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"A DYNAMIC MODEL OF AGRICULTURAL DEVELOPMENT IN SOUTHERN BRAZIL: SOME RETROSPECTIVE POLICY SIMULATIONS (1960-70)"

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"A DYNAMIC MODEL OF AGRICULTURAL DEVELOPMENT IN SOUTHERN BRAZIL: SOME RETROSPECTIVE POLICY SIMULATIONS (1960-70)"

By

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INTRODUCTION

Modern agricultural transformations have been characterized by an environment in which 1) technological change, both biological and mechanical has been at the core of the transformation process; 2) the decision making units have been mainly private and at the farm-household level; and 3) government participation (interference) either directly through the allocation of scarce resource or indirectly through established markets has been taken for granted and has often effectively directed (distorted) the development process.

The importance of technological change has been repeatedly emphasized starting with the works of Hopper [21] and Schultz [39] and more recently by Hayami and Ruttan [16]. Indeed much of the empirical work in developing agriculture has focused on the problems of the engineering, economics and diffusion of technological change. The thrust in engineering new technologies in agriculture, beginning with the pioneering work of Borlaugh is evidenced by the vast support given to institutionalized biological research, first at the international (for example at I.R.R.I.) and now national levels. The desirability of introducing new technology and its economic consequences for output, productivity, employment and income distribution accounts for a

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major proportion of the research effort in the last five to eight years by economists interested in agricultural development. The problems of the diffusion of technologies, has also received considerable, though not comparable attention as for example in the works of E. Rogers [37], and others.

Similarly, the importance of the role of government policy actions and their consequences has received considerable attention for example in the works of W. Falcon, C. Gotsch and G. Papanek (at the Development Advisory Service at Harvard), B. Johnston, W. Jones (and others at the Stanford Research Institute), P. Dorner, W. Theisenhusen, and D. Kanel (at the Land Tenure Center in Wisconsin) and in the works of E. Heady and his colleagues (at Iowa State University) to mention only a few.

In contrast, although the importance of decision making at the farm level as the eventual filter through which both technology and government policy have to pass in order to have any impact was implicit in Schultz's work and has been recently re-emphasized by Hayami and Ruttan [16], little attention has been paid to it in the empirical work on agricultural development. Of special interest here is the interdependence of the farm and the household aspect of peasant and traditional farming. This interdependence and its consequences have been emphasized by Mellor [26], Nakajima [30], and Heady [17], although empirical work emphasizing microeconomic decisions has been very limited, ... some notable attempts can be cited (Yotopoulos [45] and Raj Krishna [24]).

The purpose of this review is to emphasize two points: 1) that these categories--technology, government policies, and farm level decision making have been well recognized as the most important elements that need to be dealt with and 2) that a considerable research effort has been underway dealing with these elements and their role in modernization.

However, what agricultural planners and decision makers have been in search of our tools that can handle all these three components jointly and simultaneously and that allow us to define and measure their interrelationships and their joint as well as separable impact, quantitatively upon outcomes in the agricultural sector. Thus, in a recent review of agricultural sector studies undertaken by A.I.D. [6] agency personnel in charge of the effort supporting sector studies there inform us that what they are looking for is a tool whose aim is:

1. "... to gain an understanding of how the economic systems or sub-systems within the sector operate and how these systems in turn are related to larger systems."

2. "... to determine through analysis how one (the policy makers, e.g.) can intervene with various policy options on the system so as to improve the sectors operation in terms of the nation's goals--output, employment, income, income distribution, nutrition, etc."

Furthermore, they go on to emphasize that "the economic analysis of a sector is basically concerned with specifying alternative solutions (policy options) and tracing out the expected consequences (numerically) of each option on the nations goals." [6 , p. 39].

This is a considerable challenge to sector analysts, for what our task masters (and needless to add our financial backers to coin a Wall Street and political phrase) are asking of us is to deliver the goods in the form of a tool for economic analysis that:

a) not only provides an integrative framework within which we can trace out the dynamic consequences of all possible economic (and social) policy options, quantitatively, upon economic decisions and opportunities faced by individual decision makers in an environment undergoing rapid technological

change, but also b) to provide a framework that at the same time provides an understanding of the economic system or sub-systems and their relationships. In short, what they ask for is not only a tool for guiding economic administration and planning but also a theory of agricultural development and indeed economic development. And all this presumably in one package, within a short span of time, at a low cost and at a level where it can be understood and applied efficiently and effectively by administrators.

We are not sure whether this challenge can be successfully met, but we are here to try. The purpose of this paper is to present a dynamic sub-sector model that attempts 1) to focus on the decision making process at the farm level, by integrating consumption, production and investment decisions within one framework, 2) to incorporate both the biological and mechanical components of technological change, 3) to trace the path of regional development of farms of different size, with different initial factor endowments, which compete for common regional resources, 4) to test the model outcomes in terms of its ability to capture the process of regional transformation and 5) to trace quantitatively the impact of major policy changes on outcomes both for the sub-sector and by farm size in terms of such variables as output, employment, capital and credit use, choice of technologies, factor productivities, factor proportions and farm income distribution.

Using recursive linear programming the model is similar to those by Day [8], Heidhues [18], Schaller and Dean [41], and Müller [29] developed to investigate regional agricultural development in the developing countries, and recently, extended to investigate problems in the L.D.C.'s by Singh [42] and Mudahar [28]. The present paper based on the work of Ahn [4] introduces farm size differences using the decomposition principle and is similar although

not as comprehensive as the recent work by de Haen [12] examining regional agricultural production and investment in West Germany. Being in its initial stages of development and testing, the model focuses primary upon building "bottom-up" from microeconomic units to the sub-regional and sub-sector level. It does not yet incorporate inter-regional or inter-sectoral linkages as do the sector simulation studies of Johnson , et. al. [22] with reference to Nigeria and more recently, the work of Herdt and Kellog [20] in Northern India. However, we feel that such linkages can only be successfully introduced (through constraints on the demand for farm outputs and the supply of farm inputs for example) once the working of the sub-sector components are fully understood and effectively modeled.

The next section briefly outlines the model and its components and provides a brief evaluation; section three discusses the policy assumptions used for simulating the model and section four reports selected simulation results.

2. METHODOLOGY

The regional r.l.p. model is made up of seven basic components: (1) a set of farm activities representing decision variables for farms within the region; (2) an annual objective function measuring the expected revenues from crop sales, the costs of purchased inputs and annual investment charges for resource augmenting investments; (3) a technology matrix representing the traditional and modern input-output structure of cash consumption, farm production, investment, sales, purchase and financial activities; (4) "technical" constraints representing regional resource and financial limitations; (5) "behavioral" constraints representing adaptive, "safety-first" limitations for protection against mistakes of cropping and investment choices, and representing drags on investment due to "learning" and "unwillingness to change"; (6) feedback functions that relate the parameters of the current programming problem to previous decisions; and (7) exogenously given input and output prices, regional supplies of land and labor resources and exogenously estimated consumption requirements by farm size and supplies of regional wage labor, credit and non-farm quasi-fixed capital goods. (Singh and Day [44].)

Activities are assumed to be linear, finite in number and their levels x_j, $j \epsilon X$ are measured for the regional aggregates. Constraining factors are identified by an index $i \epsilon C$. The technical coefficients b_{ij}, $i \epsilon C$, $j \epsilon X$ are assumed constant over time and all technology is assumed to be embodied. Positive (negative) coefficients mean a given factor in a net input (output); a zero coefficient indicates a factor not involved in the activity in question. Limitation coefficients C_i, $i \epsilon C$ and also defined at the regional level; positive (negative) coefficients are associated with upper (lower) bounds on

activity combinations, zero coefficients with balance constraints. (Day and Singh [44].)

Using the above notational device the model can be briefly summarized as follows:*

Objective Function

(1) Max: $\left[\sum_{q} \sum_{j} a_{qj} x_{qj} (t) \right]$ $\qquad j \in X$

$$t = 1, \ldots, \theta$$

which defines an additive objective function summed over q farm types differentiated by size representing the expected net cash returns to fixed farm resources for each year. The farm activity set X includes production (wheat, soybeans independent and following wheat, corn, each at two levels of technology (traditional and modern) and beef cattle raised on either natural or improved summer and winter pastures); purchase (variable cash inputs such as hired labor, seeds, fertilizers, and livestock concentrates), financial (including savings, borrowings, and debt repayment) and investment (including the purchase of capital goods, combines and draft animals and land improvement) activities. Intermediate transfer activities allow for the use of corn and pasture for livestock production and the conversion of natural to improved pasture or crop land. The $a_{qj}(t)$ are the short-run pay-off coefficients and represent current variable costs of the appropriate input (seeds, manure, chemical fertilizers, pesticides, animal draft, fuel, lubricants and labor costs) when j is a purchase activity, the nominal rate of interest when j is a borrowing activity, the regional time deposit rate when j is a saving activity, the expected sales price per unit of output when j is a sales

*A more detailed exposition is available in Ahn [4].

activity and an investment charge estimated on a straight line depreciation basis from the current purchase price of the capital good when j is an investment activity.

We assume that the farmers choice of activity levels are constrained by physical, financial and behavioral limitations represented by a set of inequalities in each production period. That is (1) is subject to:

Land and Labor Constraints

$$(2) \quad \sum_{j} b_{qij} x_{qj} (t) \leq C_{qi} (t) \qquad i \in L, j \in p+c$$

and

Quasi-Fixed Capacity and Variable Input Constraints

$$(3) \quad \sum_{j \in p} b_{qij} x_{qj} (t) - \sum_{q} \sum_{j \in v} b_{qij} x_{qj} (t) \leq C_{qi} (t) \qquad i \in K$$

where p, c and v are subsets of production, purchase and investment activities respectively and L and K and subsets of land-labor and capacity-variable input constraints respectively. Investments are activities that allow farms to augment their quasi-fixed capacities or change the quality of fixed capacities. Thus physical limitations include land, family labor, machine and draft animal capacities by season, type and farm size, and annual restrictions of seeds and fertilizers by farm size. These are aggregated for the sub-region by farm size categories.

Additional dynamic elements introduced through feedback allow the augmentation and reduction of quasi-fixed capacities through investments previously made and depreciation and the growth in the labor force through time by farm size. Thus we have constraints that define these relationships:

Quasi-Fixed and Variable Resource Feedback

$$(4)\quad C_{qi}(t) = (1 - \lambda_{qi})\, C_{qi}(t-1) + \delta_{qij}\, x^{*}_{qij}(t-1) \qquad j \in v,\ i \in K \text{ and } L$$

where λ_{qi} is the rate of depreciation of the ith capacity and δ_{qj} the addition to the ith capacity of per unit level of the jth investment for each farm size q.

Financial constraints restrict cash availability by farm size group to previous years gross sales plus previous savings if any with accrued interest and non-farm incomes less cash outlays for production inputs, cash consumption expenditures and debt repayment of previous years borrowings. Thus we have:

Working Capital Constraints

$$(5)\quad \sum_{j} b_{qij}\, x_{qj}(t) \leq C_{qi}(t) \qquad j \in p,\ c \text{ and } v,\ i \in F$$

and

Financial Feedback

$$\begin{aligned}(6)\quad C_{qi}(t) = {} & \sum_{j \in s} a_{qj}(t-1)\, x^{*}_{qj}(t-1) - \sum_{j \in c} a_{qj}(t-1)\, x^{*}_{qj}(t-1) \\ & + \sum_{j \in f} a_{qj}(t-1)\, x^{*}_{qj}(t-1) + \bar{y}_{q}(t-1) \\ & - \bar{e}_{q}(t-1) \left\{ \sum_{j \in s} a_{qj}(t-1)\, x^{*}_{qj}(t-1) \right\} \qquad i \in F\end{aligned}$$

where $\bar{y}_q(t-1)$ and $\bar{e}_q(t-1)$ are the exogenously estimated level of non-farm incomes and the functional relationship between previous consumption expenditures and gross sales respectively; s, c and f are sales, purchase and financial activities respectively and a_{qj} are the pay-off coefficients previously defined, and $x^{*}_{qj}(t-1)$ are the levels of the respective activities in the previous year estimated by the model.

