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(NASA-CR-153061) UNITED STATES BENEFITS OF IMPROVED WORLDWIDE WHEAT CROP INFORMATION FROM A LANDSAT SYSTEM OVERVIEW Final Report (ECON, Inc., Princeton, N.J.) 47 p HC A03/MF A01 CSCL 02C G3/43

N77-24569

Unclas 31913

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ECON INCORPORATED

Report 76-122-1A
NINE HUNDRED STATE ROAD
PRINCETON, NEW JERSEY 08540
609 924-8778

FINAL

UNITED STATES BENEFITS OF IMPROVED WORLDWIDE WHEAT CROP INFORMATION FROM A LANDSAT SYSTEM

OVERVIEW

Prepared for

The National Aeronautics and Space Administration
Office of Applications
Washington, D.C.

Under Contract NASW-2558

August 31, 1975

Revised
January 30, 1976

NOTE OF TRANSMITTAL

This report is prepared for the Office of Applications, National Aeronautics and Space Administration under Statement of Work on Contract NASW-2558 which represents an evaluation of the improvement in worldwide wheat crop information promised by a LANDSAT-type Earth Resources Survey (ERS) System.

The results reported herein are based on the best public data available on world wheat crop information. The economic approach used for this study represents significant innovations in the valuation of improved information on agricultural crops. In addition to this report, a separate volume providing a more detailed account of this study is transmitted, wherein methodological and mathematical modeling issues are discussed. To our knowledge, this is the first empirical assessment of the economic value of a LANDSAT system in providing information on the worldwide wheat crop.

Other than the study director, the principal participants in this study effort were Francis Sand, Andrew Seidel, Dennis Warner, Neil Sheflin, Ran Bhattacharyya and John Andrews, each of whom made important contributions to this study.

Klaus P. Heiss

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Study Director

ABSTRACT

The Earth Resources Survey (ERS) and the LANDSAT Program of NASA in particular, face some important decisions over the next 12 to 18 months that will affect the future of remote sensing by satellite in civilian applications for decades to come. To provide an economic basis for the discussion of these issues, ECON, Inc. completed an overview evaluation of a LANDSAT-type Earth Resources Survey system in 1974*. Potentially large benefits to be obtained in agriculture from a continuity of LANDSAT data services when applied to the United States were identified and measured.

This report is an extension in breadth and depth of these ECON agricultural case study efforts. The value of worldwide information improvements on wheat crops, promised by LANDSAT, is measured in the context of world wheat markets. These benefits are based on current LANDSAT technical goals and assume that information is made available to all -- United States and other countries -- at the same time.

The benefits to the United States of such public LANDSAT information on wheat crops are, on the average, 174 million dollars a year. About 287 million dollars accrue

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*ECON, Inc., <u>The Economic Value of Remote Sensing of Earth Resources from Space: An ERTS Overview and the Value of Continuity of Service</u>, 10 Volumes, Princeton, New Jersey, December 1974.

directly to United States consumers in the form of lower average wheat prices; $280 million are production efficiency gains in providing for domestic and foreign demand. These benefits are those of a LANDSAT system with possibly as many as three operating spacecraft. The benefits from improved wheat crop information compare favorably with the annual system's cost of about $62 million.

A detailed empirical sample demonstration of the effect of improved information is given; the history of wheat commodity prices for 1971-72 is reconstructed and the price changes from improved vs. historical information are compared.

These results reaffirm the conclusions reached by ECON in its December, 1974 report in the most important area: LANDSAT promises substantial benefits from improved information in agriculture if present technical goals and expectations are met. The improved crop forecasting from a LANDSAT system assumed in this study are: wheat crop estimates of 90 percent accuracy for each major wheat producing region, at a 90 percent confidence level through the wheat harvest period. This translates roughly into a 1.8 percent error in December wheat crop production estimates for the United States and 5.0 percent for the rest of the world.

The technical performance and capabilities of a LANDSAT system are still being developed by NASA; our estimate on technical capabilities of a LANDSAT system are based on a considered interpretation and extension of LANDSAT investigations to date, and were given to us by NASA.

In conclusion, accurate, objective worldwide wheat crop information using space systems may have a very stabilizing influence on world commodity markets, in part making possible the establishment of long-term, stable trade relationships.

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1. OVERVIEW

> "We live only by knowing something about the future; while the problems of life, or of conduct at least, arise from the fact that we know so little."*

1.1 Introduction

This study is an attempt to measure the economic value of the improvements in worldwide wheat crop information, promised by the use of remote sensing earth resource satellites. Because the costs of such an information-gathering system are being borne by the United States, it is appropriate that the benefits be estimated with specific reference to the United States. However, the interdependence of regional economics makes it imperative that the benefits from this improved information also be estimated for the rest of the world. In particular, the study tries to answer the following questions:

(1) Can a LANDSAT-type system of gathering crop information, worldwide, improve the existing crop information?

(2) Will the United States gain or lose by publishing such information?

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*Knight, F. H., Risk, Uncertainty and Profit, Harper and Row Publishers, Inc., New York, New York 1965.

(3) What segments of the United States economy will gain or lose from this information?

(4) Will the Rest of the World gain or lose from improved crop information?

The first issue of course is a technical one in part and not really in the domain of this study. We assume here that the technical goals of LANDSAT are achievable. Moreover, we assume that the crop information generated by LANDSAT will be made available simultaneously and on an equitable basis to all countries. However, we will proceed to state carefully the existing accuracy of crop information of all major regions and the assumed improvements that a LANDSAT system promises to bring. It is understood that any such significant improvement is a long-term goal to be achieved over many years, say by 1985.

Concerning the second, third and fourth questions, this study presents several significant achievements in the analysis of benefits from improved information. Considerable theoretic interest in the economics of information has blossomed in the 1960s and early 1970s; yet astonishingly few, if any, attempts of measuring the value of information and uncertainty in markets have been made. In this sense this study is exploring new territory. It is for this reason that we set out -- rather pedantically and at length -- to state our approach and its implementation.

In addition to our assumption that all LANDSAT information will be made available to all countries simultaneously, there are two other assumptions pervading this analysis. First, the world marketplace will use LANDSAT information when and if that information is more accurate than the information from currently available alternative sources. Second, that world trade will be rational.

Although the LANDSAT system has the potential to monitor many crops worldwide, this study focuses on one of the most important -- wheat. To be sure, the greater the crop coverage, the larger the benefits from improved crop information. Nevertheless, wheat is a major world crop and likely to account for a large share of the benefits from LANDSAT.

Before turning to detailed descriptions of the satellite system, its potential importance and the scope and focus of this study, it is important to point out that there are two principal reasons why the benefits to the United States estimated in this study are likely to be on the low side. First, not all countries have historically followed our assumption of simultaneous distribution of crop information to all on an equitable basis. The United States is indisputably the world's leader in the collection and publication of agricultural crop production statistics. In contrast, a few countries knowingly distort or hide their crop successes or failures. Insofar as the LANDSAT system would apply to all countries, added benefits can be expected from improved crop information to Free World commodity markets beyond those reported here. Secondly, in the United States, as elsewhere, strong agricultural price "stabilization" policies have been pursued in the past -- sometimes with success. Thus, the price fluctuations observed in the free market reflect only part of the existing true uncertainty in crop information and only this part is measured in this study.

1.2 Information and the World Food Situation

The importance of this effort is underscored by the increasingly difficult world food situation of the next decades and the role improved information will play therein.

In 1963, the FAO Third World Food Survey estimated that 300 to 500 million people were underfed each year from 1957 to 1959 and that 60 percent of the population in underdeveloped areas lived on diets that were nutritionally inadequate [8]. The proposed solution to the problem then was to increase world food supplies by 75 percent by the year 2000. In the ensuing decade, scientists have brought the "green revolution" to the world. Harvest yields can be two or three times greater than those achieved in the late 1950s and early 1960s. Yet. eleven years after the FAO Third World Food Survey, it was reported at the World Food Conference in Rome that over a billion people now are underfed each year and that millions of people were likely to starve in the next two years [8]. As in 1963, the principal solution in this Malthusian nightmare was to increase aggregate food supply.

