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in this issue **Page**

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A Concept of Property

By Gene Wunderlich

". . . The concept of property never has been, is not, and never can be of definite content. The paradigm of a Sanskrit verb of a thousand forms could not approach in diversities the phases of that concept in any time and place. . . . Changing culture causes the law to speak with new imperatives, invigorates some concepts, devitalizes and brings to obsolescence others."[1]

CHARLES REICH took the ancient, venerated term "property" and included new relationships, to appeal for a concept of "new property." He adapted earlier concepts to include the rights of persons in government-created wealth—the "government largess" as he colorfully named it.[2] It is this process of adding on new meaning and sloughing off old meaning that Philbrick described in his classic article "Changing Conceptions of Property in Law."[3]

Philbrick wrote his article in 1938. If we recall the ideological ferment of this Keynesian era, we see that it was quite natural for him to write ". . . it becomes manifest that the justification of property can be rested on no apriorism. It is a creature of law, only justifiable . . . by utilitarian considerations . . . social interests must control our choices; the individual interests only so far as they advance the general interest."[4] Recent penetrations of formal social science into the lexicon of law have further embellished our bounteous concepts of property.[5]

Concepts are a product of time and purpose. We have an environment of ideas just as we have an environment of climate, buildings, or people. This environment of ideas represents a state of the arts in concepts, and explains why semanticists will date a word. New concepts stem from novel combinations of available ideas.[6] What may be new about our concept of property, then, is a new combination of inherited ideas. Our concept of property presumably will reflect what we now know about it and what we intend to do with it.

We employ a concept because it serves some purpose. Two broad classes of purposes are (1) models for explanation or understanding, and (2) guides or criteria for action. To scientists, the concept may be useful for relating an abstract, explanatory model to experience. To courts or legislators, a concept of property may be useful for making laws to guide actions.

The concept of property proposed below is for explanation and model building. As such, it does not evaluate the performance of all or a part of the property system, nor does it prescribe statutes or decisions to improve the property system. It is analysis rather than policy oriented, and it is intended mainly to encourage social science inquiry into an important area of law. One rationale for giving priority to explanation over prescription is that, if we first understand the phenomena we are seeking to control, we will increase the likelihood of effective and enduring choices.

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[1] F. Philbrick. Changing Conceptions of Property in Law. Univ. Pa. Law Rev. 86: 691-732, May 1938.

[2] C. Reich. The New Property. Yale Law Rev. 73: 733-787, April 1964. Reich's interpretation of largess as property is conditional. At one point (p. 739) he states that largess is not necessarily property, at another point (p. 779) that all property could be described as government largess. Then he states that government largess has eroded the usefulness of property as a protector of the individual from the State, and concludes that what is needed is a new property.

[3] Philbrick, op. cit., p. 691.

[4] Ibid., p. 730.

[5] Virtually all modern contributions to the law of property acknowledge, if they do not depend upon, economic, social, and political concepts. A noteworthy example is: M. McDougal and D. Haber. Property, Wealth and Land. Michie Casebook Co., Charlottesville, N.C., 1948. A more recent exposition of the social science approach to the property issue has been undertaken by: Harold Demsetz. The Exchange and Enforcement of Property Rights. Jour. Law and Econ. 7: 11-26, Oct. 1964. Also: Toward a Theory of Property Rights. Amer. Econ. Rev. 57: 347-359, May 1967.

[6] A. Koestler. The Act of Creation. Macmillan, New York, 1964.

Complexity and the Property System

The general issue, of which the property problem in this paper is regarded as a part, is complexity. Any system of rules of behavior requires that the rulers and the ruled clearly perceive who is affected, under what circumstances, and how. If the rules are too broad or too narrow, geographically, topically, or functionally, there will be error. If the rules are inconsistent, there will be error. If the rules have differing meanings among individuals, there will be error. These errors become the source of legal action. Failure to know a boundary, for example, may cause trespass. Failure to draft a lease properly may cause disputes between landlord and tenant. Failure of a segment of the population to understand by property what the rest of the population understands by it can result in rebellion and social upheaval.

It would seem that the first requirement of a property system is that it be understood by all persons affected by it. To this end, legal scholars have labored with varying but only limited degrees of success for centuries. So complex had law become that the American Law Institute began its monumental Restatement of the Law "to present an orderly statement of the general common law . . . including . . . the law that has grown from the application by the courts of statutes that have been generally enacted and been in force for many years."

The Institute recognized the sources of complexity as (1) the increasing volume of the decisions of the court, many of which were irreconcilable, and (2) the "growing complications of economic and other conditions of modern life." These forces, said the Institute, "are increasing the law's uncertainty and lack of clarity."[7] Despite the work of the Institute and many others, theories of the law of property contain ambiguities. These theories result in rules of social interaction that may be mysterious to most of those affected by them.

Many people and many possible relations with respect to many property objects provide a basis for the complexity of property.[8] Complexity may be reduced by classifying individuals ("freeholder," "lessee," "bailor," etc.); classifying property objects (real estate, chattels, etc.), and classifying relationships (easement, covenant, lease, etc.). Problems arise when new property objects appear, such as clear air and water, continental shelf oil, a satellite, or an unsurveyed plot of land. Problems arise when a person either feels that a rule does not apply to him or that the probability of a negative action against him is very small. Problems may arise when the semantics of the court or legislature are incorrectly understood by the man on the street. These are but a few of the problems associated with the property system. In general, the more complex a system, the greater the chance for error and confusion.

The concept of property toward which this paper is directed sees "the social (hence legal) problem" as one of complexity. Complexity impinges on the individual in the form of so many roles, so many acts, so many choices, and so many consequences that decisive rules of behavior are obscure.[9] The objective of a property system envisioned here is the clear understanding by all participants of the rules of behavior with respect to all property objects and of the consequences of alternative actions in relation to the rules.

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[7] American Law Institute. Restatement of the Law of Property. Vol. 1, p. ix, 1936. The Restatement of Property began in 1927 and the first parts were published in 1936. The ALI study of property was based to a large extent on the imaginative efforts of: W. Hohfeld. Some Fundamental Legal Conceptions as Applied in Judicial Reasoning. Yale Law Jour. 23: 16, 1913. Reprinted with Introduction by W. Cook and Foreword by A. Corbin in: Fundamental Legal Conceptions. Yale Univ. Press, 1946. Hohfeld's work, although extensively criticized, still remains a landmark for those who would arrange the bundle of rights into a comprehensive property system. In their Restatement of Property the Institute adopted the following four forms of interests in property:

"A right . . . is a legally enforceable claim of one person against another, that the other shall do a given act or shall not do a given act" (p. 4).

"A privilege . . . is a legal freedom on the part of one person against another to do a given act or a legal freedom not to do a given act" (p. 5).

"A power . . . is an ability on the part of a person to produce a change in a given legal relation by doing or not doing a given act" (p. 6).

"An immunity is a freedom on the part of one person against having a legal relation altered by a given act or omission to act on the part of another person" (p. 8).

[8] The arithmetic of property is suggested by the formula for combinations, $C = n!/r!\,(n\text{-}r)!$ where n = number of things, such as individuals capable of contracting and r = number of things taken at a time, such as number of individuals involved with each contract. Recalling that the factorials (n!, r!) are the product of a series, we can see that astronomical combinations can be obtained from a relatively small n and r. In other words, a system of property based on sets of rules between individuals with respect to each right or duty on each property object is impossible. Therefore, general rules must be developed.

[9] Legal processes may well generate rather than reduce complexity. The advocacy system, for example, rewards wins and penalizes losses. The semantic extension of justice, then, is prescribed by a "win" set. But the win set expands, and future wins depend on an increasing number of precedent wins. Justice becomes a consequence or summation of decisions rather than an a priori standard, and its meaning becomes ambiguous in proportion to the number of precedents.

Property as Communication

Many characteristics of the institution of property resemble a communication system. The relationship among people concerning property could be expressed (perhaps measured) as interactions in much the same way that we view messages. The logical structure of the property system is its syntax. The connotations and denotations of property terms are its semantics. The instruments of expression are its media.

Systematic attention to the rules of exclusion or inclusion permits an understanding of the relationship among people about things not possible through vague intuition or even some relatively well-constructed legal documents. Layman Allen has effectively illustrated the usefulness of modern logic with a direct application to section 48(a) of the Internal Revenue Code which deals with the definition of property. In analysis he reduced more than 500 words to 56 symbolic representations, and prepared a revised text with 10 percent fewer words in far more precise, readable form.[10] Another exercise in logical construction demonstrated how, in a single paragraph, a proposed international instrument contained provisions that included and provisions that excluded some of the same classes of tenants from the scope of its standards.[11]

The formal rules of classification or, more generally speaking, syntax, are useful either for the most comprehensive view of property such as the classification of estates or for a specific contract provision such as the responsibility for maintenance of improvements in a lease.

The semantic dimension of communication is meaning. In one sense, the meaning of property is the idea of property. More specifically, however, the semantics of property is the relation of a sign or symbol to a particular property object or action. "Trespass" is an eight-letter noun or verb that conjures up a whole set of experiences for judges, owners, and intruders. When an event gets classified as a "trespass" by a judge it leaves the "real world" and enters the legal world of semantic manipulation. The trespass eventually returns from the semantic world of the judge to impinge on the traveler as a fine, admonishment, or acquittal.

The semantic terms, in their syntactic arrangements, are carried by some communication media. A message is extruded through the die of some medium, hence is affected by it. Because it is the medium, and not the intent of the sender, to which the receiver is exposed, McLuhan and his followers have argued the extreme that the medium is the message. The legal difference between a written and an oral contract to convey land might illustrate the importance of the medium. Titles could be transferred by magnetic tape or by sealed and notarized scroll; court-interpreted laws will specify which may be used, and behavior of the parties to the conveyance will be influenced by the medium.

Structure, Function, and Measures of Property

The concept of property rests upon a relationship between or among people with reference to some object—tangible or intangible. In grammatical terms, property might be stated as subjects (people), verbs (behaving), and objects (in relation to things). Metaphorically, property is a sentence.

When all such property relationships are aggregated, they comprise what might be called a property system. The formal requirement of a "system" is "anything capable of existing in one or more states"[12] and the institution of property seems to fill that apparently nominal requirement. For some purposes it may be useful to distinguish changes in a particular property (say, the transfer of an object from one person to another) from changes in the property system (say, changes in the way in which transfers take place). Most of our concern is with the property system, that is, the entire body of rules for relationships among people about property objects. These rules, as they are understood by those affected, are a communication system.

The property system may be looked at in two ways: What it is and what it does. The first we call structure, and the second we call function. The structure of a system implies components and their relation to one another. Molecules, governments, and buildings each have structures. Their respective components may be expressed as atoms, agencies, and bricks. The units used to describe structures are defined in terms of their function in the system.

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[10] L. Allen. Usefulness of Modern Logic to the Readers and Writers of Legal Documents. In: L. Allen and M. Caldwell. Communication Sciences and the Law. Bobbs-Merrill, Inc., Indianapolis, p. 87-98, 1965. See also: L. Allen. Symbolic Logic: A Razor Edged Tool for Drafting and Interpreting Legal Documents. Yale Law Rev. 66: 834-879, May 1957.

