HUMAN CAPITAL AND PRODUCTION EFFICIENCY: ARGENTINE AGRICULTURE

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I. INTRODUCTION

This study attempts to explain differentials in production efficiency in Argentine agriculture. The paper focuses attention on the 1970's and 1980's. During this period, technological change was pervasive. Moreover, during the mid 1970’s and the mid to late 1980’s Argentina had the doubtful privilege of ranking as one of the countries with highest inflation of the world. The principal objective of the paper is to test the hypothesis that human capital (education) is a relevant variable in explaining efficiency differentials. This hypothesis is of interest given the rapid rate of change in agricultural technology, and the lag in education that the agricultural sector presents in relation to other sectors of the economy. The paper also analyzes the possible impact, on efficiency, of firm size as well as ownership structure. Attention is give to firm size because incentives for information-gathering depend on the magnitude of the "universe" over which decision-making will take place. If information gathering and analysis entails fixed costs, "large" firms may adopt innovations earlier than those of smaller size. A trend towards larger firms might result.
Lastly, attention is given to the separation between ownership and control as this has been a hotly debated topic in agricultural development as well as in the more applied fields of management and organization.

II. OUTPUT, INPUT AND PRODUCTIVITY

An overview of production and productivity trends helps to understand the overall context of this study. The Argentine agricultural sector grew at a modest rate during the 1950's and 1980's, somewhat higher during the 1960's, and very rapidly during the 1970's and 1990's (**Graph 1**). Determinants of growth have not been analyzed in depth. As pointed out by Schultz

(1964) growth (resulting from technology inflow) creates the need for adjustment. In this process, different types of inefficiency may arise.

A steady stream of new technologies was made available to farmers during the last decades. During the 1970's wheat varieties resulting from the Green Revolution allowed improved response to management and fertilizers. Soybeans- virtually unknown in the late 1960's - rapidly became the most important crop in the traditional corn producing areas. Hybrid sunflower replaced conventional seeds and allowed a substantial improvement in crop yields. Fabio Nider argues that crop genetics played a substantial part in the improvement of crop yields in the two or three decades previous to 1980. He also shows that farm-level yields have improved somewhat slower than "potential" yields observed in research plots. Nider also argues that a "management gap" may be responsible for such differences.

Since the early 1980's, output and land productivity increased more rapidly for oilseeds than for cereals (**Table 1**).[1] Output growth during the 1970's was caused by the availability of new crops (soybeans) as well as of improved genetics for existing crops (wheat, corn, sunflower). Managerial practices also changed, but possibly in response to improved opportunities opened up by higher performance seeds. During the 1990's, however, output growth resulted not only from improved genetics, but also from increased use of conventional inputs. For the 5 principal grain crops (wheat, corn, sorghum, sunflower and soybeans) planted area increased from 14 million hectares in the early 1970's, to 18 million in the early 1980's and more than 22 million a decade later (**Graph 2**). This reallocation of land use from livestock to grain production places significant pressure on decision-making at the firm level.

This study deals with decision-making during the 1970's and 1980's. Detection of constraints impinging on decisions is of special interest given the changes taking place since this time period. In particular, macroeconomic reforms implanted in 1990 led to elimination of export and input tariffs, and this resulted in a dramatic increase in the use of fertilizers and herbicides. Indeed, in the 1990 - 1998 period fertilizer use quadrupled and herbicide use trebled (**Graph 3**). [2]

[1] Wheat, corn, sorghum, soybeans and sunflower.
[2] Total demand for fertilizer amounted to US$ 300 million in the mid 1980's, this figure had increased to US$ 600 million by 1994. Similarly, the use of "advanced" herbicides in the soybean crop increased form 10 percent of the planted hectares in 1989 to about 80 percent in 1994 (Gallacher, 1996).

Table 1: ARGENTINA - Output and Output per Unit of Land

(1970-74 = 100)

	80-84	90-94
Total Output	205	253
Land Input	124	119
Cereal Output	155	125
Oilseed Output	819	1.733
Total Output/Land	174	212
Cereal Output/Land	147	177
Oilseed Output/Land	241	288

Source: Ministerio de Economía - SAGPyA

Lema (1999) provides additional evidence on the evolution of the Argentine agricultural sector during the last three decades. His results indicate a TFP growth (1970-1997) of 1.55 percent per year, substantially lower than the increase in overall output observed for the same period (3.22 percent). Discrepancy between increase in output and in TFP is of course explained by changes in input use: land (+ 0.44 percent), labor (- 0.47 percent) and capital (+ 1.93 percent). These results clearly show the increased capital/labor and capital/land ratios of the Argentine agricultural sector.

Complex decision-making allows the changes in input, output and productivity mentioned previously to take place. Farmers need to discover the availability of new technologies, and to change production practices in order to extract as much advantage from these as possible. Agronomists emphasize the interaction between planting dates, seed density, weed control methods, fertilizer levels and other variables in determining output levels. These interactions are particularly important in multiple-output situations that are prevalent in many Argentine production regions. Information sources include private management services (Gallacher 1988 and 1994), input dealers, public-sector institutions and other agencies. An increase in the supply of information, however, does not solve the decision-making problem: information has to be filtered, decoded, and adapted to particular circumstances.

Educational levels in rural areas lag behind those of the rest of the country. Data for 1980 for the province of Buenos Aires, indicates that 59 percent of population (6 years or older) completed primary school. For rural areas this figure is only 43 percent. The gap between education in urban and rural areas is greater in other provinces of the *pampean* areas (Cordoba and Santa Fe), and is greater still for the relatively "backward" provinces of the north-west and north-east of Argentina such as Chaco and Salta (**Table 2**). Educational gaps between rural and urban areas may reflect, in part, past economic policies that reduced economic returns (including returns to human capital) in agricultural versus non-agricultural sectors. However, they might also suggest a lower marginal productivity of human capital in agriculture than in other sectors of the economy, resulting in differential inter-sectoral migration of human resources.

Furthermore, human-capital accumulation is lower in rural areas: in rural areas learning (as measured in school tests) is lower than in non-rural settings. For example, 35 percent of students of urban areas attained a grade of 4 or less (scale 1-10) in a test of mathematics, for rural areas the relevant figure was 60 percent (Gallacher, 1994b).

III. DECISION-MAKING SKILLS

In a pioneering study Welch (1970) defines a “worker” and an “allocative” effect of education. The former relates to education as an input that allows more output to be produced from a given input vector. In turn, the latter allows adaptation of the input (and, in multi output firms) output vector to changes in price signals. An important portion of the returns to education stems from this “allocative” effect; that is education should not only be considered a shifter of the production function, but an input that allows changes in factor use and thus movements along the production surface. Huffman (1974) focuses on allocative decisions by analyzing changes in input usage (fertilizer) in a period of rapid decrease in the input/output price ratio, and of increase in the MVP of fertilizer inputs.

Table 2: Education Levels - Rural and Urban

	Primary Education:		
	Assists	Assisted	
Province		Incomplete	Complete
Buenos Aires	%	%	%
Urban	16.2	21.4	58.6
Rural	16.3	33.8	43.3
Santa Fé			
Urban	14.8	22.4	58.2
Rural	17.3	35.4	38.3
Cordoba			
Urban	15.7	23.1	56.9
Rural	17.6	39.0	34.5
Chaco			
Urban	20.3	25.6	44.7
Rural	23.3	38.2	15.9
Salta			
Urban	22.9	19.2	52.3
Rural	27.1	35.2	18.3

Source: INDEC-Censo Nacional de Población y Vivienda 1980. Serie D Población

He concludes that “decision-makers with more education can more quickly grasp changes and adjust more quickly and accurately to them”. Petzel (1978) adapts Nerlove’s supply model to take into account education as a factor affecting the speed with which adjustment occurs. He finds a positive relation between education and supply adjustment. Further, Huffman as well as Petzel find a positive relationship between firm size and adjustment speed. Lower (per unit) costs of information gathering are put forward as an explanation of this finding.

