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LAND OWNERSHIP, WORKING CAPITAL, AND AGRICULTURAL OUTPUT : EGYPT, 1913-1958

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RÉSUMÉ

Nous construisons un modèle où le crédit à court terme est requis pour l'achat des intrants, où il existe un risque de banqueroute et où la terre constitue la forme préférée d'épargne pour le petit exploitant. Ces imperfections, que nous considérons être les caractéristiques fondamentales de l'agriculture égyptienne pendant la première moitié du vingtième siècle, font en sorte que la production agricole soit une fonction de la distribution de la propriété foncière. Le résultat théorique le plus important est que la production agricole agrégée sera une fonction croissante du degré d'égalité de la distribution de la propriété foncière lorsque les rendements à l'échelle sont décroissants. Des hypothèses testables pour le court et le long terme sont formulées et testées avec soin sur les données égyptiennes pour la période 1913-1958. Nous trouvons, en contrôlant pour les intrants, qu'il n'existait pas de relation négative entre l'équité et l'efficacité pour l'agriculture égyptienne - au contraire, ces deux critères allaient main dans la main pour le court terme.

Mots clés : agriculture égyptienne, distribution de la propriété foncière, capital à court terme

ABSTRACT

A simple model is constructed in which short-term credit is needed to finance the purchase of inputs, in which there is bankruptcy risk, and in which land is the preferred means of saving of the small landowner. These imperfections, which we argue were important characteristics of Egyptian agriculture during the first half of this century, result in aggregate agricultural output being dependent on the distribution of land ownership. The main theoretical insight is that aggregate agricultural output will be increased by a decrease in the inequality of the distribution of land ownership when returns to scale are decreasing. Testable short- and long-run empirical propositions are formulated and carefully tested on Egyptian data for the 1913-1958 period. We find that, controlling for factor inputs, there is no tradeoff between equity and efficiency for Egyptian agriculture - they go hand in hand in the short run.

Key words : Egyptian agriculture, distribution of land ownership, working capital

Does the distribution of land ownership have any effect on aggregate agricultural performance? If the answer is in the positive, why? A number of authors have recently examined, in a theoretical context, the effects of changes in the distribution of landownership (and thus of agrarian reform) on output, wages, or poverty. For example, Mukesh Eswaran and Ashok Kotwal (1986) construct a model with which they study the effects on aggregate output of changes in the distribution of landownership, where the distribution of landownership is represented by the Pareto distribution. In a recent contribution Karl Ove Moene (1992) studies the effect of changes in the distribution of landownership on production and poverty and shows how the effects depend on the relative scarcity of land. In one of the few rigorous empirical studies on the topic, Mark Rosenzweig (1978) examines the impact of changes in the distribution of land ownership on agricultural wages using Indian data.[1] Based on the Egyptian experience, this paper provides an alternative, imperfect-information-based view of the mechanism through which changes in the distribution of land ownership affect aggregate agricultural output. I also test the empirical implications of the model using the aggregate data on the distribution of land ownership collected by Egyptian authorities during the first half of this century.

In this paper, the channel through which the distribution of land ownership affects aggregate agricultural output is working capital. I assume that bankruptcy obtains with some positive probability. I also

[1] For an interesting overview of case studies on the effects of land reform, see Ahmed (1989).

assume that land is the small peasant's preferred means of saving, and that moral hazard issues create a wedge between the return the small peasant reaps by cultivating the land himself and the return he would enjoy by renting the land out to larger land owners who would be able to put it to more productive use. These three imperfections yield a relationship between a peasant's output and his land ownership, and thus between aggregate agricultural output and the distribution of land ownership.

The basic intuition of the model is extremely simple. Imagine an economy constituted by a fixed number of yeoman farmers who cultivate the land that they each own. Suppose that there are no factor or product markets and that average cost curves are U-shaped. Then it is clear that aggregate output is maximized if each peasant owns and cultivates the same amount of land, where that optimal amount of land is defined by the point where average cost reaches its minimum. In other words, any change in the distribution of land ownership which decreases the inequality of the distribution of land will increase aggregate agricultural output. Though it does convey the basic intuition of the model, the preceding characterization is overly simplistic. I now turn to a description of a more complete model.

To pose the model, let land, labor and intermediate inputs be the only factors of production, and suppose that the production technology is such that average total cost is U-shaped, with a unique minimum attained at q^*.[2] Agricultural production is by its very nature time-consuming, with output obtaining only at the end of the season. During this period, peasant

[2] The consensus among writers on the subject during the period we are considering seems to be that the optimal farm size in Egypt is between 3 and 10 feddans (1 feddan = 1.038 acres = 0.42 hectares). See, for example, Ghali Bey (1947).

producers need short-term credit (working capital) to rent land, hire labor, and purchase intermediate inputs.[3] A peasant family's demand for short-term credit depends, *ceteris paribus*, on its endowments of factor inputs, in particular, land. If the rental value of the family's endowments of factor inputs is smaller than the cost of the factor inputs needed to produce q^*, then the family will need to borrow to be able to produce q^*. In other words: to q^* there correspond total costs of production $c+F$, where variable cost, $c(.)$, is a function of the level of output and of factor input prices, and F is fixed costs; if $c+F$ is greater than the rental value of the family's factor endowments (the amount of land it owns, the number of laborers the family can furnish, and the amounts of intermediate inputs it owns), then the family will have to borrow the difference, $c+F$ − (rental value of factor endowments). Thus, it is clear that, *ceteris paribus*, a family which owns less land will have to borrow more than a family which owns more. If one assumes that families are identical in their endowments of labor and intermediates, then one can classify families into three categories according to their land ownership: borrowers (for whom $c+F$ is greater than the rental value of endowments), lenders (for whom the opposite is true), and those whose endowment of land is exactly equal to the cost-minimizing land input which corresponds to q^*.[4]

I assume that production is risky and that there is a non-zero probability that a borrower will go bankrupt and will be unable to repay

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[3] One could include family subsistence requirements in the model, but it would not appreciably alter the results.

[4] Of course, this relationship will not be so clear-cut in the real data because large landowners will presumably have more than proportionally larger holdings of liquid assets. However, these larger landowners are probably in the "lender" class anyway. The upshot is that this will not affect the results because, as will become clear, all the action in the model comes from the "borrower" class.

his loan. Supply in the credit market is determined by lenders' expected rate of return on the loan being equal to the required rate of return. The interest rate paid by a borrower will depend on the amount of land he owns. This is because the amount he needs to borrow depends upon his endowment of land (continuing to assume, for simplicity, that peasant families differ only in their endowment of land). The smaller a borrower's endowment of land, the more he must borrow, and thus the greater the probability he will go bankrupt. The lender's expected rate of return from a loan is given by the rate of return weighted by the probability that it will not be repaid. In order to achieve a given required rate of return, a greater probability of bankruptcy implies charging a higher interest rate. It follows that the smaller a borrower's endowment of land, the greater the interest rate he must be charged for the lender to be able to realize his required rate. If, because of usury laws, the interest rate is fixed, then there will be borrowers —those who own less than some critical amount of land— who will be credit constrained; that is, they will be unable to borrow enough to be able to produce at q^*.[5]

Now unconstrained borrowers (and lenders) will produce q^* which corresponds to the minimum of their U-shaped average total cost curve. Credit constrained peasants, on the other hand, are unable to obtain sufficient inputs to be able to attain q^* and will therefore produce less than q^*, where average total costs are greater than the minimum. I show that

[5] I certainly do not wish to enter into the debate on Islamic banking or usury in Islamic Law. I will confine myself to reproducing the following verse from the *Qur'an*: "O believers, when you contract a debt for a fixed period, put it in writing. Let a scribe write it down for you with fairness; no scribe should refuse to write as Allah has taught him. Therefore, let him write; and let the debtor dictate, fearing Allah, his Lord, and not diminishing the sum he owes" (*Qur'an*, 2:282). Also see other parts of the same *Sura*.

the output of a credit-constrained peasant is increasing and concave in his land ownership when returns to scale are decreasing. Application of the usual Rothschild-Stiglitz result on mean-preserving spreads shows that aggregate agricultural output will be increased when the distribution of land ownership becomes more equal.

There are two issues left dangling here, however: (i) how do the credit-constrained peasants, who have higher average costs at the output levels they are able to achieve, survive in the output market? And (ii) why don't the credit constrained peasants rent out their land to non-constrained peasants and live off the proceeds?

One possible answer to the first question is that many small owners don't survive. There is a steady outflow of small owners who go bankrupt and join the class of landless laborers.[6] On the other hand, Muslim inheritance law ensures that there is a constant stream of new small owners who emerge as a result of the division of slightly larger holdings. The data on owners of less than one feddan indicates that during the sample period under consideration in this paper (1913-58) the second effect dominated the first, with this class of ownership displaying higher growth than any other

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[6] Girard (1901) writes that small properties (less than 10 feddans) are always farmed by the owner and that "grevée de frais et d'hypothèques, écrasée par les impôts fonciers, cette propriété, mal dirigée, finit tôt ou tard par être saisie par les créanciers et, vendue ou gardée, augmenter quelque gros domaine au détriment du pauvre dépossédé qui s'est rendu insolvable. . . ." (p.56). Baer (1962) writes that the "crises [1907-14 and the 1930s] and their aftermath tended to retard the increase in the total area of holdings under 5 feddans, since fragmentation through inheritance was offset by part of the small landowners becoming landless peasants; though there were not enough sequestrations and sales to prevent the total area of small properties from increasing at all. In times of prosperity, on the other hand, when small owners also benefited, the causes of fragmentation exerted their full influence, and a remarkable increase in the area of small properties resulted." (p.83)

category.[7] This is undoubtedly part of the answer. It is also clear that informational limitations in output markets for agricultural products often result in non-degenerate equilibrium price distributions (this is easy to construct in a model of search, for example), thus increasing the probability that relatively inefficient small producers will survive, for a while at least.[8] Another answer may be found in the theory of repeated games, in which Nash equilibria in which inefficient producers survive are extremely easy to come by.[9]

The second issue is more difficult to address and may stem from a number of sources. In order for the credit constrained peasant to be willing to cultivate his own land, it must be the case that some distortion(s) in factor markets outweigh the loss caused by producing to the left of q^*, where average total costs are not minimized.[10] One possible explanation is the following: suppose that land is the only means of saving available to the small peasant (in Egypt, large landowners, particularly those involved in the cotton trade, were well connected to the foreign banks, but small landowners had little or no access to the formal credit sector).[11] Also

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[7] Of course, there might be other effects at work, but inheritance seems to be the most plausible mechanism. For a detailed description of the development of land ownership during this period and of variations in the distribution of land ownership, see Baer (1962).

[8] Anecdotal evidence on a large degree of price dispersion in Egypt in the early years of this century is provided by Martin and Lévi (1910). For more recent evidence of this type see Hopkins (1988).

[9] See, for example, the discussion on cost asymmetries in Tirole (1988), chapter 6, sections 6.1.3 and 6.3.2.4.

[10] One hypothesis might be that advanced by Feder (1985) in which the productivity of family and hired labor differ. However, this would not account for inefficient production.

[11] For a detailed description of the links between large landowners involved in the cotton market and the banks, see, for example Hafez (1946). Note that one might believe that Islamic laws on usury would limit the operation of credit markets. In practice, many ingenious ways were found to get around interest rate ceilings, and many money lenders were presumably Copts, although the evidence is largely anecdotal.

suppose that renting out one's land involves a moral hazard problem, in that those individuals renting one's land have no incentive to take care of it.[12] In the case of irrigated land, for example, failure to maintain drainage canals will result in a rise in the salinity of the soil, and thus to a deterioration in its value.[13] A wedge is thus driven between the rental rate paid and the effective rent received (i.e., rent net of "damage" to the land) by the small owner. If this distortion is large enough and the difference in average total cost is not too big, the credit-constrained peasant will choose to cultivate his own land.

It is still the case today in Egypt that short-term credit for the purpose of purchasing factor inputs is largely provided by money-lenders, and this despite the considerable power vested in the Village Banks.[14] This is of particular import in the context of this paper because the mechanism through which the distribution of land ownership is assumed to affect aggregate agricultural output is the informal credit sector. It matters therefore that the informal credit sector accounted for the bulk of short-term credit and that the formal credit sector, be it in the form of foreign-owned banks or government-sponsored lending agencies has never driven the money lenders out of business. It is also important that the small farmer never had access to formal credit institutions which would provide

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[12] The cost of "upkeep" of irrigated land can be substantial. Stryker, Gotsch, McIntire and Roche (1981) calculate for a sample of irrigated areas in Sudanese-Sahelian Africa that the annual cost of upkeep of one hectare of irrigated land is equal to between 16 and 20 percent of the *construction* costs involved in irrigating one hectare.

[13] Using the FAO's definition, *all* of Egypt's land today is classified as irrigated. The percentage was somewhat lower during the sample period under consideration, but was nevertheless substantial. Among all Near Eastern countries, the moral hazard argument regarding the maintenance of land is thus particularly applicable to Egypt.

[14] Or in P.B.D.A.C., the Principal Bank for Development and Agricultural Credit.

a safe haven for funds, and thus that land became the preferred means of saving.

The root of the failure of a formal credit sector serving the small landowner to emerge in Egypt can largely be blamed on a well-intentioned but misguided piece of government legislation: the Law of Five Feddans of 1913, which rendered any holding of less than five feddans immune from seizure. Perhaps no piece of legislation produced more heated debate among all classes of Egyptian society before the outbreak of World War I than this law.[15] The year 1909 had seen one of the worst disasters in the cotton sector to date, and there were strident cries for government intervention in the agricultural sector.[16] The gravity of the situation is reflected in agricultural bankruptcy statistics reported in the *Annuaire Statistique*.[17] Although data are available only from the Mixed Tribunals, which tried cases involving foreign defendants, they are presumably representative of the general trend.[18] Writing in *L'Egypte Contemporaine* in May 1913, G. Blanchard conceded that the law was born of noble intentions, namely to "tear the peasant from the grasp of usurers."[19] Those intentions were misguided, however, because

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15 The Law was passed on 4 December 1912 and came into operation for indigenous owners on 10 March 1913.

16 See Sékaly (1910).

17 A common response in many countries to credit constraints is the emergence of important cooperative movements. For contemporary analyses of why an important cooperative movement did not emerge in Egypt at the turn of the century, see Boustani (1919); especially: *Livre Troisième: Etudes sur l'organisation et les réformes agricoles en Egypte*. The distinct roles of the Crédit Fonciers and the Crédit Agricoles are clearly laid out (p. 231). For a later view, see Ibrahim Rachad Bey (1943), the Director of the Department of Cooperatives at the time.

18 The Mixed Tribunals were a particular outgrowth of Egypt's often complex relationship with foreign powers while it was under Ottoman suzerainty.

19 Blanchard (1913).

> by rendering the land of the small holder immune from seizure, one dries up the source of credit which allows him to operate; and this credit, secured necessarily by the value of his land, is more indispensable in Egypt than anywhere else, the *fellah* being the most careless of peasants and the intensive cultivation of the Nile valley necessitating considerable cash advances.[20]

Blanchard goes on to draw the similarities between the Law of Five Feddans and the Homestead Act of 1839 (US), the Anerbengert (first passed in Hanovre) and the French "Lois du 12 juillet sur le bien de famille." Blanchard estimates the cash-in-advance requirements per feddan in Egyptian agriculture during the period to be L.E. 5-10. He concludes with a somber warning: "... the development of the wealth of the country may be gravely affected by the disappearance of all of the credit which might have been based on these lands."[21]

Polier (1913) countered Blanchard's arguments by pointing to the experience in India.[22] He also gives much lower figures for cash-in-

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[20] My translation. The original reads: "En rendant insaisissable le domaine du petit cultivateur, on tarit pour celui-ci la source du crédit qui lui permettra d'exploiter, et ce crédit, gagé forcément sur la valeur de la terre, est plus indispensable en Egypte que partout ailleurs le fellah étant plus insouciant qu'aucun paysan et la culture intensive pratiquée dans la vallée du Nil exigeant des avances considérables."

[21] My translation. The original reads: "Le développement de la richesse du pays peut être gravement atteint par la disparition de tout le crédit auquel pourrait servir de base cette masse de terres." (Blanchard, 1913, p.347).

[22] More precisely, the Punjab Law of 1900. See Polier (1913a). Also see Polier (1913b), p. 276-317.

advance requirements.[23] The upshot however, as noted by Baer (1962), was that the fellah's main source of credit "was, as before, the local money-lender, and there is no reason to suppose that his activities were stopped or even curtailed [by the Law]. He found many ways to evade the law, some of them centuries old. One of the most popular was the "reverting sale," *bai' bi-l-wafa'* or *vente réméré*. . . .[24] Baer (1962) concludes that: "The private banks and mortgage institutions, which were compelled by their positions to act strictly according to the law, were never important sources of credit for the small fellah; Cromer's Agricultural Bank was virtually put out of business by it [the Law of Five Feddans]; and the new government banks for agricultural and mortgage credit for small fellahs had to be excluded from its operation by special legislation."

The Agricultural Credit Bank, founded in July 1931 to provide short-term credit, failed to live up to its promise because "the collateral security required effectively deprived small farmers of loans."[25] As a result, the Bank served mainly large landowners, who were already well furnished with long-term credit from institutions such as the Crédit Foncier Egyptien, and came under the control of the large foreign banks (mainly French) which were primarily concerned with financing the cotton trade. The small holder, who was most likely to be in need of short-term credit, was left to the mercy of the money-lenders.[26] The inability of the

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[23] We have evidence of production cost (including cash-in-advance requirements) for the 1930s and 1940s from Muhlberg (1932, 1940, 1941), for the fifties in Tombary and Saad (1964). There is also a good discussion in Saffa (1949).

[24] Baer (1962), p. 90.

[25] Gameh (1971), p.59.

[26] As with most LDCs, there is a colorful literature dealing with the purported excesses of rapacious money lenders. For the Egyptian context, see for example Nahas (1901) or the classic by Ayrout (1952). For a balanced history of agricultural credit for the years 1910-

Egyptian small holder to have access to formal credit institutions meant that there were few means available to him to save. And the Law of Five Feddans must have increased the attractiveness of land as a store of value: virtually overnight, 32 percent of cultivated land become a perfectly secure asset. It is little wonder that land became, in the words of A. H. Nazmy (1944), the "bottomless sink" for Egyptian saving.

The remainder of the paper is divided into four parts. Part I develops the model, and characterizes the behavior of unconstrained and constrained peasants. Part II presents the main theoretical result that a decrease in the inequality of the distribution of landownership will increase aggregate agricultural output when returns to scale are decreasing. It is also shown how this result may be easily expressed in terms of Lorenz curves. This is important from an empirical standpoint because Lorenz curves constitute a particularly convenient means of summarizing information about the distribution of land ownership. I then introduce the Kakwani coordinate system. This coordinate system and a particular functional form for the Lorenz curve also suggested by Kakwani have proven to be of great empirical use in the case of income distributions. This will also be the case for the Egyptian distribution of land ownership. Part III begins by introducing the Egyptian historical data and provides summary measures of the inequality of the distribution of land ownership.

