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LINKAGES BETWEEN AGRICULTURAL TRADE AND RESOURCE QUALITY: A CONCEPTUAL OVERVIEW

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Prepared for the U.S. Department of Agriculture,
Economic Research Service

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INTRODUCTION

This overview is organized around two main themes. The first is a version of the induced innovation model. It considers the impact of land and water quantity as well as quality on the international competitiveness of U.S. agriculture. The second is a derived demand analysis, focusing upon how export demand for U.S. agricultural output is linked to the demand for agricultural inputs.

The overall perspective of the paper is that the growing "openness" of U.S. agriculture has caused agricultural trade to become increasingly linked to both the quantity and quality of domestic agricultural inputs employed, and to the market (and shadow) prices for these inputs. Critical inputs include land, water, fertilizer, and the labor/capital mix, each of which directly affects environmental quality.

When agricultural export demand is strong in an open, trade-dependent economy, demand also increases for these inputs. This intensifies agricultural production and often stimulates concern about soil erosion and water quality. Restrictions on the use of these inputs on behalf of environmental quality can raise the private costs of production, creating differential costs in countries with strong as opposed to weak environmental regulations. On the other hand, when export demand is weak, declining input demand puts downward pressure on profits in the input supply sector. This stimulates efforts to reduce inventories not only of surplus output but also of surplus inputs in production, notably land. In these circumstances, a key issue concerns which lands are to be retired, because if productive lands are removed while unproductive lands remain in crops, competitiveness is further reduced. There is evidence that the structure of current commodity programs, as well as specific environmentally targeted efforts, such as the Conservation Reserve Program (CRP), are not encouraging crop production to shift onto our most productive, least erodible acres.

Because U.S. and European environmental regulations have strong domestic constituencies, it is unlikely that the environmental regulatory climate will be substantially weakened in the name of agricultural competitiveness, even if export demand and farm prices remain depressed. Therefore, future agricultural policy should explicitly link environmental policies directed at land and water use and quality to objectives of export competitiveness. This will require, among other things, targeting land retirement policies by land category. If successful, this effort can improve both agricultural productivity and environmental quality, and will promote true comparative advantage, rather than the environmental equivalent of "beggar-thy-neighbor" trade policies.

OPENNESS AND INSTABILITY IN THE AGRICULTURAL SECTOR

In recent research, we uncovered an apparent puzzle: while instability of international prices has remained essentially constant from year to year during the 1970's and 1980's, instability in U.S. farm prices and incomes has increased substantially (Houck, 1986, Myers and Runge, 1985). This runs counter to the view that instability has increased in the international marketplace, leading, in turn, to increases in domestic price and income instability.

International price trends for wheat, corn and soybeans over the period from 1965/66 to 1984/85 show no significant upward trend in price instability for any of these commodities, no matter how one treats the aberrant price fluctuations of the early 1970's. Average percentage price changes have been substantial, but these year-to-year changes do not seem to be significantly greater (or less) at the end of this period than at the beginning. Over the entire 20 year period, yearly price changes in wheat averaged 9.4 percent; in corn (maize) 10.5 percent; and in soybeans 13.9 percent. Appendix 1 shows yearly data together with trend charts and an analysis of variance for situations including and excluding the aberrant price movements of 1972/74. Regardless of whether those years are treated as outliers or not, no significant upward trend in price variability is revealed.

This year to year variation provides a slightly different perspective than comparisons made over longer time periods. In a recent analysis, for example, Sutton (1987) compared the percentage change in export wheat price variability over the entire period 1960-72 with the entire period 1973-84, using the coefficient of variation around the period average (mean) or CVM, as a basis. Export prices for both periods were calculated as free-on-board (f.o.b.) for Argentina, Australia, Canada, and the United States. These were expressed in own currencies with the exception of Argentina, which was expressed in U.S. dollars. Sutton found that the CVM measure doubled in all four countries, increasing by an average of from 13.3 to 25.7 percent.

This finding is not inconsistent with the findings of Houck, however. Since Houck measured percentage changes from year to year, rather than over 10-12 year periods, it is possible for a step increase to occur in the period mean variation from 1960-72 to 1973-84 while year to year changes reveal an insignificant trend. By reducing variations over the two periods to single-valued averages, information is lost that may be reflected in yearly calculations.

At the same time, United States farm price and income instability has increased substantially. In wheat, farm price instability increased by 107.9 percent as measured by the coefficient of variation around trend (CVT) in nominal terms and by 159.1 percent in real terms from the 1960's (1962-1971) to the 1970's and early 1980's (1971-83). In corn, farm price instability increased 176.6 percent in nominal terms and 262.5 percent in real terms over the same period. In soybeans, the nominal increase was 152.2 percent and the real increase 164.0 percent (Myers and Runge, 1984a,b, 1985). All of these increases, calculated for domestic farm prices and income according to Piggot's (1978) method, are highly statistically significant. They contrast with the statistically insignificant year to year changes in international price instability.

These findings are consistent with Sutton's (1987) cross-county comparisons. Sutton found substantial increases in the variability of wheat prices received by United States producers. Using a CVM measure, he reports variation in U.S. prices increasing from 1960-72 to 1973-84 from 7.2 percent to 27.4 percent in real terms, or by a total of 280.5 percent. This compares with 42.2 percent in Argentina, 57.8 percent in Australia, 65.4 percent in Canada, and 35.6 percent in France. Using the CVM measure as well as the number of reversals in wheat price direction, Sutton concludes: "Both variability measures strongly suggest that U.S. producers were subject to a greater rise in price variability than producers in any other country." Despite the different approaches taken by Houck, Myers and Runge, and Sutton to measure international price instability, all find unambiguously that domestic U.S. price variation has increased substantially more that international price variation from the 1960's to the 1970's and 1980's.

When the sources of United States domestic instability were divided into supply and demand side components, clear shifts in each market in the direction of increased demand side instability were found over time. These shifts were relatively insensitive to demand elasticity assumptions, ranging from -0.3 to -1.1 (Myers and Runge, 1985, pp. 73-74). It is inescapable that most of the United States demand shifts during the 1970's and 1980's originated from the export rather than the domestic component of demand. Moreover, supply interruptions, such as those caused by weather, are of lesser importance as a cause of instability in this period than popularly assumed (Myers and Runge, 1985, p. 76).

One plausible interpretation is that instability in the international marketplace has increased less than in the United States marketplace due to the changing structure of the U.S. farm economy and U.S. agricultural policy. Increased "openness" resulting from increased agricultural trade dependence can cause a greater proportion of international market instability to be reflected in domestic farm prices and incomes (Schuh, 1983). This interpretation is supported by the increased proportions of U.S. wheat, corn and soybeans traded internationally. From 1962-1971, an average of 49.5 percent of U.S. wheat, 13.0 percent of U.S. corn and 31.1 percent of U.S. soybeans flowed into international trade. By 1971-1983, this proportion had increased to 58.4 percent for wheat, 27.0 percent for corn, and 39.4 percent for soybeans. In addition, adjustments in U.S. farm commodity programs have permitted U.S. farm prices to reflect world market conditions more fully in recent years. Additional specialization in export crop production occurred in U.S. agriculture, further strengthening the link between international markets and the domestic farm economy. The land area planted to wheat, corn, and soybeans increased 54% between 1970 and 1981. Furthermore, the proportion of total U.S. farm production value accounted for by these three export crops increased from 16% to 24% in the same period, a 50% expansion.

The increased openness of U.S. agriculture to international instability, especially to fluctuations in demand, has had both positive and negative effects. It benefited U.S. farmers as world demand strengthened relative to supply in the 1970's because the United States is a large contributor to total world grain exports. However, as weak demand and oversupply developed in the 1980's, falling purchases of U.S. grains were directly reflected in decreased U.S. farm prices and incomes.

In addition, this openness has affected the demand for farm inputs derived from production of grain crops, including land, water, fertilizer, and the capital/labor mix. It is the derived demand for these inputs in an open trading environment that explains the linkage from international trade to environmental quality. In order to explore these linkages in greater detail, we use the induced innovation model.

INDUCED INNOVATION, FACTOR ABUNDANCE, AND ENVIRONMENTAL QUALITY

Induced innovation in agriculture includes the impacts of technology on environmental quality. The induced innovation hypothesis (Hayami and Ruttan, 1985) may be extended by arguing that agricultural technology change often affects the *quality* of factors of production such as groundwater or soil fertility (Runge, 1986). Irrigation technology, for example, may affect groundwater quality once adopted. A central problem is the private market's inability to reflect the scarcity value of these environmental quality characteristics. These missing markets may also be complicated by concerns about equity and distribution (Runge and Myers, 1985). In either case, there is an incentive to innovate nonmarket institutions (including regulations) which more accurately reflect the implicit values of land or water quality. Institutional innovations affecting factor use in agriculture thus evolve in response to the environmental impacts of technological choice. In this paper, these issues will be explored using groundwater regulation as a case in point.

An important stimulus to the evolution of regulations affecting water quality is that environmental amenities are a bundle of characteristics which is more highly valued as incomes increase (Ruttan, 1971). This means that in high income countries, institutional innovations, such as the United States Clean Air and Clean Water Acts, will probably occur. They will then impinge on factor prices and, thus, on technical choice in agriculture. In poor countries such innovations are not likely to occur. The tendency of high income nations to attach more value to environmental quality, and less to agricultural production, has domestic and international policy implications.