To a large extent, however, the extent of aggregate world food production is not the problem. The protein content of aggregate world food supply theoretically is more than adequate according to safe levels of protein intake recommended by food nutritionists [2,34]. In fact, the lack of available food supply may be more apparent than real. According to Parpia [7], "The per capita availability of food grains is about two and one half times the requirement. If protein (all sources) is taken as the main qualitative measure and its daily requirement at 70 grams per capita, the total availability is also more than twice the requirement."

These considerations lend weight to the importance the distribution problem has received at the 1974 World Food Conference [8, 9]. Although only one of many recommendations of that conference, we believe this aspect of the world food crisis to be as important as the physical production of crops: distribution of supplies from surplus regions to deficit regions, from times of abundance to times of scarcity, within nations and between nations. This proposition, of course, does not imply that greatly increased world food supplies would not alleviate the current "food shortage."

Rather, it recognizes that more efficient distribution of existing supplies promises substantial direct and indirect benefits to the world where continued starvation of a large part of its people is still the rule. And developed countries, including the United States, are no exception. The organizations and structure of responsibilities resulting from the 1974 conference are shown in Figure 1.1.

There are, of course, many theories to improve world food distribution, some naive, others shortsighted and a few worth serious consideration. One of the more exciting possibilities on the technological horizon is the improvement of worldwide crop measurements.

Most people, even professional economists responsible for decisions in the agriculture field, may have the mistaken impression that crop production statistics, worldwide, region by region, are well known quantities with little further opportunity to improve such statistics and estimates. If only it were so. In fact, quite little is known in world markets of crop production on a regional basis. The country with the largest food grain production by far, the Soviet Union, does not know its own harvest, as shown by its own statistics, to within better than ± 30 percent (even well within the harvest season). Some other countries do no better. This shortcoming sometimes leads to numerous locally isolated agriculture markets even within one country -- and

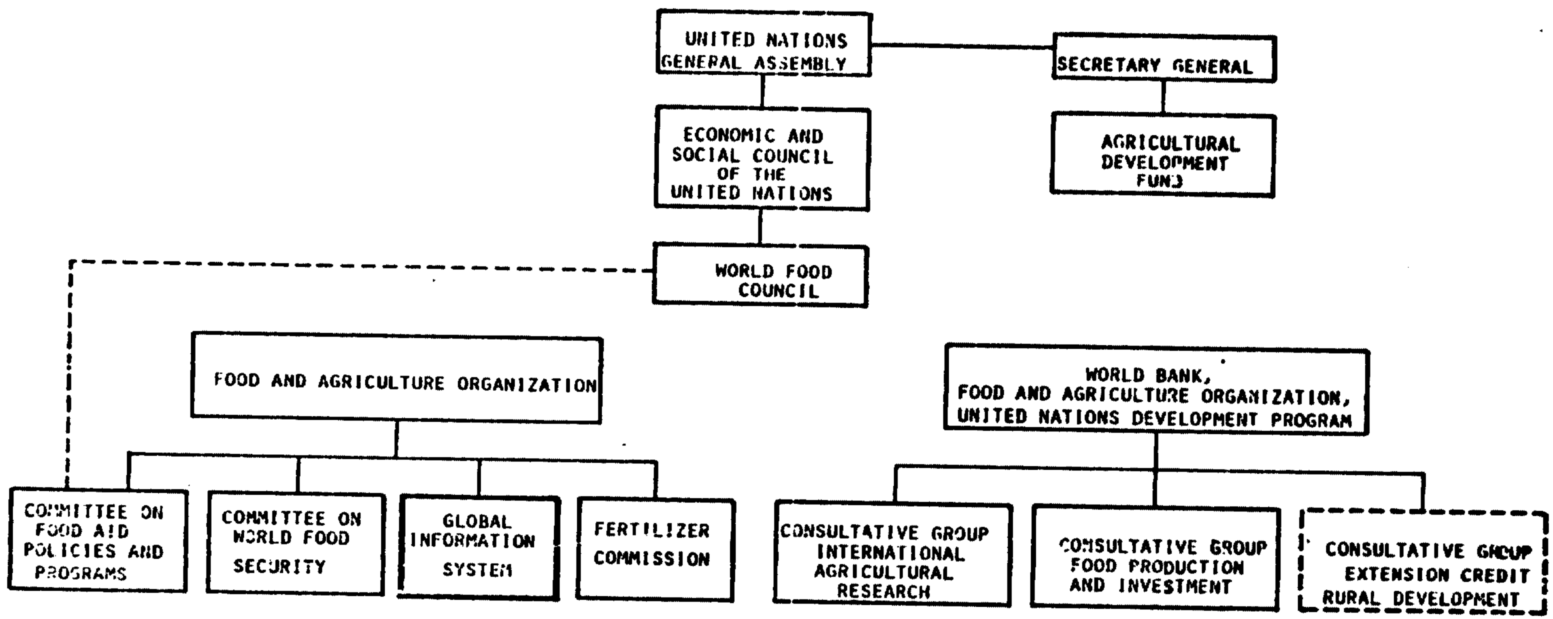

Figure 1.1 International Organizations with Responsibility for World Food Problems by Recommendations of the 1974 World Food Conference

relatively large price differences between these decentralized, nonconnected regions. While there are many other economic constraints that impose such differences in food available for consumption -- when it is needed and where it is needed -- with ensuing differences in food prices, one major contributing factor is simply the lack of accurate, timely, complete information.

1.3 World Crop Information and the Promise of LANDSAT

The potential value of improving information rests on two results in economic general equilibrium analysis. First, the allocation of resources to satisfy needs (market efficiency) improves with better public information.* Second, all parties engaged in rational, free trade stand to gain from such trade. These general statements suggest -- a priori -- that an improved, public, worldwide crop monitoring system may benefit at least some countries without hurting any others.

While exceptions to these two general rules can be found or constructed -- with considerable ingenuity -- those exceptions rest, nevertheless, rather on ingenuity than fact as long as the information improvement is on matters concerning each person more or less equally, such as is the case in a well organized futures and spot market.

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*Public information herein means information made available in readily accessible and understandable form to everybody at the same time, at little or no direct cost.

There are four attributes to each commodity transaction and its price: quantity, quality, time and place. No commodity price makes sense without stating -- explicitly or implicitly -- each of these four attributes. Yet in the discussion of world food problems, attention focuses too readily on but one of those attributes: quantity. Remote sensing systems can improve information -- and hence lead to benefits -- in all four areas: how large are crops in fact, when can they be expected, where are they located and, possibly at some future time, what is the quality of the crops? As information is improved on any one of these attributes -- or a combination of them -- price differences now observed over time and across different areas (countries, regions) will be narrowed through the workings of the commodity market. This market is most precisely developed in food commodities, spot and futures, and hence it lends itself to an empirical investigation and measurement of the value of information improvements through changes in expected price patterns.

How little is known about future supplies of commodities today is best reflected by the violent movement of wheat prices over the past several years. Movements in the price per bushel from $2 to $6, to $4, to $6, to $3 all within a few dozen months (as shown in Figure 1.2), are but one very direct expression of this uncertainty and lack of information.

