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THE IMPACT OF ADOPTED TECHNOLOGICAL CHANGE ON FARMLAND PRICES IN MANITOBA

by

John David Dyck

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JOHN DAVID DYCK

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ABSTRACT

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by JOHN DAVID DYCK

MAJOR ADVISOR: DR. DARYL F. KRAFT

Technological innovations have been rapidly and widely adopted by Manitoba crop producers in recent decades. Concurrently, Manitoba farmland prices have risen dramatically. No studies examining the causal relationship between the two have been undertaken.

This study tests the hypothesis that technological innovations have increased Manitoba farmland prices. Two models are involved in the investigation. The crop yield model measures the influence of adopted agricultural innovations on Manitoba crop production. The land price model determines the impact of these technologically induced grain and oilseed production increases on Manitoba farmland prices. The study is conducted on the crop district level.

The crop yield model is estimated with ordinary least squares. The five principal crops, wheat, oats, barley, flax, and rapeseed, grown over the period 1958 to 1976 are considered. To remove the impact of summerfallow acreage variation on average crop yields, each crop is further divided into fallow and stubble production. Crop yield is a function of the rate of application of nitrogen fertilizer,

the rate of application of phosphorous fertilizer, the level of varietal improvement, and the levels of soil moisture deficits and/or excesses throughout the growing season.

The farmland price model is a distributed lag model in the autoregressive form and is estimated using ordinary least squares. The dependent variable is the market price of farmland in each year between 1963 and 1976 and is a function of the lagged land price and lagged net income from crop production. The latter is derived from the predicted yields determined in the crop yield model and crop price and production cost data.

The statistical relationships determined from the land price model are employed to simulate farmland prices under various levels of adopted technology. The simulated land prices are compared to estimate the impact of adopted technological innovations on farmland prices in Manitoba.

Crop yield model analysis shows that Manitoba grain and oilseed yields are influenced primarily by the level of nitrogen and phosphorous fertilizers applied, soil moisture deficits and excesses during the growing season, and the level of development and adoption of improved varieties. The land price model explains over 85% of the variation in actual land prices in all districts. Both explanatory variables are statistically significant in all districts.

The comparison of land prices simulated under various levels of adopted technology was the major objective of this study. The level of adoption of improved varieties has a

negligible impact on expected net income and, hence, simulated land prices. Ignoring district 6, the combined effect of increased fertilizer use and lower summerfallow levels increased simulated 1977 land prices in southern Manitoba between $8 in district 7 and $140 in district 4. The average total effect in the Red River Region is over $105, approximately five fold the average effect in the Southwestern Region. Within each region, the effect was reasonably consistent across districts. Districts 9 and 12 experienced effects similar to the Southwest. In the remaining Northwestern districts, because of insignificant fertilizer response rates in certain districts and increasing fallow levels in others, the adoption of actual versus 1962 levels of technology had no notable impact on relative simulated land prices.

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CHAPTER 1

INTRODUCTION

In recent decades, rapid adjustments of major proportions have been taking place in Manitoba agriculture. Tremendous increases in labor productivity have been experienced as a result of increasing capital intensity and technological advances.[1] Agricultural output has increased dramatically with the adoption of innovations and improved management.[2] The value of agricultural land has climbed steadily to record levels.[3] Considerable research and discussion has been conducted on the nature, reasons for, and significance of the first two developments, but the latter phenomenon has received markedly less attention, at least until quite recently. The increased activity of non-resident buyers one of the factors affecting the price of farmland in Manitoba, has stimulated discussion and moved the provincial government to legislate restrictions on non-resident ownership of agricultural land. However, studies examining the various factors influencing the price of farmland have been rather limited, particularly in a Western Canadian context.

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[1] See Note 1.

[2] Ibid., p.63. Agricultural output in Canada (weather adjusted) in 1949 constant dollars rose from $2719 million in 1947 to $3571 million in 1965. The increase in output in Manitoba can be expected to be proportional.

[3] A representative crop district which can be used to illustrate the movement of land prices in Manitoba over the last two decades is crop district eight. The average land prices in this crop district rose from $44 in 1958 to $141 in 1976. Manitoba Agricultural Yearbooks, 1958-1976.

