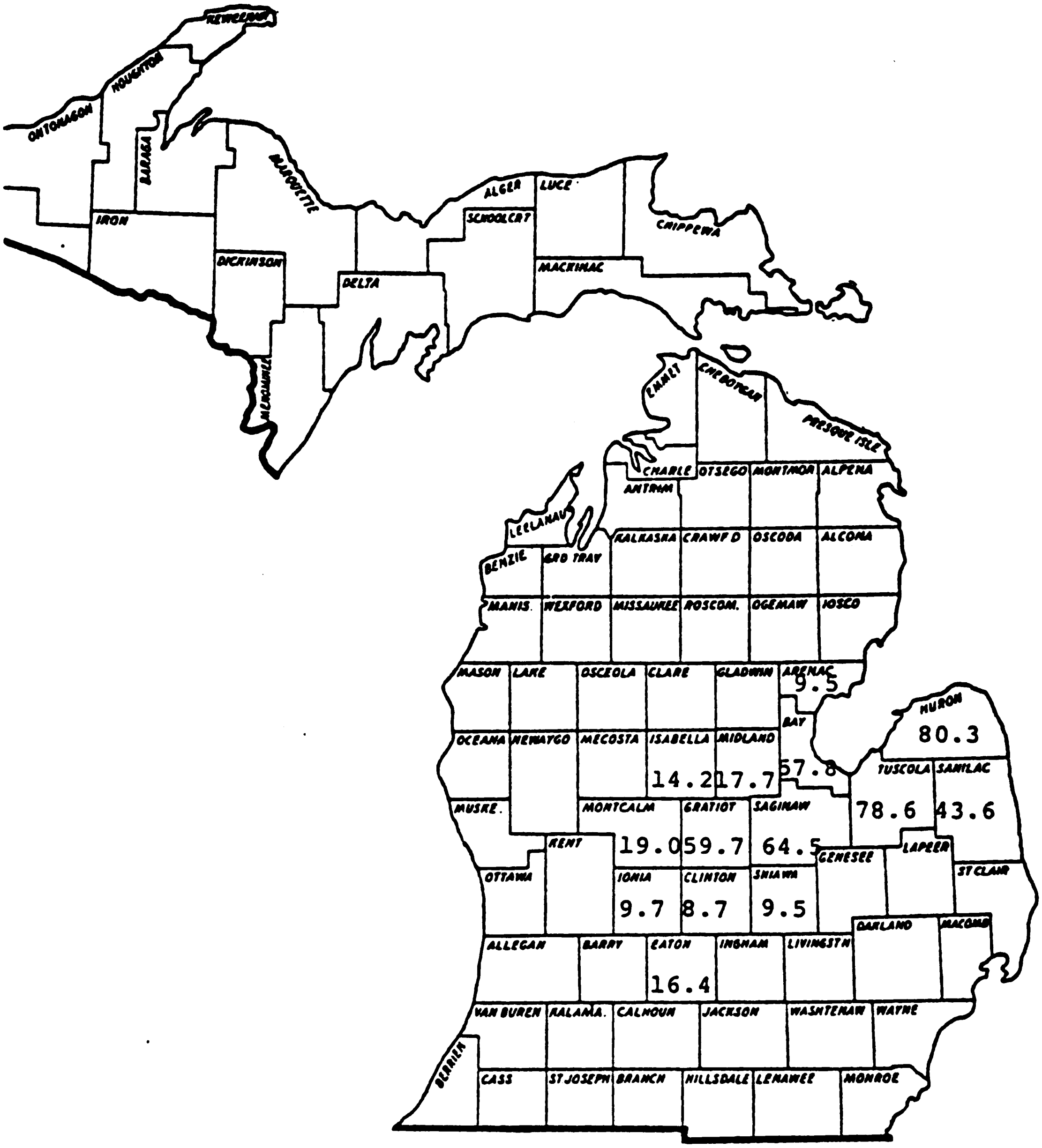

Figure 2-1. Acres Planted to Dry Edible Beans by County in Michigan (1000's) - 1975

Source: Michigan Agricultural Statistics, June 1976.

land south of the bean area, but prolonged high summer temperatures are unfavorable to pollination and the setting of well filled pods. North of the regular Michigan bean areas, fall frosts are likely to damage the crop before it has reached full maturity."

Such geographic concentration also means that yearly changes from normal weather in the area can have a disproportionate effect on U.S. navy bean production. Even within Michigan, acreage has trended toward increased geographic concentration. The percentage of the state total acreage in Tuscola, Saginaw, Gratiot and Bay counties has changed by five year periods starting with 1950-54 as follows: 30, 41, 47, 49 and 52 percent in 1970-74. This in part leads to the wide production and price variations mentioned in the first chapter.

Variability is certainly not new to the industry, as Dale Hathaway stated in 1955: "The most notable attribute regarding the production of beans in Michigan has been its variability. Few crops grown in the state have undergone such striking year-to-year variations" (Hathaway[1955]), but with the support price being at an ineffectual level for so many years and the subsequent end of government support programs for navy beans, the industry has experienced increased variability in price as well as production.

2.2 Market Structure

2.2.1 Domestic

The navy bean industry in Michigan is characterized by a large number of growers, typically growing navy beans in rotation with other crops and navy beans usually make up only a minority of any producer's total acreage. Disease and insect problems and uncertainty of return have been important factors leading to these cultural practices.

Producers commonly deliver their navy beans to local grain elevators, which have storage, drying, trucking and rail facilities. Producers generally either store their beans with the elevator at a cost to the producer, or sell outright to the elevator. Those elevators which are set up to handle navy beans are usually known within the industry as "shippers." Although there are several independent shippers around the State of Michigan, the majority of the navy beans produced are handled by four major companies or cooperatives: Michigan Bean Company (a division of Wickes Company), Michigan Elevator Exchange, Blount Agriculture and Frutchey Bean Company. The very nature of the structure of the industry with its many producers and few shippers may in part cause some of the present uncertainty in the industry. First, prices paid to producers for navy beans are determined by a small group of shippers, based on their expectations and prediction as to domestic and export market strength and the total production. Even among such a small group, the limited information available to these shippers is generally not publicly distributed for obvious business interests. Also, with a large number of producers in a limited area and a crop which often is not considered of major importance by the USDA, there is a true paucity of information available to the individual producer. Often early spring automobile trips or roadside surveys by the individual are the only estimate of acres planted a producer can get. It is not unusual for various buyers within a single elevator to differ greatly in the predictions as to the amount of acres to be planted to navy beans. The USDA makes no estimates as to the extent of carryover in the industry from one season to the next nor do they publish historic weighted prices received by producers. Given the close proximity of the various producers, speculation and rumor may play as important a role as prospective world and domestic markets, production costs and returns and opportunity costs of alternative crops. Thus it seems that the lack of good, accurate information adds to the already uncertain situation of weather and markets faced by all segments of the production chain from producers to retailers.

The beans purchased by shippers generally find their way into one of two outlets, the domestic market or the export market. About 79 percent (1971-1975 average) of all U.S. navy beans produced are taken by the domestic market. Thus about 21 percent are exported. It is estimated that 85 to 90 percent of the beans destined for domestic consumption are canned (pork and beans, beans in tomato sauce, baked beans, etc.). The remainder of the beans are packaged and sold as dry beans. Thus navy bean canners are the most important outlet for the shippers of navy beans. The major canners of navy beans include: Stokely Van-Camp, Campbell Soup Company, Bush Brothers and Company, H.J. Heinz Company, Libby, McNiell and Libby, and The Great Atlantic and Pacific Tea Company. Historically the United Kingdom has been the largest importer of U.S. navy beans. Other foreign importers in recent years have been the Netherlands, Australia, New Zealand, West Germany, Italy, and Spain. Sales of beans are usually made either to various foreign canners or to U.S. canners which can sell in foreign countries. H.J. Heinz Company is the largest user in the latter group. The major competition for export of navy beans to the United States' traditional marketing areas is Canada. Canadian export of navy beans has gone from 24 percent of their crop in 1962 to 83 percent of their crop in 1975. This occured while Canadian production doubled during the same period (see Table 2-1). For much of the study period, Canada has enjoyed a custom duty advantage over the U.S. with the United Kingdom because of its membership in the British Commonwealth. This duty advantage was 8 percent until 1968 when it was lowered to 4 percent and then when the United Kingdom joined the European Economic Community in 1972, there was no longer an advantage.

Table 2-1. Canadian Production and Exports of Navy Beans From 1960 to 1975

Year	Canadian Production	Canadian Exports
	1,000 Cwt.	1,000 Cwt.
1960	620	33
1961	744	127
1962	838	200
1963	863	218
1964	1,117	397
1965	1,182	597
1966	1,400	630
1967	824	297
1968	1,041	552
1969	1,159	649
1970	1,197	718
1971	1,550	977
1972	1,843	1,290
1973	1,594	1,084
1974	1,973	1,440
1975	1,783	1,480

Source: Ontario Bean Producers' Marketing Board.

2.2.2 Export

All the navy beans produced in Canada fall under the jurisdiction of the Ontario Bean Producers' Marketing Board. The Board established in 1944 by producers under the Agricultural Products Marketing Act (Canadian) covers navy and yellow eye beans in Ontario. In 1968, the Marketing Board started operation under a new marketing plan. Under this plan all navy and yellow eye beans grown in Ontario had to be marketed by or through the Ontario Bean Producers Marketing Board. The Board has been able to hold the Canadian share of the export market since 1972, even without tariff advantage. There may be several reasons for this. The Canadian government has a tariff on beans entering the country thus holding domestic price at a higher than free market equilibrium level. Also the Board appears to have a "no storage" policy since in only one year in the last 25 did they store any beans. Thus the export price is so adjusted as to insure the complete sale of the crop. Since all beans are pooled and each producer receives a pool price, then the pool price may not be all that much lower than a world market equilibrium price because of the higher domestic price that relatively price inelastic navy beans command. Thus due to earlier tariff advantages and more recently because of Board policies, Canadian producers have been able to market all their beans in the foreign markets before the U.S. producers approached being able to do so.

Other countries producing and exporting navy or similar white beans include: Argentina, Chile, Ethiopia, and a few southeastern European countries. A major problem in the export market is the fluctuation of currency exchange rates, often caused by differing inflation rates. This is not only a problem in the changing rates between the United States' and Canadian dollars but also adds to the risk that the real price to be paid the shipper will change between the time of contract for shipment and payment. This means that the shipper must either trade at the present rate and risk a decrease in the value of the foreign currency or he hedges his position in the currency futures market. The former alternative meaning a risk of loss to the shipper and the latter presenting the need for currency market management expertise. Most of the navy beans exported from the non-North American producing countries, which is only a small percentage of total world exports, are not exported to traditional North American export markets. This may be because of the poorer quality beans produced by these countries (poorer quality because of mixed varieties, clay, cracks, splits, etc.), or the location of the markets. Another reason may be that these growers are often only short-term producers and it takes time to get well established into the traditional or larger markets. There may also be other limits on these countries, for example, in communication with the OBPMB, it was learned that many Ethiopian beans never leave the African community because of various trade pacts.

2.2.3 Government

During much of the study period there was another purchaser of navy beans. The United States government through the Commodities Credit Corporation had a price-support program for agricultural commodities which included navy beans. The program for navy beans was in effect until the end of the 1974 marketing season, but the last year a significant purchase was made was in 1966. Table 2-2 presents the government support price and the amount of navy beans taken over each year. In those years when beans were taken over (default of non-recourse loans), the loan rate played a major role in price stability. Producers knew prior to planting what the loan rate would be approximately and could plan accordingly. The 1950 marketing season was the last time there were government acreage controls on navy beans, and such controls only lasted a short time. In more recent years the government loan rate had little or no direct effect, except possibly establishing a lower bound on price. The lack of effective loan rate setting and the subsequent end of the program in 1975 has removed any stablizing effect which had been exerted by the program in earlier years.

Table 2-2. U.S. Government Support Price For and Purchases of Navy Beans From 1951 to 1975

Year	Government Support Price	Government Take-over
	Dollars	1,000 Cwt.
1951	7.94	1,130
1952	8.75	260
1953	8.80	377
1954	8.41	0
1955	7.43	623
1956	7.38	1,747
1957	7.29	31
1958	7.17	9
1959	6.43	177
1960	6.46	1,838
1961	7.15	1,611
1962	7.15	964
1963	7.15	1,012
1964	7.15	601
1965	6.90	0
1966	6.90	1,676
1967	6.90	0
1968	6.90	0
1969	6.90	11
1970	6.90	0
1971	6.90	0
1972	6.90	0
1973	6.95	0
1974	6.95	0
1975	Program Ended	-

Source: 1951-65 Edward Krebs, _Simulated Price and Supply Control Programs for the Michigan Navy Bean Industry_.
1966-75 Michigan Crop Reporting Service.

2.3 Summary

In summary, the industry is one of many producers and few intermediate buyers. About three-quarters of production goes to the domestic market and one-quarter to the export market. The industry is plagued by a lack of reliable information, uncertainties of weather and domestic markets and an even more volatile foreign market with the outlook for an even less certain future.

CHAPTER 3

The Storage Model

3.1 The Purpose of Storage

The idea of using storage as a method of reducing variation in annual supplies of storable agricultural commodities has been evident through most of history. Storage has often been an integral part of the U.S. government's agricultural commodity programs. The subject has often dominated the literature. Many policies to be followed to achieve certain goals have been advocated. Although there are undoubtedly variations and other groupings, the following are generally given as reasons for storing commodities (private and government):

1. Stabilize producer income.
2. Market stability with respect to producers.
3. Market stability with respect to consumers.
4. Maintenance of commercial export market.
5. Provision of a buffer against food and feed shortages.
6. Assist developing countries.

A few of these goals may not be relevant to the navy bean situation, but maintaining prices and income, as well as domestic and foreign market stability are likely goals of bean producers, shippers, canners and state and federal governments. Through discussions with growers and shippers it is evident that some price stability is highly desirable. Beside the obvious beneficial effect on forward planning and fixed cost reduction, both groups were most interested in the problem of maintenance of markets at price extremes. Growers especially worry that high prices tend to expand the plantings in the next season by present and potential growers. This action then generally leads to larger crops the following seasons and accompanying lower prices. The growers then worry about the immediate effect of lower prices in the next season, as well as the possible longer run effect of opening new geographical areas to navy bean production. The shippers (and growers through derived demand) find relatively high prices undesirable because of the immediate effects of substitution of relatively less expensive products in the domestic market and the substitution of foreign produced beans in the export markets. Probably more important is the suspected long run effect of high prices on domestic and foreign use. There exists the possibility that high prices can trigger permanent change in demand for U.S. produced navy beans. Such prices may force the acquiring of new tastes or change in typical cooking and eating habits. Canning may become unprofitable enough in a given year that bean products are discontinued and start up costs may be great enough to offset resumption of canning even at lower prices in the future. Due to perceived need and the inherent uncertainty in the industry, an attempt will be made to estimate optimal carryover levels for navy beans for a specific objective.

3.2 Objectives of Storage

There are many objectives which may be adhered to in deciding on a commodity stocks policy. One familiar objective is to maintain a target level of reserve stocks. In this situation, estimates are made of appropriate target levels of stocks and these become the criteria for the functioning of the policy. Wells and Fox [1952], National Agricultural Advisory Council [1964] and Waugh [1967] are examples of studies which estimated various target levels of stocks. One problem with such a policy is that once the suggested target levels are defined, there is no suggestion as to how to facilitate their use effectively. Gustafson [1958] stated that the target-level approach is "an inadequate solution to the storage problem because the administrator of such a policy has no way of knowing if at any given point in time whether he should be adding or subtracting from stocks."

An alternative objective to absolute target quanties of stocks is to maintain a percentage of the trend production level. Bailey, Kutish, Rojko [1974] examined the effects of various percentage levels of U.S. production trend as to storage costs, net stocks and ability to overcome world short falls in production over a historical period. The percentage of production trend objective has much the same implementation problems as the absolute level objective.

To reduce price variation over time by setting upper and lower limits on commodity prices is another possible objective of a stocks program. In such a program, when prices are high stocks could be released and when prices are low stocks could be purchased. Usually suggested as accompanying such a program are policy tools such as supply controls, which would be needed to aid the price stabilization program. The greatest weakness of such a program is the proper setting of the price bounds. Stock levels too high might result over time if the price bounds were too high or levels of stocks might be depleted too quickly if the bounds were set too low. Also a problem is that future price trends would have to be accurately predicted.

Other objectives of a carryover stocks program may be concerned with social welfare measurements. Tweeten, Kalbfleisch and Lu [1971] set an objective which would minimize net social cost over time. Another social welfare criteria oriented objective is that used by Gustafson [1958] and this study. The objective is to maximize the total value function, the integral of the demand function from zero to the quantity consumed, over time.

Storage rules may be of several forms, but generally the storage rule defines how reserve stocks will be managed in order to achieve a specific objective. Some common storage rules found in the literature include:

1. reserve stocks equal a constant target quantity
2. reserve stocks as a function of production

3. reserve stocks as a function of price, loan rate, target stocks
4. reserve stocks as a function of price
5. reserve stocks as a function of supply.

The latter (5) is the rule used by Gustafson such that carryover stocks are a function of supply (beginning stocks plus production).

3.3 The Modified Storage Model

3.3.1 The Storage Rule

Gustafson used a storage rule that would maximize the sum of the discounted expected net gains to the general public from the usage of a commodity over time. A simple two period graphical representation of the criterion for optimality is presented in Figure 3-1. If $\overline{DD}$ is allowed to be a linear demand curve (assumed the same for both periods) and S_0 the production experienced in year zero (no carry in) and S_1 the production experienced in year one, then the procedure would be to adjust supply (carryover policy) such that the discounted sum of the areas bounded by the axes, the demand function and the adjusted supplies would be a maximum (adjust S_0 and S_1, through the use of storage, to maximize the sum of the areas AOCB and AOFE). Such a graph demonstrated the maximization of gross social gain over time. What the model will actually maximize is not gross gain, but rather the net social gain, where net gain takes into consideration time preference and other costs of storage. By

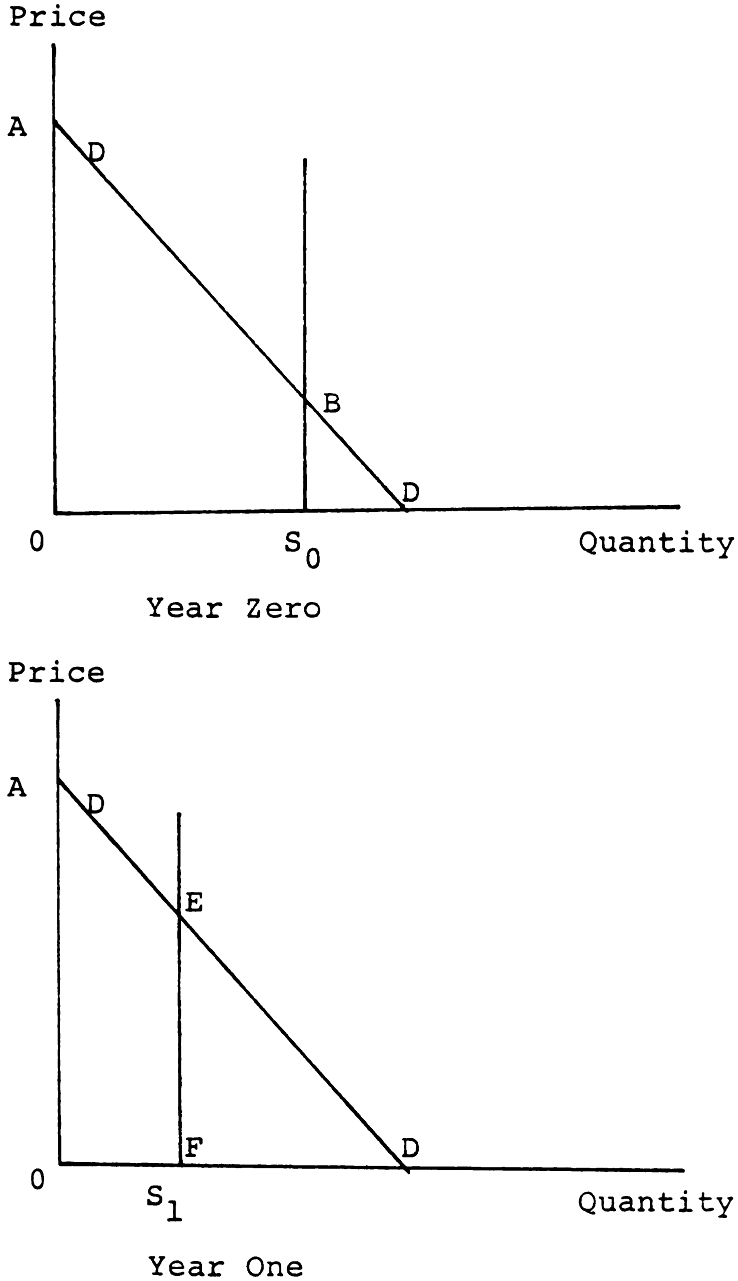

Figure 3-1. Simple Example of Optimality Criterion

assuming a state of stationarity (conditions not changing over time) for calculating purposes, this process can be carried into the indefinite future with the use of dynamic programming techniques.