Borrowing Constraints

Borrowings are assumed to be limited by gross sales in the previous year.

$$(7)\quad \sum_q C_{qi} = \sum_q \bar{\beta}_{qi} \sum_{j \in s} a_{qj}\, x^*_{qj}\,(t-1), \qquad i \in F$$

where $\bar{\beta}_{qi}$ is an exogenously given "borrowing coefficient" reflecting a rule of thumb criteria used by credit institutions beyond which they won't extend credit, so that the sum of regional borrowings cannot exceed a fraction of previous years gross sales in the region.

Balance equations allow the production of intermediate outputs and their transfer for final sales, as well as the transfers of additional capacities from investments to current capacity constraints:

Balance Equations

$$(8)\quad \sum_j b_{qij}\, x^*_{qj}\,(t) \leq 0, \qquad j \in p,\ s,\ v \text{ and } t \quad i \in E$$

where E is the subset of balance equations, and t is the subset of transfer activities.

We further include a set of behavioral constraints which reflect adoption and adjustment behavior and include upper bounds on new technologies defining S-shaped diffusion paths through time and upper and lower crop flexibility bounds on individual crop acreages in any given year to reflect a "safety-first" criteria in response to risk and uncertainty. These constraints depend upon past decisions with regard to new technologies and land allocation to various crop outputs through a recursive feedback.*

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*These safety criteria can be introduced as an axiom of behavior, Day [9], or they can be derived from the safety first, Roy [38], or focus-loss, Shackle [40], principles of decision making under risk, Boussard [7]. Petit and Boussard [32]. For an early use in agricultural sector analysis see Henderson [19] and Day [8] and for detailed use in dynamic models of developing agriculture see Day and Singh [11].

Thus we define lower and upper bounds on crop acreages by:

Flexibility Constraints

$$(9)\quad -\sum_{j\epsilon p} x_{qj}\ (t) \leq -\ (1 - \underline{\gamma}_{qi})\ \sum_{j\epsilon p} x^{*}_{qj}\ (t - 1)$$

$$(10)\quad \sum_{j\epsilon p} x_{qj}\ (t) \leq\ (1 + \bar{\gamma}_{qi})\ \sum_{j\epsilon p} x^{*}_{qj}\ (t - 1) \qquad i \in B$$

where $\underline{\gamma}_{qi}$ and $\bar{\gamma}_{qi}$ are exogenously estimated lower and upper flexibility coefficients,* and production activities p are summed by technologies for each crop separately, and B is the subset of flexibility constraints.

We diffuse the adoption of new technologies (new crops, machines, practices) through time by defining upper bounds on their use by:

Adoption Coefficients

$$(11)\ \sum_{q}\sum_{j} x_{qj}\ (t) \leq \min \begin{cases} \sum_{q}\sum_{j}\ (1 + \rho_i)^n\ x^{*}_{qj}\ (t - n) \\ \sum_{q}\sum_{j} [\alpha_i\ \{\bar{x}_{qj}\ (t) - x_{qj}\ (t - 1)\} + x_{qj}\ (t - 1)] \end{cases}$$

$$j\ e\ ,\ v,\ i \in D$$

where ρ_i and α_i are exogenously estimated "adoption" and "adjustment" coefficients for regional data, D is the subset of adoption constraints, and investment activities representing "new opportunities" are considered, and where $\bar{x}_{qj}$ is the "derived" level of the new opportunity. The "derived" level often is measured by the maximum level of the new technology possible, assuming no demand or supply constraints.**

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*See Day [8], Schaller and Dean [41], Day and Singh [11], Singh [42] and Miller [27] for the use, justification and various estimation procedures used in estimating these coefficients, and their implications for agricultural models.

**See Day et al [10], similar evidence in industrial investment behavior toward new technologies and Day [8], Nelson [31], Abe [1], Singh [42], Mudahar [28] and Ahn [4] for how these constraints are estimated for agricultural and industrial models.

The inclusion of feedback functions through inequalities (4), (6), (7) and (9) - (11) is what distinguishes recursive from ordinary linear programming problems and what gives them their rolling plan nature.

The resource constraints (2). . . (11) apply to each farm size group and reflect on-farm constraints. In addition these farm size groups are allowed to compete for regional supplies of wage labor by season, credit and non-farm capital goods. The inter-farm competition for these resources is incorporated through the following regional constraints:

Regional Coupling Constraints

$$(12) \sum_q \sum_j b'_{qij} \, x_{qj} \, (t) \leq C_i \, (t) \qquad j \in c, v, f, i \in R$$

where R is the subset of regional constraint for each resource i.

The inclusion of the regional coupling constraints leads to a structure where the diagonal farm-size sub-matrices are bordered at the bottom by an array of non-empty matrices, as shown in Figure 1, which shows the model structure for three farm size groups (q = 3).

Regional Obj. Fn	a_{1j} (t) +	a_{2j} (t) +	a_{3j} (t)	
I - O Matrix for each farm type	B_1 (t)	0	0	$\leq C_{1i}$ (t)
	0	B_2 (t)	0	$\leq C_{2i}$ (t)
	0	0	B'_3 (t)	$\leq C_{3i}$ (t)
Regional Coupling Constraints	B'_1 (t)	B'_2 (t)	B'_3 (t)	$\leq$ R (t)

Figure 1. Model Structure with Decomposition by Farm Type

Such a programming structure allows the use of the decomposition principle by coupling together almost separable sub-problems, one for each farm size group.*

*See Lasdon [25] for a detailed exposition of the decomposition principle and the implication of coupling constraints.

3. MODEL SIMULATION AND POLICY ANALYSIS

The region selected for study included the areas of the Planalto Medio and Missoes in the state of Rio Grande do Sul in Southern Brazil. This region, fairly homogenous with regard to climate and agricultural practices covers some 5.7 million hectares of land under cultivation and accounts for over 60 percent of the total wheat production in Brazil.

The model is estimated for the period 1960-70 by maximizing the regional objective function in each production period (a year), wherein the current parameter of the programming problem depends upon a sequence of previous decisions and initial exogenous data on regional land supply and family labor and input and output prices. Detailed data on input and output coefficients and on farm resources by farm size was constructed from a random sample of some 430 crop and livestock farms in the wheat region of Rio Grande do Sul. These were supplemented by information from field surveys, the Brazilian census and other published sources.* All regional farms are subsumed into three size groups (small: 0-50 hectares, medium: 50-300 hectares and large: 300-10,000 hectares) for analysis.

Since our purpose was to analyze the impact of the most important policy changes in the decade (1960-70), the focus rested upon the wheat price support program and the accompanying credit policies. Continuing work at the micro-economic level, including an initial static study of the wheat region as well as initial exercises with the current model all pointed to the crucial importanc of the wheat price subsidy program (with support prices at twice the international level), as well as the liberal credit terms (with negative real interest

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*These include the Conjucture Economica, Annuario Estatistico do Brazil, Trigo-Estudo do Custo de Producao among others. For details see Ahn [4] and Engler [13].

rates on farm loans) available to farmers in the region, in transforming the agricultural economy of this sub-region (sub-sector) from range livestock production to mechanized crop farming and livestock production on improved intensively cultivated pastures.*

In the context of this transformation and the importance of pricing and credit policies, we assumed a policy framework that would 1) allow us to test the model under historical pricing and credit policies in order to evaluate its ability to trace in detail the actual main components of the transformation as it occurred and 2) allow us to simulate changes in policy parameters to illustrate the ability of the model to show what would happen if an alternative set of policy options had been followed. We of course limit the policy options reported in order to conserve space as well as to illustrate how i) the partial outcomes of changes in a single policy instrument can be independently measured and how ii) the joint impact of changes in a set of policy instruments can be simultaneously measured.

These ideas are more clearly illustrated in Figure 2.

Let us assume, pressing our illustration, that we have only three policy instruments--output pricing policy (P), credit availability (C) and interest rates (B):

$$H\,(P_0,\ C_0,\ B_0,\ \underline{x}_{n0}) \longrightarrow \left.\begin{array}{l} S_b\ (P_0,\ C_0,\ B_1,\ \underline{x}_{n0}) \\ S_p\ (P_1,\ C_0,\ B_0,\ \underline{x}_{n0}) \\ S_c\ (P_0,\ C_1,\ B_0,\ \underline{x}_{n0}) \end{array}\right\} \longrightarrow S^*\ (P_1,\ C_1,\ B_1,\ \underline{x}_{n0})$$

Figure 2. Framework for Simulating Policy Options

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*See Rask, et.al. [36], Rask [33], [34], and Rask and Meyer [35] for a description of recent changes in the region, Adams [2], Erven and Rask [15] Adams, Davis and Bettis [3] on the importance of the credit issue; Engler and Singh [14] for results of a static study, and Singh and Ahn [43] and Ahn and Singh [5] for other applications of the current model to policy and analytic issues.

that we wish to use. Their actual historical levels are given by the policy program H (P_0, C_0, B_0, $\underline{x}_{n0}$), wherein we consider P_0, C_0, B_0 as initial conditions for these instruments. Of course there are many other policy instruments available and their initial condition is given by the vector $\underline{x}_{n0}$. The historical policy program H then represents policies as they were actually followed in the period (1960-70) for our region. These included 1) a domestic wheat to beef price ratio between two to four times the international wheat to beef price ratio* between (1960-70) through a wheat price support program (P_0); 2) liberal credits for the purchase of modern inputs with credit limits tied at 60 percent of the volume of gross sales (that is the "borrowing coefficient" $\underline{\beta}_q$ = ·6) by credit institutions (C_0) and 3) relatively low nominal rates of interests on borrowed capital (B_0).**

The model outcome of the historical program are very important because they provide the simulation which allows us to test the validity of the model through its ability to trace the actual path of development retrospectively.

Now consider the following policy changes:

1) A change of the price ratio of wheat to beef from the domestic to the international level (P_1);***

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*See Ahn and Singh [5, p. 3].

**On very liberal terms indeed. Thus after 1964, modern variable inputs, such as seed, nutrients and pesticides, could be purchased 100 percent on credit, at a nominal interest rate of 15 percent per annum, while farmers could obtain long-term, low-interest financing for agricultural machinery with a 25 percent down payment at a 7 percent rate of interest. Meanwhile, the wholesale price index for foodstuffs increased by an average of 60 percent annually between 1960-66 and 23 percent annually between 1967-71. Thus, in effect, due to inflation the real rate of interest on credit was negative during the entire decade!

***This consists of substituting the U.S. export prices for wheat and soybeans and the Argentine export price for beef, for the respective domestic price sectors. The outcome is to drop the price support program and open the sector to international competition.

2) A change in the borrowing limit by reducing it to half its previous level-(that is a change in the borrowing coefficient β_3 from ·6 to ·3) (C_1); and

3) A change in the nominal interest rate on short-term borrowing from 15 percent to 40 percent in order to allow the real rate of interest in the range of 10-12 percent per annum (B_1).

Now the policy programs S_p, S_c and S_b correspond to these changes, and the changes in model outcomes allow us to measure the partial impact of a change in a single instrument independently. The policy program S^* considers changes in all three policy instruments and the changes in model outcomes now allow us to measure the joint impact of a set of policy changes simultaneously.

Of course these are not necessarily the most important or only policy or non-policy changes we may wish to consider. For example, one of the most important options we may wish to examine is the impact of potential new technologies on the system in the future. This, too, can be handled within the framework of the model since one of the advantages of the methodology is that it allows us to enter new activity sets to handle these questions in a dynamic framework.*

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*Indeed the next stage of work under way is to project outcomes under alternative technology options.