[11] First discussion of International Labour Organisation Recommendation on the "Living and Working Conditions of Tenants, Sharecroppers and Similar Categories of Agricultural Workers," Geneva, 1967. See International Labour Conference, 51st Sess., Rpt. VII(2), p. 115, 1967.

[12] C. Osgood and K. Wilson. Some Terms and Associated Measures for Talking About Human Communication. Univ. Ill. Press, p. 2, 1961.

Structure of Property

The structure of property as a communication system implies senders, receivers, and channels. This structure permits the examination of property at any level of aggregation. For example, two persons signing a purchase contract comprise sender, receiver, and medium for transmitting the terms of the transaction. Similarly, a group petitioning a court for an easement for access to a public body of water across private land comprise sender, receiver, and medium for the exercise of an access right.

Virtually no actual communication system is closed, because it is subject to influences other than those attributable to senders, receivers, and channels. There are influences on senders and receivers. There are noises in the channels. Therefore, an adequate concept of a property system should also account for influences outside the system being examined.[13]

The use of communication to describe property extends considerably beyond mere analogy. The substantial body of knowledge accumulated on the nature and process of communication has much potential both for articulating the qualities of property relationships and for measuring some important dimensions of property. Of course, communication theory is not the only, or perhaps not even the best, way of looking at property. Communication theory does have some features, however, that recommend it. One of these features is the way uncertainty is absorbed into the meaning of formal information models. With the metric of information theory it may be possible to express the degree of success of a property system in attaining ownership and control objectives.

Functions of Property

Property as a communication system implies two distinct functions–ownership and control. Ownership in this case means the claims people place on the stream of expected benefits flowing from a property object. Control means the influence people have on the use of a property object.[14]

In a formal logic sense, ownership and control specify operations of owners and decision-makers with property objects. Ownership distributes the bounties or burdens of property objects among owners. Owner, in this case, means one with claims to the bounties or burdens of property. These ownership claims, viewed ex ante, are the stuff of which expectations and interests are built. Expected bounties or burdens are not necessarily realized, of course, but they do form the basis of value. Ownership values, then, are really claims based on operations which will yield hoped-for benefits or anticipated burdens.

Control, as an operation, may be defined as a decision. The selection among possible uses, possible places for use, and possible times for use, of a property object is the decision. Possession of the complete decision-making authority, or some lesser influence, represents a claim to decide. The claim to decide is often closely related to the claim to bounty or burden. They are, in the simplest of classical economic systems, two sides of the same coin. Under theories of behavior more complex than the simplest economic system, the claim to decide (influence) and the claim to benefit are not coterminous.

The decision process[15] consists of identifying outcomes with specified actions under specified conditions. When outcomes, actions, and conditions are known with complete certainty, the process of "choice" or "decision-making"[16] is mechanical. When degrees of certainty are introduced, decisions are improved by the addition of more information. If all necessary information is available, decisions become mechanical. Control is, therefore, a matter of information.

Ownership, on the other hand, represents claims on the benefits (or burdens) of property objects which can be used in various ways, places, and times. Ownership represents the interest of persons in outcomes of the decision process. The value of that ownership is influenced by information on the likelihood of possible outcomes. Ownership, too, is a matter of information. Both ownership and control, then, if rigorously defined as special forms of information, can be treated as operations in a property system. Only empirical research

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[13] Formally this is called "closure." The degree of closure in an information system is measured as a proportion of messages within a defined network of all messages among the network units and all sources and destinations during the observation period. See Osgood and Wilson, op. cit. p. 35.

[14] Hurst expresses property solely in terms of decision-making: "Property in law means the legitimate power to initiate decisions on the use of economic assets." J. Willard Hurst. Law and Economic Growth. Harvard Univ. Press, p. 9, 1964.

[15] The relation between science and decision-making is lucidly discussed by: C. Churchman. Prediction and Optimal Decision. Prentice-Hall, Englewood Cliffs, N.J., 1961. It is discussed more specifically in relation to law by: T. Cowan. Decision Theory in Law Science and Technology. Science 140: 1065-1075, June 1963.

[16] In quotes because the metaphysical assumption of free will is not necessary to describe the process. It doesn't matter whether people decide, or act as if they are "deciding."

can establish whether such concepts are useful in explaining behavior of people with respect to property.

Units of Rights

At the root of a useful empirical theory of property is the search for a unit of measure. Legal theories directed at providing consistent standards of how people ought to behave can avoid precise measures. Greater justice may be done, in fact, if some flexible fuzziness is attached to property relationships.[17] If social scientists are to test their theories of how people do behave, however, they cannot apply elastic criteria.

But the idea of property is basically a legal concept. No useful social science theory can be isolated from the legally articulated rules of behavior. Somewhere between the terms of a legal theory–a semantically flexible, logically consistent, rule of behavior–and the empirical units of a social science theory–a prediction model suitable for test–should be found some concepts to which law and social science can relate.

Constructs or concepts must be definable in terms of other constructs or concepts in a theory.[18] In addition to such a constitutive definition, a construct must also be related to observable data. A logical model is not a scientific theory unless its terms are related to observable units. The properties *of* an object are the characteristics regarded important by the describer. The properties *in* an object are the claims of ownership and control made by a claimant.[19]

Are properties *in* an object finite? Yes, because they can be collected into general classes of people's behavior with respect to property objects. Classes prescribe limits. No two objects, actions, or people are exactly the same so we can be satisfied that things are enough alike to be treated alike. For analytical purposes classes may be broad, like Hohfeld's famous eight categories of duties and rights,[20] or somewhat more detailed such as Ely's "kinds of property."[21]

A classification requires a scale. This is not to say that there must be one scale for all times for all purposes. General use of an agreed set of scales does improve discourse, however. Scales may be convertible, in one direction at least. For example, six classes may be reduced to two such as "1" and "all others." Ranks can be converted into "greater than" or "less than" a standard. In general, standard units of measure should be developed to meet the most detailed scale likely to be used. Classes can be developed from collections of scales but disaggregation may not be possible.

A property *in* an object may be stated as a set of rights. Each element in a set of rights may be reduced to a claim which a person either has or does not have with respect to a given object. For a system of property to be analyzed it would be necessary to state all possible rights in all objects for all persons in a community. Lacking complete knowledge, some way of expressing probable claims of broad categories of people and objects might be developed. Such probabilistic models, in fact, would be closer to the real world of uncertainty about property.

The term "quality" is sometimes used to avoid, or substitute for, the term quantity. Expressions of quality, although they may be no more than extensions of quantities, are used in both everyday and technical communications not only about property but in almost every aspect of life. Water, for example, may be "clean" when it has no less than 6 parts per million of oxygen, or has no more than so many specified bacteria per volume unit. Other characteristics can be added or deleted to make up a synthesis of characteristics for water quality. The number or precision of quantities need not be exhaustive to be adequate for specifying a quality. Likewise, the properties *in* objects may be expressed as quantities, even though the units might best be measured as 1 or 0.

Very likely a universal unit of property, say, some "element of right," would not be as useful as some more specialized forms. No such term can be ventured here at least. Such a unit of right, however, should be (1) uniform across all property being considered, (2) binary in the sense that any person either has or has not the right, and (3) summable so that properties in objects can be expressed as combinations of units of rights.

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[17] "The language of the law has never been generally precise, and it is neither possible nor desirable that it become completely so." D. Mellinkoff. Language of the Law. Little, Brown Co., Boston, p. 388, 1963. The context of the quote was the operation of law, not scientific analysis and test of law behavior.

[18] W. Torgerson. Theory and Methods of Scaling. John Wiley and Sons, Inc., New York, 1965. Chapter 1 contains a helpful exposition of the relation of concepts, theories, and tests.

[19] Transformation of the term "property" from "property in" is explained by Hamilton and Till: "In time, by dint of repeated use, a 'property in' became simply a property; and, with metaphorical significance worn away, it came to denote an abject reality." W. Hamilton and I. Till. Property. Encyclopedia of Soc. Sci., vol. 6, p. 528, 1933.

[20] W. Hohfeld, op. cit., p. 36.

[21] R. Ely. Property and Contract in Their Relations to the Distribution of Wealth. Macmillan, New York, p. 288-290, 1914.

Property and Policy

For the cold-souled practical ones who are unable to warm up to a semantic exercise on an abstraction, a word may be said on policy. In short, so what?

All this measurement of the property system, if we could do it, might be useful. We might wish to ask the question: How well does the property system in the United States perform? The question connotes both function and some standards or measures by which to evaluate the functions. Overall, we have said that the function of the property system is to inform—and this is its sole function. By informing, it lets everybody know what everybody else's rights, duties, and responsibilities are. It allows changes in these rights, duties, etc., to come about smoothly and easily with full knowledge and appropriate sanctions. By informing, the property system minimizes uncertainty and maximizes flexibility.

In the United States, for example, how fully aware are potential buyers and sellers of possible transactions in real estate? Even the identification of marketable real estate is local and specialized—so much so that this information is marketed by an elaborate brokerage profession.

How fully do owners understand the bundle of rights, and the uncertainties attached thereto, to which they lay claim when they receive title? Apparently, there is sufficient failure in the property system to call for a system of title insurance. Title insurance seems to exist because the property system is unable to inform a buyer.

How does society express its interests in a unit of territory held by a private owner? Apparently this interest is so obscure that, for example, a system of elaborate, costly judicial procedures in eminent domain is needed to find out. (Note: this has nothing to do with compensation—only to find out if the interest is compensable.)

What rights do individuals have in the public domain? How are public interests best represented by public agencies? Apparently the five-thousand-plus laws relating to public lands are sufficiently obscure and contradictory that they are under intensive investigation by a Public Land Law Review Commission—and the outcome of the investigation is under at least some doubt.

It would seem unnecessary to suggest that a property system for a populated, urbanized, and automated United States might differ from one for a United States involved with the problems of conquering and settling a new territory.[22] In essence, however, how different is it? Is our property system performing at its best? We will be hard put to say without concepts, definitions, and measures. It is toward such concepts, definitions, and answers that we began with the abstraction of property as a communication system. But the pudding's proof is implied, but not confirmed, by its recipe.

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[22] A. Miller discusses the requirements for a modern legal system in "Drawing the Indictment," Sat. Review, p. 39-42, August 3, 1968.

An Empirical Comparison of Simulation and Recursive Linear Programming Firm Growth Models

By David A. Lins

INCREASING EMPHASIS is being given to the analysis of the dynamics of firm growth. This has resulted from a general dissatisfaction with static equilibrium models in explaining the movement from one equilibrium position to another. Empirical studies involving the dynamics of firm growth have generally proceeded along two lines, differing primarily in the econometric technique employed, i.e., linear programming or simulation.

Linear programming has been employed in both recursive and multiperiod studies of firm growth. Day (1)[1] has defined recursive linear programming as "optimizing over a limited time horizon on the basis of knowledge gained from past experience." This is to say that the linear programming model is optimized for a single time period, updated based on the solution, and optimized again for each succeeding time period. Heidhues (2) has used this technique to analyze growth of farm firms in northern Germany. Dynamic or multiperiod linear programming may be defined as the linking through transfer vectors of single period decision models into a single matrix which may be solved simultaneously for all time periods. Johnson (5) and Martin (7) have conducted firm growth studies using this technique.