3.3.2 Original Model Assumptions and Modifications

The primary application of the Gustafson model to date contains some simplifying restrictions which should be stated. First, it was assumed that the following were known with certainty: 1. The basic demand curve. 2. The cost of storage for various quantities stored. 3. The acreage to be planted. With proper adjustment the model allows for assumptions one and three to be relaxed. Assumptions will be revised such that the demand function and the acreage planted will be allowed to take on a stochastic nature. Another restrictive assumption was that imports and exports were either known in advance or non-existent. For this study this restriction too is relaxed and exports of navy beans are incorporated into the carryover decision rule estimation. Finally the original Gustafson example assumed that the storage and production of the commodity is located within a single geographic region, thus causing cost of transport to be negligible. Although such a restriction would cause varying degrees of inaccuracy depending on the commodity, it appears to fit well the highly concentrated navy bean industry. Thus of the original restrictions, which caused some of the major criticism of the model (see Walker and Sharples [1975] or Taylor and Talpaz [1979]) most are either relaxed or highly applicable for purposes of estimating an optimal carryover rule for navy beans.

3.4 Predetermined Conditions

The conditions relevant and which must be estimated prior to the derivation of storage rules are the following: 1. A discount factor which equals 1/1+R, where R is the interest rate. This reflects the degree of time preference. 2. The direct cost in dollars of carrying over the quantity stored for one year. 3. The marginal value function (in this case the demand function) with price of commodity as the dependent variable. 4. A probability distribution of production (in Gustafson's application only a distribution of yields was used because acreage was assumed constant). The specific conditions employed in this study are discussed following.

3.4.1 The Discount Factor

In most simple terms, the discount factor can be viewed as a transformed version of the interest rate. Thus the obvious question is, what is the relevant interest rate or associated discount factor? Much controversy over appropriate discount factors can be found in the literature (see Weston and Brigham [1972] or Baumol [1968]). Ideally the rate might be based on the free market rate or return the capital could gain in its best alternative use, but many factors complicate the discovery of the ideal rate. The model maximizes the discounted net return to society over time. A discount rate relevant to the U.S. in general is most important. Three factors typically are considered as contributing to the discount rate. These factors are pure rate of time preference, inflation and uncertainty. It should be noted that the discount factor is not a static concept and will change over time as these factors change. This study employs a range of values for the interest rate (discount factor) in the optimal rule estimation and the effect of differing rates on the optimal storage rules can be observed.

3.4.2 Storage Costs

The Gustafson model takes cost of storage to be the amount of money it costs to store a given quantity of commodity for a year. As Gustafson noted in his original application, "serious problems of estimation are involved (in reference to estimating cost of storage)," so, too, in this study much difficulty occurred in attempting to find a composite cost of storage for navy beans. Because most of the estimated carryover in raw product form is either in the hands of producers or shippers, it would be most helpful to have a weighted average cost of beans stored on farm, those stored off-farm and owned by producers and those stored and owned by shippers. One advantage in the case of navy beans is the relative geographical compactness of the production area. Most production sites are near several storage alternatives; because of this or other causes, many shippers store producer owned beans at near shipper cost. Thus off-farm storage costs are fairly uniform through the area. It is most difficult to get a "typical" or "average" cost of on-farm storage. There are costs to storing beans on-farm. There is additional labor and machinery usage with respect to the handling in and out of storage. Significant costs due to reduced commodity quality and quantity (rodent destruction, etc.) can also be caused by typical on-farm storage practices. Given these considerations it seems reasonable that on-farm storage costs are significant yet likely to be less than the cost of storing beans at the elevator. Typically the off-farm storage charges are a function of months in storage, quantity and final sale price. Mathematically storage costs can be presented as follows:

storage cost = f(time in storage, quantity, sale price).

Although time in storage (12 months) and quantity are known with certainty the sale price in the future is not. Since final sale price is stochastic, there is a difficulty in deciding what to use for the model. This problem was alleviated by changing the cost function to percentage of expected value form (see Chapter 5). Due to the difficulty of estimating a composite cost of storage, the optimal carryover rules will be estimated for a range of storage costs.

There is some question of whether money cost alone should be considered an adequate measure of net cost to the economy. Gustafson mentions the "convenience benefit" of having working or pipeline stocks. This study does not attempt to incorporate such benefits and costs into the model. For further explanation of the concept see Gustafson [1958] or Working [1949].

3.4.3. Marginal Value Function

This is most simply the typical price-quantity relationship known as the commodity's demand curve. The total value to society of an amount Y of a commodity, can then be defined as the area under the marginal value function (demand curve) between zero amount and Y amount. Such marginal value functions can be empirically estimated. In the case of dry beans see Hathaway [1955], Vandenborre [1967] or Krebs [1970]. Gustafson assumed that the marginal value function is known with certainty, but as mentioned earlier, this study relaxes that assumption and allows the marginal value function to take on a probabilistic nature. Econometric techniques, as discussed in Chapter four, will be employed to model the domestic and export demand for navy beans. The combination of these functions will provide a total demand function for U.S. navy beans. The inclusion of a stochastic export market function into the total demand function is also a change from the restrictive assumptions in the model's original application. The use of a stochastic marginal value function based on both domestic and export market demand is an important step toward making the Gustafson model a better empirical tool.

3.4.4 Production Probability Distribution

The final condition to estimate is that of a production probability distribution. In Gustafson's original work on grains he used only a probability distribution on yields and assumed acreage to be fixed. He stated, "Ideally, provision would be incorporated to allow for the way in which year-to-year variations on acreage planted are determined in a free market by the interrelationship of supply and demand factors." (Gustafson [1959]) In this study, an econometric function reflecting the market factors effect on planted acreage will be included. Also a function to remove systematic trend factors from yields will be estimated. The production probability distribution will therefore be based on the unsystematic stochastic elements of both yields and plantings incorporated in a joint distribution.

When these conditions, the value function, cost of storage function, discount rate and probability distribution can be assumed to be the same each future year a condition of stationarity is said to hold. This condition is assumed for computational purposes and is not really restrictive in that the optimality of the resulting rule, as applied to the current year only, does not require that the conditions in fact remain unchanged in all future years; all that is really required is that the same storage rule applies in the next succeeding year. In such a case the single optimal rule can be shown to be the unique solution of a single equation.

3.5 Calculating Function

Although the fortran program of the model is presented in Appendix A, and a detailed explanation of the unmodified model can be found in Gustafson [1958], it would undoubtedly be helpful at this point to present the basic calculating equation. The basic equation to be satisfied in any year is the following:

$$(1) \quad V(S-C) + g(C) = d\sum_{x} V[C+X - \theta_{t+1}(C+X)]f(X)$$

where:

- X is the quantity produced
- C is the amount of carryover
- S is the total supply
- θ is the storage rule
- d is the discount factor
- V( ) is the marginal value function
- g(c) is the marginal cost of storage
- f(X) is the probability distribution of production (a joint probability distribution based on the probability distributions of yields and acres planted).

Now by employing the identity, $C = \theta(S)$ and assuming that $\theta(S)$ is montonically increasing for all values of S such that $\theta(S) > 0$, then S can be rewritten as: $\theta^{-1}(c)$. Substituting this into equation (1) the result is:

$$(2) \quad V(\theta^{-1}(C) - C) + g(C) = d\sum_{x} V[C+X - \theta_{t+1}(C+X)]f(X)$$

In order to make the calculating equation more explicit a linear marginal value function such as the following might be assumed:

$$(3) \quad V(Y) = \alpha - \beta Y$$

where α, β are estimated parameters. Substituting for V( ) in equation (2), the following results:

$$(4) \quad \alpha - \beta(\Theta^{-1}(C) - C) + g(C) = d\sum_{X} \alpha - \beta[C+X - \Theta_{t+1}(C+X)]f(X)$$

rearranging terms.

$$(5) \quad -\beta\Theta^{-1}(C) = -\alpha + d\alpha - \beta C - d\beta C - d\beta E(X) + d\beta\sum_{x}\Theta_{t+1}(C+X)f(X) - g(C)$$

combining terms and dividing through by $-\beta$ results in:

$$(6) \quad \Theta^{-1}(C) = (1-d)\frac{\alpha}{\beta} + (1+d)C + dE(X) - d\sum_{x}\Theta_{t+1}(C+X)f(X) - \frac{g(C)}{\beta}$$

Then from this equation comes the explicit storage rule for year t + 1.

In order to understand how the stochastic nature of the demand function is incorporated into the model, equation (2) can be rewritten as follows:

$$(7) \quad V(\Theta^{-1}(C) - C) + g(C) = d\sum_{z} V[C+Z - \Theta_{t+1}(C+Z)]f(Z)$$

where Z is defined by,

$$Z = X + U$$

and the distribution of Z, f(Z), is determined from the distributions of X and U, such that U is the random fluctuation of the marginal value function. The resulting optimal storage rule is a function of supply plus the residual for the aggregate demand function, rather than supply alone. Thus if in the year, U = 0, then the only change in the rule for the current year caused by the introduction of demand variability in the future is that due to the greater variability of Z over X. The uncertainty of future demand has the effect of increasing the optimal carryover for any level of production. Using this calculating equation, it is possible to iteratively work back to year one and the subsequent optimal rule (see Gustafson [1958]).

3.6 Summary

The modified model of this study can be employed to develop specific storage rules for a given objective. These rules are dependent on the preconditions discussed in this chapter. Estimation of these conditions prior to optimal rule calculation is essential. Chapter four will present the estimation of the value function. In Chapter five the assumptions as to the conditions will be made specific and optimal carryover rules will be estimated.

CHAPTER 4

Econometric Analysis of Supply and Demand

4.1 Introduction

In order to facilitate the functioning of the carryover stocks model, several relationships must be estimated prior to the derivation of the storage rules. These include the estimation of a marginal value function, which in this case is equivalent to the demand function. A domestic and an export demand function will be estimated to meet this need. A probability distribution of production possibilities is also required. In "Carryover Levels for Grains," Gustafson uses simple yield distributions and fixed acreage. This study will relax these simplifying restrictions. To remove that portion of the stochastic nature which is systematic, econometric methods will be used for estimating yields and acreage of navy beans. The other important conditions to be determined are a discount factor and the direct cost of carrying over navy beans (storage cost). The importance of accurate estimation of one of these conditions quickly becomes recognizable through an example presented in Table 4-1. In this table, several possible elasticities of demand and the corresponding optimal carryover levels were selected for an illustrative purpose. Those numbers in the body of the table represent the steady state supply situation as a

Table 4-1 Example Optimal Carryover Rules under Alternative Elasticities

Supply as a Percentage of Normal Production	Optimal Carryover as a Percentage of Normal Production		
	Elasticity of		
	.3	.5	.7
80	2.74	2.91	3.02
90	3.35	3.42	3.52
100	4.82	4.14	3.99
120	16.07	10.63	8.11
140	31.31	23.31	18.46

percentage of normal (mean) production. This example is merely an amplified version of that done by Gustafson [1959]. To better understand the form that the optimal rule will take, this table can be presented in graphical form. As can be seen for each level of supply (production plus carryover from the previous season) there is a corresponding optimal carryover, given the specific level of elasticities of demand. This is the type of output which is expected to be made available from the specific model in Chapter five. Thus, it should be evident from this example that the econometric estimations in this chapter are a necessary and integral part of the optimal carryover rule estimation.

4.2 Previous Research

Little previous research has been done to determine navy bean supply-demand relationships. Janet Murray [1938] studied factors affecting dry edible bean prices in the U.S.

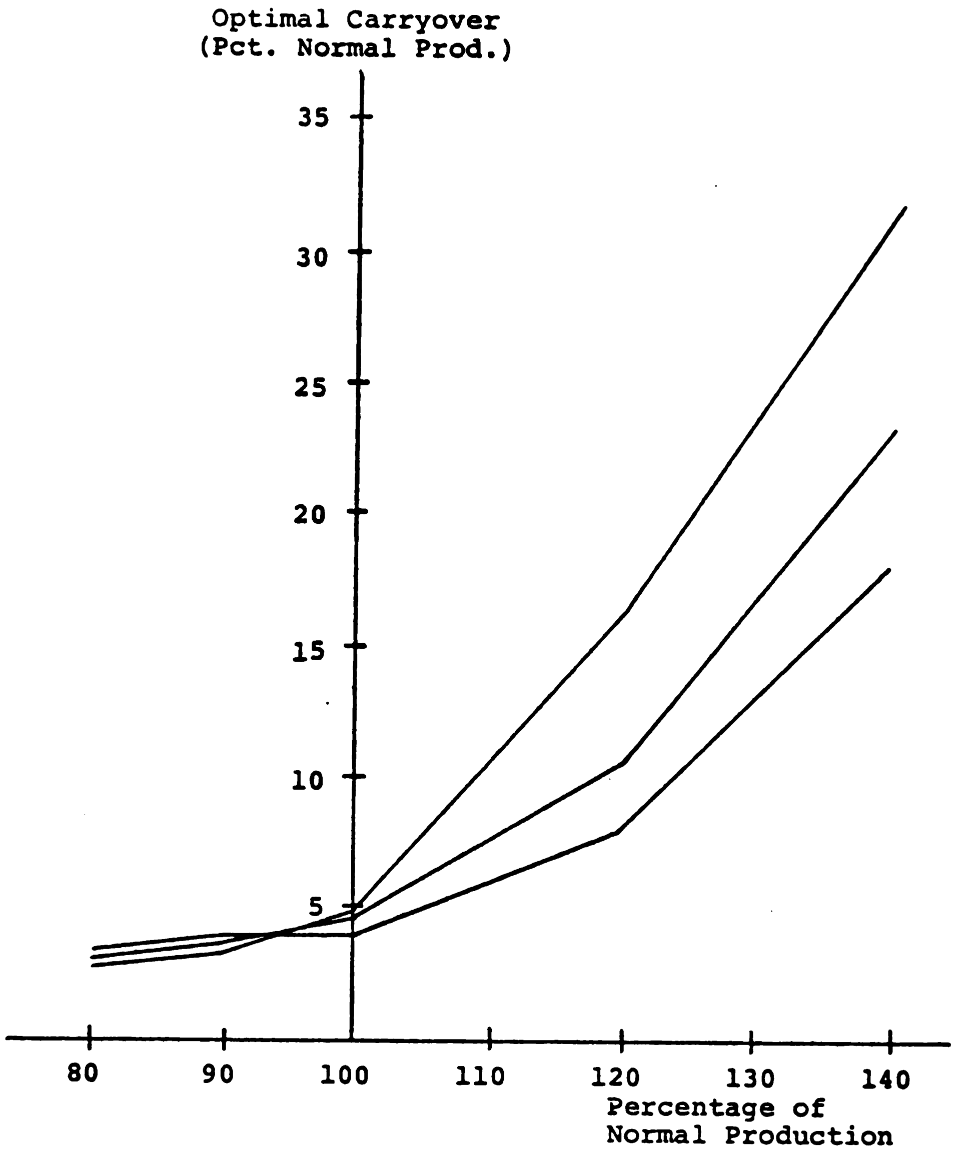

Figure 4-1 Example Optimal Carryover Rules under Alternative Elasticities

from 1922 to 1935. Although she divided beans into classes for this study, much of the results appear dated because of the retail market change from mostly dry usage during that period to a product that is mainly canned in more recent times. Dale Hathaway [1955] in an attempt to analyze the effect of price support and acreage allotment program upon production, price and income from dry beans in Michigan, estimated statistical relationships for dry beans in Michigan for the years 1920 to 1940 and 1947 to 1953. The Hathaway study did not divide all dry beans into classes. In a similar study, R. J. Vandenborre [1967] investigated the impact of governmental support programs on the production and disappearance of several important classes of dry beans, including navy beans. Edward Krebs [1970] simulated the impact of price support and supply control programs on the Michigan navy bean industry. Econometric models were established for acreage planted to navy beans in Michigan and for domestic and export demand for Michigan navy beans for the years 1951 to 1967. The paucity of previous studies, the increased time series data available and important structural changes over time warrant the updating and new estimation of the econometric relationships essential to the operation of the carryover model as described in Chapter three. The availability of these econometric estimations in this study also provides the base for better understanding of the important economic elements in the navy bean industry, especially with respect to empirical estimation of production, price and market structure relationships.

In the first sections of this chapter an attempt will be made to identify the important structural economic variables for supply and demand of navy beans. Discussion with individuals at various levels of the navy bean marketing system, a survey of contemporary literature concerning the navy bean industry, preliminary investigation of the collected data and economic theory have been the main sources of information used to make decisions as to the relevant economic components for possible inclusion in the econometric model. It is realized that all the economic variables assumed to be important may not be found statistically significant when the equations are actually estimated. Tomek and Robinson [1972] made note of this problem:

> "Since specification of the best model prior to estimation is nearly impossible for many problems in economics, some experimentation is generally necessary. The judgment of the analyst is critical in model selection, although different models sometimes give similar results."

Such difficulties are due to many factors not the least of which are availability and richness of data. The results of the econometric estimation are presented in the latter sections of this chapter. When the explanatory variables included in the estimated equations differ from those hypothesized to be relevant, an explanation for the difference and intermediary estimations will be presented. Conclusions relative to the econometric results will be discussed in the last section of this chapter. The sample period for this study will include the years 1951 through 1975. Years prior to 1951 were not included because of the lack of reliable data and the existence of acreage allotments.

4.3 Supply

Supply in a given marketing season is dependent on production in the season and carryover stocks from the previous season. Production can be divided into two components:

the number of acres planted and the yield from those acres. Acres planted and yields will be estimated using econometric and statistical methods.

