AN EMPIRICAL ANALYSIS OF FARM MACHINERY INVESTMENT IN CANADA: 1960 - 1974

by

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ABSTRACT

The resource structure in Canadian agriculture has continued to change since World War II. Two major changes are mechanisation and labor migration from the agricultural sector to other sectors. Thus the point of departure of this study is to look closely at the relationships between these two streams.

According to economic theory, labor and capital may substitute for each other. Is this really appropriate to explain the resource structure of Canadian agriculture? In order to answer this question the study uses production theory to derive demand functions for each resource and examine their relationship to one another.

This study analyses the demand for farm machinery with an econometric model. Among other relationships two important measurements were obtained, namely the elasticity of substitution and labor capital adjustment coefficient.

Several existing models on the demand for farm machinery based on CES production fuction were tried on Canadian data between 1960 and 1974 both at national and at provincial level. A part of the results will be discussed and compared at regional level. The results indicate that investment behavior in Eastern and Western regions are quite different.

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CHAPTER I

INTRODUCTION

Since World War II the Canadian farm labor force has declined continually. Concomitant to this sectoral migration, total agricultural output has continued to increase. The upshot being that average labor productivity increased markedly. Mechanization replaced some farm labor while improved chemical and biological inputs have raised total productivity per acre. However, changes in agricultural resource structure have differed significantly between Eastern and Western Canada [10].

Since 1962 Shute concluded that agricultural productivity has increased slightly at the rate of 0.3 percent a year [18]. Farm output increased at the annual rate of 1.5 percent between 1962 and 1973, while production inputs were rising 1.2 percent annually.

The distribution of inputs in total resource mix has been changing significantly. Capital equipment has become an increasingly more important factor while labor has declined both relatively and absolutely. Economic theory suggests that as real cost of labor increases relative to the cost of labor-saving capital inputs such as farm machinery, there is an economic incentive to substitute labor extensive inputs for labor intensive inputs.

Objective and Nature of the Study

Taking the above conditions of Canadian agriculture into account, this study attempts to investigate the determinants of demand for farm machinery in Canada. Farm machines are durable productive agents of which services are inputs in the production of agricultural outputs. The theory of the firm suggests that the demand for those services, i.e. for the stock of farm machinery, depends on the price of the machines, the prices of inputs which are close substitutes or complements, the price of output and other economic variables [11]. The alternative explanations of "machanization" suggested by the theory of the firm may be examined in terms of the goodness of the fit to the data of a demand function for farm machinery containing these economic variables.

Thus this kind of study becomes an econometric study of the demand for farm machinery. One of the advantages of this type of study is that knowledge of the demand function for farm machinery may also provide useful knowledge on the responsiveness of farm investment to cyclical fluctuations in the demand for agricultural products and on the elasticity of farm output with respect to the prices of farm products and inputs.

Previous Studies

Previous studies on farm machinery demand are by Rayner and Cowling [6], Griliches [11], Scott and Smyth [17], Auer [2] and Dhruvarajan [3]. These studies may be classified into two categories, that is, analysis of demand function for farm machinery based on neoclassical assumptions and formulation and the investment function based on a macroeconomic accelerator model.

The following chapters review (i) the theoretical model of the demand for farm machinery, (ii) the source of data and construction of the major variables, (iii) the results of fitting alternative explanation of stock and gross investment demand and (iv) the discussion on farmers adjustment behavior and the responsiveness of farm machinery employment to changes in product and factor prices.

CHAPTER II

Theoretical demand function of farm machinery

Jorgenson [13] reviewed numerous investment models that started with the flexible accelerator models developed by Kaldor, Goodwin, and Hicks. Accepting Jorgenson's point of departure, Klein [14] outlines the issues in contemporary investment analysis as follows.

1. Specification of a functional relationship for desired investment.
2. Treatment of replacement and capital consumption.
3. Time structure of investment decision and implementation.
4. Estimation methods appropriate to the investment model.
5. Testing of alternative models of investment behaviour - method and results.
6. Applications to policy and forecasting.