Simulation has been described as the use of models for the study of the dynamics of existing or hypothesized systems. The decision process or strategy of operation is formulated by the programmer; the simulation model merely calculates the results of the decision rules specified. Hutton (3) has stated that simulation models are nonoptimizing; that is, they do not guarantee an optimal solution. Frequently a simulation model which can handle multiple goals and indivisible inputs is desired. Patrick (8) has developed a simulation model to study the impact of management ability and capital structure on farm firm growth.

[1] Underscored numbers in parentheses refer to items in the Literature Cited, p. 12.

Difference in Simulation and Linear Programming

At least three basic differences are inherent in the use of simulation compared with linear programming. For one, linear programming requires an assumption of complete divisibility of all inputs whereas simulation does not.[2] Frequently an assumption of complete divisibility does not reflect reality for purchased inputs, especially land and buildings. Second, the simplex method used in linear programming generates a "mathematically optimal" solution. Third, the simultaneous solution of the LP matrix is in essence an assumption of perfect knowledge; for one time period in recursive linear programming, and for all time periods in multiperiod programming. Simulation models, however, typically provide a sequential rather than a simultaneous solution and, therefore, do not guarantee a "mathematically optimal" solution. Likewise, a sequential decision process does not imply perfect knowledge.

Research workers conducting empirical studies of firm growth need to decide when to use linear programming and when simulation may be more appropriate. Irwin (4) has suggested that simulation is appropriate when the decision process involves (1) multiple goals, (2) indivisibilities, and (3) sequential suboptimizing decisions. However, little emphasis has been given to empirical comparisons of the two techniques. What are the magnitudes of the differences in solution values when simulation and linear programming are applied to the same set of data? If differences arise, are they significant? Is the optimal expansion strategy indicated by linear programming identical to the best strategy as determined by simulation?

[2] Linear programming models which use an integer program do not require an assumption of complete divisibility. However, little use has been made of this type of model.

Comparison of Land Investment Models

A simulation model and a recursive linear programming model, both constructed to analyze long-term land investment strategies on Midwest cash-grain farms, offer a unique opportunity to explore the above questions (6). Details of the models are not discussed here. Identical costs, prices, interest rates, debt limits, etc., were used in both models. Both models represent 1-year planning periods. Evidence to show that solution values are not significantly affected by numerical differences in the models is given later.

The recursive LP and simulation models were used to test six alternative land investment strategies, which may be summarized as follows:

1. Fixed land investment
2. Conventional mortgage contract; no refinancing of equity capital allowed
3. Conventional mortgage contract; refinancing of equity capital is allowed
4. Cash rent or conventional mortgage contract
5. Land contract
6. Cash rent only

Strategy 1: Table 1 presents the outcome of strategy 1 for both the recursive LP and the simulation model. Strategy 1 represents a nonexpansionary land investment policy which allows for prepayment of land debt and for investment in nonfarm assets when land debt is reduced to zero. No further purchases of land will be made since the goal is 100 percent equity of owned resources. Since no indivisibilities exist, differences in the two solutions can be attributed to a simultaneous solution compared with a sequential solution, or to numerical differences in the models. Notice in table 1 that interest expense in year 1 is $164 lower for the LP solution. This resulted because of the simultaneous solution of the LP model which prepaid land debt at the start of the year on the basis of perfect knowledge of income for that year. In contrast, the simulation model generated the income, and then prepaid land debt at the end of the year. The differences in net operating income, net taxable income, net worth, and consumption are a direct result of interest expense which in turn is the result of the difference between a simultaneous versus a sequential decision process. Numerical differences in the models are negligible.[3]

The linear programming solution indicates a cumulative net worth of $189,901 for strategy 1 after 10 years of growth. The simulation solution indicates a cumulative net worth of $188,535 after 10 years. The relative difference between the two solutions is of minor importance. The implication is that if all indivisibilities

[3] By subtracting the $164 difference in interest expense from the net operating income in the LP solution a value of $10,748 is determined. Compare this with $10,742 net operating income for the simulation solution. Thus, the difference between the two solutions is explainable with the exception of a small rounding error. Differences in net worth, net taxable income, and consumption can be traced directly to the difference in net operating income.

Table 1.–Growth of net worth, net operating income, and consumption on a specified base farm, simulation and recursive linear programming solutions, strategy 1[a]

Year	Recursive linear programming solution					Simulation solution				
	Net Worth	Net operating income	Interest expense	Net taxable income	Consumption	Net worth	Net operating income	Interest expense	Net taxable income	Consumption
	Dollars					Dollars				
1	84,580	10,912	2,816	6,309	4,091	84,460	10,742	2,980	6,139	4,074
2	94,018	11,472	2,523	6,843	4,147	93,785	11,304	2,698	6,674	4,130
3	103,975	12,052	2,210	7,396	4,205	103,625	11,883	2,403	7,225	4,188
4	114,474	12,668	1,875	7,984	4,269	114,006	12,495	2,080	7,809	4,249
5	125,518	13,305	1,520	8,593	4,331	124,938	13,133	1,735	8,418	4,313
6	137,133	13,978	1,143	9,237	4,398	136,437	13,799	1,368	9,055	4,380
7	149,337	14,670	743	9,900	4,467	148,525	14,493	978	9,719	4,449
8	162,159	15,403	319	10,602	4,540	161,225	15,216	563	10,411	4,522
9	175,685	16,254	0	11,423	4,625	174,561	15,968	124	11,133	4,597
10	189,901	17,091	0	12,228	4,709	188,535	16,718	0	11,851	4,672

[a] The objective function maximized in the recursive linear programming solution is the annual increase in net worth, subject to consumption and debt limit restraints. Strategy 1 represents a nonexpansionary land investment strategy which allows for prepayment of land debt and investment in nonfarm assets when land debt is reduced to zero.

can be removed, the choice between recursive LP and simulation depends upon whether the researcher desires a simultaneous or sequential decision process, and upon which process can be most easily implemented. In any event the difference between the outcomes is not likely to be great in such a situation.

Strategies 2 through 6: Strategies 2 through 6 represent alternative methods of expansion of crop acres, through purchase or renting or both. These strategies have one common feature—they all allow for the acquisition of land, a "lumpy" input. Only strategy 2 is discussed in detail with the realization that many of the comparisons made between the recursive LP and simulation models will hold for all strategies.

Table 2 presents the results of strategy 2 for both models of analysis. Strategy 2 represents an alternative for expansion of land acreage through a conventional mortgage contract with no refinancing of equity capital allowed. This represents a very restricted source of real estate credit. Units of purchase of 40, 80, and 160 acres are computed for the simulation solution. This represents an increasingly indivisible land input. The recursive LP model assumes purchases of any size are possible. Both models provide a nonfarm investment alternative for surplus cash. This alternative is used by the simulation model to accumulate assets in anticipation of future purchases of land.

The recursive LP solution indicates 353 crop acres owned with a net worth of 228,893 after 10 years. The simulation solutions indicate substantially lower acreage and net worth at all size levels tested. As the indivisibility of the land input increases, the acres owned and net worth decline substantially. However, the decline in net worth as indivisibility increases is closely related to the rate of return on nonfarm assets. If one assumes that an equal return could be achieved on nonfarm assets, and on investment in the farm firm, then the indivisibility factor is of minor importance.

The accumulated net worth after 10 years is over $41,000 higher for the recursive LP solution than for the simulation solution at size 160. Land purchases in the cash-grain area of the Midwest average close to 160 acres.[4] Therefore, the "optimal" solution generated by the recursive LP model may be unrealistically high.

The outcome of the simulation solutions could have been roughly estimated by a close inspection of the growth pattern of land acreage in the recursive LP solution. Acres purchased in the recursive LP solution ranged from a high of 37 acres in year 2 to a low of 15 acres in years 3 and 4. Since these acreages are substantially less than those tested in the simulation model, one would expect less net worth in the simulation solutions.[5]

[4] Farm Real Estate Market Developments, Econ. Res. Serv., U.S. Dept. Agr., p. 16, April 1968.

[5] This assumes nonfarm assets are less profitable than farm investments. When the spread between returns on nonfarm assets and farm investments is known, a rough approximation of the simulation outcome can be made on the basis of LP results.

Table 2.–Growth of net worth and acres owned, simulation and recursive linear programming solutions, strategy 2[a]

Year	Recursive linear programming solution		Simulation solutions					
			Minimum purchase 40 acres		Minimum purchase 80 acres		Minimum purchase 160 acres	
	Acres owned	Net worth	Acres owned	Net worth	Acres owned	Net worth	Acres owned	Net worth
	Acres	*Dollars*	*Acres*	*Dollars*	*Acres*	*Dollars*	*Acres*	*Dollars*
1	185	84,580	185	84,460	185	84,460	185	84,460
2	222	95,304	225	95,171	185	93,773	185	93,773
3	239	107,222	225	106,489	185	103,589	185	103,589
4	254	120,353	225	118,458	185	113,931	185	113,931
5	269	134,971	225	131,062	185	124,810	185	124,810
6	283	150,436	265	145,913	265	139,475	185	136,238
7	299	167,274	265	161,520	265	154,845	185	148,237
8	316	186,355	265	177,931	265	171,048	185	160,828
9	334	206,716	305	196,838	265	188,022	185	174,033
10	353	228,893	305	216,653	265	205,808	185	187,875

[a] The objective function maximized in the recursive linear programming solution is the annual increase in net worth, subject to consumption and debt limit restraints. Strategy 2 represents an alternative for expansion of crop acres through a conventional mortage contract with no refinancing of equity capital allowed.

In general, the results of strategies 3 through 6 were comparable to strategy 2. In all cases the recursive LP model indicated substantially higher accumulated net worth than the simulation solutions. In all strategies net worth declined as the degree of indivisibility was increased. In strategies where an assumed maximum acreage was achieved, it was reached from 2 to 5 years sooner in the recursive LP solution.

Annual Increase in Net Worth

Figure 1 presents a diagram of the annual increase in net worth for each of the six land investment strategies. With minor exceptions, the recursive LP solution achieved an increase in net worth equal to or exceeding that of the simulation solutions.

For strategy 1, the difference in annual increases in net worth is negligible for the two models. Size of purchase is irrelevant since purchases of land are not allowed in either model. Accumulated net worth after 10 years is only slightly higher for the recursive LP solution.