4.3.1 Acres planted

The "How many acres to plant to navy beans?" decision is a complicated process, probably unique to each producer. However, some factors in the decision process are of both greater importance and universality in their application; for example, the price producers expect to receive for their crop. If the price to be paid in the upcoming marketing season were known, then some desired level of acres planted could be partially explained by that level of price. Future prices are unknown; thus expected price or expected prices adjusted for risk are used. It is thought these expected prices are based upon a combination of sources, including: past prices, probable future production, perceived market trends, the magnitude of stocks from past periods and government loan price. That source which is most available and easily understood by the producers is past price of the commodity. Knowledge about sources like market trends, future production and stocks is less available to producers and can be highly speculative. Thus expected price in the next marketing period might be expressed as some function of prices received in past marketing periods and expectations of past prices:

$$PNB_t^E = f(PNB_{t-1}, PNB_{t-1}^E)$$

where:

PNB^E_t is expected price for navy beans in periot t.

PNB_{t-1} is actual price for navy beans in period t-1.

PNB^E_{t-1} is expected price for navy beans in period t-1.

The number of lagged periods and their relative importance in the formulation of price expectations can differ considerably from one commodity to another. A common assumption is that producers project the price of the most recent past period as next period's expected price. Heady [1952] discusses several methods via which farmers might arrive at an expected price. Nerlove [1958] presents a more formal version of the mechanics of price expectations. More recently R. J. Vandenborre [1967] used a similar model with respect to dry beans. Navy beans is an annual crop. The decisions as to the number of acres to be planted can be made annually. This characteristic allows for a rather rapid response to highly fluctuating production and price. Thus, the price received in the previous marketing period is likely to have the most influence on expected future price. Another argument for use of most recent past year's price was put forward by Hathaway [1955]. The essence of this supportive argument is that after a year of high prices, bean producers were financially in a position to risk higher acreage of a crop on which they might incur either large financial losses or larger financial gains (relative to land competing crops such as corn). The logical conclusion to this argument is that bean producers would respond positively to a higher price in the previous year. The aforementioned implicit expectations function was presented in an explicit form by Nerlove [1958]. Explicitly, PNB_t^E might be a function of last period's expected price and some adjustment for the difference between last period's actual and expected prices. Such an expression might be:

$$PNB_t^E = PNB_{t-1}^E + \Psi[PNB_{t-1} - PNB_{t-1}^E] \qquad 0 < \Psi \leq 1$$

Here the constant, Ψ, implies a proportional adjustment. Nerlove called the Ψ factor the "coefficient of expectation."

If the producer does formulate some expected price for the next period, then that information plus information about inputs and prices of competitive crops can be used to maximize his returns. This is a typical production economics problem as to the determination of an ideal production level. The ideal level of production implies some planting level, thus the price expectations of the producer ought to imply some desired or long run planting level. A simple relationship might be proportional, such as:

$$APNB_t^E = aPNB_t^E$$

where: $APNB_t^E$ is the desired acres to be planted to navy beans. The producer has at his disposal in the present a set of resources which are fixed to varying degrees.

Because of this the producer's production possibilities may be restricted. Even if his price expectations point to a particular ideal or desired level of production, he may not in the short run be able to comply with the desirable levels implied by the perceived longer run equilibrium.

Such constraints to adjustment undoubtedly exist. Constraints influencing acreage might include: the producer's managerial expertise, machinery and labor available on the farm, crop rotations and market availability. Although these constraints may be changed over time, they are not easily changed from one year to the next as in the case of some of the other factors important to the planting decisions for navy beans. Given the year's particular circumstances (prices, costs, etc.), it is expected that the producer would have a desired planting level. Yet, because of these constraints he would not be able to adjust fully in a single period. The level of plantings in previous periods and the rate of adjustment will in part affect the acres planted in the present season. Nerlove [1958] presented one possible relationship between desired plantings and actual and past plantings. In this simple adjustment model actual acreage is adjusted in proportion to the difference between desired and actual output of the previous period. This can be presented mathematically:

$$APNB_t - APNB_{t-1} = \gamma[APNB_t^E - APNB_{t-1}]$$

$$0 < \gamma \leq 1$$

The factor, γ, is a constant that allows for the proportional adjustment. Nerlove called γ the "coefficient of adjustment." Due to price expectations and constraints to adjustment, acreage planted in any given year is at least a function of past own price and past actual planted acreage.

$$APNB_t = f(PNB_{t-a}, APNB_{t-b})$$

where a = 1, 2, 3 ... and b = 1, 2, 3 ... .

The usefulness of lagged variables of more than one period ($a > 1, b > 1$) will be tested (see Kmenta [1971] or Johnston [1972]), but the significance of models containing lags of two or more years will probably be quite low. This can be implied from the nature of the industry (annual crop, etc.), or from the results of previous econometric studies of dry beans or through the function derived from Nerlove's explicit functions. Thus both lagged own price and lagged acreage planted will be variables included in the model. More specifically in the case of own price, the prices received by producers in the first eight months (September to April) of the previous marketing season are thought to be of primary importance to the formulation of price expectations. Although beans are planted in mid June, the decision as to when to quit planting other crops, such as corn, is made in April and May. Thus a lagged eight month weighted (by marketings) average price is used as an explanatory variable in the econometric equation for estimating acres planted.

As previously stated, the government loan rate for navy beans should be a source of information in the formulation of price expectations. The U. S. government had a price support program for navy beans for the first twenty three-years of the study period, 1951 to 1973 (see Hathaway and Peterson [1952] or Krebs [1970]). An explanation of the effects of this program will be put forth in this chapter in Section 4.4.1. At this point it is important to realize that the government loan rate (for non-recourse loans) was known prior to planting for most seasons. Since the loan rate changed only a few times (seven times out of twenty-five years it changed more than a dime) over a period (see Table 4-2), most of its effect is already included in the formulation of expected market prices presented earlier. In years when the government took over navy beans (farmers defaulted on non-recourse loans), the market price was about one dollar less than the loan rate due to handling and other charges (see Hathaway [1955]), in the other years the market price is determined independent of the loan rate. Thus, the price used in the eight month weighted average implicitly reflects the government loan rate in those years when it was an effective floor price (due to a relatively slow to change loan rate). Because of this, the government loan rate was not used as a separate explanatory variable.

Another set of factors affecting acres planted to navy beans concerns the opportunity costs associated with alternative uses for the land. There exist some limitations

Table 4-2. U.S. Government Support Price for Navy Beans From 1951 to 1975

Year	Government Support Price	Change from Previous Year
1951	7.94	
1952	8.75	+.81
1953	8.80	+.05
1954	8.41	-.39
1955	7.43	-.98
1956	7.38	-.05
1957	7.29	-.09
1958	7.17	-.12
1959	6.43	-.74
1960	6.46	+.03
1961	7.15	+.69
1962	7.15	--
1963	7.15	--
1964	7.15	--
1965	6.90	-.25
1966	6.90	--
1967	6.90	--
1968	6.90	--
1969	6.90	--
1970	6.90	--
1971	6.90	--
1972	6.90	--
1973	6.95	+.05
1974	6.95	--
1975	Program Ended	

Source: Crop Reporting Service, ESCS of the USDA.

to free substitution between crops due to rotation requirements, weather, available machinery and producer expertise, but in general some substitution is possible. The two crops probably most competitive with navy beans for the land are corn and other classes of dry beans. Recently, some evidence points to soybeans as becoming a competitor for land, especially in the fringe areas of navy bean production. Probably, because this is a more recent phenomenon, no statistically significant relationship could be found between soybeans and acres planted to navy beans for the study period. The net return to land is a criterion upon which many budgeting and linear programming techniques used in the planting decision process are based. The net returns would be based on costs of production, expected price, expected yields and sometimes a risk factor. In most of the bean producing counties farmers have a good idea of the expected yields of the various land competitive crops. Production costs among the various varieties of beans don't appear to differ significantly but good cost account budgets for those areas are not readily available. In the production of corn, more nitrogen fertilizer is used than with beans, but seed and times over the field with beans are generally more costly. Discussions with extension experts have indicated that cost differences are minor among corn and various varieties of beans. Given expected yields are known, prices and degrees of risk are probably the most important elements in the decision process. Thus, expected prices, although not ideal, are not as naive in the case of navy beans as in the case of some other commodities. The price of competing crops in the past period is assumed to be the main factor in the formulation of expected prices (using the same argument as made for own expected price). A seven month average weighted price for corn (seven months because the new marketing season for corn begins in October instead of September as for beans) and an eight month weighted composite price for all other important dry bean classes produced in Michigan will be used in the estimation of the acres planted equation.

There are undoubtedly other factors which affect the number of acres planted to navy beans. Price movements immediately preceding planting, as well as announced forward contracting prices (set by shippers) probably play a role of varying degrees from one year to the next. Weather experienced during planting periods of navy beans or other crops grown in the bean producing areas may make it either necessary or more profitable to change planting intentions, or other conditions that otherwise change the intentions regarding bean plantings with which farmers began the planting season. While it is possible to take note of such factors in certain years, it is difficult to measure them accurately. No attempt was made to analyze such factors in this study.

The following equation represents the important variables assumed to influence acres planted to navy beans.

$$APNB_t = f(PNB_{t-1}, PC_{t-1}, PCB_{t-1}, APNB_{t-1})$$

where:

$APNB_t$ is the acreage planted to navy beans in the U.S. in thousands of acres in year t.

PNB_{t-1} is the average weighted price in real dollars paid to producers in Michigan per hundredweight of navy beans in the eight months prior to the planting period (Sept. thru April).

PC_{t-1} is the average weighted price in real dollars paid to producers in Michigan per bushel of corn in the seven months prior to the navy bean planting season (Oct. thru April).

PCB_{t-1} is the average composite price in real dollars paid to producers in Michigan per hundredweight of the major classes of dry edible beans other than navy beans grown in Michigan. The price is for the eight months prior to the planting season (Sept. thru April).

$APNB_{t-1}$ is the acreage planted to navy beans in the U.S. in the previous period, in thousands of acres.

It is expected that acres planted will demonstrate a positive relationship with the price of navy beans in the previous period. Coefficients for prices of corn and other classes of dry edible beans in the previous period would be expected to have negative signs as an increase in these prices, holding other things constant, should cause a decrease in the in the acres planted to navy beans in the present season. The coefficient for acres planted in the previous period is expected to have a positive sign, because of the structural constraints discussed.

4.3.2 Yield

Navy bean yields have varied greatly over the period of study. Average yields on acres planted were as high as 1452 pounds per acre in 1963 and as low as 682 pounds per acre in 1954 and 1957. For the first half of the period, 1951-1963, yields generally increased followed by a gradual downward trend in subsequent years (Figure 4-2). The downward trend has been given much consideration in bean production studies (see MSU Ag Facts No. 46, Ext. Bull. E854, or Navy Bean Cultural Practice and Management Check List). Weather is undoubtedly the most important factor affecting variation in navy bean yields. There are several periods during the growing season when proper moisture and temperature are critical. Considering the geographic concentration of production, poor conditions at these critical periods or adverse weather at other times can greatly reduce the yield potential. Although weather may explain much of the variability between production periods, it cannot fully explain the trends of yields over time. The early portion of the study period was marked by improved cultural practices, improved seed varieties, more efficient harvesting and handling machinery and a general increase in farm size (Dike [1972]). Continual use of land for production of navy beans

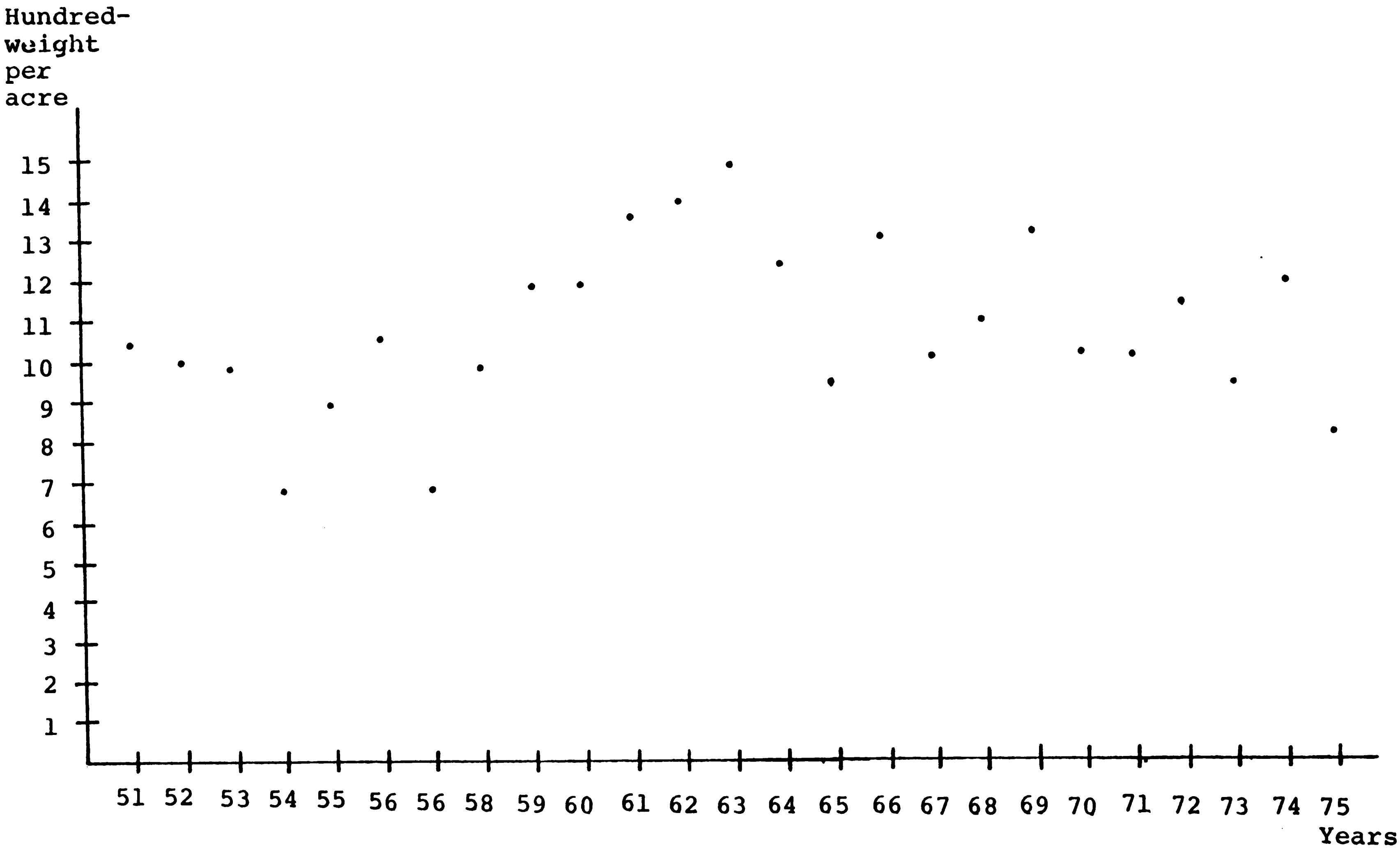

Figure 4-2. Trends of Yields on Acres Planted to Navy Beans, 1951 to 1975

has caused problems. In an attempt to raise crops perceived to be more profitable, producers have reduced their use of green manure or other such rotation crops which build up the organic matter in the soil. In addition to the organic material building rotation, the Michigan Agricultural Experiment Station specialists recommend a minimum tillage program (MSU Ag Facts No. 46, Ext. Bull E854 or Navy Bean Cultural Practice and Management Checklist). Producers till their fields more than is necessary. This problem accompanied by the use of large and heavier machinery, because of increase in farm size and efficiency of larger machines, has created the problem of soil compaction, especially in those soils which have higher clay content. Soil compaction can cause poor air and moisture movement in the soil, resulting in dryness and inhibition of root development. These conditions can cause the bean plant to be even more susceptible to weather variations and various disease problems. Overcropping of navy beans and reduced strength of the plant due to soil compaction have only worsened the problem of bean blight and root rot. Also, more recently, ozone pollution may be becoming a problem. Ozone pollution produces a bronzing effect on the bean plant, thus reducing the plant's production efficiency. In all probability, these factors have led to the slow decline in yield we have witnessed in the past ten to twelve years. Although the soil and crop scientists can identify the major causes of both yield variability and the trends which were witnessed over the study period, the capability to measure some of these factors accurately is not available nor are good forecasts possible for most, which would be necessary for functioning of the carryover model. Thus, those variables which would probably explain much of the observed changes in yield cannot be included in an econometric model for the yields of navy beans. Although such explanatory variables as weather and cultural practices can't be included, it would seem reasonable that we could estimate some of the trend effect by using time as a variable. It is likely that an equation for yields using only time or functions of time as predetermined variables would have a poor fit with the actual yields experienced. The primary reason for estimating the structural economic relationships for navy beans will be for the facilitation of the optimal carryover model. The carryover model is in part driven by the mean production and the variability of that production (which is partially variability in yield). Rather than assuming no trend factors and simply using the average yield over the study period and the variation from that, an attempt will be made to take out those factors that can be predicted, by using time as a proxy.

Several yield functions will be estimated using time in various degrees of a polynomial, to find that equation which has the best fit with statistically significant coefficients. The following equation represents the important variables used to estimate the yield on acres planted function:

$$YAPNB_t = f(T, T^2, T^3)$$

Where:

YAPNB is yield on acres planted to navy beans in pounds per acre in period t.

T, T^2, T^3 are representative of various powers of time such that: T = 1 for 1951 and so on to T = 25 for 1975.

Due to the shape of the yield function over time (Figure 4-3), it would be expected that both T and T^2 would be statistically significant and possibly T^3. Alternate signs would be expected on the coefficients for the time variables.

4.4 Demand

4.4.1 Domestic Disappearance

Demand for U.S. navy beans can be divided into two parts: U.S. domestic demand and U.S. export demand. The domestic and export demand functions are each discussed separately.

Domestic demand will be defined as domestic disappearance for purposes of this study such that:

$$DDNB = QNB - XNB - GOVNB + CARIN - CAROUT$$

Where:

DDNB is the domestic disappearance of navy beans measured in thousands of hundredweight.

QNB is the quantity of navy beans produced in the

U.S. during the period, measured in thousands of hundredweight.

XNB is quantity of U.S. exports of navy beans during the period measured in thousands of hundredweight.

GOVNB is the quantity of navy beans purchased during the periods by the government through the commodity nonrecourse loan program of the CCC. The quantity is measured in thousands of hundredweight.[1]

CARIN is the quantity of navy beans carried over from the previous marketing season into the present (beginning inventory) measured in thousands of hundredweight.

CAROUT is the quantity of navy beans remaining at the end of the present marketing season which will be carried into the next season (ending inventory) measured in thousands of hundredweight.

Many factors affect the quantity of disappearance of a commodity. The most obvious is the commodity's own price. Economic theory tells us that own price and consumption or disappearance are usually expected to have an inverse relationship. It would be expected that an increase in price

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[1]The estimation of domestic disappearance is based on the assumption that those navy beans purchased and later disposed of by the government did not re-enter the commercial market. This assumption probably leads to an underestimation of domestic disappearance in some years. Since most of the government purchased beans went into non-typical commercial markets and it is very difficult to estimate just how many went into typical commercial markets in short supply years, no attempt was made to adjust the model.

would cause a decrease in disappearance. Generally product price at the retail level is the most appropriate market factor to consider in a demand function. Because of the lack of data and the varied nature of the retail product in the case of navy beans, derived or farm level price will be used as a proxy.