Issues (1), (2), (3), and (6) are covered in the following sections of this chapter and (4) and (5) will be discussed in detail in the following chapter.

Specification

Most previous studies on the aggregate demand for agricultural factors have been based on the neoclassical theory of production where farmers are assumed to maximise profits. However, some studies have not been based directly on economic theory, rather they have taken into account economic issues in the choice of variables. The underpinnings of the econometric hypothesis are based upon economic theory, intuitive reasoning, or institutional information. If the study fails to explain or forecast farmers investment behavior neatly this structure provides more information about the subject through interpreting economic parameters hypothesised and tested.

(a) Static demand fuction for farm machinery

Farm machinery is a durable good and the annual influence of farm machinery services upon agricultural production is provided by the stock of farm machinery not by the quantity of new farm machinery purchased during the production period. If we deal with the long-run equilibrium demand function, annual purchases are hypothesised to be linked to the price of farm machinery services (P_m), the expected price of product (P_y) and the prices of other input flows, especially its substitute labor (P_L). As the next step we have to specify the homogeneity of the function. If the homogeneity of degree zero is assumed, then the demand function for farm machinery services is strictly a function of relative prices [6].

Since the elasticity of substitution between inputs is unknown a priori as unity as well as returns to scale, there is no reason to reject the CES (Constant Elasticity of Substitution) technology which has broader concept of factor substitution in production than other theoretical production technology such as Cobb-Douglas or Leontief type technology.

Assuming agricultural technology can be depicted by a CES relationship, then the following function is applicable

$$Q = A(a_1 S^{-b} + a_2 L^{-b} + \ldots)^{-v/b} \qquad \text{Eq. 2-1}$$

where Q denotes output and S and L denote the stock of farm machinery and hours of labor respectively. The production function may, of course, contain other factors of production. Assuming neoclassical profit maximisation and a competitive market, then the following relationship from the first order condition exists.[1]

$$(S/L) = a(P_L/P_m)^{\frac{1}{1+b}} \qquad \text{Eq. 2-2}$$

If an estimate of $\frac{1}{1+b}$, elasticity of substitution between farm machinery and labor, is significantly different from unity, then farmer's production decisions can be explained by the CES production function in the time period.

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1. Assuming the CES production function (Eq. 2-1) and that the price of product is P_y, then the maximisation may be formulated as follows.

   Maximise: $\pi = P_y Q - P_m S - P_L L$. The first order conditions for maximisation are:

$$\partial\pi/\partial S = P_y(\partial Q/\partial S) - P_m = 0 \qquad \text{Eq. 2-3}$$

$$\partial\pi/\partial L = P_y(\partial Q/\partial L) - P_L = 0 \qquad \text{Eq. 2-4}$$

$$\frac{\frac{\partial Q}{\partial L}}{\frac{\partial Q}{\partial S}} = \frac{a_2}{a_1} \cdot \left[\frac{S}{L}\right]^{\frac{1}{1+b}} \qquad \text{Eq. 2-5}$$

The demand for farm machinery services can be described as[2]:

$$S^*_t = a_0(P_m/P_L)_t + a_1(P_y/P_m)_t \quad , \qquad \text{Eq. 2-6}$$

or if economies of scale are taken into account, then the average farm size (F_t) may be included in Eq. 2-6, thus

$$S^*_t = b_0(P_m/P_L)_t + b_1(P_y/P_m)_t + b_2F_t \qquad \text{Eq. 2-7}$$

where S* denotes an equilibrium or optimal level of stock of farm machinery.

(b) Dynamic demand fuction for farm machinery

It is extremely unlikely that farmers adjust the stock of farm machinery to its desired level and reach the equilibrium position at the end of each period (17). Assuming this to be more likely, then farm machinery purchases are in disequilibrium and farmers adjust the actual stock of farm machinery toward the desired level in response to changes in relative prices. To account for this a partial adjustment model is combined with the static demand function in the following equations,

$$S_t - S_{t-1} = r(S^*_t - S_{t-1}) \qquad \text{Eq. 2-8}$$

where $S^*_t = f(P_m/P_L)_t \;,\; (P_y/P_m)_t \;,\; \bar{F}_t)$ and $0 < r < 1$.

