# THE CHANGING STRUCTURE OF PRODUCTION: ARGENTINE AGRICULTURE 1988 - 2002

**MARCOS GALLACHER**

**ABSTRACT**

The agricultural sector of many countries shows increasing farm size with corresponding decrease in farm numbers. Despite abundant research, the determinants of these changes have not been clearly identified. This paper attempts to explain small firm survival in Argentine agriculture in the 1988 - 2002 period. The evidence suggests that labor market considerations, as well changing optimal size in response to production specialization are important factors affecting small-firm disappearance. In contrast, factor proportions (the K/L ratio) does not appear to have an impact on changes in firm size.

*JEL Classification:* D20, Q12

*Keywords:* economies of scale, Argentine agriculture, agricultural labor markets.

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## I. Introduction

Firm size distributions change through time. This is true of all sectors of the economy: auto plants, retail stores, the service industry (e.g. restaurants) and of course agriculture. Understanding the determinants of such changes is of considerable interest to economists, as it bears upon aspects such as capital constraints, asset fixity, technology adoption, management and control, the role of human capital in production and many others. The size-efficiency linkages, however, are not clear cut. In auto manufacturing, for example, changes in the organization of production (in particular, the reduction in the extent of vertical integration) appear to have reduced the optimal size of plants if not of firms (The Economist, 2002). In other industries opposite forces may be at work: in many countries retail stores appear to grow in size, gradually displacing small family firms. Economies in market procurement, in the use of shelf space, in inventories or in consumer "effort" for purchasing may explain this trend.

The agricultural sector has been subject to numerous studies related to firm scale and efficiency (see, e.g. Kislev and Peterson, 1991, MacDonald, Hoppe and Banker, 2004). In some sub-sectors (e.g. poultry, or up to a point dairy production) the evidence supporting the efficiency of larger units is quite clear-cut (Doll and Orazem, ch.7). These sub-sectors are characterized by relatively "capital-intensive" technology (high capital/land and capital/labor ratios). Moreover the production technology is "semi-industrial": standardized processes, materials taken to machines and animals instead of the other way round, single- as opposed to multiproduct orientation, contracts with output purchasers, etc. In contrast with the above, agricultural sub-sectors such as grain crops and pasture-fed livestock production are characterized by multi-output firms highly dependent on variable weather factors. In these firms agricultural land is a heterogeneous and spatially dispersed production factor.

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These characteristics place a burden on management decision-making and thus seem to favor a relatively small scale of production. Schmitt (1986, 1991) has argued that family farms are efficient and survive because labor markets allow family labor to be allocated efficiently among farm- and non-farm uses. Given a stock of fixed resources (land and/or capital) labor will be allocated among alternatives so as to equate marginal productivities, hence allocative efficiency is achieved. In larger production units, adjustment will result in a smaller portion of family labor allocated to off-farm work, or labor will be hired to complement that supplied by the farm family. The possibility of equating labor productivity in on- and off-farm use results in both "small" and "large" units co-existing.

The above model is possibly one explanation for the persistence of small production units. Nevertheless increased farm size seems to characterize farms of many parts of the world. In the U.S., the number of farms decreased from 7 million in the 1930´s to less than 2 million in 2002 (MacDonald, Hoppe and Banker, 2004). A similar pattern appears in Argentina, where farm numbers peaked at 550,000 in 1966, falling to less than 300,000 in 2002 (Gallacher, 2008). Understanding the determinants of these changes is not easy: in American agriculture, for example, farm numbers have decreased (with a corresponding increase in farm size) despite research results reporting constant returns to scale.[2] Theoretical cost curves are a guide to inquiry, however applying these concepts to real-world situations calls for considerable ingenuity: aspects such as constraints to asset mobility, asset "lumpiness" or differential adjustment to new technologies may all be at work in affecting optimal firm size, and observed size distribution of firms over time.

This paper is focused on the driving forces that underlie changes in the structure of production of Argentine agriculture. An attempt is made to identify reasons for the decrease in farm numbers observed during the past decades. Issues that need addressing include: (a) is growth in firm size associated with changes in factor proportions, (b) what role do labor and capital service markets play in changes in firm size and (c) has adaptation to changing profit opportunities affected firm size. The paper is organized as follows. Section II summarizes changes that have occurred in the agricultural

[2] For the U.S., Heady (1952) presents early (1940´s and early 1950´s) evidence of constant returns to scale in agriculture. Kislev and Peterson (1991) discuss the constant returns hypothesis with evidence up to the late 1980´s.

sector, and attempts to link these to changes to farm numbers. In Section III specific hypothesis related to the dynamics of firm size are presented. Section IV summarizes empirical analysis; conclusions are in Section V.