As noted earlier, the price of navy beans in many years of the period under investigation has been affected by the government support price. The government operated a price support program for navy beans until 1974. Through the support system a minimum price is set such that the government attempts to remove a sufficient quantity from the market to keep the market price from falling below the support price. Due to handling and other costs the price received by producers was usually about one dollar lower than the support price. Because of this the market price sometimes fell below the support price.

A typical government commodity price support program can be presented in a simple example. For this example a linear demand curve is assumed and supply (carry in plus production) is assumed fixed once a crop has been harvested for a given season.

In Figure 4-3, the demand curve is represented by $\overline{D'D''}$. Two levels of supply are presented by S_0 and S_1. If the net government price received by producers is P_g then the demand curve faced by the producer with a government support program is D'AB. The demand curve with no government

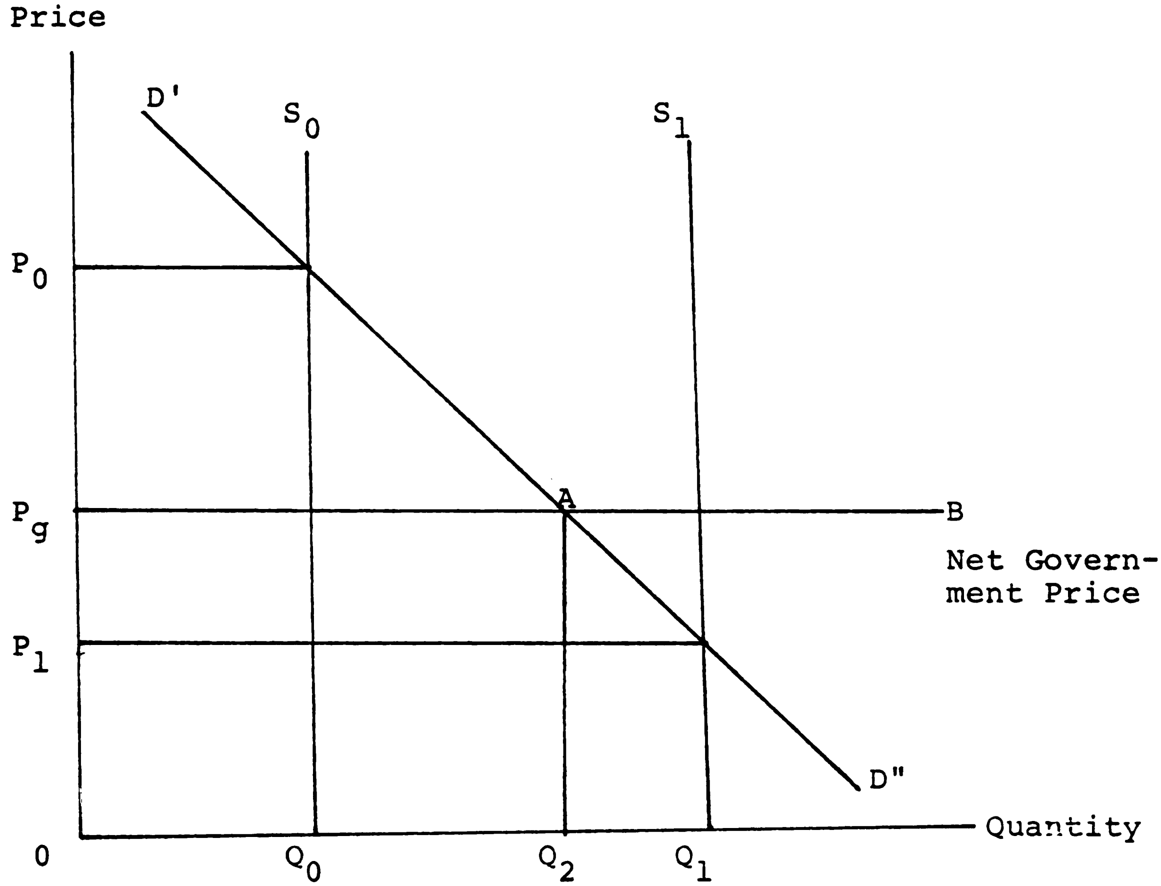

Figure 4-3. Example of Government Price Support Program

support program would be represented by D'AD". Thus when a government support program is in effect and there is a supply of S_0, the price received will be the normal market equilibrium price of P_0, and Q_0 will be removed by the commercial market at that price. The normal market equilibrium would be true for any season that the quantity available was less than Q_2. If the supply is S_1 and there is a government support program in effect, the market price will be supported at P_g and Q_2 will be taken by the commercial market. The quantity Q_1-Q_2 would be acquired by the government through the default of nonrecourse loans. Q_1 is the quantity which would be taken at P_1 if there was no government price support program. Thus when a season's supply exceeds Q_2 then a portion of the supply would be removed from the market by the Commodity Credit Corporation in order to insure the net price of P_g.

In years of large government takeovers of navy beans the market price may not equal the net support price. This is because of the mechanism of the commodity support system. In years when market price approached the net support price, producers could place all or part of their production under loan to the government through the Commodity Credit Corporation. They would then receive the net support price. Up until a date set each season by the Commodity Credit Corporation the producer had the opportunity of selling his beans commercially and repaying the government loan. The producer would do this if the market price went above the net support price. Thus even in years of high takeover, market price may be above net support level because some beans were marketed at higher prices. Once the established date is past, the government then defaults the loans and takes over ownership of the beans. If producers held some beans back from the government program, past the aforementioned date, which often happened, then they are still subject to below net support level prices. If enough are held off then the average weighted market price may be below net support price. Because season average weighted price is dependent on government price in some years and the price actually experienced was slightly above or below the support price even in large crop years, net government support price was not used as an explanatory variable separate from market price.

Population and/or consumer income are often found to affect the quantity of a commodity consumed. These factors may have their direct influence on the retail level, yet it is reasonable to assume that this influence will follow through the marketing system to the derived or producer level demand. Changes in population would be expected to cause similar directional changes in quantity disappearance. The expected sign for the income variable is not clear. Navy bean products are generally considered convenience foods, since most of the canned products are heat and serve. The argument is sometimes made that as incomes grow the increased income spent on dining away from home has become relatively more important than the increased income spent on convenience foods made of navy beans. It would seem that dining out (fast food chains, etc.) has undoubtedly affected the rate of increase in dollars spent on bean products, yet it is unclear whether an increase in income actually brings about a decrease in bean usage. Hathaway [1955] states "It is generally assumed that dry beans are a product with a negative income elasticity. However, the case for this assumption for navy beans is not entirely clear-cut. The proportion of navy bean crop that is canned is not available, but estimates for various years run from 50 to 90 percent. It is generally accepted that income elasticity of the canned product is not negative, so that income elasticity for both forms of consumption of navy beans probably approaches zero." As noted earlier, present estimates of percentage of navy beans canned is about 90 percent, thus it seems totally reasonable that the income elasticity for navy beans may be positive for the study period. Both population and income will be tried as explanatory variables in the demand function. In order to remove some of the effect of a generally increasing trend in population on the income variable, per capita disposable real income will be used as the income variable. Total population of the United States will serve as the population variable.

Economic theory generally suggests that prices of substitutes and complements affect the quantity demanded. Few, if any, complements are thought to be of much importance for navy beans. There are few good substitutes for the majority of the retail navy bean products. Some exceptions to this statement might be considered. In the dry packaged bean market consumers may make limited substitution between navy beans and other classes of dry edible beans, but this market is so small (less than 10% of domestic disappearance) that it would be of little consequence.

In the canning market, substitution is even more restricted. This is because most of the other classes of beans don't can well or with a similar appearance (cracking, splitting, mushy texture, etc.). Small white beans, which in the U.S. are grown mainly in California, are probably the only close substitute. The production of small white beans is very small relative to that of navy beans (about 6%). There seems to be a general belief in the industry that small white beans have very little effect on the domestic disappearance of navy beans. This belief is supported in the findings of Krebs [1970]. He states that, "the cross elasticity of demand (for navy beans and price of small beans) has been .03. Thus, the small white bean price has very little influence on the domestic demand for navy beans." It seems even questionable that Krebs should have included the variable at all in his domestic demand equation, since the t-statistic for the coefficient related to price of small white beans was only .029 (indicating a lack of statistical significance). It has also been argued that at times the prices and availability of fresh vegetables affects the quantity demanded. Substitution probably occurs at both the wholesale and retail levels. At the wholesale level canners sometimes switch over canning lines during periods of high fresh vegetable availability. Since the fresh vegetables are considerably more perishable than the dry beans, such a change over makes economic sense. On the retail level, consumers may also substitute fresh vegetables for canned navy bean products during periods of relatively low vegetable prices. Both the cannery substitution and the retail substitution are extremely difficult to demonstrate econometrically. These are generally short run occurrences and often only of importance in isolated geographic markets. It can also be argued that assembly line switching only temporarily affects the quantity of navy beans canned and that fresh vegetables at the retail level are not a good substitute for the convenience oriented consumer. Because of these considerations, no variables representing substitutes or complements are included in the econometric model.[2]

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[2]Canned navy beans in the forms of "pork and beans," beans in tomato sauce, baked beans, bean soup, etc. are typically considered a convenience food in the United States and Canada. The introduction of many new convenience foods into the market in recent years has caused some concern in the navy bean industry. It is generally believed that new and improved frozen convenience foods like frozen pizza, improved frozen dinners, and other specialities have begun to be substituted at an increasing rate for navy bean products in the retail market. An even more recent development, causing increased interest in development of new navy bean products is the advent and subsequent high acceptance rate by consumers of the microwave oven. The microwave oven has brought with it a whole convenience food classification of its own. This includes many frozen products. Bean products don't freeze well and few new navy bean products are seen to be coming forward in the immediate future. The effect of microwave ovens is only recent and little of the sample

It was observed from the data that domestic disappearance was considerably lower from 1952 to 1957 than in the years 1958 to 1975. The residuals from preliminary estimation also bear out this difference. Thus the economic variables presented to this point could not explain the change. No apparent explanation for this change is available. Changes in data collection and reporting procedure and changes in taste have been put forward as possible explanations. Yet, these explanations do not seem adequate in explaining the change. Another possible explanation is that acreage controls in the 50-51 season may have caused production to adjust more slowly than otherwise might have occurred (lag effects). Even this reason can only be viewed as a partial explanation. Although no clear-cut single explanation can be found, it is necessary to account for the obvious change illustrated in the data. A binary or dummy variable (Kmenta [1971]) is used, such that the variable equals zero for the years 1952 to 1957 and one for the years 1958 to 1975. The variable has the effect of shifting the constant term after 1957.

The following equation represents the variables assumed to influence domestic disappearance of navy beans.

$$DDNB_t = f(PNBALL_t, PCDI_t, POPUS_t, DUM)$$

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period reflects their existence. While these points may be important, they are not included analytically in the present study.

where:

$DDNB_t$ is the quantity of domestic disappearance of navy beans in thousands of hundredweight for the twelve month marketing period beginning on September 1.

$PNBALL_t$ is the average weighted price of navy beans in real dollars per hundredweight paid to producers in Michigan for the twelve month marketing year beginning on September 1.

$PCDI_t$ is the average per capita disposable income in real dollars for the U.S. during the period t.

$POPUS_t$ is the yearly average U.S. population in millions of people in period t.

DUM is a dummy variable which has a value of zero for the years 1952 to 1957 and one for the years 1958 to 1975.

4.4.2 Export Demand

The other part of the U.S. demand function for navy beans is the export demand. Most of the navy beans exported from the U.S. go to the United Kingdom. The United Kingdom imported 54% of the 1975 export crop. The percentage of U.S. exports going to the United Kingdom in the 1970 to 1975 period ranged from a low of 38% to a high of 75%. Most of the remaining exports of navy beans typically go to The Netherlands, Japan, West Germany, France, Italy, Australia and New Zealand. In some of the non-United Kingdom countries markets have been developed relatively more recently. Although the United Kingdom importation of U.S. navy beans has historically fluctuated somewhat, many of the less traditional markets have had the tendency of being even less stable. It should also be noted that in the 1973-74 marketing season and the 1974-75 marketing season the percentage of total U.S. exports of navy beans to the EEC (European Economic Community) was 80 and 61 respectively. Since this community is highly volatile and political decisions with respect to trade often affect more than a single U.S. export or import commodity, there appears to enter an even increased possibility of variability in the future.

Canada is the largest competitor of the U.S. navy bean industry in the world market. Under present conditions Canada produces about 20% of world production while the U.S. produces about 65%. In Canada, navy beans are produced in Ontario Province and more specifically the area of southwestern Ontario and some along the northern fringes of Lake Ontario. In the last 25 years, Canadian production of navy beans has increased steadily. During the 1967 to 1975 period, the domestic use in Canada remained relatively stable at about 500,000 hundredweight. Thus, most of the increase in production has gone into the export market. Even though Canada only produces about 30% (1970 to 1975) as many navy beans as the U.S., about 75% of its beans now go to export, while only about 20% of the U.S. beans typically go into the export market. The quantities available for export (carry-in + production - domestic use) by the two countries have been about the same over the past few years. Also, both countries traditionally export to the same market (the United Kingdom and the rest of Europe). Yet, Canada usually sells all their beans available for export before much of the U.S. export crop is sold to these countries. This is because the Canadian beans are usually priced slightly lower then the U.S. navy beans. One explanation put forward for this lower price is that the Canadian producers have lower costs per unit than their counterparts in the U.S. This theory is probably based mainly on the generally better yields realized by Canadian producers over the past few years. This explanation alone seems incomplete. A more reasonable explanation may be due to the existence and effectiveness of the Ontario Bean Producers Marketing Board. The marketing board which controls all navy beans produced in Ontario (basically all navy beans produced in Canada) has three policies (see discussion in Chapter II), which when combined, better explain the lower export price which Canadian producers are willing to take. The first is the import tariff on beans entering Canada. The second is the unwillingness of the Board to be storers of beans. The third is the fact that a pool price is received by producers. In other words, the Board prices its beans at such a price so as to move all the beans produced in any year.

Argentina and Ethopia and a few other countries produce white beans which find their way into those markets which have traditionally been supplied by the U.S. and Canada. While these countries' exports must certainly affect U.S. exports both the extent of the effect and the actual country or countries involved have changed from year to year during the last ten years. In summary, then:

1. The U.S. will be competing with more countries in the future in the traditional bean import markets.

2. Because beans produced in non-North American countries are generally of lower quality, the U.S. will have some base amount of beans it will most certainly be able to export in the near future.

3. Because many of these countries are merely experimenting in the white bean industry and because of various political uncertainties, it seems likely that the extent of competition will be highly variable in the future.

It should be evident that the U.S. export market for navy beans has been a highly volatile market in the past and that the prospects in the future point to more of the same. While the growth in Canadian production shows signs of leveling off, the prospects of other competing countries appear on the increase. The advance of competitive convenience foods and political uncertainties both internal and in various agricultural import pacts between U.S. and the EEC have led to the continuation of export demand uncertainty. The international monetary exchange rate variability coupled with the lack of good forward contracting to foreign markets has added to the problem. Finally it should be noted that the quantity exported in part depends on the size of the crop, which, as has been discussed, is also highly variable.

The nature of the export market has caused some problems in the decision process as to what variables are likely to be most important in the export demand model. As with domestic disappearance, the price paid for the beans is likely to be an important explanatory variable. The actual export price paid the shippers would be the best price to be used for this part of the model, but any estimation of such a price would be highly subjective, if at all possible. Because the weighted price received by producers (same as for domestic disappearance) is available and considerably more reliable, it will be used as an explanatory variable. The price of navy beans would be expected to have a negative relationship with quantity exported. As with the domestic disappearance, theory tells us that income and population in the importing countries should be important to the quantity of a commodity exported. Since the United Kingdom is so important in the U.S. export market, some measure of their demand should be included. Population and per capita national income of the United Kingdom will be tried as explanatory variables in the export demand model. Population and income variables from other importing countries were not used because of the small percentage of the market any other individual country makes and the high variability of the amount any of these countries might import. Again it would be expected that population of the United Kingdom and the quantity exported by the U.S. would move in like directions. The effect of changes in income in the United Kingdom on quantity exported is less obvious. It is believed by some that as income increases in the United Kingdom, more dining out is done, thus reducing the amount of navy beans consumed and as incomes decrease, less dining outside the home is done and bean consumption would increase. It seems highly likely that this does occur to some extent, although it may not be the dominant effect. Other factors, like the move to convenience foods as incomes rise, increased product acceptability, increase in food consumption in general with higher incomes, and the fact that even on a per capita basis separating the income and population effects in time series data can be difficult. Thus the sign of this independent variable is difficult to predict a priori. Other factors, which have been discussed and are likely important to the export market, such as production of competing countries other than Canada and the political policies followed by both these competitors and those of the various importing countries, have traits which make them very difficult to quantify.

Finally the navy bean situation in Canada must be a factor in the U.S. navy bean export market. Some evidence was presented earlier in this chapter of the possibility that because of the policies of the Ontario Bean Producers Marketing Board, only part of the U.S. crop available for export can be exported until all the Canadian crop is exported. Thus part of the U.S. crop is exported only due to the surplus demand remaining after the beans available for export in Canada have been sold. The economic significance of this factor year in and year out is not clear. The lack of clarity is probably at least twofold. First, is the fact that a certain quantity of U.S. beans has been exported regardless of other countries' crops, due to quality reasons. Second, is that the "surplus effect" mentioned above has been incorporated into the U.S. navy bean industry's thinking due to the marketing advantages with the United Kingdom that Canada enjoyed for most of the study period. A good argument can be made that in an econometric study of this nature a combined North American export demand function might be desirable. Difficulties arise in relation to price comparison between the U.S. and Canada brought about because of the Canadian import tariff and the aforementioned tariff advantages into the United Kingdom. The limited Canadian data available relative to that available for the U.S. also makes the direct addition of Canadian export and production factors to the export demand function impractical at this time. A simple North American export equation is presented in Appendix A.

The following equation represents the variables assumed to influence export demand for U.S. navy beans.

$$XNB_t = f(PNBALL_t, POPUK_t, PCNIUK_t)$$

where:

XNB_t is the quantity of exports of navy beans in thousands of hundredweight for the twelve month marketing period beginning on September 1.

$PNBALL_t$ is the average weighted price of navy beans in real dollars per hundredweight paid to producers in Michigan for the twelve month marketing year beginning on September 1.

$POPUK_t$ is the yearly average population of the United Kingdom in millions of people in period t.

$PCNIUK_t$ is the average per capita national income in real dollars for the United Kingdom during the period.

4.5 Complete Proposed Model

The proposed model for the supply and demand of U.S. navy beans is now complete. It consists of the following four functional equations and two identities.