2. Eq. 2-6 and Eq. 2-7 are derived from Eqs. 2-3, 2-4 and 2-5.

Thus,

$$S_t = rS_t^* + (1-r)\ S_{t-1} \quad . \qquad \text{Eq. 2-9}$$

The alternative way of representing the above adjustment process is to hypothesise that farmers adjust the percentage difference between the optimal stock level in year t and actural stock in year t-1, that is,

$$S_t/S_{t-1} = (S_t^* \ / \ S_{t-1})^r \qquad \text{Eq. 2-10}$$

Thus,

$$\log S_t = r\log S_t^* + (1-r)\log S_{t-1} \quad . \qquad \text{Eq. 2-11}$$

In both models, Eq. 2-9 and Eq. 2-11, the coefficient r is called an adjustment coefficient. Equation 2.12 is derived by substituting the equilibrium demand function for S_t^*,

$$S_t = f(\ (P_m/P_L)_t\ ,\ (P_y/P_m)_t\ ,\ \bar{F}_t\ ,\ S_{t-1}) \qquad \text{Eq. 2-12}$$

It is plausible to assume that the rate of adjustment depends mainly upon liquidity condition of the farm, that is, available funds for capital expenditure including interest rate and credit availability (3). Farm cash receipts and realised farm net income have been utilised as indicators of the available funds in predicting expenditure for farm machinery. There is no single interest rate in this study and, especially, it is not possible to obtain interest rates for different regions.

Moore (16) has demonstrated that farm machinery sales in the current year are highly correlated (90 percent) with the change in net farm income in the previous year (14). In this study realised net income is used as a proxy variable explaining the influence of financial availability of capital funds.

(c) Net Stock Adjustment Model

In a previous section the disequilibrium farm machinery demand model has been discussed and this section copes with an adjustment model in more detail. Since there is likely to be a lag of some years before full adjustment in the factor proportions is made to a change in the relative price prices, it is necessary to introduce an adjustment mechanism into our investment demand model. One of the advantages of the adjustment model based on the theoretical demand function for farm machinery is to provide us both short-run (disequilibrium) elasticity of substitution and long-run (equilibrium) elasticity of substitution.

Assuming Eq. 2-1 represents agricultural technology and farmers maximize profit, the optimum use of farm machinery, S, can be related to an alternate factor, L. and their relative price.

$$\ln(S) = \text{const.} + s \cdot \ln\,(P_L/P_m) + \ln(L) \qquad \text{Eq. 2-13}$$

The above equation shows that the optimum level of stock of farm machinery is a function of relative price of labor to farm machinery and the level of labor employment.

If we accept the well known approximation of stock adjustment by means of Gomperts curve

$$S = S^{*}A^{B^{t}} \qquad \text{Eq. 2-14}$$

where t is time, then the following equation is obtained as a final function form[3].

$$\ln S_t - \ln S_{t-1} = a(\ln S^* - \ln S_{t-1}) \qquad \text{Eq. 2-15}$$

If ln(A) is less than zero and B is greater than unity, then S converges to S* as time goes on; and the rate of change of the stock, S, depends upon the discrepancy between actual and desired level of farm machinery stock.

The rate of change of stock can be approximated by the change of the stock of the natural log form during the current period, so that

$$d\ln(S)/dt = \ln(S_t) - \ln(S_{t-1}) \qquad \text{Eq. 2-16}$$

and thus the equation (2-15) is obtained. It is evident the hours of labor employed cannot be considered independent of the relative price of labor to farm machinery, nor is it appropriate to assume the adjustment in the labor force occurs instantly. To account for this equation (2-17) is introduced.