Worker Effect: The worker effect of education is analyzed by comparing Total Factor Productivity of decision-making units identical in all senses, except for human capital endowment. Total factor productivity of the *i-th* firm in period *t* is defined as:

$$[1] \quad TFP_{it} = Y_{it}/X_{it}$$

where input bundle *X* includes “conventional” factors of production, but excludes “non conventional” ones such as human capital. Thus, for firms using identical “conventional” factors, differences in *TFP* can be explained by differences in non conventional (and unmeasured) inputs used. In empirical work, however, the “conventional” input vector will seldom be measured without error. In particular, between-firm differences in resource “quality” will limit the possibility of inter-firm comparisons. This is especially important in agricultural firms, where productivity of land resources plays an important role, and where measures of use of land input “corrected” by quality are difficult to come by. Comparison of *TFP* growth is of greater interest than comparison of absolute *TFP* at a given point in time, because *TFP* growth is less affected than absolute *TFP* by relative resource endowments. In symbols *TFP* growth for firm i between periods 0 and 1:

$$[2] \quad \Delta\, TFP_{i0,1} = [Y_{i1}/X_{i1}]/[Y_{i0}/X_{i0}] = [Y_{i1}/Y_{i0}][X_{i0}/X_{i1}]$$

Productivity growth represents “technological change” (increased output per unit of input). Decision-making skills can be hypothesized to be a determinant of increased efficiency, thus human capital can be seen as an important factor affecting *TFP* growth though time. In expression [2] above, decision-making skills allow "high" values of $[Y_{i1}/Y_{i0}]$ (increases in output levels) to be associated with "high"values of $[X_{i0}/X_{i1}]$ (thus reflecting relatively "low" increase in input usage). A hypothesis to be tested, then, is that Δ *TFP* is a function of available human capital inputs as well as of firm-level characteristics associated with the economics of information.

The above approach is non-parametric in the sense that no explicit production function is assumed: attention centers only on output and input quantities. Within a production-function framework, human capital can be assumed to enter as a neutral shifter. Let e denote human capital, and x_1 and x_2 denote respectively variable and fixed inputs:

$$[3] \quad y(x_1, x_2, \mathrm{e}) = H(e)\, f(x_1, x_2) \qquad \text{where } 0 < H(.) \leq 1.$$

Given that x_2 is fixed, returns to the fixed factor can be expressed as:

$$[4] \quad \boldsymbol{p} = p\, H(e)\, \mathrm{f}(x_1, x_2) - w_1 x_1$$

With first-order condition:

$$[4a] \quad d\boldsymbol{p}/dx_1 = p\, H(e)\, f'(x_1, x_2) - w_1 = 0$$

$$[4b] \quad f'(x_1, x_2) = MP_1 = w_1/pH(e) > w_1/p$$

That is, resource use is lower when $H(e) < 1$ than would be the case when decision-skills allow potential output to be achieved. **Graph 4** shows the downward shift in the MP schedule brought about by human-capital constraints. When $H(.) = 1$ optimum input use is x_1^{**}, with profits represented by area *abc*; however with $H(e) < 1$ optimum input use is x_1*. The "worker" effect acts reducing input MP and thus returns to fixed factors.

Allocative Effect: The fall in profits presented above is due to a reduction in input productivity due to lower human capital. Human capital however, will have a second impact on profits through allocative decisions. As above, let x^{**} and x^{*} represent efficient input allocations under $H(e) = 1$ and $H(e) < 1$, and let x^A denote the actual input use chosen by the decision-maker. Define *allocative error* as $| x^{**} - x^{A**} |$ and $| x^* - x^{A*} |$ for decision-makers with "high" and "low" human capital. Decision-skills will result in $| x^{**} - x^{A**} | < | x^* - x^{A*} |$. This implies that economic loss due to allocative error will be lower for $H(e) = 1$ than for $H(e) < 1$. A simple graphic analysis can be presented for $| x^{**} - x^{A**} | = 0$ but $| x^* - x^{A*} | > 0$. Net revenue differences are *abc - a'b''b'c* . These are greater than would be expected if decision-skills only affected marginal productivity of resources but not the extent to which marginal conditions for profit maximization are met.

Optimal level of factor use as in [4b] represents one of the several dimension of (allocative) production efficiency (for a summary of efficiency measures, see Fried, Knox Lovell and Schmidt, 1993). In a multiple-input, multiple-output framework cost minimizing input combinations, and output maximizing output combinations must also be met. In particular, for a two-output, two-input production process ($Y_1(x_1, x_2)$, $Y_2(x_1, x_2)$) this implies:

$$[5a] \quad [\delta Y_1/\delta X_i]/ [\delta Y_2/\delta X_i] = p_2/p_1 \qquad i = 1,2$$

$$[5b] \quad [\delta X_2/\delta X_1] = w_1/w_2$$

Allocative errors due to non-optimal decisions result in [5a] and [5b] being not met. This, plus lower resource productivity results in firm level profits being lower than those attainable with flawless decision-making capacity:

$$[6] \quad \pi^A [Y_1(x_1, x_2)^A, Y_2(x_1, x_2)^A] \leq \pi^*[Y_1(x_1, x_2)^*, Y_2(x_1, x_2)^*]$$

where superscripts "^{A}" and "*" stand for, respectively, actual and optimal firm-level efficiency.

Quality of decisions depends not only on human capital. *Firm size* is an additional factor. This occurs due to fixed costs associated with information gathering. For example, a given decision requires investment of time in search, and this search is largely independent on the amount of resources controlled. Profit difference between "optimal" and "actual" resource use is $\pi^*[Y_1(x_1, x_2)^*, Y_2(x_1, x_2)^*] - \pi^A [Y_1(x_1, x_2)^A, Y_2(x_1, x_2)^A]$. As before, assume that x_1 is the variable factor, and that x_2 is fixed at different levels according to firm size. For a given human-capital level, allocative error $| x^* - x^A |$ may be reduced by investing C_I in improved information; however if:

$$[7]\ C_I > \pi^*[\ Y_1(x_1, x_2)^*, Y_2(x_1, x_2)^*] - \pi^A\ [Y_1(x_1, x_2)^A, Y_2(x_1, x_2)^A]$$

information will not be gathered; hence input level will remain x^A . In contrast, for a higher level of x_2, the above inequality will be reversed, thus inefficiency is eliminated.

Management structure: the impact of firm ownership on efficiency has long interested agricultural economists. In sectors (such as agriculture) where economies of scale are weak and technology is not overly complicated firms controlled by families may have an advantage over those where a clear separation between ownership and control exists (see, e.g. Pollak, 1985). Family-firms, in particular, may monitor resource use more efficiently; furthermore "speculative" (as opposed to "purely productive") use of land may be less important for firms where net incomes depend only on farming, as opposed to those where capital gains through timing of purchase and sale of land may be a primary concern. The linkage between resource ownership and efficiency, however, is clearly an empirical one: firms owned by outside investors might be less concerned by risk considerations, tradition, or other constraints on optimal resource use.