Production

$$APNB_t = B_{10} + B_{11}\ PNB_{t-1} + B_{12}\ PC_{t-1} + B_{13}\ PCB_{t-1} + B_{14}\ APNB_{t-1} + U_{1t}$$

$$YAPNB_t = B_{20} + B_{21}T + B_{22}T^2 + U_{2t}$$

Supply Identity

$$QNB_t = APNB_t * YAPNB_t$$

Demand

$$DDNB_t = B_{30} + B_{31}\ PNBALL_t + B_{32}\ PCDI_t + B_{33}\ POPUS_t + B_{34} DUM + U_{3t}$$

$$XNB_t = B_{40} + B_{41}\ PNBALL_t + B_{42}\ POPUK_t + B_{43}\ PCNIUK_t + U_{4t}$$

Market Clearing Identity

$$DDNB_t = QNB_t - XNB_t - GOVNB_t + CARIN_t - CAROUT_t$$

4.6 Estimating Procedures

Estimating procedures are considered next. A linear functional form will be estimated. Since the acres planted equation and the yield equation each have only one endogenous variable, ordinary least-squares may be used as the estimating procedure. Given the assumptions that the expected value of the error term is zero, that the variance of the error term is equal and less than infinity for all terms, that the covariance between error terms is zero for any length of time between them and the covariance between the nondependent variables and the error term is zero (truly exogenous); the ordinary least-squares procedure will give best, linear, unbiased, consistent estimates of the equation coefficients. Some care must be taken when considering the acres planted equation. This equation includes the dependent variable lagged one period as an explanatory variable; thus depending on the original nature of the correlation, first order autocorrelation may be introduced. Since the procedure is simple and Hanusheh and Jackson [1977] state "... with dynamic models it may be superior not to test for serial correlation but instead to proceed as if it were present," the Cochrane-Orcutt iterative correction method will be applied to this equation.

The demand structure has two functional equations and a market clearing identity and three endogenous variables (DDNB, XNB, PNBALL). The values of the endogenous variables are determined simultaneously within the system. Ordinary least-squares cannot be used as an estimating procedure in this case. The estimates of the equation parameters would be biased using this procedure (Johnston [1972]). The equation may be estimated using one of several simultaneous estimating procedures. In order to use these procedures, each equation in the system must be just identified or over-identified according to the rank and order conditions of identifiability (Kmenta [1971]). Since each equation in the demand structure is identified or over-identified according to these conditions, one of the simultaneous procedures can be used. Two stage least-squares was selected as the simultaneous estimating method. This method was selected because among the limited information procedures, two stage least-squares estimators generally seem to be the most robust and have the least small sample bias as well as the smallest variance among consistent estimators (Johnston [1972], Hanushek and Jackson [1977]). Also important in selecting this procedure are its relative computational simplicity and cost efficiency. If the same assumptions as made for ordinary least-squares estimates are met with the exception that the covariance between explanatory dependent variables and the error terms need not be zero, then two stage least-squares estimates of the parameters have large sample properties of being asymptotic unbiased, asymptotic efficient and consistent.

4.7 Result of Econometric Estimation

As stated earlier, little empirical work has been done in estimating navy bean supply and demand. The relationships and variables presented earlier in this chapter were proposed as those most likely to be important to the structural relationship of the model and of greatest value in explaining the endogenous variables. The estimated equations in Table 4-3 are the result of the initial proposed structure and an iterative process of computation and specification decisions. The final specification of the model was seen as most desirable with respect to statistical significance and economic theory. The intermediary decisions made in the estimating procedure are commented on as the estimation results of each structural equation are discussed.

Reported in Table 4-3 are the endogenous variables, the means of the endogenous variables and the standard error of the regression. The explanatory variables and their estimated coefficients are also presented. The standard

Table 4-3. Results of Econometric Estimation

Endogenous Variable (Mean) [σ of Regression]	Explanatory Variables and Coefficients (Standard Errors) [t-statistic]	$\bar{R}^2$	Durbin-Watson Statistic	F-Stat.
$APNB_t$	$= 424.16 + 8.82\ PNB_{t-1} - 117.61\ PC_{t-1} + 0.33\ APNB_{t-1} + U_{1t}$	.81	1.26	33.7
(511.83)	(66.93) (1.86) (16.82) (0.11)		(Durbin-h)	
[26.64]	[6.34] [4.74] [6.99] [2.95]			
$YAPNB_t$	$= 688.25 + 66.09T - 2.29T^2 + U_{2t}$			
(1054.42)	(133.10) (22.51) (0.81)	.23	1.85	4.3
[170.19]	[5.17] [2.94] [2.81]			
$DDNB_t$	$= 1742.14 - 160.72\ PNBALL_t + 1.22\ PCDI_t + 648.53\ DUM + U_{3t}$			
(3828.32)	(727.02) (57.94) (0.47) (380.40)	.55	1.90	10.6
[564.95]	[2.40] [2.77] [2.58] [1.71]			
XNB_t	$= -9243.79 - 127.97\ PNBALL_t + 213.92\ POPUK + U_{4t}$			
(1102.83)	(2696.74) (35.29) (51.69)	.39	2.02	15.8
[453.51]	[3.43] [3.63] [4.14]			

APNB - Acres planted to navy beans
PNB - 8 month weighted price navy beans
PC - 7 month weighted price corn
YAPNB - Yield on acreage planted to navy beans
T - Time or trend variable
DDNB - Domestic disappearance of navy beans
PNBALL - 12 month weighted price navy beans
PCDI - Per capita disposable income (U.S.)
DUM - Binary variable
XNB - Exports of navy beans
POPUK - Population of United Kingdom

errors of each coefficient and the related t-statistic are located directly under each estimated parameter. The t-statistic is the ratio of the estimated parameter to its standard error. For the equations in this study a t-statistic of 2.1 or greater would indicate a significance level of .05 in the case of a two tailed test or one can be at least 95% confident that the null hypothesis of a parameter equaling zero can be correctly rejected. It should be noted that when simultaneous systems are estimated (demand side), a t-distribution is not necessarily appropriate. Kmenta [1971] states: "In small samples the desired acceptance regions or confidence intervals are usually determined by reference to the tabulated t-distribution. This procedure is clearly not exactly valid, since the test statistic does not have a t-distribution. The question, then, is whether the t-distribution can serve as a tolerable approximation of the true distribution so that the results of the tests and of interval estimation are not seriously distorted. The available Monte Carlo evidence suggests that the distortion is usually reasonably small." Thus it will be assumed for purposes of this study that the use of t-ratios would lead to reasonably reliable inferences. Included in the table are values for $\bar{R}^2$, the Durbin-Watson test and the F-statistic. The $\bar{R}^2$ is a measure of the proportion of variation in the normalized endogenous variable explained by the independent variables in the equation and adjusted for degrees of freedom. Because two stage least squares procedure was used for the domestic disappearance and export demand equations, $\bar{R}^2$ cannot be strictly interpreted as stated above. If proper discretion is used, $\bar{R}^2$ can be used as a measure of the goodness of fit of the equation. Due to the method of calculating the structural coefficients, there is no guarantee that the two stage least squares $\bar{R}^2$ value has a lower bound of zero. The Durbin-Watson test is a test for autocorrelation or the absence of autocorrelation. The Durbin-Watson test is not applicable to the acres planted equation because of the lagged dependent variable, but the equation in Table 4-3 has been corrected for autocorrelation and the Durbin-h statistic is reported. The Durbin-h statistic is applicable when there is a lagged dependent variable. The h statistic can be tested as a standard normal deviate.

The F-statistic is used to test the hypothesis that all the parameters except the constant term are jointly equal to zero. If one rejects this hypothesis, it basically means that at least one parameter is different from zero at the selected significance level or that one would reject the naive model of no systematic explanation for the endogenous variable (null hypothesis) in favor of the hypothesized model. That hypothesis would be rejected in all the equations of the model at the .95 confidence level or higher.

In the next section of this chapter an analysis and summary will be presented for each estimated equation in the economic model. The iterative decision process linking the proposed model specification and the final estimated version will also be briefly discussed in each section.

4.7.1 Acres Planted

In the acres planted equation, the estimated relationship is

$$APNB_t = 424.16 + 8.823\ PNB_{t-1} - 117.606\ PC_{t-1} + 0.331\ APNB_{t-1} + U_{1t}$$

The signs of the parameters of the explanatory variables are as expected. An increase in the price of navy beans of one dollar in the preceding period, typically is associated with an 8823 acre increase in the acres planted in the next period. Or, a one percent change in the price of navy beans implies a 15 percent change in the number of acres planted (price elasticity of .15) in a like direction (holding other things constant). Although the response in acres planted to price changes seems low, it is important to realize that this is a short run elasticity. The above stated price elasticity of .15 is really only reflective of the short run adjustment. The long run or total adjustment to a permanent shift (everything else held constant) in price can also be calculated but due to the structure of the equations some difficulty arises. Because lagged own price, lagged acreage and lagged corn price appear in the equation, two effects discussed earlier play a role in the long run elasticity determination. Both the coefficient of expectations and the coefficient of adjustment are involved; if one or the other were involved then little problem would occur. Because these effects enter the equation symmetrically it is difficult to separate them. Since the price elasticity for acreage is not important to the functioning of the stocks model, no attempt was made to distinguish these effects. An iterative procedure developed by Nerlove [1958] can be used to separate the effects and thus estimate long run price elasticity. It was observed that the price coefficient (elasticity) was robust with respect to different specifications. In an earlier econometric study, Krebs [1970] found the short run elasticity of navy bean acreage planted with respect to the previous period's navy bean price to be .28.

Because of the lagged nature of the acres planted equation, it seemed reasonable that nonlinear lag models might more accurately represent what was occurring. In such models, prices from more than one lagged period could be allowed to be weighted considerably less than those of the most recent lag period, yet still could be statistically significant. Thus preliminary tests of the usefulness of such lag structures were attempted. (For typical testing procedure see Johnston [1972]). The tests indicated that response is most important in the preceding period and that other lagged periods had little effect even in nonlinear models.

In much of the navy bean production area, corn is a competitor for the land. Hence, results indicated a negative relationship between the price of corn in the previous period and the acres planted to navy beans in the next period. A ten cent increase in the price of corn would typically cause a 11,800 acre decrease in navy beans planted the next season. Thus the short run elasticity of the acres planted to navy beans with respect to last season's corn price is estimated at -.29. Krebs' [1970] estimate for the short run elasticity was -.44. In a study on all dry beans in 1967, Vandenborre [1967] found the short run elasticity of dry bean acreage planted with respect to last year's corn price to be -.34. What is important to note is that navy bean acreage is responsive to changes in the price of corn. One might expect this response to increase in the future as more good short season varieties of corn come to the market, helping raise corn yields in the "Thumb" area of Michigan. As mentioned earlier, soybeans have probably become a competitor for the land with navy beans and corn in the past few years, yet the inclusion of a soybean price variable proved to have parameters not statistically different from zero for the study period. There also was some question as to whether corn price from more than one lagged season had a significant effect on acres planted in the present season. This really would imply that the adjustment or price expectation horizon was longer than two periods due to the immobility to change factors of production completely or because the price change was not yet fully viewed as permanent. Statistical results on various attempts at lags for corn price of more than one period showed that such a lag effect is not statistically significant.

The estimated equation indicates that acreage planted to navy beans in the present season is positively related to acreage planted to navy beans in the previous season. This would appear to represent the expected limitations to the complete adjustment to a desired level of planting discussed earlier. Such limitations, due to the inability to change, cost of changing or lack of adequate knowledge, demonstrate that if a certain acreage was planted last season at least some percentage of those acres will be planted again this season.

It was stated earlier that price of other classes of dry beans in Michigan was suspected of being important to the acres of navy beans planted. The economic variable of the previous season's composite price for these classes was not statistically significant (t-statistic of 0.4), the resulting equation with price of colored beans lagged one period (PCB_{t-1}) was as follows.

$$APNB_t = 368.2 + 8.51\ PNB_{t-1} - 133.5\ PC_{t-1}$$
$$+ 0.38\ APNB_{t-1} + 1.6\ PCB_{t-1}$$

There are probably many reasons for the lack of significance. One is that those areas which grow the other classes are usually the fringe counties, such that only in the fringe of the navy bean producing area are other classes likely to be competitive for the land. A second reason is that the various colored bean markets in Michigan are "thin" markets. Thin markets are those markets where only a small amount of a commodity is produced. In such a marketing situation, small increases in acreage are likely to have a large depressing effect on prices, thus this may cause producers to refrain from much substitution.

It appears that changes in own price and changes in price of alternative crops have limited influence on the acres planted. This is also reflected in the constant term which is about 77% of the mean value of the endogenous variable. Several reasons for this result are possible. The first may be the government price support program which for many years during the study period set an effective floor price. A floor price would tend to help limit fluctuations in acres planted. Producer specialization due to preference, the lack of good short season corn varieties or rotational and diversification requirements, may have created a built in base acreage for navy beans which is slow to react to other changes. As agricultural traditions, corn and soybean seed varieties and navy bean markets change we may see a greater willingness of navy bean producers to react to price changes.

The equation reported (Table 4-3) was corrected for serial correlation. This was done because use of a lagged dependent variable may introduce first order serial correlation (see earlier discussion). The Cochrane-Orcutt iterative correction procedure was used. There was very little change in the parameters from the original (below) to the corrected equation.

$$APNB_t = 380.04 + 9.00\ PNB_{t-1} - 112.29\ PC_{t-1}$$

$$+ 0.39\ APNB_{t-1} + U_{1t}$$

Rho (estimate of autocorrelation) was .218 with a t-statistic of 1.09. The elasticity of acres planted with respect to past seasons own price is still .15.

4.7.2 Yield

The other equation concerned with U.S. production is that of yield on acres planted. The trend effects demonstrated by the yield data are presented in the equation:

$$YAPNB_t = 688.25 + 66.09T - 2.29T^2 + U_{2t}$$

As expected, powers of time greater than the second power were not statistically significant. As presented earlier, only time was used in order to capture apparent trends in the data, because of the lack of measurable explanatory variables. Although the use of these trend factors did improve the fit over a simple mean (see F-statistic), the $\bar{R}^2$ was very low at .23, as was expected. What is important, i.e., taking the trend factors into consideration for the carry-over stocks model, was accomplished by this naive model. When making predictions of future yields, extreme care should be made in the use of such an equation. Limiting the equation to the second power explicitly assumes that yield will continue in a downward trend into the future. Such an assumption is probably incorrect and adjustments to future yields would have to be made when using a similar trend model for forecast.

4.7.3 Domestic Disappearance

The coefficients of the explanatory variables in the estimated equation for domestic disappearance of navy beans had signs consistent with expectations. In the equation

$$DDNB_t = 1742.14 - 160.72\ PNBALL_t + 1.22\ PCDI_t + 648.53\ DUM + U_{3t}$$

the price of navy beans was found to be negatively related to the quantity of domestic disappearance. The domestic price elasticity of demand for navy beans was estimated to be -.37 for the study period. This price elasticity would seem reasonable for an agricultural food commodity at the derived demand level. Empirical studies indicate that the aggregate farm-level elasticity of demand for all food in the United States is less than -0.2 and is probably closer to -0.1 (Tomek and Robison [1972]). It must be remembered that elasticity estimates are influenced by the degree of product aggregation. The more products are combined, the fewer the number of substitutes and therefore the less elastic (more inelastic) demand is likely to be. Thus, it would be expected that the estimates of price elasticity of demand for all food would be more inelastic than that of navy beans. Since there are few if any substitutes for navy beans in the canning industry, it is to be expected that the price elasticity would be relatively inelastic.

There had been some thought in the industry that high prices one year would have an adverse effect on demand for a few seasons into the future. Such an effect seemed possible especially in the export market where canners and consumers might have made adjustments to other food varieties and there would be some lag time required to respond to changes from the higher price levels. Variables for lagged own price (one and two periods) were added to the demand functions (domestic and export). Resultant coefficients on the lagged variables were found to be not statistically different from zero. It was therefore concluded that at times there may be some longer run price effect, but there was no apparent systematic statistical relationship over the study period.

Per capita disposable income is estimated to have a positive relationship with domestic disappearance. As mentioned earlier, an a priori judgment as to what the sign of this variable ought to be was extremely difficult. It should be noted that in the final equation a population variable is not included. It was discovered in the intermediary steps that both population and income variables had about the same effect (see Appendix A for equation with both included). This is not unreasonable because both have generally been increasing with time. The correlation coefficient between the two variables is 0.97. Because of this, only one of the two variables was used and per capita disposable income was chosen because it contributed slightly more to the overall fit. Because of this decision there was some concern that the positive sign for income may be due to the overall effect of time (trend due to changes in taste, marketing or acceptance). When time was added as a variable to the model it seemed that some purely trend effect may be included in the income variable, but what is important is that the sign on the income variable was still positive. Because of the lower level of significance for the time and income variables when both were included, it was decided to use only the income variable and realize that in doing so care must be taken in interpreting the income variable. The income elasticity is estimated to be .79, but to place considerable importance on the magnitude would be misleading since the variable is not likely structural, rather the fact that the income elasticity turned out to be positive is what is important.

The coefficient for the dummy variable is 648.53. This means that for the period of 1957 to 1975, the constant term is increased by 648.53 thousand hundredweight. This result was expected after preliminary inspection of the data. The possible reasons for the need of this variable were presented previously. What this variable does is provide the ability to represent a systematic change in disappearance which can at this point only be done with a binary variable.

4.7.4 Export Demand

The final equation, export demand for U.S. navy beans is as follows:

$$XNB_t = -9243.79 - 127.97\ PNBALL_t + 213.92\ POPUK + U_{4t}$$

As expected the price variable took on a negative sign. The estimated price elasticity of exports is -1.03. Export elasticities of this magnitude for agricultural commodities are not uncommon. Theory suggests that in almost all cases export elasticities would be more elastic than domestic elasticities for the same commodity. The income variable was deleted from the equation because when income and population variables were included, both had positive signs, but each was statistically not significant. This probably occurred because of the high correlation between the two variables (.96). Thus only one, population of United Kingdom, was used. It should be noted that in doing so, it is likely that the variable also had some of the income effect included. Population was chosen because it was the better of the two in improving goodness of fit for both estimated equations in the simultaneous system.

4.8 Summary

In conclusion, the acres planted equation and the yield equations on the supply side turned out about as expected. Although the yield equation demonstrated a low $\bar{R}^2$

it was important that the trends be taken into consideration for use in the carryover stocks model. Explanatory variables used in all the equations had coefficients statistically different from zero at the .05 significance level or lower. (One exception was DUM in the Domestic Disappearance equation, its coefficient was statistically significant at the .10 level.) Although the coefficients for the economic variables in the domestic and export demand equations were significant, the variables only explain about half of the variation of the dependent variable in each equation. It thus seems that either these variables exhibit a highly unsystematic nature or other factors are relevant to the demand schedules. Some such factors were discussed earlier and it was decided that problems of measurement and reliability made them impossible to be entered at this time. The equations were developed to facilitate the functioning of the stocks model. Due to the addition of stochastic capabilities for demand (stochastic supply capabilities already existed) to the model, the explanatory level is not of critical importance.

CHAPTER 5

The Optimal Carryover Model Results

5.1 Introduction

This chapter presents the results of the optimal carryover model. As described in Chapter three, the results take the form of optimal rules. A rule consists of a supply-carryover relationship for a set of specific conditions. The important conditions which must be set prior to rule determination are (see Chapter three for description):

1. Cost of carrying over navy beans.
2. A probability distribution of production.
3. A marginal value function.
4. A discount factor.

More specifically, the conditions manifest themselves in the computer program in the form of the following required input data.

1. A marginal cost of carryover function.
2. A set of production quantities and related probabilities.
3. An expected value for production.
4. An intercept for the demand function.
5. A slope for the demand function.
6. A discount factor.
7. An initial set of carryover quantities.

As discussed in Chapter three, it is not always reasonable to assume one set of conditions for all circumstances. It is thus a good idea to test how sensitive the carryover rule is to certain changes in the assumptions. The following sections present and discuss the specific assumptions.