Consider a three-stage model of technological choice in agriculture. The first two stages involve, (1) the choice of technology and, (2) the impact of this choice on the quality of factors, groundwater in this illustration. The third stage occurs as changing water quality induces institutional changes which in turn affect the choice of agricultural technology.

Let there be two types of activity. The first is agricultural production using land, water and energy to produce food; the second is consumption. There are two classes of agents: farmers and consumers. Some agents (farmers) are both producers and consumers. Consumers demand food produced by farmers. They also consider the quality of land and water a distinctly superior consumption good. Farmers and consumers may both consider water quality as a consumption good, but farmers also consider it a factor of production. Producer-consumer externalities resulting from this interdependence will be considered below.

In the first stage, relative factor scarcity determines technical choices for producers. As a typical illustration, consider the case of irrigation and its impact on groundwater. In Figure 1, land, water and energy are factor inputs; OO and DD represent the relative abundance (and implicit value) of land and water in two particular times and places; the dotted curves IPC_0 and IPC_1 represent innovation possibilities curves; and isoquants I_0 and I_1 represent particular agricultural production technologies chosen in situations 0 and 1 respectively. The straight line [W,E] represents a fixed complementarity between water and energy. IPC_0 represents the technological possibilities associated with relatively abundant land and relatively scarce water, such as dryland cropping prior to irrigation pumping. The particular technology in use, I_0, is one in a set of possible techniques lying inside the envelope of IPC_0. I_0 is a cost-minimizing technology when it is tangent to OO at point X. With the relative factor abundance prevailing at OO, L_0, W_0, and E_0 are implied levels of land, water and energy used by the dryland cropping technology I_0.

Now suppose that water becomes more abundant relative to land, due to increased underground water extraction, as from the Ogallala Aquifer of the High Plains or from the Central Sands region of Wisconsin during the 1960s and 1970s (Kneese, 1986; MacKenzie, 1983). This change is reflected in the new price line, DD. The change from OO to DD, if correctly

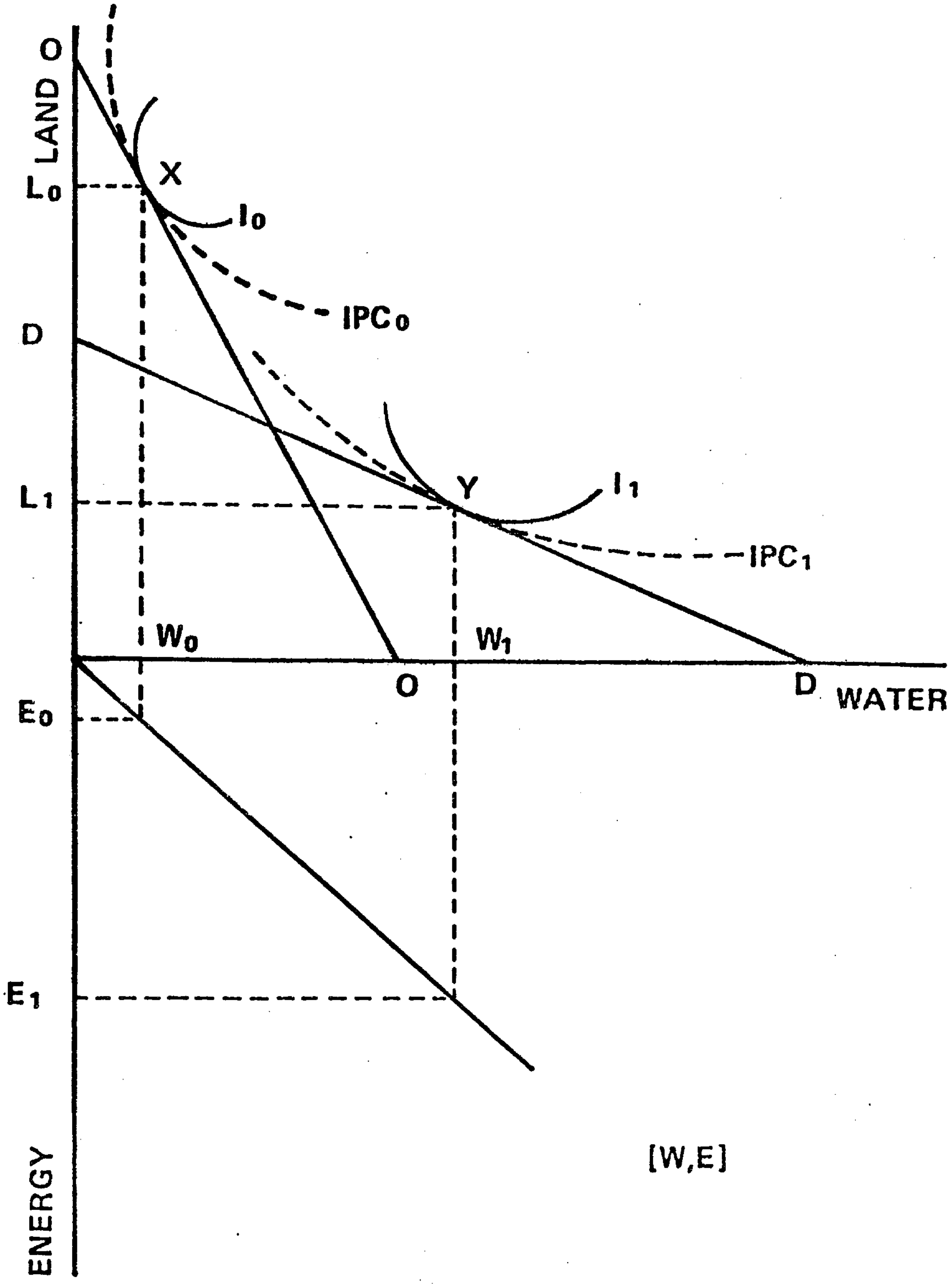


FIGURE 1

INDUCED TECHNOLOGICAL INNOVATION

perceived, stimulates research by agricultural engineers and others into new irrigation technologies, such as center-pivot irrigation, that are water and energy using. This innovation process leads to an inward shift in the innovation possibilities curve from IPC_0 to IPC_1, implying efficiency improvements. Within these new innovation possibilities, the particular technology chosen (center-pivot irrigation) is I_1, at point Y, with L_1, W_1 and E_1 representing the levels of land, water and energy used.

The relative scarcity of land, water, and energy explain research into technologies such as center-pivot irrigation. In the Central Sand Counties of Wisconsin, for example, unreliable rainfall, low water-holding capacity of the soil, high commodity prices, and abundant underground water encouraged research during the 1950s and 1960s into the application and adoption of center-pivots. In 1974 irrigated acreage in these counties was 10 times higher than in 1945, while from 1974 to 1977 irrigation with center-pivot technology increased nationally by only 61.9 percent (Sloggett, 1979).

A second-stage effect of the center-pivot was on water quality for non-agricultural purposes. In Wisconsin, the coarse-grained sandy soils of the Central Sand Counties hold less than one inch of water per foot, and are quite permeable where groundwater is near the surface. While the quantitative abundance of water encouraged irrigated crop production, the soil characteristics contributed to the leaching of nitrate into groundwater sources (Griffin and Bromley, 1981). This leaching contaminated some local water supplies, reducing water quality even though water quantity was unaffected. Although this example is specific, the phenomenon is general: technical choices in agriculture affect the quality of the physical environment. As Saliba (1985) observes, the quality and quantity of groundwater are not separable. This makes appraisal of specific water quality characteristics crucial to evaluating alternative agricultural production techniques.

If consumers demand different quality levels than producers, the impact of agricultural technology on environmental quality may eventually affect the technology chosen by farmers themselves. This recursive effect, leading from consumers' demand for water quality back to producers' choice of technique, can be market driven if consumers' environmental quality demands are reflected in market prices. However, the market mechanism often fails. Such "missing market" phenomena create an incentive to develop nonmarket signaling mechanisms, such as environmental regulations.

Consider the following plausible sequence. Extensive irrigation leads to nitrate pollution of groundwater. Despite continued abundance of water as an agricultural input, declining water quality affects some consumers' health. If consumers' value water quality highly and are willing to pay for it at prices in excess of those reflected in the market, this disequilibrium creates incentives for institutional innovation such as taxes, subsidies, or regulations to restrict groundwater or fertilizer use by farmers. These measures raise the relative factor price of water used in production and cause a fall in its use. If enacted, these measures reduce farmers' incentives to continue water-intensive irrigation even if some downward pressure on land prices occurs in the longer run. New research is stimulated into less water-intensive irrigation techniques, inducing a new round of water conserving technological innovations like drip-irrigation.

This third stage in the induced innovation process can be triggered even if markets for environmental quality characteristics are missing. It can profoundly affect subsequent choices of agricultural technique. Regulations impose costs on producers, altering implicit factor values and inducing subsequent changes in agricultural technology. The range of possible institutional innovations is large and need not include government regulation. The relative costs and perceived equity of various institutional alternatives affecting water quality may lead to arrangements such as local water users associations or quasi-market options (Anderson, et.al., 1983). Thus, changes in the relative scarcity of factors <u>and</u> changes in environmental quality cause technology and institutions to evolve together.