## II. Changing structure of production in Argentine agriculture

In the early 1970´s Alain de Janvry explained the lack of progress in Argentine agriculture as a result of insufficient and mis-directed public-sector investment in modern agricultural technology (de Janvry, 1973). The argument presented was that larger farmers did not face incentives conducive to pressuring the public-sector research system for the development of modern production systems. Small farmers, it was argued, lacked the political clout to affect research allocation priorities. The “induced innovation” model developed by de Janvry possibly explains what happened until the late 1960´s, however the last four decades have witnessed changes in technology that have resulted increases in the price of land, thus benefiting producers that – according to de Janvry´s induced innovation hypothesis – were more resistant (or at least indifferent) to change. Indeed, the fall in the number of small as opposed to larger farms further suggests that technological progress benefited the latter as opposed to the former.

Lack of appropriate technology was a retarding factor in agricultural growth. However, product and factor markets (as de Janvry recognizes) also played a role. The dynamics of fertilizer use illustrates this point. In the early and mid-1970´s, fertilizers were used very sparingly in extensive (non-irrigated) crops: demand totaled some 70,000 tons. Reduction in fertilizer prices (resulting from a fall in import taxes) as well as increased availability of fertilizer-responsive seeds resulted in a rapid and continuous increased in the use of these inputs: in 2006 total use was some 3.5 million tones, that is some seventy times the level used three decades earlier. In an early paper White (1977) shows the major differences in input/output prices faced by Argentine farmers as compared to other major grain exporters: for example, an Argentine farmer had to sell 12 – 14 kg of wheat to purchase a kg of nitrogen fertilizer, as compared to less than 5 by his French or American counterpart.

New technologies resulted in a reduction in the demand for farm labor as well as tillage services: “minimum tillage” and “no-tillage” production was practically non-existent in the mid to late 1980`s, but represented some 70 percent of planted area in 2005 (AAPRESID, undated). Under these new tillage systems, total labor use of the most important grain crops fell from some 3.0 – 3.5 to 1.0 hours per planted hectare. This results in labor costs falling to no more than 5 - 10 percent of total costs of production (excluding land). The low level of labor use can be put into perspective by considering that in a "medium" sized crop farm (of say, 500 planted hectares) annual labor use for planting and crop protection is not more than 1000 hours, clearly well below the 2.000 hours worked per year by a full-time employee.

Although labor-saving factor substitution predominated until the late 1950´s, farm numbers appear to have increased during this period from some 300,000 farms in the early 20th century, to 550,000 in 1966.[3] Labor- and land-saving technologies gathered steam from the 1960´s onward and this was accompanied by farm numbers declining from the 550,000 mentioned above (1966) to less than 300,000 in 2002. Table 1 shows farm numbers and size for 1988 and 2002 in the most important production zone of the country (the "pradera pampeana"). As shown, in the main grain-producing areas of the country (provinces of Buenos Aires, Córdoba and Santa Fe) farm numbers in 2002 were 65 to 75 percent of those in 1988.

The above can be summarized as follows. First, a steady stream of new technologies was adopted by farmers during the last four decades. Technology adoption probably took place at different rates among firms: access to know-how and financing are two constraints that impinge to a greater extent in some farms than in others. Second, a significant reduction in labor use has taken place. This is a result of: (a) increased use of high-capacity capital inputs and (b) change in technology, in particular a shift from mechanical to chemical – based crop production systems. Reduction in labor use results in a labor surplus situation: in order to equalize input productivity with opportunity costs, either farm assets have to be increased, or reallocation of labor and management to other uses has to occur. Lastly, in some areas farms have increased their degree of specialization. Specialization is a result of two processes: (a) "mixed" crop-livestock farms are increasingly focused on crops and (b) furthermore, the mix of crops in part of the production area shows a reduction of cereals and an increasing proportion of oilseeds (in particular

[3] One referee pointed out that animal power was still important in the late 1940´s. According to this source, the substitution of tractor for animal power was only completed in the late 1960´s. The author acknowledges the referees´ contribution on this point.

soybeans). As occurs in industry, specialized technology allows larger-scale production to take place through increased use of standardized processes and control. Coordination with input suppliers (including service suppliers) is also facilitated.

## III. Explaining changes in farm size

The size distribution of firms observed in a given time period (“$t_1$”) is a result of: (a) the distribution of firms existing in an “initial” time period (“$t_0$”, for convenience, consider this exogenously determined) and (b) the impact of economic forces acting on firms of different sizes during $t_0 - t_1$. As pointed out by Stigler (1958), the existence of heterogeneous resources implies that no “one” is optimal: two firms differing in size and in “ex-post” estimated average costs may in fact have similar economic costs if resources were valued at true “ex-ante” implicit prices.[4] The “survival technique” approach proposed by Stigler recognizes these difficulties, and will be used in the empirical analysis presented below.