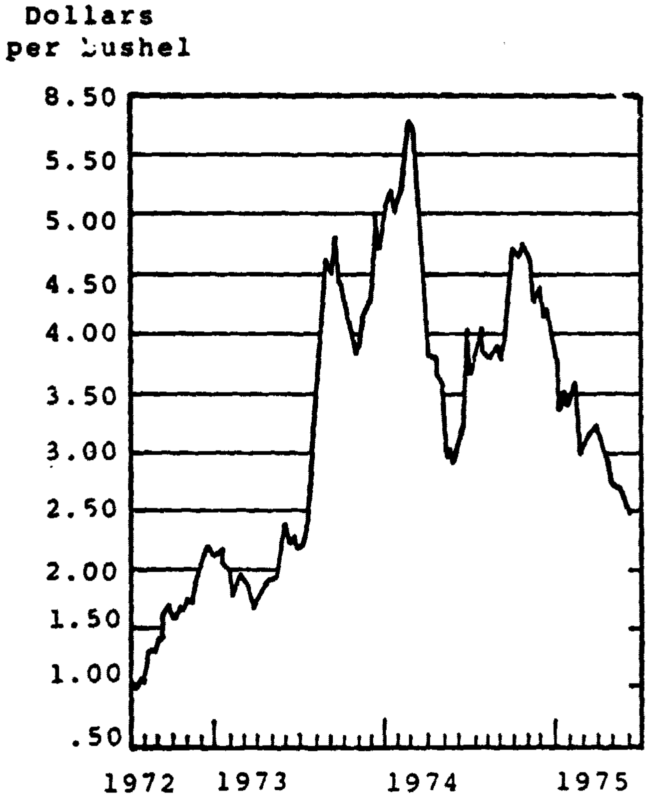


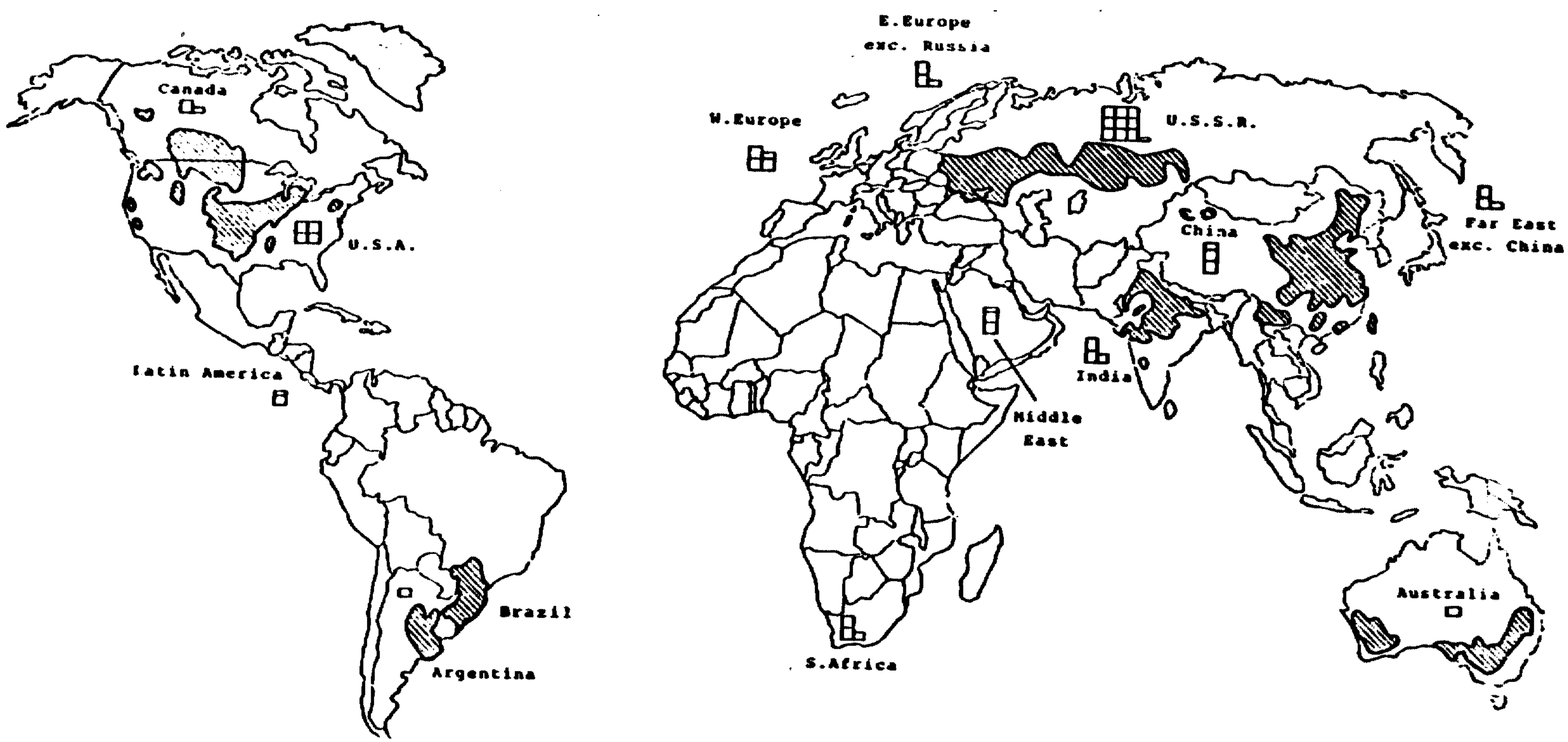
Figure 1.2 Wheat Price Movement, 1972-1975

To date, worldwide crop measurements are heavy with errors and they are late, if available to all. Improved accuracy and timeliness of worldwide crop measurements may, on the average, improve the ability of famine-prone areas to prepare for harvest shortfalls months in advance of their current capabilities and eliminate, or at least reduce the suffering that otherwise would have occurred. Similarly, improved worldwide crop monitoring would give all trading partners a clearer picture of the market and reduce the frequency and amount of waste owing to inaccurate information among the market participants. Short of involving the specter of starvation, improved crop information may lead to a closer worldwide agreement of spot prices where any difference in spot prices between regions may be interpreted as an economic measure of existing inefficiencies in distribution of crops and <u>relative</u> scarcities.

To appreciate the potential for such a worldwide system, consider the 1974 world food situation as of July 1, 1974 -- a more or less recurring situation in recent years. At that time, the expected world food grain crop was 710 million metric tons, assuming that all the harvests came in without a serious shortfall. However, there was considerable uncertainty surrounding the 1974 harvest at that date. Over 100 million metric tons were in jeopardy and most of it could not be monitored regularly, if at all. The major areas of uncertainty were North America between 112°W to 95°W and 45°W to 55°N; U.S.S.R. between 65°E to 90°E and 45°N to 57°N; China between 110°E to 125°E and 40°N to 52°N; and India, where the timing of the monsoon and its location posed a serious threat. Improved knowledge of the world grain crops at that time could have led to improved distribution of existing and expected supplies in several ways.

Among the measures proposed to deal with such uncertainties is the creation of a world food fund (then proposed at 10 million metric tons), and the use of futures contracts to hedge against a large shortfall. But that food fund -- however large -- has to come from somewhere too! The information necessary to coordinate the acquisition and distribution of world food funds is lacking too. One result of this imperfect state of knowledge is a wild fluctuation in wheat prices.

In Figure 1.3 the major wheat growing areas of the world are shown. The areas shown in Figure 1.3 are very large and extensive. Foremost among them are the Soviet Union, the United States, China, Canada, Australia, India and Argentina. Two of these regions are in the Southern Hemisphere: their production cycle is "out-of-phase" with that of the Northern Hemisphere. Thus, worldwide wheat harvesting occurs in several seasons. Moreover, there are