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3. The equation can be derived as follows. The equation 2-14 can be transformed into natural log form

$$\ln S = \ln S^* + B^t \ln A$$

so $$d\ln S/dt = B^t \ln A \ln B$$

but $$B^t \ln A = -(\ln S^* - \ln S)$$

so $$d\ln S/dt = a(\ln S^* - \ln S) \text{ where } a = -\ln B.$$

$$\ln(L_t/L_{t-1}) = b(\ln L^* - \ln L_{t-1}) \qquad \text{Eq. 2-17,}$$

where L* is the optimum level of labor employment. If the adjustment of labor employment can be explained in the same fashion as the level of farm machinery is explained in terms of Gomperts curve, then

$$\ln S^* = \text{const.} + s\ln(P_L/P_m) + \ln L^* \qquad \text{Eq. 2-18.}$$

Combining the equations (2-17) and (2-18), the equation (2-19) is obtained.

$$\ln(S_t/S_{t-1}) = \text{const.} + as\ln(P_L/P_m) + \frac{a}{b}\ln(L_t/L_{t-1}) - a\ln(S/L_{t-1}) \qquad \text{Eq. 2-19,}$$

where as, a/b, and a denotes short-run elasticity of substitution, short-run labor adjustment and adjustment coefficient respectively. Solving the above relationships with respect to s and b, long-run elasticity of substitution and labor adjustment, can be obtained [17].

Treatment of replacement and capital expenditure

Gross investment in farm machinery in year t, I_t , is equal to net investment in year t, $(S_t - S_{t-1})$ plus replacement investment in year t, R_t. Net investment represents the adjustment which is made in year t toward the equilibrium farm stock in that year. Therefore, it is limited to the variables detemining the equilibrium stock and by the level of stock in the previous period. "The coefficient of beginning capital stock in equations for gross capital outlays can be either negative or positive" while the beginning capital stock has a negative influence on net investment [14]. The demand function for gross investment is formulated as follows.

$$G_t = S_t - S_{t-1} + R_t = f(P_m/P_L,\ P_y/P_m,\ F_t,\ Y_{t-1},\ S_{t-1}) \qquad \text{Eq. 2-20}$$

Since actual replacement occurs in a world that is changing technologically, it is hard to identify any particular investment outlay as being strictly for replacement in whole or part.

Time structure

Presently it is accepted that a lag period exists between actual investment and investment decision. Jorgenson [13] suggests the possible stages involved in the investment process:

1. planning the project,
2. securing financing,
3. preparation of blue print,
4. construction of fabrication,
5. modification during gestation period, and
6. installation.

The above may be, in general, the possible reasons for the existence of lags between investment and investment decision. However, in agriculture some special institutional factors should be considered. For instance, the final paymentfrom the pooled price of wheat is available 18 months after sales period.

Basically this study adopts Nerlove's partial adjustment model and data availability requires that the adjustment be estimated in terms of annual observations. However, the actual adjustment period may be longer or shorter. Since the measurement of farm machinery in this study contains all types of farm machines and equipment for different types of production, lag periods existing between decision and actual investment of these machines differ from each other. However, the formulation and estimation of aggregate model lag periods for farm machinery must be assumed to be equal. If the assumption of homogeneity does not hold, then one may have so-called 'aggregation bias' on the estimates.

Application

Elasticity of substitution between capital and labor is a fundamental parameter describing the structure of production in an economy or its component sectors. This elasticity is a measure of the relative ease with which these factors may be substituted in production; and for this reason, it plays a crucial role in most modern partial and general equilibrium models of income distribution. CES (Constant Elasticity of Substitution) production function shows that under the assumptions of (i) constant returns to scale; and (ii) purely competitive product and factor markets, the elasticity of substitution may be estimated from the first-order profit maximisation condition of a farm. Since the demand analysis of farm machinery discussed in this paper is also based on the assumptions of CES technology and profit maximisation principle, the elasticity of substitution may be estimated from the hypothesized relationships.

The estimation of the elasticity of substitution is certainly one of the objectives of the study as well as the estimation of adjustment coefficients.