IV. DATA AND EMPIRICAL ANALYSIS

Analysis is made of the “worker” and “allocative” effects of the educational, firm size, and firm ownership inputs, using production data for the most important agricultural region of Argentina (provinces of Buenos Aires, Santa Fe and Cordoba). Decision-making units correspond to *partidos* ("departamentos” for Cordoba and Santa Fé). A total of 146 cross-section data points were available. Average values of production, revenue, land use and costs for each of these were computed using a 20 year time period (1970-1989). Time period 0 corresponds to the 1970-79 period, and time period 1 to the 1980-89 period. Ideally, hypothesis testing should proceed by fitting a production function to cross-section, time-series data. This function allows estimation of the impact of human capital and the other variables on the position of the production surface. Such an econometric exercise, however, requires a high-quality data set, particularly if a multiple-output production process is to be modeled. Further, errors due a badly specified technology might well mask inefficiency (or efficiency) levels. As an alternative, simple measures of worker and allocative efficiency levels can be computed without recourse to production function estimation. This is the approach to be taken here.

Total Factor Productivity: *TFP* change was calculated as the product of output change times the reciprocal of change in input use. Change in total input use was derived as: $[\alpha E + (1-\alpha)T]$ where E represents change in cash production expenses, T represents change in land use and α represents an estimate of the share of production expenses in total costs (production expenses + land rent). A value $\alpha = 0.6$ was assumed. [3]

Returns to Fixed Factors: The extent to which price and technology changes are acted upon by decision-makers can be gauged by comparing returns to fixed factors in a base period, with returns in a future time period. Define change in returns as:

$$[8]\ \Delta\pi_{10} = \frac{\{\pi^A[Y_1(x_1, x_2), Y_2(x_1, x_2)/H_1]\}}{\{\pi^A[Y_1(x_1, x_2), Y_2(x_1, x_2)/H_0]\}}$$

where H_t (t= 0,1) represents planted hectares in period 0 and 1. Change in TFP (expression [1]) as well as in returns to fixed factors (expression [8]) are used as dependent variables for hypothesis-testing.

Land Input: planted hectares to the 5 principal crops constitutes the land input.

Variable Expenses: data at the "partido" level on variable expenses are not available from formal surveys. Estimates of production expenses was obtained by using "engineering" cost estimates reported in agricultural business publications (in particular from the ***Agromercado*** monthly). These publications allow inter-zonal and inter-crop differences in resource use patterns to be detected. Subjective corrections to data published in 1987 and 1999 were made in order to capture - at least roughly - differences in input use between the 1970's and the 1980's.

Human Capital: A human capital (*HC*) proxy was derived by using the quotient:

[3] E = Per-hectare Expenses 1980's/Expenses1970's.
T = land 1980's/Land 1970's. Expenses estimated using budget estimates reported in Agromercado.

[9] $HC = 100*[S + T]/Pop$

where S and T represent population having assisted to secondary tertiary education, and Pop is the population aged 14 and older. Two different HC values are derived . The first ($HC1$) corresponds to human capital levels in the *rural* portion of each partido. This is "farm" educational level. The second measure ($HC2$) is average HC of both rural and the urban population. The rationale for this choice is the fact that "agricultural" decision-making skills reside in farms as well as in urban areas that are surrounded by farms. Indeed, many farm managers reside in urban areas; furthermore input and output markets depend crucially on the level of decision-making skills that exist in "non-farm" businesses. It is expected that these markets affect efficiency at the farm level. INDEC data of the ***Censo Nacional de Población y Vivienda - Serie D Población*** (1980) was used to derive the HC indexes.

Firm Size: is defined as Land in Farms/Number of Farms. This measure is imperfect, as it does not take into account differences in potential output due to differences in land quality. Further, for this and the next variable, data was obtained from the ***Censo Nacional Agropecuario*** (1988). Ideally, data from the late 1970's or early 1980's would have been more appropriate given that the objective was to compare changes in efficiency levels between the 1970's and the 1980's.

Firm Ownership: separation between ownership and control was defined as the quotient:

[10] $Owner = (PP + FP)/Total\ Land$

where PP and FP represents, respectively, land area under personal and family property. The denominator ("Total Land") includes PP and FP as well as firms under a "corporate" legal form.

Hypothesis testing is carried out by regressing ΔTFP_{10} and $\Delta\pi_{10}$ on human capital (rural and urban), firm size and ownership variables. Further, dummy variables were used to attempt to capture regional differences in technology and production potential (land- and weather induced). A total of 5 production regions were defined. [4] These correspond roughly to the classification of production areas frequently employed in agricultural business publications.

V. RESULTS

Data Description: Graphs 5-7 report variability of independent variables used in regression models. *Human Capital*: Educational levels are lower in rural than in urban areas (**Graph 5a**). The most frequent interval of the former is 10; of the latter 22 (as mentioned previously these figures reflect percentage of population having assisted to secondary or tertiary education).[5] Further, human capital levels appears considerably less variable in rural than in urban settings. Rural areas thus can be characterized by uniformly low educational levels; in urban settings education is higher but also more variable. The regression model uses as independent variable both *rural* as well as *average* (rural + urban) human capital. **Graph 5b** reports variability of this last measure in the sample. As shown, in some 3/4 of observations the proportion of individual who assisted to secondary or tertiary education ranges from 14 to 22 %.

Firm size is concentrated in the intervals spanning 0 - 600 hectares (**Graph 6**). Despite the long-run trend to firm growth that appears pervasive in many agricultural economies, firms (in 1988) were "medium sized". In 1999 dollars, assuming 100 % land ownership, total land investments for a 300-hectare "modal" farm was approximately US$ 600.000. Total investment will of course be larger due to (non-land) capital inputs; however land typically represents about 80 % of total investment. In summary, the agricultural firm as analyzed here corresponds (in total investment) to typical "medium sized enterprises" such as small manufacturing or service firms. Net returns to the owner - operator (assuming a 5 percent return on capital) might total US$ 30.000 a year, not much higher than that obtained by a supervisory white-collar worker.

Firm Ownership: Personal or family property of land resources the dominant form of organization. In 2/3 of the "partidos", this type of ownersip accounts for more than 3/4 of total land controlled (**Graph 7**). Thus, "corporate" forms of organization are relatively infrequent.

[4] These were: I = North of Buenos Aires-South of Santa Fe, II = West of Buenos Aires, III = South-East and East of Buenos Aires, IV = East of Cordoba and V = Rest of the "pradera pampeana".
[5] In Graph 5, data values in X-axis correspond to interval upper limit.

Regression Results: Appendix 1 reports regression results for models:

[11] $\Delta TFP_{10} = f(HC1, Size, Owner)$

[12] $\Delta\pi_{10} = f(HC2, Size, Owner)$

A one-tailed test ($p = 0.10$) is used to reject the null hypothesis of no effect of the independent variables. The following results can be highlighted:

1. A relatively small (20 - 30 percent) of variation in ΔTFP and Δp can be explained by variables included in the models. Difficulty in predicting these dimensions of efficiency - even when including dummy variables for different agronomic areas - is readily apparent.

2. The hypothesis of no relationship between HC and efficiency is not rejected for both measures of HC and for both dependent variables. Thus, human capital does not appear to be a variable explaining TFP productivity differentials (1980's vs 1970's), or changes in returns to fixed factors in the same time period.

3. Firm size appears - as hypothesized - to have a positive effect on efficiency. t-values for all models are highly significant. The existence of fixed costs in information-gathering and technology adoption is therefore likely.

4. "Family" firms appear to be associated with higher TFP. However the evidence on the impacts of ownership type on allocative efficiency is inconclusive.

VI. IMPLICATIONS

This paper analyzes the linkages between production efficiency, human capital, firm size and ownership pattern. The main hypothesis tested is that improved education is associated with better decision-making in the agricultural sector. Empirical results do not provide support for this hypothesis. The crudeness of the HC proxies could account for these results. In the US agricultural censuses report educational levels of farmers at the county level. Further, censuses are completed every five years. In contrast, this study uses a (1980) proxy for education in attempting to explain productive performance in the 1970-1989 period. Nevertheless, the absence of a positive link between education and performance is intriguing: the Argentine agricultural sector has appears to provide an important opportunity for improved decision-making skills.