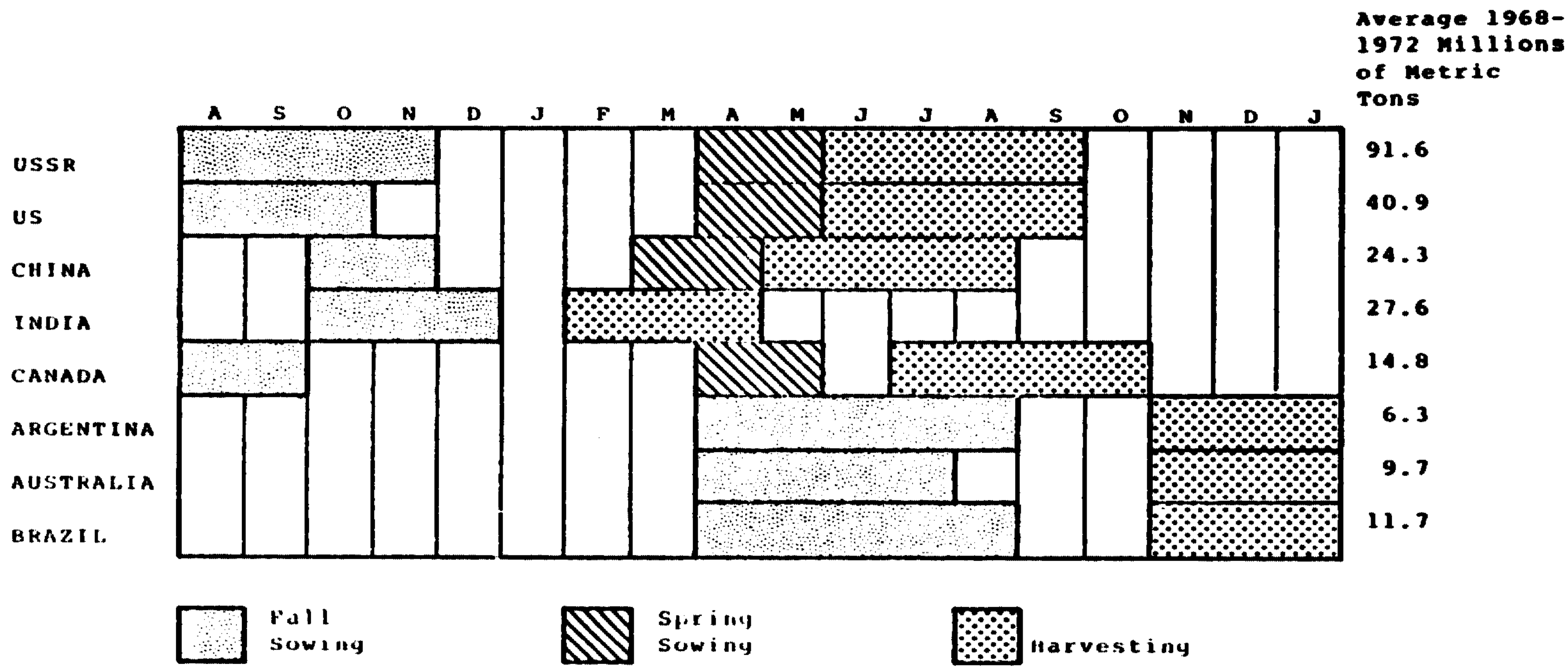
Legend

□ = 10 million metric
tons of wheat production

Figure 1.3 World Map of Wheat Production: Major Producing Areas important time differences even within the Northern Hemisphere in the agricultural crop calendars for wheat (plowing, sowing, growth and harvesting) depending on the region and the type of wheat (e.g., winter wheat, spring wheat). In Table 1.1 these times are shown by major region and by month for 1974. Thus, world wheat production is a continuous, dynamic process, ideally requiring a measurement system able to deal with continuous, large-scale, worldwide changes. To measure these areas, worldwide, with sufficient accuracy and in a timely fashion is a very "natural" application of space systems.

The promise, therefore, is to increase worldwide crop monitoring capabilities by a sizeable factor. At this time, NASA is experimenting with earth resource satellite systems (LANDSAT) that may be able to provide monthly monitoring of worldwide crop production with accuracies well beyond those of the information sources available today.

Based on Morain's [6] winter wheat experiment for NASA and other principal investigator results to date, a reasonable LANDSAT goal is a total year-end estimation error of 1-2 percent for the United States and 5 percent for other world regions. This level of accuracy represents an improvement over current USDA capabilities. The worldwide accuracy improvements promised by LANDSAT are substantial.



1968-72 Production
Millions of Metric Tons; World
Total = 417

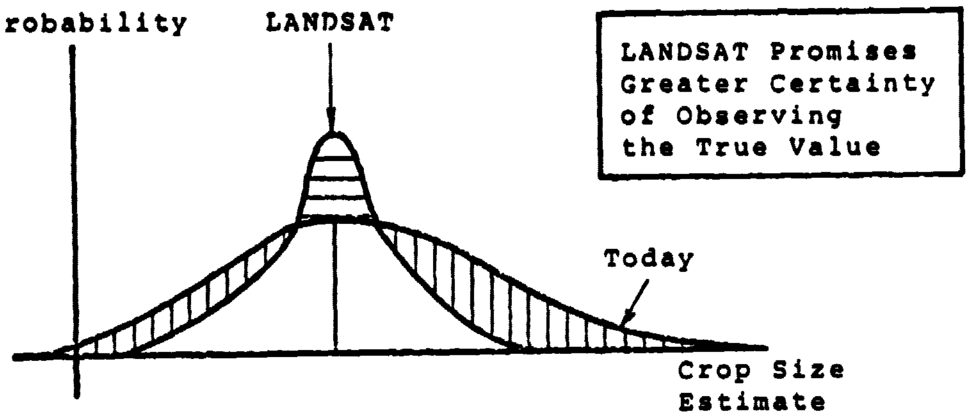
Table 1.1 Wheat

The ultimate question of course is how much is this accuracy improvement worth.

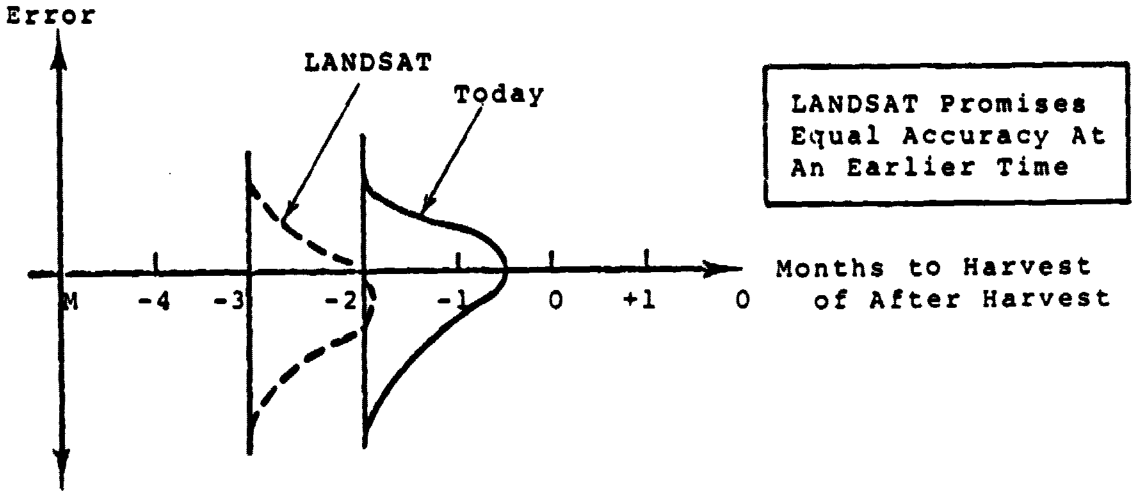
1.4 Information, Prices and Benefits

Information on agricultural crops as used in this study is simply defined as statements (estimates) of the quantity (to be) harvested, in each time period, by region. Each of these statements has a date and error associated with it. If such statements have been made over a long time, and consistently on the same region, it is possible to measure the accuracy ("goodness") of that information in terms of an error distribution that shows how close these statements come to the true crop, and whether the expected value from all these statements actually is the true crop quantity.

Improved information may be viewed as crop estimates (at the same time) that show less widely dispersed errors about the "true" value. This is illustrated in the upper part of Figure 1.4. Also shown in Figure 1.4 is the observation that estimates with the same error distribution, but one or two months earlier, may also be of value, since the error distribution within this period will be substantially reduced. Indeed, under certain conditions, "earlier" and "more accurate" crop estimates are equivalent statements. The measurement of the value of improved information somehow has to quantify in dollars and cents the effect of this reduction in dispersion of crop estimate errors.



Error Variation At A Point in Time



Error Variation Over Time

Figure 1.1 Types of Potential LANDSAT "Improvements" In Crop Production Information

The value of improved information -- the subject of this study -- is a timely and difficult topic. While economic theory and practice have successfully dealt with topics such as the value of apples and oranges, (i.e., physical commodities) information, and the value of information, have not been treated so successfully in the economic literature.

The basic difficulty of coming to grips with the value of information can be reduced to two basic reasons.

(1) The cost of gathering information has sometimes little, if anything, to do with the value of the information thus gathered. A few telephone calls -- e.g., those of "John Smith" of Russian Wheat Deal fame in 1972 -- can mean many millions of dollars in gains. On the other hand, lengthy and greatly expensive efforts at the systematic gathering of information sometimes -- or often -- lead to few if any tangible results. (Foremost among the latter enterprises one may well classify the "China watchers" of the 1960s.) Yet, in a very loose sense, even here one may say that in the long run the expected value of information generally ought to offset the very immediate, and more certain, costs.