4. MODEL RESULTS (1960-70)

4.1. Model Evaluation

Before going into comparative results of policy changes, we wish to provide an evaluation of the model. This is done by comparing the predicted model outcomes under the historical policy program H with observed actual outcomes for the period. In spite of serious difficulties, methodological and practical, in arriving at evaluation criteria, several methods have been developed to evaluate such models.* However, in this study we have so far been restricted by the extreme paucity of regional and sub-regional data from attempting a rigorous evaluation. This would require data for the sub-region by the various outcomes by farm size. All we have by way of time series are the wheat, soybean and corn hectarage for the sub-region (wheat region) and for the entire state of Rio Grande do Sul. Some additional data on wheat hectarage by technology is available, but only at the state level.

These are presented in Figures 3 and 4 along with the corresponding model-predicted values for the historical policy program.

The model predicts the wheat hectarage fairly closely with slight over-predictions for the years 1964, 1965 and 1966 and small underprediction in 1966; performs best for soybeans, and continually underpredicts slightly for corn for the years for which data are available. In addition, the model does fairly well in predicting wheat hectarage by technology. (For Figure 4 note that observed values are for the entire state, while the predicted are for the wheat region only.)

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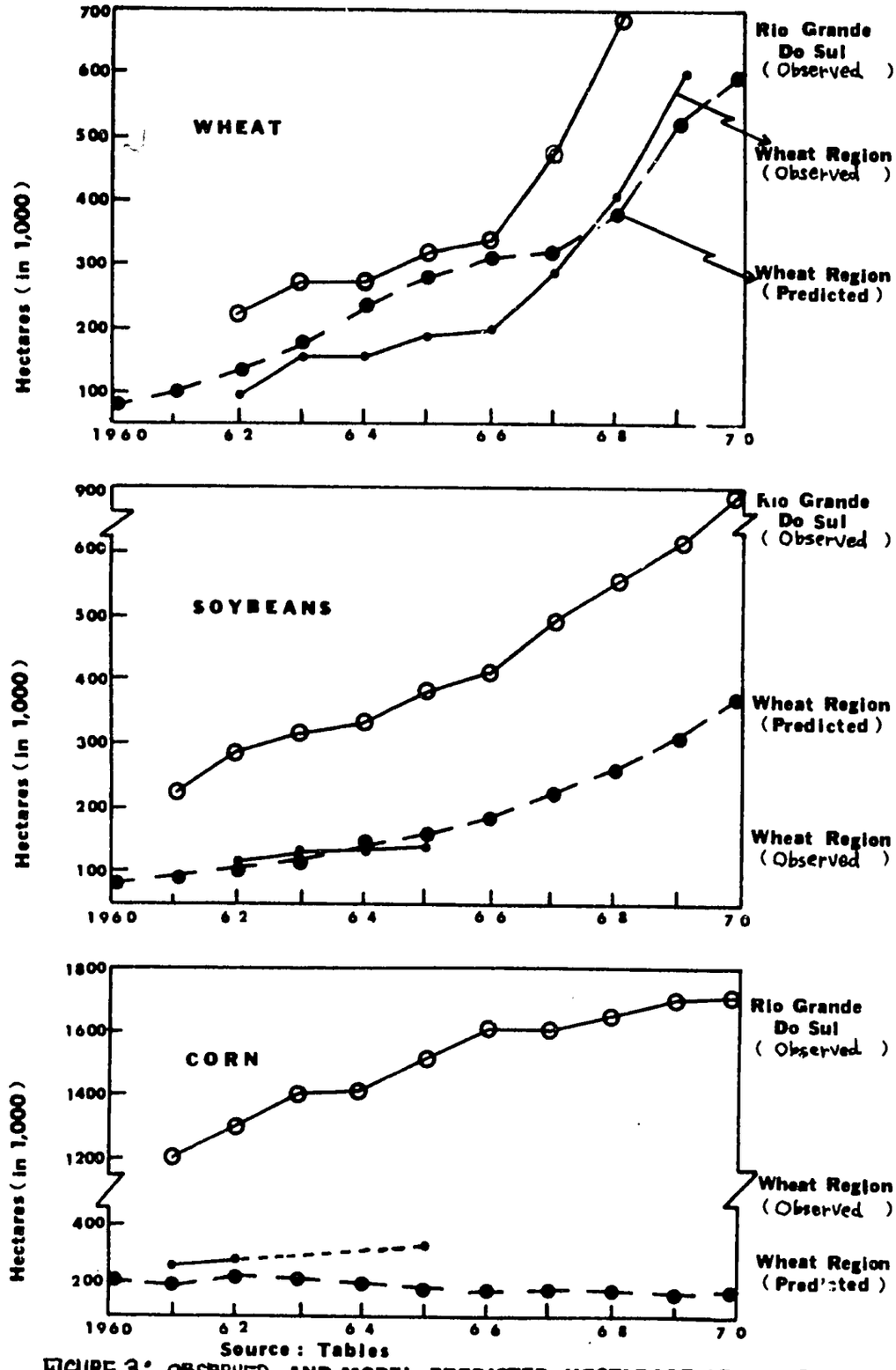
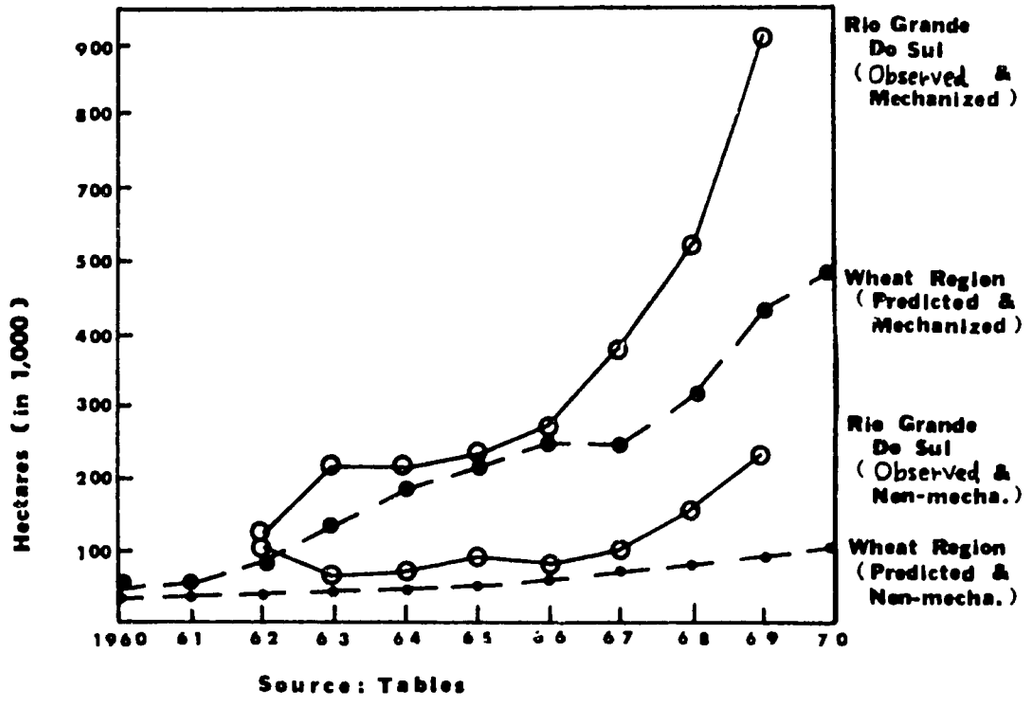
*See Johnson and Rausser [23] for a discussion of problems in developing evaluation criteria and Day and Singh [11] for several evaluation techniques that can be used.



Source: Tables

FIGURE 3: OBSERVED AND MODEL PREDICTED HECTARAGE OF FIELD CROPS IN THE WHEAT REGION AND RIO GRANDE DO SUL, SOUTHERN BRAZIL (1960–1970)

NOTE: The Observed Hectarage Data are not Available for Missing Observations.



Source: Tables

FIGURE 4: OBSERVED WHEAT HECTARAGE OF RIO GRANDE DO SUL AND PREDICTED WHEAT HECTARAGE OF THE WHEAT REGION BY MECHANIZATION, SOUTHERN BRAZIL (1960—1970)

NOTE: The Data are not Available for the Missing Historical Observations.

This paucity of data at the regional level prevents direct evaluation, but corroborative evidence relating to the model's performance is also available. The model was able to correctly capture over the period:

1) The rapid increases in wheat and soybean production and relative decline in corn and natural pastures, along with the rapid increase in beef production on improved pasture;

2) The rapid trend in wheat mechanization especially among large farms;

3) The increased use and reliance on credit, especially among large and medium farms;

4) The large investments in new farm power (tractors and harvestors) on medium and large farms and the exclusive reliance on animal draft on small farms;

5) The increase in working capital expenses per hectare directly related to increases in farm size;

6) Diminishing average returns to land, and increasing average returns to labor as farm size increases;

7) Rising land and labor productivity on all farms, especially after 1964;

8) Decreasing average return to capital as farm size increases; and

9) The increase in farm incomes and their positive correlation with farm size, with increasing income inequalities;

as verifiable from a study of sample farms in the region in 1965 and 1969 for which we have data. Further studies in the region will allow cumulative evidence to evaluate model performance.*

While only the availability of better sub-regional data can allow proper validation, we do believe that the model was able to capture the main directions in the important components that deliniate the process of transformation in the region in the decade of the sixties.

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*See Ahn [4] for a detailed discussion and sources that substantiate the results.

4.2. Impact of Policy Changes (1960-70)

We present here the model results for policy programs H, S_b, and S^* for illustrative purposes. Only the results of outcomes that focus on output, capital and credit use, employment and some factor productivities and proportions are reported here although a whole variety of outcomes are generated by the model.* Detailed tables are provided in the appendix.

4.2.1. Total Output and Land Use

The impact on the value of total output of alternative policy programs is shown below and in Graph 1.

Compound Growth Rates of Total Output Under Alternative Policy Programs (1960-70)
(Output Valued at Constant 1970 Domestic Prices)

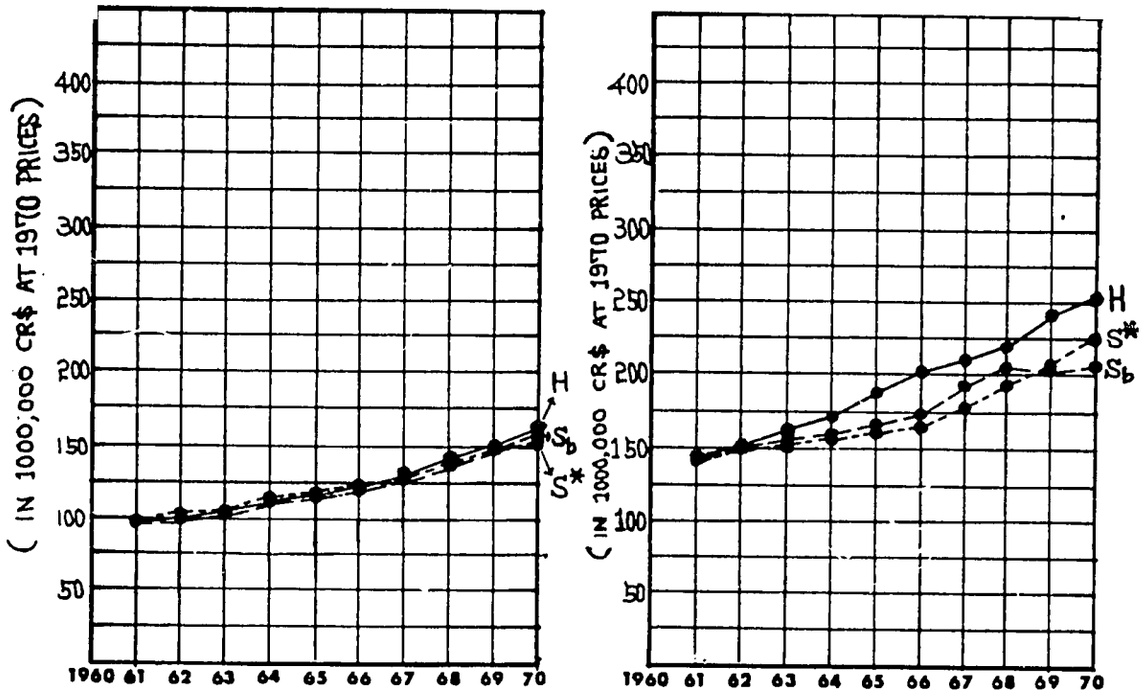
Farm Size	Policy Program		
	H	S_b	S^*
Small Farms (0-50 hectares)	5.4%	5.54%	4.81%
Medium Farms (51-300 hectares)	5.9%	4.18%	4.75%
Large Farms (>301 hectares)	8.5%	4.27%	5.64%
Regional	6.8%	4.39%	5.16%

Source: Table 1.**

*The model generates outcomes for land use by technology, employment by season, capital stocks, farm power use, investments, total cash use, borrowings, total output and income, factor productivity, credit use and measures of income distribution. See Ahn [4] and Ahn and Singh [5] for a complete description of model results.