Ruttan (1971) has tied the evolution of public concern over environmental quality directly to income, arguing that a high quality environment is more highly valued as incomes increase. He argues:

> [I]n relatively high-income economies, the income elasticity of demand for commodities and services related to sustenance is low and declines as income continues to rise, while the income elasticity of demand for more effective disposal of residuals and for environmental amenities is high and continues to rise. This is in sharp contrast to the situation in poor countries where the income elasticity of demand is high for sustenance and low for environmental amenities (pp. 707-708).

If environmental quality has a high income elasticity and food (sustenance) has a low income elasticity, two important implications follow. Engel's Law that the demand for food falls relative to other goods as income increases implies that food producers may have less claim on social rents than producers of other goods and services as incomes rise. In contrast, if the demand for environmental quality rises strongly with higher incomes, societal resources may be shifted toward the supply of environmental quality and the technologies which promote it. The interplay of Ruttan's argument and Engel's Law helps explain recent trends in the environmental regulation of agriculture, including groundwater. Ruttan predicts that if environmental quality is not achieved by markets, then higher income countries will have greater reason than poor ones to correct this through environmental regulation.

This suggests, first, that debates over environmental quality characteristics, and remedies for missing markets, will be most intense in high income circles. Second, these debates can be expected to revolve around the political desirability of different strategies to protect environmental quality. Some may favor market or quasi-market solutions; others may prefer regulation. But among high income groups, environmental quality is increasingly a consensus objective. Correspondingly, debate over environmental quality is likely to occur primarily within high income countries such as Canada, Western Europe and the United States. Low income countries will show less interest in the environment than in expanded food output.

From an international perspective, the technological innovations of the 1970s, which responded to increased world food demands, occurred instead of the domestic adjustments which Engel's Law would have dictated had U.S. farmers been producing solely for domestic markets. Yet as agricultural output (and technology) responded to the export market boom, Ruttan's principle was also operating, creating increasing demands for environmental quality. The perception that market forces in agriculture failed to account adequately for environmental quality created support for institutional innovations to regulate agricultural use of herbicides, pesticides, groundwater, and cultivation practices. These innovations generally conflict with the maximum output goals embodied in the "fence row to fence row" dictum.

Environmental quality considerations entered the 1985 Food Security Act in the form of conservation compliance, strict sodbuster language, and the acreage retirement provisions of the Conservation Reserve Program. Such institutional innovations were largely the work of environmental interest groups with new and significant interests in agriculture. Although difficult to measure, it appears that as these groups gained influence, the general farm organizations' overall strength continued to decline. While considerable disagreement remains over agricultural policies, there is a surprisingly strong consensus about environmental quality as a policy objective. Evidence of willingness to pay for improvements in environmental quality through higher taxes is strongly indicated by surveys conducted by Resources for the Future (1980) and others.

In lower income countries, however, the demand for increases in environmental quality seems to take second place to the demand for increases in agricultural output. This is typified by several major agricultural export competitors, such as Argentina and Brazil. Like the United States in its own early period of economic growth and expansion, lower income countries are likely to impose few environmental regulations on their agricultural sectors. One result is that the herbicides and pesticides outlawed in North America and Western Europe are readily marketed in the Southern Hemisphere. (Even so, consumers are increasingly demanding regulatory protection for foreign-grown foods that may be tainted by chemicals outlawed in the United States.) These trends are detrimental both for environmental quality in the Third World and for competing U.S. farmers, who bear the additional costs that higher incomes bring as production technology adjusts to stricter environmental regulations.

In summary, the induced innovation model provides insight into the choice of agricultural technology, the impact of this choice on environmental quality, and the consequent restrictions imposed on agricultural inputs. When interpreted in light of the differential income effects on environmental quality versus food, this process is likely to create stronger regulatory regimes in rich rather than poor economies. The comparative value attached to environmental quality by individual societies may have direct effects on agriculture cost structures and international competitiveness.

THE DERIVED DEMAND FOR AGRICULTURAL INPUTS: LINKAGES TO ENVIRONMENTAL QUALITY

Having considered the impact of choices of agricultural technique on environmental quality, we turn now to the impact of external forces on the valuation of factor inputs in an open trading environment. While export market shifts have been discussed broadly in terms of stresses on agricultural inputs, a more explicit analytical framework is helpful. This is offered by the concept of derived demand.

The producer's input demands are derived from the demand for the final commodity produced. This well-known relationship implies that as agricultural output prices change relative to input prices in response to changes in world markets, profit-maximizing producers will respond by altering land, water, fertilizer, and labor/capital applications. This is because input demand functions are directly related to output price levels. Higher relative output prices lead to increases in input demands at all input prices and vice versa. Hence, increases (decreases) in output demand, if translated to output price increases (decreases) will lead to more (less) inputs demanded at all input prices.

The derived demand relationship, when paired with the induced innovation hypothesis, provides a basis for examining both upswings and downswings in exports and the resulting impacts on input values. However, because environmental constraints affect agricultural factor prices differently in high versus low income countries, and because land is immobile within countries, the relevance of the factor price equalization theorem central to much of international trade theory is diminished (see Leamer, 1984).

In the first stage of the induced innovation model, relative factor abundance determines the choice of technique. Differential factor abundance determines the international distribution of production in neoclassical trade theory as well. Mutually beneficial trade arises <u>because</u> basic production conditions differ from country to country. In empirical analysis, Hayami and Ruttan (1985) show that the historical development of agricultural technologies in Japan and the United States reflect the relative abundance of labor in Japan, and land in the United States. In a recent econometric survey, Leamer (1984) finds that land area together with literate labor are the two major factor inputs associated with exports of cereals and textile fibers worldwide. The United States is by far the major exporter of these products, and the statistical analysis identifies land as a "clear contributor to comparative advantage in cereals" (Leamer, p. 257). Overall, Leamer argues that adequate explanations can be derived for comparative advantage in the crops and raw materials, but large question marks surround that for manufactured commodities (p. 115).

Hence, there is relatively strong historical and econometric evidence to indicate that agricultural sectors develop technology which is biased in favor of abundant factors. Since U.S. agriculture is a sector with increasing exposure to international trade over time, we expect that the demand for heavily traded agricultural commodities (notably wheat, corn and soybeans) is reflected in the demand for and prices of abundant inputs, notably land.

In recent research, we have examined the statistical relationship between land values and export demand. Preliminary results support the derived demand linkage. Based on previous work by Melichar (1979); Burt (1986); and Alston (1986), we argue that land values are a function of current and expected net farm income. Developing this relationship in greater depth, we argue that net farm income may be decomposed into non-random components associated with domestic and export market demand, government payments, farm costs, real rates of interest, and some purely random fluctuations. The particular role of export markets as a source of expected increases in net farm income should then play an important role in the determination of farmland prices. When changes in land values are plotted against changes in the value of major export crops, a striking correlation is revealed. The possibility that this correlation is spurious or due to other causal variables cannot be rejected. However, we believe that market-driven returns affect farmland prices and not the reverse (Phipps, 1982). Since export market demand has been a major source of expected increases in these returns, exports should predict changes in land values in highly export-dependent states such as Minnesota, as suggested by Figure 2.