The other major component of study is to forecast the expenditures on farm machinery, although theoretically the formulation of models of investment demand does not differ from models for analytical purposes. Prediction however, has some difficulties. Some of the explanatory variables which determine future investment levels are not known and must be estimated. The other difficulty is the changing structure of the Canadian economy. If in the future the structure of economy differs significantly from the conditions under which the observations were determined, then the model may not be an accurate representation of future events. Nevertheless, it may be still useful for obtaining a general perspective of future trends.

the possible relevant independent variables in it. If these omitted variables and dependent variables are serially correlated and it is likely that the omitted variables and lagged dependent variables, such as S_{t-1}, are also correlated and then upward biased estimates may result. To cope with this problem the regressions with first order serially correlated errors have been applied and the results are tabulated in Appendix C.

Zellner estimated coefficients from a system of regression equations to incorporate the distrubances in different equations which are contemporaneously correlated [21, 4]. In other words, the investment of farmers in one region may influence economic activities including farmers investment on farm machinery in other regions and these relationships should be accounted for in the estimation procedure. Zellner proposed a method which applied Aitken generalised least squares estimation to estimate the covariance matrix. Furthermore, Dhruvarajan suggested that in many situations where Zellner's method is likely to be useful, particularly in time series applications, both contemporaneous and serial correlations are encountered among disturbances of different equations[4]. The Three Stage Least Squares analogus method of estimation has been proposed by Dhruvarajan [5]. The estimation of coefficients based on these methods shall be discussed in the extended version of this study in the future.

Simultaneous systems bias is not serious since both the prices and output of agricultural products and the prices of agricultural inputs can be assumed to be predetermined. The reason being that farm machinery purchases are highly unlikely to influence agricultural production prices in the short run, both because the output effect of the purchases may be small and agricultural production is subject to relatively large random fluctuation [11]. The supply of farm machinery is dominated by somewhat oligopolistic firms and it is not subject to price dependent activities in the perfectly competitive market in the short run. The supply side of farm machinery investment is interesting and important subject in the investment study, since adjustment process changes in labor employment, output and net income may be influenced heavily by the available supply of machinery.

Testing

Since the model discussed in the paper is based on the received theory, the hypothesis on CES technology must be tested in addition to the ordinal statistical tests for the estimates. The tests, however, may not be based on unbiased estimates and since autocorrelation simultaneous bias may exist. In other words, even if the model passed all tests it may be still inappropriate explanation of the real system. Klein [14] writes that "Until I see a large battery of extraporation tests on a multi-period basis from complete system solutions, I cannot accept rankings of superiority of investment functions".

CHAPTER IV

Results

Tests for the CES assumptions

The demand relationships for gross investment and farm machinery stocks assume a CES (Constant Elasticity of Substitution) production function, it should be examined whether the CES technology is applicable to explain farm machinery investment. In other words, it has to be tested whether the estimated elasticity of substitution is significantly different from unity.

The equation estimated is as follows.

$$\ln(S/L) = \ln a + e \cdot \ln(P_m/P_L) + u \qquad \text{Eq. 5-1}$$

where e denotes 1/(b + 1) in Eq. 2-2 and constant term is ln(a).

The results shown in Table 1 indicate that the CES technology is an appropriate assumption in Manitoba, Alberta, and Atlantic provinces. Becuase autocorrelation is a serious problem in the equations for all provinces the estimates could be incorrect[1]. Therefore an elasticity of substitution could be equal to unity for all cases. Incidently, the Durbin-Watson ratio indicates that the equation for all provinces except Quebec cannot reject the null hypothesis for existence of negative autocorrelation.

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1. The estimates of the parameters are statistically unbiased when the u's are temporally dependent, however, their value in any single sample is not correct.

Table 1. The Provincial estimates of Farm Machinery Useage with a CES function.