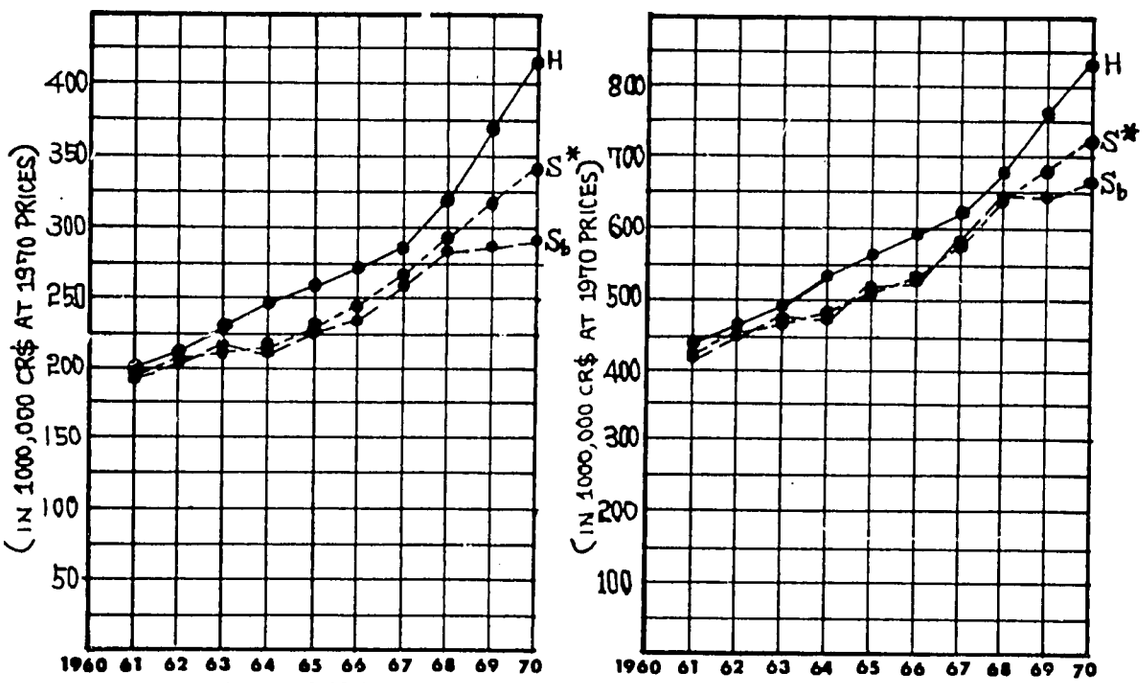
**Table numbers refer to tables in the appendix.

GRAPH 1 : TOTAL FARM OUTPUT BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS



GRAPH 1A : SMALL FARMS

GRAPH 1B : MEDIUM FARMS



GRAPH 1C : LARGE FARMS

GRAPH 1D: REGIONAL TOTAL FARMS

$\{H, S_b, S^*\}$ = ALTERNATIVE POLICY PROGRAMS

Source: Model Results

Wheat Region in the State of Rio Grande Do Sul, Southern Brazil(1960-1970)

It is obvious that raising nominal interest rates would have had a substantial impact on growth of regional output, reducing its compound rate of growth from 6.8 percent to 4.4 percent per annum. However, the impact on growth would have been most uneven, with a decrease in the growth rate of 4.23 percent on large farms and 1.82 percent on medium farms, while the growth rate on small farms would have actually increased though very slightly!

These results point to two important insights: i) the price subsidization program often credited with the large growth would not have accelerated growth without the accompanying credit subsidies and ii) it is the medium and large farms that are most sensitive to changes in interest rate policies, since it is these that depend most heavily on credit as will be shown later.

Furthermore, if price and credit subsidies had not been applied and the sub-sector had been left open to international competition, this, too, would have dampened growth rates, though somewhat less than the removal of the credit subsidies alone. This is due to the fact that the impact of curtailed domestic credit is ameliorated somewhat by an increase in the production and price of livestock products and soybeans.

What these results can provide us with are the differential <u>benefits</u> realized from alternative policy programs. Thus the potential gain in benefits that accrued from a program including price and credit subsidies as actually followed over the period, amounts to Cr. $553 millions when measured in terms of the value of real output.* Against these gains have been offset the costs of the wheat subsidy program, losses on account of decreased beef and

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This is easily calculated from Table 1 in the appendix as the sum of the differences in the value of regional output under programs H and S.

soybean production that resulted and the costs of the credit subsidies.* These costs amount to approximately Cr. $399 millions. Since the costs of administering the subsidy program have not been included, these are only a partial accounting of the costs offsetting the gains achieved.

These meagre gains of Cr. $154 millions realized over a period of a decade, were probably offset by the costs of program administration on which we have no data. However, the impact of a policy program should not be evaluated only in terms of a single criterion such as output but should consider the impact on other factors such as employment, efficiency of resource allocation and income distribution to mention only the economic criteria.

Since the main impact of the wheat price support program was to increase the production of wheat substantially, especially on medium and large mechanized farms, at the expense of range livestock farming; both alternative policy programs S_b and S^* reduce substantially the production of wheat (Table 2 and Graph 2). The production of beef is not affected by changes in the interest rate, while it actually increases slightly when international beef prices are used (Table 3).

The reduction in wheat hectarage, however, is confined mostly to medium and large farms which have used price and credit subsidies to mechanize their operations substantially. Small farms have not benefitted because as we see

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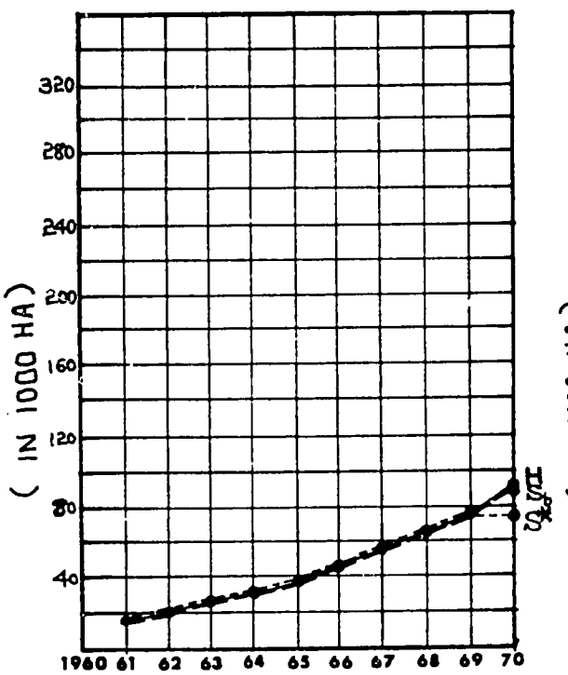
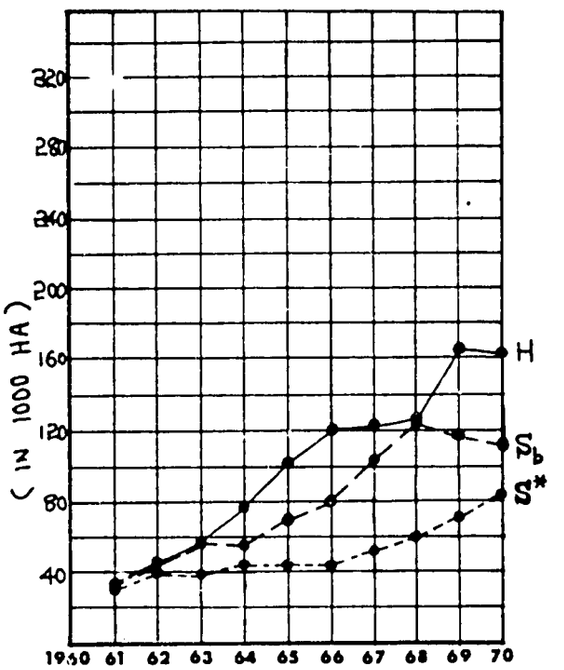
*The costs of the wheat subsidy program and losses due to differences in beef and soybean production can be easily calculated by the following formula. $\text{Loss} = \sum_j \sum_t \left\{ (P^j_{S^*} - P^j_H) \cdot (Q^j_{S^*} - Q^j_H) \right\}$, where j = 3 for the three crops and t = 61, ..., 70 and $P^j_{S^*}$ and P^j_H are the prices and $Q^j_{S^*}$ and Q^j_H the outputs of the jth crop under programs S^* and H respectively. The losses due to the credit subsidy are .25 times the differences in total regional short-term borrowing under the two programs.

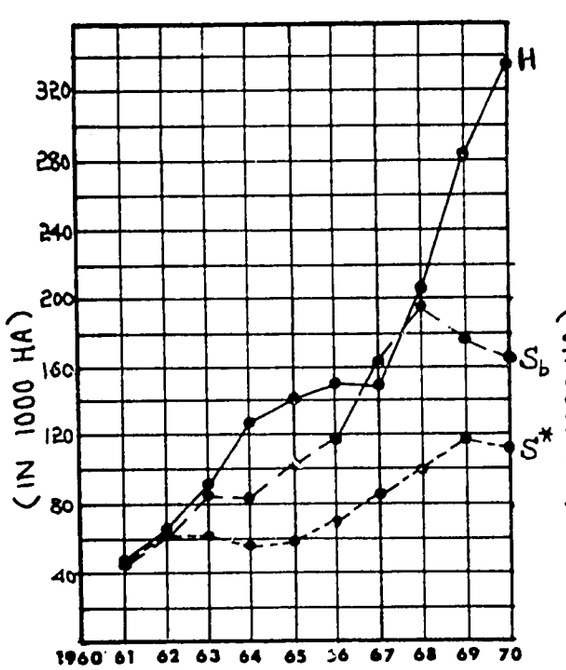
GRAPH 2 : TOTAL WHEAT HECTARAGE BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS



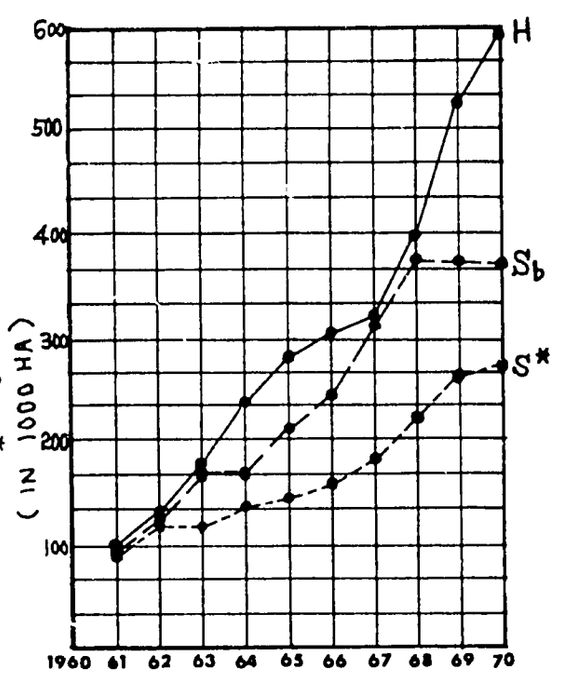
GRAPH 2A : SMALL FARMS



GRAPH 2B : MEDIUM FARMS



GRAPH 2C : LARGE FARMS



GRAPH 2D : REGIONAL TOTAL FARMS

$\{H, S_b, S^*\}$ = ALTERNATIVE POLICY PROGRAMS

Source: Model Results

Wheat Region in the State of Rio Grande De Sul, Southern Brazil (1960-1970)

their wheat production confined to animal draft technology remains unchanged when both subsidies are removed. Thus the transformation from range livestock production to mechanized crop farming that took place in the decade of the sixties was considerably accelerated by the price and credit subsidies and the major benefits were confined to medium and large farms only.