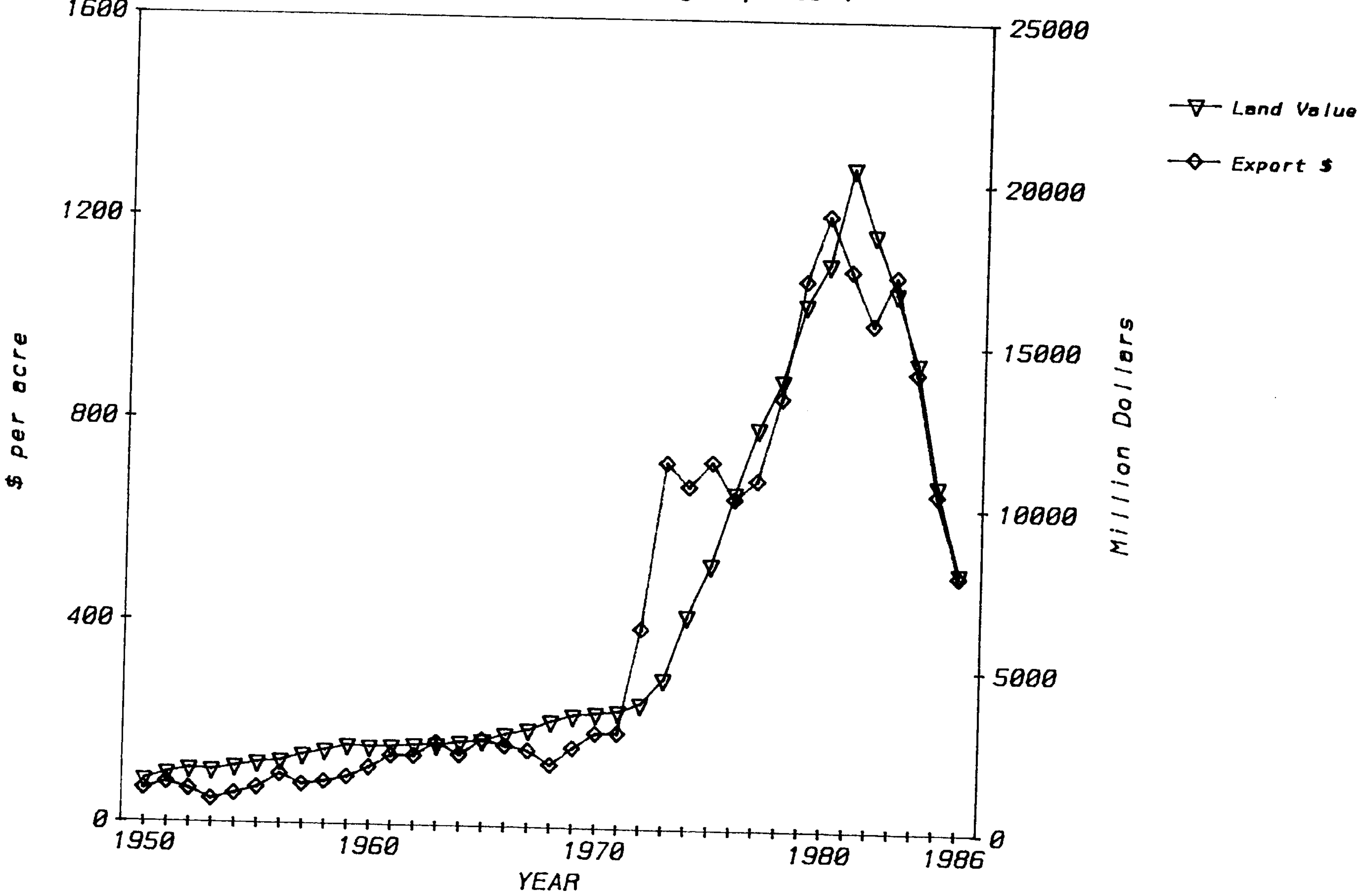
The relationship, of course, is related in part to agricultural trade policies. When target prices and income deficiency payments were introduced by the Agriculture and Consumer Protection Act of 1973, the policy regime of the United States changed to the form under which it has largely continued to operate. In essence, the United States accumulates inventories in periods of excess supply and reduces them in periods of excess demand. As "stock manager to the world," it therefore absorbs a disproportionate share of world price instability (Sutton, 1987). As its dependence on world trade in agriculture has grown, it would be natural to expect this openness to be transmitted to input prices and quantities.

Hence, we maintain that the market for land in an open, trade-dependent agricultural sector will be directly affected by export demand. If this hypothesis holds true for other inputs, then the derived demand relationship can be used to explain the impact of exports on input markets and the agricultural sector as a whole.

We divide the discussion of these impacts into two parts, corresponding to the "upswing" in agricultural exports during the 1970's, and the "downswing" during the 1980's. This impact is not likely to be symmetrical, since overall "openness" appears to have increased during the same period, suggesting that the "downswing" may have affected input demand more profoundly than the "upswing".

In the 1970's, increasing U.S. exports of wheat, corn, and soybeans were accompanied by increasing land values. When land values increase, the return required to justify the purchase of this input must also rise, creating incentives for more intensive land use. This intensity characterized land use, as well as the use of water, fertilizer, and chemicals. Concern arose over the extent to which the United States was exporting its topsoil and engaging in a non-reversable exploitation of basic productive resources. Also questioned was the degree to which

Figure 2. MN Ave. Estimated Value/Acre of Farmland
U.S. Value of Selected Ag Exports *



* Commodities: Corn, Soybeans, Wheat, Oats, and Barley
Export Value = Export Quantity * Season Average Price
Sources: U of MN, Department of Ag and Applied Economics - Econ Report ER 86-3
USDA Agricultural Statistics, FATUS

environmental pollution, because of heavy applications of fertilizer and chemicals, could be justified in pursuit of greater exports (see Batie and Healy, 1980).

As noted, these market driven trends also corresponded to the growth of an environmental movement, largely outside of agriculture, which viewed them with increasing alarm. Environmental legislation was passed partly to protect against the shifting of external costs of intensive production to the public at large (Batie, et al. 1986). This legislation, despite recent attempts to weaken or veto it (e.g. the Clean Water Act), is strongly supported by the Congress and public. These measures are increasingly likely to impinge on agriculture over time.

In the 1980's, we have seen a reversal of growth in U.S. exports. The familiar statistics describing this decline are underscored by even more dramatic declines in land prices. These have fallen by over 50 percent in the most export-dependent regions of the nation including the Corn Belt and the Great Plains. As land values have fallen with weak export markets, the incentive to farm the land intensively also has been reduced. This has caused declines in the demand for a variety of agricultural inputs, including fertilizer, chemicals, seed, and farm equipment. Inventories of these non-land inputs have been cleared by bankruptcy, business consolidations, and falling prices.

Domestic consumption of all fertilizer in the 1986/87 year is projected to be down 20 percent from its peak in 1980/81. Farm machinery expenditures have fallen from a peak of $10 billion in 1981 to an estimated of $4.5 billion in 1987, a 55 percent drop (Kiplinger, 1987). Land inventories have been absorbed at huge losses by commercial banks, the Farm Credit System, and the federal government through the Conservation Reserve Program and the Acreage Reduction Program (ARP) of the Food Security Act of 1985. If this argument is accurate, then, as long as export demand remains weak, input inventories in U.S. agriculture will continue to accumulate or to fall in price through the derived demand linkages described above.

Meanwhile, the differential restraints imposed by environmental legislation in both the United States and (to an even greater degree) Europe will attach higher implicit costs to scarce natural resources over time. These restraints imply higher operating costs for U.S. and European producers than for their competitors in countries with fewer environmental restrictions.

IMPLICATIONS FOR POLICY AND POLICY RESEARCH

Taken together, the induced innovation model and derived demand linkages suggest that: (1) environmental regulation is a binding constraint affecting agriculture in developed Western economies, but not in less-developed countries; (2) in an open, trade-dependent economy, upswings and downswings in the demand for export crops will be linked to corresponding increases and decreases in demand for land, water, fertilizer, chemicals, and farm machinery. The differential cost structure implied by (1) poses a problem of competitiveness for U.S. producers. The instability in prices and incomes implied by (2) suggests a need for policies capable of responding to fluctuations in world demand without imposing either unnecessary environmental costs during demand peaks or unnecessary liquidations and retirement of inputs during demand weakness.

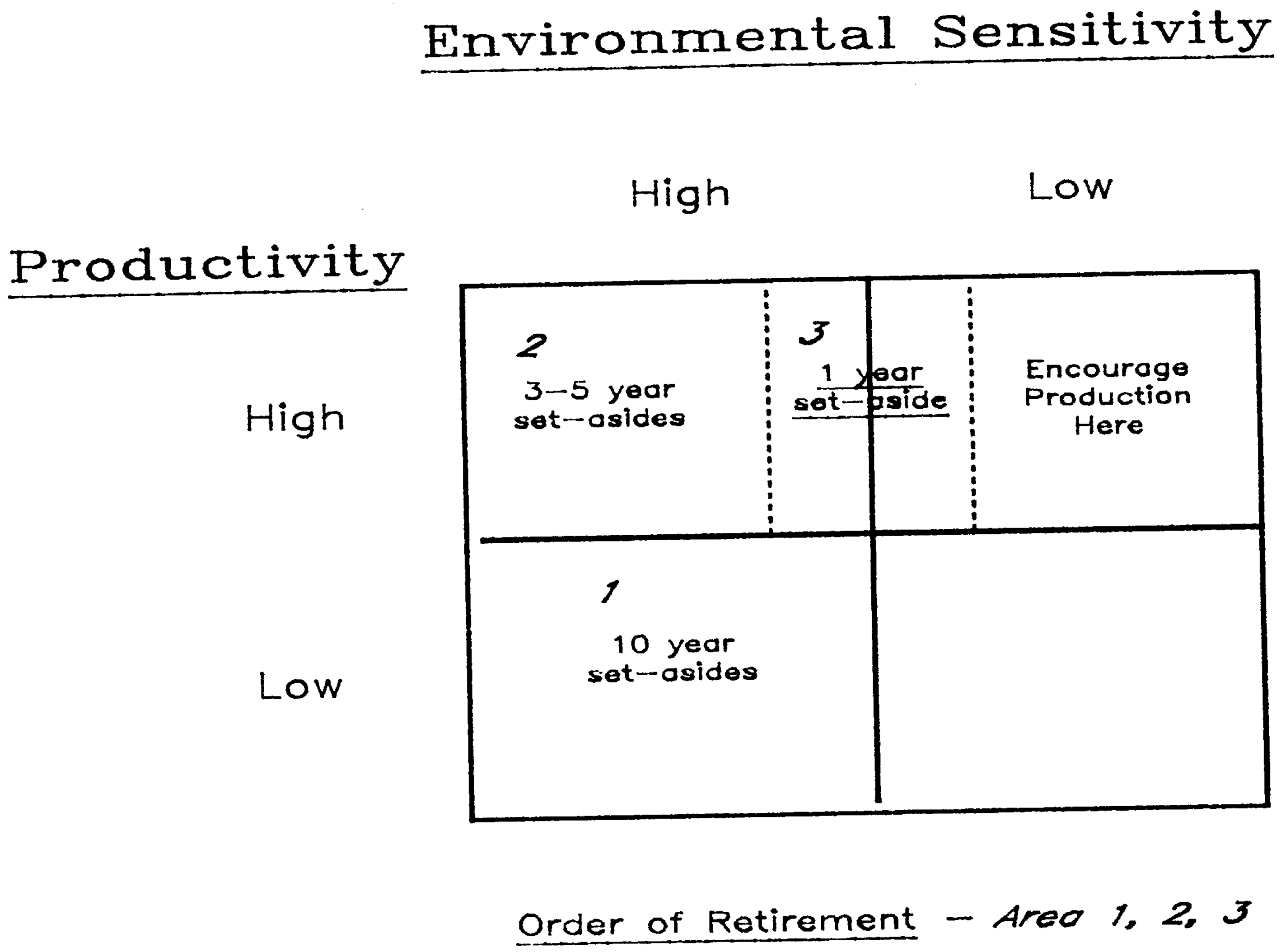
At the most general level, these problems suggest that environmental regulations in agriculture should be a key focus of policy research and analysis, not only because of immediate concerns for environmental quality, but also because they will affect international competitiveness. Hence, natural resource economists and trade policy analysts will be forced to develop a more common set of understandings and approaches to policy analysis. Secondly, the attempt to improve general trade competitiveness and to manipulate U.S. agricultural trade policy through commodity programs and inventory adjustments, must acknowledge environmental constraints in both economic and political terms.