	ê	t-value	t'=(ê-1)/S.E.(ê)	R^2	d.w.
Canada	.423	3.88	- 5.29	.98	.41
Atlantic	.826	1.77	- .373	.85	.43
Quebec	- .216	2.19	-12.40	.97	1.94
Ontario	.108	1.01	- 8.34	.97	1.27
Manitoba	.828	4.269	- .897	.70	.55
Saskatchewan	- .599	2.38	- 6.36	.48	1.05
Alberta	1.147	6.84	.877	.93	.65
British Columbia	.194	1.74	- 7.23	.98	1.43

Another way to test the appropriateness of the CES model is to estimate the following equation and examine whether the factor price terms are equal but opposite sign.

$$\ln(S/L) = \ln a + c \cdot \ln(P_L) - d \cdot \ln(P_m) + u \qquad \text{Eq. 5-2}$$ [2]

The equation (5-2) implies that if c and d have the same magnitude the theoretical demand function derived from a CES production function may be said to be homogeneous of degree zero[3].

2. Taking the log of both side of equation (2-2), we have

$$\ln(S/L) = \ln a + \frac{1}{b+1} \ln(P_L) - \frac{1}{b+1} \ln(P_m)$$

where constant term is lna.

3. That is, the same percentage increase or decrease of prices of farm machinery and labor does not affect the quantity demand.

Two different estimation methods have been tried to the same formulation, namely, the Ordinary Least Squares and OLS with first order autoregressive scheme. An equation which has a lower standard error of regression for each province is selected and tabulated in Table 2.

Table 2. The Provincial estimates of Farm Machinery Stocks With Equation 5-2.

	$c(P_m)$	$d(P_L)$	Ratio (d/c)	R^2	d.w.
Canada	- .963	.806	.84	.96	1.57
Atlantic	-1.88	1.36	.72	.89	.918
Quebec	- .902	.725	.80	.74	.302
Ontario	- .365	.281	.77	.97	1.08
Manitoba	-1.35	1.27	.94	.79	.870
Saskatchewan	.572	- .573	-.99	.48	1.03
Alberta	.393	- .543	-.72	.75	1.07
British Columbia	.382	- .733	-.52	.94	1.26

In all provinces except Quebec the equation based on first order autoregressive scheme has a lower standard error of regression. Thus some degree of autocorrelation exists in the model. One of the sources of existence of autocorrelation may be the effects of the omitted variables that are unknown or difficult to measure. However they may be correlated with other independent variables. In the case of equation (5-2) the economies of scale variable is omitted and this may be a source of autocorrelation, although this may not be the only reason.

In all regions, estimates, c and d, have the similar magnitude (see, ratios shown in Table 2) and opposite signs. Saskatchewan, Alberta and British Columbia, however, have a different pair of signs on two parameters from other provinces.

In economic terms, 1 percent rise in relative price of labor to farm machinery brings 0.5 percent to 1 percent decrease in farm machinery labor ratio. In other words, farm machinery cannot be said a close substitute for labor in these three provinces while in Eastern provinces farm machinery appears to be a substitute for labor. One possible reason being that farm machinery is a complement to labor in Western provinces in the expansion of agricultural production. If proper measurement of the level of expansion of agriculture is included in the model, more clear-cut results about substitutatility or complementarity of labor and farm machinery becomes evident.

Taking into account the above results from two kinds of test, it may be said that generally the CES model can explain the production processes of Canadian agriculture.

Differences in production technologies, regional factor and product markets and other locational divergences are basically accounted for through in terms of relative price ratios of input factors and output. However, the existing price vectors do not reflect farmers' expectations about future factor and output prices, the influence of risk and institutional uncertainty. These dynamic influences suggest that in addition to the elasticity of substitution an adjustment relationship should be included.

Adjustment lags in farm machinery investment

The equation 2-19 was estimated for each province and is shown in Table 3. It is assumed that c, d, and c/d are normally between 0 and 1. However, they can be greater than 1 in the case where the adjustment process, in other words investment behavior, is unstable during the observed time periods. Contrarily, the short-run and long-run elasticity of substitution may have any value depending upon whether agriculture production is expanding or contracting.