The basic decision the producer makes relates to land area to be farmed and the contractual agreement to be used in payment for land, labor and capital services. The producer may expand by renting additional land (by various contractual agreements) or may alternatively downsize by renting to others land owned by himself. Increase in farm size and corresponding farm numbers results from control of land being transferred (by land rental or outright purchase) from smaller- to larger than average producers. Firm size expansion as defined above focuses on the control of land. However, capital inputs (farm machinery) are also necessary in the production process. Given the multiple-output nature of the agricultural firm, firm expansion may in some cases imply contraction in the use of land and expansion in the use of capital: the firms´ output may increasingly be composed of the production machine-services (for other firms) instead of agricultural products. Adjustment is then one of increased specialization: control of land is concentrated in fewer farm numbers, while simultaneously the same occurs with the control of capital

[4] Why firms use different proportions of heterogeneous resources raises an “academic” problem: under cost minimization, and assuming a homogeneous technology and equal input prices factor proportions of different-sized firm should be identical. Economic models are of course very useful; however, the correspondence between these models and real-world conditions may be tenuous.

inputs used in the production process.

### A. Capital/Labor Substitution

As pointed out by Hayami and Ruttan (1971) and by Mundlak (2005), the increasing capital-labor ratio is one of the important changes occurring in agriculture during the 20th century. Changing capital intensity could well be one of the determinants of changing firm size: lumpiness of capital inputs may result in cost advantages for larger farms. However, capital services used by farm firms are non-specific: thus no "hold-up problem" (Williamson, 1985) exists between purchasers and purveyors of these services. This allows an active rental market to develop, reducing the impact of lumpiness mentioned previously.

In contrast to the above, supervision and coordination costs of using high-capacity machinery inputs may result in higher total cost, per unit of service, for small as compared to larger firms. If the "firm" considered is the vertical unit composed of the service- plus the commodity-producing firm, average cost of output falls as size of this unit increases. The resulting economies are a consequence not only (or necessarily) of the increased efficiency of large- as compared to small- machines, but of the lower fixed cost of coordinating service flows from these machines in larger as compared to smaller production units. [5]

Coordination costs, in particular, may be an issue: machinery services have to be allocated in a timely fashion among plots of land. If these plots belong to different farmers an allocation mechanism has to be designed ("first come first served", "old customers first" etc). Ideally services could be allocated among farmers on an auction basis; however this may prove costly. An alternative is for the "n" plots under the control of different farmers to be merged into one under the control of an overall manager: coordination is achieved here via centralized administrative decision as compared to the various "personal bargaining" solutions used previously.

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[5] Consider as an example fertilizer application: hiring this service eliminates the need of owning application equipment, but requires metering if quantity applied by the hired contractor is what was agreed upon. A "small" producer (who possibly has other activities in addition to agriculture) may find this metering costly. If firm size increases, supervision can be "spread out" over a larger number of purchased service units.

In summary, the falling price of capital in relation to labor results in capital - labor substitution. In turn, efficient use of capital inputs results in increasing separation in the ownership/management of these inputs, on the one hand, and of land inputs on the other. Economies of scale in the production of machinery services (custom machinery operators), coupled with fixed costs in delivering these services to individual firms lead to consolidation of commodity-producing firms. Furthermore, increasing separation facilitates (a) higher throughput of capital services and (b) benefits from the specialized managerial/entrepreneurial function in both service and commodity-producing firms.

## B. Adaptability

Pioneering work done by T.W.Schultz in the 1950s focused on farmer adaptation to change, and on farmer characteristics that speed up this adaptation process (see, e.g.Schultz, 1975). Further work done by Welch (1978) as well as other researchers provides additional support for this idea. Changing farm numbers may well result from differential adaptation to change.

Adjustments in the capital-labor ratio mentioned in the previous section are a function, in particular, of changing input price ratios and the “lumpiness” in the production of capital services. In contrast, adjustment under uncertainty is a function not only of these variables but of changing input productivity (which requires adaptive ability). Farmer education and access to private consulting services are important determinants of the adoption of new technologies. Furthermore farm size is correlated both to education as well as to access to these information-providers

The price of land (either for rental or outright purchase) results from expectations which differ among decision-makers. If “small scale” entrepreneurs lag behind in technology adoption, or if they discount risky returns more heavily than entrepreneurs managing larger enterprises, control of land can be expected to migrate from smaller to larger producing units. Speed of this adjustment process will depend on outside opportunities of exiting farmers. Improved access to labor markets will increase out-migration, and increased sector-specific capital will reduce it. In particular, quasi-rents associated with sector-specific capital will result in higher survival rates of small commodity-producing firms.

## C. Specialization

Reduction in the number of different outputs produced, and/or of different technologies used results in a fall in supervision and coordination costs. In the agricultural sector, “specialized” firms such as feedlots, sugar plantations or poultry operations tend to have larger size (measured for example by sales) than multi-output crop/livestock units. A-priori then, the specialization that has occurred in a large part of the Argentine agricultural area should favor increases in firm size.