(2) Information, once obtained, is difficult to "market," that is to restrict the beneficiaries of information to that select group that paid for the information and thus generate enough revenues to cover the cost of gathering the information. It is difficult to keep information "secret,"

i.e., to exclude nonpayers from its benefits. Nor is it clear that such secrecy is in the national economic interest. (Quite the contrary is true for crop information, as we will see!) The reason for this latter state of affairs is the low cost of reproducing (distributing) information once it is obtained. Today's technology is particularly apt to bring this about.

Given the low cost of information distribution vs. the often very large cost of gathering the desired information, the market and the economists are faced with a dilemma: (1) The low incremental cost of distributing information does not allow the private enterpreneur to recover this investment for gathering the information; e.g., in the case of crop estimates using a LANDSAT system, the annual systems cost may be anywhere from $20 to $60 million a year, while the reproduction of those estimates may cost 5¢ to 10¢ a copy. (2) On the other hand, economics of efficiency -- and the public good -- clearly indicate that the information should be distributed at its marginal (incremental) cost to derive the largest benefits to society.

While patent law, copyrights, etc., try to deal at least in part with this dilemma, it nevertheless is all too easy to destroy such legal paramonopolies when the value of information greatly exceeds its cost of reproduction and, furthermore, when the public good thereby is increased.

Given these observations on the value of information and the market, the difficulty faced by economists in dealing with information -- and the measurement of its value -- is understandable. The task is furthermore confounded when the requirement is imposed that the information be made public to all; i.e., not limited even to the United States.

The complexity of the task is reflected in the intuitive question: "How can there be value to information if everybody knows about it?" Although the answer is far more difficult to state than the question, one of the appealing insights of this study is that when information is not published it will have no value to the nation -- or very limited value at best. Some insight into the latter statement can be obtained from the recent past.

In the past several years prices for wheat have fluctuated by unusually large amounts. This in part is a reflection of the increasingly tight world food situation and a very incomplete state of knowledge of what the world food supply actually is (demand for food being rather continuous and predictable). What influence -- in principle -- improved information could have had on recent wheat prices is shown in Figure 1.5. Herein we reproduce the wheat history of 1972, the year of the "great" Russian Wheat Deal. If through some mechanism, e.g., LANDSAT, one had known in May what everybody knew by September, namely the dismal situation of

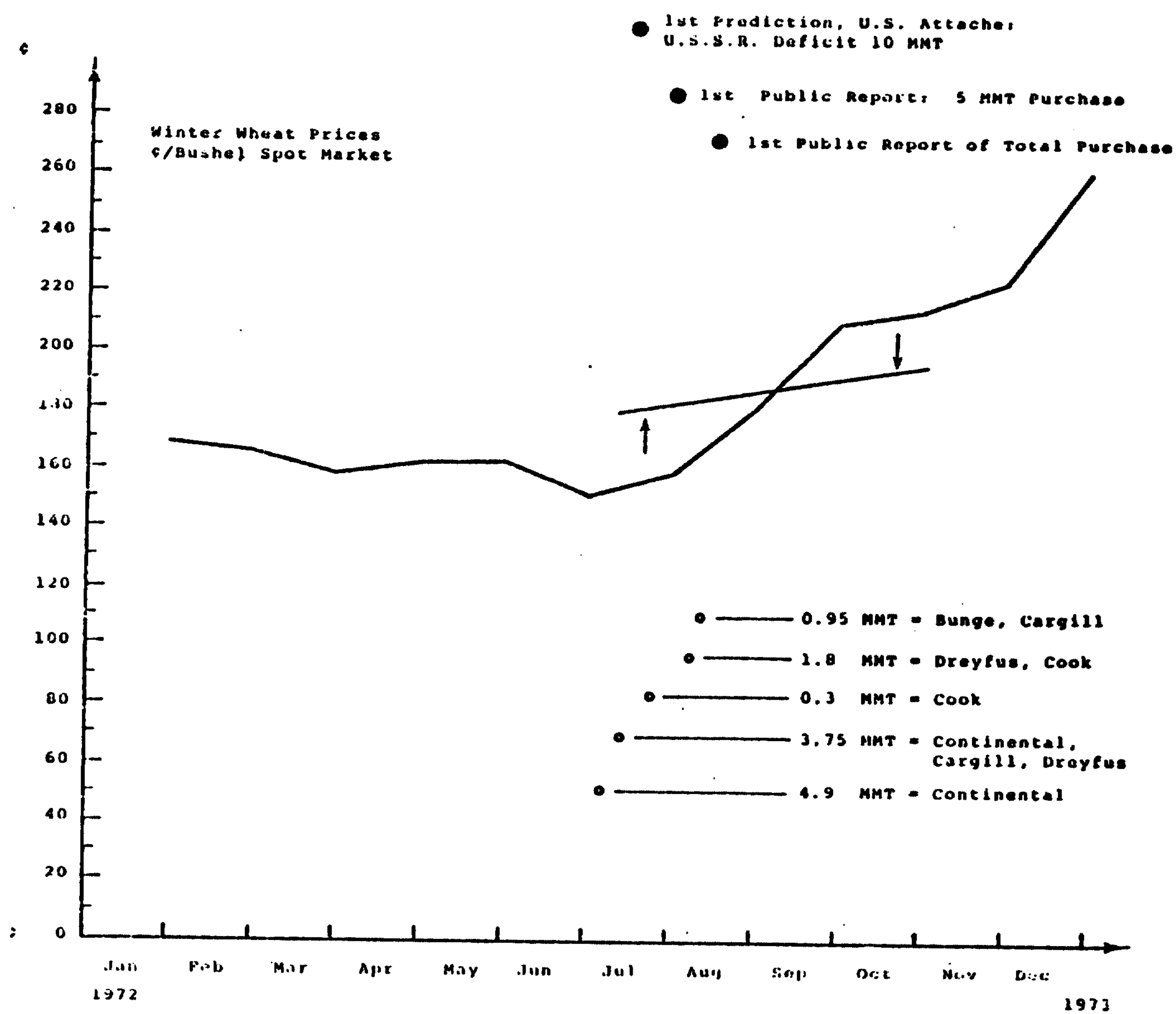


Figure 1.5 An Example of the Effect of Improved Information: The 1972 Russian Wheat Deal

the Russian grain crop that year, then two price effects would have set in: (1) prices in May, June and July would have risen above the historical prices, and (2) prices in August, September, November, etc., would have risen less than the historical prices. That is to say, improved public information would have led to price smoothing effects over time. The full economic impacts of such a change in wheat prices would have been considerable: exports in the early and later months would have been different in quantities and prices transacted, inventory decisions (on the farms and off the farms) would have changed, and so would industrial and feed use of wheat. With regard to international trade, it is likely that at a higher world market price, the Soviet Union would have bought less wheat thus diminishing the full price impact on United States households.

All these myriads of decisions would have been made automatically by the market once improved accurate information entered it in May: there is no economic need to distribute crop information to "final users" once it has been made public -- an often misleading concern in technical investigations on the uses of LANDSAT information -- since commodity markets exist that transmit this information through changed prices.

To state and measure the value of such public information, this study proceeds in two steps:

Step 1: Improved public information on agricultural crops will have -- measurable -- price effects.

Step 2: The measured price effects from improved information lead to measurable benefits to society.

This second step one could accept at face value -- based on the history of economic thought -- but for two reasons. First, one needs to balance the cost of improving information with the benefits derived from this information. Secondly, the erroneous belief is still widespread -- and sometimes put in writing -- that improved information, world-wide, is harmful to the United States. This would be quite a startling discovery, going not only against hundreds of years of economic thought and doctrine on the workings of free markets but, beyond that, it contradicts the history of 1972 which still should be fresh in our memory.

This question often has been reversed: if the United States were to gain from LANDSAT information, does that imply that other regions and countries will be harmed thereby? The answer, of course, is no! On the contrary, the gains of other countries may be larger -- in proportion -- than those of the United States. Most economic transactions and events are of this type, foremost in international trade, but also, of course, as regards improved public information.

1.5 Scope and Methodology

The overall approach -- or logic -- of this study is depicted in Figure 1.6. First, the accuracy profile of crop information is measured for different length projections. This information then is traced through the market where it helps determine today's prices. These prices of course are determined jointly with flows of quantities by the many participants in the commodity (wheat) markets. Improved (LANDSAT) information then is introduced into the commodity market, leading -- if relevant -- to new flows and different prices. The changes in flows and prices owing to improved information are then used as the basis for measuring benefits to society, e.g., the United States and individual sectors, e.g., farmers, inventory holders and consumers.