1950, see el Tanamli (1960, 1962). Also see Malache (1930). Economidès (1952) provides a discussion of rural indebtedness. Schatz (1942) discusses government measures (especially during the Depression) aimed at providing debt relief to peasants. Haggag (1946) provides a different perspective. On the operations of the Agricultural Credit Bank, see Amer (1948). Many of these same authors also provide evidence on government-decreed upper bounds on interest rates.

I go on to describe the two methods by which the Lorenz curves of the distribution of land ownership were estimated for the sample period. I then summarize the empirically testable propositions which stem from the theoretical work. Estimation results are presented for aggregate output as a function of factor inputs and variables describing the shape of the distribution of land ownership. Coefficients on the variables describing the distribution of land ownership are both significant and of the sign predicted by the theoretical results: on the other hand, these results are rather weak. The empirical results also reveal that cropped land and capital in irrigation and drainage were the primary constraints on the growth of aggregate agricultural output, and that the interactions between primary factor inputs and the distribution of land ownership are complex. I then examine time series evidence which takes into account the order of integration of the series under consideration. Various cointegration test are performed which show that agricultural output, factor inputs and the distribution of landownership are cointegrated and thus reflect a long-run equilibrium relationship. The short-run error correction representation of the cointegration equations reveals strong short-term correlation between the degree of inequality of landownership and agricultural output which are not present in the long-run cointegration equations. Finally, I present additional evidence, confined to the years 1933-58, which provides strong support for my working capital based explanation for the relationship between aggregate agricultural output and the distribution of landownership. In particular, I present evidence based upon (i) land expropriated because of bankruptcy and (ii) the magnitude of the average short-term production loan granted by the Crédit Agricole d'Égypte which

suggests that the working capital model presented in this paper is indeed the right theoretical lens to use. Part IV concludes.

I. THE MODEL

The very simple model I present in this section differs from usual models of the determination of the cost of credit under bankruptcy risk because short-term credit is explicitly assumed to be needed to purchase inputs utilized in production. In contrast, most models of imperfect credit markets assume that the credit is needed to finance a lumpy investment, the size of which does not depend upon the cost of credit.[27] On the one hand, the model resembles those developed in corporate finance to study the connection between a firm's cost of credit and its equity.[28] On the other hand, the model is similar to those developed to study the effects of wealth and access to capital in the development literature (e.g. Feder (1985), Eswaran and Kotwal (1986), Shetty (1988), Carter (1988)). Roughly-speaking, the model falls into the broad category of imperfect information models of the credit market initiated by the seminal paper of Stiglitz and Weiss (1981).[29]

Suppose that agricultural output is produced with three inputs: land, labor and intermediate inputs. The peasant family must pay for its factor inputs at the beginning of the harvest year; it only realizes its profit at the

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[27] See the survey by Bell (1988).

[28] See Froot and Stein (1989).

[29] I do not consider sharecropping and interlinked transactions in the context of credit constraints. See, e.g. Braverman and Guasch (1984).

end of the year. As a result, the peasant family needs short-term credit if it is to produce. That is, if the cost of the optimal inputs are greater than the value of the peasant family's liquid endowment, the family will have to borrow. It may obtain short-term credit from a lender at rate i, where i may be specific to the borrower in question. The timing is therefore as follows: (i) the peasant family determines its optimal factor inputs; (ii) the peasant family obtains an amount D of short-term credit from the lender; (iii) uncertainty is realized, the peasant family harvests its crop and repays the lender $(1+i)D$, if it can.

The peasant family's *ex ante* profits (on fixed factors) are given by $\pi = \Theta P f(h,l,m) - (1+i)[n(h-h^e) + w(l-l^e) + u(m-m^e) + F]$, where P is the price at which the peasant family sells its output (which for the time being I will normalize to one), $f(h,l,m)$ is the production function, h is the input of land, l is the input of labor, m are intermediate inputs, h^e is the family's endowment of land, l^e the family's endowment of labor, m^e is the family's endowment of intermediate inputs, n is the rental rate on land, w is the wage rate, u is the unit cost of intermediate inputs, i is the cost of short-term credit, F represents fixed costs, and Θ is a random variable distributed uniformly over [0, 2], with $E(\Theta) = 1$.[30] FOCs for expected profit maximization yield notional demands for land and labor, $h(w,n,u)$ and $l(w,n,u)$, and thus the (variable) cost function $c(q,w,n,u)$. For simplicity, let us assume that average total cost is U-shaped and attains its minimum at $q^*(w,n,u)$. Let D^D represent the notional demand for credit

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[30] One needs a non-degenerate distribution of θ to obtain the results. Assuming that θ takes on "high" and "low" values with probabilities p and $1-p$ does not yield any interesting results because i, the cost of short-term credit, will be independent of h^e.

of the peasant family, and let D^S represent the supply of credit to that family. Notional demand for credit (D^D) is given by production costs ($c(.)+F$), *minus* the rental value of the peasant family's endowments ($nh^e + wl^e + um^e$).[31]

A peasant family is defined to be bankrupt if the realization θ of Θ is such that *ex post* realized profits are non-positive. This is a particularly simplistic definition of bankruptcy, since I do not allow for the peasant being able to borrow from the money lender in order to repay the initial loan. It is, however, standard in the credit-rationing literature. Adding such intertemporal considerations explicitly complicates the analysis, but does not change the basic results. For given optimal input choices, and given endowments of land and labor, I define θ^* to be the cutoff realization of Θ; that is, for $\theta \leq \theta^*$, the peasant goes bankrupt. More precisely, here $\theta^* = (1+i)D/q^*$. The probability of bankruptcy, given the uniform distribution of Θ, is given by $p_B = \theta^*/2$. Note that this is the probability of

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[31] The credit constraint in this model $D^D = n(h-h^e) + w(l-l^e) + u(m-m^e) + F \leq D^S$, resembles that in Eswaran and Kotwal (1986, equation (2), p.483) and that in Feder (1985, equation (5), p. 300). The difference is that here we will be providing micro-foundations for the behavior of Eswaran and Kotwal's "B" and Feder's "S" (where B and S represent the amount of working capital or credit available to the peasant, and are held to be increasing functions of the peasant's land ownership). Micro-foundations for credit-constraints in the context of the development literature is also provided by Carter (1988), who constructs a similar, Stiglitz-Weiss (1981) type model. Carter's model differs from mine in that he assumes that the stochastic component in the output of smaller farms is derived by mean-preserving spread of the stochastic component of the output of larger farms. That is, the output of smaller farms is "riskier" than that of larger farms. The results in my model are *not* driven by such a correlation between farm size (or land ownership) and production uncertainty. My model contrasts with Shetty's (1986) in that he considers land ownership (the peasant's wealth) to be a source of collateral which is appropriated by the lender in case of bankruptcy. In my model the peasant is liable only for the value of his output in case of bankruptcy. It is not the collateral aspect of land ownership which drives the result; rather, it is the impact of land ownership on the probability of bankruptcy. My model could be extended to include the case of collateral; this would strengthen the results at the expense of simplicity.

bankruptcy, *conditional* on land ownership h^e (and labor and intermediate input endowments). Let $D = \min(D^D, D^S)$. Then, since the density of the uniform distribution is given by the constant 1/2, the expected return to a lender who lends D is given by

$$(1+i_E)D = \int_{\theta^*}^{2}(1+i)D\frac{d\theta}{2} + \int_0^{\theta^*}\theta q^* \frac{d\theta}{2}.$$

Dividing by D and performing the integration then yields

$$1+i_E = (1+i)\left[\frac{\theta}{2}\right]_{\theta^*}^{2} + \frac{q^*}{2D}\left[\frac{\theta^2}{2}\right]_0^{\theta^*} = (1+i)\left(1-\frac{\theta^*}{2}\right) + \left(\frac{\theta^{*2}}{4}\right)\left(\frac{q^*}{D}\right);$$

using the fact that $q^* / D = (1+i)/\theta^*$ and rearranging the previous expression yields the expected rate of return[32]

$$(1) \qquad i_E = i - \frac{\theta^*(1+i)}{4}.$$

There are two cases to consider, depending on whether the peasant family obtains its notional demand for credit or whether it is constrained by the lenders. Whether the family is constrained or not will often depend on institutional factors, such as usury laws or social customs which impose an upper bound on permissible rates of interest (such an upper bound may also be the result of rational lender behavior, as shown by Carter (1988);

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32 Note that I have assumed that lenders do not incur a fixed cost of appropriating the peasant's output in the case of bankruptcy. This is an important restriction which represents the cost one must pay to obtain analytically tractable results. See the survey by Bell (1988) for a discussion of different types of fixed costs and their effects in the traditional models of LDC credit markets.

this is also the case in the present model). Also note that intentional default is ruled out by assumption.

Recall that demand for credit by the unconstrained peasant is given by

(2) $$D^D = c(q^*, w, n, u) + F - (nh^e + wl^e + um^e)$$

I assume that lenders face a required (and exogenously determined) rate of return R.[33] Supply of credit is thus given by $R = i - \theta^*(1+i)/4$, or $R - i + (1+i)^2 D/q = 0$, which can also be written as

(3) $$D^s = \frac{(i-R)q}{(1+i)^2}$$

It is easy to show that D^D is upward sloping in (i,D) space, and that D^S has an "inverted-U" shape, with the peak being reached at $i = 1 + 2R$.[34] This is shown in Figure 1. Suppose that the endowment of land of a peasant family increases; then the DD curve shifts to DD', and both the quantity of credit demanded and the interest rate charged decrease. This is because as the peasant family's ownership of land increases, it has to borrow less, and the probability of going bankrupt decreases, thus reducing the interest rate that the lender has to charge in order to achieve an expected return equal to

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[33] One could also consider alternative market structures, but we opt for perfect competition for simplicity.

[34] It is also easy to show that i_E has an "inverted-U" shape in (i_E, i) space. Stable equilibria are always on the upward sloping portion of the i_E curve.

the required rate R. Thus, for stable equilibria (equilibria on the downward portion of the D^S curve are unstable):[35]

$$\frac{di}{dh^e} = \frac{n}{-\frac{q}{(1+i)^3}(1+2R-i)} < 0$$

Of course, the unconstrained peasant always produces at the minimum point of average total cost, q^*, where $c'(q^*,w,n,u)q^* - c(q^*,w,n,u) - F = 0$, so that output remains unaffected by changes in landownership.

Now let us consider the case of the constrained peasant. For simplicity, suppose that usury laws or social custom fix i below the equilibrium rate determined by the intersection of the D^D and D^S curves (note that the results are preserved when one endogenizes credit rationing by letting i vary). For the constrained peasant, $D^D > D^S = D$. Output is determined by $c(q,w,n,u) + F - (nh^e + wl^e + um^e) - D^S = 0$, while the supply of credit is still determined by equation (3), except that i is no longer variable. Substituting equation (3) into the equation which determines the constrained peasant's output yields:

$$c(q,w,n,u) + F - (nh^e + wl^e + um^e) - \frac{(i-R)q}{(1+i)^2} = 0,$$

from which one can easily see that

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35 For the equilibrium to be stable (in the Walrasian sense), excess demand for short-term credit must be decreasing in price, that is, the slope of D^S must be greater than the slope of D^D.

$$\frac{dq}{dh^e} = \frac{n}{\frac{\partial c}{\partial q} - \frac{i-R}{(1+i)^2}}.$$

The denominator of this last expression may be rewritten as $\partial c(q)/\partial q - c(q)/q + (nh^e + wl^e + um^e - F)/q$. Now as long as variable returns to scale are decreasing, long-run marginal cost lies above long run average variable cost, so that $c' - c/q > 0$; therefore, if fixed costs F are small, there is no doubt that this expression will be positive and that $dq/dh^e > 0$. One can represent this in Figure 2, where the QQ curve corresponds to equation (2), while DD corresponds to equation (3). An increase in h^e causes QQ to shift to Q'Q', and output increases. It is also true here that $d^2q/dh^{e2} = 0$.

One must now ask why the constrained peasants do not simply rent out their land, on which average total costs are greater than the minimum attained by unconstrained farmers, to unconstrained peasants, for the rental rate n. Indeed, why might credit-constrained peasant families prefer to cultivate their own land? Expected profits for the credit-constrained peasant family are equal to

$$E[\pi^c] = Pq - (1+i)[c(q) + F - (nh^e + wl^e + um^e)],$$

where $q < q^*$, and where I have brought the price at which the peasants sell their output, P, back into the picture. The lowest price at which any peasant family can expect to sell its output in equilibrium is the minimum of average total cost: $P \geq c(q^*)/q^*$. Thus a lower bound on expected profits of the credit-constrained peasant is

$$q\left\{\frac{c(q^*)+F}{q^*}-(1+i)\frac{c(q)+F}{q}\right\}+(1+i)(nh^e+wl^e+um^e).$$

Now the moral hazard argument, which posits that there exists a wedge between the return that credit-constrained owners would receive from renting out their land *versus* cultivating it themselves can be expressed analytically in the following manner: a peasant family renting out all of its endowments effectively receives $(n-B)h^e+wl^e+um^e$, and not $nh^e+wl^e+um^e$, where B is the "wedge" referred to in the earlier discussion. This distortion induced by moral hazard considerations in the market for land must therefore be large enough to outweigh the difference in average total cost if the credit-constrained peasant family is to cultivate its own land instead of renting out to an unconstrained producer.[36] Of course, if there are similar distortions in the labor market (arising, for example from a difference in productivity of family versus hired labor, as in the Feder (1985)), then the likelihood that the credit constrained peasant will choose to cultivate his own land instead of renting it out is simply increased.

In summary, there are three types of peasant families: (i) lenders, for whom $D^D<0$, (ii) unconstrained borrowers, for whom $D^D>0$ and $D^D=D^S$, and (iii) constrained borrowers, for whom $D^D>0$ and $D^D>D^S$. If, for simplicity, one assumes that peasant families differ only in their ownership of land, then lenders are those peasants who own more than $h^{**}=[c(q^*,w,n,u)+F-wl^e-um^e]/n$; unconstrained borrowers are those who own between h^* and h^{**}, where

36 By "cultivating its own land," I do not mean that it uses only family labor; there is nothing to prevent the family from using hired labor as well.

$$h^* = \frac{c(q^*, w, n, u) + F - \frac{(i-R)q^*}{(1+i)^2} - wl^e - um^e}{n}.$$

Constrained borrowers are those peasants who own less than h^*. This can be represented in (D, h^e) space as is shown in Figure 3 (the figure is drawn for fixed i).

Price risk

The preceding analysis is partial in nature in that it assumes that production risk in the only source of uncertainty faced by the peasant. I now briefly address the issue of uncertainty associated with the price at which the peasant markets his output. Let Φ and Θ be two random variables distributed respectively over the intervals $[\underline{\phi}, \overline{\phi}]$ and $[\underline{\theta}, \overline{\theta}]$, with joint density $g(\Phi, \Theta)$, which can be written as

$$g(\Phi, \Theta) = z(\Phi|\Theta)y(\Theta)$$

where $z(\Phi|\Theta)$ is the density of Φ conditional on Θ, and $y(\Theta)$ is the marginal density of Θ. The random variable Θ will, as in the preceding section, refer to production risk. The random variable Φ, for its part, will represent exogenous shocks to aggregate demand which affect price risk faced by the peasant. Recall that realized profit for the peasant is given by

$$\pi = \Theta P f(h, l, m) - (1+i)[n(h - h^e) + w(l - l^e) + u(m - m^e) + F],$$

and where I now suppose that the price of the agricultural output is a random variable. Then expected profits are given by

$$E[\pi] = E[\Theta P]f(h,l,m) - (1+i)[n(h-h^e) + w(l-l^e) + u(m-m^e) + F],$$

which one can rewrite as

$$E[\pi] = (E[\Theta]E[P] + \mathrm{cov}[\Theta,P])f(h,l,m) \\ -(1+i)[n(h-h^e) + w(l-l^e) + u(m-m^e) + F].$$

As an illustration, suppose that the aggregate inverted demand curve for agricultural output is given by the isoelastic specification:

$$P = \Phi\eta Q^{-\alpha} = \frac{\Phi\eta}{\Theta^{\alpha}\left(\int_0^{+\infty} qf\left(H^e\right)dH^e\right)^{\alpha}},$$

where Φ is the random variable alluded to above which characterizes stochastic shocks to market demand (in the Egyptian case, these might be shocks to the international demand for cotton). Note that $Q = \int_0^{+\infty} \Theta qf\left(H^e\right)dH^e$ is aggregate output. Then one can rewrite the expected profit of the peasant as

$$E[\pi] = E\left[\underbrace{\frac{\Phi\eta}{\Theta^{\alpha}\left(\int_0^{+\infty} qf\left(H^e\right)dH^e\right)^{\alpha}}}_{P}\Theta f(h,l,m)\right] \\ -(1+i)[n(h-h^e) + w(l-l^e) + u(m-m^e) + F].$$

We can rewrite this as

$$E[\pi] = \frac{\left(E[\Phi] + E[\Theta^{1-\alpha}] + \mathrm{cov}[\Phi\Theta^{1-\alpha}]\right)\eta f(h,l,m)}{\left(\int_0^{+\infty} qf\left(H^e\right)dH^e\right)^{\alpha}}$$
$$-(1+i)[n(h-h^e) + w(l-l^e) + u(m-m^e) + F].$$

For notational simplicity, let

$$\tilde{P} = \frac{\left(E[\Phi] + E[\Theta^{1-\alpha}] + \mathrm{cov}[\Phi\Theta^{1-\alpha}]\right)\eta f(h,l,m)}{\left(\int_0^{+\infty} qf\left(H^e\right)dH^e\right)^{\alpha}}.$$

Then, after solving for optimal factor inputs, we can write the cost function as

$$c(.) = c\left(q, \frac{w}{\tilde{P}}, \frac{n}{\tilde{P}}, \frac{u}{\tilde{P}}\right).$$

The notional demand for credit can then be derived in a manner similar to that in the case of a single source of risk. Let us now define the cutoff realization of the random variables such that the peasant is defined to be bankrupt. Zero profit for the peasant may be written as

$$0 = \theta Pq - (1+i)D = \frac{\phi\theta^{1-\alpha}\eta}{E[Q]^{\alpha}}q - (1+i)D,$$

where one poses $E[Q] = \int_0^{+\infty} qf\left(H^e\right)dH^e$. This implies that one can define our "critical set" of realizations of the random variables to be those values of θ and ϕ which satisfy the equality:

$$\phi\theta^{1-\alpha}\frac{\eta}{E[Q]^{\alpha}}=\frac{(1+i)D}{q}$$

Note that one can rewrite this in terms of the critical realization of the random variable which describes exogenous demand shocks as

$$\phi^{*}=\frac{D(1+i)E[Q]^{\alpha}}{\eta q}\theta^{\alpha-1}.$$

The expected rate of return to the lender is then given by

$$1+i_{E}=(1+i)\int_{\underline{\theta}}^{\bar{\theta}}\int_{\phi^{*}}^{\bar{\phi}}g(\Theta,\Phi)d\Phi d\Theta+\int_{\underline{\theta}}^{\bar{\theta}}\int_{\underline{\phi}}^{\phi^{*}}\frac{\phi\theta^{1-\alpha}\eta q}{E[Q]^{\alpha}D}g(\Theta,\Phi)d\Phi d\Theta.$$

