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**The Determinants of Agricultural Productivity - the
Cases of Israel and the United States**

Y. Mundlak, D.G. Johnson

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c. *ABSTRACT*

The organization of production is an economic decision which takes into account the incentives and the constraints faced by the firms. The scope for firm's decision is the choice of inputs, outputs and the technology to be implemented. Technical change is generated by changing the implemented techniques. The implementation of new techniques changes the composition of inputs, or the demand for inputs. As such, the final outcome depends also on the input, or factor, supply. The factor supply faced by the firm is different from that faced by the industry. As our interest is in productivity changes at the industry level, it is of important to relate such changes to factors affecting factor supply.

The purpose of this research is to apply and integrate this view of the world to empirical analysis of productivity. This is indeed a very broad topic and the present project deals with several aspects of this general problem:

1. Estimation of production functions. The dominating approach to estimation since the mid-sixties has been to use duality. A methodological paper shows that the estimation of production functions indirectly through their dual (factor demand and product supply) is statistically inferior to direct estimation and that in fact some improvement can be obtained by combining the dual and the primal. Further more, and more pertinent to the our subject, the fact that the technology is endogenous exasperates the shortcomings of the dual estimators.
2. Empirical applications to United States agriculture.
3. Empirical applications to Israel agriculture.
4. The study of labor and capital supply in United States agriculture.
5. The effect of macro policies on incentives to United States agriculture.

6. The political economy and its effect on the incentives to United States agriculture.

d. *OBJECTIVES OF THE RESEARCH*

The objectives were stated in the research proposal "... to construct a framework for studying agricultural productivity change in terms of production growth and also in terms of the interrelationships between agriculture and the rest of the economy. An important aspect of our framework of analysis is the ability to measure the effects of various economy wide variables upon the productivity change in agriculture."

e. *REPORT*

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6. The political economy and its effect on the incentives to United States agriculture.

A short summary of each of these studies with the names of the principal investigators follows. The full reports are attached.

Sources of input variations and the (in)efficiency of empirical dual production functions - Yair Mundlak .

The integration of the concept of duality in economic analysis has had a considerable influence on the econometrics of production functions. It has become a common practice to infer about the production structure by estimating behavioral functions, such as product supply or factor demand. The main idea here is that as prices change, inputs and outputs change accordingly and that such changes provide the information for the estimation of the production function. This is true, but prices are not the only cause for input variations and therefore this approach utilizes only part of the

available information. In a quantitative sense, the information neglected may be by far more important than the information utilized.

This problem is analyzed here within a very simple framework and its message is largely methodological. If a choice has to be made between the primal and the dual, it is often more efficient to estimate the production function directly. Furthermore, assuming that all the conditions required for inference from the dual functions hold, then it is often more efficient to derive empirically the dual functions from the primal functions: exactly the opposite of the current practice. However, there is no need to choose between the two and it is possible to combine them and thereby utilize more efficiently the available information.

*The choice of techniques and technological change
in U. S. agriculture: 1948-1983 - John Mc Millan*

This research uses the choice of techniques approach, to characterize technological change in United States agriculture (Mundlak 1987). The choice of technique approach begins with the observation that different techniques exist, and are used, in producing an output. Estimation of an aggregate production function involves aggregating across different implemented techniques. Traditional estimation of aggregate technologies assume that each producer has access to and implements the same techniques. Technological change in the traditional framework meant an expansion in the set of techniques available to producers. The choice of techniques approach extends this understanding of technological change to include changes in the implementation of available techniques.