Our practical aim is to structure an analysis of benefits from improved crop information (wheat) in such a way as to satisfy our goals without introducing order of magnitude errors. With this as our principal operating thesis, we have adopted the following conventions and operational constraints.

First, an empirically detailed benefits analysis is made only for wheat. Substitution effects for other crops are included in the analysis however.

Second, benefits are estimated for the United States and for the aggregated rest of the world.

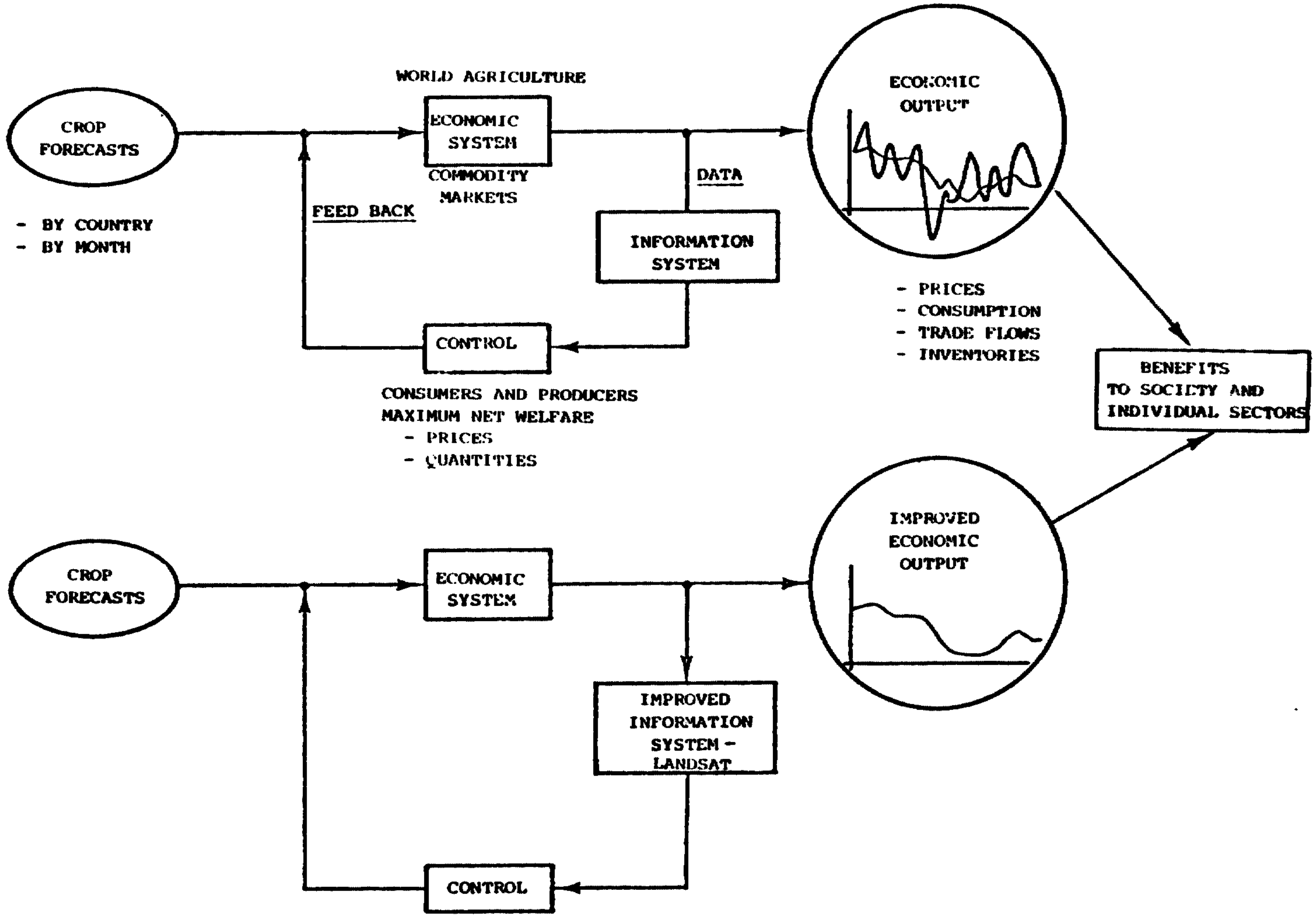


Figure 1.6 Effects of Improved Crop Information

Third, benefits are separately assessed for consumers and producers in the United States.

Fourth, the "futures" market is treated as a world market.

Fifth, wheat is treated as a homogeneous commodity.

Sixth, ERS information will be made publicly available in the same final form as current commodity information through the same distribution network.

Seventh, benefits to regions and economic groups are based on rational, i.e., profit-oriented, economic behavior.

At the heart of this study there are several major methodological issues. They are:

- Identifying the costs or losses owing to inaccurate information to consumers, producers, inventory holders and societies.
- Identifying the benefits for different groups and regions.
- Measuring the effect of improved information on prices.
- Empirically estimating the market impulse response coefficients in the U. S. and other markets for wheat (i.e., quantifying the relevant elasticities).

1.6 Organization of the Study

The organization and flow of the study are shown in Figure 1.7. The study is divided into three parts; in each of the three parts separate analytic efforts were carried out. First, current wheat crop statistics and likely improvements are analyzed; secondly, the effect of this improved information on world wheat markets is studied; thirdly, benefits from changed prices, quantities and trade flows are assessed.

There are four chapters and a set appendices in the main report. Chapter 1 presents a slightly more technical version of the Overview volume.

In Chapter 2 the technical and statistical characteristics of current wheat crop estimates -- for major world regions -- are set forth, as well as the potential improvements -- assumed for this study -- of an Earth Resources Survey system of the LANDSAT type. The assumptions used for these potential improvements are based on the technical goals expressed in current research and development efforts -- foremost, the Large Area Crop Inventory Experiment of NASA -- as well as an intelligent interpretation of results of LANDSAT investigations to date.

From these foundations, a structural model of the world markets for wheat is presented in Chapter 3. The world markets for wheat are described and structured with careful review of the parameters and factors central to the benefits assessment. First, the economic characteristics of the various economic regions, the principal factors influencing