For strategies 2 through 6 the annual increase in net worth declines as the degree of indivisibility is increased. The variability of annual increases in net worth becomes more pronounced as the degree of indivisibility is

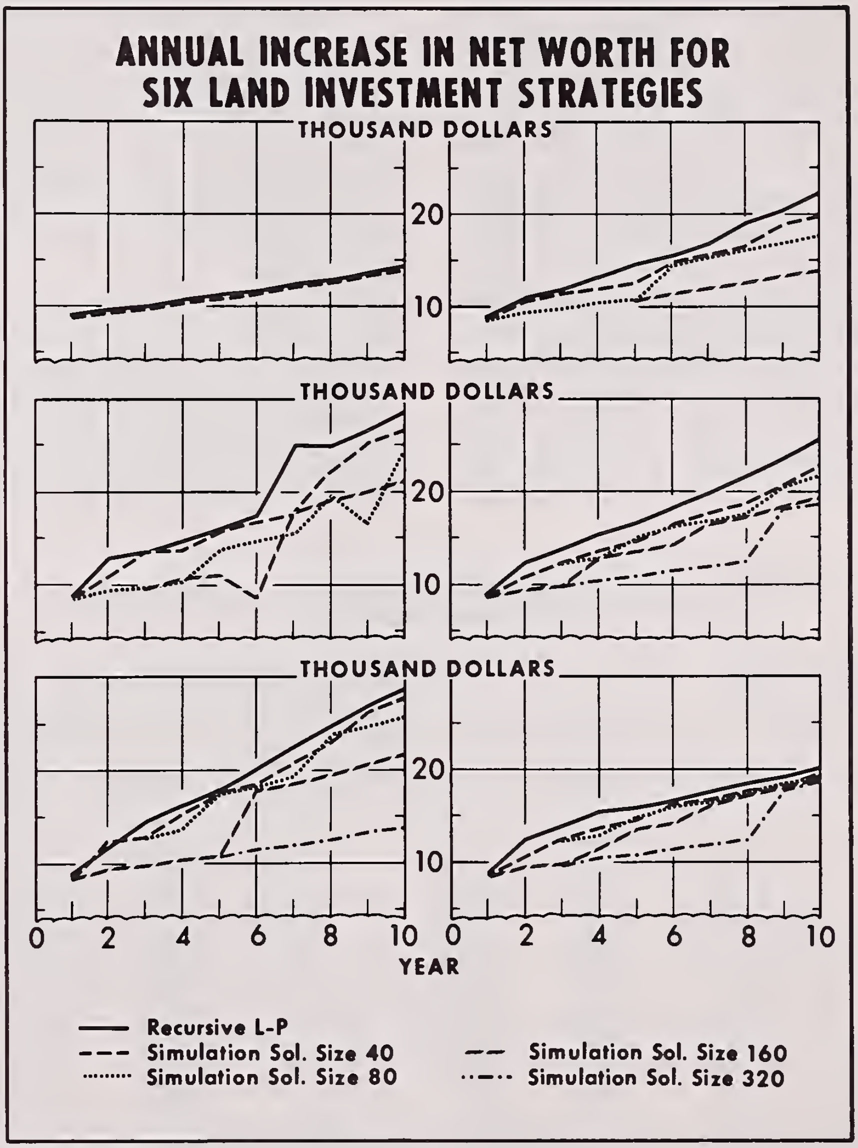

Figure 1

increased. Exceptions to this occur in strategies 2 and 5 at sizes 160 and 320 respectively. In these cases the annual increase is linear since land expansion was not achieved.

Comparisons Between "Optimal" Strategies

An important concern is whether the optimal strategy suggested by recursive LP is the strategy which yields the best solution in simulation. Table 3 summarizes the outcome of each strategy for the recursive LP solution and for four simulation solutions. Each solution is ranked on the basis of accumulated net worth after 10 years.

On the basis of net worth in the recursive LP solution, strategy 5 ranks highest, followed by strategies 3, 4, 6, 2, and 1 respectively. This is exactly the same ranking that occurs for the simulation solution at size 40. At size 80, the simulation solution indicates strategy 3 is ranked fourth, a drop from the ranking of second at size 40. Strategies 4 and 6 each moved up one position to second and third respectively. This implies that indivisible land inputs are more restrictive to purchasing through a conventional mortgage contract than to cash renting.

At size 160 the simulation solution indicates that strategy 5 ranks highest in accumulated new worth. Strategy 5 has the same rank in the LP solution and in simulation solutions at sizes 40 and 80. Strategies 6 and 4 rank second and third respectively, but are practically equal.

At size 320 the highest accumulated net worth is achieved by strategy 6, followed closely by strategy 4. Notice that strategy 5, considered the "optimal" strategy for the recursive LP model, is tied with strategies 2 and 3 for being the poorest strategy in the simulation solution at size 320.

Conclusions and Implications

Simulation and recursive linear programming have two inherent differences: sequential versus simultaneous solutions, and divisible versus indivisible inputs. An understanding of the relative importance of these differences is essential in evaluating the outcome of the particular model constructed.

Strategy 1 provided an opportunity to measure a simultaneous versus a sequential decision process. For this analysis the difference between the two solution values was of minor importance. The magnitude of the difference is, however, a function of the type of decision process set up and is likely to vary from study to study. The important point here is that the difference does exist and that some attempt should be made to measure it.

Strategies 2 through 6 offer alternative land investment policies. These strategies provided an opportunity to compare the results of a model which assumes complete divisibility of the land input with one that accounts for "lumpy" land inputs. In all cases the recursive LP model generated a substantially higher net worth than the corresponding simulation model. Only a

Table 3.–Relative ranking of land investment strategies on the basis of accumulated net worth, recursive linear programming and simulation solutions

Strategy	Recursive linear programming solution		Simulation solutions							
			Minimum purchase 40 acres		Minimum purchase 80 acres		Minimum purchase 160 acres		Minimum purchase 320 acres	
	Net worth	Rank	Net worth	Rank	Net worth	Rank	Net worth	Rank	Net worth	Rank
	Dollars		*Dollars*		*Dollars*		*Dollars*		*Dollars*	
1 (fixed land investment)	189,901	6	188,535	6	188,535	6	188,535	5	188,535	3
2 (conventional mortgage contract, no refinancing)	228,893	5	216,653	5	205,808	5	187,875	6	187,875	4
3 (conventional mortgage contract, refinancing allowed)	263,576	2	245,720	2	218,809	4	211,417	4	187,875	4
4 (conventional mortgage contract or cash rent)	251,018	3	231,390	3	227,547	2	215,456	3	197,496	2
5 (land contract)	267,242	1	258,080	1	251,615	1	223,323	1	187,875	4
6 (renting only)	233,497	4	224,001	4	223,288	3	215,568	2	197,518	1

small part of the difference can be attributed to a sequential versus a simultaneous decision process.

Although the results of the recursive LP model may be unachievably high, there is no great misconception unless the "optimal" strategy changes as indivisibilities are considered. For this analysis, the optimal strategy suggested by the LP model did not agree with the best strategy of the simulation solution at the 320-acre size. Implications are that under certain circumstances the linear programming solution can give a "false" optimum, i.e., an assumption of divisible inputs may lead to the wrong conclusion, if in fact inputs are indivisible.

Research workers conducting firm growth studies need to give careful consideration to the implications of choosing a linear programming model over a simulation model or vice versa. Evidence was given to show that a "mathematically optimal" solution generated by the linear programming model was in fact not a "logical optimum" if indivisibility of land was placed at 320 acres. Clearly, an evaluation of alternative methods of analysis is needed in discussing the results of a particular econometric model.

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Technological Change in Agriculture

By Robert O. Nevel[1]

AMERICAN AGRICULTURE has become one of the most productive industries in the world. The tremendous growth of its productivity may be attributed in part to the great advances made in agricultural technology. This paper attempts to quantify in index form the rate at which technology has changed in agriculture from 1950 to 1966. In addition an analysis is made of the role of farm machinery in increasing agriculture's output.

Many authors have attempted to measure changes in the production function using various modifications of the Cobb-Douglas model. Their analysis, however, is limited to a specific time period. Any attempt to measure the contribution of the productive factors over time will be faced with the familiar problem of multicollinearity. Attempts to determine the role of each factor are then limited by the accuracy of the regression coefficients.

This paper employs the basic mathematical approach developed by Robert M. Solow (9)[2] with some modifications for its application to agriculture. This method eliminates some of the problems mentioned above but is still limited by the assumptions which must be made.

The Model

Technological change can be broadly defined as a change in the total farm output that results from a given set of production inputs. These changes will cause both neutral shifts and changes in the slope of the production function. Solow's method measures technological change as a residual of the output per unit of labor minus the capital inputs per unit of labor. Therefore improvements in education, management techniques, quality of the production inputs, and all the other things that result in an increase in farm output will appear as "technological change."

To measure technological change, the variations in output due to movements along the production curve must be separated from those that are due to shifts in the curve. This can be accomplished by making three basic assumptions: (1) each factor is paid its marginal product, (2) the production function is homogeneous to the degree one, and (3) there is neutral technological change.

The first assumption is the usual assumption for an economy in an equilibrium condition. The second assumption states that there are constant returns to scale to the factors employed. There are some indications that the limitations imposed by the first two assumptions are not overly restrictive. Agriculture has not shown any substantial bias resulting from violation of the equilibrium condition and production economic research has shown some evidence that agriculture is characterized by approximately constant returns to scale (10).

Technological change is not always neutral in agriculture but this assumption is made to simplify the analysis. Neutral technological change occurs when the production function shifts either up or down and the productivity coefficients remain unchanged. Solow attempts to test for neutrality of technological growth but the results are rather inconclusive.

Although these assumptions are rather restrictive, they are probably as tenable in describing agriculture's production function as they would be in describing any other industry. Any interpretations or conclusions drawn from this study must be made in light of these assumptions.

The production function is described as a functional relationship of all the inputs used in production to the final output. The inputs are usually characterized by the physical units of labor and capital. The production function can be written:

$$Q = f\ (K, L, \ ; t) \qquad (1)$$

Q represents the total output, K and L represent physical units of capital and labor used in production. The variable t is a time variable that is used to measure the technological change that occurs. Solow describes t

[1] The author is indebted to Hazen F. Gale of the Bureau of Labor Statistics for his many useful comments and criticisms.

[2] Underscored numbers in parentheses refer to the Literature Cited, p. 18.

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"as a shorthand expression for any kind of shift in the production function" (9).

Based on the assumption that technological change is neutral, we can rewrite equation (1) as:

$$Q = A(t)\ L^{1-B}\ K^{B} \tag{2}$$

The multiplicative factor A(t) changes over time and causes the output to change for any given set of factor inputs. Since we have also assumed constant returns scale, the exponents will add to unity. This makes it very convenient to express the production function in terms of output per man-hour or capital per man-hour. The equation would take the form:

$$Q/L = A(t)\left(\frac{K}{L}\right)^{B} \tag{3}$$

Equation (3) can be written as a log function and used to describe a time series or a change from period to period by the form

$$\Delta \log\ (Q/L) = \Delta \log A(t) + B\Delta \log (K/L) \tag{4}$$

where Δ signifies the differences in values between two adjacent periods. The differences in logarithms can be expressed as a percentage of change in the original variables. Therefore, we can write:

$$\frac{\Delta (Q/L)}{Q/L} = \frac{\Delta A(t)}{A(t)} + B\frac{\Delta (K/L)}{K/L} \tag{5}$$

From equilibrium theory we know that $B = \frac{I \cdot K}{P \cdot Q}$ where P is the price of the output (Q) and I is the cost of capital (K). If we represent $Q/L = q$, $K/L = k$, $B = W_k$ which is capital's share of output, and $\Delta A/A$ as the percentage change in the production function, then equation (5) can be written:

$$\Delta A/A = \Delta q/q - Wk\ \Delta k/k \tag{6}$$

The change in output caused by the total changes in the use of capital per unit of labor is subtracted from the total change in output. The residual $\Delta A/A$ is then the change in production that was caused by some neutral change in technology.

Solow's method must be modified somewhat to describe agriculture's production function. The capital used in agriculture's production has been placed into three separate categories. The first category includes land, buildings, livestock, and other inventories; the second includes farm machinery and equipment; and the last includes the intermediate purchased products used in production for a single year only, i.e., feed, fertilizer, seed, etc.