## IV. Empirical Analysis

We seek to explain determinants of changes in the size distribution of firms in the main production area of Argentina. Due to data availability, we focus attention on the period 1988 - 2002. This period is particular interest as it includes important changes that took place in macroeconomic policy: beginning in 1991, these include monetary stabilization, deregulation and privatization as well as increased openness to trade. Changes affecting the agricultural sector include the elimination of export taxes, reduction in the price of imported inputs and increased access to medium-term financing. According to some observers from the late 1980`s to the mid 1990`s the relative capital/labor price fell by 30 - 40 percent (Bour, 1994).

Figure 1 summarizes changes that have taken place in the size distribution of firms the 1988 - 2002. Histograms were constructed on the basis of “partido” or “departamento” (“county”) data. These correspond to political/administrative units each comprising several hundreds of farms. The variable analyzed is the ratio of “small” (< 200 hectare) to total firm numbers in 2002 as compared to 1988, and the ratio of land resources to total land resources controlled by these firms in these two time periods.[6] As shown, considerable difference exists in the survival rate of small firms: in approximately one-fourth of the *partidos* more than 75 percent of small firms survived in this 13-year period. But, in a similar percentage of cases, less than

[6] “Small” firms are defined here as those totaling less than 200 hectares. Figure 1 includes data from the provinces of Buenos Aires, Córdoba and Santa Fé. The “size” definition used here (total farm area) may well be subject to criticism, however census does do not allow a more precise definition of scale of production.

45 percent of firms survive. As shown, the modal survival rate is 60 - 70 percent -- that is some 30 - 40 percent of firms have ceased production.

If survival is analyzed on the basis of changes in land resources controlled by small firms the pattern is similar. However the distribution shifts to the right: survival rate is somewhat “higher” as measured by resources controlled than by firm numbers. This possibly results from exiting firms being smaller than all firms that in 1998 controlled 200 or-less hectares.

Data pertaining possible determinants of changes in the distribution of firm size are shown in Table 2. Family labor in 2002 is some 10 – 12 percent of that reported in 1988. These figures probably exaggerate the reduction in this input, as the census does not estimate time actually worked but the “stock” of family labor allocated to production. However, even allowing for mis-measurement, an important fall in family labor use is apparent. The reduction in non-family labor is significant and larger in “small” (less than 200 hectares) than in all farms: in 2002, non-family labor was reduced by one-half in the former and by one-third in the latter.

Total capital stock increased by 35 percent in small and nearly 50 percent in all farms. Improvements in the efficiency of agricultural machinery suggest that these figures under-estimate the “true” increase in productive capacity. More importantly, the shift from tillage-based to chemical-based crop production resulted in a dramatic increase in the productivity of capital inputs: as mentioned previously, labor-hour requirements dropped – as a result of chemical-based technologies – to less than one half of previous levels. Increases in capital stocks, coupled with reductions in labor inputs resulted in increases in capital stock per worker: as shown, in the 1988 - 2002 period this metric increased four-fold in all farms, and nearly eight-fold in (surviving) small farms. Small firms surviving in 2002 thus are considerably more “capitalized” than those existing in 1988.

Human capital figures should be interpreted with caution: they appear to the author lower than expected. More detailed information on how the questionnaire was administered is necessary to elucidate this issue. With this caveat, it appears that the gap between average and small-farm educational levels has increased over time. Possibly, surviving small firms have - relative to those ceasing production – lower levels of general human capital, differential off-farm opportunity cost being a relevant variable guiding allocation of family labor to farm and non-farm uses. In relation to this point, the percentage of farmers reporting non-farm time allocation shows a small decline. Differences in time allocation between small and all firms are minor in 1988, and practically non-existent in 2002. The (weak) trend suggests increasing specialization in agricultural production.

Capital-labor substitution occurring in the 1988 - 2002 period is shown in Figure 2.[7] Y-axis depicts the ratio of 2002 to 1988 labor, X-axis the change in K/L ratio between these two periods ($K/L_{2002}/K/L_{1988}$). The pattern that emerges is quite clear: increases in K/L are accompanied by decreases in L. Estimating "by eye" from the graph, a doubling of the K/L ratio (for example from 1 to 2) results labor falling to one-half (from 1 to 0.5). The resulting "elasticity of substitution" is then 0.50/(1+0.5))/(1/(1+2) = 1. This "rough and ready" elasticity of substitution among inputs is only illustrative; however it corresponds to what results from a Cobb-Douglas technology, a widely used functional form in applied production analysis. An implication of this elasticity value is that relative income shares to capital and labor will be independent of relative factor prices.