The positive relation between firm size and efficiency lends support to the existence of fixed costs in information-gathering. This result is coincident with research made by Huffman, Petzel and other authors. Attention must be given however, to confounding effects in the size-efficiency linkage. In particular: firm size might be correlated with resource (particularly land) quality. If modern inputs allow a larger (in relative terms) productivity gain in highly productive environments, larger firms will then be associated with higher ΔTFP_{10} and $\Delta\pi_{10}$.

Lastly, the evidence of higher ΔTFP_{10} in "family" as opposed to "corporate" farms lends support to the prevalence of the former in most agricultural economies. The importance of corporate-type ownership appears to have increased in Argentina since the mid 1980's; however it is not at all clear whether family firms face the threat of extinction. The issue of the impact of different managerial forms on efficiency is important and merits further study. In particular, "corporate" type of organizations provide a mechanism whereby equity capital can flow into agriculture from other sectors of the economy. An interesting avenue for future work concerns the linkages between technology, ownership and efficiency. In particular, the possibility that under some technologies separation between ownership and control results in lower costs of delegation than under others.

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APPENDIX 1: REGRESSION RESULTS

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ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
º  Current sample contains     141 observations.
º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ
º Ordinary    least squares regression    Weighting variable = ONE      º
º Dependent variable is DTFP      Mean =    1.30771, S.D. =      0.2899 º
º Model size: Observations =     141, Parameters =   8, Deg.Fr. =   133 º
º Residuals:  Sum of squares=    7.82326     Std.Dev. =         0.24253 º
º Fit:        R-squared = 0.33496, Adjusted R-squared =         0.29996 º
º Model test: F[  7,    133] =    9.57,    Prob value =         0.00000 º
º Diagnostic: Log-L =      3.7916, Restricted(á=0) Log-L =     -24.9660 º
º             Amemiya Pr. Crt.=    0.062, Akaike Info. Crt.=      0.060 º
º Autocorrel: Durbin-Watson Statistic =   1.71635,   Rho =      0.14182 º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ1/4
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Variable	Coefficient	Standard Error	t-ratio	P[³T³òt]	Mean of X
Constant	0.7222923	0.16368	4.413	0.00002	
D2	0.1253573	0.81646E-01	1.535	0.12707	0.9220E-01
D3	0.2013879	0.60897E-01	3.307	0.00121	0.2979
D4	0.3076778	0.63060E-01	4.879	0.00000	0.2482
D5	0.1472806	0.85826E-01	1.716	0.08848	0.9220E-01
CH1	-0.1889543E-02	0.29456E-02	-0.641	0.52231	12.37
SZ	0.2189305E-03	0.79377E-04	2.758	0.00663	387.0
OWNER	0.4745921E-02	0.21284E-02	2.230	0.02743	76.40