Solow's original equation—equation (6) in this paper—is therefore rewritten to include both farm machinery and the intermediate purchased products:

$$\Delta A/A = \Delta q/q - WM\ \Delta m/m - WI\ \Delta i/i - WK\ \Delta k/k \tag{7}$$

where m is the inputs of farm machinery per unit of labor, WM is machinery's share of the output per unit of labor, i is the intermediate products used per unit of labor, WI is the intermediate purchased inputs share of output per unit of labor, k is the capital input in the form of land, buildings, and inventories per unit of labor, and WK is k's share of output per unit of labor.

The terms of the equation, $\Delta q/q$, $\Delta k/k$, $\Delta m/m$, and $\Delta i/i$, are correct only for infinitesimal changes. If there are large changes, q, k, m, and i would be incorrect divisors and would introduce a bias into the technological index. To minimize this bias, values of q, k, m, and i are taken to be an average value between two adjacent 3-year averages (2). The final equation which is used in this study can be written:

$$\frac{\Delta A}{A} = \frac{\Delta q}{\frac{q_{t_1} + q_{t_2}}{2}} - WK\frac{\Delta k}{\frac{k_{t_1} + k_{t_2}}{2}} - WM\frac{\Delta m}{\frac{m_{t_1} + m_{t_2}}{2}} - WI\frac{\Delta i}{\frac{i_{t_1} + i_{t_2}}{2}} \tag{8}$$

The output and the inputs in equation (8) are expressed in constant dollar units. $\Delta A/A$, which is the expression for technological change in agriculture, can now be derived as a residual by subtracting the change in the inputs from the change in output.

The index of technological change was computed by setting the first period A(t) 1950 = 1 and then using the equation

$$A(t+1) = A(t)\left(1 + \frac{\Delta A(t)}{A}\right)$$

to construct a value for the remaining periods. This will give a separate measure of technological change for each period in the study.

Nature of the Data

All the data used in this paper are obtained from USDA sources (10). The data were adjusted to constant 1957-59 dollars by deflating the output and each input separately by an appropriate price index (1957-59 = 100). Because of the sharp fluctuations in the data, a 3-year moving average was used to smooth out the major irregularities due to weather and other extraneous factors.

The gross value of all crops and animals raised on the farm was used as a measure of agriculture's output. This includes both the products sold off the farm and those which were used on the farm. All the values in this study are expressed in terms of either gross value of output per unit of labor or gross capital per unit of labor. When using gross terms in a Solow-type model, we must consider depreciation as a part of the factor shares.

Labor inputs are expressed in total man-hours worked. This includes all the man-hours worked by the farm operator, his family, and hired workers.

The data have been arranged in 15 time periods covering the years from 1950 to 1966. Each period represents a 3-year moving average of both the gross farm output per unit of labor and the capital per unit of labor. Since the mathematical method used in this analysis calls for each factor to be paid its marginal product, we must assume that a perfectly competitive equilibrium exists for each period. It is generally considered that agriculture is not in a state of equilibrium for any year but the use of the 3-year moving average would tend to approximate this condition. The number of years used in the moving average was only limited by the fact that each additional year decreased by one the already small number of degrees of freedom.

The capital input "K" was defined to include land, buildings, and inventories of livestock and crops on the farm as of January 1 of each year. An annual charge of 5.0 percent for this type of capital input was used to compute its share of the gross farm output. This rate was the average interest rate charged by the Federal land banks during the time covered in the analysis.

The inputs in the farm machinery sector include 40 percent of the autos on the farm, 78 percent of the trucks, and the entire stock of tractors and all other types of farm machinery. An annual charge of 6.4 percent for machinery was used to compute its share of gross farm output. This percentage was the average interest rate charged by the Farm Production Credit Association during the time covered in this analysis.

The use of the interest rate to determine each input's factor share may not be realistic, but it is consistent with the assumptions of the Solow type model. If we assume a state of equilibrium for every time period, each unit of capital should be earning a rate of return equal to the interest rate charged. In many studies of this type a rate of interest of 6 to 8 percent is used to compute farm machinery's factor share. In this context, my interest charge of 6.4 percent is not entirely out of line. The interest rates used in my study also show the differential between the interest rates charged on land and buildings and the interest charged on machinery and equipment for the time period covered in this analysis.

The value of purchased intermediate capital inputs "I" was the sum total of the operating expenses incurred for each period covered in the analysis. The intermediate capital inputs include feed, seed, fertilizer, building and machinery repairs, taxes, and other miscellaneous expenses.

Results

The index of agriculture's technological change shows that A(t) has increased about 87 percent over the 15 time periods (table 1). The average rate of technological growth over the 15 periods is about 4.6 percent. At the same time, table 1 also shows that the output per man-hour has more than doubled.

A plot of the movements of A(t) over time shows that technology has increased in all years except for a slight decrease in 1961-63. The constant increase can be partly attributed to the effects of use of the moving average in the data series.

Chart 1 shows a plot of $\Delta A/A$ over the 15 time periods covered in the analysis. A regression of the $\Delta A/A$ against the sum of all the capital inputs showed no correlation. Using Solow's reasoning, we can therefore assume that from 1950 to 1966 shifts in the aggregate production function "netted out" to be approximately neutral (9). Solow describes neutrality to mean the shifts in the production that change output but leave the marginal rate of substitution between the factors unchanged at some given capital to labor ratio.

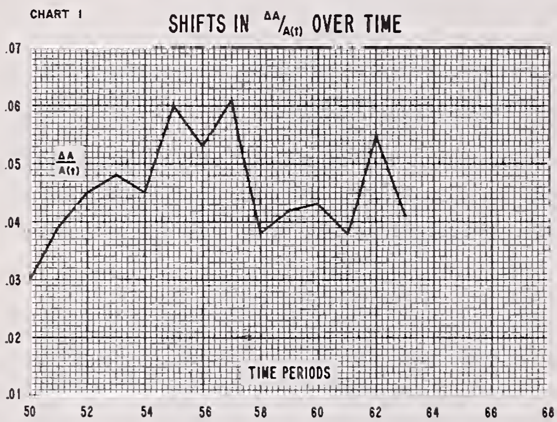
Murray Brown states that the method used by Solow to test for neutrality is not conclusive in itself because the capital-labor ratio could change in such a way as to leave the proportional changes in the function zero and still there might be a nonneutral change (1). Griliches, however, indicates that there is no reason to dispute the finding that agriculture does have neutral technological growth (3).

By using Solow's approach, it is possible to show that over the 15 time periods used in my analysis, one-fifth

Table 1.–Index of technological change in agriculture and the components of the index, 1950 to 1966

Period	Output per unit of labor (q)	Capital per unit of labor (k)	Machinery per unit of labor (m)	Intermediate products per unit of labor (i)	Capital share (K)	Machinery share (M)	Intermediate share (I)	Change in production function Δ A/A	Technological change index A(t)
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Ratio*	*Ratio*	*Ratio*		
1950 - 52	1.733	8.965	0.993	0.774	0.258	0.0366	0.0453	0.0304	1.000
1951 - 53	1.824	9.487	1.098	.814	.260	.0385	.0446	.0394	1.0304
1952 - 54	1.936	10.032	1.213	.858	.259	.0400	.0443	.0452	1.0709
1953 - 55	2.047	10.259	1.303	.907	.251	.0416	.0443	.0484	1.1193
1954 - 56	2.178	10.586	1.398	.976	.243	.0411	.0448	.0449	1.1734
1955 - 57	2.325	11.224	1.488	1.063	.241	.0409	.0457	.0603	1.2260
1956 - 58	2.531	12.097	1.573	1.173	.239	.0397	.0464	.0538	1.2999
1957 - 59	2.731	12.937	1.643	1.286	.237	.0385	.0474	.0611	1.3698
1958 - 60	2.952	13.604	1.707	1.394	.230	.0370	.0472	.0382	1.4534
1959 - 61	3.111	14.217	1.768	1.487	.228	.0363	.0478	.0425	1.5089
1960 - 62	3.290	14.744	1.859	1.601	.224	.0361	.0487	.0429	1.5730
1961 - 63	3.474	15.248	1.902	1.720	.219	.0350	.0495	.0381	1.6404
1962 - 64	3.658	15.866	1.982	1.841	.217	.0346	.0503	.0550	1.7028
1963 - 65	3.908	16.479	2.066	1.963	.211	.0338	.0502	.0414	1.7964
1964 - 66	4.141	17.301	2.235	2.113	.209	.0345	.0510	–	1.8708

CHART 1



of agriculture's increase in output can be attributed to the use of total capital per man-hour and four-fifths to technological change. To compute the contribution of capital divide the 1964-66 value of output per man-hour (4.141) by 1.8708 which is the 1964-66 index of technological change (value for A(t)). This will produce a value of output per man-hour that is net of all technological change resulting from shifts in agriculture's production function over the 15 time periods. This new or "corrected" value (2.213) minus the 1950-52 output per man-hour of 1.733 determines a measure of capital contribution toward the increase output. Therefore, about 48 cents of the $2.41 increase can be attributed to increased capital intensity and the remainder to increased productivity.

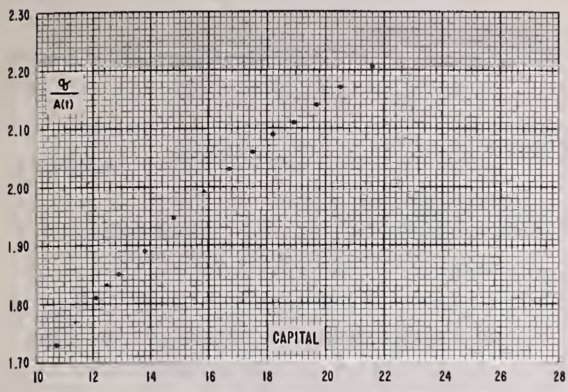
This means that approximately 80 percent of the increase in output per man-hour can be attributed to technological change and 20 percent to the increase in capital intensity.

If we had started with factor technology and had credited the remainder to capital intensity, we would find that 37.3 percent (rather than 20.0 percent) of the increase in output per man-hour could be imputed to increased capital intensity. The percentage increase in output per man-hour is 138.9 percent and the increase in technology A(t) is 87.1 percent. Thus, technology accounts for 87.1/138.9 or 62.7 percent and the remainder or 37.3 percent is credited to capital intensity (8).

If we combine the two methods described above, we can say that between 62 and 80 percent of the increase in output per man-hour can be attributed to technical change and between 20.0 and 37 percent can be attributed to capital intensity.

A plot of the output per man-hour corrected for any change in technology (Q/A(t)) against the total capital used shows that there is a close relationship (chart 2). Chart 2 gives the visual impression that the graph is slightly downward sloping. By fitting various types of regression equations to the data it was shown that a curvilinear function had a slightly higher coefficient of determination than the linear function. This would seem

CHART 2 A SCATTER OF $Q/A(t)$ AGAINST CAPITAL



to indicate that agriculture's aggregate production function does show a tendency toward diminishing returns.

It is of interest to note that when the Cobb-Douglas function was applied to the aggregate production function for agriculture, the B value for total capital was 0.351. This seems to be consistent with both Douglas's and Solow's findings that capital contributes about one-third to the total output.