5.2 Specific Assumptions as to Conditions

Since cost of carryover is a function of final selling price as well as number of months in storage, this originally presented some problem. The problem concerned what to use for the cost function. One possibility was to put all the calculations (functions and data) on a percentage of normal (expected value) basis. All relevant calculations would have to be algebraically transformed to a percentage basis. With this approach, the cost function could be expressed in terms of percentage of carryover (which in this case amounts to the same as percentage of expected price). This alternative, although slightly inconvenient due to the algebraic manipulation, made the handling of the cost function much simpler.

If, for example, the non-interest cost of storage is one percent per month multiplied by the sale price, as typically quoted by shippers, then the twelve month storage cost could be expressed as:

12 months * 1%/month * quantity carried = total cost of carryover, or

12% = marginal cost of carryover

This method is also convenient in that the function can be changed easily. If it is believed that a significant amount of on-farm storage is available at a lower cost, say 0.5%/ month (due to handling and damage), then the cost function could be easily adjusted to the following:

12 months * 0.5%/month * Quantity carried = Total cost of carryover, or

6% = marginal cost of carryover.

Obviously other more sophisticated functions could be employed if knowledge of the system or other need so warrants. One such need might be evident if working stocks or inventories were found to be necessary for the efficient functioning of the navy bean marketing system.

As stated in Chapter three, a range of feasible marginal costs will be investigated. For the purposes of this study, 1.33% per month will be considered the upper limit for non-interest cost. The lower limit will be set at 0.5% per month. The upper bound might be illustrative of a high charge for beans stored at the elevator but owned by the producer. The latter figure indicates a situation where a majority of the stored raw product was held on farm in already existing storage facilities. Thus the upper and lower bounds on marginal cost would be set at sixteen and six percent respectively. The intermediate marginal cost possibilities of nine percent and twelve percent will also be examined in the analysis. The nine percent figure might be looked upon as a "middle of the road" or most likely estimate of weighted marginal cost. This would be indicative of a situation where both on-farm and off-farm storage of navy beans existed. This situation is typical of practices in Michigan bean production areas.

5.2.1 Production Quantities and Related Probabilities

Econometric functions for both yield and acreage planted were derived in Chapter four. In order to get quantity produced, yield must be multiplied by acres planted. Thus the probability distribution of quantity produced is a joint distribution based on the non linear (multiplicative) combination of the distributions of the error terms of the yield and acres planted equations (see RAO [1973]). This joint distribution has the large sample property of being normal if the original distributions are normal. Due to the assumptions about the properties of the error terms in least squares estimation, the distributions for both equations are assumed to be normal.

Given that the joint distribution is normal, then only the first and second moments are needed to completely describe the distribution. Only the expected value and the variance need be estimated. The description of the calculation for expected value is in the next section. The estimated variance for the joint distribution is 1,188,100 (standard deviation = 1,090 (1,000's cwt)).

One problem occurs with the large sample properties in the case of yield. Because of the trend variable, it cannot be assumed that the variance will converge to a finite limit. Yet given the equation specification, this technique for establishing the joint distribution is the best approximation. It would appear that the longer the trend, the greater the distortion. A simple test was done on the resultant variance to check possible distortion. The outcome gave added confidence in the approximation method. The test was to check how many of the twenty-five observations fell within a range of plus or minus two standard deviations about the expected value. Of the twenty-five observations, twenty-four (96%) fell within the range. Also, seventeen of the twenty-five (68%) observations fell within a range of plus or minus one standard deviation about the mean.

Next a joint distribution based on the above estimated distribution and the distribution of the error terms from the total demand function must be generated. This step is necessary due to the addition of a stochastic demand function into the model (see Chapter 3, Section 5). Once the variance for the joint distribution based on the linear combination of domestic and export demand functions (each distribution again assumed normal) was established, linear combination methods could be used to estimate the variance of the production-demand joint distribution. The resultant variance, with the expected production, could be used with a set of standard normal tables to get a distribution to input into the computer program. The variance for the production-demand joint distribution is estimated to be 1,795,600 (standard deviation = 1,340 (1000's cwt)).

5.2.2 Calculation of Expected Production

The expected value of production must be calculated in order to complete the distribution. Expected production (yield per acre planted * acres planted) for 1976 will be used as the mean value for the distribution. The year 1976 was chosen for some obvious reasons. It is the first year outside the range of the data used in econometric estimation. The further into the future the estimate is made the poorer the estimate is likely to be. This problem can be handled by periodically updating the econometric estimates. Calculations based on 1976 are also appropriate because it is the first year for which the optimal carryover model can be tested. Thus the values for the explanatory variables for 1976 are used both in mean estimation as well as in the nonlinear variance estimation for production mentioned in the previous section. Estimation of the expected value is not a difficult matter, because all the explanatory variables for the yield and acres planted equations are known with certainty. Simply by substituting the values for the explanatory variables, the expected production for 1976 can be estimated. The estimate of that production was calculated to be 4,923 (1,000's of cwt).

Using the standard normal tables, a distribution of production (x+u) ∿ N (4923, 1340) can now be specified. This distribution can then be input into the computer program. A typical distribution might be the following:

Table 5-1. Production Possibilities and Related Probability

Production (x+u)		Probability of Occurrence
1000's CWT	Percentage of Expected	
1573	31.95	.009
2243	45.56	.028
2913	59.17	.066
3583	72.78	.121
4253	86.39	.176
4923	100.00	.200
5593	113.61	.176
6263	127.22	.121
6933	140.83	.066
7603	154.44	.028
8273	168.05	.009

5.2.3 Discount Factor

The discount factor is also a data input requirement of the program. As stated in Chapter three, it is difficult to establish a single social discount factor universally acceptable. Thus, it was decided that a realistic range would be used. Discount factors of 0.9524, 0.9090, 0.8696, and 0.8333 (based on the corresponding interest rates of 5%, 10%, 15% and 20%) will be attempted to test the sensitivity of the carryover rule to changes in the assumptions about this precondition.

5.2.4 Intercept and Slope of the Total Demand Function

The intercept and slope of the total demand function are necessary inputs to the model. The demand function must be in the following general form:

$$\text{Price} = \alpha + \beta * \text{Quantity}$$

Where:

α is the intercept

β is the slope

To derive such a structure from the econometrically estimated equations, it is necessary to follow a three stage process.

The first stage involves the aggregation of the domestic and export demand functions. The resultant total demand function then must be algebraically manipulated into price dependent form. The following is the result of stage one.

$$(1) \quad \text{PNBALL} = -7501.65 - .003486\ (\text{DDNB}+\text{XNB}) + 0.75\ \text{POPUK} + .00423\ \text{PCDI} + 2.25\ \text{DUM}$$

where:

PNBALL = Price of navy beans

POPUK = Population of the United Kingdom

PCDI = Per capita disposable income, U.S.

DDNB = Domestic disappearance for navy beans

XNB = Exports of navy beans

DUM = A binary variable

A check on the aggregation might be to look at the price elasticity of the total demand function. The estimated price elasticity is -.508. This estimate is within expectations given the elasticities of the individual demand functions and the nature of the commodity under consideration.

The second stage involves the incorporation of the effects of the independent variables into the constant term. This is done by substituting the values for these variables into the equation. Since 1976 values were used in production estimation, they will likewise be used here. All the independent variables are either known or good projections can be acquired (as in the case of population and income) affecting a fairly simple estimation. The following equation is the result of the substitution:

(2) PNBALL = 31.39 - .003486 (DDNB + XNB)

The third stage involves the algebraic transformation of equation (2) into a percentage form. The change is necessary to keep the units in accord with the cost function. The transformed equation is:

(3) PNBALL = 220 - 1.20 (DDNB + XNB)

220 and 1.2 can then be used as input data to the computer program for the intercept and slope respectively.

Allowing aggregate elasticities to differ somewhat from the estimated value of -.508 is an interesting exercise. Alternative elasticities of -.60 and -.40 will be examined to better understand the sensitivity of the optimal rule to variations in elasticity. The results of using these alternatives are presented in Sections 5.3 and 5.4.

5.2.5 Set of Carryover Quantities

It is necessary to input an initial set of carryover quantities to start the dynamic programming process. In general, the range of the carryover quantity set depends on several factors.

1. The final distribution of carryover quantities generated by the rule itself.
2. The non-negativity requirement.
3. The specific crop under consideration.
4. The initial level of supply (if any).
5. The nature of the cost function.
6. The nature of the demand function.

There is also a question as to the size of the intervals between carryover quantities. Since interpolation between points is used, the degree of accuracy can be affected. Generally it is best to use smaller intervals over the most relevant regions and larger outside these areas (relevancy here is a function of typical production, magnitude of the variance and the shape of the cost function). Both the range and interval size therefore are selected through an iterative process. Some initial set is used and then adjusted when the preliminary output is analyzed. An example of a set of carryover quantities for navy beans follows:

Table 5-2 Set of Carryover Quantities

Percentage of Expected Production		
0.05	0.80	5.00
0.10	1.00	10.00
0.30	2.00	20.00
0.50	3.00	300.00

These quantities can be found on the printout in Appendix B labeled "carryover vector."

Once the values for the required input data have been determined, then the computer program can be run. A rule was computed for each possible combination of assumptions as to the values of the predetermined conditions. The results are presented in the following section.

5.3 Estimated Optimal Carryover Rules

The results presented are optimal storage rules for navy beans, under alternative assumptions about the conditions. In Table 5-3 the optimal rule for each set of assumptions is enumerated. For subsequent discussion, each set of assumptions and the corresponding rule are numbered. In the table the production and carryover figures have been transformed from percentages back to physical quantities. No carryover is ever recommended for production of less than

Table 5-3. Estimated Optimal Carryover Rules Under Various Assumptions

	Rule Number															
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	#16
Conditions:																
Elasticity	-.508	-.508	-.508	-.508	-.508	-.508	-.508	-.508	-.508	-.508	-.508	-.508	-.40	-.60	-.508	-.508
Cost of Storage[1]	6	6	6	9	9	9	12	12	12	16	16	16	9	9	9	9
Discount Factor	.9090	.8696	.833	.9090	.8696	.8333	.9090	.8696	.8333	.9090	.8696	.8333	.8696	.8696	.8696	.8696
Std. Deviation (x+u)[2]	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,090	1,590
Production Equals[2]	OPTIMAL CARRYOVER															
<4923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4923 (Expected Value)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0	0	47	0	0	0
5500	101	13	0	28	0	0	0	0	0	0	0	0	214	0	0	0
5750	261	135	11	166	39	0	58	0	0	0	0	0	369	0	22	66
6000	399	273	156	299	170	72	202	90	0	87	15	0	541	0	140	219
6250	561	426	310	450	325	217	352	231	138	228	123	25	704	79	281	379
6500	719	578	460	603	473	364	497	379	281	369	261	167	866	217	428	522
6750	876	738	610	761	623	514	647	527	423	512	406	310	1,044	354	574	677
7000	1,058	901	778	923	785	671	805	679	574	663	555	458	1,260	501	729	832
7250	1,265	1,083	923	1,110	935	822	953	829	724	807	698	600	1,452	645	879	1,004
7500	1,472	1,294	1,123	1,314	1,132	983	1,157	990	886	962	849	753	1,708	793	1,063	1,196

[1] Units are %.
[2] Units are 1000's cwt.

the expected value (see Table 5-3). Since cost is positive, and the interest rate is positive, this result is as expected. All carryover levels shown here are quantities in excess of minimum working stocks. Minimum working stocks are the aggregate quantity of beans which farmers, shippers and canners hold in inventory to facilitate efficient day-to-day market operations, no matter how small the total available supply. If some minimum level of working stocks or pipeline stocks is seen as necessary for the efficient functioning of the market, then it ought to be included either directly (added in when carryover rule < minimum level working stock) or as an adjustment in the cost function.

In order to better understand the results, an example will be discussed. The example will be based on rule #5. For this rule the following assumptions about the conditions were made:

Demand price elasticity = -.508

Marginal Cost of Storage = 9%

Discount Factor = .8696

Of the various assumption combinations examined, that for rule #5 most closely fits the conditions experienced in the 1976-77 marketing season. As discussed in Section 5.2.1, nine percent is a reasonable estimate of a weighted average marginal cost of storage. A discount rate based on a fifteen percent interest rate is also not unreasonable. Given the economic scenario of that period, most estimates of the interest rate ought to fall between ten and fifteen percent.

Much of the difference could be attributed to the perceived level of risk. The elasticity of -.508 was selected because this was the econometrically estimated aggregate elasticity. Thus given these assumptions about the conditions, an optimal rule can be reviewed and deviations from these assumptions discussed.

Under the assumptions of rule #5, no carryover is recommended until production is over 5,500,000 cwt. If production should be high for 1976, let's say 6,000,000 cwt. or about one standard deviation greater than the expected production, then the optimal carryover would be 170,000 cwt. If production should be exceptionally good and 7,000,000 cwt. or about 1.9 standard deviations greater than expected production is produced, then optimal carryover would be 775,000 cwt. How do these figures compare to recent actual carryover quantities? In the ten year period, 1966-1976, actual carryover ranged from a low of 100,000 cwt. to a high of 500,000 cwt. Over the same time period, production ranged from 4,080,000 cwt. to 7,290,000 cwt.

How do we interpret the magnitude of the rule? The rule is that result which maximizes over time the net area under the demand function (net refers to after cost). This area represents the return to society in general of producing and consuming navy beans. Thus if production were 6,500,000 cwt., then optimal carryover would be about 473,000 cwt. This is not the optimum for producers alone, nor is it the optimum for consumers alone. Such rules could be estimated if the algorythm were rewritten with an objective function to maximize producer or consumer return. Because the rule maximizes net return to society, the actual carryover experienced may not correspond well with the suggested optimum. The rule itself says little as to who should incur the cost of storage. It is essential that it be understood that this is a macro optimum. The rule probably says little as to what an individual producer or shipper ought to do. The rule is prescriptive only in that it provides a standard with which to compare actual storage with a social optimum.

Another important consideration is that of "what happens when the assumptions as to the conditions are modified?" Simply by observing Table 5-3 some of the effects on the optimal rules become evident. The next sections explore changes in the individual assumptions.

5.4 Sensitivity to Change in Assumptions

The final sections of this chapter are concerned with the sensitivity of the optimal carryover rule with respect to changes in: interest rate, marginal cost, elasticity and variance of the distribution. Figures 5-1 through 5-4 each display the effects of changing the assumptions about just one of the conditions. The implications of the changes follow.

5.4.1 Changing the Interest Rate

As observed in Figure 5-1, reducing the discount rate (increasing interest rate) causes optimal carryover at any

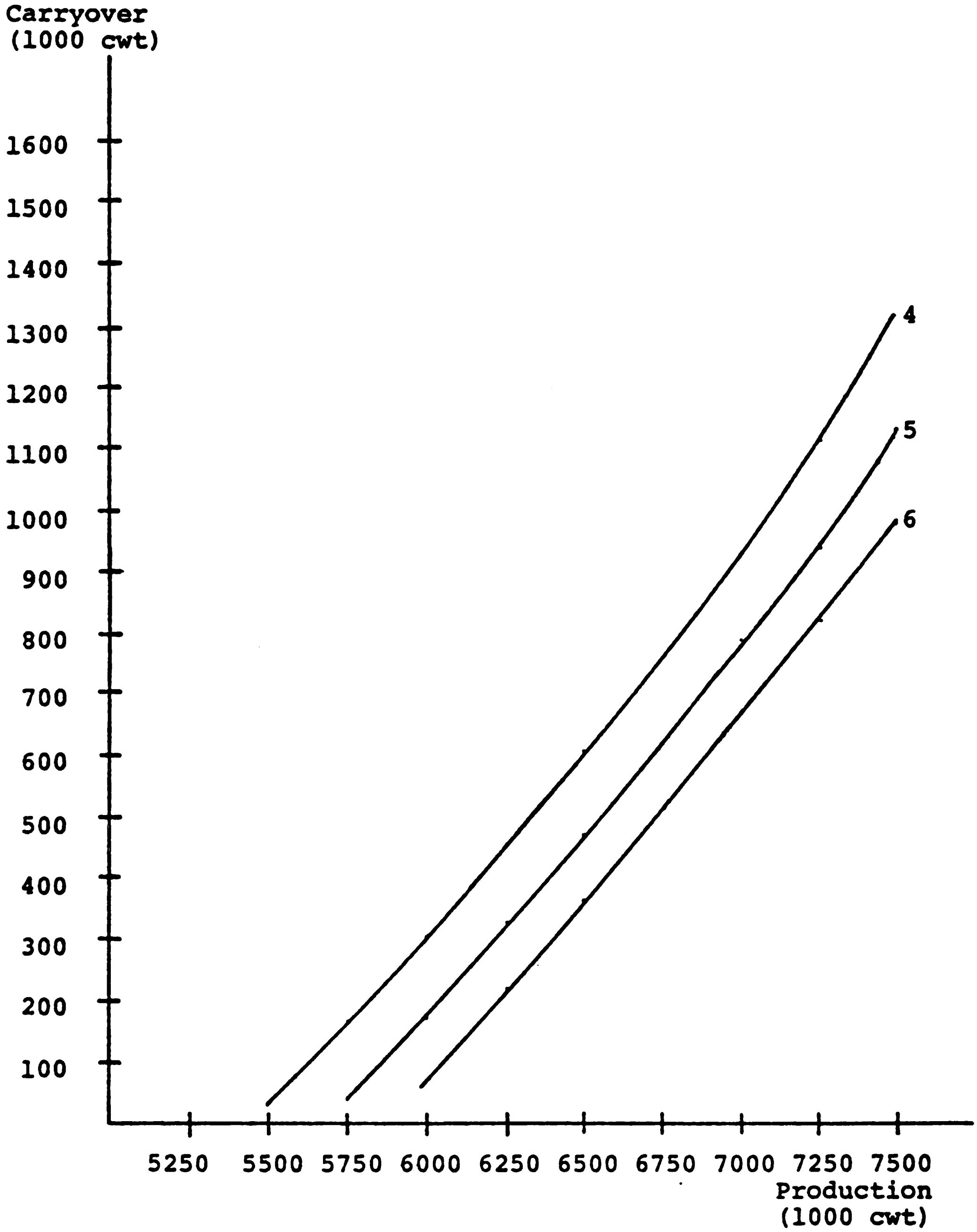

Figure 5-1. Optimal Carryover Rule Comparison Under Differing Discount Rate Assumptions

given level of production to be less (except carryover of zero). For example, when changing from rule #5 to rule #6, at the production level of 6,500,000 cwt., the optimal carryover goes from 473,000 cwt. to 364,000 cwt. Thus a change from a discount rate based on a 15% interest rate to one based on a 20% interest rate reduced optimal carryover at 6,500,000 cwt. by about 90,000 cwt. The optimal rule is fairly sensitive to changes in the assumption about the interest rate. It also appears that the magnitude of the interest rate is inversely related to the magnitude of the sensitivity to a change.

5.4.2 Changing the Marginal Cost

In the analysis, the marginal cost of storage was allowed to vary from a low of 6% per year to a high of 16% per year. Figure 5-2 represents a situation where only the assumption about marginal cost is allowed to vary. As expected, the optimal carryover at any given production level is inversely related to the level of marginal cost. If production were 6,500,000 cwt., then optimal carryover would be reduced about 100,000 cwt. for each increase of three percentage points in the marginal cost. If marginal cost goes from 9% to 12% (rule #5 to rule #8), then optimal carryover declines from 473,000 cwt. to 379,000 cwt. Thus it is evident that the optimal rule is sensitive to the assumption about marginal cost.