Regression analysis is used to test the significance of selected variables on firm survival. No explicit optimizing model is presented; however the following economic forces are explored:

1. Substitution of capital for labor allows reductions in average cost of production; however these reductions are scale-dependent. This occurs because set-up, supervision and coordination costs associated with the use of high-output farm machinery are proportionally higher in smaller as compared to larger production units. Small-farm survival will therefore be negatively correlated with increasing substitution of capital for labor.
2. Small-farm survival rates will be negatively related to farmer education, as the marginal productivity of human capital is greater in off- than in on-farm allocation (constraints on land and capital availability limit the impact of human capital on farm production).
3. Sector-specific capital increases survival possibilities of small commodity-producing firms. This occurs through two channels. First, quasi-rents associated with this capital reduce incentives to migrate. Second, sector-specific capital in period $t_0$ facilitates investment in additional capital of this type: not only capital constraints are less

[7] Figure 2 includes data from the provinces of Buenos Aires and Córdoba. Santa Fe is excluded because capital data for 1988 are unavailable.

intense the more capital is available, but also know-how in managing this type of capital is presumably a function of the amount of existing capital.

4. Specialization allows increased standardization of production methods. As in industrial production, increased specialization is expected to have a greater impact on high versus low output firms. “Diseconomies” due to managerial limitations are expected to be less of an issue the higher the extent of production specialization.
5. Differential perception of technological opportunities, as well as differential capacity to adapt to these opportunities exists. This differential capacity results in resource re-allocation from smaller to larger firms or, alternatively, it results in the “merging” of small firms. In both cases, the number of small firms falls.

The survival of firms through time is presumably associated with their cost and profit structure. An index of the relative profitability of firm size “i” can be thus defined as the change in the number of firms of the group in two time periods:

$$IP_i = N_{i1}/N_{i0} \qquad (1)$$

Where the “i” subscript defines a given firm size (small, large) and the subscripts 0 and 1 define two time periods, and $N_{it}$ is the number of firms the *i-th* strata. If $IP_i < 1$, firm numbers (or resource controlled) by the ith farm strata are falling, which implies resource productivity is lower in this group than in alternative uses.

Devising metrics for factors (1) – (5) above depends on data availability. The following indexes are used here:

1. Capital/labor ratio (K/L): the hypothesis to be tested is that a change in the intensity of capital use (capital/labor ratio) is a variable affecting optimum firm size.
2. Farmer education (HC) is taken as a proxy for general human capital. The hypothesis predicts a higher exit rate of small firms with increases in this variable.
3. The stock of agricultural machinery in period $t_0$ ($KS_0$) of small-firms measures sector-specific capital. The hypothesis is that an increase in $KS_0$ increases small-firm survival.

4. Specialization: indexes of specialization in land use (Sc = crop acreage/total acreage) and in crop production (Ss = soybean acreage/crop acreage) capture possible impact of increased specialization on firm size.
5. Adjustment to uncertainty (ChTec): growth in output per unit of land is taken as a proxy of the rate of inflow of new technologies. This growth rate is then defined as: $(Y_1/T_1)/(Y_0/T_0))$ where Y is an index of crop production, and T is land in planted hectares.
6. Additional variables are included in order to capture effects that a-priori appear of potential importance. These are: (i) the extent of the market for machinery services (an output of particular importance for land-constrained firms), (ii) the extent of the use of private consulting services in the region (a measure of supply and demand of modern know-how), (iii) an index of the diffusion of chemical-based tillage methods (an important labor- and durable-capital saving technology) and finally (iv) a measure of the participation of farm producers in the non-farm labor market. This variable is possibly correlated with the human capital variable previously mentioned, however it may "pick-up" different effects relative to resource allocation.

The following regression model is used:

$$IP_i = f(K/L, Ks_0, HC, Sc, Ss, Ch, Serv, Cons, NoTill, NonFarm) \qquad (2)$$

Where:

K/L = Change in the K/L ratio (2002/1988)
$Ks_0$ = Durable capital (small farms, 1988)
HC = Farmer education (small farms, 1988)
Sc = Specialization, crops (Cropland/Total Land, 2002)
Ss = Specialization, soybeans (ΔSoybeans 1988-2002/Cropland 1988)
Ch = Land productivity growth 1988/2002
Serv = Supplied + demanded custom machine services as % of cropland
Cons = % farms using consulting services
NoTill = no-tillage diffusion, 2002 (no-till hectares/planted hectares)
NonFarm = % farmers with non-farm work

Data for the provinces of Buenos Aires and Córdoba are used (n = 110).