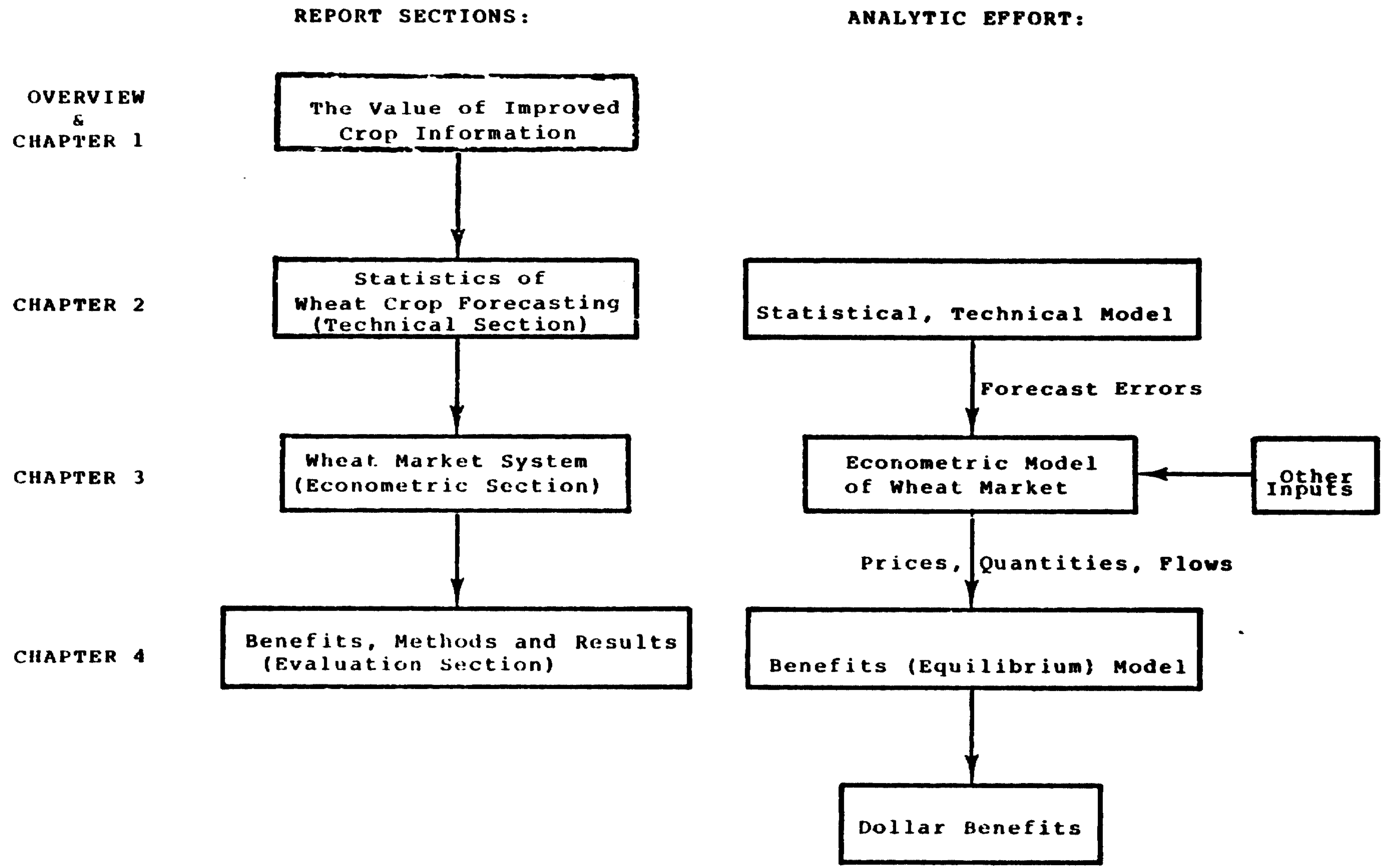


Figure 1.7 Study Flow and Organization

trade and the analytical and empirical heritage of our modeling effort are described. Then the relationships describing the actions of the consumers, producers, inventory holders, speculators and hedgers in wheat world trade are set forth. Finally, the linkages between the various components of the full model and skeletal framework of its numerical solution are presented.

The empirical quantification of the world markets for wheat and the results of the benefit measures are presented in Chapter 4. First, the estimated relationships and the estimation strategy are described, and then the empirical results are given. The benefit estimation model and the results are then reported. Included here are estimated total benefits to the United States along with their distribution patterns between consumers and producers. Benefits to the rest of the world also are presented.

In a separate appendix the foundations of crop information are described. It is supplementary to information contained in the main report.

1.7 Results of the Benefit Study

1.7.1 The Long-term Benefits

A national, United States decision on the merits of a worldwide LANDSAT system providing improved wheat crop measurements has to be based on the long-term, lasting benefits to the United States from such an investment.

The assumed performance of a worldwide LANDSAT system in this study is to provide 90 percent wheat crop estimates, with 90 percent confidence, from the time when the crop is mature until harvest is complete in each of the eleven wheat regions. No information improvement was assumed for China. These "percentages" translate roughly into a 1.9 percent standard error in the December United States wheat crop estimate and 5.0 percent for the rest of the world. While this performance may seem very modest, in fact such a worldwide capability is a significant improvement upon what is known today on wheat crops. Using these performance standards as inputs to the AGR-ECON II wheat commodity model, indeed significant impacts from such information have been measured.

The principal long-term effects of such information are first, a reduction in the fluctuation of wheat prices; i.e., increased price stability and second, a lowering of the average wheat price by about six to seven percent.

These price effects result in -- and in turn explain -- the following other economic effects: United States wheat consumption will increase by about 14 million bushels a year, United States wheat exports will significantly increase by about 361 million bushels a year; United States consumers will spend about $250 million a year less on the wheat consumed (directly or on wheat products) and United States suppliers of wheat (farmers, inventory holders, distributors, exporters) will save about $280 million a year net in production costs. However, after allowing for the slight drop in the average wheat price level they will experience an average net loss of $113 million.

The total export revenue to the United States will increase by a net of $334 million a year -- where the gains from the increased export volume of 361 million bushels are offset, in part, by a $293 million loss on United States wheat exports from the new, lower average wheat price.

These joint effects of improved information on the United States wheat economy are shown in Figure 1.8. United States demand for wheat, prices of wheat in world markets before and after improved LANDSAT information, the cost of wheat produced -- including risk and uncertainty -- and United States wheat exports to the rest of the world are shown in simplified form. All these variables change simultaneously and by significant amounts. The long-term benefits to United States society are listed in Table 1.2.

It goes without saying that each of these benefit estimates has some uncertainty attached to it, and the gains in each particular year -- and for each region -- can be much larger or smaller, depending on that year's events (weather, economic conditions, trade policies, among others). For example, the computer analyses done by ECON to date show the total United States gains ranged from a low of $42 million to a high of $331 million. The estimated benefits for the United States and the rest of the world are the expected long-term gains.

1.7.2 Short-term Effects and Benefits

The introduction of improved wheat crop information leads to important short-term effects immediately after the

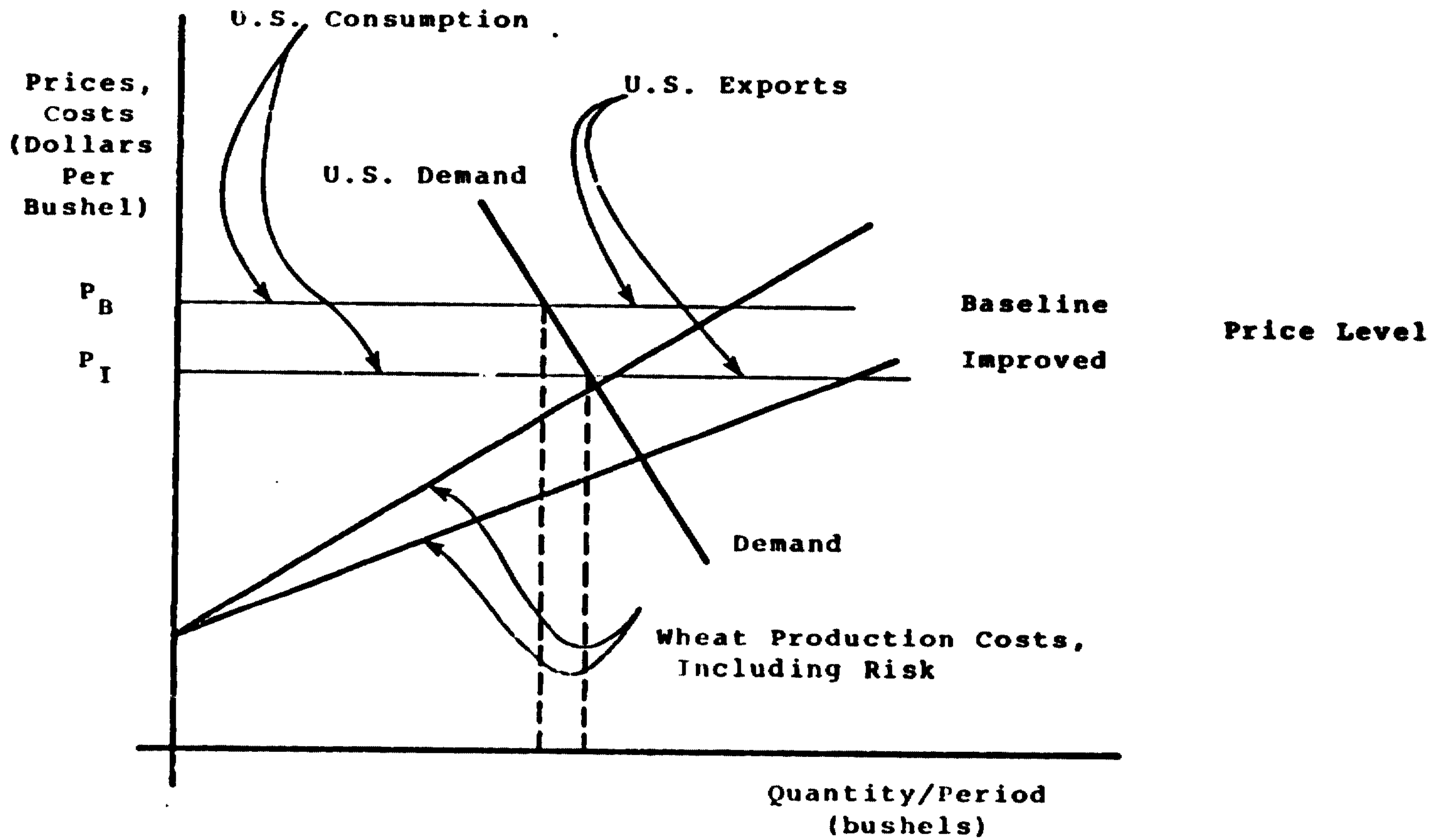


Figure 1.8 The Principal Long-term Effects of Improved Wheat Crop Information on the United States