The model is build upon an individual producer's choice problem where a producer allocates variable (v_j) and fixed (b_j) inputs to techniques (F_j) in order to maximize profits:

$$(1) \quad \pi = \sum_{j=1}^J [p_j F_j(v_j, b_j) - wv_j]$$

subject to the constraint that allocated fixed inputs sum to the available total of fixed inputs:

$$(2) \quad \sum_{j=1}^J b_j = b$$

First order conditions characterizing the maximization of (1) include:

$$(3) \quad \frac{\partial F_j}{\partial v_j} \leq \frac{w}{p_j}, \quad (4) \quad \frac{\partial F_j}{\partial b_j} \leq \lambda$$

where λ is the multiplier on the fixed input constraint. By the weak inequalities in (3) and (4), if the value marginal product of a technique is less than the cost of implementing it (measured by input costs w for variable inputs and shadow prices λ for fixed inputs) then the technique is not implemented. However, as the economic environment, defined by fixed inputs and input and output prices, changes, the mix of techniques implemented changes.

If observations of inputs and outputs were made at the individual technique level, the prescription of the above analysis would be to make estimations at this level: estimations at an aggregate level are inconsistent, since the process of aggregation is endogenous. The choice of technique approach to estimation at an aggregate level exploits the endogeneity of aggregation to allow a more meaningful estimation of aggregate technological relationships. A functional form is needed which will allow aggregated data to approximate the micro relationships:

$$(5) \quad F(\sum v_j, \sum b_j) \approx \sum F_j(v_j, b_j)$$

The functional form is provided by taking a second order Taylor series expansion of the right hand side of (5) and collecting terms to obtain:

$$(6) \quad F(\sum v_j, \sum b_j) \approx \Gamma(v_j, z) + \beta(v_j, z) \sum v_j$$

where z is a vector of variables which characterize the economic environment in which production decisions are made.

Equation (6) is a convenient form for estimation since it is similar to a Cobb-Douglas technology with the innovation that the technology variables Γ and β are functions of the state of the economy (z). Additionally, equation (6) is a relationship between aggregate inputs and output, and thus can be directly applied to aggregated data.

The empirical application of the research uses U. S. agricultural data to estimate production functions of the form of equation (6). Four input groups (capital, land, raw materials and labor) are used to explain

production of an aggregated output. Variables which define the state of the economy are expectations of ratios of input to output prices, expectations of government intervention in the agricultural sector, the variability of output prices, the ratio of crop to livestock prices, and economy wide stocks of physical and human capital.

The estimations suggest that increases in the price of crops relative to livestock, and in physical and human capital increase productivity in agriculture while increases in price variability decrease productivity. Additionally, changes in the variables which characterize the state of the economy induce biases in the factor intensities of implemented techniques. Increases in human capital increase capital and land shares and decrease labor and raw material shares. Government commodity programs offset changes in the labor share.

The induced innovation hypothesis of Hayami and Ruttan is that economic variables influence directions of change of the set of available techniques. This analysis suggests that economic variables additionally influence technological change as measured by changes in the collection of available techniques actually implemented.

Israel Agriculture - Yair Mundlak and Ruth Ben Zvi

The framework of this analysis is the same as that used for the U.S agriculture, with one major extension that outputs are disaggregated. Thus, the model is described by the same set of equations. The outputs are: field crops, vegetables, citrus, fruits (other than citrus), fish, meats, milk and eggs. The crops and fruits were represented by two variables, area and production. Similarly, livestock were also represented by two variables, size of herd and output.

The incentives were product prices, index of agricultural input prices, wage rates in agriculture, water prices. To allow for expectation, the prices used in the analysis were derived from autoregression on their past values. In some cases, the differences between the actual values and the "expected" values were introduced as well to represent surprises.

The constraints are: total area, available water, own farm labor, product specific capital, such as stock of livestock or area planted in fruits, and in some cases we also used total capital stock in agriculture.

The technology carrier is the average labor productivity in the economy. The rationale for this is given in Mundlak and Hellinghausen. The variable was introduced by its historical, excluding current year, maximum value.

The period of analysis was 1952-84. At a late stage, the data base was extended up to 1987, but this did not change the results in any substantive way.

The model was estimated by non linear three stage least squares, the coefficients were then filtered using the principal components procedure described in Mundlak (1981). The model was then simulated, using dynamic simulation. Various combinations of the variables in question were tried and the results can be generalized as follows:

1. The fit of all the output supply equations was very good. The fit of the area allocation was not as high.
2. In general, some coefficients had the "wrong" signs. The signs were not robust to changes in specification. This is a weakness of the results which indicates that more work is required. In this sense, the results are still preliminary.