In Prairie provinces the elasticity of substitution was found to be positive with respect to relative price of farm machinery to labor (P_m/P_L). When compared with other Provinces the adjustment coefficients of farm machinery are relatively large and range from 0.27 to 0.55. That is, 27 percent to 55 percent of discrepancy between actual and désired stock of farm machinery is fulfilled within a year. The short-run labor adjustment coefficient has also large proportions relative to other provinces. It may be said, therefore, that the agricultural production in Prairies has been expanding during the observed periods. One may raise a question about the negative sign for the adjustment coefficient of farm machinery in Saskatchewan and British Columbia. One possible reason may be the omission of variables, such as economies of size. The model discussed here is aggregate farm machinery investment and thus all types of agricultural production are included. Therefore, it is not sure that output level or farm size are appropriate explanations of the economies of scale. For this reason variable of economies of scale has not been included.

Table 3. Estimations of dynamic investment equations for farm machinery.

Independent Variables	(P_m/P_L)	(L_t/L_{t-1})	$(S/L)_{t-1}$	s	b	R^2	d.w.
Canada	.006	.815**	.003	-	-	.99	.71
	.308	.820**	.005	61.6	.006	.99	1.33
Atlantic Provinces	-.080*	-.252**	.016	-5.0	-.063	.88	1.97
	-.044	-.245**	.012*	-	-	.93	1.40
Quebec	-.023	.540**	.027**	- .84	.05	.99	2.19
	.0004	.540**	.025	-	-	.99	1.92
Ontario	-.008	.604**	.012	- .67	.020	.99	1.66
	.020	.604**	.009	-	-	.99	.96
Manitoba	.012	.631**	-.009	-	-	.95	.94
	.856**	.861**	.554	1.55	.64	.98	.80
Sask-atchewan	.034	1.12**	.273**	.120	.243	.98	.82
	-.217	1.14**	-.508*	-	-	.99	1.63
Alberta	.153	.693**	-.053	-	-	.99	.98
	1.304**	.860**	.550**	2.37	.64	.99	1.17
British Columbia	.162**	-.326**	-.027**	-6.04	.08	.99	1.03
	-.029**	.210**	.327**	-	-	.97	1.53

* and ** put on the estimate denote that the estimate is statistically significant at 5 percent and 1 percent confidence level respectively.

Long-run elasticity of substitution of farm machinery and labor, s, and long-run labor adjustment coefficient, b, are calculated based on the equation which gives smaller standard error of regression.

In general it may be said that farms in the Prairie provinces tend to expand and it is expected that the relative price of farm machinery to labor might have positive sign and average farm size (F_t) may have also positive sign in a demand function for gross investment and net stock of farm machinery.

In Eastern provinces, on the other hand, elasticity of substitution is negative and is of low magnitude. Farmers in these provinces may be said, therefore, to be insensitive to the relative price in short-run, although long-run elasticity of substitution of these provinces is ranging from -0.67 to -5.0. The short-run labor adjustment coefficient for these provinces except Atlantic provinces is fairly high.

As we see in Appendix C, the results of estimation for Eastern provinces as well as British Columbia are somewhat odd from theoretical point of view. One possible reason is 'aggregation bias'.

It should be noted that the estimates from our models are unbiased if and only if the models are free from 'simultaneous system bias', 'aggregation error' and 'omission of variables'. As discussed in Chapter 3 simultaneous system bias may not be serious for this study, however, the other two may be crucial, especially aggregation error.

Assumptions underlying in aggregation are:

1. neoclassical assumptions such as profit maximising behavior and a competitive market,
2. no externalities exist, and
3. homogeneity of subsystems that are to be aggregated.

If the composition of agricultural production system and farm machinery are assumed to be the same as well as dairy farmer's investment decisions being similar to grain farming, then the models presented here can be free from aggregation bias.

However, in Eastern provinces and British Columbia, agricultural production system has been diversified to a certain degree and the composition of production has been changing during observation period while in Prairie provinces, agricultural production is based mainly on grain and crop production, thus the system is monocultural in some sense.