The commodities policy of the United States is now highly uncoordinated with environmental policies affecting agriculture, even <u>within</u> the 1985 Food Security Act. To illustrate the need for policy research, this section considers the problem of targeting land eligible for agricultural price support and set aside programs with the Conservation Reserve Program (CRP) of the 1985 Act. While specific to this particular Act, the problem is representative of the need to integrate environmental and agricultural policy analysis and research.

The CRP is increasingly seen as competing with the supply control, or "set aside," provisions of the 1985 Farm Bill. Both programs attempt to remove acres from production, but are in effect bidding against one another to remove many of the same acres (Taff and Runge, 1986). This has led to calls for increased targeting of program coverage. Consider the importance of a new round of innovations in agricultural policy focused on targeting land according to demonstrated productivity and environmental sensitivity. Such a land-targeting scheme would be based on the principle that environmental policy constraints cannot be satisfied unless production is moved <u>away</u> from environmentally sensitive lands. At the same time, competitiveness cannot be assured unless production is moved <u>on</u> to high productivity lands with comparatively lower input requirements. These changes would satisfy the environmental quality constraint while actually improving the comparative advantage of U.S. producers by lowering input costs.

At the same time, instability resulting from increased openness to world markets need not lead to a desire to close our export markets nor to support for wholesale acreage retirement schemes (see Rogers, 1985). Rather, we should seek to buffer our agricultural sector from wide swings in world demand. Here a land targeting scheme also has an important role to play. If production of intensively grown surplus grains on low-productivity/environmentally sensitive lands is eliminated by targeting the 10-year Conservation Reserve Program (CRP) specifically to these lands, then the cost of the CRP would fall, because lower bids are

Figure 3.



Environmental Sensitivity
High
Low
Productivity
High
Low
2
3–5 year
set–asides
3
1 year
set–aside
Encourage
Production
Here
1
10 year
set–asides
Order of Retirement – Area 1, 2, 3

necessary. Also, the competition between the CRP and the Acreage Reduction Program (ARP) of the 1985 Farm Act would be eliminated. If higher-productivity/environmentally sensitive lands were then slated for 3-5 year retirements through some form of paid diversion similar to the ARP, remaining export crop production could be concentrated on those lands that are highly productive but <u>not</u> environmentally sensitive (see the <u>Economic Report of the President</u>, Chapter 5). The comparative advantage of U.S. agriculture is greatest on these lands. They are the <u>last</u> lands that should be retired from production on both environmental and competitiveness grounds. One year set-asides could, if necessary, then be devoted to the high-productivity/low sensitivity lands in periods of excess supply. However, they should not be eligible for 10-year or 3-5 year retirement. The combined effect of such targeting would be to retain the most productive lands in cultivation, reduce input costs, and retain a high level of potential production and export competitiveness. This will lead to greater overall demand in the input supply sector. A schematic diagram of such a targeting program is shown in Figure 3.

Contrast this approach with current programs. Now, high productivity acres are <u>intentionally</u> being retired under the CRP at higher than cash-rent bids, plus additional "sweeteners" to make the CRP competitive with ARPs and deficiency payments. Moreover, as abundant, high-productivity land is reduced in quantity, incentives are created to substitute capital and machinery, further exacerbating the negative environmental quality effects described above. The recently announced CRP "bonus" payments for corn base acres, for example, are not only expensive, but a threat to U.S. competitiveness since they will retire many internationally competitive acres that should remain in production. At the same time, the continued eligibility of low-productivity/environmentally sensitive lands for 1-year ARPs means than environmental policy objectives are unmet while supply control objectives are continually subverted because of "slippage." Slippage occurs when farmers rationally "set aside" acreage in low-productivity areas, many of which are also environmentally sensitive. Rather than focusing on maximum production efficiency in an international context, these policies encourage producers to "farm the programs" to the detriment of environmentally sound resource allocation.

Land targeting schemes also can provide a constructive, piecemeal approach to supply control, in contrast to stringent proposals to retire large productive areas. Policies for coordinated conservation set-asides are an especially appealing basis for bilateral negotiations with the European Community. In this arena, recent gains by environmentalist political groups make supply reduction for environmental quality good politics.

CONCLUSION

The U.S. agricultural sector is and likely will remain highly dependent on international trade. It will also be increasingly constrained by environmental regulations. These realities dictate the development of a common language and research agenda for environmental and agricultural trade policy interests. This can lead to programs in which competitive, low-cost lands are brought under intensive cultivation, while the most environmentally sensitive are retired. Only by developing such a common agenda can programs be structured that link international trade to resource conservation.

The policy research agenda defined by this overview is rather straightforward. First, careful attention should be given to the interface between environmental regulation and agriculture, both domestically and internationally. Second, more precise estimates of derived demand linkages from export markets to input demands are needed if the domestic effects of trade are to be better understood. Third, the data available for land targeting schemes need to be applied to actual policies. These issues define a research agenda for the 1990's which promises greater environmental benefits and improved competitiveness in the next century.

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APPENDIX A

Table A1 International Prices and Price Changes for Wheat, Corn, and Soybeans, Marketing Years 1965-66 to 1984-85.

	Wheat[a]		Corn[b]		Soybeans[c]	
Year	Price[d]	% Change[e]	Price[d]	% Change[e]	Price[d]	% Change[e]
1965/66	1.59	-	1.43	-	2.97	-
1966/67	1.80	13.2	1.45	1.4	3.20	7.7
1967/68	1.68	-6.7	1.21	-16.6	2.84	-11.3
1968/69	1.71	1.8	1.30	7.4	2.69	-5.3
1969/70	1.45	-15.2	1.56	20.0	2.34	-13.0
1970/71	1.64	13.1	1.34	-14.1	2.97	26.9
1971/72	1.64	0.0	2.17	61.9*	3.19	7.4
1972/73	2.48	51.2*	3.12	43.8*	5.31	66.5*
1973/74	4.82	94.4*	3.34	7.1	6.65	25.2
1974/75	4.45	-7.7	3.02	-9.6	6.31	-5.1
1975/76	4.13	-7.2	2.87	-5.0	5.46	-13.5
1976/77	3.08	-25.4	2.41	-16.0	7.33	34.2
1977/78	3.16	2.6	2.57	6.6	6.57	-10.4
1978/79	3.83	21.2	2.92	13.6	7.48	13.9
1979/80	4.74	23.8	3.20	9.6	6.93	-7.4
1980/81	4.95	4.1	3.20	0.0	7.87	13.6
1981/82	4.65	-6.1	3.33	4.1	6.40	-18.7
1982/83	4.32	-7.1	2.79	-16.2	6.55	2.3
1983/84	4.19	-3.0	3.45	23.7	7.64	16.6
1984/85	4.13	-1.4	3.20	-7.2	6.30	-17.5

[a] #2 Hard Red Winter, F.O.B. Gulf

[b] #2 Yellow, F.O.B. Gulf

[c] #2 Yellow, C.I.F. Rotterdam

[d] U.S. Dollars

[e] From Previous Year

*Outlier, Dropped in Regression Series #1, included in Regression Series #2

Sources: International Wheat Council, <u>World Wheat Statistics</u>; <u>F.A.O. Production Yearbook</u>; USDA Foreign Agricultural Services, Oilseed Circulars.