Farm Machinery Analysis

It was shown above that 48 cents or 20 percent of the increase in the output per man-hour could be attributed to the increased use of total capital. Using the usual assumptions made for the Cobb-Douglas function, we can say that each factor contribution toward its output is proportional to its beta coefficient. The b value for farm machinery during the periods covered in the analysis was found to be 0.03319. From this value we are able to compute the contribution made by farm machinery as a percentage of the increase attributable to the use of total capital. Of the 48 cents attributed to total capital, farm machinery contributed about 9.4 percent or about 4½ cents.

Table 1 shows that the factor share of farm machinery (W_M) has shown a definite decline for the periods 1955-57 to 1963-65 while the farm machinery per unit of labor (m) has continued to increase. There seems to be a slight increase in farm machinery's factor share in 1964-66.

In an effort to determine the direct effects that farm machinery has played in the agricultural technology change, I recomputed the index of technology excluding the farm machinery input. This had the effect of lumping the increase in output directly attributed to farm machinery with the new index of technology $A(t)'$. The recomputed index showed an $A(t)'$ value of 1.9269 for the last period. Therefore, the extra output, which can be directly attributed to the use of farm machinery, increased the index by only 0.0561 index point.

A semilog graph of the output per man-hour corrected for technological change ($Q/A(t)' - Q/A(t)'$) plotted against the inputs of farm machinery used in each period showed a downward sloping curve. The chart indicates that the output due to farm machinery is increasing but at a decreasing rate. These results indicate that farm machinery is reaching a point of saturation, but the data presented here do not show this conclusively.

The data seem to indicate that farm machinery has not had an appreciable direct impact on agriculture's increase output. Since technology in this paper is measured as a residual of the output produced and inputs used in production, farm machinery's contribution to the agricultural index of technology would be very slight. G. Johnson and R. Gustafson studied the effects of farm machinery's role in increasing farm output and obtained results similar to my findings (5). They found that the increase in farm mechanization just offset the decrease in the labor input and that machinery's contribution toward output netted out to be either a very slight increase or decrease, depending on how the "interaction" effects between the inputs were allocated.

Throughout this paper I refer to only slight direct effects that farm machinery has contributed toward farm output and technological change. Farm machinery, however, when used in combination with other inputs, does help to increase output, but these so-called interaction effects are impossible to measure accurately. The Cobb-Douglas function as used here expresses the inputs in logs which are then additive. This has the effect of expressing the input variables independently of the level of application. The results would then only show the direct effects of the use of the measured variable, and would not show the effects of using the variables in combinations or the interaction effects.

Summary

1. Agriculture's index of technology increased about 87 percent from 1950-52 to 1964-66. This indicates that technology has had an average annual growth rate of about 4.6 percent.

2. Gross output per man-hour more than doubled, with between 62 and 80 percent of increase attributed

to technical change and between 20 and 38 percent to increased capital intensity.

3. Capital has accounted for approximately 35 percent of the total output. This finding is consistent with the findings of Douglas and Solow in their studies in the nonagricultural sectors of our country.

4. Agriculture's aggregate production function, corrected for technological change, shows a tendency toward diminishing returns. This tendency, however, seems to be very slight.

5. Farm machinery seems to play only a minor *direct* role in agriculture's increased output.

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Impact of Weather and Technology on Net Return Estimates

By E. L. Michalson

STUDENTS OF AGRICULTURAL economics have observed that many budgetary linear programming and other econometric models tend to overestimate crop production. This overestimation of crop production subsequently leads to very optimistic estimates of net returns for optimum farm organizations developed from such models. The cause of this overestimation of production results from the practice of using average or representative crop yield coefficients which are not weighted to eliminate the effects of weather and technology. Such yield coefficients are usually normative and often are determined independently of their relationships to other crops. The use of this type of crop yield coefficient tends to create an upward bias in estimated production because it abstracts from the normal variability inherent in crop yields. Day reported that his work on regional production dynamics tended to overpredict field crop yields (1, p. 713-741).[1] He demonstrated that the asymmetry of the crop yield probability function is an important cause of this imprecise prediction. Skewness was only part of the problem. An interaction existed between the shape of the yield probability function and the amount of nitrogen fertilizer applied to the crop. Day concluded that an econometric model of a single firm or a small relatively homogeneous area that used average yields at high nutrient levels would overpredict yields more often than underpredict them.

The results of this study tend to support Day's conclusion. Under the cropping conditions observed in the study area, average yields tended to overestimate production compared with yields weighted to eliminate the effects of weather and technology.

In this analysis it is assumed that the effects of weather and technology on crop yields are temporal with considerable variation occurring from year to year. It is also assumed that the combined effects of weather and technology on crop yields are interrelated, and that these effects are independent of managerial control.

Weather is defined as all those environmental forces influencing crop production which are beyond the control of the farm manager (4, p. 3). These forces include rainfall, temperature, and other influences such as crop diseases and insect infestations. Technology is defined as all those factors which have gone into developing higher crop yields. These factors include fertilizer, herbicides, and varietal improvement. In addition, all allocative decisions affecting resource use are assumed a priori, and no attempt is made to determine the effects of weather variation on resource allocation. Finally, this study does not attempt to explore price and quantity variance as they might be affected by weather.

The Study Area

The setting of this study is in the wheat-pea area of eastern Washington and northern Idaho. This area consisted of about 1,120,000 acres of cropland and 3,000 farms in 1964 (3, p. 2-3). The average farm size was 484 acres of which 377 acres were cropland. The wheat-pea area covers parts of Spokane and Whitman counties in Washington, and Latah, Nez Perce, and Lewis counties in Idaho.

Sources of Data

Crop yields, monthly temperatures, and rainfall data were obtained from records maintained at the Palouse Conservation Field Station located near Pullman, Wash.[2] The meteorological data consisted of hourly rainfall records and daily maximum and minimum temperatures for each month.

[1] Underscored numbers refer to Literature Cited, p. 22.

[2] G. M. Horner and L. C. Johnson maintained these records over 22 years.

A variable measuring the aggregate effects of technology was also used in the analysis. The aggregate technology variable was defined in terms of pounds of nitrogen, which permitted measuring its application in discrete units. This aggregate technological variable was derived by using a linear function developed by Legget (2, p. 11-15).[3] This formula indicated that about 3.0 pounds of nitrogen are required from all sources for each bushel of wheat grown. This functional relationship was used to determine the aggregate effect of technology on wheat yields because no records of fertilizer or pesticide use were available. The technological variable also reflects the effects of herbicides and varietal changes. Because of a lack of data, it was not possible to identify how much each individual item has contributed toward increasing yields. It was, however, possible to identify the dates of important technological changes in the wheat-pea area. These were: 1949, the introduction of fertilizer; 1956, the introduction of the Omar wheat variety; 1962, the introduction of Gaines wheat. Average yields increased from about 34 bushels to about 63 bushels per acre during this time.

Analytical Procedure

A multiple regression model was hypothesized using meteorological and technological variables to estimate crop yields. Originally both additive and multiplicative relationships among these variables were hypothesized, and both types of statistical models were tested. The additive model had a much higher R^2 and all of the β values were significant at the 0.01 level, which was not the case for the multiplicative model.

The additive model contained meteorological variables–June and July average daily temperatures, and seasonal rainfall–and the aggregate technology variable. Other variables hypothesized had been rejected on the basis of their lacking significant β values.

[3]The formula used was $Y = 11.8 + 0.348X$; where Y = bushels of wheat per acre, and X = points of soil nitrate and nitrogen fertilizer. This equation was solved for total pounds of nitrogen required to produce the yield reported for each year. The pounds of nitrogen available from natural sources were deducted and the remainder was assumed to be available from fertilizer, pesticides, and the increased vigor of new varieties. These data were then averaged over the time periods relevant to technological change and the resulting amount of nitrogen was used as an input for the aggregate technology variable. The average amount of nitrogen applied was 40 pounds per acre from 1949 to 1951, 60 pounds per acre from 1952 to 1956, 80 pounds per acre from 1956 to 1961, and 120 pounds per acre from 1962 to 1967.

Wheat was selected for the analysis because (a) it has benefited most from technological change, (b) adequate data were available, (c) it is the most important crop produced in the area, and (d) the effects of weather are relevant to specific crops (5, p. 4).

The model hypothesized for the study was:

$$Y = 276.450 - \underset{(0.641)}{2.062X_1} - \underset{(0.678)}{2.317X_2} + \underset{(0.394)}{1.539X_3} + \underset{(0.031)}{0.282X_4}$$

where Y = yield per acre,
X_1 = June average temperature,
X_2 = July average temperature,
X_3 = total rainfall, and
X_4 = technology.

The coefficient of determination and the standard error of estimate of the regression curve were $R^2 = 0.843$, and $S_{y.x_1.x_2.x_3.x_4} = 5.632$. The partial regression coefficients were all significant at the 0.01 level or greater, and all signs were logical. The standard errors of the betas are shown below the coefficients.

Yield Categories

The multiple regression equation hypothesized above was used to develop a yield probability distribution for wheat. To develop any probability distribution some class interval must be defined. This class interval is usually selected from an arbitrarily defined frequency distribution. In this analysis, the standard error of estimate of the estimated regression curve was used to define normal yield. This normal yield is a range of yields varying from the +1.0 to –1.0 standard errors around the regression curve.

The standard error of estimate calculated for the above multiple regression curve was 5.6 bushels per acre. A normal yield would be any yield falling within a range of +5.6 or –5.6 bushels per acre around the regression curve. If the estimated yield were 40 bushels per acre, then a normal yield would vary from 34.4 to 45.6 bushels per acre. This definition created three categories of yields: A, supernormal yields lying above one standard error ($P = 0.09$); B, normal yields lying within one standard error of the estimated yields ($P = 0.68$); and C, subnormal yields lying below one standard error ($P = 0.23$).

Crop Yield Indexes

Once the yield categories were defined, crop yield indexes were developed for each crop. The formula used to develop these indexes was:

$$I = (\Sigma Y/N)(1/X)$$

where I = the index for a category (A, B, or C),
Y = the summation of yields (in A, B, or C),
N = the number of observations in each category (A, B, or C), and
X = the weighted average yield for all categories.

A yield index was computed for each category using the yields observed in each category. These indexes were all based on the probability distribution developed above for wheat. This procedure related the crop yields of other crops in the rotation to those of wheat, and was used because all these crops are grown simultaneously in a rotation. If separate yield probabilities had been computed for each crop, the estimated net returns would not have been consistent with the yield levels resulting under a specific set of weather and technological conditions. In other words, the optimum weather for maximum wheat yields is not necessarily that for maximum barley or dry pea yields.

Estimating Net Returns

The above yield indexes and probability distributions were used to compute a new set of gross returns estimates for a set of farm organizations developed using linear programming (3, p. 18). The basic cost structure of these firms, developed in the linear programming analysis, is maintained and net returns are estimated for each crop yield category. Then a simple expectation model is used to determine the expected value of net returns for each farm size.

The mathematical model used was:

$$\phi = \Sigma X_{ij}Z_j \ (i = 1, 2, 3)$$

where ϕ = weighted value of net returns,
X_{ij} = the expected net return for each yield outcome, and
Z_j = the probability of a yield outcome.

This mathematical expectation is the average net return expected over time.