In the case of the unconstrained borrower, and assuming that the lender must achieve a required rate of return R, this implies that the interest rate charged by the lender is determined by the solution in i of the equation

$$1+R=(1+i)\int_{\phi^{*}}^{\bar{\phi}}\underbrace{\left(\int_{\underline{\theta}}^{\bar{\theta}}g(\Theta,\Phi)d\Theta\right)}_{y(\Phi)}d\Phi+\int_{\underline{\theta}}^{\bar{\theta}}\int_{\underline{\phi}}^{\phi^{*}}\frac{\phi\theta^{1-\alpha}\eta q}{E[Q]^{\alpha}D}g(\Theta,\Phi)d\Phi d\Theta.$$

As an illustration of what happens to the output of constrained borrowers, suppose that the two random variables are independent and distributed according to the joint uniform density $g(\Theta,\Phi)=1/4, \Theta\in[0,2], \Phi\in[0,2]$, $\mathrm{cov}[\Theta,\Phi]=0$. Independence of Θ and Φ is not an assumption of particularly heroic proportions because one is essentially decomposing the risk associated with price into two components: the first, incorporated in the random variable, Φ, reflects exogenous shocks to the demand for

agricultural products, while the second (Θ) stems from variations in agricultural prices caused by domestic weather conditions and pest infestations which affect peasant output. Moreover, for simplicity, we will assume that the demand function is of unitary elasticity.[37] One can then rewrite the previous equation as

$$1+R=(1+i)\int_{\phi^*}^{2}\int_0^2\frac{d\theta d\Phi}{4}+\int_0^{\phi^*}\int_0^2\frac{\phi\eta q}{E[Q]D}\frac{d\theta d\Phi}{4}$$

Performing the integration with respect to Φ yields

$$1+R=(1+i)\left(\frac{2-\phi^*}{2}\right)+\frac{\eta q}{E[Q]D}\frac{(\phi^*)^2}{4},$$

while substitution of the critical value ϕ^* gives us

$$1+R=(1+i)\left(1-\frac{(1+i)D}{2\eta q}E[Q]\right)+(1+i)^2\left(\frac{D}{\eta q}\right)\frac{E[Q]}{4}.$$

One can thus write the expected rate of return, which equals the lender's opportunity cost of capital, as

$$R=i-\frac{(1+i)^2D}{4\eta q}E[Q].$$

Alternatively, one can write the supply of credit as a function of the interest rate and the required rate of return as

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[37] Unitary elasticity considerably simplifies the example; an elasticity different from unity simply makes the algebra more complex. The crux of the results which follow, however, remains.

$$D = \frac{(i-R)4\eta q}{(1+i)^2 E[Q]}.$$

The cutoff realization of landownership below which a peasant is credit-constrained is given by

$$h^* = \frac{c\left(q^*, \frac{w}{\tilde{P}}, \frac{n}{\tilde{P}}, \frac{u}{\tilde{P}}\right) + F - D^S - wl^e - um^e}{n}.$$

Notice that the cutoff value h^* is a function of aggregate agricultural output through its dependence on $\tilde{P}$, that is, $h^* = h^*(Q)$. Output of the credit constrained peasants is given as before by the solution in q to the equation

$$c\left(q, \frac{w}{\tilde{P}}, \frac{n}{\tilde{P}}, \frac{u}{\tilde{P}}\right) + F - D^S(q,\ldots) - wl^e - um^e - nh^e = 0,$$

One can then easily see (assuming for simplicity that the source of the credit constraint is a cap on the interest rate, which we hold fixed), assuming that each individual peasant is "small" relative to the whole (i.e., $\partial E[Q] / \partial q \approx 0$), that

$$\frac{dq}{dh^e} = \frac{n}{\frac{\partial c}{\partial q} - \frac{\partial D^S}{\partial q}},$$

which is positive by the same argument as in the previous section.

II. The Effect on Aggregate Agricultural Output of Changes in the Distribution of Land Ownership

Assume as in the previous sections that peasant families differ only in their endowment of land. Also assume that the distribution of land can be parametrized by ρ, its parameter of increasing risk, so that the p.d.f. of land ownership is $f(H^e,\rho)$.[38] For simplicity, assume that i is fixed by usury laws. Aggregate output is given by the integral over the distribution of land ownership of the output of unconstrained (q^*) and of constrained (q^c) peasants; h^* is the cutoff point between constrained and unconstrained borrowers (this corresponds to the intersection of D^D and D^S in Figure 3). Aggregate output is therefore:

$$Q = \int_0^{+\infty} qf(H^e,\rho)dH^e = \int_0^{h^*} qf(H^e,\rho)dH^e + q^* \int_{h^*}^{+\infty} f(H^e,\rho)dH^e, \tag{4}$$

which may be rewritten as

$$Q = \int_0^{h^*} \left(q^c(H^e) - q^*\right) f(H^e,\rho)dH^e + q^*.$$

The basic theoretical result is the following:

Proposition 1. When returns to scale are decreasing, a mean-preserving increase (decrease) in the inequality of the distribution of land decreases (increases) aggregate agricultural output. When returns to scale

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[38] In what follows, since the distribution of land ownership is described by a density, I will use H^e to represent the random variable "land ownership," while h^e will represent a realization of that random variable.

are constant, changes in the shape of the distribution of landownership have no impact on aggregate agricultural output.

PROPOSITION 1 is a straightforward application of Rothschild and Stiglitz's Fundamental Theorem of Risk. The proof is of the standard form and is relegated to the APPENDIX. PROPOSITION 1 implies that aggregate agricultural output should be negatively correlated with measures of the inequality of the distribution, controlling for the mean, if returns to scale are decreasing.[39] Note that a result similar to PROPOSITION 1 is also obtained by Eswaran and Kotwal (1986), although they assume that the distribution of land ownership is described by a Pareto distribution with parameter δ lying between 0 and 1, where a larger δ denotes a more equal distribution of land ownership. They find that "a move towards a more egalitarian land-ownership distribution increases the aggregate output."[40]

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[39] Note that it is immediate that $dQ / d\mu > 0$, where μ is the mean of the distribution (and the distribution is parametrized by its mean). PROPOSITION 1 may also be applied to a model of intertemporal profit maximization. This allows one to study the effect of changes in the distribution of land ownership on aggregate capital accumulation. In the standard models (see Lucas (1967), Gould (1968), Treadway (1970) for the model under certainty, Pindyck (1981) and Abel (1983) for the model under uncertainty where use is made of simple Itô calculus) investment is determined by an Euler equation which under credit constraints becomes

$$\dot{I}_t = \left(c''(I_t)\right)^{-1}\left((r_t + \delta)(v_t + c'(I_t) - \frac{F_K}{1 + i_t + \lambda_t}\right),$$

where $c(I_t)$ is the adjustment cost of investment, I_t is investment, v_t is the cost of capital, F_K is the marginal product of capital, $i_t(h^e)$ is the cost of short-term credit, and λ_t is the shadow value of the credit constraint. In the case of an unconstrained peasant, it is easy to see that steady state capital stock will be increasing and concave in h^e. Thus, we would expect a negative correlation between the private (i.e., not government furnished, such as irrigation and drainage) capital stock and measures of inequality, controlling for the mean.

[40] Eswaran and Kotwal (1986), p. 494. Note that the effects of a redistribution of land ownership will not be so clear-cut when efficiency wage effects are present. See, e.g.

Note that consideration of price risk in addition to output risk does not modify the preceding PROPOSITION. The reason is as follows. The effect of a mean-preserving spread in the distribution of landownership is given by the sign of the expression

$$\frac{dQ}{d\rho} = \frac{d}{d\rho}\left(\int_0^{h^*} \left(q^c(H^e) - q^*\right) f(H^e,\rho) dH^e + q^*\right),$$

where $q^c(H^e)$ is the output of credit-constrained peasants and q^* is the output of non-constrained peasants. The complication introduced by endogenizing the agricultural price (it becomes a function of aggregate agricultural output) is that the cutoff value of landownership below which a peasant is credit-constrained also becomes a function of aggregate agricultural output. Thus, one cannot differentiate the preceding integral with respect to the spread of the distribution without taking into account the effect on the limits of integration. Applying Leibnitz 's Rule, it is immediately apparent that

$$\frac{dQ}{d\rho} = \underbrace{\left[\frac{\partial h^*}{\partial \rho}\left(q^c(H^e) - q^*\right)\right]_{H^e = h^*}}_{=0} + \int_0^{h^*} \left(q^c(H^e) - q^*\right) f_\rho(H^e,\rho) dH^e.$$

The second term on the right-hand-side corresponds to the case without price risk. The first term on the right-hand-side, however, vanishes because the output of a credit-constrained peasant, evaluated at the cutoff

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Stiglitz (1988), pp. 129-131. As Stiglitz notes: "... efficiency and equity issues cannot be neatly separated. . . ." Also see Shapiro and Stiglitz (1984, p. 440). Rosensweig (1978), in contrast to my model, studies the effect of changes in the distribution of land ownership on *wage rates* using aggregate Indian data.

value of landownership, is by definition equal to the optimal level of output. Thus, PROPOSITION 1 goes through even when price risk is integrated into the picture (see the APPENDIX for the details of the basic proof).

In order to test PROPOSITION 1 empirically, one must be able to describe the distribution of land ownership. One possibility is to use a summary inequality measure such as the Gini coefficient as a proxy for ρ. It is obvious that such an approach results in the loss of potentially important information: for example, information on the skewness of the distribution is lost in the Gini coefficient. The other possibility is to describe the shape of the distribution of land ownership in a manner which does not obscure such information. It is a well-known empirical fact that data on income distributions are best described by Lorenz curves: empirically estimated distributions, for their part, have not been particularly successful.[41] In what follows, I briefly define the Lorenz curve, derive the equivalent version of PROPOSITION 1 for Lorenz curves in the standard coordinate system, examine the transformation to Kakwani's (1980) coordinate system and derive PROPOSITION 1 for a specific functional form suggested by Kakwani.

The Lorenz curve of the distribution of land ownership may be constructed in the following manner. Define the c.d.f. of land ownership $F(h^e)$ and a continuous and differentiable first moment distribution function $F_1(h^e)$

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[41] See Jain (1975). Also see the citations in Kakwani (1980). Experimentation with several commonly used distribution functions (Pareto, Beta, etc.) proved this was also the case with the Egyptian land ownership distribution data.

$$F(h^e) = \int_0^{h^e} f(H^e)dH^e$$

$$F_1(h^e) = \frac{1}{\mu}\int_0^{h^e} H^e f(H^e)dH^e$$

where μ is the mean of the distribution. The Lorenz curve $F_1(F(h^e))$, $F \in [0,1]$, of the distribution of land ownership is then given by the curve which maps out (F,F_1). An illustration is provided in Figure 4. One limitation of PROPOSITION 1 is that it is distribution-specific, in the sense that one must assume the existence of a family of distributions parametrized by ρ. Another limitation is that results based on the Rothschild-Stiglitz concept of increasing risk are limited to cases of second-order stochastic dominance. Expressed in terms of Lorenz curves this means, speaking loosely, that only changes which involve Lorenz domination are allowed. PROPOSITION 1 thus corresponds to cases where the Lorenz curves change in such a manner that one curve does not intersect the other.[42] PROPOSITION 1 may be reformulated in the context of Lorenz curves in the following manner.[43]

Proposition 2. Let $f(H^e)$ and $f'(H^e)$ be two p.d.f.s of land ownership with means μ and μ'. If $\mu = \mu'$, then $Q(f(H^e)) \geq Q(f'(H^e))$ for all Schur-concave $Q(.)$, if and only if $F_1(F(h^e)) \geq F_1(F'(h^e)), \forall F$.[44]

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[42] For a recent simple treatment of this equivalence, see Laffont (1989), p. 27.

[43] For this theorem in the context of social welfare functions, see Dasgupta *et al* (1973), THEOREM I, and Rothschild and Stiglitz (1973), THEOREM I.

[44] Q is Schur-concave if $Q\left(Bf(H^e)\right) \geq Q\left(f(H^e)\right)$ for all bistochastic matrices B.

PROPOSITION 1 gives conditions for $Q(.)$ to be Schur-concave (decreasing returns to scale and relatively small fixed costs). Of course, a weakness of PROPOSITIONS 1 and 2 is that they assume that the spreads are mean-preserving. PROPOSITION 2 can only handle cases where the Lorenz curves do not cross. The generalized Lorenz criterion, introduced by Shorrocks (1982) establishes a partial ordering over distributions by considering the Lorenz curve multiplied by the mean of the distribution. The generalized Lorenz criterion can handle situations in which the simple Lorenz curves do cross. Shorrocks defines the generalized Lorenz curve as $GF_1(F(h^e)) = \mu F_1(F(h^e))$. The Corollary to Shorrocks' Theorem 2 can be expressed in our context as

Proposition 3. If $GF_1(F(h^e)) \geq GF_1(F'(h^e)), \forall F$ then $Q(f(H^e)) \geq Q(f'(H^e))$ whenever $Q(.)$ is increasing and concave in H^e.

Again, recall that it was established in part I that the output of credit constrained peasants was increasing in h^e when returns to scale are decreasing. Thus if the distribution of land ownership changes in a manner such that the new Lorenz curve GF_1–dominates the previous one, then aggregate output will increase. If returns to scale are constant, on the other hand, there will be no effect.

For empirical purposes a transformation proposed by Kakwani (1980) is of particular use. Parametric estimates of the Lorenz curve under this coordinate system have been particularly successful in the income distribution literature. I thus briefly sketch Kakwani's re-parametrization and derive some empirically testable proposition for a

functional form suggested by Kakwani. This functional form for the Lorenz curve allows to account for the effect of changes in the distribution of land ownership when included in a standard production function describing aggregate agricultural output. Kakwani's coordinate system is based on the re-parametrization $\pi = [F(h^e) + F_1(h^e)]/\sqrt{2}$ and $\eta = [F(h^e) - F_1(h^e)]/\sqrt{2}$, so that $\pi \in [0, \sqrt{2}]$. The Lorenz curve is then given by $\eta = g(\pi)$. This is illustrated in Figure 4. The correspondence between the distribution and the Lorenz curve remains, and one can write: $f(H^e)dH^e = (1 + g'(\pi))d\pi/\sqrt{2}$.[45] One can then write the expression for aggregate agricultural output as

$$Q = \int_0^{+\infty} q(H^e) f(H^e) dH^e = \frac{1}{\sqrt{2}} \int_0^{\sqrt{2}} q(\psi(\pi))(1 + g'(\pi)) d\pi$$

and therefore to equation (4) there corresponds, under the Kakwani coordinate system,

$$Q = \frac{1}{\sqrt{2}} \int_0^{\pi^*(\zeta)} \Phi(\psi(\pi;\zeta))(1 + g'(\pi;\zeta)) d\pi + \frac{q^*}{\sqrt{2}}, \quad \text{where } \pi^* = g'^{-1}\left(\frac{\mu - h^*}{\mu + h^*}\right),$$

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[45] To see the correspondence between the Lorenz curve and the distribution, note that:

$$f(H^e) = \frac{1}{\sqrt{2}}\left(\frac{d\pi}{dH^e} + \frac{d\eta}{dH^e}\right) = \frac{1}{\sqrt{2}}\left(1 + \frac{d\eta}{d\pi}\right)\frac{d\pi}{dH^e}$$

which can be rewritten as $f(H^e) = \dfrac{\sqrt{2}\mu}{\mu + H^e}\dfrac{d\pi}{dH^e}$. Moreover:

$$g'(\pi) = \frac{\mu - H^e}{\mu + H^e}, \quad H^e = \mu\frac{1 - g'(\pi)}{1 + g'(\pi)} = \psi(\pi).$$

and the Lorenz curve $g(.)$ for the distribution of land is parametrized by a $1 \times n$ vector ζ (that is, one can write $\eta = g(\pi;\zeta)$); moreover, I have defined $\Phi(\psi(\pi;\zeta)) = q^c(\psi(\pi;\zeta)) - q^*$. One may then define the $1 \times n$ vector of partial derivatives $Q_\zeta = \partial Q / \partial \zeta$. Though little can be said in general about these derivatives without numerical integration, one can express the result of PROPOSITION 2 for one particular functional form. Suppose (Jain, 1975, Kakwani, 1980) that the equation for the Lorenz curve is given by:[46]

$$\eta = a\pi^{\alpha}\left(\sqrt{2} - \pi\right)^{\beta}. \tag{5}$$

PROPOSITION 2 allows one to say that $\partial Q / \partial a < 0$ for Q Schur-concave. This is because, for given α and β, a Lorenz curve $\eta(\pi;a,\alpha,\beta)$ lies above Lorenz curve $\eta(\pi;a'',\alpha,\beta)$, if $a > a''$. In the usual coordinate system, this means that $F_1(a'';...) \geq F_1(a;...)$. For the derivatives with respect to α and β, numerical integration using functional form (5) showed $\partial Q / \partial \alpha$ and $\partial Q / \partial \beta$ could go either way and that the sign was particularly sensitive to the value of π^*.

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[46] To be precise, this functional form is valid only to within approximately h $=10^{-7}$ of the endpoints. See Kakwani (1980), p. 136. The first derivative is given by

$$g'(\pi) = a\alpha\pi^{\alpha-1}\left(\sqrt{2} - \pi\right)^{\beta} - a\beta\pi^{\alpha}\left(\sqrt{2} - \pi\right)^{\beta-1}$$

while the second derivative is

$$g''(\pi) = -\eta\left(\frac{\alpha(1-\alpha)}{\pi^2} + \frac{\beta(1-\beta)}{\left(\sqrt{2} - \pi\right)^2} + \frac{2\alpha\beta}{\pi\left(\sqrt{2} - \pi\right)}\right).$$

Note that the Lorenz curve is restricted by definition to be concave, so that $g''(\pi) < 0$.

III. AN APPLICATION: EGYPT, 1913-1958

For Egypt, the years 1913-1951 are remarkable because of the lack of any major institutionally induced change in the size distribution of land ownership. Though the revolution of 1952 did result in the beginning of a movement to redistribute land, it did not produce any major innovation in the credit sector. This was to remain the case until the sixties. As a result, the mechanism —the informal credit market— through which I have posited that agricultural output is affected by the distribution of land ownership, was not substantially affected during the sample period.[47] I begin by briefly reviewing the data. I then sketch the method by which the Lorenz curve for the distribution of land ownership was fitted to the Egyptian data.

Agricultural Output

There have been several attempts to construct aggregate indices of Egyptian agricultural output.[48] One well-known index is that constructed by O'Brien (1968), which covers the period 1894-1960 and includes eight important field crops (cotton, sugar-cane, wheat, maize, barley, beans, lentils, rice).[49] I have chosen to use the index of agricultural output

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[47] The second wave of the agrarian reform movement struck in 19581, the third in 1961, and the fourth in 1964. Extensive government intervention in the provision of short-term credit did not occur until the early sixties.

[48] See Issawi (1942).

[49] Though O'Brien provides a lengthy description of the manner in which he constructed his index, I have been unable to reproduce his results, despite having access to a complete set of *Annuaires Statistiques* at Harvard. O'Brien's index only includes 8 crops because the purpose of his study was to examine the development of agricultural output from 1821

provided by the Department of Statistics and Census in the *Annuaire Statistique*. This is a base-weighted index with average values for the period 1935-39 used as weights. The data are presented in Table 1, while agricultural output is plotted in Figure 5.