Table A2   Regression Series # 1

Trend for Soybeans

```
19 Observations
OLS - Dependent Variable is PCSYPI ( % Change in Price from Previous Year)
==========================================================================
                  COEFFICIENT    STANDARD ERROR     T-STATISTIC
==========================================================================
     CONSTANT      9.8228070       4.1768222         2.351742
     TRENDS        0.3335088       0.3663315         0.9104015
==========================================================================
R-squared           0.046488     Mean of dependent var    13.15789
Adj. R-squared     -0.009601     S.D. of dependent var     8.70436
S.E. of regression  8.746046     Sum of squared resid     1300.386
Durbin-Watson stat  2.392273     F-statistic              0.828831
```

Trend for Corn

```
18 Observations
OLS - Dependent Variable is PCCRPI ( % Change in Price from Previous Year)
==========================================================================
                  COEFFICIENT    STANDARD ERROR     T-STATISTIC
==========================================================================
     CONSTANT      7.5627451       3.4216669         2.2102517
     TRENDC        0.2460268       0.3161081         0.7782996
==========================================================================
R-squared           0.036478     Mean of dependent var    9.900000
Adj. R-squared     -0.023742     S.D. of dependent var    6.876815
S.E. of regression  6.957970     Sum of squared resid     774.6136
Durbin-Watson stat  1.863311     F-statistic              0.605750
```

Trend for Wheat

```
18 Observations
OLS - Dependent Variable is PCWHPI ( % Change in Price from Previous Year)
==========================================================================
                  COEFFICIENT    STANDARD ERROR     T-STATISTIC
==========================================================================
     CONSTANT      8.7862744       4.0800604         2.1534668
     TRENDW        0.0102167       0.3769333         0.0271048
==========================================================================
R-squared           .00004591    Mean of dependent var    8.883333
Adj. R-squared     -0.062451     S.D. of dependent var    8.049278
S.E. of regression  8.296816     Sum of squared resid     1101.394
Durbin-Watson stat  2.051048     F-statistic              0.000735
```

Table A3 **Regression Series # 2**

Trend for Soybeans

```
20 Observations
OLS - Dependent Variable is PCSYPI ( % Change in Price from Previous Year)
==========================================================================
                        COEFFICIENT     STANDARD ERROR      T-STATISTIC
==========================================================================
     CONSTANT           14.60526        6.974785            2.094009
     TRENDS              0.1161654      0.582243            0.1995134
==========================================================================
R-squared                0.002206       Mean of dependent var     15.825
Adj. R-squared          -0.053226       S.D. of dependent var     14.6305
S.E. of regression      15.014666       Sum of squared resid      4057.9237
Durbin-Watson stat       1.971057       F-statistic               0.039806
```

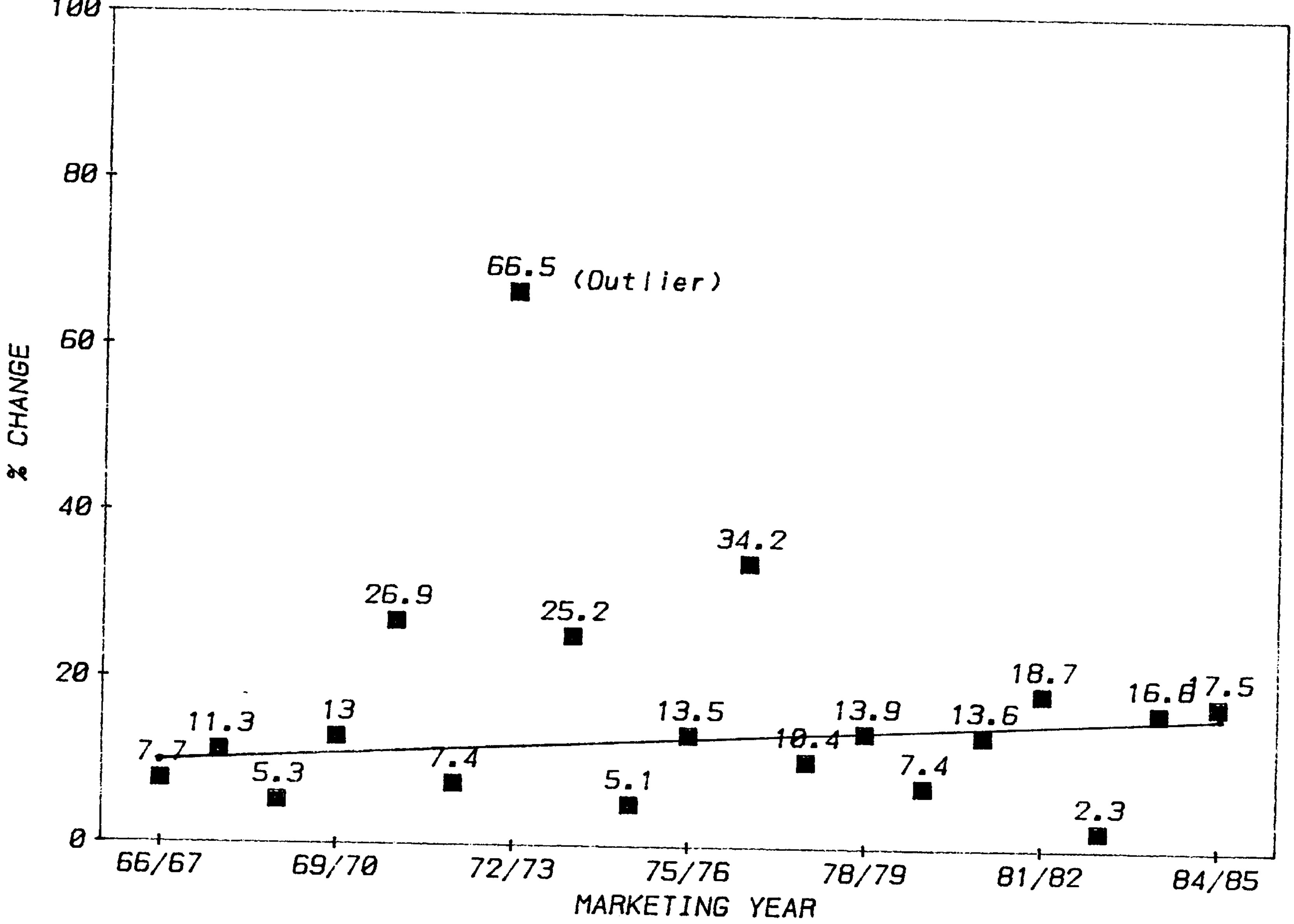
Trend for Corn

```
20 Observations
OLS - Dependent Variable is PCCRPI ( % Change in Price from Previous Year)
==========================================================================
                        COEFFICIENT     STANDARD ERROR      T-STATISTIC
==========================================================================
     CONSTANT           16.52789        7.142466             2.314032
     TRENDC             -0.2221805      0.5962415           -0.3726350
==========================================================================
R-squared                0.00765521     Mean of dependent var     14.195
Adj. R-squared          -0.04747505     S.D. of dependent var     15.02316
S.E. of regression      15.375634       Sum of squared resid      4255.3823
Durbin-Watson stat       1.25966056     F-statistic               0.138857
```

Trend for Wheat

```
20 Observations
OLS - Dependent Variable is PCWHPI ( % Change in Price from Previous Year)
==========================================================================
                        COEFFICIENT     STANDARD ERROR      T-STATISTIC
==========================================================================
     CONSTANT           18.50789        10.57320             1.7509740
     TRENDW             -0.3078947       0.8826337          -0.3488364
==========================================================================
R-squared                .00681918      Mean of dependent var     15.260
Adj. R-squared          -0.0483581      S.D. of dependent var     22.23651
S.E. of regression      22.767820       Sum of squared resid      9330.7271
Durbin-Watson stat       1.5239820      F-statistic               0.123582
```

Regression Series #1 (w/o outliers)
2 YELLOW SOYBEANS C.I.F., ROTTERDAM
PERCENT PRICE CHANGE FROM PREVIOUS YEAR