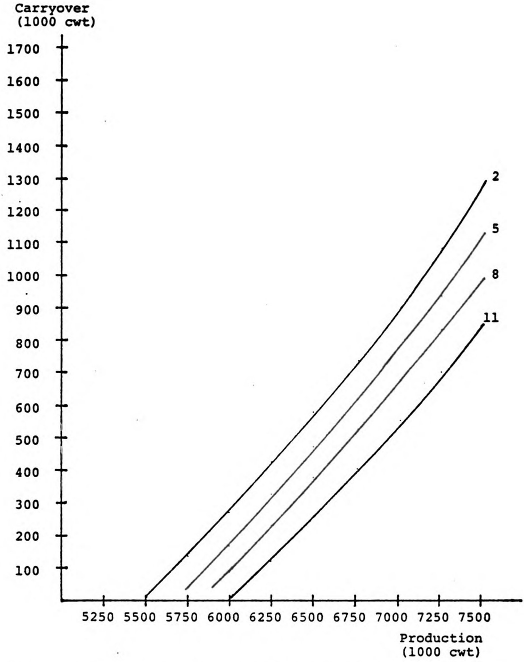

Figure 5.2. Optimal Carryover Rule Comparison Under Differing Marginal Cost Assumptions

5.4.3 Changing Demand Price Elasticity

The aggregate demand price elasticity was econometrically estimated to be -.508. It seemed useful to test the optimal rule response to changes in the assumption. Optimal rules were obtained for elasticities of -.40 and -.60. These approximately represented the estimated elasticity ± 0.1. The direction of the change in optimal level to a change in elasticity is as expected (see Figure 5-3). As the elasticity becomes more negative (more elastic) the optimal carryover decreases. The magnitude of the change is quite dramatic. Again consider the production level of 6,500,000 cwt. At this level the optimal carryover for an elasticity of -.40 is 866,000 cwt. (rule #13) and the carryover drops to 473,000 cwt. for an elasticity of -.508 (rule #5) and further falls to 217,000 cwt. when the elasticity is set at -.60 (rule #14). Because of the magnitude of the sensitivity of the rule to changes in assumptions about demand price elasticity, it is important to carefully estimate the elasticity and update that estimate regularly.

5.4.4 Changing the Variance of the Distribution

All the rules except two (#15, #16) were based on a standard deviation for the (X+U) distribution of 1,340,000 cwt. A standard deviation of 1,090,000 cwt. was used for derivation of rule #15. This standard deviation is indicative of a situation where no demand uncertainty exists (variance U=0). A standard deviation of 1,590,000 cwt. was used for

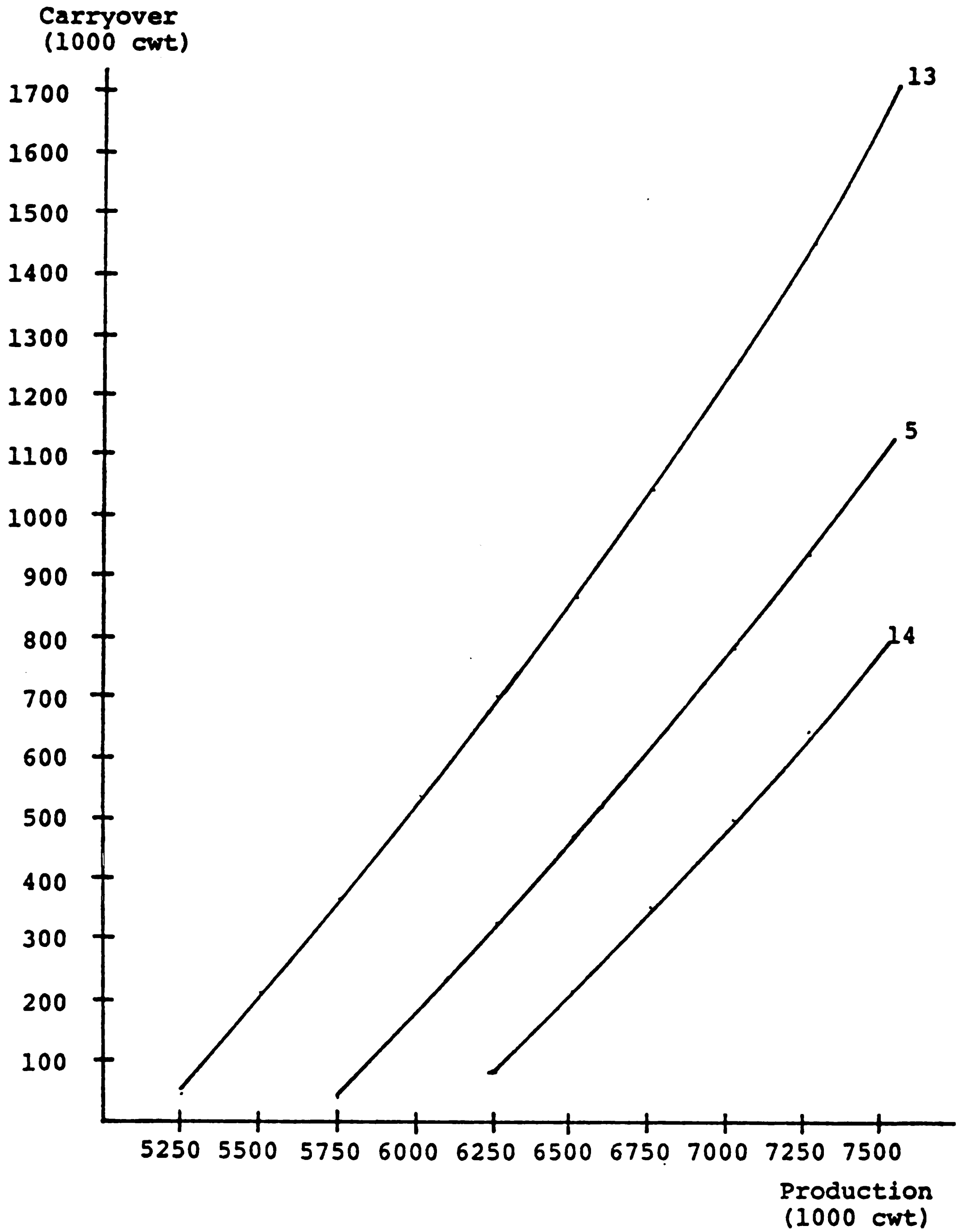

Figure 5-3. Optimal Carryover Rule Comparison Under Differing Demand Elasticity Assumptions

rule #16. This allows for the inspection of the effect of a greater than calculated variance for X+U. The standard deviation 1,590,000 cwt. was selected for symmetry, as 1,590,000 cwt. and 1,090,000 cwt. are equal to 1,340,000 cwt. plus 250,000 cwt. and minus 250,000 cwt. respectively. As seen in Figure 5-4, the optimal carryover at any given level of production increases as the variance (standard deviation) of the distribution increases. The change in optimal level was actually small relative to the change in standard deviation. A reduction of standard deviation by 19% (1,340,000 cwt. to 1,090,000 cwt.) in changing from rule #5 to rule #15, resulted in a decrease of only 10% (473,000 cwt. to 418,000 cwt.) for the optimal level of carryover at the 6,500,000 cwt. production level. A similar response was found in increasing the standard deviation. A 19% increase of the standard deviation caused a 10% increase in the optimal carryover level. This result suggests that carryover level is not greatly sensitive to moderate errors in estimation of the variance of the distribution.

5.5 Summary

It is important to understand how changes in the assumptions about the predetermined conditions affect the optimal rule. In order to select the "best" set of assumptions, the particular situation must be considered for each rule estimation. Timing is very important in setting the conditions. One's decision as to the cost structure is

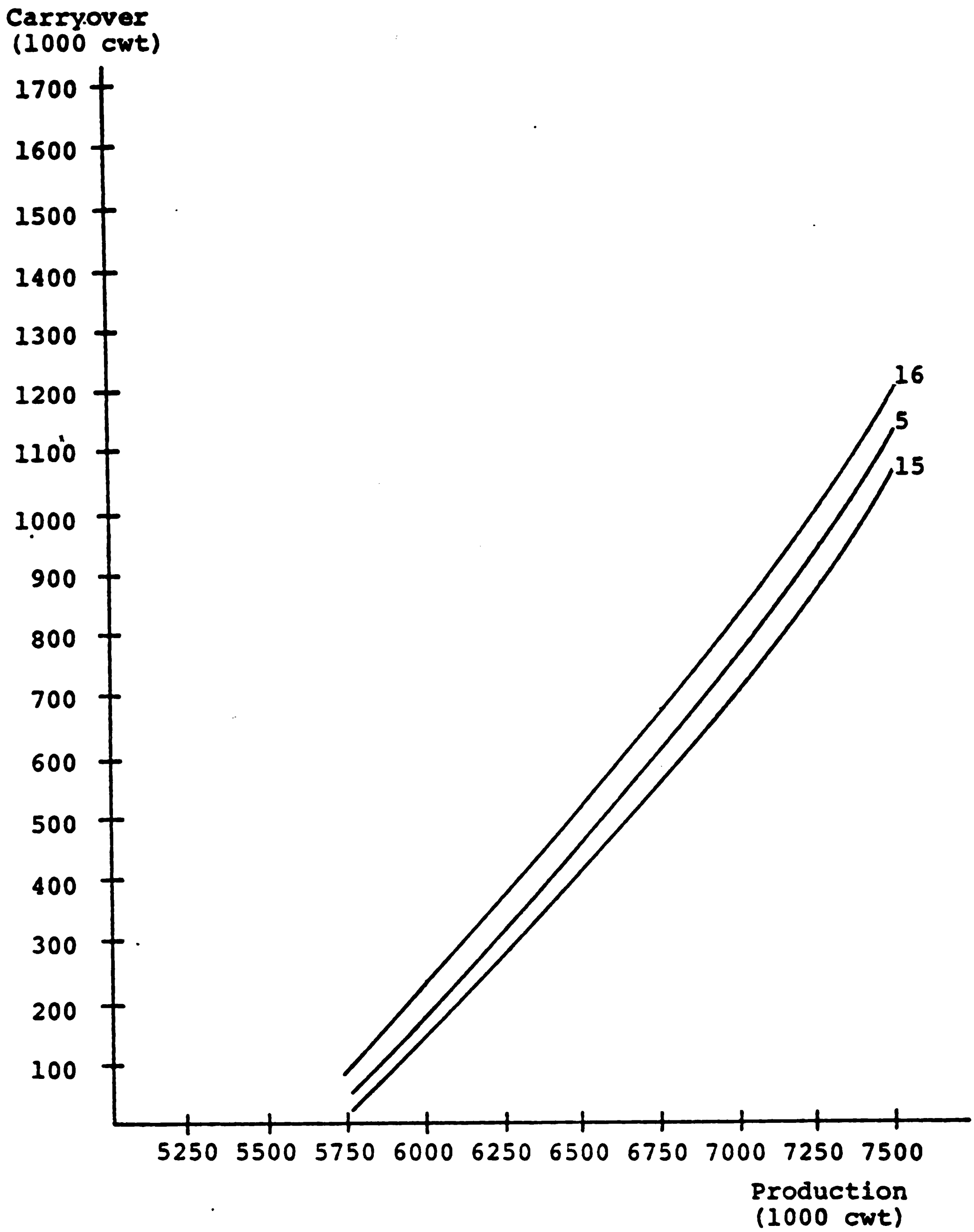

Figure 5-4. Optimal Carryover Rule Comparison Under Differing Distribution Assumptions

important, as are the factors contributing to the estimation of the social discount rate. It was demonstrated that great care must be taken in estimation of the elasticity and that periodic updating on all estimates is essential.

Optimal rules as presented here are not meant to be effective guidelines to either producers or shippers in storage decision making. They are meant to be a basis by which state and Federal government agencies as well as industry wide associations can interpret the carryover situation at any particular time. The rules can be used as an effective guide to the free market's ability to handle uncertainty with respect to society's welfare. Kept in proper perspective, the carryover stocks model and its results can be useful to the navy bean industry.

CHAPTER 6

Summary and Future Research

6.1 Introduction

Over the last decade the navy bean industry has been characterized by large price variation, poor information flow, highly variable export markets, increasing geographic concentration and limited development of new products. With these attributes and their implications in mind, the objectives of this study became threefold:

1. To estimate optimal carryover stock rules, based on sets of specific assumptions, for navy beans in the U.S.
2. To estimate U.S. supply and demand relationships for navy beans. First to supply the necessary input data to the stocks model and secondly to establish a workable base for econometric estimation with respect to navy beans.
3. To collect and summarize time series price and production data in order to facilitate the econometric estimation and make available such data for other information generation.

The fulfillment and completion of the objectives is outlined in the following sections.

6.2 Objective Fulfillment

6.2.1 Data Base

A revision and updating of the data base necessary to drive econometric equations were completed. A series of average annual prices, weighted by marketings, was established for navy beans for the first time. Also, a series of 25 years of carryover inventory levels is unique to this study. Twenty-five years (1951-1975) of time series data are available (see Appendix B) for the following variables: Weighted average price navy beans (8 months, 12 months), acres planted, yield, total production, domestic disappearance, exports, carryover, government take-over and others.

6.2.2 Demand and Supply Estimation

A set of econometric equations relative to the supply and demand of navy beans for the United States was estimated. The econometric model consisted of four equations and two identities. The supply side was made up of an equation for acres planted, one for yield and a production identity. Acres planted were estimated as a function of lagged own price, lagged price of corn, lagged acres planted and a constant term. Yield was estimated as a quadratic function of time. The short run price elasticity of a change in acres planted with respect to a change in price was estimated at 0.15.

The demand side consisted of an equation for domestic disappearance, another for export demand and a market clearing identify. Domestic disappearance was estimated as a function of own price, U.S. disposable income, a binary variable and a constant term. Export demand was estimated as a function of own price, the population of the United Kingdom and a constant term. The domestic price elasticity of demand for navy beans is estimated to be -0.37 while the export demand price elasticity estimate is -1.03.

These equations supplied the necessary input data (probability distributions, demand slope and intercept) to the carryover stocks model. Not only do the equations contribute to the functioning of the model, but the results may be employed in several other areas. Domestic, export and aggregate demand price elasticities are available. Short run and long run supply price elasticities can be computed. The equations supply important information contributing to probabilistic acreage, supply and price forecasting (see Black and Love [1978]) as well as generally allowing for a better understanding of the statistically important factors of production and demand.

6.2.3 Revision and Rule Estimation

The fulfillment of objective one required two stages. The first stage was completed by removing the causes of the major criticism of prior applications of the Gustafson model as being effective and realistic with respect to commodity storage. Accomplishment of this stage took the following form:

A. Adding export demand.

B. Incorporating stochastic demand.

C. Econometrically estimating production mean and distribution.

D. Writing a base algorithm for use in high speed computers.

The second stage involved the employment of the revised model for optimal carryover rule estimation for navy beans. Rules were generated for a set of reasonable assumptions about the conditions in the 1976-77 marketing season. Several general conclusions could be reached. Society's welfare could be enhanced by the use of carryover stocks to reduce year to year fluctuations in production and demand. It would appear that in years of relatively good production generally insufficient crop is carried over, when compared to the optimal rule. This has probably been true in most good production years, with the exception of some of those years when the U.S. government purchased stocks through the non-recourse loans program.

The data presented in this study make a contribution as market information. Such information can, with proper discretion, facilitate the improvement of efficient market functioning. Estimated levels of social optimal carryover stock quantities ought to be indicative of those realized in a well functioning free market. Producers, consumers and government may then use this information in decision making and policy analysis with respect to questions of production planning, timing of marketings, canned product production and inventory control, pricing, income and price support, market coordination and market power.

If government should again establish some type of commodity storage program for navy beans, it would be imperative to have a workable model to assist in setting rules for acquiring and disbursing stocks. A model could be altered to maximize a variety of objective functions. Whatever is the goal, it is essential that a model, capable of calculating supply-storage relationships for a given objective as close to reality as is economically feasible, be used to reduce welfare losses due to over or under storage. The application presented in this study has sufficiently employed the original abilities of the Gustáfson model so as to make it a relevant tool in a storage decision process. High speed computer techniques have allowed for testing of the model's sensitivity to changes in conditions and objective function as well as the ability to inexpensively update the required input data.

Based on the sensitivity analysis, some notable observations could be made as to the magnitude of the changes in the rules. The rules were sensitive to all the changes in the assumptions about the conditions. They were particularly sensitive to changes in marginal cost and elasticity of demand. These results point to the need for accurate and up-to-date estimation of these two conditions to insure proper optimal rule determination. More generally, the research involved in this study brought to light several distinct areas where there is a need for future research. The following section presents these areas.

6.3 Future Research

In order to do effective research in navy beans it is important that a data base be available. The data accumulated for this study are a start to alleviating the problem. At least four other measures are necessary to facilitate useful research. The first concerns crop reporting procedures. These include planting intentions, production, export and price. The crops need to be divided into more useful (generally less aggregative) reporting classes. All too often navy beans are combined with all other dry beans as a single entity. Also, dry beans are typically combined with peas and lentils in various reporting publications. Crop reporting services must take more care in being consistent in reporting. This is especially evident where season's average price is concerned. Ideally a price weighted by marketings ought to be published. Unfortunately sometimes the price is weighted and sometimes it is not.

An effective cost account study needs to be done to better understand production and marketing practices. Although dry beans are the fourth largest agricultural commodity produced in Michigan, very little production practice or cost data are actually available for even rudimentary econometric study. A cost account or similar type of study would supply the essential data to do effective budgeting, econometric modeling, linear programming and marketing strategy formation. Because of the geographic nature of the industry the study need not be of monumental budget proportions. Economies ought to be available if crop and agronomic research, already on-going, was incorporated into an interdepartmental program. Such a study should seem imperative if the state of Michigan is to look to the bean industry in the future as a continued and stable source of income.

Another data set necessary for efficient planning and research is that of quantity stored in both raw and processed form. Although several industry originated estimates are usually available as to the quantity stored in raw form, it is often difficult to discern their accuracy. Even more important and practically non-existent are data related to canners' inventories. It must be realized that due to the small number of canners, the revelation of such data by any one canner would not be practical. Such information is important when doing econometric modeling or production planning. Government agencies ought to be able to accumulate such information in an aggregative form that would be defined enough to be useful to producers and researchers and broad enough not to cause harm to individual canners.

Another important requirement of future economic research is that it must effectively incorporate the Canadian navy bean industry along with that of the U.S. In order to do realistic econometric and storage modeling and forecasting, it is becoming more and more important that U.S. and Canadian production be viewed as close to a single entity. This has become especially true since Canada's rapid growth in production of the past decade. Because exports play such an important role in price determination, the effect of the increased export competition from the Canadians is felt all along the marketing chain. Some obvious problems exist due to differences in the industry in the two countries. These include market structure, export restrictions, length of data base and currency differences. Despite these obstacles, close investigation of the U.S. navy bean industry points to the need for just such incorporation in the future.