Unfortunately, capital data (1988) is unavailable for Santa Fé (an important province). Results are shown in Table 3. The dependent variable is the ratio of small farms in 2002 as compared to 1988. This regression focuses on "small" (< 200 hectares) farm survival, and is based on the "survivor" concept of firm size dynamics. The F-value is significant at p = 0.01. However, R-sq is low. Possible measurement errors (further discussed below) as well as "what is attempted to explain" (changes in farm size) may be an underlying cause this result. Model results are as follows:[8]

- Changes in the K/L ratio do not appear to have affected firm survival. This finding suggests that capital intensity of production is not a relevant factor in returns to scale: the rental market for capital services possibly operates smoothly, eliminating part of the "lumpiness" associated with capital items.
- The initial capital stock of small firms (Ks0) shows "wrong" sign: small firm survival falls as small firm capital stock increases. A possible rationalization for this result is that increasing specialization has occurred among firms: small, "capital abundant" firms have expanded via the production of custom services, land being re-allocated from these firms to (larger) commodity-producing units that contract out most machine services.
- Production specialization appears a relevant variable explaining small firm survival: specialization in crops is significant (p= 0.10), and specialization in soybeans, while not significant at conventional probability levels has a t-value greater than 1.2: weak evidence of the (negative) impact of specialization on soybean production on firm survival can thus be inferred.
- Increase in land productivity (a rough measure of "technical change"), on the other hand, does not have a significant effect. The same occurs to the no-till technology diffusion index. These results suggest that smaller farms have not been "pushed out" because of lags in technology adoption: other reasons bear more weight on the issue of farm size dynamics. [9]

[8] Empirical results presented here should be interpreted with caution: census data on firm numbers and planted area by farm size class are possibly subject to quite large errors as preliminary evaluation of the data base suggests to the author that in some "partidos" census coverage was well below 100 percent. This issue will be addressed in future research.

[9] This does not imply that small farms adopt new technology as fast as larger ones.

- Labor-market variables bear scrutiny as determinants of small-firm survival: the small-firm human capital is significant a p = 0.15, the off-farm labor participation at p = 0.05. The t-values of the small-firm human capital variable, and the off-farm allocation of labor indicate that labor market, as opposed to pure "technological" (e.g. the K/L ratio) are important determinants of continuing operation of small firms: opportunity cost considerations of the farm family plays an important part.
- Lastly, a "weak" effect of private consulting services reducing small-firm survival is apparent (t = 1.53). The consulting services variable can be interpreted as a proxy for the demand of "new" information in each of the "partidos". If larger units have easier access to these inputs, a reduction in small-firm survival could – as appear to be the case here – occur in production areas were supply/demand of new technology is particularly intense.

An additional regression was run in order to explore the possibility of improving estimation results. The vector of independent variables was the same as before, however in this regression the dependent variable was percentage change in farm size (farm size 2002/farm size 1988) instead of reduction in small farm numbers as used en Table 3. Results (Table 4) do not improve those of the previously reported regression. In this model human capital as well as specialization in crops appear to be associated with growth in farm size. The positive sign for the human capital variable suggests that the "pull" factor of non-farm labor opportunities (which increased with improved education) account for part of the observed increase in farm size. Some evidence exists then that higher opportunity cost (small) farmers have ceded control of land to larger units.

As mentioned in the Introduction, non-trivial distributive effects of observed factors arise when they interact with non-observables. This section presents a simple structure for these interactions and proposes the use of quantile regressions to model them.

## V. Conclusions

Understanding the determinants of firm size and the changing distribution

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Lags in adoption may have occurred, however these lags do not appear to have been sufficiently severe so as to result in exit from farming.

of firm size through time remains an important issue for economists to address. Textbook discussions are a useful starting point however; most of these focus almost exclusively on the geometry of cost curves vis-à-vis the underlying forces that determine how costs change as a function of output. Empirical analysis presented here suggests that labor-market forces, in particular, are an important determinant of the survival of "small"(defined here as less than 200-hectare) farms. Higher human capital in these farms and more fluid access to labor markets results in a lower number of these farmers continuing production. Production specialization also seems to be associated with firm growth. In contrast with the above, factor proportions (the capital-labor) ratio do not appear statistically significant in explaining firm disappearance. This finding is somewhat surprising. However one explanation is that rental markets for capital services operate efficiently, "lumpiness" being then not an important issue.

Beginning in the 1980´s, but particularly in the 1990s and 2000s, very large business units (many of them not owning productive assets but renting these) have started to operate in Argentine agriculture. These "financial pools" as they are known, channel short- and medium term investor funds into crop production. Informal inquiry suggests that as of 2009, some 5 percent of total area was controlled by these business units. These pools spread out their resources anywhere from 10,000 to more than 250,000 planted hectares, renting land from landowners, contracting machinery services, hiring crop supervisors and arranging multiple contractual forms with suppliers of fertilizers, seeds, herbicides and other production inputs.[10] The "logic" behind these enterprises has been subject to considerable debate; however it is not clear whether this type of organization will ultimately displace family firms that traditionally have formed the back bone of the agricultural sector.