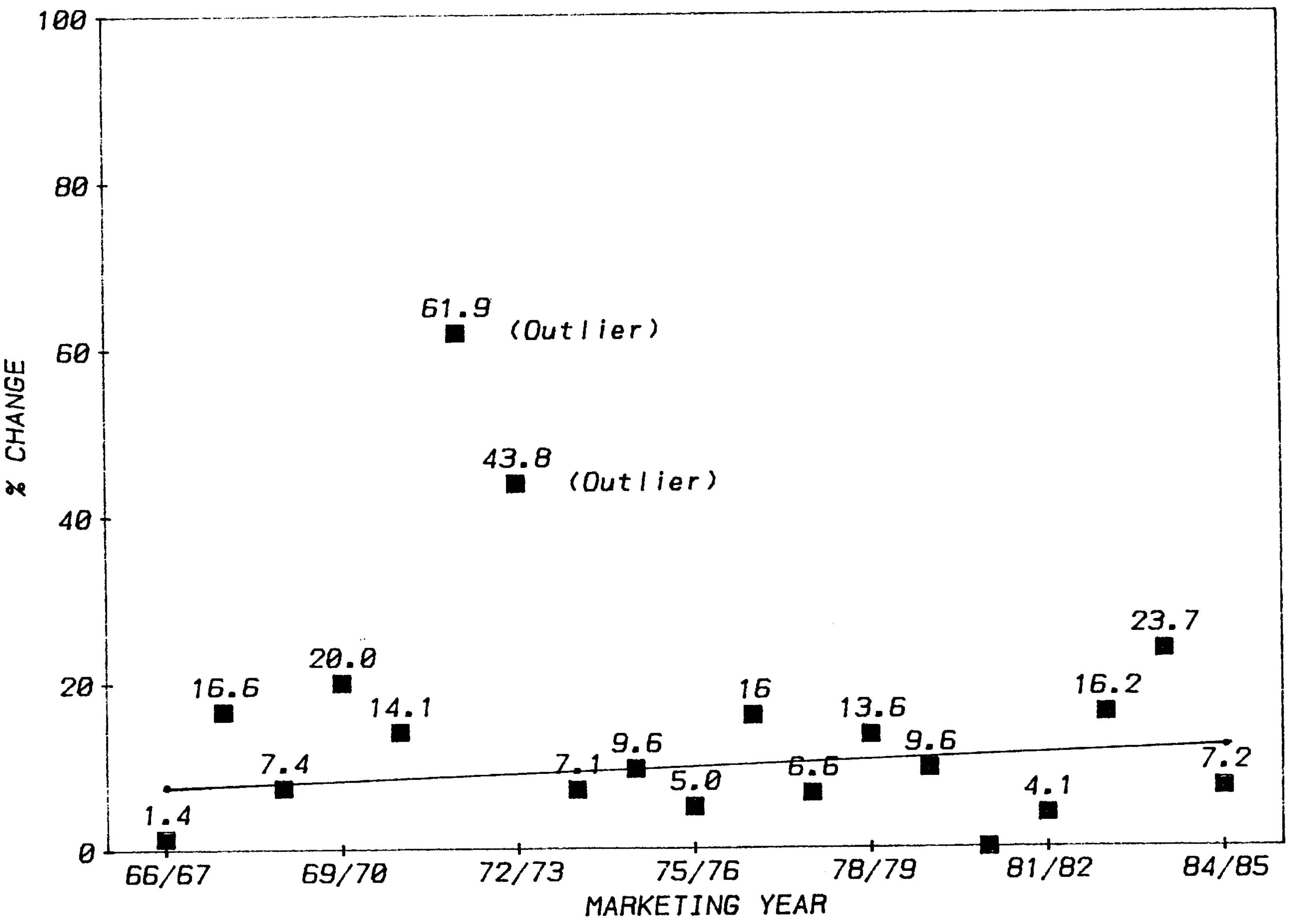


* Regression Line Fitted Without Observation From 72/73.

Regression Series #1 (w/o outliers)

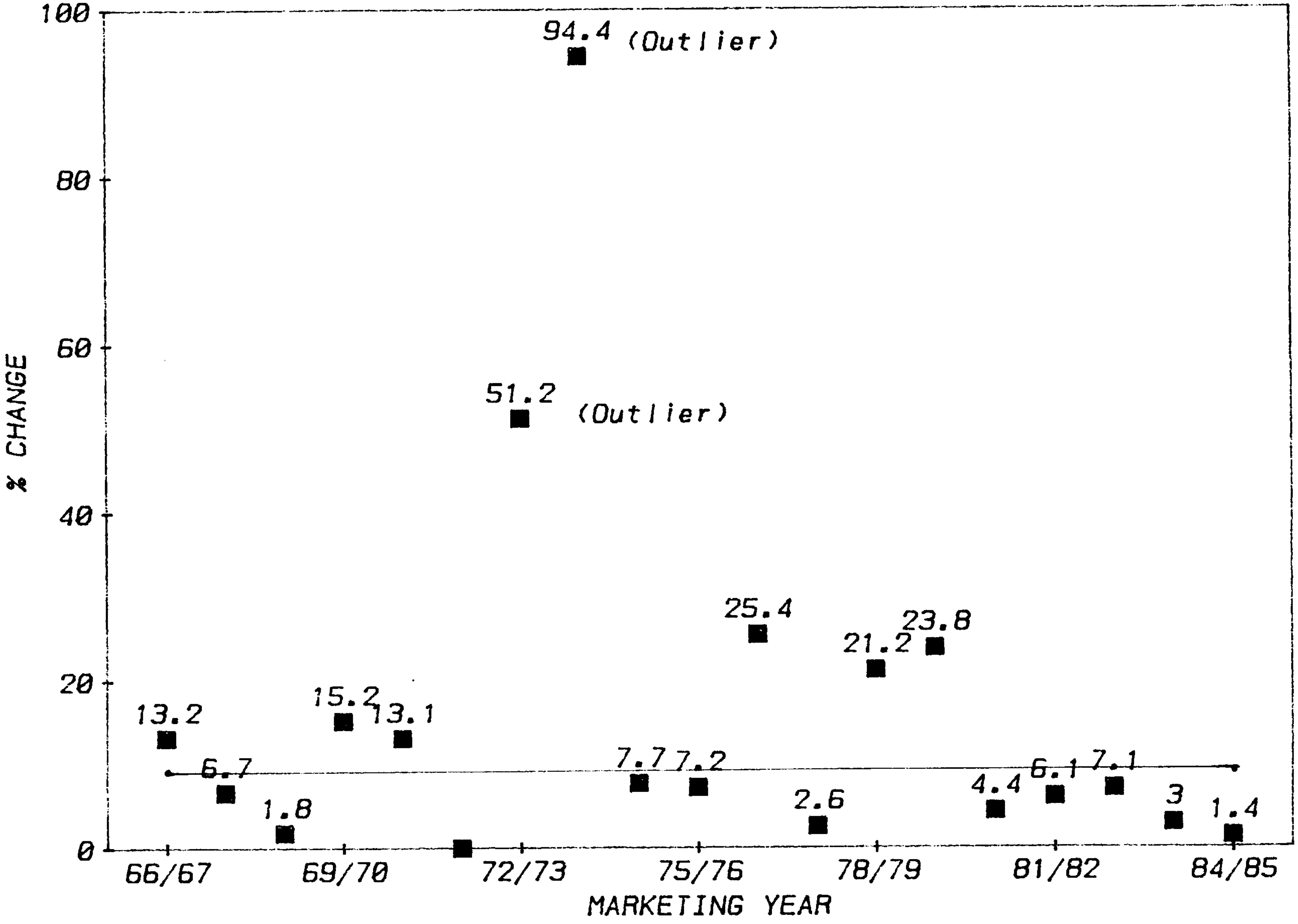
2 YELLOW CORN, F.O.B. GULF

PERCENT PRICE CHANGE FROM PERVIOUS YEAR



* Regression Line Fitted Without Observations From 71/72 and 72/73.

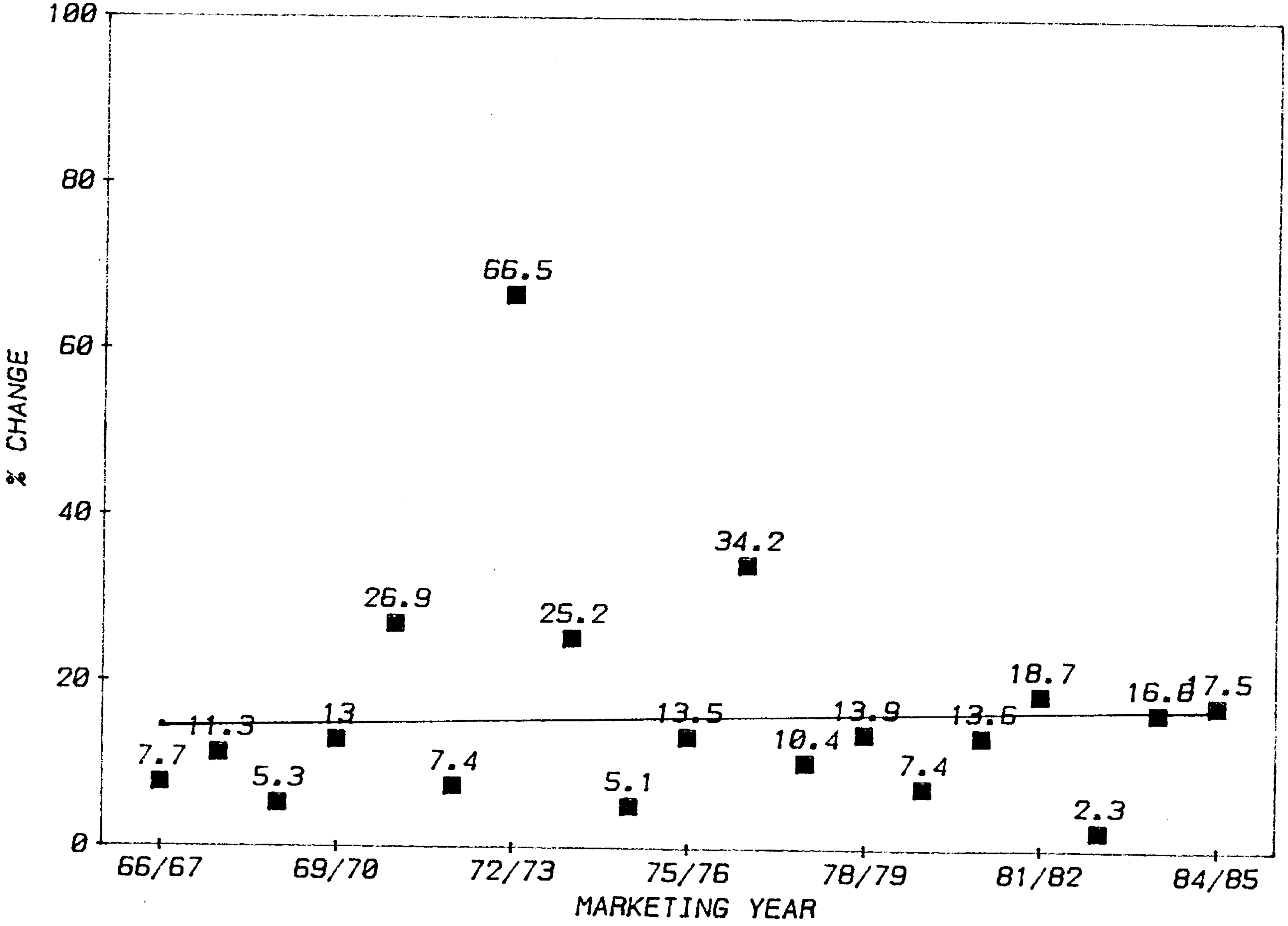
Regression Series #1 (w/o outliers)
2 HARD RED WINTER WHEAT, F.O.B. GULF
PERCENT PRICE CHANGE FROM PREVIOUS YEAR



* Regression Line Fitted Without Observations From 72/73 and 73/74.