It seems obvious, at least to one familiar with the navy bean industry, that the above improvements are necessary. Not only would they be significant from the point of view of the researcher, but very valuable tools, either not now available or in an inefficient form, for use by producers and processors in efficient planning. Use of these data when available could supply sufficient information to significantly reduce the risk involved in the production and marketing of navy beans. The data made available, if these four measures were put into practice, might be a better uncertainty reduction tool than any sort of aggregate carryover program and the results would be of benefit to all concerned.

Another area of specific research follows from the results of this study. A study focusing on optimal carryover from a producer's point of view might be a significant contribution. During data collection for this study, it was expressed to this researcher by a party whose interests were shipper oriented that "the optimal carryover is no carryover at all." Considering shippers basically are paid on a constant margin, this statement is not unreasonable. The problem exists when farmers are told this constantly. Is there some advantage to producers from aggregate storage? This is a question economists ought to be able to answer if producers show an interest. Several attributes of the navy bean industry make collective producer storage a relevant issue. One is an already established producer organization that presently acts collectively for some purposes. The other attribute is a political environment in the state of Michigan highly conducive to producer cooperative action. Thus a study identifying the advantages or disadvantages of aggregate carryover with respect to the individual producer's return could be a useful service.

APPENDIX A

This equation is the domestic disappearance equation specified to include both population for the U.S. and per capita disposable income.

DDNB = 7428.65 - 180.87 PNBALL + 3.39 PCDI - 60.69 POPUS
[t-stat] [1.28] [2.54] [1.43] [0.98]

+ 1247.02 DUM
[1.81]

$\bar{R}^2$ = .50 F-statistic = 7.1

This equation estimates combined Canadian and U.S. exports of navy beans (CUXNB).

CUXNB = -17491.9 - 59.4 PNBALL + 365.7 POPUK
[t-stat] [6.25] [1.53] [6.80]

$\bar{R}^2$ = .64 F-statistic = 22.6

APPENDIX B

The Computer Model

```
      PROGRAM BEANS(INPUT,OUTPUT,TAPE1=INPUT)
C
C        OPTIMAL CARRYOVER STOCKS PROGRAM BASED ON THE ALGORITHM
C        DEVELOPED BY ROBERT GUSTAFSON AND ADJUSTED TO INCLUDE
C        EXPORT DEMAND, DEMAND VARIABILITY AND ACREAGE VARIABILITY.
C
C                   DEFINITIONS:
C          X(N2)=PRODUCTION VECTOR TO BE INPUT FROM LOWEST VALUE TO HIGHEST
C          FX(N2)=PROBABILITY DISTRIBUTION OF X
C          C(N1)=CARRYOVER VECTOR
C          TEMP(N1)=TEMPORAY STORAGE ARRAY
C          SL(N2,N1)=SUPPLY AS CALCULATED USING C AND X
C          DISC=DISCOUNT RATE PER ANNUM
C          ALPHA=INTERCEPT ON PRICE AXIS IN DEMAND EQUATION
C          BETA=SLOPE OF DEMAND CURVE
C          EX=EXPECTED VALUE OF X
C          IMAX=MAXIMUM NUMBER OF ALLOWABLE ITERATIONS DEFAULT=15
C          SN(N2,N1,2)  1=LAST ITERATION  2 =PRESENT ITERATON
C
      DIMENSION X(100),FX(100),C(100),TEMP(100),
     +          SL(100,100),SN(100,100,2)
C
      DATA TEMP/100*0/,SN/20000*0/,SL/10000*0/,ITER/0/
      PRINT 101
101   FORMAT(*1*,20X,*BEAN SIMULATOR*)
C
C                   READ IN CARRYOVER VECTOR
C
      READ(1,1)N1
1     FORMAT(I10)
      DO 3 I=1,N1
      READ(1,2)C(I)
2     FORMAT(F20.10)
3     CONTINUE
      PRINT 102,(C(I),I=1,N1)
102   FORMAT(*0CARRYOVER VECTOR*,10X,5F10.2,19(/,27X,5F10.2))
C
C                   READ IN X AND FX VECTORS
C
      READ(1,1)N2
      DO 4 I=1,N2
4     READ(1,2)X(I)
      PRINT 103,(X(I),I=1,N2)
103   FORMAT(*0PRODUCTION VECTOR*,9X,5F10.2,9(/,27X,5F10.2))
      DO 5 I=1,N2
5     READ(1,2)FX(I)
      PRINT 104,(FX(I),I=1,N2)
104   FORMAT(*0PROBABILITY VECTOR*,8X,5F10.3,9(/,27X,5F10.3))
      READ(1,6)DISC,ALPHA, BETA,EX,IMAX
6     FORMAT(8F10.5)
      IF(IMAX.EQ.0)      IMAX=1
      PRINT 105,DISC,ALPHA,BETA,EX,IMAX
105   FORMAT(*0DISCOUNT RATE=*,F10.5,10X,*INTERCEPT=*,F10.5,10X,
     + *SLOPE=*,F10.5,/,* EXPECTED VALUE=*,F10.5,9X,*MAXIMUMUM ITERATION
     +S=*,I3)
      DO 14 I=1,N1
      DO 14 J=1,N2
C
C        CALCULATE SUPPLY
C
14    SL(I,J)=C(I)+X(J)
7     ITER=ITER+1
      IF(ITER.GT.IMAX)GO TO 1000
      PRINT 140,ITER
140   FORMAT(//,40X,"************ ITERATION",I2," ************")
      DO 13 I=1,N1
      TEMP(I)=0
      DO 8 J=1,N2
C
C        CALCULATE SUPPLY EXPECTATIONS
C
8     TEMP(I)=TEMP(I)+(SN(I,J,1)*FX(J))
      TEMP(I)=DISC*TEMP(I)
      PRINT 9,I,TEMP(I)
9     FORMAT(//,* I=*,I3,* TEMP1=*,F8.2)
10    TEMP(I)=DISC*ALPHA-DISC*BETA*C(I)-DISC*BETA*EX
     +        +BETA*TEMP(I)-COST(C(I))
```

```
      PRINT 11,TEMP(I)
11    FORMAT(25X,*Y(I)=*,F8.3)
C
C        BASIC CALCULATING EQUATION (EQ. 6 SEC. 3.5)
C
      TEMP(I)=(ALPHA-TEMP(I))/BETA + C(I)
      PRINT 12,TEMP(I)
12    FORMAT(42X,*TEMP2=*,F8.2)
13    CONTINUE
C
C        INTERPOLATION TO GET TEMPORARY CARRYOVER FOR A SUPPLY
C
      SNO=C(1)+((X(1)-TEMP(1))/(TEMP(2)-TEMP(1)))*(C(2)-C(1))
C
      DO 17 I=1,N1
      DO 17 J=1,N2
      ICHECK=1
15    IF(ICHECK.GE.N1)GO TO 1002
      IF(SL(I,J).GT.TEMP(ICHECK+1))GO TO 16
C
      SN(I,J,2)=C(ICHECK)+(C(ICHECK+1)-C(ICHECK))*
     +         ((SL(I,J)-TEMP(ICHECK))/(TEMP(ICHECK+1)-TEMP(ICHECK)))
      IF(SN(I,J,2).LT.0.0) SN(I,J,2)=0.0
      GO TO 17
16    ICHECK=ICHECK+1
      GO TO 15
17    CONTINUE
180   PRINT 19,SNO
19    FORMAT(/,20X,F12.3)
      DO 21 J=1,N2
      DO 21 I=1,N1
      PRINT 20,SL(I,J),SN(I,J,2)
20    FORMAT(10X,F10.2,F12.3)
21    CONTINUE
      IGO=0
      DO 18 I=1,N1
      DO 18 J=1,N2
C
C        MAX. CHANGE IN RULE FROM ONE ITERATION TO THE NEXT
C
      DIF=SN(I,J,1)-SN(I,J,2)
      SN(I,J,1)=SN(I,J,2)
C
C        STOPPING CRITERION
C
18    IF(ABS(DIF).GT.0.900)      IGO=1
      IF(IGO.NE.0)       GO TO 7
      GO TO 999
 1000 PRINT 1001
 1001 FORMAT(* ITERATIONS EXCEEDS UPPER LIMIT*)
      GO TO 999
 1002 PRINT 1003
 1003 FORMAT (* BOUNDS FOR SL ARRAY NOT FOUND IN TEMP2*)
 999  CONTINUE
      END




      FUNCTION COST(X)
      COST = 9.
      RETURN
      END
```

Input Data

BEAN SIMULATOR

CARRYOVER VECTOR	.05	.10	.30	.50	.80
	1.00	2.00	3.00	5.00	10.00
	20.00	300.00			
PRODUCTION VECTOR	31.95	45.56	59.17	72.78	86.39
	100.00	113.61	127.22	140.83	154.44
	168.05				
PROBABILITY VECTOR	.009	.028	.066	.121	.176
	.200	.176	.121	.066	.028
	.009				

DISCOUNT RATE= .86960 INTERCEPT= 220.00000 SLOPE= 1.2
EXPECTED VALUE= 100.00000 MAXIMUMUM ITERATIONS= 1

Input Data

```
                   BEAN SIMULATOR
CARRYOVER VECTOR                   .05        .10        .30        .50        .80
                                  1.00       2.00       3.00       5.00      10.00
                                 20.00     300.00
PRODUCTION VECTOR                31.95      45.56      59.17      72.78      86.39
                                100.00     113.61     127.22     140.83     154.44
                                168.05
PROBABILITY VECTOR                .009       .028       .066       .121       .176
                                  .200       .176       .121       .066       .028
                                  .009
DISCOUNT RATE=    .86960          INTERCEPT= 220.00000          SLOPE=    1.2
EXPECTED VALUE= 100.00000         MAXIMUMUM ITERATIONS=   1
```

Table B-1. Data Base

	ID	APNB	YAPNB	QNB	CAPRD
1951	1951.00	395.000	1031.00	4072.00	729.000
1952	1952.00	340.000	1001.00	3412.00	768.000
1953	1953.00	367.000	982.000	3601.00	696.000
1954	1954.00	463.000	682.000	3158.00	595.000
1955	1955.00	496.000	892.000	4428.00	713.000
1956	1956.00	486.000	1033.00	5020.00	673.000
1957	1957.00	492.000	682.000	3358.00	641.000
1958	1958.00	521.000	967.000	5042.00	679.000
1959	1959.00	511.000	1175.00	6069.00	633.000
1960	1960.00	498.000	1174.00	5845.00	620.000
1961	1961.00	510.000	1324.00	6755.00	744.000
1962	1962.00	514.000	1303.00	6725.00	838.000
1963	1963.00	521.000	1452.00	7599.00	863.000
1964	1964.00	558.000	1213.00	6801.00	1117.00
1965	1965.00	599.000	912.000	5480.00	1182.00
1966	1966.00	575.000	1268.00	7289.00	1400.00
1967	1967.00	491.000	975.000	4801.00	824.000
1968	1968.00	534.000	1052.00	5589.00	1041.00
1969	1969.00	592.000	1221.00	7224.00	1159.00
1970	1970.00	526.000	985.000	5180.00	1197.00
1971	1971.00	512.000	980.000	5020.00	1550.00
1972	1972.00	580.000	1113.00	6450.00	1843.00
1973	1973.00	535.000	912.000	4882.00	1594.00
1974	1974.00	577.000	1168.00	6943.00	1973.00
1975	1975.00	486.000	840.000	4140.00	1783.00
	1	2	3	4	5

1. Year.

2. Acres planted to navy beans U.S. Michigan Crop Reporting Service.

3. Yield on acres planted to navy beans. By calculation.

4. Quantity navy beans produced. Crop Production, ESCS of the USDA.

5. Canadian production of navy beans. Ontario Bean Producers Marketing Board.

Table B-2. Data Base

	ID	DDNB	XNB	CARIN	CAROUT
1951	1951.00	2497.00	701.000	400.000	144.000
1952	1952.00	2556.00	250.000	144.000	490.000
1953	1953.00	2924.00	716.000	490.000	74.0000
1954	1954.00	3130.00	52.0000	74.0000	50.0000
1955	1955.00	3031.00	674.000	50.0000	150.000
1956	1956.00	1970.00	1209.00	150.000	244.000
1957	1957.00	3538.00	8.00000	244.000	25.0000
1958	1958.00	3999.00	1029.00	25.0000	30.0000
1959	1959.00	4126.00	1433.00	30.0000	363.000
1960	1960.00	3570.00	640.000	363.000	160.000
1961	1961.00	4370.00	902.000	160.000	32.0000
1962	1962.00	3751.00	1704.00	32.0000	338.000
1963	1963.00	4848.00	1938.00	338.000	139.000
1964	1964.00	4405.00	1550.00	139.000	384.000
1965	1965.00	4290.00	1075.00	384.000	499.000
1966	1966.00	3818.00	2044.00	499.000	250.000
1967	1967.00	4189.00	762.000	250.000	100.000
1968	1968.00	4233.00	1156.00	100.000	300.000
1969	1969.00	5366.00	1828.00	300.000	480.000
1970	1970.00	3804.00	1526.00	480.000	330.000
1971	1971.00	4039.00	961.000	330.000	350.000
1972	1972.00	4501.00	1849.00	350.000	450.000
1973	1973.00	3833.00	1069.00	450.000	430.000
1974	1974.00	5455.00	1518.00	430.000	400.000
1975	1975.00	3465.00	575.000	400.000	350.000
	1	2	3	4	5

1. Year.

2. Domestic disappearance of navy beans.
   By calculation.

3. Exports of navy beans.
   Michigan Bean Shippers Association.

4. Carryover into the year.
   By subjective calculation.

5. Carryover out of the year.
   By subjective calculation.

Table B-3. Data Base

	ID[1]	PNBALL[2]	PNB[3]	PC[4]	PCB[5]
1951	1951.00	8.33000	8.33000	2.20000	13.7000
1952	1952.00	9.41000	9.26000	1.81000	12.9200
1953	1953.00	9.95000	9.73000	1.71000	10.2800
1954	1954.00	11.5900	11.5300	1.70000	11.1700
1955	1955.00	8.08000	8.08000	1.37000	9.27000
1956	1956.00	7.61000	7.63000	1.47000	16.3700
1957	1957.00	9.18000	8.93000	1.27000	8.99000
1958	1958.00	7.45000	7.37000	1.20000	8.44000
1959	1959.00	6.21000	6.22000	1.16000	8.16000
1960	1960.00	6.25000	6.12000	1.07000	7.99000
1961	1961.00	6.71000	6.65000	1.02000	7.52000
1962	1962.00	6.72000	6.66000	1.07000	7.51000
1963	1963.00	6.70000	6.68000	1.15000	7.76000
1964	1964.00	6.97000	7.13000	1.14000	8.48000
1965	1965.00	8.67000	8.88000	1.11000	8.71000
1966	1966.00	6.25000	6.16000	1.27000	7.91000
1967	1967.00	8.45000	8.37000	.970000	8.59000
1968	1968.00	7.20000	7.38000	.950000	7.72000
1969	1969.00	5.51000	5.44000	.980000	7.13000
1970	1970.00	8.39000	7.92000	1.14000	6.53000
1971	1971.00	9.65000	9.87000	.810000	9.13000
1972	1972.00	8.64000	6.64000	1.02000	7.83000
1973	1973.00	21.7700	21.9900	1.78000	16.6400
1974	1974.00	9.18000	9.33000	2.05000	17.1100
1975	1975.00	15.9300	17.2700	1.41000	13.2100

1. Year.

2. Twelve month weighted average price for navy beans.
Price: Michigan Elevator Exchange. Weightings: Michigan Crop Reporting Serv.

3. Eight month weighted average price for navy beans. Price: Michigan Elevator Exchange. Weightings: Michigan Crop Reporting Service.

4. Seven month weighted average price corn in Michigan. Price: Michigan Elevator Exchange. Weightings: Michigan Crop Reporting Service.

5. Eight month weighted average price all colored beans Michigan.
Price: Michigan Elevator Exchange. Weightings: Michigan Crop Reporting Service.

Table B-4. Data Base

	ID	POPUS	PCDI	POPUK	PCNIUK
1951	1951.00	154.900	1880.00	50.3000	861.000
1952	1952.00	157.600	1903.00	50.7000	869.000
1953	1953.00	160.200	1968.00	50.9000	907.000
1954	1954.00	163.000	1961.00	51.1000	924.000
1955	1955.00	165.900	2069.00	51.2000	955.000
1956	1956.00	168.900	2134.00	51.4000	969.000
1957	1957.00	172.000	2128.00	51.7000	997.000
1958	1958.00	174.900	2106.00	51.8000	1012.00
1959	1959.00	177.800	2172.00	52.2000	1036.00
1960	1960.00	180.700	2183.00	52.5000	1094.00
1961	1961.00	183.700	2213.00	52.9000	1132.00
1962	1962.00	186.500	2281.00	53.4000	1116.00
1963	1963.00	186.200	2370.00	53.6000	1253.00
1964	1964.00	191.900	2457.00	54.2000	1257.00
1965	1965.00	194.300	2576.00	54.6000	1391.00
1966	1966.00	196.600	2680.00	54.7000	1425.00
1967	1967.00	198.700	2749.00	55.1000	1252.00
1968	1968.00	200.700	2827.00	55.3000	1262.00
1969	1969.00	202.700	2851.00	55.5000	1294.00
1970	1970.00	204.900	2903.00	55.7000	1323.00
1971	1971.00	207.100	2970.00	55.6000	1433.00
1972	1972.00	208.800	3071.00	55.8000	1350.00
1973	1973.00	210.400	3230.00	55.9000	1409.00
1974	1974.00	211.900	3145.00	56.0000	1385.00
1975	1975.00	213.500	3108.00	56.0000	1380.00
	1	2	3	4	5

1. Year.

2. Population of U.S.
   Economic Report of the President.

3. Per capita disposable income, U.S.
   Economic Report of the President.

4. Population of the United Kingdom.
   Production Yearbook, FAO.

5. Per capita national income, United Kingdom.
   Production Yearbook, FAO.

Table B-5. Data Base

	ID	GOVP	GOVNB	CANEX
1951	1951.00	10.2000	1130.00	16.0000
1952	1952.00	11.0000	260.000	156.000
1953	1953.00	10.9800	377.000	516.000
1954	1954.00	10.4500	0.	150.000
1955	1955.00	9.27000	623.000	55.0000
1956	1956.00	9.07000	1747.00	49.0000
1957	1957.00	8.65000	31.0000	82.0000
1958	1958.00	8.28000	9.00000	34.0000
1959	1959.00	7.36000	177.000	58.0000
1960	1960.00	7.28000	1838.00	33.0000
1961	1961.00	7.98000	1611.00	127.000
1962	1962.00	7.89000	964.000	200.000
1963	1963.00	7.80000	1012.00	218.000
1964	1964.00	7.69000	601.000	397.000
1965	1965.00	7.30000	0.	597.000
1966	1966.00	7.10000	1676.00	630.000
1967	1967.00	6.90000	0.	297.000
1968	1968.00	6.62000	0.	552.000
1969	1969.00	6.29000	11.0000	649.000
1970	1970.00	5.93000	0.	718.000
1971	1971.00	5.69000	0.	977.000
1972	1972.00	5.51000	0.	1290.00
1973	1973.00	5.23000	0.	1084.00
1974	1974.00	4.71000	0.	1440.00
1975	1975.00	0.	0.	1480.00
	1	2	3	4

1. Year.

2. Government support prices for navy beans.
   ESCS of the USDA.

3. Government takeover of navy beans (loan default).
   ESCS of the USDA.

4. Canadian exports of navy beans.
   Ontario Bean Producers' Marketing Board.

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