To give some idea on the nature of the results, estimates of a particular run are presented in the following table. As the state

(explanatory) variables appear in a non linear form, their effects are summarized by their elasticities at the mean point.

Price elasticities - the equations included only the own price, deflated by the index of input prices. The signs, except for eggs, are all positive and thus confirm a positive supply response.

Farm operators - the number of farm operators has a positive effect on all outputs, except eggs.

Wage rates - the wage is deflated by an index of agricultural product price. Its effect on output is positive, opposite to expectation. The conjecture is that the wage rate represents productivity. This was not examined more carefully, but if this conjectured is correct, it implies that the model is not adequately identified.

Water - water appeared in terms of both, price (deflated by the index of agricultural product price) and quantities. The sign of the elasticity of field crops is positive for both quantity and price. The livestock are less important here and are ignore in this review. The water price elasticity is negative for most products. The conceptual framework for evaluating this result for water can be presented in a simplified form assuming two products, one with a declining demand function, say the domestic product (fruits), and the other is the traded product (field crops) for which the demand is perfectly elastic at the level determined by the world price and the domestic policies. The allocation of the given quantity of water to the two products is demonstrated in the figure. The available by quantity of water is given by length of the horizontal axis, $O-O'$, the price of water is w . Point A indicates that the domestic and traded products get q_1 and q_2 units of water respectively. An increase in the

Signs of Production Elasticities - Israel Agriculture.

		R^2	Material		Agricultural	No. of	
			Price	Quantity	Made	Farm Operators	GNP
Field Crops	Output	.94	+	+	+	+	+
	Area	.51					
Vegetables	Output	.94	+		+	+	+
	Area	.72					
Citrus	Output	.95	+		-	+	+
	Area	.98					
Fruits	Output	.92	+		-	+	+
	Area	.49					
Fish		.87	+		-	+	+
	Output	.98	+	-	-	+	+
Milk	Output	.99	+	-	+	+	+
	Herd	.93					
Eggs	Output	.94	-	+	+	-	+
	Flock	.52					

Water Allocation

Water Demand

water supply doesn't effect q_1 , but it increases q_2 . For this reason, the quantity was not significantly different from zero except for field crops.

As indicated above, there are still some open questions which require further work, to be continued in future research.

Resource Mobility in American Agriculture, 1940-85. - Andrew, P. Barkley

Following Mundlak (1979, 1988), a two-sector model was utilized to study the determinants of changes in the quantities of capital and labor employed in the production of food and fiber over the period 1940 to 1985. The major subject in this research was the estimate the the degree to which resources in American agriculture respond to economic incentives. The two-sector formulation allows for the statistical study of the relationships between the changing levels of labor and capital employed and the returns of these resources in agriculture relative to the returns in non farm pursuits.

Labor Migration

The quantity of labor employed in agricultural production has diminished dramatically over the past several decades; farm employment dwindled from over nine million workers in 1940 to just over three million persons in 1985. Earlier studies of aggregate off-farm migration in the United States experienced difficulties in finding empirical relationships between the flow of labor out of agriculture and economic variables that were expected to influence the quantity of labor in the farm sector.

The objective of this research was to evaluate the economic determinants of the migration of labor out of production agriculture in the United States for (a) all farm laborers, (b) farm operators, (c) family

labors, and (d) hired labor. The research examined the theoretical aspects of occupational migration out of agriculture, followed by the specification of a migration equation that is tested empirically using aggregate time-series data.

The results indicate that farm labor in the United States is relatively mobile. Mobility was measured by the high elasticity of annual changes in farm employment to changes in the relative returns to farm labor. The study provides empirical evidence that (a) farm labor responds to economic incentives in the short run, and (b) the value of farmland, as a proxy for returns to resources in agriculture, is associated with the decision to migrate out of the agricultural sector.