Agricultural Capital Stock and Fertilizer Input

The source of the capital stock series presented in Table 1 is Radwan (1974) who carefully details the manner in which he constructed the data. The bulk of the Egyptian agricultural capital stock is accounted for by irrigation and drainage, which includes dams, barrages and canals.[50] "The central government has been almost entirely responsible for the provision, expansion and maintenance of the country's hydraulic system."[51] The remainder is made up of dwellings and farm buildings, livestock, and various types of machinery. The data are presented in Table 1. Figures 6 and 7 plot the two capital stock series. Figure 8 plots the aggregate capital stock. Fertilizer input comes from Radwan (1974) and is plotted in Figure 12.

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to 1962. Data on agricultural production is incomplete prior to 1913, and quite scanty for the pre-1894 period. By making certain (reasonable) assumptions about yields, O'Brien had sufficient data to push his eight crop index back to 1894. After 1913, data is easily available in the *Annuaire Statistique* and it therefore seemed unwarranted to confine one's attention to only eight crops, which would have meant accounting for only 60 percent of agricultural output during the 1950s.

50 The data presented in Table 1 are *indices*. For the same series expressed in nominal and constant price terms, see Radwan (1974).

51 Radwan (1974), p.29. The major dams and barrages built or heightened during the sample period were Aswan (1933, which brought most of the delta under perennial cultivation), Assiut (rebuilt 1934-8), Nag-Hammadi (1928-30), Gebel el-Aulia (Sudan, 1934), and Edfina (1951).

Agricultural Population and Working Force

The source for these data are the censuses of 1907, 1917, 1927, 1937, 1947 and 1960, interpolated for intervening years. The data are presented in Table 1. The two series are plotted in Figure 11.

Cultivated and Cropped Area

The sources for cultivated area are the various *Annuaires Statistiques*. The data are presented in Table 1 and plotted in Figures 9 and 10.

Distribution of Land Ownership

Our data on the distribution of land ownership comes from the *Annuaire Statistique*, and is "based on the tax certificate or *wird* given to the landowners in each village." Baer (1962), after careful consideration of the various biases injected into the data by the manner in which they were collected, concludes that "landownership in Egypt is concentrated in fewer hands and in larger property holdings than might be supposed from the statistical evidence."[52] Table 2 presents two summary measures of the inequality of the distribution of land ownership. Kakwani's inequality measure is defined by:[53]

$$L_K = \left(\int_0^1 \left(\sqrt{1 + \left(\frac{dq}{dp} \right)^2} \right) dp - \sqrt{2} \right) \left(2 - \sqrt{2} \right)^{-1}$$

[52] Baer (1962), p. 72.
[53] See Kakwani (1980), pp. 83-85.

where (p,q) are the coordinates of the Lorenz curve in the usual coordinate system and dq/dp is the slope of the Lorenz curve. The Gini coefficient is given by

$$G = 1 - 2\int_0^{+\infty} F_1(H^*) f(H^*) dH^*$$

Actually, the values of Kakwani's inequality measure and the Gini coefficient presented in Table 2 are lower bounds on these measures since information is lacking on inequality within classes.[54] It is well-known that the Gini coefficient attaches more weight to transfers of income near the mode of the distribution than at the tails.[55] On the other hand, Kakwani's inequality measure attaches higher weight to transfers at the lower end than at the middle and upper ends of the distribution.[56] As a result Kakwani's measure is more sensitive to transfers at the lower tail of the distribution of land ownership.

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54 This is so because we are estimating from grouped observations. Note that there are several other aggregate measures of inequality, constructed in the same manner as the Gini coefficient, such as the Mehran and Piesch coefficients. See Sandström (1983), p.20. The empirically estimated version of Kakwani's measure is

$$\overline{L}_K = \frac{1}{2-\sqrt{2}}\left(\frac{1}{\mu}\sum_{t=1}^{T+1} f_t \sqrt{\mu^2 + \mu_t^2} - \sqrt{2}\right)$$

where t indexes the classes into which land ownership is divided, μ is mean land ownership, and μ_t is mean land ownership within class t, while the Gini coefficient I present is

$$\overline{G} = 1 - \sum_{t=1}^{T+1} f_t \left(q_t + q_{t-1}\right)$$

55 Kakwani (1980), Lemma 5.6.

56 Kakwani (1980), Lemma 5.11.

Figures 13 and 14 represent the Lorenz curve for land ownership for the years 1913, 1938, 1946, 1956 and 1958 in the Kakwani coordinate system. The size categories underlying the representation are: less than 1 feddan, 1 to 5 feddans, 5 to 10 feddans, 10 to 20 feddans, 20 to 30 feddans, 30 to 50 feddans, and more than 50 feddans. The curve is extremely skewed because owners of less than one feddan account for a very great share of owners while owning relatively little of the land. This presents estimation problems because any attempt to fit a curve to the data will attach insufficient weight to the first category. This is made clear by Figures 13 and 14: the first ownership category, which corresponds to the line segment linking the origin with the first point is extremely large, yet only two data points, the origin and the first point, will be picked up by a parametric estimate of the curve. Because of this, I estimate the Lorenz curve in two ways which attempt to compensate for the lack of observation in the large first ownership category. *Method 1.* I interpolate for points within the first category on the assumption that the curve is linear over this range and I then estimate the Lorenz curve. *Method 2.* I estimate the Lorenz curve only for those categories after the first: the estimated Lorenz curve is thus only valid for the 6 upper ownership categories and inequality stemming from the first category must be measured in some other fashion. As in Jain (1975) and Kakwani (1980), I assume that the Lorenz curve under the Kakwani coordinate system is given by equation (5). In method 1, where the equation is valid for the entire range of $\pi \in [0,\sqrt{2}]$, a sufficient condition is that $\alpha \in [0,1]$ and $\beta \in [0,1]$, $a \in [0,+\infty)$. Table 3 gives parameter estimates for method 1. Table 4 gives parameter estimates for method 2.

Table 5 presents information on that portion of the Lorenz curve which corresponds to the first ownership category.[57]

The theoretical model implies that aggregate agricultural output is a function of factor inputs and the shape of the distribution of land ownership: $Q = Q$(Factor Inputs, Distribution of Land Ownership). Since one has no knowledge about the functional form of the agricultural production function and one does not know how the technology of production may vary with the size of land ownership, it is perhaps wisest to view the estimates which follow as rough exercises in growth accounting.[58]

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57 The information about the shape of the distribution one surrenders by using the Gini coefficient instead of the parameter estimates of the Lorenz curve can be illustrated for the functional form of the Lorenz curve that has been chosen. Under the Kakwani coordinate system G is given by the equation

$$G = 2\int_0^{\sqrt{2}} g(\pi)d\pi$$

Kakwani shows that for the functional form (5), this last expression may be rewritten as $G = 2a\left(\sqrt{2}\right)^{1+\alpha+\beta} B(1+\alpha,1+\beta)$, where $B(1+\alpha,1+\beta)$ is the Beta distribution function, and that the partial derivatives are given by

$$\frac{\partial G}{\partial a} = \frac{G}{a}$$

$$\frac{\partial G}{\partial \alpha} = \left(\log\sqrt{2} + \psi(1+\alpha) - \psi(2+\alpha+\beta)\right)G$$

$$\frac{\partial G}{\partial \beta} = \left(\log\sqrt{2} + \psi(1+\beta) - \psi(2+\alpha+\beta)\right)G$$

where ψ is Euler's psi function. These expressions underline the fact that changes in the Gini coefficient are the result of the sum of changes to various characteristics of the Lorenz curve of the distribution of land ownership. Using the Gini coefficient as a proxy measure of the inequality of the distribution of land ownership will at best result in the loss of information, at worst it will be misleading.

58 It is entirely possible that constrained and unconstrained borrowers may differ in some systematic manner in the technology they use, which would make me even more reticent to impose a particular functional form, since there is no concrete empirical evidence upon

Aggregation over such a diversity of individual producers precludes drawing specific structural conclusions from the data. On the other hand, parameter estimates will be useful in determining binding constraints on aggregate production. Moreover, as will be argued in the context of the time series evidence presented below, one can view the relationship between aggregate output, distributional variables and aggregate factor inputs as a long-run equilibrium relationship whose existence can be tested for using standard co-integration techniques.

From the theoretical discussions, one expects, if returns to scale are decreasing, that the partial derivatives of aggregate agricultural output with respect to mean land ownership should be positive, whereas the partial derivatives with respect to the Gini Coefficient, the Kakwani coefficient of inequality, a_1, a_2 and l_1 (the length of the Lorenz curve in the first ownership category) should be negative. Theory tells one nothing unambiguous about the signs of the partial derivatives of aggregate agricultural output with respect to $\alpha_1, \alpha_2, \beta_1$ and β_2.[59]

There are several issues of an econometric nature which are particular to the Egyptian data: (i) there were important acreage restrictions imposed on cotton for several years included in the sample period; (ii) cropped land is potentially endogenous; (iii) there are very visible structural breaks in at least two of the factor input series —the

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which to base a model incorporating those differences, at least for the sample period under consideration.

[59] Recall that $\left(a_{1t}, \alpha_{1t}, \beta_{1t}\right)$ are the coefficients of the Lorenz curve using method 1, $\left(a_{2t}, \alpha_{2t}, \beta_{2t}\right)$ are the coefficients of the Lorenz curve using method 2.

capital stock in irrigation and drainage, and the agricultural work force; (iv) the 1952 revolution may have had important real effects; (v) the distribution of land-ownership, particularly its lower tail (very small owners), may be endogenous. I shall briefly address each in turn.

Cotton acreage restrictions

Cotton has always constituted a large fraction of Egyptian agricultural output, and during the 1913-58 period was the largest earner of foreign exchange for the Egyptian economy. During this period, the Egyptian authorities tried at various times to exercise their presumed monopoly power in the international market for long and extra-long staple cottons by imposing restrictions on the acreage that could be devoted to cotton.[60] Of course, this may have led to inefficient allocations of factor inputs, so that one may hypothesize that there would be a negative relationship between aggregate agricultural output and the cotton acreage restrictions.[61] I have quantified these restrictions by using Hansen and Nashashibi's (1975) effective acreage restriction series, which combines official acreage restrictions with knowledge of the extent to which restrictions were actually in effect.[62]

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60 Acreage restrictions on cotton were imposed in 1915, 1918, 1921-3, 1927-9, 1931-3, 1942-7, and 1953-58.

61 For a concise summary of Egyptian cotton policies, see, for example, el-Sarki (1964), pp. 32-47.

62 For example, for 1955 to 1958, the average upper limit on a cultivator's total acreage that could be devoted to cotton was 33 percent, but it is believed that there was widespread evasion of the controls which rendered them wholly ineffective. See Hansen and Nashashibi (1975), Table A-1, p.330, column (4).

Endogeneity of cropped land

The intensity with which land is cultivated, in particular the extent to which there is multiple cropping, is a function of expected prices and yields. It is thus quite likely that cropped land is endogenously determined, and may thus be correlated with the error term, leading to inconsistent parameter estimates. To correct for this, I have estimated all equations instrumenting for cropped land.

Structural breaks in factor input series

Figure 6 reveals that capital stock in irrigation and drainage enjoyed a burst of growth in the 1928-1939 period.[63] The agricultural working force, for its part, shows a break in its growth rate in 1937 (see Figure 11). Since the technology underlying my estimates may not be adequately described by a conventional smooth Neoclassical production function, I do not restrict the coefficient on the agricultural working force to be the same during the pre- and post-1937 periods. Similarly, I do not constrain the coefficient on the capital stock in irrigation and drainage to be the same during the 1928-39 period and the rest of the sample. I also include a dummy for the 1928-39 period since the choice of technique may have been affected by the perennial irrigation made possible by the construction and heightening of so many dams and barrages. On the other hand, it is likely that this dummy will display a negative effect on output since it corresponds to the Great Depression. Note that one would expect the two constraining factors on the growth in aggregate agricultural output to be (i)

[63] As noted above, this period corresponds to a series of major dam projects.

the state of the hydraulic system (reflected in the capital stock in irrigation and drainage) and especially (ii) the amount of cropped land.

Effects of 1952

Though the major government policy innovations in the agricultural sector occurred after the end of the sample period under consideration, there can be little doubt that the Revolution had real effects. First there was the initial redistribution of land and the upper limits placed on individual and family ownership, although this will be reflected in the distributional variables. Second, there was the impact on the markets for agricultural credit. Here, the effect may go in either direction: on the one hand one might expect that money lenders, especially foreigners and minorities, would be wary of the new régime and might curtail their activities. This may not have been true until the major nationalizations, but little evidence is available either way. On the other hand, government intervention in the credit sector may have facilitated the flow of credit to the mass of very small owners. *A priori*, it seems reasonable to expect the second effect to dominate the first, especially since the sample period ends in 1958.

Endogeneity of the lower tail of the distribution of land-ownership

The causality in the model presented in this paper runs from the distribution of land ownership to agricultural output. However, the causal link may also run in the opposite direction, with agricultural output affecting the distribution of landownership as bankruptcies and variations in output move individuals from one ownership category into another. The

lack of sufficient instruments precludes endogenizing all four distributional variables in a model in which the second method of estimation of the Lorenz curve is used. On the other hand, one might expect the effects of fluctuations in output to be felt primarily at the lower end of the distribution, where owners of less than one feddan cling precariously to their independence and where one bad harvest may be sufficient to force them to sell.

Estimation results: a first pass

I begin by presenting simple results of regressions in levels whose purpose is to investigate the relationship between the distributional variables, the factor inputs and aggregate agricultural output. As such, these results should be taken with a grain of salt as they do not consider the order of integration of the variables and other time-series concerns. These issues will be taken up in the following section.

Models 1 through 5 in Table 6 give parameter estimates for the barebones model in which only factor inputs and distributional variables are included.[64] The parameter estimates based on method 1 of estimating the Lorenz curve (model 4) appear to be highly unstable, which confirms our lack of faith in this method.[65] On the other hand, the coefficients on the mean of the distribution of land-ownership (models 2 and 3) are positive (though insignificant at the usual confidence levels), those on the summary measures of the spread of the distribution are always negative:

[64] Models 1 through 5 are estimated by OLS.

[65] For example, note the magnitude and very low t-statistic on a_1.

this conforms with the theoretical predictions. The estimates based on the second method of obtaining the Lorenz curve (model 5) indicate that most of the action is coming from the first ownership category (less than 1 feddan), as indicated by the coefficient on the ll_1 variable, as well as from effects from higher moments of the distribution (note the coefficient on β_2). Thus, the greater the degree of inequality at the lower end of the distribution (as measured by the length of the Lorenz curve for the first ownership category), the lower the output. This is not surprising given that those farmers who own less than one feddan are probably severely credit constrained.

It is comforting to find a relatively strong relationship between output and the aggregate capital stock for models 4 and 5, although there is the puzzle of the statistically insignificant coefficient on the agricultural working force and especially on the amount of cropped land. One would expect, in a country where arable land is as scarce as it is in Egypt, that cropped land would have a great deal of explanatory power vis-à-vis aggregate agricultural output. In light of previous econometric findings, however, the rejection of the null hypothesis that the coefficients on labor and land presented in Tables 6 and 7 are individually different from zero is not surprising. For example, in estimating acreage response functions for the eleven major crops over roughly the same period,[66] Hansen and Nashashibi (1975) found that "the coefficients for the lagged and unlagged primary inputs, land, labor, and water" were "generally insignificantly different from zero."[67]

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66 Specifically, 1913-61.

67 Hansen and Nashashibi (1975), p.338.

Models 8 and 9 reveal that the puzzle with respect to cropped land is merely a function of the extremely parsimonious specifications used in models 1 through 5.[68] Consider model 8. As one would expect, disaggregating capital reveals that it is capital in irrigation and drainage which is of paramount importance (this is also true in models 6, 7 and 9).[69] It is also clear that cropped land is an extremely important determinant of aggregate output. The extremely large (1.4) and highly significant coefficient in models 8 and 9 reveal that land is indeed a binding constraint in Egyptian agriculture. On the other hand, the coefficient on cropped

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[68] Models 6, 7, 8, and 9 are estimated by instrumental variables. In model 6, cropped land is assumed to be endogenous; in models 7 and 8, cropped land and the length of the Lorenz curve in the first ownership category (ll_1) are assumed to be endogenous; in model 9, cropped land, ll_1 and a_2 are assumed to be endogenous. For all four models, the instrumental variables were: two lags of agricultural output, one lag of cropped land, and dummies for the world wars. Lagged output can be safely assumed to be orthogonal with respect to the included variables. I assume that the length of the first ownership category is a function of lagged output because any effects through expropriation stemming from poor agricultural performance are likely to manifest themselves most strongly in the first ownership category. In the case of cropped land, the potential dependence on lagged output stems from the adjustment of the intensity of cultivation (cropped over cultivated land) in the wake of poor performance in the previous year. The instrumenting equations (t-statistics in parentheses) are given by

$$CR = \underset{(-0.29)}{-0.08} + \underset{(0.34)}{0.03}\, Q_{-1} + \underset{(0.89)}{0.08}\, Q_{-2} + \underset{(14.24)}{0.90}\, CR_{-1} + \underset{(0.39)}{0.003}\, WW,$$

$$\bar{R}^2 = 0.89,\ \sigma = 0.02,\ DW = 2.15;$$

$$ll1 = \underset{(-6.80)}{-1.27} + \underset{(1.22)}{0.07}\, Q_{-1} + \underset{(1.09)}{0.07}\, Q_{-2} + \underset{(6.52)}{0.28}\, CR_{-1} - \underset{(-1.09)}{0.006}\, WW,$$

$$\bar{R}^2 = 0.73,\ \sigma = 0.01,\ DW = 0.28;$$

$$a_2 = \underset{(7.41)}{3.65} - \underset{(-1.12)}{0.17}\, Q_{-1} + \underset{(1.17)}{0.20}\, Q_{-2} - \underset{(-4.74)}{0.54}\, CR_{-1} - \underset{(-1.42)}{0.02}\, WW,$$

$$\bar{R}^2 = 0.41,\ \sigma = 0.04,\ DW = 1.92;$$

[69] That portion of capital which is *not* irrigation and drainage (namely, rural dwellings and draft animals) has, unsurprisingly, no effect on output, and has been omitted from the specifications presented in Table 6.

land in model 7, which differs from model 8 only in that a post-1952 dummy is included, is significantly smaller: this suggests that it is in the post-1952 era that land has become exceedingly scarce. As the limits of multiple cropping possibilities rendered feasible by perennial irrigation are reached, the land constraint becomes increasingly binding.[70]

It is interesting to note that the coefficients on capital stock in irrigation and drainage are significantly greater for the major dam projects period (1928-39), when, as noted earlier, capital stock in irrigation and drainage grew at a markedly faster pace than during the rest of the sample. This is true for all four models (6, 7, 8, and 9). It is likely that the growth in the capital stock in irrigation and drainage was the driving force behind growth in the agricultural sector during this period, when the possibilities opened up by perennial irrigation had not yet been exhausted: temporarily at least, the rapid growth of capital in irrigation and drainage pushed back the land constraint.