From observation of the rapid and widespread adoption of technological innovations in agriculture in recent decades and the concurrent steady rise in farmland prices, it may be hypothesized that a causal relationship exits between the two. Technological change increases the marginal productivity of some or all of the agricultural inputs, thereby reducing the per unit costs of production. Given that product price levels do not fall by a corresponding amount, the result is an increase in 'net income' per acre, that is, total receipts per acre minus all costs other than the return to land, management, and operator labor. These costs might be termed 'intermediate variable costs'. If farmers and other real estate investors perceive the existence and expected continuance of higher net income per acre, economic theory suggests the increased residual stream will be capitalized into the price of the fixed factor which controls access to the income stream. The hypothesis advanced in this study is that technological progress has increased farmland prices in Manitoba.

The capitalization of agricultural innovations into farmland prices may create less equal distribution of provincial wealth. This involves the redistibution of wealth among farmland owners (including non-resident owners), consumers, the agribusiness industry, and taxpayers. In Canada, the bulk of the cost of agricultural research is borne by the agribusiness industry and the federal government while extension is predominantly a provincial domain. Expendi-

tures on the development of improved varieties of the principle cereal and oilseed crops are shouldered exclusively by federal taxpayers while industry largely bears the burden of research costs for the development of improved fertilizers, pesticides, and farm machinery. The distribution of the investment benefits is of concern from an equity standpoint.

In the event that crop prices do not decline with the adoption of a technical innovation, the increased net income per acre is expected to be capitalized into land prices in which case land owners are the sole beneficiaries. If the innovation is in the form of a higher yielding variety, wealth is distributed from taxpayers to land owners. If improved fertilizers, pesticides, or farm machinery constitute the adopted technological change, land owners capture some of the benefits of the agribusiness industry's research. Because the private sector cannot capture all the revenues from its research expenditures, the level of research and development by the agribusiness industry is less than socially optimal.

Alternatively, if crop prices decline with the adoption of a new technology and the net income per acre remains unchanged or possibly even declines, consumers receive all the benefits. Therefore, with a technological change in the form of improved varieties, wealth is transfered from taxpayers to consumers and in the event of a decline in net income per acre, from both land owners and taxpayers to

consumers. However, if the technological innovation is developed by the agribusiness industry, the redistribution is less clear. Provided the industry realizes a satisfactory return on their research investments and farmers' net income remains unchanged, consumers capture the benefits from research which in the above situation would have gone to land owners. If net income declines, wealth is redistributed from land owners to consumers.

The third and most likely case involves a crop price decline and a concurrent net income per acre rise. If the research was financed by the government, there is a redistribution of wealth from taxpayers to both land owners and consumers, the proportion accruing to each depending upon the impact of the technolcgical change on crop prices. If industry bore the cost of research while realizing a satisfactory return on its research investment, the benefits not captured by the firms will be divided among consumers and land owners. Relative shares depend upon the relative effect on crop prices and net income per acre.

The problem raised in this study is of particular relevance at this point in time because of the recent rejection of a grain check-off proposal by Western Canadian farmers. The check-off plan would have deducted a very small levy from each bushel of grain sold with the proceeds financing additional agricultural research. The proposal was voted down in a referendum held in June, 1977. The rejection appears to be due largely to a lack of

information---it is unclear who receives the benefits of research expenditures.

The purpose of this study is to estimate the impact of the adoption of agricultural innovations on Manitoba land prices. This objective is pursued in two steps. First, the impact of adopted agricultural technological developments on Manitoba grain and oilseed production is determined on the crop district level. Secondly, the influence of these technologically induced crop production increases on the price of Manitoba farmland is determined by crop district.

A review of the underlying theory and related studies is conducted in Chapter 2. The analytical model is presented in Chapter 3 and numerically specified. Chapter 4 examines the statistical analysis and results. Finally, the conclusions are drawn and the study is summarized in Chapter 5.