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ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
º Ordinary    least squares regression    Weighting variable = ONE      º
º Dependent variable is Dπ      Mean =    1.44728, S.D. =      0.6255 º
º Model size: Observations =     141, Parameters =   8, Deg.Fr. =   133 º
º Residuals:  Sum of squares=    41.4922     Std.Dev. =         0.55854 º
º Fit:        R-squared = 0.24241, Adjusted R-squared =         0.20253 º
º Model test: F[  7,    133] =    6.08,    Prob value =         0.00000 º
º Diagnostic: Log-L =   -113.8310, Restricted(á=0) Log-L =    -133.4022 º
º             Amemiya Pr. Crt.=    0.330, Akaike Info. Crt.=      1.728 º
º Autocorrel: Durbin-Watson Statistic =   1.76065,   Rho =      0.11967 º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ1/4
```

Variable	Coefficient	Standard Error	t-ratio	P[³T³òt]	Mean of X
Constant	0.5135530	0.37696	1.362	0.17539	
D2	0.1198890	0.18803	0.638	0.52482	0.9220E-01
D3	0.4025555	0.14024	2.870	0.00477	0.2979
D4	0.5288614	0.14523	3.642	0.00039	0.2482
D5	0.1610024	0.19766	0.815	0.41678	0.9220E-01
CH1	-0.5337357E-02	0.67836E-02	-0.787	0.43279	12.37
SZ	0.4252227E-03	0.18280E-03	2.326	0.02152	387.0
OWNER	0.7305314E-02	0.49016E-02	1.490	0.13849	76.40

ÉÍÍÍ»

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º Ordinary    least squares regression    Weighting variable = ONE      º
º Dependent variable is DTFP      Mean =    1.30771, S.D. =      0.2899 º
º Model size: Observations =     141, Parameters =   8, Deg.Fr. =   133 º
º Residuals:  Sum of squares=    7.78700     Std.Dev. =         0.24197 º
º Fit:        R-squared = 0.33804, Adjusted R-squared =         0.30320 º
º Model test: F[  7,    133] =    9.70,    Prob value =         0.00000 º
º Diagnostic: Log-L =      4.1192, Restricted(á=0) Log-L =     -24.9660 º
º             Amemiya Pr. Crt.=    0.062, Akaike Info. Crt.=      0.055 º
º Autocorrel: Durbin-Watson Statistic =   1.69884,   Rho =      0.15058 º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ1/4

  Variable   Coefficient  Standard Error  t-ratio  P[³T³òt]   Mean of X
  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
  Constant   0.6178396       0.17704        3.490   0.00066
  D2         0.1260869       0.81448E-01    1.548   0.12398  0.9220E-01
  D3         0.1986558       0.60786E-01    3.268   0.00138  0.2979
  D4         0.3096293       0.62883E-01    4.924   0.00000  0.2482
  D5         0.1114706       0.85382E-01    1.306   0.19396  0.9220E-01
  CH2        0.2654554E-02   0.26119E-02    1.016   0.31133   20.89
  SZ         0.2341798E-03   0.80648E-04    2.904   0.00432   387.0
  OWNER      0.5050902E-02   0.21391E-02    2.361   0.01966   76.40

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º Ordinary    least squares regression    Weighting variable = ONE      º
º Dependent variable is Dπ      Mean =    1.44728, S.D. =      0.6255 º
º Model size: Observations =     141, Parameters =   8, Deg.Fr. =   133 º
º Residuals:  Sum of squares=    41.5924     Std.Dev. =         0.55922 º
º Fit:        R-squared = 0.24058, Adjusted R-squared =         0.20061 º
º Model test: F[  7,    133] =    6.02,    Prob value =         0.00000 º
º Diagnostic: Log-L =   -114.0010, Restricted(á=0) Log-L =    -133.4022 º
º             Amemiya Pr. Crt.=    0.330, Akaike Info. Crt.=      1.731 º
º Autocorrel: Durbin-Watson Statistic =   1.74938,   Rho =      0.12531 º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ1/4

  Variable   Coefficient  Standard Error  t-ratio  P[³T³òt]   Mean of X
  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
  Constant   0.3448698       0.40915        0.843   0.40080
  D2         0.1180669       0.18824        0.627   0.53159  0.9220E-01
  D3         0.3982336       0.14048        2.835   0.00530  0.2979
  D4         0.5333919       0.14533        3.670   0.00035  0.2482
  D5         0.9401564E-01   0.19733        0.476   0.63454  0.9220E-01
  CH2        0.3290613E-02   0.60365E-02    0.545   0.58658   20.89
  SZ         0.4437153E-03   0.18639E-03    2.381   0.01870   387.0
  OWNER      0.7741034E-02   0.49436E-02    1.566   0.11976   76.40
```
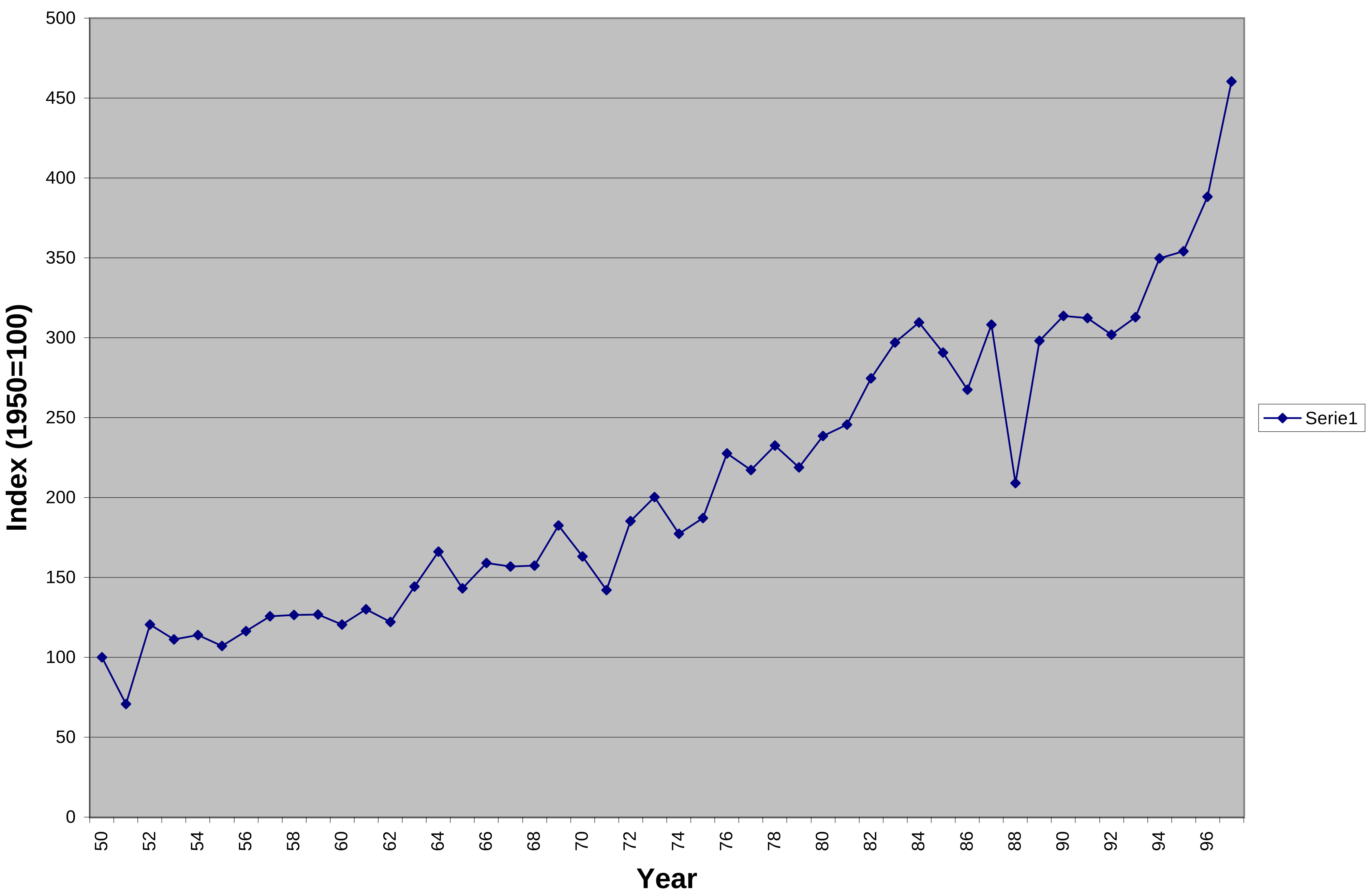
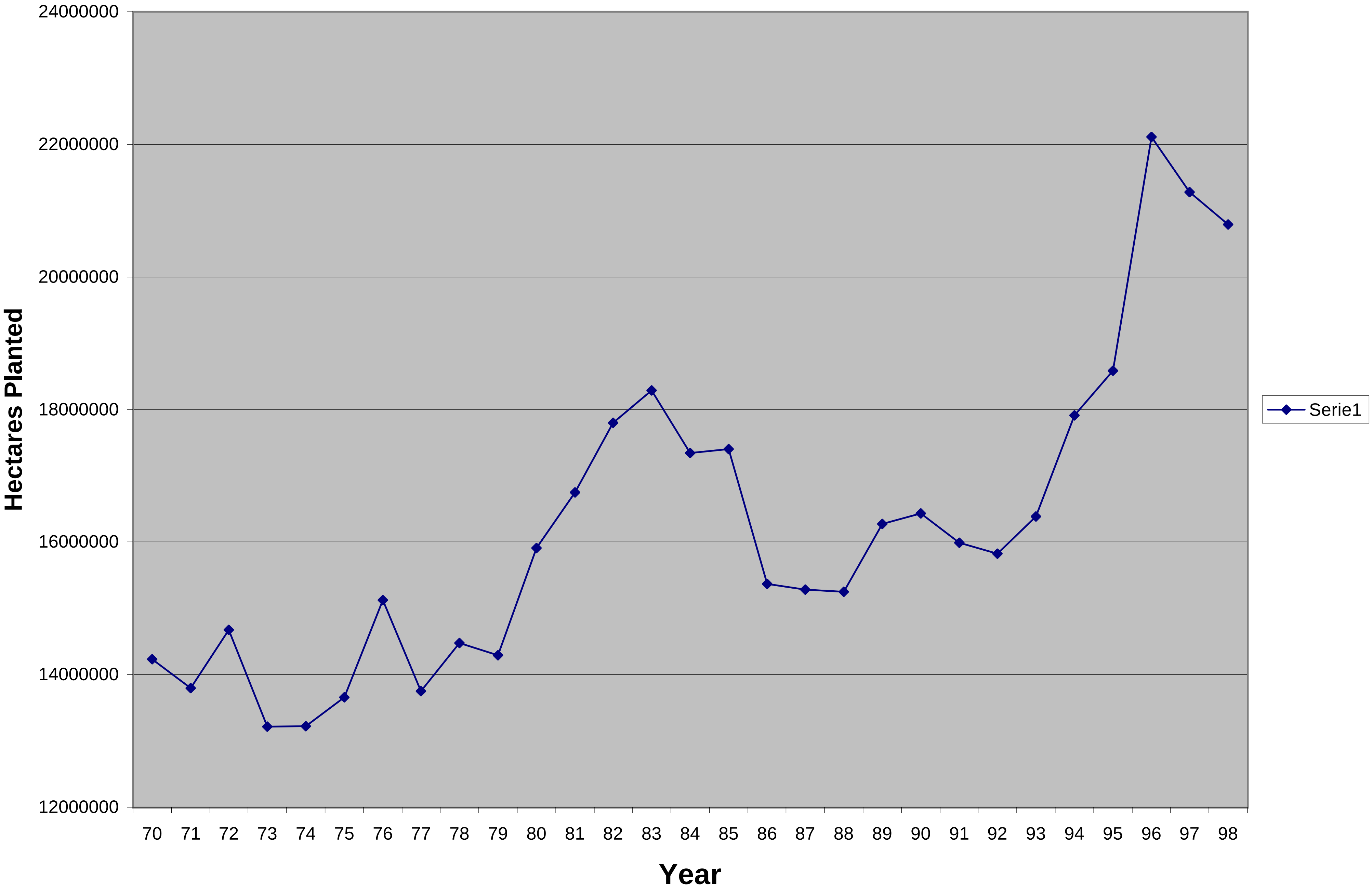
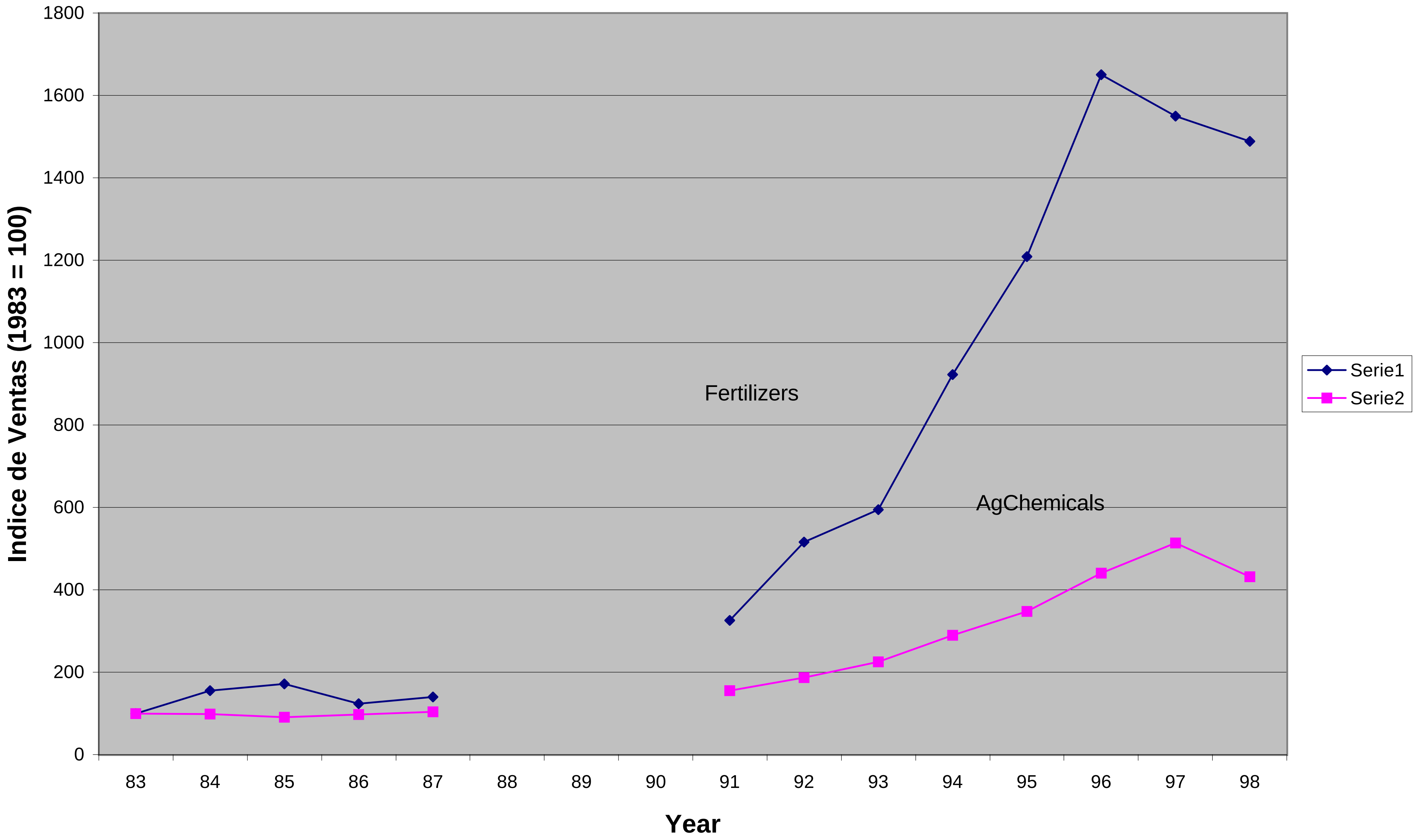