4.2.2. Employment and Capital Utilization

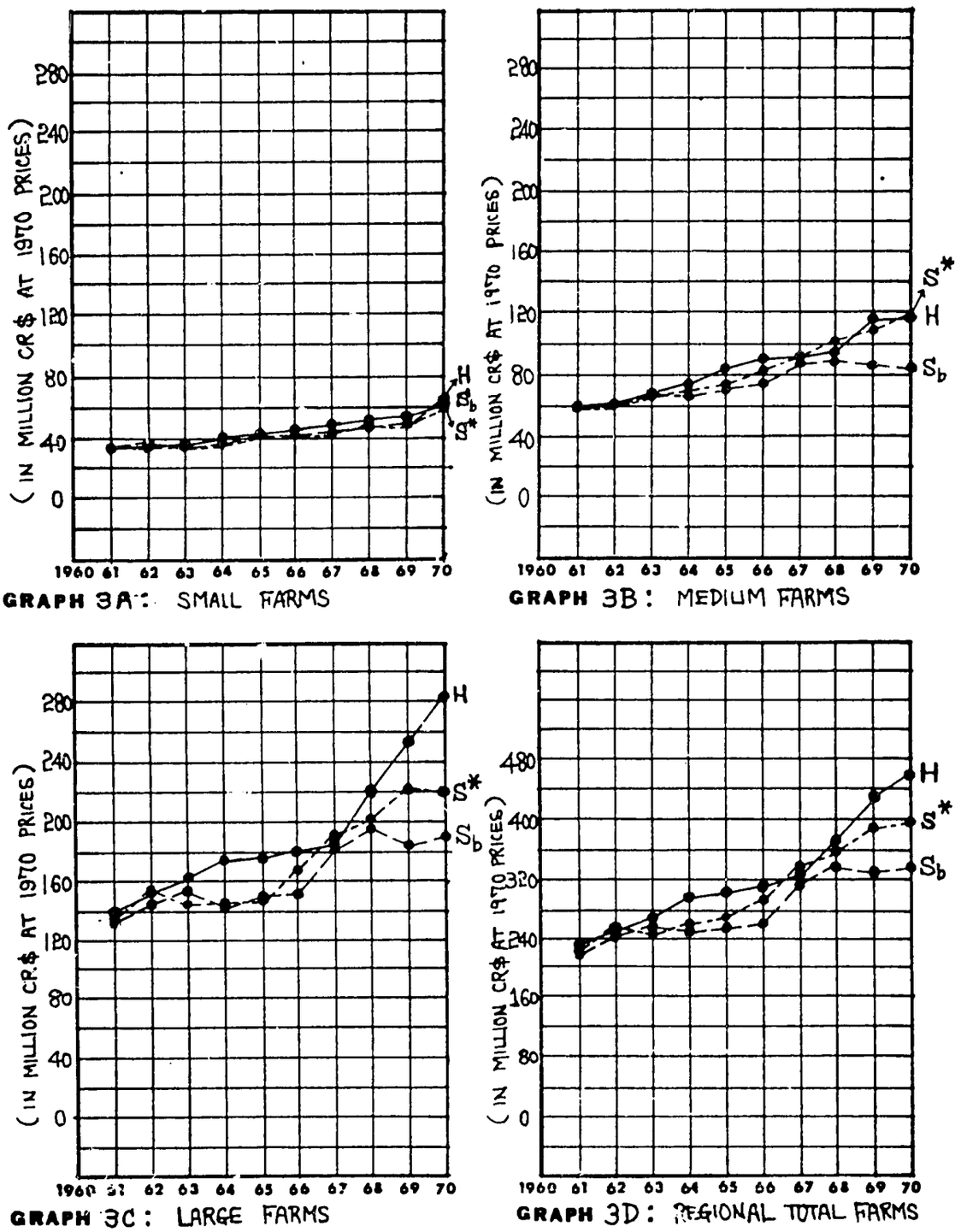
The overall impact of raising the interest rate and of further removing the price subsidy is to dampen total regional employment (Table 4). The decline is confined mainly to small farms as they tend to fall back to livestock and independent soybean production instead of the more labor intensive soybeans following wheat cropping pattern when subsidies are not assured. Thus one of the gains of the subsidy programs was to provide a slightly higher level of year-round employment on small farms.

The pivotal impact of increasing the rate of interest was on short-term borrowings on medium and large farms (Table 7) and the graph 4 and the consequent decline in their large growth of investment capital outlays (Table 6), working capital (Table 5) and total capital use (Graph 3). Small farms on the other hand continue to borrow, and at increased levels after 1966, whereas their working and investment capital outlays remain unchanged.

When price subsidies are also dropped, short-term borrowing disappears, investment outlays and working capital use is further dampened on medium and large farms, but increase only slightly on small farms.

These results point to the important role price and credit subsidies have played in the region. Increased wheat price supports made wheat production relatively very profitable on medium and large farms. They expanded their production for which they required large investments in farm equipment

GRAPH 3 : TOTAL CAPITAL USE BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS

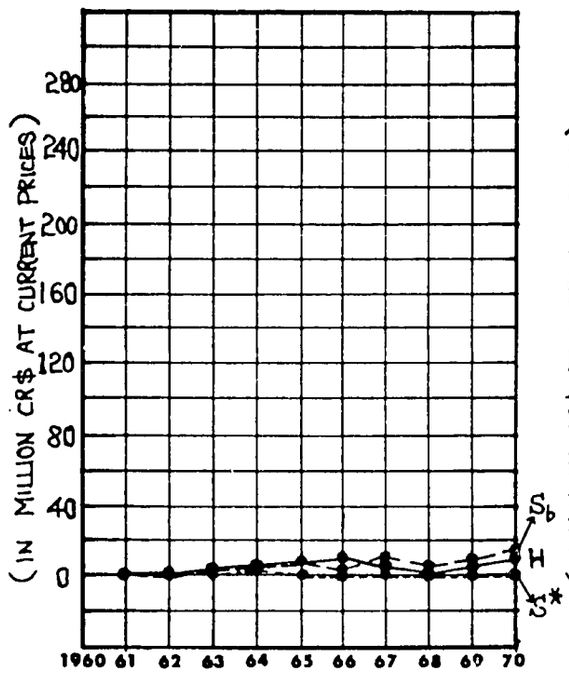


$\{H, S_b, S^*\}$ = ALTERNATIVE POLICY PROGRAMS

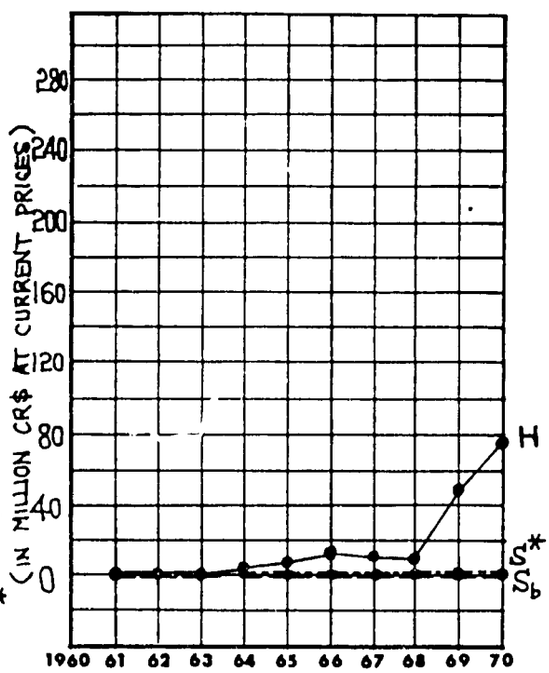
Source: Model Results

Wheat Region in the State of Rio Grande Do Sul, Southern Brazil (1960-1970)

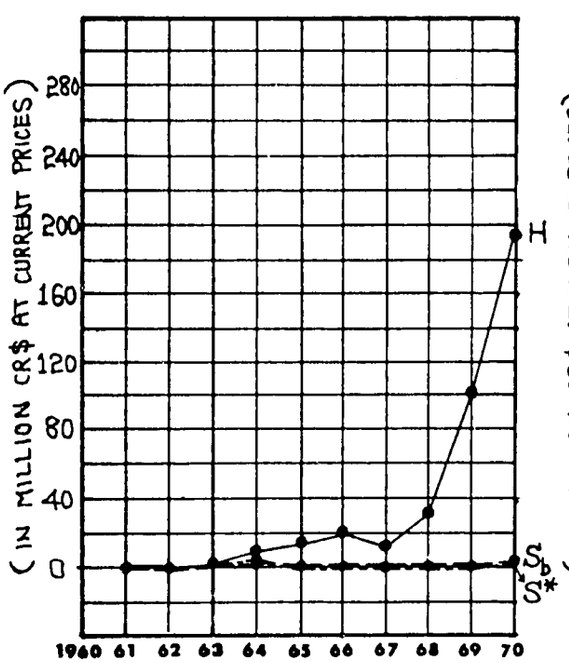
GRAPH 4: SHORT-TERM BORROWING BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS



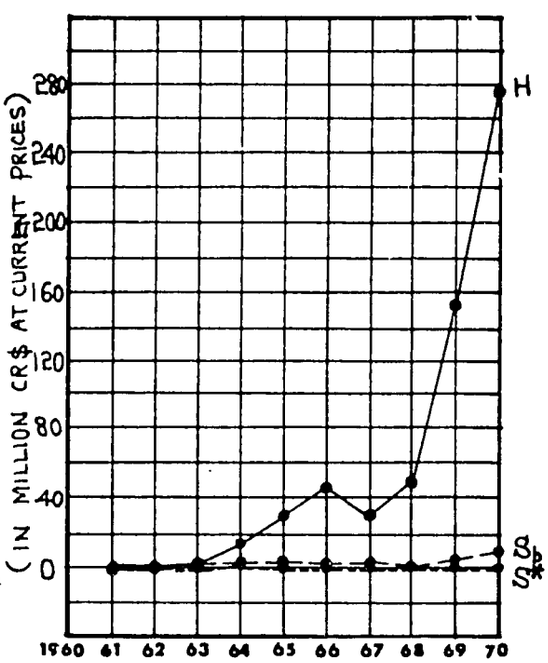
GRAPH 4A: SMALL FARMS



GRAPH 4B: MEDIUM FARMS



GRAPH 4C: LARGE FARMS



GRAPH 4D: REGIONAL TOTAL FARMS

$\{H, S_b, S^*\}$ = ALTERNATIVE POLICY PROGRAMS

Source: Model Results

- Wheat Region in the State of Rio Grande De Sul, Southern Brazil (1960-1970)

(tractors and harvestors mainly), and increased working capital. This was then forthcoming at obligingly low real interest rates. With greater access to capital markets, and credit rules based on ability to pay rather than on capital productivity, medium and large farmers expanded their credit use enormously, and became increasingly dependent on it over time. The price subsidy provided the catalyst (incentive) and the liberal credit terms provided the lubricant for the engine of growth.