Results

The net returns estimated using the regression results were compared with those developed by the linear programming analysis, and are shown in table 1. The net returns in the linear programming models varied from $1,228 for the 600-acre wheat-pea farm to $18,604 for the 1,900-acre farm. When the multiple regression data are used these returns vary from $629 to $16,904. The linear programming analysis overestimated net returns by 49 percent for the 600-acre farm, 17 percent for the 800-acre farm, 11 percent for the 1,200-acre farm, and 9 percent for the 1,600- and 1,900-acre farms. These differences are estimates of the bias resulting from using single-value yield coefficients, which represent average-yield response, compared with using those that reflect the impact of weather and technology on crop yields.

One interesting point that came out in this study is that errors in estimated net returns vary with farm size. As size is increased from 600 to 1,600 acres, the farm's fixed resource capacities are more fully utilized. This

Table 1: Net returns estimated using constant and variable crop yield coefficients

Item	Crop yield categories			Multiple regression model	Linear programming model	Percent (5) is of (6)
	A	B	C			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Probability	.09	.68	.23	1.00	1.00	–
Farm size:	Dollars					
600 acres	3,816	702	-833	629	1,228	51.2
800 acres	8,046	3,984	1,903	3,871	4,645	83.3
1,200 acres	16,161	10,032	6,880	9,369	10,526	89.0
1,600 acres	24,054	15,929	11,765	15,702	17,253	91.0
1,900 acres	26,411	17,265	12,119	16,904	18,604	90.9

increased utilization tends to have a modifying effect on estimated net returns, which can be observed in column 7 of table 1. The percentage that net returns are overestimated declines as size increases. This upward bias of net returns declined from 49 percent to 9 percent from the smallest to the largest farm sizes. This result implies that larger farms may be more able to withstand the vagaries of weather.

This analysis provides a more realistic estimate of net returns than linear programming or budgeting, because it eliminates the variation introduced by weather and technology from the determination of normal yields. This permits a direct evaluation of the bias introduced into an analysis by using average-yield coefficients to estimate crop production. The advantages of this procedure are that it requires only a minor amount of additional data, and that it can be used in almost any kind of study which relies on budgetary or programming techniques.

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Book Reviews

The Analysis of Response in Crop and Livestock Production

By John L. Dillon. Pergamon Press, New York. 135 pages. 1968. $4.50.

THIS IS A SMALL, concise handbook on the theory of agricultural response; a primer on the production function. The title is slightly misleading, because Dillon's presentation stresses "theory" more than "analysis." Graduate students or advanced undergraduate students studying production economics should find this book very useful. It fits neatly between the introductory texts for undergraduates and the more advanced mathematical treatment of production response in microeconomic theory texts. Prerequisites to this book are elementary calculus and an introduction to production economics.

The author uses a formal mathematical presentation well augmented with empirical examples from agriculture. He divides his book into four chapters. The first three cover the theory of production response. Chapter 1 deals with the physical relationships between inputs and outputs. In the second chapter he adds prices and works through the calculus of simple profit equations. He includes least-cost production of a given level of output, and maximization of profits from a given level of expenditure on inputs. Chapter 3 adds the time dimension. Conventional concepts of maximization over time are presented. He also discusses complications caused by a production process that includes a time sequence of input injections and a time sequence of output harvests. Figures showing response curves and surfaces, isoquants, iso-profit lines, expansion paths, etc., are liberally sprinkled throughout these three chapters. The book is concluded with a very brief chapter on methods and problems of estimating physical production functions. Dillon presents several analysis-of-variance models with possibly the briefest discussion to be found anywhere in the literature. Problems associated with statistical estimation are also discussed. But this chapter serves the author's purpose of introducing the student to production response research.

The highlight of Dillon's book is his liberal reference to supporting literature. He refers to about 150 textbooks and research publications pertaining to production response. At the end of each chapter there is a section that describes where to find more information on each of the major subjects in the chapter. This should be especially useful for the student audience.

Jerry A. Sharples

Agribusiness Coordination: A Systems Approach to the Wheat, Soybean, and Florida Orange Economies

By Ray A. Goldberg. Harvard Business School, Boston. 256 pages. 1968. $12.

AGRIBUSINESS AS DEFINED by the Harvard Business School includes farm supply industries, farming, and the many food and fiber processing and distribution industries. Employment in the farm supply sector was 8 percent of total U.S. employment in 1947 and again in 1966. Processing and distribution accounted for 16 percent during the same 2 years. But farm employment dropped from 17 to 7 percent of the total work force employed.

In this context, Goldberg sketches recent trends in U.S. agribusiness, and launches into his main theme and its illustration in three commodity fields. The central concept is that managers, private and public, must be fully aware of the total commodity system in which they participate if they are to develop effective strategies and policies.

The commodity analyses are in terms of dynamics (developments), structure, and behavioral and performance patterns. The method is essentially descriptive, abundantly illustrated with tables and charts. The examination of all phases of marketing of the three farm products selected is thorough and detailed, even to the point of tedium. Almost neglected, on the other hand, are the other two sectors of agribusiness.

The book is informative. The subjects are well researched. Much information is given on the marketing and distribution systems for wheat and wheat products, soybeans and soybean products, and Florida oranges and frozen concentrated orange juice. Such comprehensive and detailed information can be drawn upon by advanced students of marketing and probably by many in the affected industries themselves, as stated by the author as his central theme.

A major drawback, however, is the high "fog index"–too many long sentences, dependent clauses, dangling phrases, and long words. Many examples of this kind of error in communication might be given. One, chosen from the summary, will do. "Although managers of firms in any kind of industry structure must be aware of their total industry environment, the peculiar characteristics of agricultural industries with unpredictable and seasonal supplies, the expanding interrelationships in the vertical structure from farm supplier through ultimate distributor, the need for a strong infrastructure, the increasing significance of world markets, and the existence and importance of complex coordinating machinery make a systems approach much more critical in the development of strategies for firms in agricultural industries than for firms in other types of industrial structures."

Robert M. Walsh

Perspectives in Developmental Change

By Art Gallaher, Jr. University of Kentucky Press, Lexington. 263 pages. 1968. $8.50.

THE TECHNOLOGICAL REVOLUTION, a 20th century phenomenon, has thrust the concept of developmental change into a major area for study. There are several forces creating problems of developmental nature, namely (1) the disintegration of colonial empires, which has left newly emerging nations with more economic and social problems than they had as dependencies, (2) the difficulties attending the development process which are widely advertised through forums like the United Nations and its specialized agencies, and (3) the fact that developed nations have made development aid an integral part of their foreign policy.

The problems are not solely restricted to economic change; they include improvement in other social dimensions. In this book several eminent social scientists examine essential problems associated with developmental change utilizing the theoretical know-how and empirical data of various disciplines.

Morris E. Opler contends that the concept of developmental change is fundamentally grounded in theories about the nature of man. Human behavior is not determined by impersonal forces; man is free to design his own future. Leonard W. Doob holds that developmental change is aimed at modifying the behavior of people. Development is not purely institutional; planning developmental change should be approached through psychology. Education is one of the most important ingredients in the development process. It is therefore, Solon T. Kimball states, the obligation of social scientists to clarify education. This can be done by having the social scientist and educator sharing responsibilities on development projects, an association which was lacking in the past.

Bert R. Hoselitz and H. W. Hargreaves are concerned with the problems of investment planning and decision-making in particularly difficult development situations. Policymakers should not restrict themselves to making purely economic decisions but must also choose between conflicting political goals. Fred W. Riggs argues against a linear process of development that proceeds from one institutional system to another. Changes are not simply additions of desirable goods, but are rearrangements of previously existing systems. Edward H. Spicer states that developmental change is directed towards achieving a new form of cultural integration. However, to understand his concept of developmental change requires knowledge of the functional process which unites input to output goals.

Developmental change is essential to the future of both urban and nonurban societies. Wilbert E. Moore urges that change is an integral part of the behavior of societies and no society can ever believe that it has arrived at an ideal development situation. Edward Weidner asserts that change must be the product of multidiscipline efforts.

The group is in overall accord that developmental change is made through planned and purposive actions; involving all social scientists, not only economists. Implicit in the planning is knowing the exact extent to which developed nations of the world are willing to commit themselves to help less fortunate nations.

Jack Ben-Rubin

European Economic Integration and the United States

By Lawrence B. Krause. The Brookings Institution, Washington, D.C. 265 pages. 1968. $6.75.

EUROPEAN ECONOMIC INTEGRATION has been a popular subject among social scientists and journalists during the last decade. Lawrence Krause's book is one of the most significant yet written on this topic—at least from the point of view of Americans. His book is the first to provide a thorough appraisal of the economic consequences for the United States of the formation of the European Economic Community (EEC), the European Free Trade Area (EFTA), and their web—primarily that of the EEC—of preferential arrangements with a variety of third countries. He also examines the political underpinnings of the two trade blocs as well as the bases for official U.S. attitudes toward them.

This book is not only valuable for its economic analysis. The four chapters on the origins and development of European integration, agriculture, internal issues, and foreign relations document very succinctly the political movement leading toward integration. Yet, the main merit of the book lies in the analysis of the impact of integration on economic growth, trade in manufactured goods, trade in farm products, and foreign investment. In each case, Krause attempts to quantify this impact. However, he warns "those who would take the numerical estimates in this study too seriously."

The estimates of the trade impact allow for the effects of the EEC and the EFTA upon income growth via stimulation of business investment and trade. Krause estimates (by methods developed by Edward Denison) that the annual income increments induced by integration vary among EEC countries from 0.18 percent in Germany to 0.22 percent in Italy. Among EFTA countries, the increments to gross domestic product (GDP) range from 0.03 percent in Norway to 0.25 percent in Denmark. Overall, he concludes that the EEC has had a "somewhat greater" effect on the GDP of its members than EFTA has had on its members. He also concludes that, as expected, integration has stimulated trade among members of both blocs—profoundly in the case of the EEC.

Krause estimates the loss of trade in manufactured goods caused by creation of EEC and EFTA at $238 million (1958 prices) annually for the United States. This amount represents the difference between actual sales to the two trade blocs during the respective transition periods and the estimated sales without integration. The loss of EEC exports is estimated at $161 million, while the EFTA loss is $77 million. There would be secondary effects; for example, the United States would suffer repercussions from a $250 million trade loss by other nonmember countries.

Most journal readers will undoubtedly be most interested in the chapter simply entitled "Agriculture." This chapter is heavily weighted toward the EEC because of the EEC emphasis on agriculture. The analysis of this chapter is approached as follows: a review of European agriculture before integration to allow a judgment of its possible development without the EEC, an examination of EEC policies to determine their consequences for agriculture, and an estimate of the consequences of integration on the EEC and on nonmember farm trade.

The author first puts the agricultural protectionism of the EEC into historical perspective by pointing out that "it has a long tradition on the continent," and reviewing the rationale behind it. Protectionism, domestic price policies, improved technology, and other factors allowed the six EEC countries to increase self-sufficiency; output grew by 65 percent from 1948 to 1958, while consumption of farm products grew by only 40 percent.