CHAPTER 2

Technological progress is a major dynamic force in the agricultural sector, affecting its structure, level of income, and role in the nation's economy. A steady flow of innovations in agricultural production, particularly over the past half century, has brought about a continuously changing physical and economic productivity of farm resources. Constant readjustment of resource allocation by individual farmers has been necessitated by this steady technological advance and in aggregate, the proportion of the nation's resources employed in agriculture relative to other sectors has been substantially altered. The theoretical nature of agricultural technological change, factors affecting the rate of adoption of new technology, and the consequences of adopted agricultural technological developments are considered below. In addition, the theoretical determinants of farm land prices are examined.

BASIC CONCEPTS

The economic theory underlying the concept of technological progress is the theory of the firm. At the heart of the theory of the firm lies the production function. Whether for the individual firm or for the industry, a production function expresses the maximum output obtainable

from every possible input combination.[1] Every production function has embedded within it a certain level of technology. However, economic magnitudes such as prices and interest rates, although important in determining the input combinations, are excluded from the concept of the production function. The production function's four characteristics noteworthy for the purposes of economic analysis are:

1) the efficiency of the technology,

2) technologically determined economies of scale,

3) the capital intensity of the technology, and

4) the elasticity of substitution between inputs.[2]

Before considering the nature and consequences of technological change, a definition of the concept must be presented. According to Solow, technical change is "a shorthand expression for any kind of shift in the production function".[3] The developments causing these shifts, such as new seed varieties, are not substitutes for land and labor by themselves but facilitate the substitution of the factors

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[1] J.M. Henderson and R.E. Quandt, Microeconomic Theory: A Mathematical Approach, 2nd edition, McGraw-Hill, New York, 1971, p.54.

[2] M. Brown, On the Theory and Measurement of Technological Change, Cambridge University Press, 1966, p.12. A discussion of each of the characteristics follows on pp. 13-20.

[3] R.W. Solow, "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, 1957, p.312.

which are relatively scarce for those less scarce.[4] An economic convention begun by Hicks[5] classifies technical advances into:

1) "labor-saving" changes (which facilitate the use of other labor substituting inputs), and

2) "capital-saving" changes (which facilitate the use of other capital substituting inputs).

In the context of this study, the second type of technological progress may be better represented by the classification "land-saving" changes.

Agricultural technical progress can, from a physical standpoint, be classified as biological or mechanical, the former corresponding to "land-saving" changes and the latter to "labor-saving" changes.[6] Mechanical innovations are designed to facilitate the substitution of capital in the form of power and machinery for labor. Biological innovations, on the other hand, facilitate the substitution of industrial inputs and/or labor for land. Typically one or more of the following three elements are involved in this latter type of change:

1) development of land and water resources to enhance the plant environment,

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[4] V.W. Ruttan and Y. Hayami, Agricultural Development: An International Perspective, John Hopkins Press, Baltimore, 1971, p.44.

[5] J.R. Hicks, "Distribution and Economic Progress", Review of Economic Studies, Vol.4.

[6] E.O. Heady, "Basic Economic and Welfare Aspects of Farm Technological Advance", Journal of Farm Economics, 1949, p.296.

2) modification of the environment by introduction of chemical and biological agents to destroy insect pests and disease and by addition of plant nutrients to the soil to stimulate plant growth, and

3) development of biologically improved crop varieties designed to have a greater response to environmental elements subject to man's control.[7] This study is primarily concerned with biological technology.

Biological (and mechanical) technological change consists of two general types---neutral and non-neutral.[8] Neutral technological changes are produced by changes in the efficiency of a technology. Variations in the capital intensity of a technology and in the ease of substitution of industrial inputs and/or labor for land are non-neutral technological changes.

THE RATE OF ADOPTION OF NEW TECHNOLOGY

With particular relevance to the agricultural sector, research creates new technology while extension and education distribute the available knowledge to producers. The discovery of new technology by research leaves producers in a position of non-optimal allocation of resources. With improved levels of education, producers are better able to comprehend the new situations and respond rapidly and to benefit from economic opportunities to remedy non-optimal resource allocation. The function of education can be

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[7] Ruttan, op.cit., p.51.
[8] Definitions are given in Solow, op.cit., p.312.