Due to institutional factors, in the credit markets, factor proportions that encouraged labor intensive mechanical technologies and the fact that no real shifts in the biological production function to which farmers had access were involved, the small farmers were deprived of the main driving forces. Of course farm incomes increased somewhat due to larger year around employment, but inequalities in farm incomes increased most substantially.*

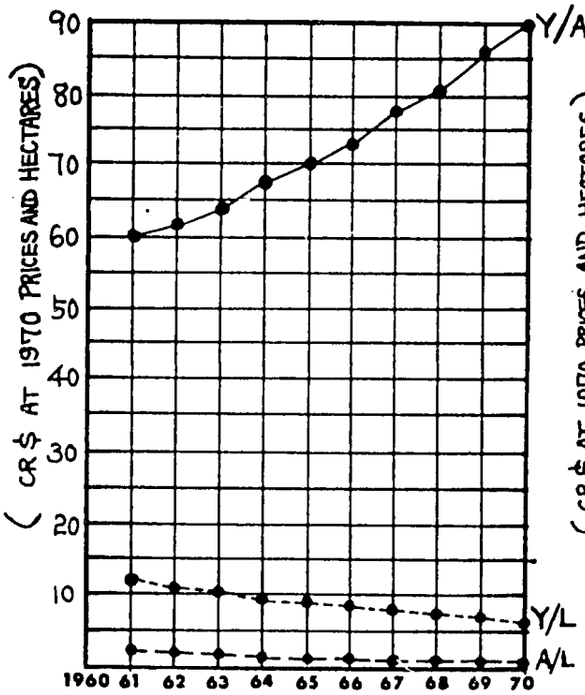
4.2.3. Factor Productivity and Proportions

As we would expect, average labor productivity is positively related to farm size (Table 8), as are the land-labor and capital-labor ratios (Tables 10 and 11 and Graphs 5, 6 and 7) under all policy programs. As a matter of congruency average land and capital productivity (Table 9) are inversely related to farm size. Thus substantial efficiency is to be gained if more of the credit were to be channelized to small farmers. But this is unlikely as long as the price subsidies remain intact, interest rates are kept at low or negative real levels and credit institutions look only to the ability to pay and deny credit access to small farmers.

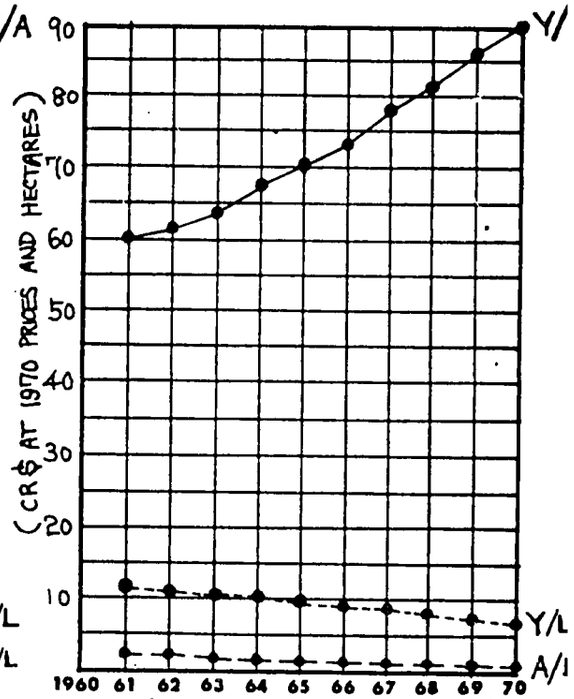
However, are small farmers likely to use the credit if the interest rate mechanism is used to deny credit use to medium and large farmers? Yes, if

*See Ahn and Singh [5], Adams, Davis and Bettis [3].

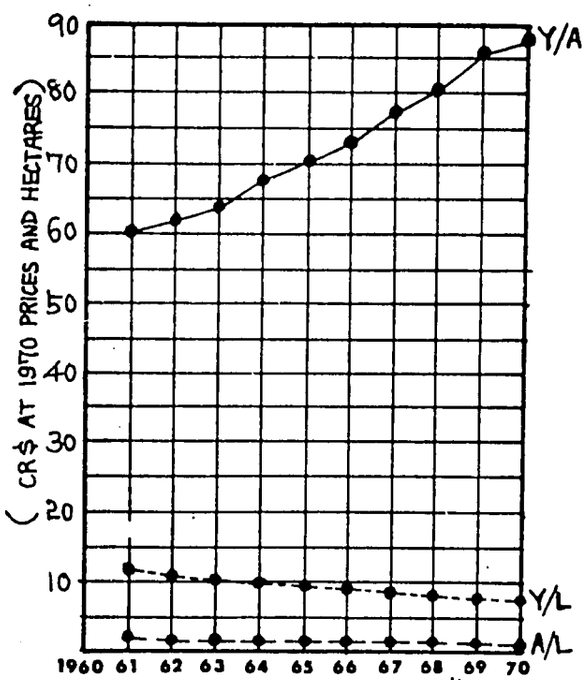
GRAPH 5 : LABOR PRODUCTIVITY (Y/L), LAND PRODUCTIVITY (Y/A) AND LAND/LABOR RATIOS (A/L) ON SMALL FARMS UNDER ALTERNATIVE POLICY PROGRAMS



GRAPH 5A : POLICY PROGRAM = H



GRAPH 5B : POLICY PROGRAM = S_b



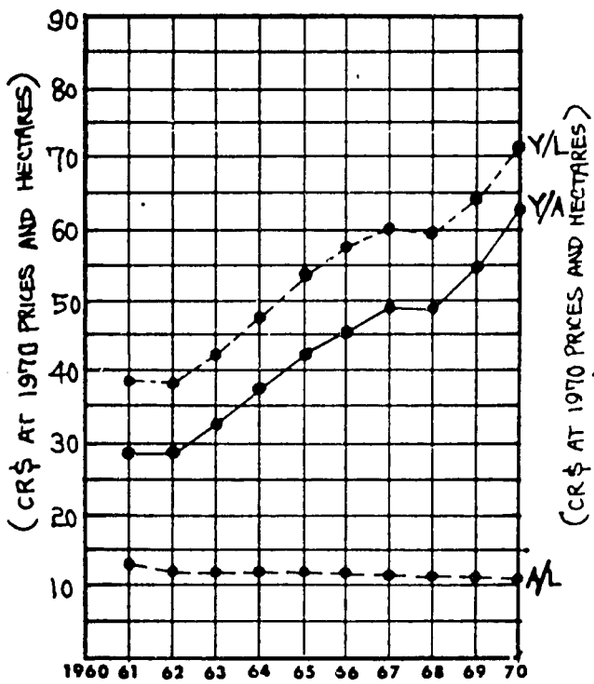
GRAPH 5C : POLICY PROGRAM = S^*

Y/L : CR$/10 LABOR HOURS Y/A : CR$/HA A/L : HA/100 LABOR HOURS.

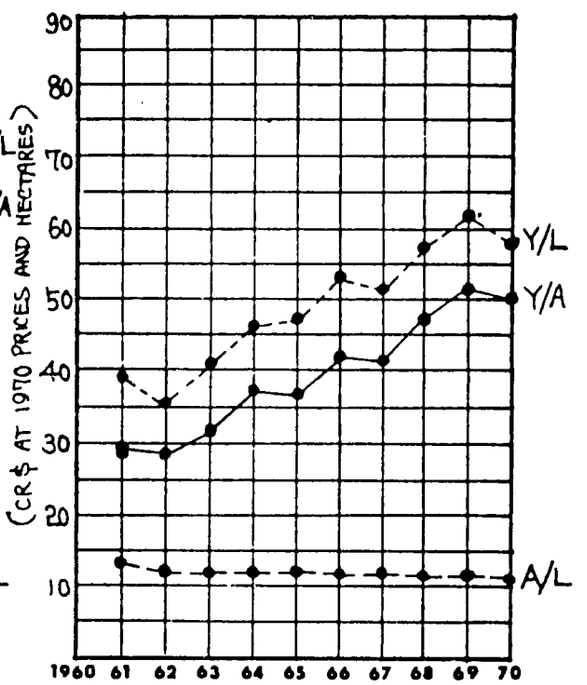
Source: Model Results

Wheat Region in the State of Rio Grande Do Sul, Southern Brazil (1960-1970)

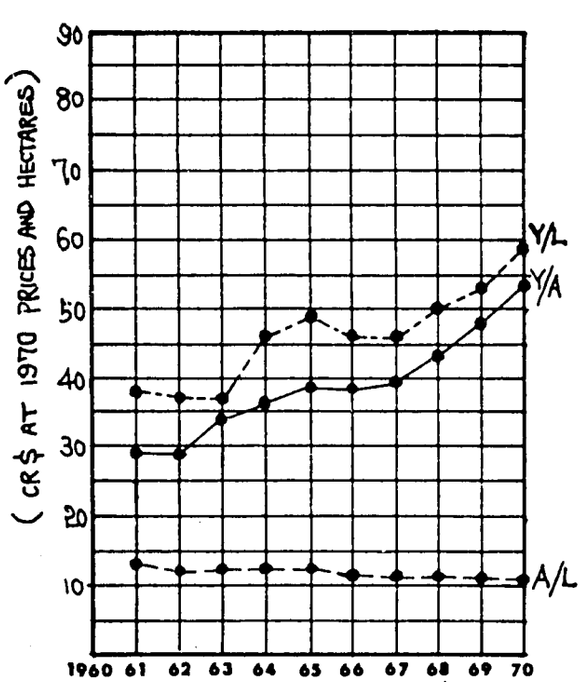
GRAPH 6 : LABOR PRODUCTIVITY (Y/L), LAND PRODUCTIVITY (Y/A) AND LAND/LABOR RATIOS (A/L) ON LARGE FARMS UNDER ALTERNATIVE POLICY PROGRAMS