The relationships linking the agricultural working force, the distribution of land ownership and the effects of the 1952 revolution are complex. For models 8 and 9, the coefficients on the agricultural working force are insignificantly different from zero. This suggests, as is indeed plausible, that there is no shortage of labor in Egyptian agriculture. Once the effects of 1952 are taken into account however, the relationship becomes quite strong: for model 8, the coefficient on the agricultural working force after 1937 is equal to 0.35 with a t-statistic of 0.61, while in

[70] Note that estimating these models with the inclusion of fertilizer input (not reported) has little effect on parameter estimates and that the coefficient on fertilizer input is insignificantly different from zero.

model 7 (which included the post-1952 dummy) the same coefficient is equal to 0.86 with a t-statistic of 2.13. It may be that agricultural labor has only become extremely abundant in the post-revolutionary era: certainly the explosion in the Egyptian population corresponds to that period.[71] It is also clear that the strength of the link between the agricultural working force and aggregate agricultural output is related to the distribution of land ownership. Once one drops the inequality of the first ownership category from the specification (this corresponds to model 6), the agricultural working force loses its explanatory power. While the model presented in this paper has focused on the direct link between the distribution of land ownership and aggregate output, it may be that there are additional incentive (or disincentive) effects (which affect labor productivity) stemming from changes in the distribution of land ownership. This is in line with Rosenzweig's (1978) findings on the effects of changes in the distribution of land-ownership in India on labor supply and agricultural wages. Note also that the coefficient on cropped land in model 6, which does not include the lower tail of the distribution of land ownership, is insignificantly different from zero. In model 7, on the other hand, which includes the lower tail of the distribution of land ownership, the coefficient on cropped land is much larger.

It is clear that the effects of changes in the distribution of land ownership were muted by the revolution of 1952. In model 8, the coefficient on the inequality of the first ownership category is -4.14 with a t-statistic of 1.67. Once the revolution is accounted for in model 7, the

[71] There is an increase in the population growth rate in the late forties.

coefficient remains approximately the same (-4.45) but becomes much more significant (the t-statistic is equal to 2.62). This is what the theoretical model would predict: greater intervention by the government in the credit sector should weaken the link between the informal credit sector and aggregate output, and thus also weaken the statistical link between the lower tail of the distribution of land ownership and aggregate output. Note that the effect of the revolution on aggregate agricultural output, as reflected in the coefficient on the post-1952 dummy, is positive. As expected, the coefficients on the 1928-39 and cotton acreage restrictions dummies are both negative, the first because it effectively proxies for the Great Depression (and this obviously must outweigh any positive effects of the dam projects), the second because the cotton acreage restrictions probably led to important inefficiencies in the allocation of resources.

Time series analysis

In this section, I begin by analyzing the order of integration of the series under consideration. I then examine the links between output, factor inputs, and the distribution of landownership as a long-run equilibrium relationship which implies cointegration among the variables in question. After performing Engle-Granger cointegration tests, I examine the implied short-run relationships using the error correction representation of the cointegrated process. This reveals very strong short-term links between the distribution of landownership and aggregate agricultural output which do not appear in the long-run relationships.

The stationarity properties of the time series being considered are examined using the standard augmented Dickey-Fuller equation (Dickey and Fuller (1981)) given by

$$X_t = \delta_0 + \delta_1 t + X_{t-1} + \sum_{i=1}^{i=l} \delta_{i+1} \Delta X_{t-i},$$

where the value of l is chosen so as to eliminate all remaining serial correlation. Here X_t is successively the logarithm of: aggregate agricultural output (Q_t), the aggregate capital stock (K_t), the agricultural population (N_t),[72] cropped land (H_t), the Gini coefficient ($GINI$), the Kakwani coefficient (KAK), and the coefficients from the Lorenz curve, that is, a_{1t}, α_{1t}, β_{1t} (method 1). The results of the augmented Dickey-Fuller tests are presented in Table 7. It is interesting to note that agricultural output and all of the input variables can be taken to be I(2); the higher moments distributional variables (α_{1t} and β_{1t}) are I(2), as is the measure of Lorenz domination, a_{1t}. For their part, the summary measures of inequality —the Gini and Kakwani coefficients— are also both I(2). The relatively high order of integration of the variables suggests why the initial representation in terms of level regressions presented in the previous section yielded such weak results.

The key issues here are: (i) whether agricultural output, the factor inputs, and the distribution of landownership are linked by a long-run equilibrium relationship, as is predicted by the theoretical model presented

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72 I have picked the agricultural population in place of the agricultural working force for the analysis using time series techniques because of the very evident structural break in the working force series. This leads to tests for unit roots and cointegration equations with structural breaks which would lead us beyond the scope of this paper. See Perron (1989).

in part I of this paper; and (ii) if so, whether a given short-run representation of the corresponding cointegration equation can reveal short-run effects which are not apparent in the long-run. Moreover, given that all variables are I(2), it will be worthwhile testing not only whether the variables are cointegrated in levels, but also whether they are cointegrated in first differences, as they are still I(1) after first differencing (ΔL will be I(2)).

The distinction between short-run and long-run effects here is not a mere statistical *curiosum*. Indeed, I would argue that it lies at the heart of the effects of the distribution of landownership on aggregate agricultural output. In the long-run, when the peasant is free to vary all of his factor inputs, it is not unreasonable to assume that returns to scale are constant. From PROPOSITIONS 1, 2 and 3, we know that this implies that $\partial Q / \partial \rho$ or $\partial Q / \partial a_1$, to use the parametric representation of the Lorenz curve, are equal to zero. In the short-run, if returns to scale are decreasing, we will have $\partial Q / \partial a_1 < 0$, while the opposite will hold if returns to scale are increasing

In order to address these issues, I begin by performing co-integration tests (Engle and Granger (1987)). That is, I posit that the long-run equilibrium relationship between aggregate agricultural output, factor inputs and the distribution of landownership is characterized by the relationship

$$Z_t = Q_t - \delta_0 - \delta_1 t - \delta_2 K_t - \delta_3 L_t - \delta_4 H_t - \delta_5 a_{1t} - \delta_6 \alpha_{1t} - \delta_6 \beta_{1t},$$

where Z_t is stationary. Here, the right-hand-side (R.H.S.) variables are integrated of order 2. We are thus seeking a cointegrating vector δ such that Z_t is I(0), that is, we are testing whether the variables in the equation above are CI(2, 2). The results of these regressions are presented in Table 8 (columns 1, 2 and 3), along with the augmented Dickey-Fuller test statistics on the residuals from these equations. The null hypothesis is of course that the variables are not cointegrated. This null is rejected at the 5% level of confidence when one considers the Lorenz curve representation of the distribution of landownership, but is not rejected when one uses the summary measures of inequality (the Gini and Kakwani coefficients). The existence of a cointegrating vector when the Lorenz curve is used and its absence when the summary measured of inequality are employed strengthens our argument in favor of using more detailed information on the shape of the distribution of landownership in place of summary measures of inequality. Moreover, as one is led to believe by the level regressions presented in the previous section, the long-run equilibrium relationship does not reveal any striking correlations between agricultural output and the distribution of landownership. This is consistent with the argument presented above that long-run returns to scale are roughly constant, implying no effect in the long-term of the distribution of landownership on aggregate agricultural output.[73]

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[73] A weaker, though interesting, test of our theoretical model is whether aggregate agricultural output, factor inputs and the distribution of landownership cointegrated in first differences. That is, one considers the cointegrating equation

$$W_t = \Delta Q_t - \delta_0 - \delta_1 t - \delta_2 \Delta K_t - \delta_3 \Delta L_t - \delta_4 \Delta H_t - \delta_5 \Delta a_{1t} - \delta_6 \Delta \alpha_{1t} - \delta_6 \Delta \beta_{1t},$$

where the cointegrating vector must be such that W_t is I(0). Here, the right-hand-side variables are integrated of order 1. In this case one is testing whether the variables in the

It is also worth noting that the cointegration results presented above do not appear to be particularly sensitive to the specification chosen. As an illustration, column 5 of Table 8, presents the results of a test for cointegration where the dependent variable is output *per feddan* of cultivated land, and where the dependent variables are now the agricultural capital stock per feddan, the agricultural population per feddan, and the intensity of cultivation (the ratio of cropped to cultivated land: this ratio is greater than one because of multiple cropping), as well as the variables describing the distribution of landownership. As was the case with the aggregate variables, the null of no cointegration is strongly rejected by the data.

A Theorem by Stock (1987) states that the estimates presented in Table 8 are consistent estimators since the (potential) endogeneity problems are of second order. More importantly from our perspective, however, is that Granger and Engle (1987) show that if a set of variables is cointegrated then there is an error correction model that can explain the variations in one of the variables in terms of a distributed lag of itself and the other variables' first differences as well as the lag of the error obtained from the corresponding cointegration equation. The error from the cointegration equation is the difference between the value of the left-hand-side variable and its long-run value as predicted by the long run

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equation above are CI(1,1). Here, I find that the null of no-cointegration is strongly rejected in all cases, including those cases where summary measures of inequality are used in place of the Lorenz curve representation. A similar result holds when one tests the equation in *levels* for cointegration of order CI(2,1), that is, that the residuals Z_t are I(1). These results are not reported but are available from the author upon request.

cointegration equation. Since the error is stationary, it must be eliminated in the long run and so in each period the value of at least one of the cointegrated variable must be adjusted in proportion to the error. This means that the coefficient of the cointegration error in the error correction model should be negative.

Table 9 presents the results of several error correction models. The present discussion is based on columns 1,2, 3, 4 and 5. As is predicted by the theory, the coefficient on the cointegration error term is negative and significant. Of greatest interest here are the coefficients on the variables describing the distribution of landownership. In column 1 (Table 9), for example, the coefficients on the growth rate of a_{1t} lagged one and two periods are negative and significant. Thus, an increase in the degree of inequality represented by a positive growth rate of a_{1t} leads to a negative short-run impact on the growth rate of agricultural output. The absence of long run effects, as shown in the cointegrating regressions, may, as argued earlier, stem from differences in the structure of costs in the long-run and in the short-run: in the long-run, returns to scale may be roughly constant, implying the absence of any discernible long-run effects in the cointegration regressions. In the short-run, returns to scale are likely to be decreasing (average costs are increasing) which translates into the strong short-term effects pinpointed by the error correction representation. Column 2 drops the insignificant capital stock terms: the results do not change noticeably. Columns 3, 4 and 5 present models where the specification becomes more and more parsimonious: it is worth noting that the coefficient on the degree of inequality of the Lorenz curve (particularly

when it is lagged two periods) remains consistently negative and significant.

The time series evidence presented above suggests that: (i) aggregate agricultural output, factor inputs, and the distribution of landownership are cointegrated, as is predicted by the theoretical model; (ii) that long run effects of changes in the shape of the distribution of landownership are extremely weak, implying that returns to scale in the long-run are roughly constant, but that (iii) short-run effects are strong and are consistent with the conclusions of the theoretical model when returns to scale are decreasing in the short run. While the preceding results establish a strong link between the distribution of landownership and aggregate agricultural output in the short-run, they neither confirm nor disprove the mechanism —the market for short-term working capital and the probability of bankruptcy— which has been posited in the theoretical part of this paper. We now turn to additional empirical evidence which, I believe, provides support in favor of my working-capital-based explanation for the link between the distribution of landownership and aggregate agricultural output.

Additional evidence on the role of agricultural credit and expropriation

Although the evidence is limited to a relatively brief time-span, it is worth considering additional tests of the credit-based explanation for the impact of the distribution of landownership sketched in the first part of this paper. The data consists of series stemming from the operation of the Crédit Agricole d'Égypte and the Crédit Agricole et Coopératif, S.A.E

(henceforth these two institutions will be referred to as the C.A.É.). For the years 1933 to 1958, we have the magnitude, in Egyptian pounds, of short-term production loans granted by the C.A.É. This is plotted in Figure 15. Figure 16 plots the average size of short-term production loans granted by the C.A.É. Founded in August 1931, the mission of the C.A.É. was to provide short-term production loans, to be used for the purchase of factor inputs such as fertilizer, seeds, and other cultivation costs. A large proportion of these loans was defined as "advances on agricultural output." These data therefore correspond quite nicely to the theoretical model sketched in part I, especially since the clientele aimed at by the C.A.É. was essentially small holders.[74] Despite this raison d'être, it is clear from the available evidence that the C.A.É. was in part co-opted by wealthy landowners and failed to address fully the credit needs of the small-holders who would have been severely credit-constrained.

The other series of interest here, which comes from the *Annuaire Statistique* and begins in the year 1930, relates to the value and area of land expropriated because of unpaid debts. These two series are plotted in Figures 17 and 18, respectively. There are two tests we have in mind in light of the available information on agricultural credit and expropriation. The first consists in adding either credit or the area expropriated to the cointegration equations tested above and testing for cointegration of this expanded set of variables. The second, more "structural", test consists in

[74] Data exist on expropriations (both area in feddans and value of property seized) by the Agricultural Bank of Egypt for the years 1911-1933 (the earliest data appear in the *Annuaire Statistique* of 1914). Since we do not have data on the magnitude or average size of the short-term production loans granted by this bank, we have prefered to concentrate on the C.A.É. and the years 1933 to 1958. Note that the Agricultural Bank of Egypt was liquidated in 1934, leaving the C.A.É. as the main *official* source of short-term working capital.

examining whether the area expropriated because of bankruptcy is cointegrated with the average size of short-term loans provided by the C.A.É., and seeing whether the correlation between these variables reflects the credit-based theoretical explanation sketched above.

Table 7 gives the results of augmented Dickey-Fuller tests on the order of integration of these variables: in what follows, we will assume that they are I(2). Column 6 in table 8 presents the results from a test of cointegration among aggregate agricultural output, the average size of loans granted by the C.A.É., the variables describing the distribution of landownership, and factor inputs. Column 7 of the same Table presents a similar test of cointegration where we replace the credit variable by the area in feddans expropriated because of bankruptcy. In both cases the null hypothesis of no cointegration is strongly rejected suggesting that indeed there exists a long-run equilibrium relationship among these variables. For the case of the cointegration equation with the expropriated area, column 6 of Table 10 presents the corresponding short-run error correction representation. Note that: (i) the coefficient on the error correction terms continues to be negative and significant, (ii) that the coefficient on the degree of inequality of the Lorenz curve lagged two periods continues to be negative and highly significant, as does (iii) the coefficient on the expropriated area lagged two periods.

The last two columns of Table 8 (Columns 8 and 9) provide strong support of our hypothesis that the link between the distribution of landownership and agricultural output is effected through the market for short-term agricultural credit. Here, the dependent variable in the

cointegration equation is the area expropriated because of bankruptcy. If our credit-based model is correct, an increase in the average size of loans extended by the C.A.É., indicating a shift away from lending to severely credit-constrained small holders in the lower tail of the distribution of landownership, should increase the expropriated area as small holders lose an "official" source of credit and are forced to turn towards the informal market. This is indeed what we find: in column 8, the coefficient on the average size of loans is positive and significant. The null hypothesis of no cointegration is strongly rejected (at the 0.1% level of significance). This result carries over even in column 9, where we drop the factor inputs as well as the variables describing the distribution of landownership.

In summary, the additional evidence presented in this section, though confined to a reduced sample period (1933 to 1958), provides strong support in favor of the view that: (i) agricultural output, factor inputs, the distribution of landownership and credit/expropriation are cointegrated, (ii) the expropriated area, the average size of loans granted by the C.A.É., factor inputs, and the distribution of landownership are cointegrated, and most importantly, that (iii) severely credit-constrained small landowners were excluded from C.A.É. when the average size of its short-run production loans was increased, leading to an increase in the area of land expropriated because of bankruptcy. Though we have no means of checking whether it was indeed the small holders who suffered the greatest increase in bankruptcy, this would seem to be a reasonable conjecture.

IV. CONCLUDING REMARKS

This paper may be viewed within the wider context of the literature on the relationships between distributional issues and growth. The study of how income distribution evolves during the course of development, and of how growth is affected by changes in the distribution of income is a traditional topic in development economics.[75] Empirical work has been hampered by the lack of adequate time-series on income distribution for more than a handful of countries, the result being that investigators have relied on cross-sectional studies. If one really wants to get a grasp of the equity versus efficiency issue in the context of the development process, however, one has to look at time-series. If time-series are not available for income distributions, then one should look to the data which are available. In the case of Egypt, this naturally leads to the study of the distribution of landownership, for which data were collected in a systematic manner beginning in 1894. It is probably fair to say that one will not be grossly misled by the distribution of land ownership as a rough indicator of equity in agricultural sector, at least for the sample period that has been considered.

This paper has explored one channel —the informal credit market— through which the distribution of land ownership affects aggregate agricultural output. A simple theoretical model in which market imperfections played a central role led us to posit that, *ceteris paribus*, aggregate agricultural output would be positively affected by a decrease in the inequality of the distribution of land ownership. Thus, the paper

[75] At least since the seminal work of Kuznets (1955).

certainly makes the case, as does much of the so-called *New Development Economics*, that the purely Walrasian approach is *passé* when it comes to studying the effects changes of the distribution of landownership. Indeed, apart from the demand-composition effect, Walrasian models have little to say on this topic.[76]

The initial empirical results using standard least square and instrumental variable techniques conform to what one would expect in the Egyptian context: cropped land and the capital stock in irrigation and drainage were the two major constraints on growth in the Egyptian agricultural sector during the first half of the century. Moreover, controlling for factor inputs, there appears to be no tradeoff between equity and efficiency for Egyptian agriculture —the opposite is true, although the relationship was found to be weak. The greatest potential efficiency gains from improvements in the equality of the distribution of land ownership appear to be concentrated in the lowest reaches of the distribution of land ownership, among peasants who own less than one feddan. These peasants are indeed those most likely to be credit constrained.

The time series evidence, on the other hand, established that an important distinction must be drawn between the short and the long-run. As is predicted by the theoretical model in the case of constant long-run returns to scale and decreasing short-run returns to scale, the long-run evidence reveals little if any correlation between the degree of inequality of

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[76] See Eckaus (1970) and Stiglitz (1988) for general arguments on this point. On the demand-composition problem see Baland and Ray (1991).

the distribution of landownership and output, while the short-run error correction representation shows a strong relationship. Indeed, in the short run, we can safely posit that equality and efficiency went together in Egypt for the years 1913 to 1958.

There are perhaps two morals to be drawn from the paper. First, the empirical work, particularly using time series techniques, shows that the distribution of land ownership *matters*.[77] Second, the theoretical work suggests *one possible* mechanism —the need for short-term credit in the presence of a non-zero probability of bankruptcy and distortions in factor markets— by which the distribution of land ownership affects aggregate agricultural output: there may be others. That is, the estimated correlations between aggregate output and the shape of the distribution of land ownership could arise from many other structural models, although I have tried to make a case for an explanation based on the workings of the market for short-term credit.[78] The additional empirical evidence presented (although admittedly for relatively short time spans) on the relationship among agricultural credit, expropriation and the distribution of landownership lends a good deal of credence to the working capital based explanation that I have espoused. What is not open to dispute,

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[77] In a study of the agrarian reforms (1952, 1958, 1961, 1964), Askari, Cummings and Harik (1977) estimate the price-elasticity of supply for several Egyptian field crops before and after the reform and find that price elasticity increased for wheat and onions, but decreased for rice and cotton.