Table 1.2 Long-term Annual Benefits from LANDSAT Wheat Crop Information

	Benefit, in Millions of 1975 Dollars
United States	
Consumers Gains	$287
Net Supply Losses	-113
Total U.S. Benefits	$174 million
Net Gain in U.S. Wheat Export Revenues	$334 million

initial worldwide operations capability of a LANDSAT system. Some of these effects are one-time and unique. Futures prices will be affected first with spot prices following a few months behind. Both futures and spot prices level off after the initial twelve months of introducing, region-by-region, improved wheat crop estimates. From then on, wheat prices show less volatility, at a lower average price level, leading to the long-term benefits listed in Section 1.7.1.

1.7.3 A Reconstruction of 1972: The Year of The Russian Wheat Deal

The AGR-ECON II wheat commodity model was used to reconstruct the likely price changes -- month-by-month -- for 1972, in one without a LANDSAT system (baseline series) and then with a LANDSAT system. The results of the price changes between the two series are shown in Figure 1.9: while the historical prices began to move only after most of the wheat export contracts were signed between the respective parties in July and August of 1972, improved public information would have led to substantially earlier price rises, beginning in May of that year and persisting through July 1972. While the Soviet Union would have benefited from earlier, more accurate wheat crop information, so would the United States and all other participants in world commodity markets -- without unfair gains or losses, real or perceived, by the countries involved. Among other things, with the earlier movement of wheat prices in commodity markets, the Soviet Union would have contracted for fewer wheat imports, leading to lower world wheat prices in the last part of 1972.

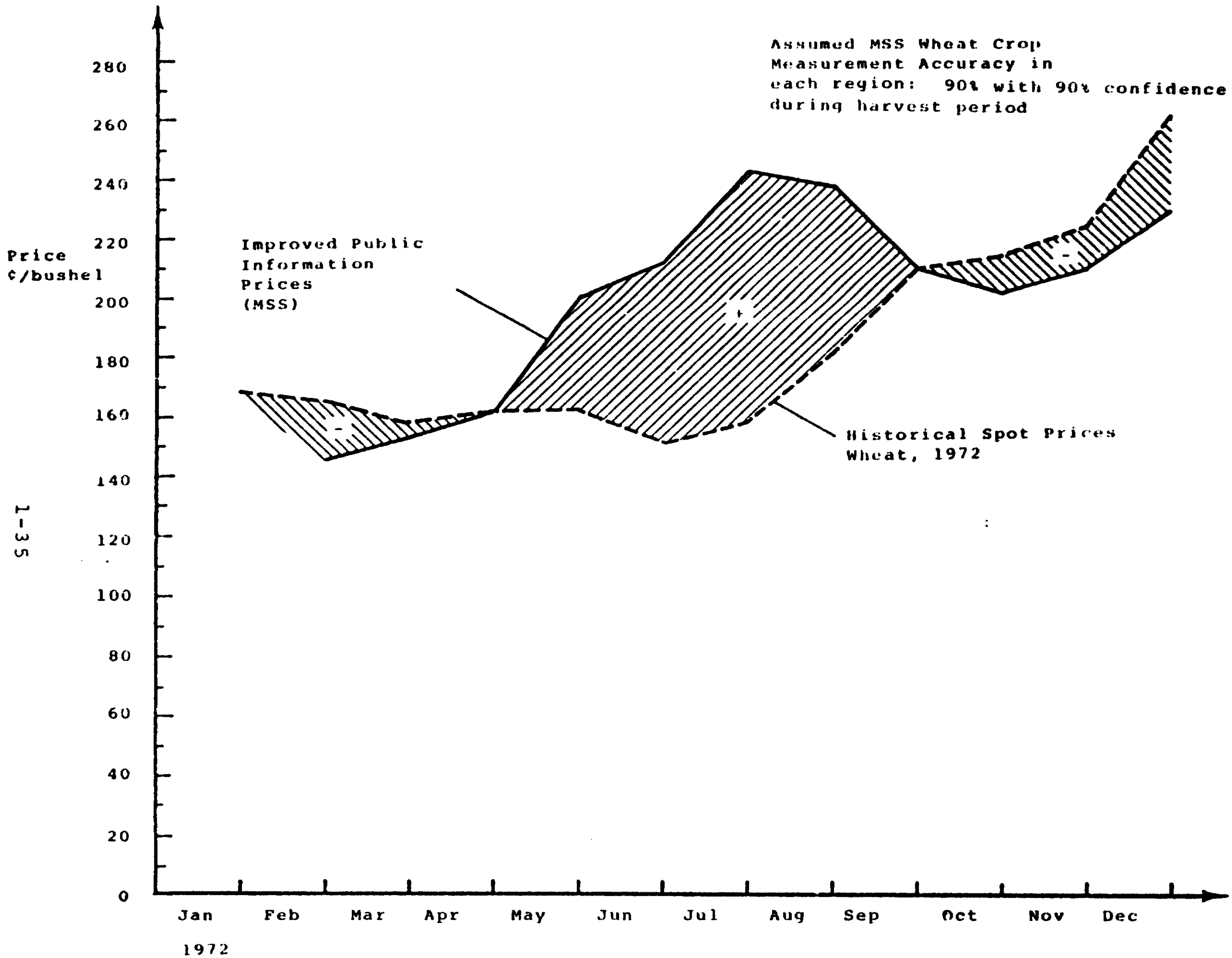


Figure 1.9 Historical vs. Improved Wheat Crop Information Price Series, 1972 (ARG-ECON II Model)

Consumers in the United States and other world regions would have been affected less.

Would the Soviet Union have gained from improved, earlier information in 1972? Most certainly yes, since the gains to the Soviet Union in the production and distribution of its <u>domestic</u> crop (more than twice that of the United States) would have outweighed by far the loss on the import deals which the Soviet Union would have had to transact at higher wheat prices. The benefits to the United States from such objective, early and improved information would have been substantial in 1972.

In summary, improved public information on worldwide wheat crops will substantially benefit the United States <u>and</u> the rest of world. It is important to note that the information improvements due to the LANDSAT-MSS assumed in this study occur <u>mostly</u> outside the United States, in the rest of world. The information derived from LANDSAT is assumed to be made available to all countries at the same time, on a non-discriminatory basis, similar to present practices of the Statistical Reporting Service of USDA.

The quoted annual United States benefits of $174 million are expected long-term benefits from wheat crop information. These have to be compared to the "annualized" cost of a three-satellite LANDSAT system of about $62 million.* The benefit

*<u>The Economic Value of Remote Sensing of Earth Resources from Space: An ERTS Overview and the Value of Continuity of Service, Summary</u>, ECON, Inc., December 1974.

numbers are subject to further verification. The benefits listed are more sensitive to changes in economic and technical variables than are the relatively certain costs. The long-term annual benefits listed herein might well be realized by 1985 if the United States were to decide in the near future on the deployment of such a system.

In conclusion, accurate, worldwide wheat crop information using space systems is likely to have a stabilizing influence on world commodity markets, in part making possible the establishment of long-term stable trade relationships. While some may fear such public knowledge -- this might be the very basis of making expanded agricultural trade possible. In this regard, the effect of improved objective information on agriculture markets is potentially similar to the stabilizing effect that information gathered from space has in strategic areas.

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