In agricultural economics, the economies-of-size literature has focused attention on the owner-operated farm-firm. In modern agriculture a significant portion of capital services (planting, weed control, harvesting) is delivered by outside contractors. Understanding size-efficiency issues will require looking not only to the commodity-producing firm but to how these interact with outside contractors, and in particular looking into the market for contracting

[10] In 2009, six firms farm each more than 100,000 hectares (one of these plants 260,000 hectares). Some 15 additional firms plant each 35,000 – 60,000 hectares. Alejandro Bustamante, personal communication. (2009).

services. The existence of scale efficiencies in the production of contracting services can possibly “spill over” to efficiencies in crop production, therefore explaining the reduction in the number of firms through time.

One last comment is in order. Regression results reported here are disappointing: the included vector of explanatory variables does not account for a significant portion of the observed change in firm numbers or size. It is possible that forces operating outside the agricultural sector (not considered here) have an impact on farm size. In particular, if land is an “attractive” investment opportunity farm size consolidation could result not because of “size” advantages

(in production) but because of changing landownership patterns in response to an inflow of financial resources into the sector. This issue should be addressed in future research.

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## Appendix: Data Sources

IPi = Change in "small" (< 200 hectares) farm numbers measured as the ratio of small farms in 2002 with respect to 1988. Total farm area includes owned plus rented-in land, minus land rented-out.

K = Capital. Total farm tractor horse-power is used a as proxy for capital. This proxy is probably a good measure of capital stock as tractors and other capital inputs are used in approximately fixed proportions.

L = Labor. Total laborers (family plus hired) working on the farm. Labor-hours worked (a better measure of the labor input) was not available.

HC = Small-farm (< 200 ha) farmer education. An index of years of schooling calculated using the eight education classes reported in the census.

Sc = Specialization in crop production calculated as area of crops planted/total "partido" (or "departamento") area (for 2002).

Ss = Specialization in soybean production calculated as change in soybean production (1988-2002)/cropland in 1988.

Ch = Change in land productivity, 1988-2002. Calculated as per-hectare index of land productivity (2002)/land productivity (1988).

Serv = Market for custom machinery services. Machinery services supplied + demanded (hectares) as a percentage of cropland

Cons = percentage of farms reporting the use of consulting services.

No-till = no-till or minimum till area /total crop area in 2002.

Non-farm = percentage of farmers reporting non-farm work, either in the agricultural or the non-agricultural sector.

**Figure 1**
**Small farm (<200) survival: numbers and land área**
**("partido/departamento" data of Buenos Aires, Córdoba y Santa Fe)**