[78] In particular, it has been suggested to me that, since the distribution of land ownership variables are trending, the observed correlation could be coming from technological change. My response to this suggestion, however, is that if there is one country in the world and one time-period during which technology was essentially unchanged, it was Egypt during the first half of this century. When substantial technological innovations did come, they came in the form of "Green Revolution" seed varieties, and this in the sixties —outside the sample period considered in this paper.

however, is that equity and efficiency went hand in hand in the short-run in Egyptian agriculture during the first half of this century.

This paper has studied the effects of small changes in the shape of the distribution of landownership, but the results clearly say something about the economic effects of agrarian reforms. This is particularly interesting in the case of post-revolutionary Egypt because of the political importance attached to agrarian reform by the Free Officers: within six weeks of coming to power in 1952, they promulgated the first of several land reform laws; more would follow in 1958, 1961 and 1964.[79] The *prima facie* reason for the law was the political emasculation of the big landowners (including king Farouk). It was also widely believed that land reform would improve the economic efficiency of Egyptian agriculture, though why this was thought at the time is not at all clear.[80] Most of all, the law was popular: if political expediency and economic efficiency went hand-in-hand, so much the better. But the big question remains: can LDC governments equalize the distribution of land ownership without foregoing output and growth in the agricultural sector?[81] The results presented in this paper suggest that, at least in the Egyptian case, equity could be

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[79] On the economic effects of land reform, see Berry (1971), Gersovitz (1976) and Rosensweig (1978); also see the discussion in the survey by Adelman and Robinson (1989) and the references cited therein. On the Egyptian agrarian reforms in particular, see Marei (1957), Saab (1967), Warriner (1962, 1969, 1970), Eshag and Kamal (1968), and especially Radwan (1977). Other references include Long (1969), Abdel-Fadil (1975), and Askari, Cummings and Toth (1977, 1978).

[80] In proposing the Agrarian Reform Law, Mohamed Naguib proclaimed that it would "narrow the wide gap among classes, raise the standard of living of the fellah and divert capital to investment in industry." (*Al-Misry*, 11 August 1952).

[81] In his well-known survey, Reynolds (1985, p. 55) writes that land "...reforms are generally judged to have made a substantial contribution to the subsequent rise in agricultural output."

improved without sacrificing efficiency in the long run. Indeed, in the short-run, increasing equity had a strong positive impact on efficiency.

APPENDIX

PROOF OF PROPOSITION 1.

Assume, as is usual, that the two integral conditions hold:

$$\int_0^{+\infty} F_\rho(H^e,\rho)dH^e = 0;$$

$$\int_0^y F_\rho(H^e,\rho)dH^e \geq 0,\ \forall y \in [0,+\infty).$$

Then the effect of a mean-preserving spread in the distribution of land on aggregate output can be expressed as

$$\frac{dQ}{d\rho} = \frac{d}{d\rho}\left(\int_0^{h^*}\left(q^c(H^e)-q^*\right)f(H^e,\rho)dH^e + q^*\right) = \int_0^{h^*}\left(q^c(H^e)-q^*\right)f_\rho(H^e,\rho)dH^e$$

Integrating by parts yields

$$\frac{dQ}{d\rho} = \left[\left(q^c(H^e)-q^*\right)F_\rho(H^e,\rho)\right]_0^{h^*} - \int_0^{h^*}\frac{\partial\left(q^c(H^e)-q^*\right)}{\partial H^e}F_\rho(H^e,\rho)dH^e.$$

The first term on the R. H. S. of this expression vanishes by the usual arguments. Integrating by parts again yields

$$\frac{dQ}{d\rho} = -\left[\frac{\partial\left(q^c(H^e)-q^*\right)}{\partial H^e}\int_0^{h^*}F_\rho(u,\rho)du\right]_0^{h^*} + \int_0^{h^*}\left(\frac{\partial^2 q^c(H^e)}{\partial H^{e2}}\int_0^{h^*}F_\rho(u,\rho)du\right)dH^e.$$

The sign of $dQ/d\rho$ therefore depends upon the properties of the first and second derivatives of $q^c(H^e)$. As can be seen, if q^c is increasing and concave in H^e, then $dQ/d\rho < 0$. This will be true when returns to scale are decreasing and fixed costs F are not too large, as was shown in the main body of the text. Note that the proof shows that there is also a corollary to the proposition, namely that when q^c is decreasing and convex in H^e, a mean-preserving increase (decrease) in the inequality of the distribution of land increases (decreases) aggregate agricultural output. By a continuity

argument, and if q^c is everywhere increasing and concave in H^e, agricultural output will be maximized when the distribution $f(H^e)$ becomes a Dirac-δ function with all the mass concentrated at μ_h, that is, when the distribution of land ownership is perfectly equal.

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Figure 1
The Market for Short-term Credit

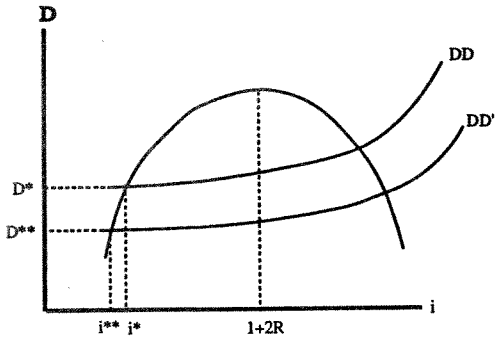


Figure 2
Credit Availability and Output

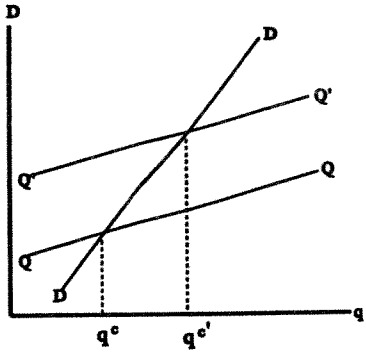


Figure 3
Types of Peasants Based on their Land Ownership

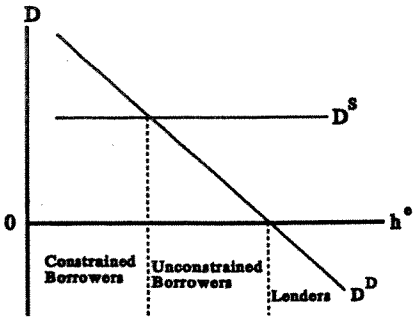


Figure 4
The Lorenz Curve

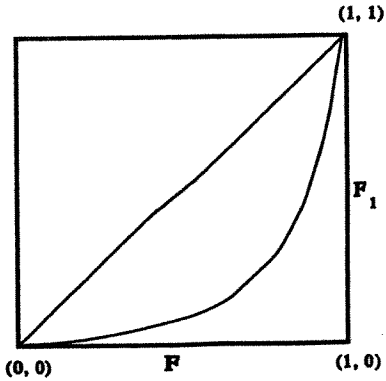
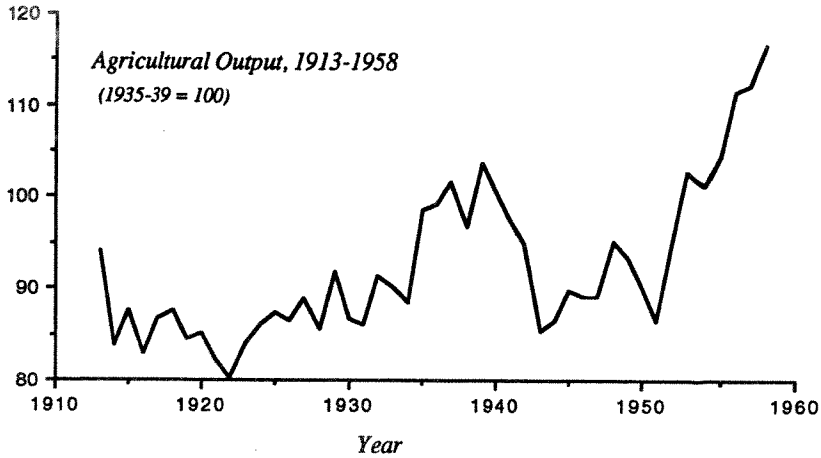
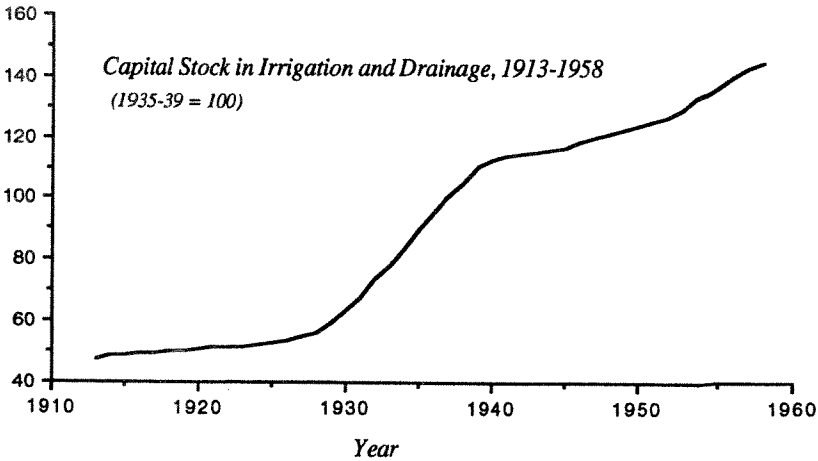


Figure 5



Source: Table 1.

Figure 6



Source: Table 1.

Figure 7

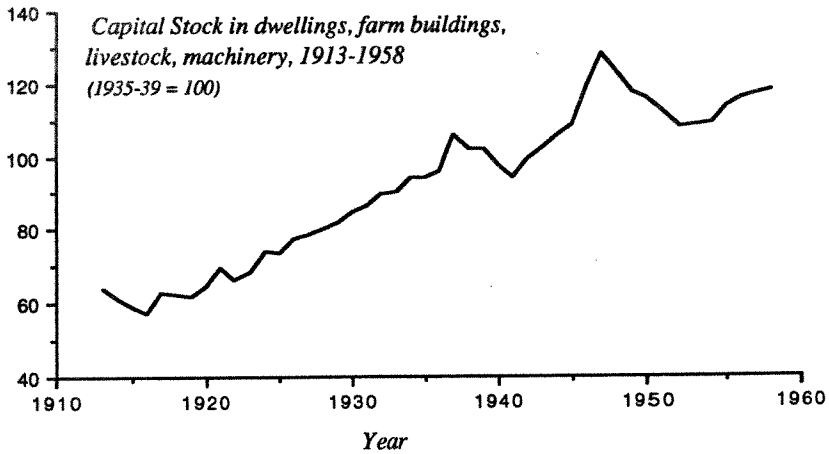


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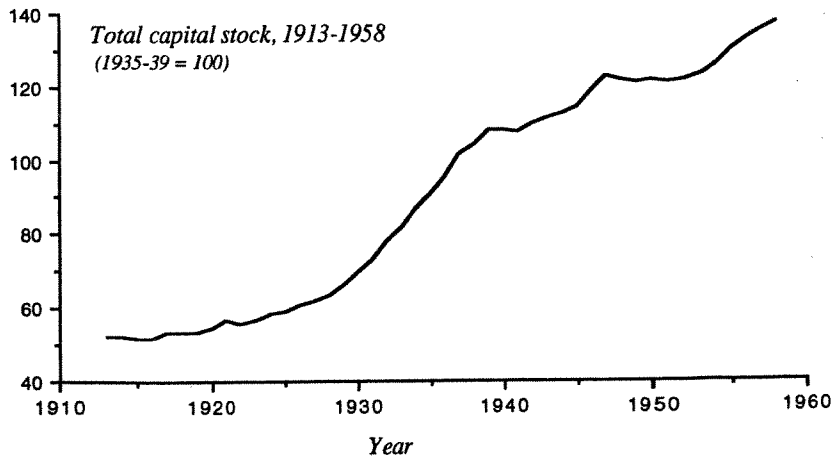
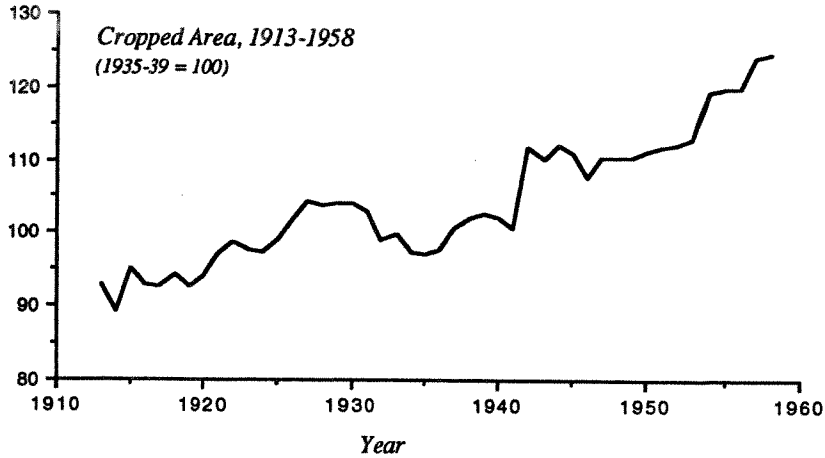
Figure 8



Source: Table 1.

Figure 9



Source: Table 1.

Figure 10

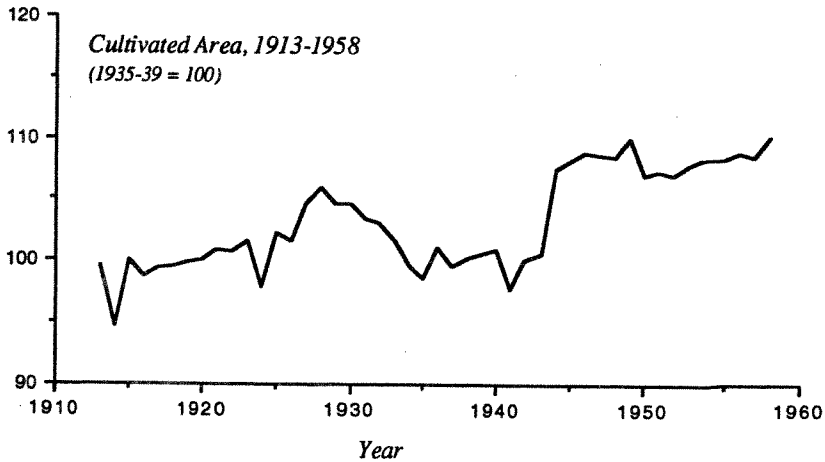


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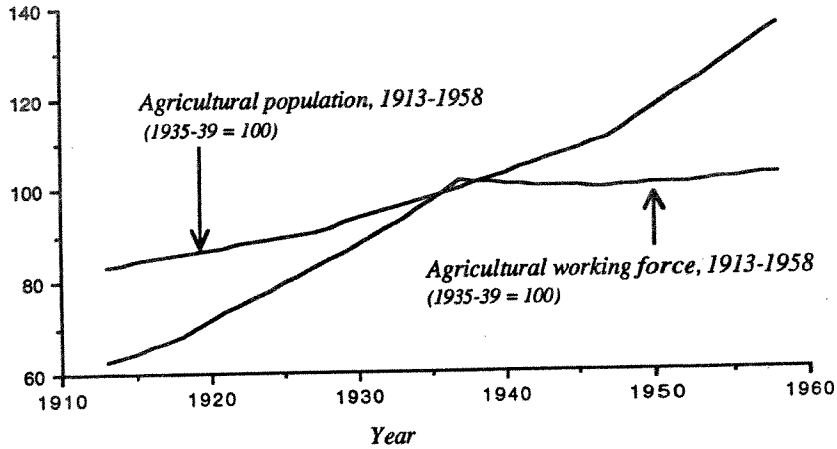
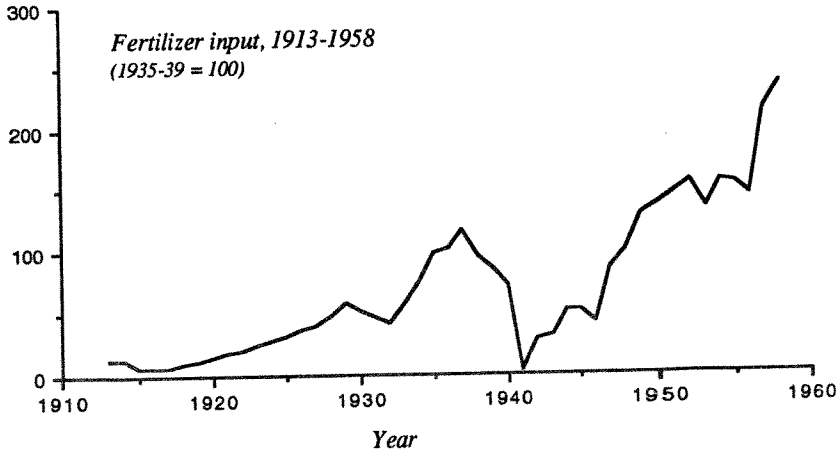
Figure 11



Source: Table 1.

Figure 12



Source: Table 1.