Capital Flows

The intersectoral allocation of capital goods between agriculture and the rest of the United States economy was pursued by reviewing the theoretical determinants of investment were studied, followed by the specification of a capital flows equation that was empirically tested using data at the aggregate level for the period 1940-1985.

Following Mundlak (1988), the specification of a capital flows equation allowed for the estimation of the responsiveness of agricultural investment to the returns to capital in the agricultural sector relative to return in the nonfarm sector.

Results of several empirical specifications of the model reveal that the allocation of capital goods between agriculture and the nonfarm sector depends on economic conditions. Specifically, the share of agriculture in total investment increases when the returns to capital in the farm sector rise relative to the returns in the nonfarm sector. The level of government

intervention does not appear to directly influence the allocation of capital between agriculture and non-farm pursuits.

The flow of capital goods between sectors is sensitive to economic conditions in the short run; investable funds will be allocated to either agricultural or non-farm uses depending on: (1) the relative sector returns to capital in the present period, and (2) the expectations of relative returns in future periods.

*The Effect of Macro Policies on Incentives
to United States Agriculture - Diana Shejnberg*

The objective of this research was to evaluate the effect of macro variables on the growth of the agricultural sector. The effect of changes in macro variables is summarized by their effect on the real exchange rate. The model contains several extensions of the Cavallo Mundlak work: (1) The model is constructed to be applied to the U.S. data and as such, it extends the "small country" framework in that the product price is determined endogenously. (2) The aggregate demand for agricultural product contains demand for farm inventories. (3) The model contains a monetary sector at home and abroad. This allows the determination of the flexible exchange rate.

In the short run the modifications affect more the demand than the supply and this was emphasized in this work. A framework was developed, using the two-country world model, to evaluate the relationships between the level of farm stocks and export on the one hand and the real exchange rate, production and support prices in the U.S, on the other hand.

The empirical work was not completed because of the sudden death of Diana Shejnberg.

The volatility of government transfers to agriculture
A political economy approach. - David Bullock

In the crop year of 1988, a great drought struck the Midwest region of the United States. The resultant contractions in the supplies of corn and soybeans caused prices of these commodities to rise sharply. At the time, the existing government program to transfer income to corn farmers was set up to handle demand shocks, not supply shocks: the target price/deficiency payments program guaranteed a floor price to corn farmers meeting participatory requirements, so that in years of weak foreign excess demand farmers would receive larger government transfer payments than in years when strong foreign excess demand kept prices high. But when prices rose after the negative supply shock, the target price/deficiency payments program could not transfer income to drought-struck corn farmers. In response, despite a politically unpopular federal fiscal deficit, Congress quickly moved to pass new legislation to aid Midwest farmers.

When world grain and fiber prices nearly tripled in the early 1970's in response to increased Soviet excess demand and certain unusual climatic conditions, U.S. consumers protested vigorously. Some members of Congress even talked of using the 1973 Farm Bill to impose price ceilings instead of maintain price floors for agricultural products (Cochrane and Ryan, pp. 66-68). Though legislators never took such drastic steps, acreage controls were removed and relatively little income was transferred from U.S. consumers and taxpayers to farmers during their peak market income years of 1973-1976.

Recent federal aid to California earthquake and South Carolina hurricane victims--existing and functioning contingency markets notwithstanding--showed that while Congress has tended in the past to

respond speedily to changing agricultural market conditions, farmers do not make up the only constituency that receives governmental favor in hard times. The "Windfall Profits Tax" debate after the 1979 oil crisis showed that farmers are not the only ones to lose governmental favor when market conditions favor them.