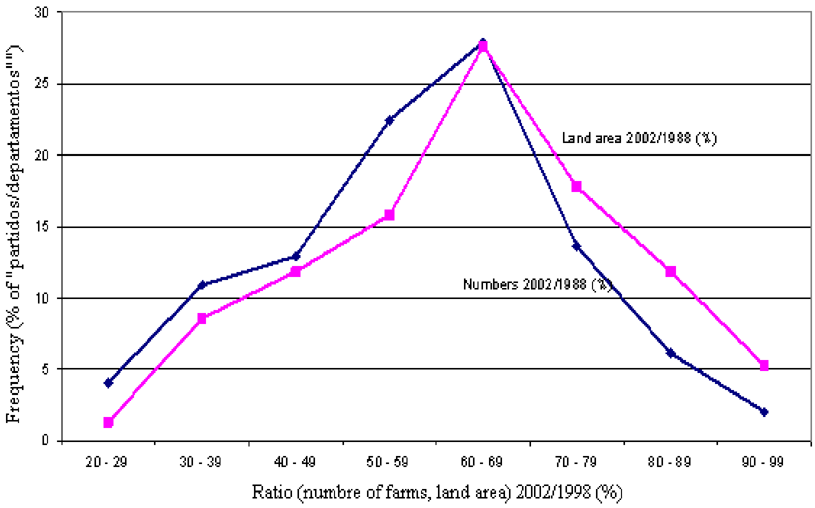

**Figure 2**
**Capital-Labor substitution**
**("partido/departamento" data of Buenos Aires and Córdoba)**

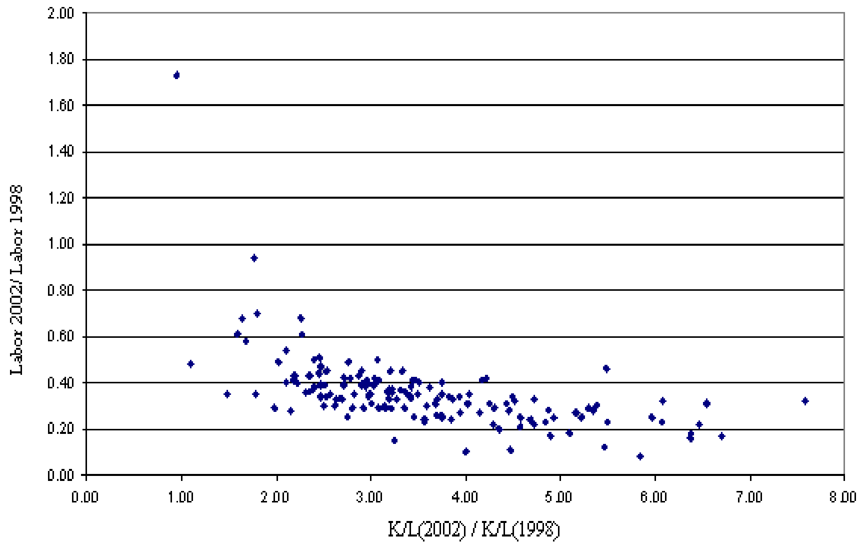

**Table 1**
**Changing Farm Numbers**

| | | Census year | | |
|---|---|---|---|---|
| Province | | 1988 | 2002 | 02/88 (%) |
| Santa Fe | Number of firms | 36862 | 28103 | 76 |
| | Size(hectares) | 300 | 400 | 133 |
| Entre Ríos | Number of firms | 27132 | 21577 | 80 |
| | Size(hectares) | 228 | 294 | 129 |
| La Pampa | Number of firms | 8631 | 7775 | 90 |
| | Size(hectares) | 1444 | 1638 | 113 |
| Córdoba | Number of firms | 40061 | 26226 | 65 |
| | Size(hectares) | 343 | 467 | 136 |
| Buenos Aires | Number of firms | 75479 | 51116 | 68 |
| | Size(hectares) | 361 | 505 | 140 |

Source: Instituto Nacional de Estadísticas y Censos (INDEC), CNA 1988 and 2002.

**Table 2**
**Imput trends (*)**

| | 1988 | 2002 | 2002/1998 |
|---|---|---|---|
| Family Labor (1998=100) | | | |
| All farms | 100 | 12 | 0.12 |
| Small farms | 100 | 10 | 0.1 |
| Non-Family Labor (1998=100) | | | |
| All farms | 100 | 64 | 0.64 |
| Small farms | 100 | 45 | 0.45 |
| Capital (1998=100) | | | |
| All farms | 100 | 147 | 1.47 |
| Small farms | 100 | 135 | 1.35 |
| Capital/Labor ratio (HP/Worker) | | | |
| All farms | 28 | 124 | 4.44 |
| Small farms | 17 | 129 | 7.61 |
| Human Capital (years schooling) | | | |
| All Frms | 7.7 | 9.6 | 1.25 |
| Small farms | 7.1 | 8.6 | 1.21 |
| Off-farm allocation of operator labor (% of farms) | | | |
| All farms | 24 | 21 | 0.88 |
| Small farms | 27 | 22 | 0.81 |

(*) Provinces of Buenos Aires and Córdoba
Source: INDEC, Censo Nacional Agropecuario 1988 and 2002

## Table 3
## Regression results
## (provinces of Buenos Aires and Córdoba)

*Dependent variable: Ratio small farms 2002/1998 ("small": <200 hectares)*

| | Coefficient | T-value | Significance |
|---|---|---|---|
| Constant | 109.67 | 6.62 | 0 |
| K/L | -1.11 | -0.66 | 0.51 |
| Ks0 | -0.19 | -2.04 | 0.04 |
| HC | -2.67 | -1.49 | 0.14 |
| Sc | -0.27 | -2.11 | 0.04 |
| Ch | -0.01 | -0.41 | 0.69 |
| Serv | 0 | 1.59 | 0.11 |
| Ss | -0.01 | -1.24 | 0.22 |
| No Till | 0 | 0.25 | 0.8 |
| Cons | -0.13 | -1.53 | 0.13 |
| Non-Farm | -0.31 | -2.06 | 0.04 |
| Adj. R Sq. | | | 0.13 |
| F-value | | | 2.65 (sig p=0.05) |
| Number of observations | | | 110 |

## Table 4
## Regression results
## (provinces of Buenos Aires and Córdoba)

*Dependent variable: Ratio of farm area 2002/1988*

| | Coefficient | T-value | Significance |
|---|---|---|---|
| Constant | 75.68 | 2.24 | 0.03 |
| K/L | 3.66 | 1 | 0.32 |
| Ks0 | -0.5 | -1.44 | 0.15 |
| HC | 6.41 | 1.84 | 0.07 |
| Sc | 0.62 | 2.69 | 0.01 |
| Ch | 0 | 0.25 | 0.81 |
| Serv | 0 | -0.08 | 0.94 |
| Ss | 0 | -0.11 | 0.91 |
| No Till | 0.13 | 0.77 | 0.44 |
| Cons | -0.01 | -0.46 | 0.65 |
| Non-Farm | -0.06 | -1.25 | 0.21 |
| Adj. R Sq. | | | 0.15 |
| F-value | | | 2.91 |
| Number of observations | | | 110 |