Graph 1: Production Index (1970=100)



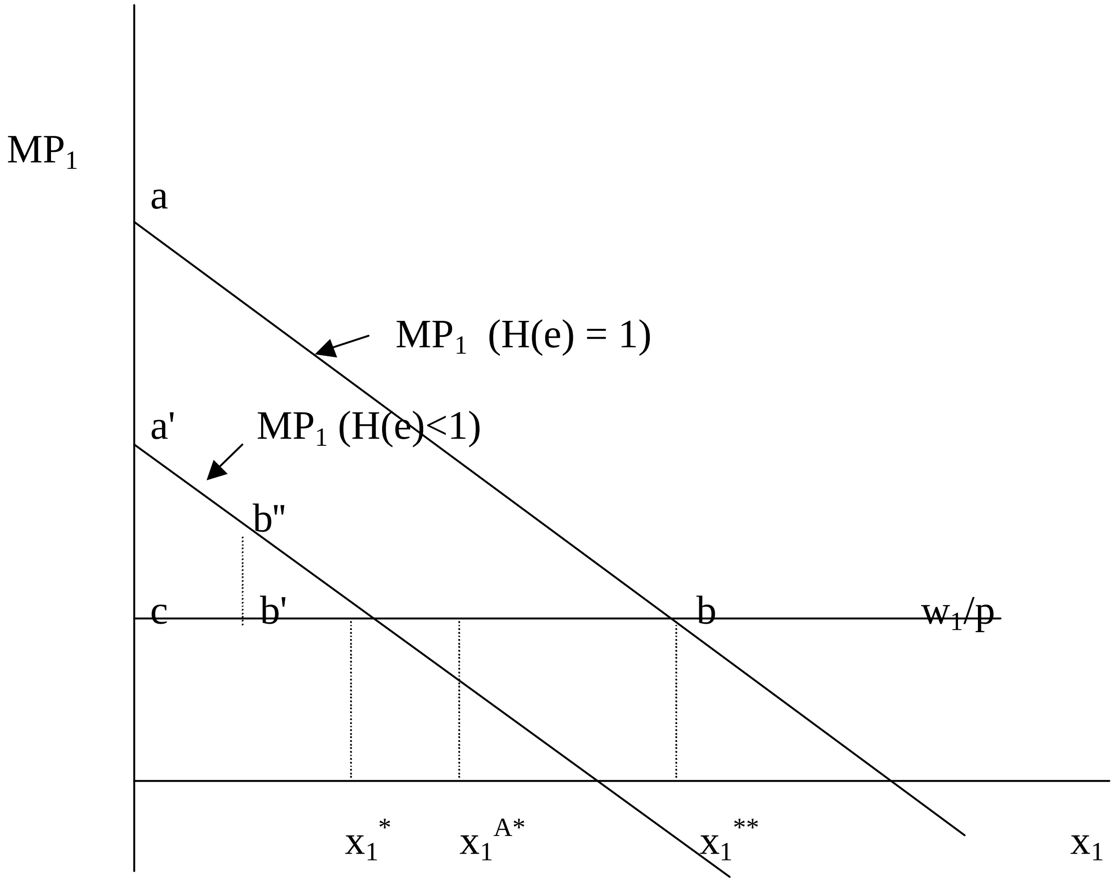
Graph 2: Hectares Planted - 5 Principal Crops