Figure 13
Lorenz Curves for Land Ownership
Kakwani Coordinate System, 1913 and 1938

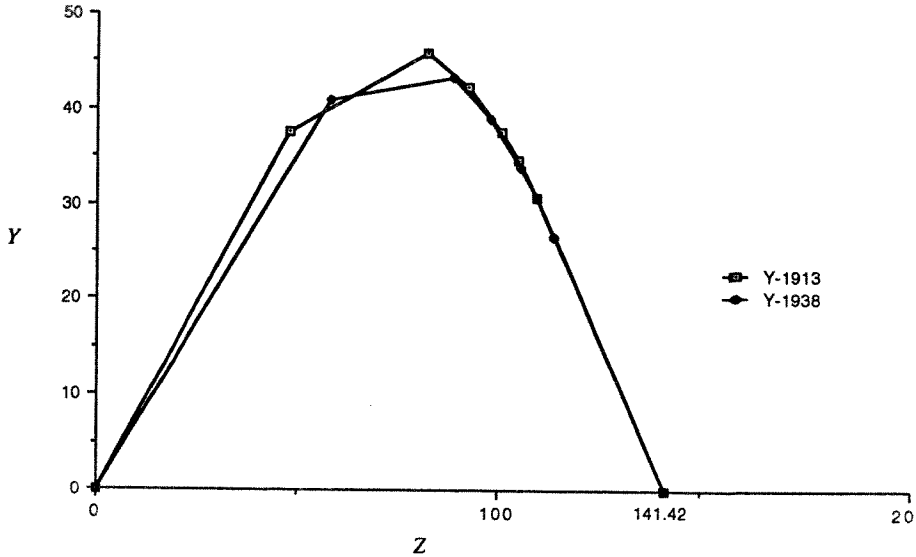


Figure 14
Lorenz Curves for Land Ownership,
Kakwani Coordinate System, 1946, 1956 and 1958

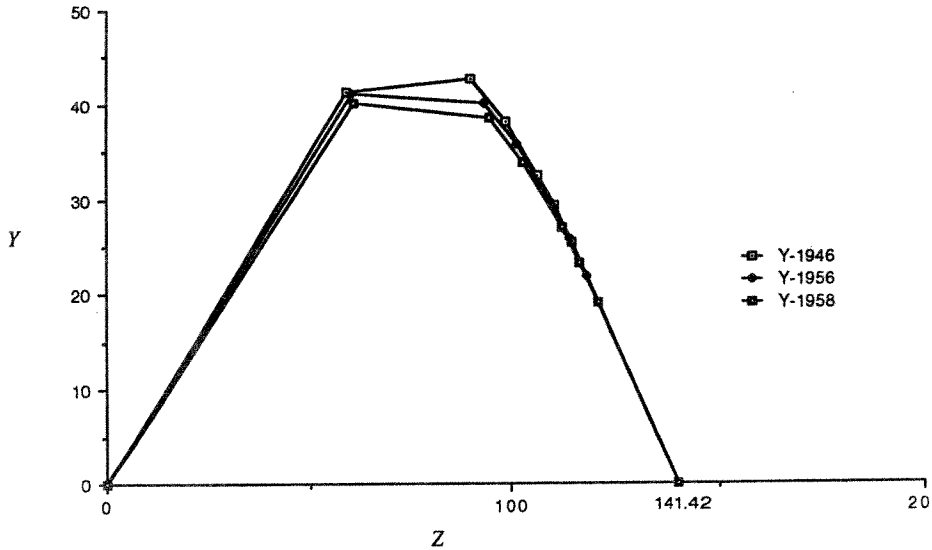


Figure 15
Crédit Agricole d'Égypte and Crédit Agricole et Coopératif, S.A.E.
Aggregate value of loan (short-term agricultural credit): 1932-1958

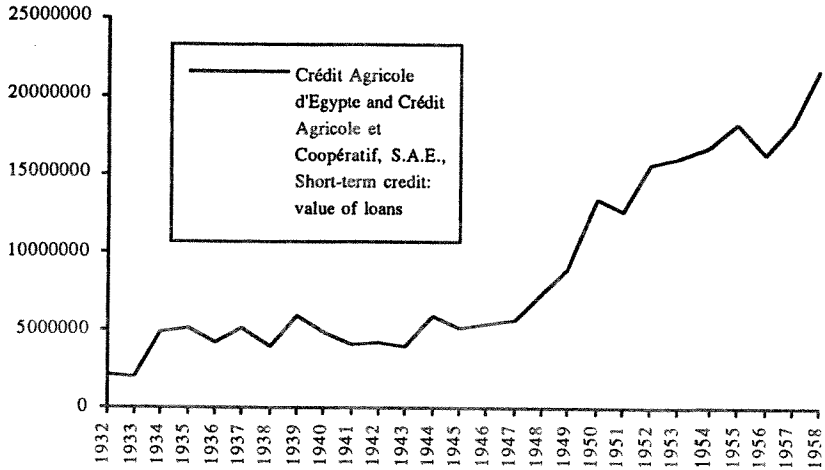


Figure 16
Crédit Agricole d'Égypte and Crédit Agricole et Coopératif, S.A.E.
Average value of loans (short-term agricultural credit): 1932-1958

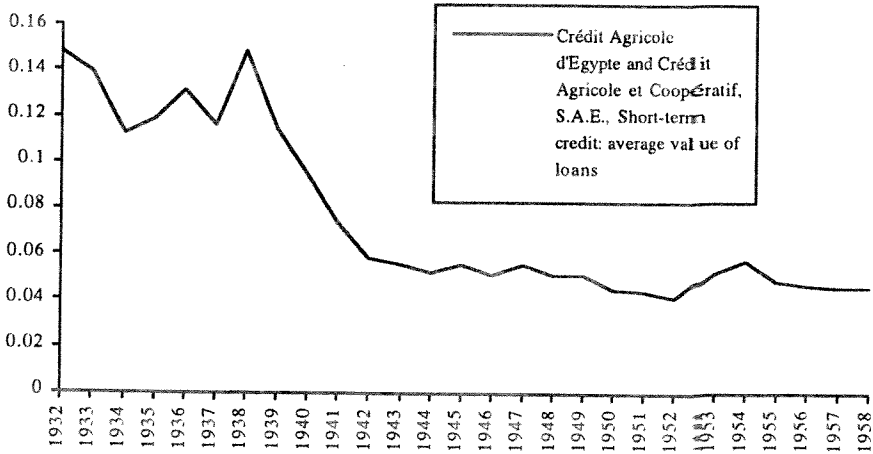


Figure 17
Value of land and buildings expropriated because of bankruptcy (in Egyptian pounds)

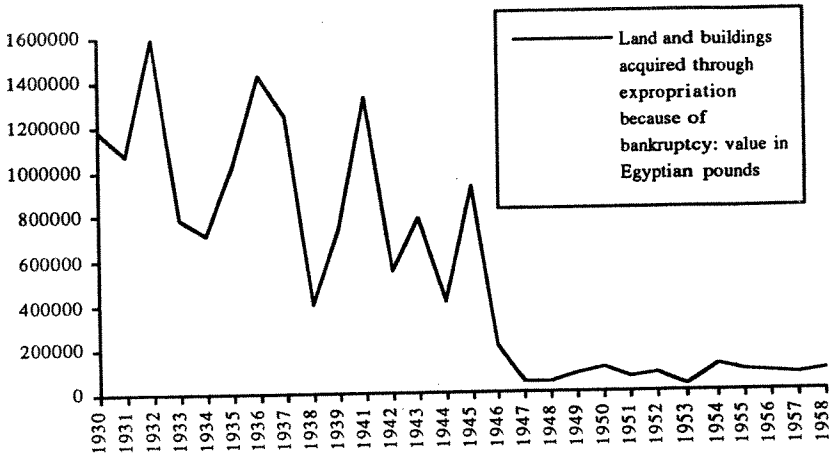


Figure 18
Area of land expropriated because of bankruptcy (in feddans)

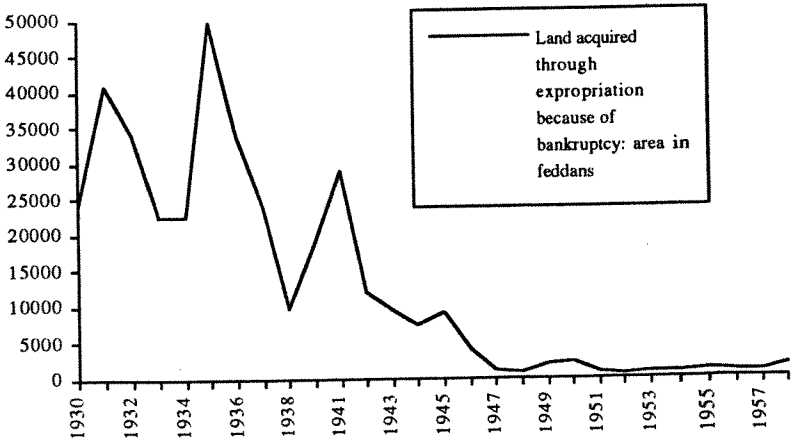


Table 1. Agricultural Indices, 1913-1958 (1935-39 = 100)

Year	Output	Capital Stock (Irrigation & Drainage)	Capital Stock (Other)	Capital Stock (Total)	Cropped Area	Cultivated Area	Agri-cultural Popu-lation	Agri-cultural Working Force	Fertilizer Input
1913	94.0	47.5	63.9	52.3	92.9	99.6	83.4	62.7	12.8
1914	83.9	48.5	61.3	52.2	89.2	94.7	83.9	63.7	13.0
1915	87.5	48.8	58.8	51.7	95.1	100.1	84.4	64.6	6.6
1916	82.8	49.1	57.1	51.5	92.9	98.6	84.9	65.6	6.6
1917	86.8	49.4	62.7	53.3	92.5	99.3	85.3	66.6	6.6
1918	87.5	49.8	62.2	53.5	94.2	99.6	85.9	68.3	9.4
1919	84.5	50.0	61.9	53.5	92.7	99.9	86.4	69.9	12.3
1920	85.2	50.6	64.6	54.8	94.0	100.0	86.9	71.6	15.2
1921	82.3	51.1	69.4	56.5	97.1	100.9	87.4	73.2	18.1
1922	80.3	51.4	66.3	55.8	98.8	100.7	87.9	74.9	20.9
1923	84.1	51.7	68.7	56.7	97.6	101.6	88.5	76.5	24.7
1924	86.1	52.2	74.1	58.7	97.2	97.9	89.0	78.0	28.5
1925	87.4	52.8	73.5	58.9	98.9	102.2	89.5	79.6	32.3
1926	86.4	53.4	77.5	60.5	101.9	101.5	90.0	81.2	36.1
1927	89.0	54.6	78.3	61.6	104.3	104.5	90.6	82.7	39.9
1928	85.6	56.3	80.2	63.3	103.9	105.9	91.5	84.4	48.8
1929	91.8	59.5	81.7	66.0	104.0	104.6	92.4	86.1	58.2
1930	86.8	63.2	85.0	69.6	104.0	104.6	93.4	87.7	52.7
1931	86.0	67.6	86.6	73.2	103.0	103.4	94.3	89.4	47.2
1932	91.5	73.3	89.7	78.1	99.0	103.0	95.2	91.1	41.7
1933	90.1	78.2	90.2	81.7	99.8	101.5	96.2	93.1	58.3
1934	88.5	83.8	94.3	86.9	97.3	99.5	97.1	95.2	74.9
1935	98.6	89.6	94.4	91.0	97.0	98.6	98.1	97.2	99.7
1936	99.2	94.8	95.7	95.0	97.6	101.1	99.0	99.3	102.4
1937	101.6	100.0	105.7	101.7	100.7	99.6	99.9	101.4	117.1
1938	96.8	105.2	102.2	104.3	102.1	100.1	101.0	101.2	94.7
1939	103.7	110.5	101.9	108.0	102.7	100.6	102.0	101.0	86.1
1940	100.5	112.6	97.4	108.1	102.1	100.9	103.1	100.8	71.9
1941	97.8	113.6	94.2	107.9	100.6	97.8	104.2	100.6	3.9
1942	94.9	114.2	99.2	109.8	111.7	100.1	105.2	100.4	28.6
1943	85.4	115.1	102.5	111.4	110.1	100.5	106.3	100.3	31.2
1944	86.5	115.8	105.7	112.8	112.2	107.4	107.4	100.2	52.7
1945	89.9	116.4	108.6	114.1	111.1	108.0	108.4	100.1	51.8
1946	89.2	118.1	119.5	118.6	107.8	108.8	109.5	100.0	41.9
1947	89.1	120.1	128.3	122.5	110.4	108.6	110.5	99.9	86.1
1948	95.1	121.3	122.7	121.7	110.4	108.5	112.8	100.1	100.6
1949	93.4	122.6	117.4	121.0	110.4	110.0	115.1	100.3	129.0
1950	90.0	123.9	116.2	121.6	111.2	106.9	117.4	100.5	138.2
1951	86.6	125.1	111.8	121.2	111.7	107.2	119.7	100.7	147.3
1952	94.3	126.8	108.3	121.3	112.1	106.9	122.0	100.9	155.4
1953	102.8	129.3	108.6	123.2	113.0	107.7	124.3	101.2	134.7
1954	101.1	133.0	109.5	126.0	119.4	108.3	126.5	101.4	155.6
1955	104.6	136.8	113.9	130.0	120.0	108.3	128.8	101.7	153.7
1956	111.4	140.1	115.7	132.9	120.0	108.8	131.1	102.0	143.4
1957	112.3	142.5	117.2	135.0	124.2	108.5	133.4	102.3	212.4
1958	116.6	144.8	118.5	137.0	124.7	110.2	135.7	102.6	235.5

Source: see text.

Table 2. Summary Measures of Inequality: 1913-1958

Year	Kakwani Coefficient of Inequality	Gini Coefficient
1913	0.5216	0.7805
1914	0.5196	0.7787
1915	0.5195	0.7781
1916	0.5197	0.7783
1917	0.5203	0.7780
1918	0.5171	0.7752
1919	0.5137	0.7717
1920	0.5168	0.7744
1921	0.5139	0.7714
1922	0.5120	0.7701
1923	0.5122	0.7697
1924	0.5138	0.7709
1925	0.5344	0.7620
1926	0.5121	0.7683
1927	0.5142	0.7701
1928	0.5132	0.7694
1929	0.5179	0.7728
1930	0.5167	0.7715
1931	0.5146	0.7705
1932	0.5102	0.7654
1933	0.5118	0.7665
1934	0.5124	0.7663
1935	0.5053	0.7597
1936	0.5029	0.7568
1937	0.4970	0.7514
1938	0.4977	0.7523
1939	0.4998	0.7544
1940	0.4967	0.7510
1941	0.4950	0.7496
1942	0.4945	0.7472
1943	0.4905	0.7461
1944	0.4906	0.7450
1945	0.4905	0.7454
1946	0.4934	0.7476
1947	0.4928	0.7458
1948	0.4882	0.7412
1949	0.4817	0.7408
1950	0.4852	0.7413
1951	0.4848	0.7408
1952	0.4871	0.7429
1953	0.4861	0.7421
1954	0.4879	0.7431
1955	0.4843	0.7388
1956	0.4705	0.7289
1957	0.4681	0.7199
1958	0.4484	0.7099

Table 3. Estimated Lorenz Curve Parameters: Method 1

	Coefficients				Standard Errors			
Year	a'	a	alpha	beta	SE-a'	SE-alpha	SE-beta	R-Square
1913	-0.3421	0.7103	0.9952	0.6499	-0.0234	0.0025	0.0525	0.999
1914	-0.3460	0.7075	0.9950	0.6500	-0.0236	0.0026	0.0526	0.999
1915	-0.3485	0.7057	0.9949	0.6481	-0.0239	0.0026	0.0531	0.999
1916	-0.3486	0.7057	0.9949	0.6507	-0.0243	0.0026	0.0536	0.999
1917	-0.3517	0.7035	0.9947	0.6464	-0.0246	0.0026	0.0544	0.999
1918	-0.3574	0.6995	0.9945	0.6490	-0.0253	0.0027	0.0549	0.999
1919	-0.3654	0.6939	0.9941	0.6495	-0.0260	0.0028	0.0557	0.999
1920	-0.3585	0.6987	0.9947	0.6606	-0.0265	0.0028	0.0563	0.999
1921	-0.3638	0.6950	0.9943	0.6578	-0.0266	0.0028	0.0559	0.999
1922	-0.3686	0.6917	0.9941	0.6557	-0.0268	0.0028	0.0563	0.999
1923	-0.3712	0.6899	0.9939	0.6533	-0.0272	0.0029	0.0568	0.999
1924	-0.3691	0.6914	0.9941	0.6582	-0.0277	0.0029	0.0570	0.999
1925	-0.3739	0.6880	0.9945	0.6867	-0.0290	0.0030	0.0545	0.999
1926	-0.3759	0.6867	0.9936	0.6526	-0.0280	0.0029	0.0576	0.999
1927	-0.3717	0.6896	0.9939	0.6553	-0.0279	0.0029	0.0577	0.999
1928	-0.3766	0.6862	0.9934	0.6446	-0.0278	0.0029	0.0581	0.999
1929	-0.3689	0.6915	0.9940	0.6522	-0.0282	0.0029	0.0578	0.999
1930	-0.3709	0.6901	0.9939	0.6532	-0.0285	0.0030	0.0577	0.999
1931	-0.3722	0.6892	0.9939	0.6570	-0.0287	0.0030	0.0574	0.999
1932	-0.3883	0.6782	0.9928	0.6404	-0.0289	0.0030	0.0588	0.999
1933	-0.3849	0.6805	0.9930	0.6449	-0.0291	0.0030	0.0585	0.999
1934	-0.3866	0.6794	0.9929	0.6413	-0.0292	0.0030	0.0591	0.999
1935	-0.4021	0.6689	0.9918	0.6305	-0.0295	0.0030	0.0594	0.999
1936	-0.4098	0.6638	0.9913	0.6253	-0.0297	0.0031	0.0599	0.999
1937	-0.4211	0.6563	0.9907	0.6223	-0.0300	0.0031	0.0595	0.999
1938	-0.4183	0.6582	0.9909	0.6269	-0.0302	0.0031	0.0599	0.999
1939	-0.4116	0.6626	0.9916	0.6400	-0.0308	0.0032	0.0596	0.999
1940	-0.4207	0.6566	0.9910	0.6330	-0.0309	0.0032	0.0604	0.999
1941	-0.4235	0.6548	0.9908	0.6329	-0.0310	0.0032	0.0602	0.999
1942	-0.4265	0.6528	0.9907	0.6352	-0.0310	0.0032	0.0595	0.999
1943	-0.4293	0.6510	0.9905	0.6339	-0.0308	0.0032	0.0593	0.999
1944	-0.4302	0.6504	0.9904	0.6323	-0.0309	0.0032	0.0591	0.999
1945	-0.4320	0.6492	0.9904	0.6324	-0.0312	0.0032	0.0598	0.999
1946	-0.4271	0.6524	0.9907	0.6369	-0.0316	0.0032	0.0603	0.999
1947	-0.4341	0.6478	0.9901	0.6248	-0.0318	0.0032	0.0611	0.999
1948	-0.4434	0.6419	0.9896	0.6250	-0.0325	0.0033	0.0618	0.999
1949	-0.4391	0.6446	0.9903	0.6475	-0.0326	0.0033	0.0603	0.999
1950	-0.4327	0.6488	0.9909	0.6576	-0.0330	0.0034	0.0602	0.999
1951	-0.4335	0.6482	0.9909	0.6588	-0.0332	0.0034	0.0603	0.999
1952	-0.4287	0.6514	0.9912	0.6624	-0.0333	0.0034	0.0601	0.999
1953	-0.4300	0.6505	0.9911	0.6610	-0.0331	0.0034	0.0599	0.999
1954	-0.4290	0.6512	0.9912	0.6620	-0.0335	0.0034	0.0608	0.999
1955	-0.4339	0.6480	0.9910	0.6651	-0.0337	0.0034	0.0598	0.999
1956	-0.4494	0.6380	0.9905	0.6783	-0.0347	0.0035	0.0587	0.999
1957	-0.4321	0.6491	0.9780	0.0950	-0.0387	0.0059	0.2637	0.996
1958	-0.3119	0.7321	1.0000	0.8327	-0.1650	0.0128	0.2051	0.987

Table 4. Estimated Lorenz Curve Parameters for Owners of More than One Feddan. Method 2