GRAPH 6A: POLICY PROGRAM = H



GRAPH 6B: POLICY PROGRAM = S_b



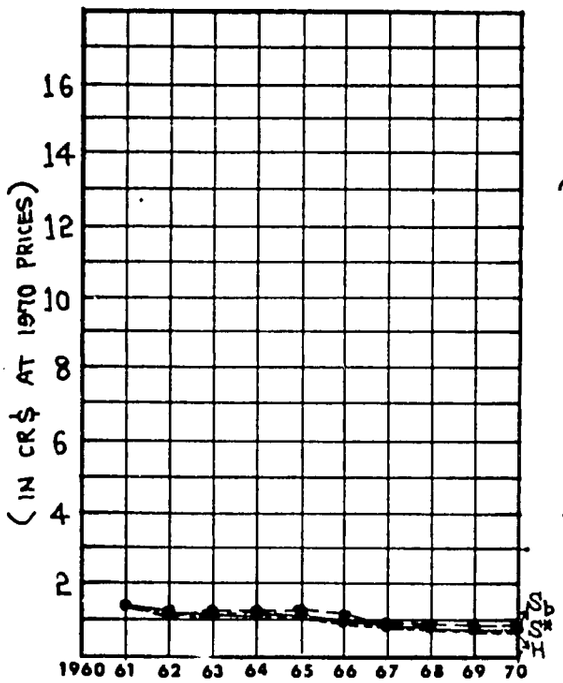
GRAPH 6C: POLICY PROGRAM = S^*

Y/L : CR$/10 LABOR HOURS Y/A : CR$/HA A/L : HA/100 LABOR HOURS

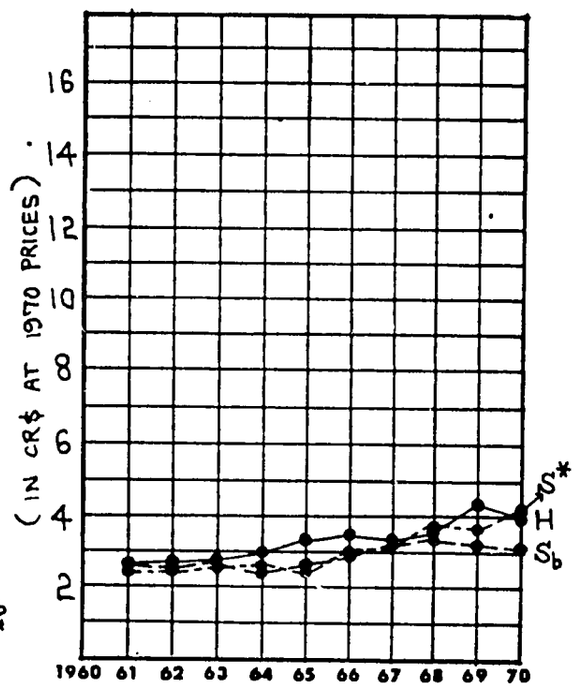
Source: Model Results

Wheat Region in the State of Rio Grande Do Sul, Southern Brazil (1960-1970)

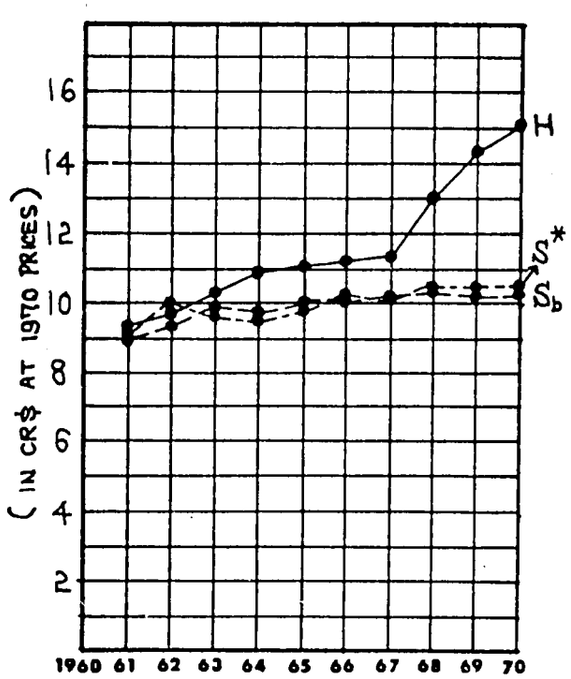
GRAPH 7: AVERAGE ANNUAL TOTAL CAPITAL EXPENDITURES PER LABOR HOUR ON LARGE FARMS UNDER ALTERNATIVE POLICY PROGRAMS



GRAPH 7A: SMALL FARMS



GRAPH 7B: MEDIUM FARMS



GRAPH 7C: LARGE FARMS

$\{H, S_b, S^*\}$ = ALTERNATIVE POLICY PROGRAMS

Source: Model Results

- Wheat Region in the State of Rio Grande Do Sul, Southern Brazil (1960-1970)

price support programs remain intact--no, if they are removed (Table 7). Under what alternative conditions are they likely to demand more credit at reasonably positive real interest rates? When they first have access to new technologies.

On large farms if the credit subsidy is removed the labor productivity, capital-labor and capital-land ratios will decline with a consequent increase in the efficiency of capital. However, if price subsidies are also dropped then the capital-labor and capital-land ratios increase slightly with a consequent decline in capital efficiency.

5. CONCLUSIONS

It has not been the purpose of this paper to analyze all policy programs available or even to analyze comprehensively the impact of the price and credit subsidy programs in the decade of the sixties, although some useful insights have been gained. Rather the main purpose has been to integrate questions of policy with the questions of technology and its structure in order to allow us both a tool that provides quantitative answers to policy options as well as a better understanding of the way an economic sub-system behaves through time. Furthermore it allows us to specify these impacts on a variety of criteria--output, employment, income, income distribution and resource allocation and efficiency, by farm size and region.

APPENDIX

TABLE 1: TOTAL OUTPUT (IN MILLION CR$ AT 1970 PRICES) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms	Regional Total
		Policy Program = H (P_o, C_o, B_o)		
1961	98,443	146,176	200,503	445,622
1962	101,917	153,419	213,496	468,833
1963	106,164	162,253	228,371	496,789
1964	110,939	173,141	248,889	532,970
1965	115,450	187,693	261,549	564,692
1966	122,272	201,333	273,373	596,978
1967	130,327	208,523	284,423	623,274
1968	140,032	217,744	322,433	680,210
1969	150,839	243,152	372,008	766,000
1970	162,829	251,526	416,104	830,460
		Policy Program = S_b (P_o, C_o, B_1)		
1961	98.943	146.176	194.776	439.896
1962	102.217	153.419	206.849	462.486
1963	105.040	162.203	218.142	485.386
1964	108.643	160.575	214.533	483.751
1965	113.162	167.372	224.950	505.485
1966	119.876	174.884	238.060	532.821
1967	127.734	193.346	266.538	587.618
1968	137.240	208.072	287.554	632.867
1969	148.565	205.542	288.742	642.850
1970	164.141	208.131	291.396	663.670
		Policy Program = S^* (P_1, C_1, B_1)		
1961	98.943	143.623	198.373	440.941
1962	102.217	151.267	212.928	466.412
1963	106.148	152.164	214.655	472.968
1964	109.732	158.765	218.473	486.971
1965	114.231	161.221	227.569	503.022
1966	121.005	167.308	246.248	534.561
1967	128.946	178.817	269.022	576.787
1968	138.531	192.852	292.314	623.699
1969	149.677	207.591	320.925	678.195
1970	154.173	225.542	331.737	711.453

TABLE 2: WHEAT HECTRAGE (IN 1000 HA) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Traditional Technology			Modern Technology		
	Small Farms	Medium Farms	Large Farms	Small Farms	Medium Farms	Large Farms
			Policy Program = H (P_o, C_o, B_o)			
1961	18.0	14.4	0.0	0.0	19.3	48.3
1962	21.0	19.1	0.0	0.0	25.4	66.7
1963	25.9	18.2	0.0	0.0	40.5	92.0
1964	31.1	17.3	0.0	0.0	60.2	126.9
1965	37.3	16.3	0.0	0.0	86.0	141.5
1966	44.8	17.3	0.0	0.0	102.7	150.3
1967	53.7	18.6	0.0	0.0	102.4	149.7
1968	64.5	17.8	0.0	0.0	108.5	206.6
1969	77.4	16.6	0.0	0.0	150.2	283.0
1970	91.9	16.0	0.0	0.0	147.0	337.0
			Policy Program = S_b (P_o, C_o, B_1)			
1961	18.0	14.4	0.0	0.0	19.3	45.9
1962	21.0	19.1	0.0	0.0	25.4	63.4
1963	25.9	18.1	0.0	0.0	40.5	87.5
1964	31.1	17.6	0.0	0.0	39.9	81.4
1965	37.3	16.7	0.0	0.0	55.8	101.3
1966	44.8	17.9	0.0	0.0	62.2	118.4
1967	53.7	18.9	0.0	0.0	86.8	163.3
1968	64.5	17.8	0.0	0.0	107.6	190.8
1969	77.4	17.5	0.0	0.0	101.7	177.4
1970	91.9	17.0	0.0	0.0	96.2	165.0
			Policy Program = S^* (P_1, C_1, B_1)			
1961	18.0	15.1	0.0	0.0	15.3	48.3
1962	21.6	18.2	0.0	0.0	21.8	66.6
1963	25.9	19.3	0.0	0.0	18.8	61.9
1964	31.1	17.9	0.0	0.0	28.1	57.6
1965	37.3	18.2	0.0	0.0	25.5	59.6
1966	44.8	17.4	0.0	0.0	25.8	70.9
1967	53.7	17.5	0.0	0.0	33.4	84.5
1968	64.5	17.6	0.0	0.0	42.6	100.5
1969	77.4	17.7	0.0	0.0	53.3	119.6
1970	75.1	17.6	0.0	0.0	66.1	111.3

Source: Model results.

TABLE 3: BEEF PRODUCTIONS (IN 1000 METRIC TONS) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Using Natural Pasture			Using Improved Pasture		
	Small Farms	Medium Farms	Large Farms	Small Farms	Medium Farms	Large Farms
			Policy Program = H (P_o, C_o, B_o)			
1961	63.7	90.2	120.2	4.7	7.5	12.5
1962	62.7	88.9	118.4	5.4	9.0	14.1
1963	61.8	87.5	116.6	6.2	10.8	17.6
1964	60.9	86.2	113.5	7.1	13.0	21.9
1965	59.9	84.9	112.6	8.2	15.6	27.3
1966	59.0	83.7	110.9	9.4	18.7	34.3
1967	58.2	82.4	109.3	10.9	22.5	42.9
1968	57.3	81.2	103.1	12.5	26.9	53.6
1969	55.7	77.3	94.8	14.4	32.3	67.0
1970	53.5	76.1	87.2	16.5	38.8	83.7
			Policy Program = S_b (P_o, C_o, B_1)			
1961	63.7	90.3	120.4	4.7	7.6	11.3
1962	62.8	89.0	118.6	5.4	9.1	14.1
1963	61.9	87.6	116.8	6.2	10.9	17.6
1964	60.9	86.3	115.1	7.2	13.1	22.1
1965	60.0	85.1	113.3	8.3	15.7	27.6
1966	59.0	83.7	111.6	9.5	18.8	34.5
1967	58.2	82.5	108.7	10.9	22.6	43.1
1968	57.3	81.2	104.5	12.7	26.9	53.9
1969	56.5	80.0	102.7	14.5	28.5	67.3
1970	55.2	78.8	100.1	16.6	32.8	84.2
			Policy Program = S^* (P_1, C_1, B_1)			
1961	63.7	90.5	120.4	4.7	7.5	11.3
1962	62.8	89.2	118.6	5.4	9.1	14.1
1963	61.9	87.8	116.9	6.2	10.8	17.6
1964	60.9	86.5	115.1	7.2	13.1	22.1
1965	60.0	85.2	113.3	8.3	15.7	27.6
1966	59.1	83.9	111.6	9.5	18.8	34.5
1967	58.2	82.7	109.9	9.3	22.6	43.1
1968	57.4	81.4	106.0	12.6	27.1	53.9
1969	56.5	80.2	101.1	14.5	32.5	67.4
1970	55.6	79.0	96.9	16.6	39.1	84.2

Source: Model results.