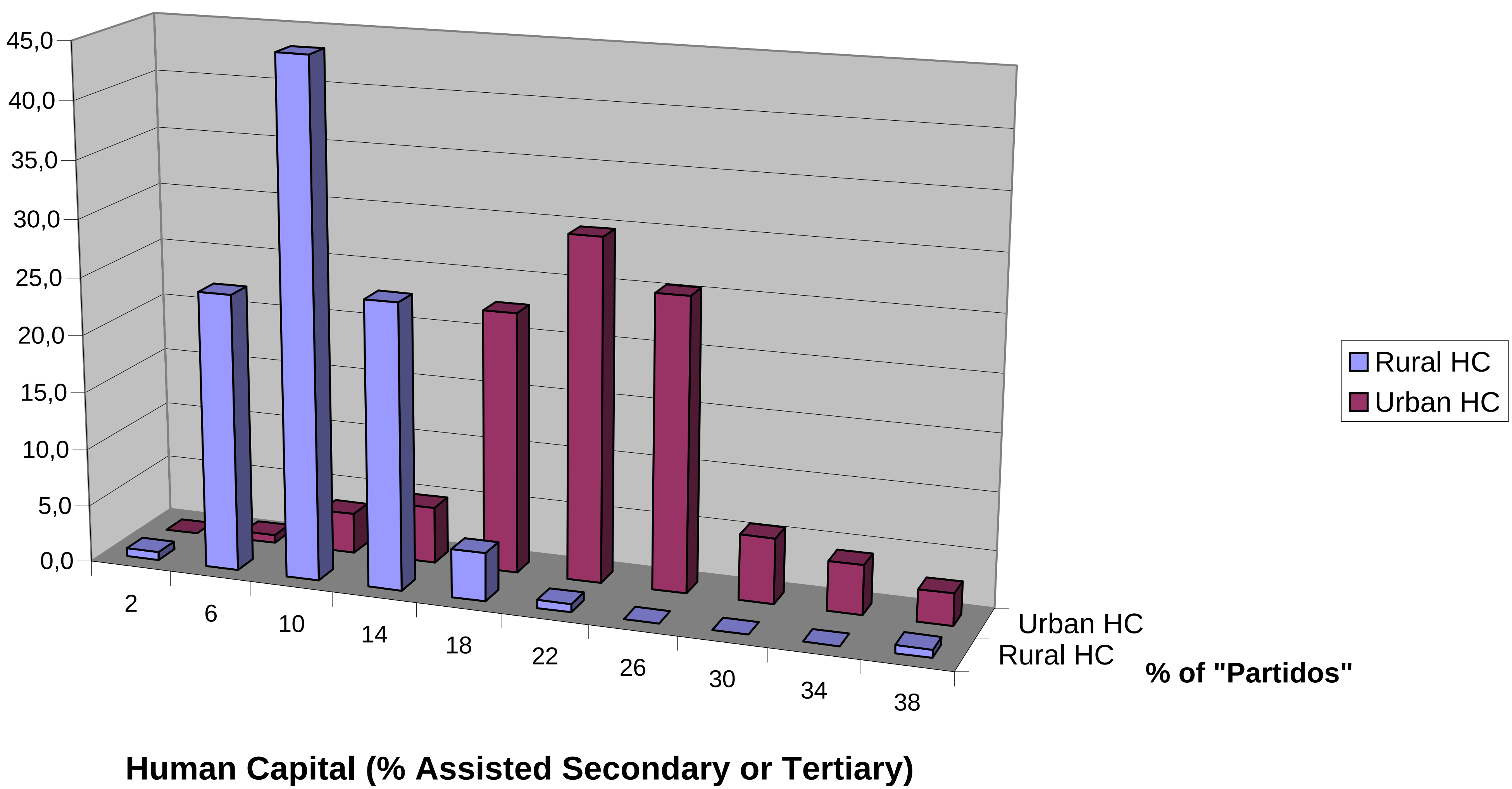
Graph 3: Fertilizer and AgChemical Sales
(1983 = 100)