Krause hypothesizes, however, that without a unified market for farm commodities, "rather powerful constraints" (the need to stabilize prices, the need to move workers from farm to factory, and fiscal demands) would have required a more rational approach to agriculture by each country. He points out that the principles of agricultural policy contained in the Rome Treaty (raising farm productivity, raising farm incomes, stabilizing markets, and ensuring reasonable consumer prices) may be contradictory. That is, while higher incomes could result from increased productivity, requiring "a drastic disregard of structural problems," the alternative of higher producer prices would "disregard the consumer interest." The Mansholt Plan was an attempt to resolve this contradiction by having one long-term program to improve the economic structure of agriculture and another to deal with more immediate problems of the market. Krause observes that this idea, if approved, would not have completely resolved the conflict of interests since the desired structural changes could easily have been frustrated by price policies which hindered rather than stimulated resource mobility. Nevertheless, the structural program was relegated to a remotely secondary position and the plan was never tried intact. Thus, the Common Agricultural Policy (CAP) relied almost exclusively on high price policies, backed up by a system of variable levies which is "recognized by Europeans as highly protectionist. . ."

To evaluate the effect of the EEC, Krause estimates the stimulative impact of integration upon farm prices and output to 1965. The estimated average farm price increase varied from 8 percent in the Netherlands to 14 percent in France, and the resulting increase in output ranged from 0.8 percent in the Netherlands to 2.8 percent in France. In contrast, consumption of farm products was increased by amounts from 0.16 percent in Germany to 0.50 percent in Italy by the effects of integration. Agricultural import replacement by EEC production in 1963-64, valued at world prices, is placed at $340 million. The annual loss of export sales of the

United States is estimated at $150-200 million for 1965–about half of the nonmember country impact. Further trade diversion stemming from the CAP through stimulation of grain output is estimated to reach $200 million by 1970, $65 million being the U.S. loss in grain sales (the latter based on projections by others).

Noting that EFTA has no direct influence on farm policies of its member governments and is limited in its influence on farm trade, Krause concludes that EFTA "does not appear to have affected the agricultural trade of the United States." While U.S. exports of cotton, tobacco, and feed grains have declined, they have not been displaced by EFTA producers, Krause notes.

Examining some other implications of integration, the author states that abandonment of the CAP would be very important from a balance-of-payments viewpoint. A potential half-billion-dollar increase in imports per year by an area with a balance-of-payments surplus would be highly significant in the context of current imbalances. The stimulation of agriculture in high-cost areas also results in (1) the displacement of exports (and production) of low-cost areas and (2) a misallocation of such countries' resources through distortion of the international pricing mechanism. Both of these considerations, according to Krause, strengthen the case for condemning the CAP. Krause's work appeared only shortly before EEC inhabitants, including many farmers, began to increasingly condemn the CAP because of its mushrooming cost and burgeoning farm surpluses. Some reassessment is underway in the EEC; the United States will anxiously await news of any change of direction.

In the final chapter, the author analyzes the current issue of British membership in the EEC, the roles of the EEC and the EFTA in the Kennedy Round, and some noneconomic aspects of integration.

This book is a "must" for analysts, scholars, and policymakers interested in the effects of European economic integration. The analysis is very thorough and helps to fill a serious breach in our knowledge of economic integration.

Robert Shepherd

African Agricultural Production Development Policy in Kenya, 1952-1965

By Hans Ruthenberg. Springer Verlag, New York. 164 pages. 1966. $7.

COST-BENEFIT ANALYSIS is a controversial technique of economic diagnosis and prognosis and has piqued economists and policy administrators involved in economic development.

This study is basically a cost-benefit analysis of resource investment in Kenya from 1952 to 1965.

Professor Ruthenberg attempts to evaluate Kenya's experience in allocating and using public sector funds for a wide range of specific projects for the promotion of African farming.

A cost-benefit analysis is performed on the following development projects in Kenya: (1) Agricultural administration and extension; (2) small-holder tea plantations; (3) grazing schemes; (4) land settlement in new areas; (5) resettlement in former European areas; and (6) large African farms in the former European-held areas.

What are the precise costs of a particular project? What benefits are to be received from the investment in available resources? What priority is to be given to the allocation of resources to the particular problem at hand? What are the alternative uses of resource inputs? These are questions that are germane in order to make realistic appraisals of development projects in Africa. Providing the answers–or a basis for the answers–is one of the author's goals.

Professor Ruthenberg's major contributions in this study are the presentation of a systematic methodology useful in tackling cost-benefit analysis problems, and the ability to conceptualize the socioeconomic problems facing Kenya and present them in a precise sequential manner.

The author makes it abundantly clear that tribal rigidities, cultural constraints, and the lack of economic incentives among the Africans exacerbate the problems of economic growth in Kenya and are major deterrents to the economic development of countries in Africa south of the Sahara.

The scope for increasing the acreage of cultivated land in Kenya is limited; however, significant possibilities exist for irrigation development. Professor Ruthenberg states:

> Kenya has reached a stage in development where large irrigation schemes are urgently needed:
>
> • There is a growing land shortage and little unused land that can profitably be farmed intensively without irrigation.
>
> • There is a growing internal market for the produce of irrigation farming.
>
> • There are more and more farmers' sons who cannot be absorbed elsewhere, who have a background of arable farming and realize the necessity of putting great efforts into their performance as irrigation settlers.

• Irrigation development and farming has a rather high employment content.
• Kenya is highly vulnerable to the vagrancies of unreliable rainfall. Food production in particular is strongly influenced by the variation in weather. Irrigation development would bring some stability into the farming industry and could substantially lower the costs of famine relief in dry years.
• The task of irrigation development could largely be transferred to private enterprises, and the additional burden on Government departments could thus be kept low. The staff demands of irrigation farming are low compared with extension: in irrigation farming the subordinate staff receive clearcut orders which have to be executed and it is far easier to obtain suitable staff for such a purpose than for extension.

. . . Future irrigation development in Kenya is likely to be more expensive than in many other parts of the world. There are undoubtedly numerous possivilities for small local schemes which do not offer sufficient scope for the organization of a proper scheme and for the employment of a highly qualified manager. These possibilities could be developed cheaply if the peasants concerned would be prepared (1) to do unpaid communal work in order to establish the necessary works, (2) to submit themselves to strict water control, (3) to farm the area properly and (4) to pay a water rate sufficient to repay the initial investment. All this has been customary in East Asia but it is certainly not likely—at least within the present setting—to occur in Kenya.

Concerning the future economic development of Kenya, Professor Ruthenberg states:

Finally it should be pointed out that sustained economic growth in Kenya—more than in most other African countries—is highly dependent on the free movement of goods and labor within a market which should preferably be even greater than the East African Common Market. Free traffic in goods is required for the expansion of industry, which in turn provides local buying power for smallholder produce. The pressing population problems could be eased if Kenya's rural surplus population could and would develop the habit of moving into expansion areas in Tanzania, Uganda and, in particular, in the Republic of the Congo, where ample land is available.

This study is of great value to international economists, agricultural economists, government policy administrators, and academicians working in the field of agricultural development.

It is hoped that these cost-benefit guidelines to economic development and agricultural policy that have been formulated by the author will not go unheeded, but will be put into action.

Never in the course of modern times has history required that so much change be compressed into so short a period of time. The transition from traditional agriculture to commercial agriculture must be made in a hurry, telescoping the transition that required centuries in the past into years and months for the future.

Carey B. Singleton, Jr.

Israel and the Developing Countries: New Approaches to Cooperation

By Leopold Laufer. Twentieth Century Fund, New York. 298 pages. $2.50.

DIGGING INTO THE MOUNTAIN of material written in the last decade on Israel's aid to emerging nations, Leopold Laufer has come up with a workable survey of this unusual situation. Israeli aid is unique, not only because it comes from a developing nation but also, as Laufer says, "Of all the emerging countries engaged in mutual assistance activities, Israel has the largest and the most varied program."

The Israeli aid program to other countries began in 1954, only 6 years after Israeli independence, when Burma sent a military mission to Israel. Soon afterward government-to-government relations began with Ghana. One of the results was the successful establishment of the Ghana Black Star Shipping Line as a joint venture. At the same time, Israel helped reorganize Ghana's trade unions and initiated many technical assistance programs. This was the beginning. From then on, working with the host governments, Israel set up many needed programs and projects so that today a foreign aid program has evolved for some 80 other emerging nations throughout Africa, Asia, and Latin America.

Israeli aid falls into a few general categories: Direct technical assistance, joint ventures, training programs in Israel, academic and vocational programs, each of these having its own aspects and serving a very definite need of the developing countries. Laufer has done an admirable job in classifying each program and presenting its many facets. The technical assistance program centers largely on sending Israeli experts to host countries. The program began with 40 technicians in 1958 and involved some 640 people by 1966. Israeli experts in foreign lands serve a dual purpose. First, they plan and carry out projects; this is the immediate goal. Secondly and perhaps more important for the future, they teach the local population to take charge of projects once the Israelis leave.

Israeli technicians work in many fields and are usually chosen because of their specialties. Thus in 1958, Israel began work in Ghana to help develop cooperative farming and resettlement projects, water control, cooperative banking, and electrical facilities. In Liberia, Israeli ophthalmologists opened an eye clinic which in the first 18 months served more than 12,000 patients. Israeli workers are popular and much sought after because as Laufer says, ". . . Israeli experts are generally hard-working, devoted to their jobs and intent on transmitting their knowledge to the people in the host countries." As with all aid, demand exceeds supply and the shortcomings of this direct technical aid have prompted Israel to establish a program of bringing foreign personnel into Israel for special training in both technical and academic courses. Frequently, on-the-job training is provided in various state and municipal departments in Israel. Special programs and even institutions, such as the Afro-Asian Institute to train leaders in trade unionism and cooperation, have been established to expedite training.

Israeli aid to foreign countries is minuscule compared with that of the industrial powers, in some years involving the relatively small outlay of $10 million in contrast to the more than $2 billion expended annually by the United States for such purposes.

Why have other emerging nations sought Israeli aid? Many countries see themselves as Israel was 20 years ago. Their problems are similar and they know that Israel has solved them or is solving many of them. Because of Israel's own size, her projects are naturally small and are thus readily adaptable to the needs of other developing nations. Laufer senses that industrial powers are often unaware of the problems of emerging nations and find it difficult to realize the process of development.

Frequently, as in Africa, countries prefer Israeli help over aid from larger powers, particularly former colonial masters. While young nations have second thoughts about accepting aid from the industrial powers, they see little difficulty in accepting Israeli aid. Primary here is the veiw that cooperation with Israel is expedient in accomplishing intended goals without compromising political positions.

For Israel, support in the international arena, especially at the United Nations vis-a-vis Arab votes, is the yardstick by which success is measured. Often, recipients of Israeli aid have voted with Israel or abstained on questions dealing with the Middle East conflict. But the author notes that following the armed conflict of June 1967 many nations receiving Israeli aid were vociferous in their denunciation of Israel.

Laufer's theme is that although Israeli aid is financially small, it is highly effective. He stresses that size need not be the criterion for effective aid but a willing attitude among those giving aid and those receiving it is absolutely essential.

Laufer devotes a chapter to aid provided by other developing countries such as Nigeria, Ethiopia, Turkey, and the Ivory Coast. These countries, having been the recipients of aid, now provide aid to other nations. Here, perhaps, is the goal of every aid program—a pool of the common knowledge and experience of all developing nations, to create a more effective program and delete waste and mutual mistakes. Toward this end Laufer makes some valuable suggestions.

Michael E. Kurtzig

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