Such shifting in governmental favor do not surprise most non-economists: after all, who would expect for the government to be less generous towards agricultural interests while banks are foreclosing on thousands of farm mortgages? Similarly, if Congress can't raise Exxon's taxes after consumers have recently seen their fuel bills triple, when should we expect Exxon's taxes to be raised? But current economic models of public choice do not adequately endogenize government behavior, and so do not adequately explain this counter-cyclical nature of government transfers to political interest groups. The theme of many other papers in the area of public choice economics is that market conditions are influenced by government intervention: demand and supply are manipulated by government policy (see Stigler; Peltzman; and Becker 1983). The theme of this paper, on the other hand, is that while government intervention influences the market, government intervention is also influenced by the market. The effects of market forces on government actions are studied with a model that treats members of political pressure groups much like conventional microeconomic theory treats consumers and resource owners. Preferences of these political agents are defined over two "goods": own income and some other good, which is only produced in the presence of government transfers. In maximizing utility, the political agents are constrained by their abilities to use the political process to "transform" consumption of one good into consumption of the other. Utility maximization results when at

the margin the rate at which agents are willing to substitute one good for the other equals the marginal rate at which agents are willing to substitute one good for the other equals the marginal rate at which agents are able to transform one good into the other.

In the specific case of the political economy of U.S. agriculture, consumers, non-farm taxpayers, and even some farmers have generally opposed farm programs, which they have criticized for transferring much to few. This paper argues that opposition to these transfer programs rises and falls counter-cyclically with farm income: whereas non-farmers are generally opposed to the high taxes and prices that are forced upon them to support agricultural incomes, they become even more opposed when the market is able to do the job without their help. Market conditions might also affect income transfers by changing the efficiency with which these transfers can be made. Dead weight costs invariably accompany the various farm programs, and changing demand and supply conditions vary the degree to which the different transfer schemes are burdened by this waste. It is hypothesized in this paper that waste is not politically popular, and an investigation of whether market conditions can change dead weight costs of income transfer so as to encourage the government to transfer more to farmers during years of unfavorable market conditions than during years of favorable market conditions is made.

The first part presents a model of transfers between political interest groups whose members are utility maximizers. This model is solved for the pressure groups' equilibrium quantities of per capita political pressure expenditures, and the taxes and subsidies that result from these exertions of political pressure. This model shows how different real shocks, causing a "farm boom" or a "farm crisis," can lead political

pressures to change in ways that cause transfers to agriculture to be counter-cyclical. The theory of surplus transformation is presented and advanced in the second part of this paper, in which are shown analytically and systematically the dead weight losses inherent in target price/deficiency payments programs, production quota programs, and acreage reduction programs. Since much of the volatility in U.S. agricultural markets originates in the export sector, in part three the effects in changes in foreign excess demand upon the dead weight costs that accompany these income transfer programs are investigated. It is argued that production quota and acreage reduction programs become more efficient methods of transferring income to agriculture after an increase in foreign excess demand, and therefore that the tendency of the U.S. government to loosen acreage restrictions during years of poor foreign harvest cannot be explained by the changes in surplus transformation efficiency from such a foreign excess demand shock. It is shown, however, that it is possible for target price/deficiency payments programs to become less efficient in transferring income after increases in foreign excess demand, since a larger proportion of U.S. taxes will go to subsidize foreign consumption in such years. It is argued in the third part of this paper that the data suggest U.S. government transfers to farmers are counter-cyclical to market-provided income, and that this counter-cyclicity is seen in the trends of farm income and transfers, as well as in the deviations from these trends. It is also argued that the data do not show any significant systematic relationship between transfers to agriculture and the potential transfer efficiency of the transfer programs.

f. COOPERATION

The cooperation was very close. Most of the work was done at the University of Chicago where Mr. Mundlak spent extended periods.

g. *ACHIEVEMENTS*

The work and the main findings are described in section e.

h. *PUBLICATIONS*

Barkley, P. Andrew "The determinants of the Migration of Labor Out of Agriculture in the United States, 1940-85" Amer. J. Agr. Econ. August, 1990.

Other work in various stages of publication process. Most of the work was discussed in professional meetings and seminars in some leading universities.

BARD Final Scientific Report: Project No. I-741-84

Please note that the "full reports" referred to on page 4 of the attached final report are not included due to their extreme bulkiness.

These reports are available upon request from the BARD offices, P.O. Box 6,
Bet Dagan.