Year	Coefficients				Standard Errors			R-Square
	a'	a	alpha	beta	SE-a'	SE-alpha	SE-beta	
1913	0.2293	1.2577	1.522	1.353	0.0077	0.0108	0.0085	0.999
1914	0.2250	1.2523	1.521	1.349	0.0075	0.0105	0.0082	0.999
1915	0.2301	1.2587	1.530	1.355	0.0058	0.0083	0.0064	0.999
1916	0.2295	1.2580	1.529	1.355	0.0060	0.0085	0.0065	0.999
1917	0.2400	1.2712	1.546	1.365	0.0047	0.0068	0.0051	0.999
1918	0.2331	1.2625	1.543	1.360	0.0047	0.0069	0.0051	0.999
1919	0.2303	1.2590	1.548	1.359	0.0048	0.0072	0.0052	0.999
1920	0.2304	1.2591	1.536	1.361	0.0067	0.0100	0.0071	0.999
1921	0.2193	1.2452	1.529	1.348	0.0058	0.0088	0.0062	0.999
1922	0.2220	1.2486	1.539	1.353	0.0065	0.0099	0.0069	0.999
1923	0.2240	1.2511	1.543	1.354	0.0065	0.0100	0.0069	0.999
1924	0.2240	1.2511	1.537	1.353	0.0073	0.0114	0.0077	0.999
1925	0.1508	1.1628	1.436	1.288	0.0065	0.0103	0.0067	0.999
1926	0.2258	1.2533	1.549	1.355	0.0086	0.0135	0.0090	0.999
1927	0.2281	1.2562	1.546	1.356	0.0088	0.0138	0.0093	0.999
1928	0.2393	1.2704	1.569	1.369	0.0081	0.0128	0.0086	0.999
1929	0.2364	1.2667	1.551	1.363	0.0080	0.0126	0.0085	0.999
1930	0.2282	1.2563	1.541	1.354	0.0066	0.0105	0.0070	0.999
1931	0.2209	1.2472	1.532	1.348	0.0060	0.0095	0.0063	0.999
1932	0.2394	1.2705	1.582	1.369	0.0090	0.0145	0.0094	0.999
1933	0.2336	1.2631	1.566	1.362	0.0083	0.0134	0.0087	0.999
1934	0.2399	1.2711	1.578	1.367	0.0089	0.0145	0.0093	0.999
1935	0.2363	1.2666	1.595	1.366	0.0087	0.0144	0.0091	0.999
1936	0.2429	1.2749	1.616	1.374	0.0103	0.0170	0.0107	0.999
1937	0.2361	1.2663	1.622	1.369	0.0102	0.0170	0.0106	0.999
1938	0.2292	1.2576	1.606	1.363	0.0108	0.0180	0.0111	0.999
1939	0.2165	1.2417	1.574	1.349	0.0105	0.0176	0.0108	0.999
1940	0.2215	1.2479	1.590	1.356	0.0120	0.0203	0.0123	0.999
1941	0.2174	1.2428	1.594	1.352	0.0119	0.0202	0.0122	0.999
1942	0.2079	1.2311	1.585	1.344	0.0103	0.0176	0.0106	0.999
1943	0.2162	1.2414	1.604	1.352	0.0129	0.0218	0.0132	0.999
1944	0.2102	1.2339	1.597	1.344	0.0117	0.0198	0.0119	0.999
1945	-0.0290	0.9714	0.965	-0.149	0.0763	0.0885	2.8113	0.999
1946	0.2160	1.2411	1.594	1.351	0.0142	0.0244	0.0145	0.999
1947	0.2220	1.2486	1.611	1.356	0.0131	0.0229	0.0134	0.999
1948	0.2091	1.2326	1.601	1.346	0.0132	0.0235	0.0135	0.999
1949	0.1867	1.2053	1.561	1.334	0.0117	0.0205	0.0118	0.999
1950	0.1655	1.1800	1.519	1.306	0.0132	0.0232	0.0132	0.999
1951	0.1632	1.1773	1.515	1.304	0.0136	0.0239	0.0135	0.999
1952	0.1610	1.1747	1.503	1.301	0.0130	0.0228	0.0129	0.999
1953	0.1622	1.1761	1.509	1.303	0.0130	0.0228	0.0129	0.999
1954	0.1635	1.1776	1.505	1.303	0.0142	0.0252	0.0142	0.999
1955	0.1438	1.1547	1.484	1.283	0.0140	0.0249	0.0138	0.999
1956	0.1097	1.1159	1.452	1.262	0.0121	0.0218	0.0118	0.999
1957	0.0797	1.0830	1.427	1.242	0.0135	0.0245	0.0129	0.999
1958	0.0526	1.0540	1.409	1.223	0.0138	0.0253	0.0128	0.999

Table 5. Estimated portion of the Lorenz Curve: Owners of Less than One Feddan

Year	p	q	z	y	Length of Segment of Lorenz Curve
1913	0.6056	0.0741	0.4806	0.3758	0.6101
1914	0.6076	0.0757	0.4832	0.3761	0.6123
1915	0.6121	0.0774	0.4875	0.3781	0.6170
1916	0.6191	0.0788	0.4935	0.3821	0.6241
1917	0.6262	0.0813	0.5003	0.3853	0.6315
1918	0.6336	0.0846	0.5079	0.3882	0.6393
1919	0.6425	0.0891	0.5173	0.3913	0.6486
1920	0.6469	0.0876	0.5194	0.3955	0.6529
1921	0.6485	0.0898	0.5220	0.3951	0.6547
1922	0.6512	0.0920	0.5255	0.3954	0.6577
1923	0.6587	0.0946	0.5326	0.3989	0.6655
1924	0.6655	0.0953	0.5380	0.4032	0.6723
1925	0.6682	0.0967	0.5409	0.4041	0.6752
1926	0.6698	0.0987	0.5434	0.4038	0.6770
1927	0.6695	0.0972	0.5422	0.4047	0.6766
1928	0.6716	0.0996	0.5453	0.4045	0.6790
1929	0.6781	0.0983	0.5490	0.4100	0.6852
1930	0.6813	0.0997	0.5522	0.4113	0.6886
1931	0.6819	0.1002	0.5530	0.4114	0.6892
1932	0.6866	0.1072	0.5613	0.4097	0.6949
1933	0.6898	0.1067	0.5632	0.4123	0.6980
1934	0.6925	0.1080	0.5661	0.4133	0.7009
1935	0.6961	0.1145	0.5732	0.4113	0.7055
1936	0.6988	0.1180	0.5775	0.4107	0.7087
1937	0.7012	0.1225	0.5825	0.4092	0.7118
1938	0.7024	0.1218	0.5828	0.4105	0.7128
1939	0.7059	0.1202	0.5842	0.4141	0.7161
1940	0.7073	0.1240	0.5878	0.4124	0.7180
1941	0.7079	0.1251	0.5890	0.4121	0.7188
1942	0.7054	0.1254	0.5875	0.4101	0.7164
1943	0.7010	0.1253	0.5843	0.4071	0.7121
1944	0.7028	0.1261	0.5861	0.4078	0.7140
1945	0.7077	0.1281	0.5910	0.4099	0.7192
1946	0.7123	0.1276	0.5938	0.4134	0.7236
1947	0.7213	0.1326	0.6038	0.4163	0.7334
1948	0.7278	0.1378	0.6121	0.4172	0.7407
1949	0.7161	0.1326	0.6001	0.4126	0.7283
1950	0.7177	0.1308	0.6000	0.4150	0.7295
1951	0.7187	0.1314	0.6011	0.4153	0.7306
1952	0.7203	0.1300	0.6013	0.4174	0.7319
1953	0.7183	0.1299	0.5998	0.4160	0.7299
1954	0.7235	0.1311	0.6043	0.4189	0.7353
1955	0.7223	0.1325	0.6044	0.4170	0.7343
1956	0.7201	0.1373	0.6063	0.4121	0.7331
1957	0.7133	0.1398	0.6032	0.4056	0.7269
1958	0.7149	0.1467	0.6092	0.4018	0.7298

Table 6
Regression Results
Dependent Variable: Aggregate Output

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Capital Stock	0.17 (1.74)	0.005 (.03)	0.058 (.36)	0.35 (2.18)	0.28 (2.13)				
Capital Stock in Irrigation and Drainage (1928-39)						0.31 (3.08)	0.31 (2.93)	0.58 (4.95)	0.66 (3.77)
Capital Stock in Irrigation and Drainage (rest of sample)						0.13 (1.88)	0.13 (1.82)	0.26 (2.79)	0.31 (2.86)
Agricultural Working Force	-0.003 (.02)	0.29 (.71)	0.16 (.41)	0.08 (.38)	0.53 (1.67)				
Agricultural Working Force (Pre-1937)						-0.07 (.47)	0.87 (2.16)	0.32 (.53)	0.32 (.53)
Agricultural Working Force (Post-1937)						-0.08 (.51)	0.86 (2.13)	0.35 (.61)	0.29 (.49)
Cropped Land	0.045 (.19)	-0.048 (.15)	-0.023 (.07)	-0.019 (.08)	-0.34 (1.25)	0.2 (.67)	0.52 (1.52)	1.41 (4.22)	1.49 (2.33)
Mean Land Ownership		0.09 (.16)	0.25 (.16)						
Gini Coefficient		-3.85 (1.34)							
Kakwani Coefficient			-2.08 (.91)						
a1				9.74 (.43)					
alpha1				-82.3 (.27)					
beta1				1.65 (.24)					
a2					0.43 (.41)				1.18 (.86)
alpha2					-1.6 (1.82)				-0.84 (.81)
beta2					0.629 (2.96)				0.14 (.58)
l1l					-1.91 (1.29)		-4.45 (2.62)	-4.14 (1.67)	-3.72 (1.4)
Cotton Acreage Restrictions Dummy						-0.18 (3.86)	-0.29 (4.5)	-0.33 (3.71)	-0.34 (2.83)
Major Dam Projects (1928-1939) Dummy						-0.74 (2.32)	-0.77 (2.3)	-1.34 (3.14)	-1.47 (2.59)
Post-1952 Revolution Dummy						0.13 (4.28)	0.12 (3.92)		
Constant	3.56 (3.47)	6.09 (1.81)	4.62 (1.51)	76.7 (.27)	4.88 (3.29)	3.35 (3.22)	0.69 (.46)	-1.14 (.78)	-2.96 (.81)
Degrees of Freedom	40	38	38	37	36	35	34	35	32
Adjusted R-Square	0.449	0.446	0.432	0.511	0.576	0.848	0.832	0.67	0.62
Estimated Rho	0.76	0.72	0.75	0.6	0.41	0.11	-0.02	0.2	0.12

Table 7
Augmented Dickey-Fuller Unit Root Tests

Variable	Dickey-Fuller Statistic (p-value) X	Dickey-Fuller Statistic (p-value) ΔX	Dickey-Fuller Statistic (p-value) $\Delta^2 X$	Order of integration of series
Q_t aggregate agricultural output	-2.085 (0.572)	-2.392 (0.401)	-3.720 (0.032)	I(2)
K_t agricultural capital stock	-2.099 (0.564)	-2.287 (0.458)	-5.262 (0.000)	I(2)
N_t agricultural population	0.421 (0.997)	-2.745 (0.233)	-3.071 (0.128)	I(2)
H_t cropped land	-2.083 (0.573)	-2.202 (0.505)	-3.914 (0.020)	I(2)
Average short-term loan granted by the C.A.É.	-2.392 (0.368)	-2.307 (0.401)	-3.158 (0.128)	I(2)
Area in Feddans expropriated by the C.A.É.	-1.395 (0.671)	-2.829 (0.204)	-3.354 (0.116)	I(2)
GINI	-1.801 (0.716)	-2.438 (0.376)	-3.434 (0.061)	I(2)
KAK	-1.722 (0.751)	-3.094 (0.122)	-3.891 (0.021)	I(2)
Distribution of land ownership				
a_{1t}	-1.997 (0.616)	-2.242 (0.480)	-3.793 (0.028)	I(2)
α_{1t}	-1.628 (0.784)	-2.122 (0.547)	-3.772 (0.029)	I(2)
β_{1t}	-0.991 (0.937)	-2.264 (0.468)	-3.984 (0.018)	I(2)

Note: p-values in parentheses.

Table 8
Cointegration Regressions: aggregate agricultural output and area expropriated because of bankruptcy

	(1)	(2)	(3)	(4)	(5)*	(6)	(7)	(8)	(9)
	1913-58	1913-58	1913-58	1913-58	1913-58	1931-58	1933-58	1933-58	1933-58
Dependent variable	Q_t	Q_t	Q_t	Q_t	Q_t	Q_t	Q_t	Exprop. area**	Exprop. area**
Intercept	9.17	8.13	-272.60	-376.80	-371.14	51.88	-9.12	-3699	15.15
	(2.89)	(3.16)	(-1.20)	(-1.72)	(-2.05)	(0.20)	(-0.03)	(-0.99)	(2.36)
Time	0.009	0.01	-0.004	-0.01	-0.009	-0.09	-0.08	-0.43	-0.14
	(1.61)	(1.73)	(-0.45)	(-1.18)	(-2.97)	(-5.55)	(-5.51)	(-2.09)	(-6.42)
Acreage restrictions				-0.18					
				(-2.39)					
Q_t									0.03
									(0.02)
K_t agricultural capital stock (a)	-0.14	-0.13	0.13	0.24	0.18	1.25	1.31	0.56	
	(-0.79)	(-0.74)	(0.75)	(1.45)	(1.41)	(3.90)	(3.61)	(0.11)	
N_t agricultural population (b)	0.003	0.01	1.12	1.18	1.40	5.69	5.62	14.78	
	(0.01)	(0.06)	(2.34)	(2.61)	(4.44)	(6.84)	(6.64)	(1.31)	
H_t cropped land (c)	-0.59	-0.57	-0.58	-0.13	-025	-0.38	-0.61	2.86	
	(-1.54)	(-1.48)	(-1.66)	(-0.35)	(-0.75)	(-1.24)	(-1.75)	(0.61)	
Average short-term loan granted by the C.A.É. ***							-0.05	1.50	1.62
							(-1.07)	(2.35)	(2.75)
Area expropriated by the C.A.É.						-0.02			
						(-1.57)			
GINI	-1.96								
	(-0.78)								
KAKWANI		-1.23							
		(-0.58)							
a_{1t}			-20.00	-28.42	-27.89	8.32	3.53	-351.69	
			(-1.07)	(-1.59)	(-1.86)	(0.38)	(0.14)	(-1.08)	
α_{1t}			294.34	403.93	399.12	-82.35	-15.93	3962	
			(1.21)	(1.73)	(2.04)	(-0.30)	(-0.05)	(0.98)	
β_{1t}			-6.94	-9.40	-9.29	1.84	0.32	-91.55	
			(-1.25)	(-1.76)	(-2.07)	(0.29)	(0.04)	(-0.98)	
R^2	0.54	0.48	0.68	0.73	0.63	0.84	0.83	0.92	0.89
σ	0.06	0.06	0.05	0.05	0.05	0.03	0.04	0.54	0.55
DW	0.52	0.50	0.91	0.97	1.02	1.68	1.80	1.72	1.30
ADF test on equation residuals (p-value)	CI(2,2)	CI(2,2)	CI(2,2)	CI(2,2)	CI(2,2)	CI(2,2)	CI(2,2)	CI(2,2)	CI(2,2)
	-2.02	-1.85	-3.48	-3.69	-3.78	-4.46	-4.24	-5.63	-4.29
	(0.611)	(0.702)	(0.053)	(0.033)	(0.026)	(0.008)	(0.01)	(0.001)	(0.01)
Null hypothesis of no co-integration	not rejected	not rejected	rejected at 5% level	rejected at 3% level	rejected at 3% level	rejected at 0.8% level	rejected at 1% level	rejected at 0.1% level	rejected at 1% level

Note: t-statistics in parentheses, except for ADF test where it is the p-value of the test which is in parentheses. * Dependent variable is output per feddan. (a) In equation (5), this is capital per feddan. (b) In equation (5), this is agricultural population per feddan. (c) In equation (5), this is cropping intensity. ** Dependent variable is expressed in feddans. *** Expressed in constant 1960 Egyptian pounds (normalization carried out using Radwan's money wage index for the agricultural sector).

Table 9
Error Correction Representation

Dependent Variable: $\Delta Q_t / Q_t$	(1) (1913-58)	(2)* (1913-58)	(3) (1913-58)	(4) (1913-58)	(5) (1913-58)	(6) (1933-58)
Intercept	-0.04	-0.04	-0.04	-0.03	-0.006	0.61
	(-2.62)	(-2.49)	(-2.59)	(-2.13)	(-0.71)	(2.32)
$\Delta Q_{t-1} / Q_{t-1}$	0.23	0.15	0.23	0.09		0.91
	(1.31)	(0.89)	(1.45)	(0.62)		(1.94)
$\Delta Q_{t-2} / Q_{t-2}$	0.14	0.15				-0.09
	(0.83)	(0.81)				(-0.42)
$\Delta K_{t-1} / K_{t-1}$	0.81	0.71	1.08		0.66	0.83
	(2.01)	(1.69)	(3.42)		(2.26)	(1.24)
$\Delta K_{t-2} / K_{t-2}$	0.48	0.52		0.85		-1.10
	(1.14)	(1.16)		(2.74)		(-1.18)
$\Delta N_{t-1} / N_{t-1}$	-3.65	-5.32	-1.78	-2.63		-10.56
	(-1.01)	(-1.36)	(-0.55)	(-0.82)		(-1.68)
$\Delta N_{t-2} / N_{t-2}$	4.91	6.84	3.38	4.78		-6.19
	(1.33)	(1.74)	(0.99)	(1.44)		(-0.91)
$\Delta H_{t-1} / H_{t-1}$	1.07	1.03	1.04	0.85	0.66	0.65
	(3.85)	(3.56)	(3.98)	(3.27)	(2.72)	(1.61)
$\Delta H_{t-2} / H_{t-2}$	0.59	0.62	0.44	0.37		-0.38
	(2.09)	(2.03)	(1.90)	(1.55)		(-1.12)
Δa_{1t-1}	-8.16	-6.35	-13.47			-39.83
	(-0.68)	(-0.49)	(-1.23)			(-1.86)
Δa_{1t-2}	-36.13	-33.46	-37.57	-28.95	-22.55	-66.58
	(-3.17)	(-2.78)	(-3.36)	(-2.86)	(-2.26)	(-2.91)
$\Delta \alpha_{1t-1}$	87.90	59.78	148.14			429.73
	(0.56)	(0.35)	(1.02)			(1.68)
$\Delta \alpha_{1t-2}$	505.71	474.91	525.72	422.88	345.79	791.10
	(3.41)	(3.03)	(3.61)	(3.14)	(2.60)	(3.21)
$\Delta \beta_{1t-1}$	-0.65	-0.44	-1.80			-7.78
	(-0.18)	(-0.12)	(-0.55)			(-1.45)
$\Delta \beta_{1t-2}$	-12.18	-11.88	-12.94	-10.99	-8.88	-16.15
	(-3.51)	(-3.26)	(-3.83)	(-3.45)	(-2.88)	(-3.13)
$\Delta Exprop_{t-1}$						0.02
						(1.15)
$\Delta Exprop_{t-2}$						-0.07
						(-2.03)
Lag of error from corresponding cointegration equation	-0.56	-0.60	-0.47	-0.42	-0.34	-1.55
	(-3.26)	(-2.79)	(-3.25)	(-3.00)	(-2.85)	(-3.23)
R^2	0.62	0.59	0.60	0.52	0.41	0.85
σ	0.03	0.03	0.03	0.03	0.03	0.03
DW	1.65	1.60	1.66	1.65	1.42	2.17

Note: t-statistics in parentheses.
* Same as (1), but with lag error from equation (4) of Table 8 (i.e., with acreage restriction dummy in cointegration equation).

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