TABLE 4: TOTAL LABOR USE (IN MILLION HOURS) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms	Regional Total
		Policy Program = $H(P_o, C_o, B_o)$		
1961	52.880	23.245	15.075	91.201
1962	59.099	23.718	15.739	98.557
1963	66.052	24.184	15.724	105.961
1964	74.044	24.668	15.844	114.558
1965	79.873	25.180	15.940	120.994
1966	90.211	25.665	16.112	131.989
1967	102.168	26.178	16.378	144.725
1968	116.019	26.702	16.986	159.708
1969	132.035	27.236	17.831	177.103
1970	150.107	27.780	18.801	196.689
		Policy Program = $S_b(P_o, C_o, B_1)$		
1961	52.880	23.253	14.968	91.102
1962	59.099	23.710	15.615	98.426
1963	63.161	24.184	15.529	102.876
1964	68.119	24.668	15.596	108.384
1965	74.125	25.161	15.298	114.585
1966	84.003	25.665	15.482	125.151
1967	95.464	26.178	15.967	137.610
1968	108.779	26.699	16.383	151.861
1969	124.266	27.236	16.724	168.227
1970	138.684	27.780	17.217	183.682
		Policy Program = $S^*(P_1, C_1, B_1)$		
1961	52.880	23.245	15.033	91.159
1962	59.099	23.710	15.724	98.535
1963	66.052	24.984	15.486	106.523
1964	70.922	24.811	15.332	111.066
1965	76.845	26.131	15.386	118.386
1966	86.941	27.648	16.306	130.895
1967	98.637	28.388	17.283	144.308
1968	112.205	29.150	17.683	159.038
1969	127.240	29.502	18.271	175.014
1970	135.816	29.862	18.755	184.434

Source: Model results.

TABLE 5: WORKING CAPITAL USE (IN MILLION CR$ AT 1970 PRICES) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms	Regional Total
		Policy Program = H (P_o, C_o, B_o)		
1961	35.437	55.613	136.302	227.353
1962	36.682	59.650	147.148	243.481
1963	38.406	63.477	152.205	254.090
1964	40.350	68.390	161.142	269.882
1965	41.851	75.048	165.918	282.818
1966	44.524	81.684	170.833	297.042
1967	47.675	84.984	175.919	308.578
1968	51.435	88.674	197.483	337.593
1969	55.642	100.574	226.721	382.938
1970	60.288	103.580	254.114	417.983
		Policy Program = S_b (P_o, C_o, B_1)		
1961	35.437	55.613	133.387	224.438
1962	36.801	59.585	143.765	240.152
1963	37.703	63.458	147.129	248.291
1964	38.898	62.833	141.925	243.657
1965	40.421	66.327	146.209	252.958
1966	43.010	70.196	147.897	261.103
1967	46.035	79.246	168.737	294.019
1968	49.663	85.945	181.066	316.676
1969	53.972	85.218	183.661	322.852
1970	60.529	85.500	188.751	334.781
		Policy Program = S^* (P_1, C_1, B_1)		
1961	35.448	54.768	135.362	225.579
1962	36.801	58.628	147.119	242.549
1963	38.403	65.481	143.904	247.789
1964	39.586	62.703	142.445	244.735
1965	41.097	70.415	144.874	256.387
1966	43.723	81.885	159.952	285.560
1967	46.798	89.247	177.164	313.210
1968	50.495	97.848	189.292	337.636
1969	54.690	102.471	205.488	362.649
1970	56.173	108.499	214.147	378.820

Source: Model results.

TABLE 6: INVESTMENT CAPITAL USE (IN MILLION CR$ AT 1970 PRICES) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms	Regional Total
		Policy Program = H (P_o, C_o, B_o)		
1961	0.285	4.905	5.416	10.607
1962	0.314	3.162	7.627	11.104
1963	0.355	6.005	9.890	16.251
1964	0.404	6.955	13.087	20.447
1965	0.389	9.256	9.446	19.092
1966	0.507	8.693	9.599	18.800
1967	0.578	5.909	9.203	15.691
1968	0.663	7.857	24.155	32.677
1969	0.762	17.497	30.182	48.442
1970	0.867	7.521	28.149	36.538
		Policy Program = S_b (P_o, C_o, B_1)		
1961	0.285	4.905	2.210	7.401
1962	0.314	3.162	7.132	10.610
1963	0.296	6.005	7.247	13.550
1964	0.329	0.151	0.268	0.749
1965	0.369	4.753	6.945	12.068
1966	0.472	4.672	7.831	12.975
1967	0.541	10.334	15.578	26.454
1968	0.625	9.114	12.405	22.145
1969	0.721	2.012	1.511	4.245
1970	0.757	1.580	1.924	4.263
		Policy Program = S^* (P_1, C_1, B_1)		
1961	0.285	4.293	5.172	9.751
1962	0.314	4.014	8.191	12.520
1963	0.355	0.778	3.439	4.572
1964	0.336	5.255	4.708	10.301
1965	0.380	1.731	6.909	9.021
1966	0.490	3.283	10.257	14.031
1967	0.599	6.556	12.143	19.259
1968	0.644	7.634	14.541	22.820
1969	0.724	9.128	17.531	27.385
1970	0.644	11.013	6.587	18.245

Source: Model results.

TABLE 7: SHORT-TERM BORROWING (IN MILLION CR$ AT CURRENT PRICES) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms	Regional Total
		Policy Program + H (P_o, C_o, B_o)		
1961	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0
1963	0.254	0.0	0.975	1.229
1964	2.756	4.113	10.022	16.891
1965	3.803	9.931	15.681	29.415
1966	6.135	17.807	21.287	45.229
1967	2.700	14.888	14.399	31.987
1968	0.0	14.613	33.877	48.490
1969	2.434	50.764	102.069	155.267
1970	7.879	77.777	192.536	278.192
		Policy Program = S_b (P_o, C_o, B_1)		
1961	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0
1963	0.204	0.0	0.0	0.204
1964	2.362	0.391	0.767	3.520
1965	3.457	0.0	0.0	3.457
1966	1.031	0.0	0.0	1.031
1967	3.793	0.0	0.0	3.793
1968	0.897	0.0	0.0	0.897
1969	4.002	0.0	0.0	4.002
1970	9.277	0.0	2.068	11.345
		Policy Program = S^* (P_1, C_1, B_1)		
1961	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0
1963	0.0	0.0	0.0	0.0
1964	2.440	0.0	1.009	3.449
1965	0.0	0.0	0.0	0.0
1966	0.0	0.0	0.0	0.0
1967	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0

Source: Model results.

TABLE 8: AVERAGE NET LABOR PRODUCTIVITY PER HOUR (IN CR$ AT 1970 PRICES) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms
	Policy Program = H (P_o, C_o, B_o)		
1961	1.195	3.684	3.899
1962	1.098	3.820	3.730
1963	1.020	3.835	4.214
1964	0.947	3.964	4.711
1965	0.916	4.105	5.406
1966	0.856	4.323	5.768
1967	0.803	4.493	6.063
1968	0.757	4.539	5.933
1969	0.715	4.592	6.455
1970	0.677	5.054	7.118
	Policy Program = S_b (P_o, C_o, B_1)		
1961	1.195	3.683	3.953
1962	1.101	3.824	3.582
1963	1.061	3.834	4.106
1964	1.019	3.956	4.638
1965	0.976	3.827	4.692
1966	0.909	3.896	5.317
1967	0.850	3.963	5.149
1968	0.799	4.232	5.742
1969	0.755	4.343	6.192
1970	0.741	4.357	5.849
	Policy Program = S^* (P_1, C_1, B_1)		
1961	1.195	3.637	3.847
1962	1.101	3.737	3.664
1963	1.020	3.438	3.346
1964	0.984	3.659	4.651
1965	0.946	3.408	4.925
1966	0.883	2.970	4.663
1967	0.827	2.924	4.612
1968	0.778	2.997	5.003
1969	0.740	3.253	5.358
1970	0.716	3.550	5.918

Source: Model results.

TABLE 9: AVERAGE NET PRODUCTIVITY OF ANNUAL CAPITAL EXPENDITUPES (IN CR$) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms
	Policy Program = H (P_o, C_o, B_o)		
1961	1.769	1.415	0.414
1962	1.754	1.422	0.379
1963	1.738	1.335	0.408
1964	1.722	1.297	0.428
1965	1.733	1.226	0.491
1966	1.715	1.227	0.515
1967	1.700	1.294	0.536
1968	1.687	1.255	0.454
1969	1.674	1.059	0.448
1970	1.662	1.263	0.474
	Policy Program = S_b (P_o, C_o, B_1)		
1961	1.769	1.415	0.436
1962	1.754	1.449	0.470
1963	1.764	1.335	0.413
1964	1.769	1.549	0.508
1965	1.774	1.354	0.468
1966	1.756	1.335	0.528
1967	1.742	1.158	0.446
1968	1.729	1.188	0.486
1969	1.716	1.356	0.559
1970	1.678	1.390	0.528
	Policy Program = S^* (P_1, C_1, B_1)		
1961	1.768	1.431	0.411
1962	1.754	1.414	0.370
1963	1.738	1.296	0.456
1964	1.748	1.336	0.484
1965	1.754	1.234	0.499
1966	1.736	0.964	0.446
1967	1.722	0.866	0.421
1968	1.708	0.828	0.434
1969	1.701	0.860	0.439
1970	1.713	0.887	0.502

Source: Model results.

TABLE 10: AVERAGE ANNUAL TOTAL CAPITAL EXPENDITURES PER LABOR HOUR (IN CR$ AT 1970 PRICES) BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms
	Policy Program = $H\ (P_o,\ C_o,\ B_o)$		
1961	0.675	2.603	9.400
1962	0.626	2.648	9.833
1963	0.586	2.873	10.308
1964	0.550	3.054	10.995
1965	0.528	3.348	11.001
1966	0.499	3.521	11.198
1967	0.472	3.472	11.303
1968	0.449	3.615	13.047
1969	0.427	4.335	14.407
1970	0.407	3.999	15.012
	Policy Program = $S_b\ (P_o,\ C_o,\ B_1)$		
1961	0.675	2.602	9.058
1962	0.628	2.646	9.663
1963	0.601	2.872	9.940
1964	0.575	2.553	9.117
1965	0.550	2.824	10.011
1966	0.517	2.917	10.058
1967	0.487	3.421	11.543
1968	0.462	3.560	11.809
1969	0.440	3.202	11.071
1970	0.441	3.134	11.074
	Policy Program = $S^*\ (P_1,\ C_1,\ B_1)$		
1961	0.675	2.540	9.348
1962	0.628	2.641	9.876
1963	0.586	2.652	9.514
1964	0.562	2.739	9.597
1965	0.539	2.760	9.864
1966	0.508	3.080	10.438
1967	0.480	3.374	10.953
1968	0.455	3.618	11.526
1969	0.435	3.782	12.205
1970	0.418	4.002	11.769

Source: Model results.

TABLE 11: AVERAGE LABOR HOURS PER HECTARE BY FARM SIZE UNDER ALTERNATIVE POLICY PROGRAMS: WHEAT REGION IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL (1961-1970)

Year	Small Farms	Medium Farms	Large Farms
	Policy Program = H (P_o, C_o, B_o)		
1961	50.3	15.7	7.6
1962	56.5	16.0	7.9
1963	63.3	16.3	7.8
1964	70.9	16.6	7.8
1965	76.6	16.7	7.8
1966	85.9	16.8	7.9
1967	96.2	17.1	7.9
1968	107.5	17.3	8.2
1969	121.1	17.5	8.5
1970	136.8	17.7	8.8
	Policy Program = S_b (P_o, C_o, B_1)		
1961	50.3	15.7	7.6
1962	56.5	16.0	7.9
1963	60.9	16.3	7.8
1964	66.0	16.9	8.0
1965	71.9	17.2	7.8
1966	81.0	17.5	7.9
1967	91.1	17.5	8.0
1968	102.3	17.6	8.2
1969	114.6	17.9	8.4
1970	124.1	18.3	8.6
	Policy Program = S^* (P_1, C_1, B_1)		
1961	50.3	15.7	7.6
1962	56.5	16.1	7.9
1963	63.3	17.1	7.8
1964	68.3	17.0	7.8
1965	74.2	18.0	7.8
1966	83.3	19.0	8.1
1967	93.5	19.2	8.4
1968	104.8	19.4	8.6
1969	116.7	19.4	8.8
1970	123.8	19.2	9.0

Source: Model results.

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