Regression Series #2

2 YELLOW SOYBEANS C.I.F., ROTTERDAM
PERCENT PRICE CHANGE FROM PREVIOUS YEAR

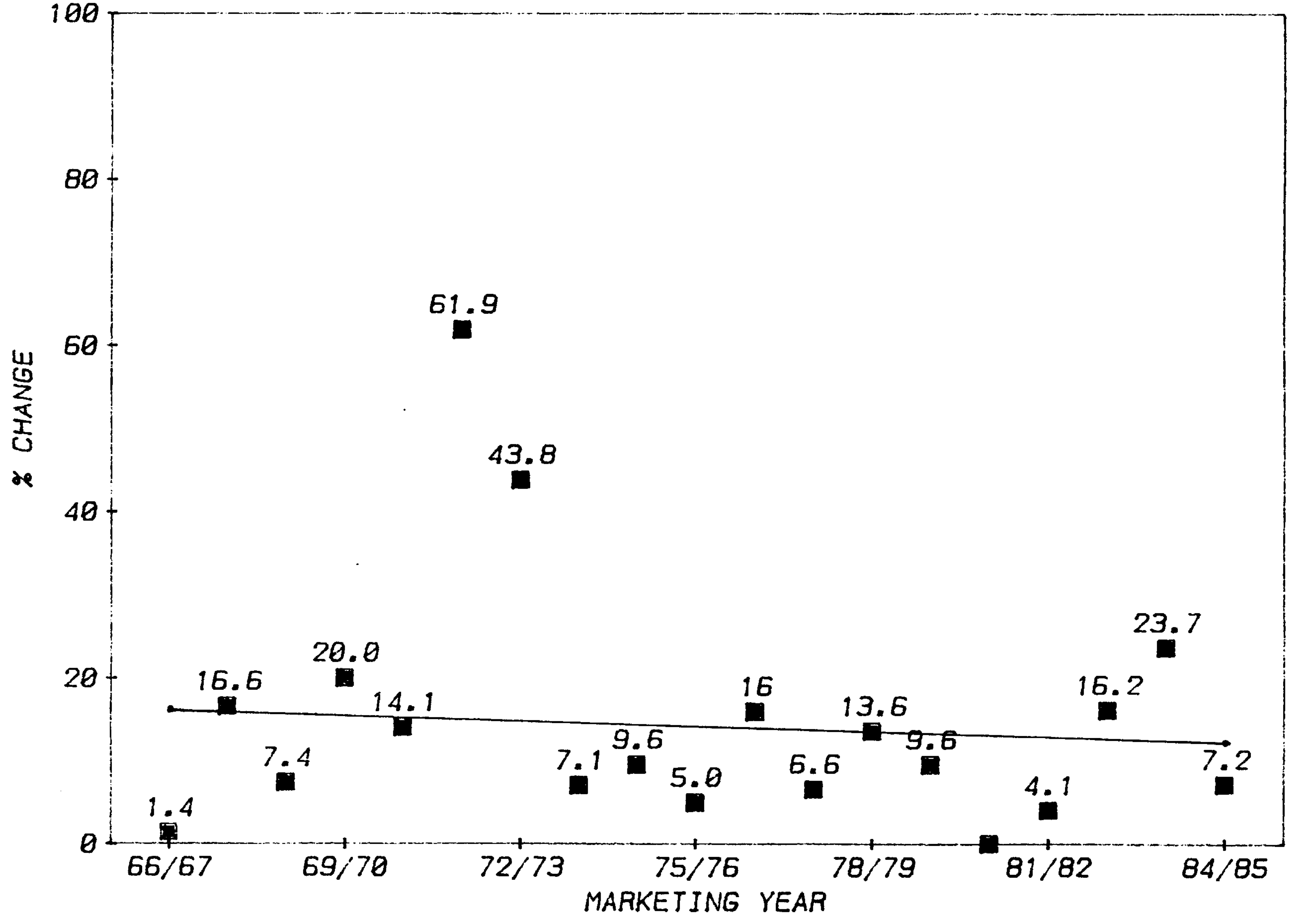


* Regression Line Fitted With All Observations

Regression Series #2

2 YELLOW CORN, F.O.B. GULF

PERCENT PRICE CHANGE FROM PERVIOUS YEAR

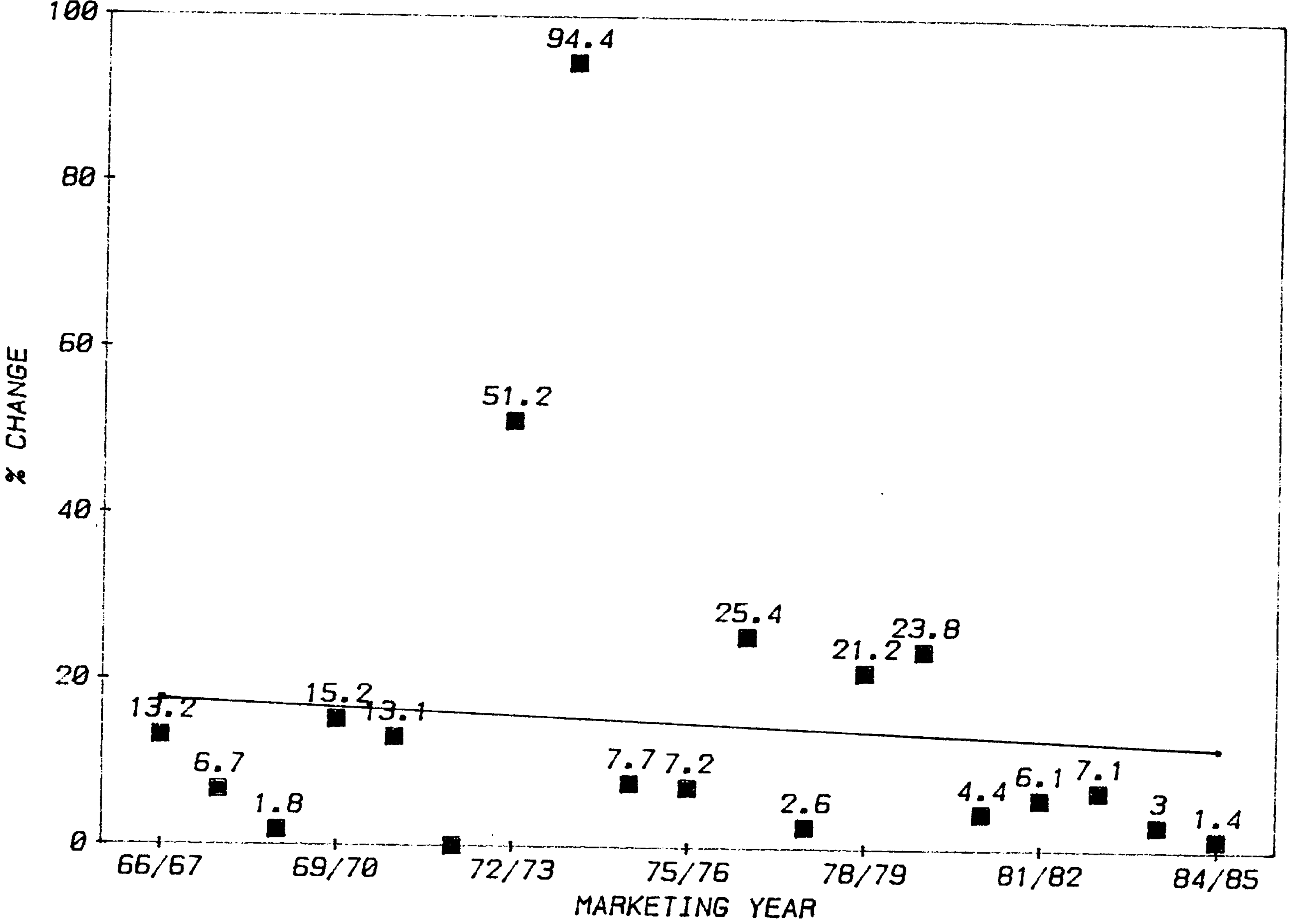


* Regression Line Fitted With All Observations

Regression Series #2

2 HARD RED WINTER WHEAT, F.O.B. GULF

PERCENT PRICE CHANGE FROM PREVIOUS YEAR



* Regression Line Fitted With All Observations