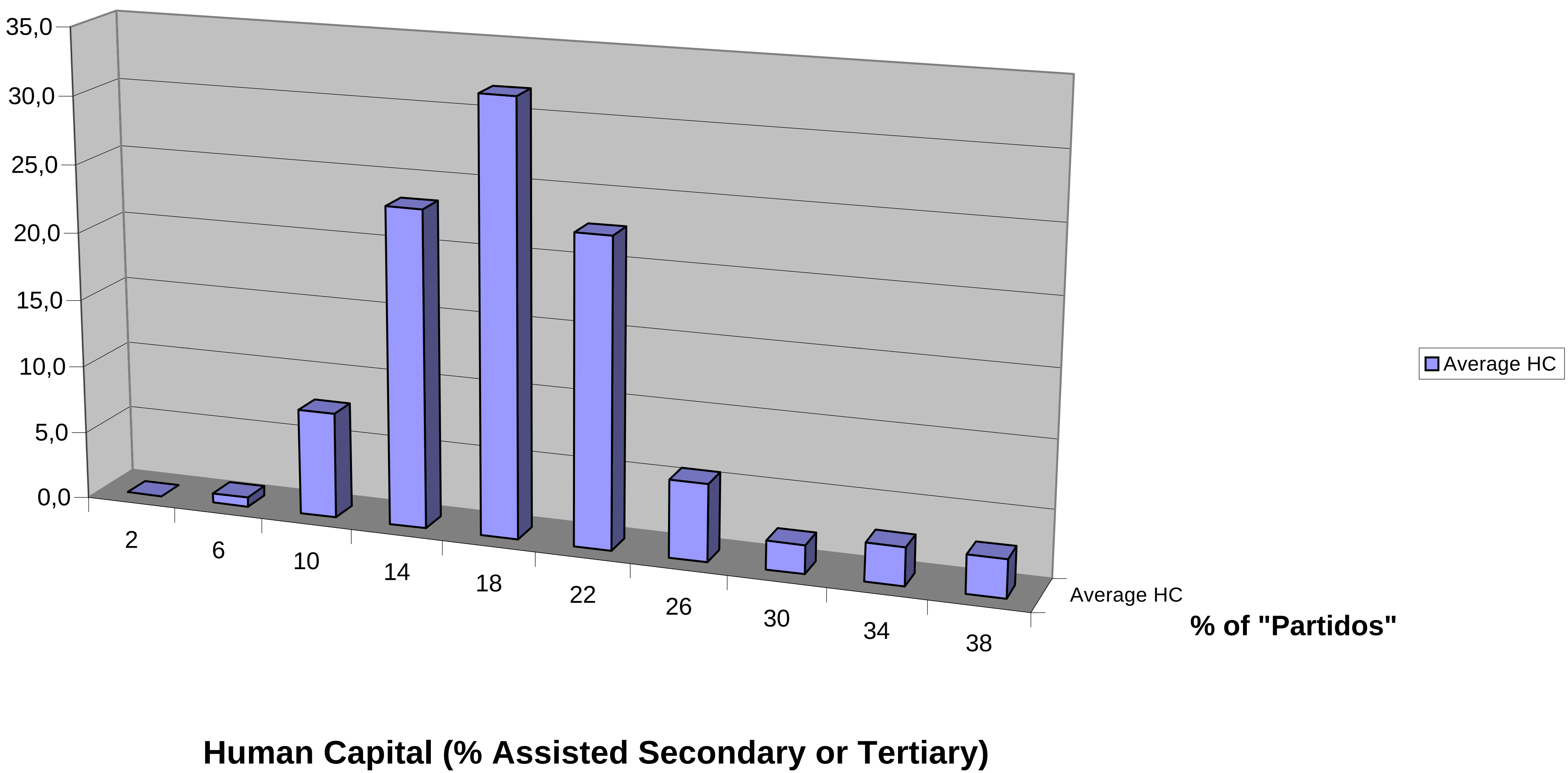
Graph 4: Input Allocation



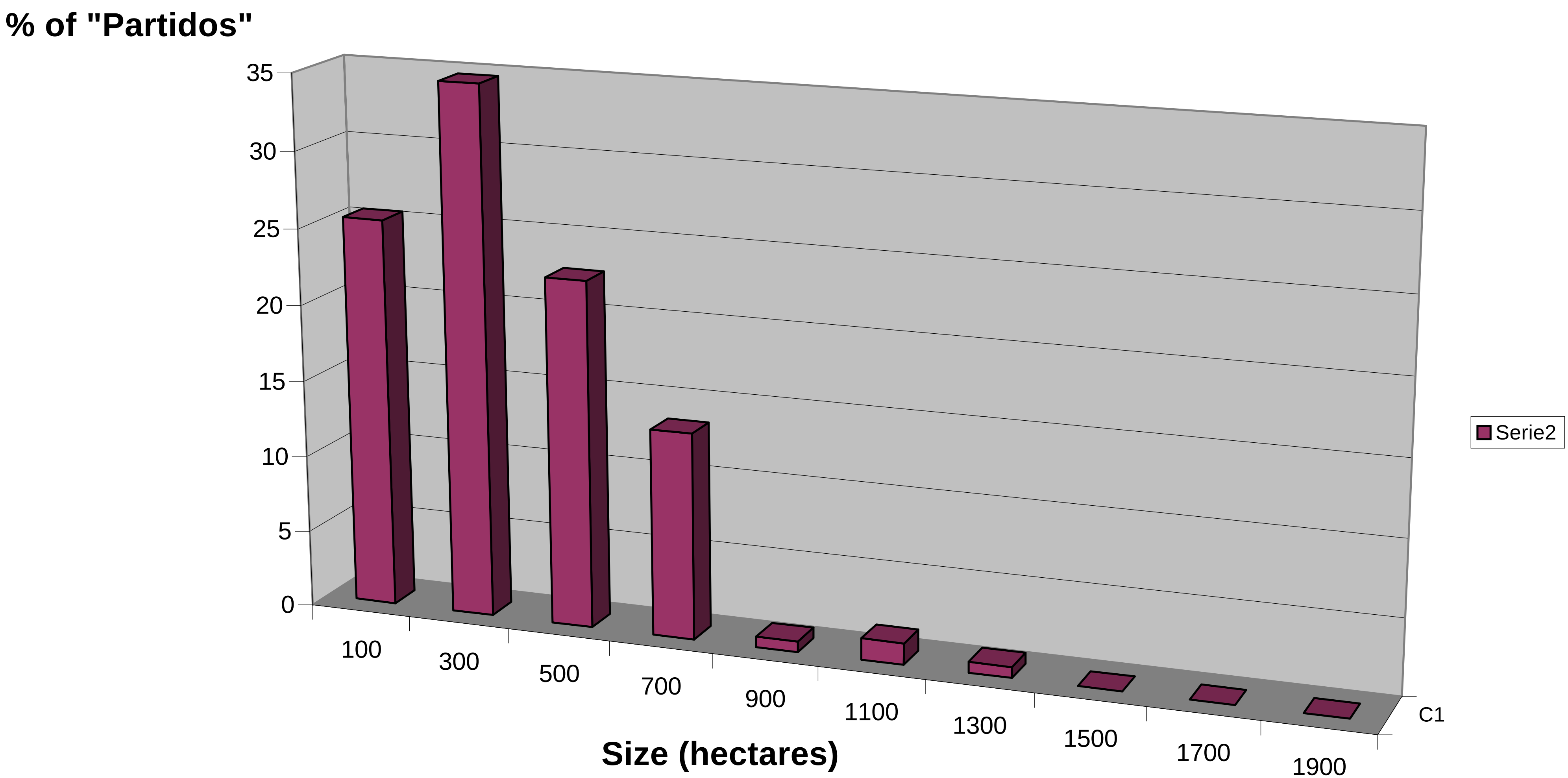
Graph 5a: Human Capital Rural/Urban

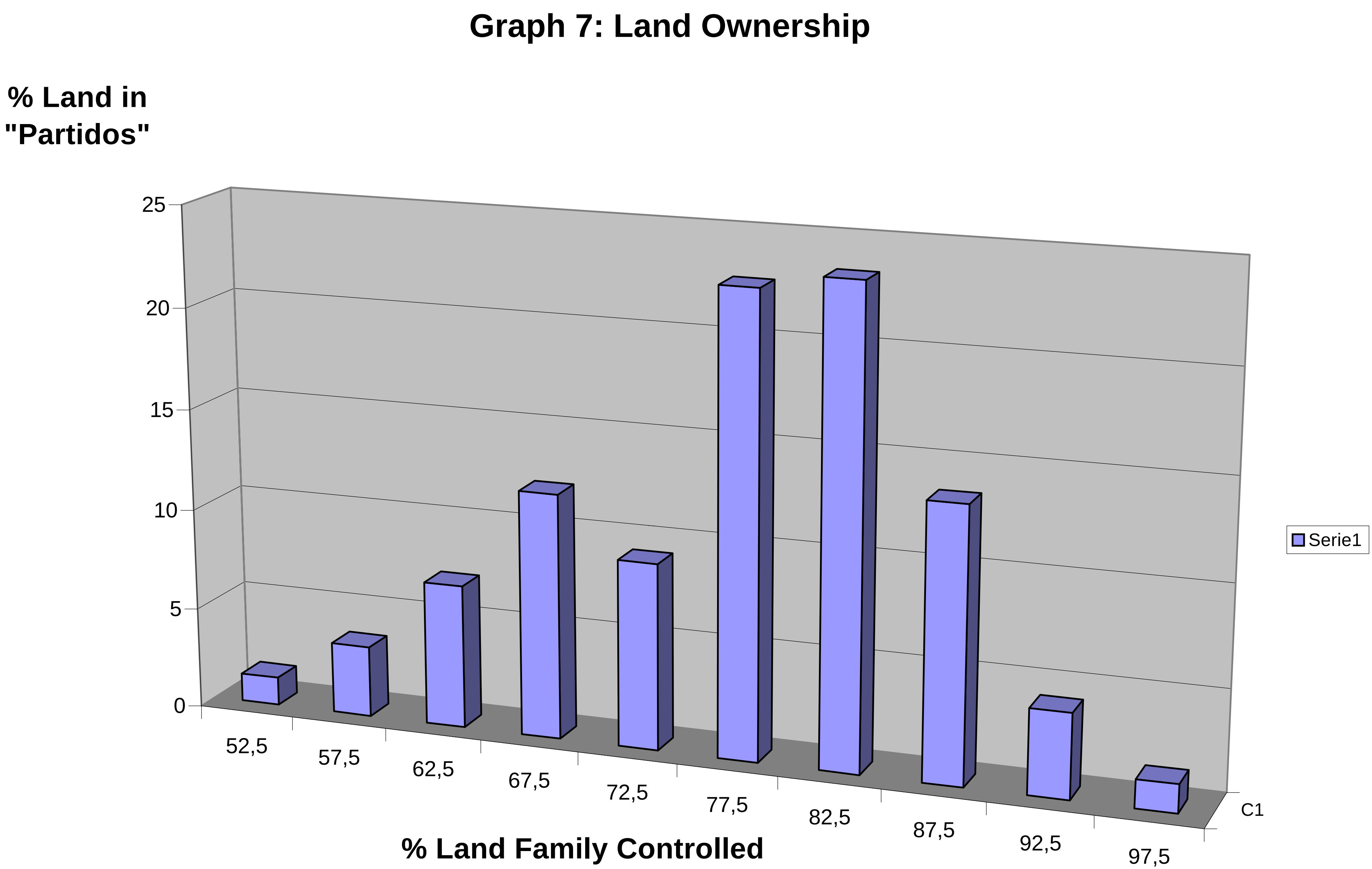


Graph 5b: Average (Rural/Urban) Human Capital



Graph 6: Farm Size (hectares)




Graph 7: Land Ownership
% Land in "Partidos"
25
20
15
10
5
0
52,5
57,5
62,5
67,5
72,5
77,5
82,5
87,5
92,5
97,5
C1
Serie1
% Land Family Controlled