Speed of response to the discrepancy between actual and desired level of farm machinery stock seems to depend upon:

1. farmers' ability to finance,
2. relative price of farm machinery to other factors and output, and,
3. institutional issues, such as quota system, dairy policies and Canadian Wheat Board payment system.

However, the supply side conditions of farm machinery have not been considered. If market of farm machinery is assumed to be competitive, the supply conditions are reflected in machinery prices. However, the farm machinery industry is dominated by a few firms. It is not known, however, how to adequately specify a model that depicts oligopolistic behaviour and therefore these relations were not considered explicitly.

Since supply conditions of farm machinery and some institutional issues which can influence the demand for farm machinery are not taken into account in the models here, some bias due to omisison of variables may be evident.

Gross investment demand for farm machinery

The sign and significance of estimates from gross investment demand function (Eq. 2-20) are shown in Table 4. Regression equations estimated by the OLS with first order autoregressive scheme provide better estimates

Table 4. Estimates of Factors Influencing the Gross Investment of Farm Machinery

Independent Variables	P_m/P_L	P_y/P_m	Y_{t-1}	F_t	S_{t-1}	R^2	
Canada[a]	− (*)[c]	+ (**)	+	−	− (**)	.97	*[b]
	−	+ (*)	+	+	−	.78	
Atlantic Provinces	− (**)	+	+	− (*)	+	.90	*
	−	+	+	+	−	.68	
Quebec	−	+ (*)	+	+	−	.90	*
	−	+	+	+	−	.83	
Ontario	+	+ (**)	−	+	−	.94	*
	−	+ (*)	+	+	− (*)	.77	
Manitoba	+ (*)	+ (*)	+	+	+ (*)	.75	
	−	+ (*)	+	+	− (*)	.77	*
Saskatchewan	+	+	+	+	+	.59	
	−	+	+	+	−	.86	*
Alberta	+	+	+	+	−	.67	
	−	+ (*)	+	+	−	.76	*
British Columbia	−	+ (*)	+ (**)	− (**)	− (**)	.98	*
	− (**)	+ (**)	+	+ (**)	− (*)	.94	

a. The result on upper line is obtained from Ordinary Least Squares and on lower line is from Least Squares with first order auto regressive scheme.

b. The equation put on an asterisk has smaller standard error.

c. * and ** indicate that the estimate is significant at 5% and 1% level of confidence respectively.

than the OLS in terms of standard error of regression. One possible reason for the improvement is that some of the unknown variables are correlated to other independent variables. For example, technological improvements and quality changes in farm machinery was not represented by the purchase price and subsequently omitted from the model. The autocorrelation problem could also result if the composition of farm machinery purchases changes from year to year. The variable farm machinery stock represents various types of equipment. In each agricultural sector farmers have different price expectations and their investment behavior may vary accordingly. In this case the autocorrelation is related to aggregation bias. The relationship between aggregation bias and serial correlation shall be studied in the extended version of this study. As expected the relative price of farm machinery to labor has a negative sign in most provinces except Ontario, Manitoba, Saskatchewan and Alberta. The average farm size has positive effects on gross investment in Prairie provinces and Quebec and Ontario. In Prairie provinces production the trend is towards extensive use of labor and farm machinery which indicates the existence of economicies of scale. The same argument seems possible for Ontario. The price elasticity of gross investment obtained from the double log form of Eq. 2-20 are shown in Table 5.

Prairie provinces and Ontario have relatively high elasticity of gross investment with respect to the relative price of output to farm machinery. In these provinces except Alberta the elasticity of gross investment with respect to the relative price of factors is positive. The findings coincide with the results obtained from Eq. 2-20 estimated.

Table 5. Short and Long Run Estimates for the Investment of Farm Machinery

with respect to	P_m/P_L	P_y/P_m
Canada	-2.72	.131
Atlantic	-3.58	.055
Quebec	- .126	.523
Ontario	1.47	1.13
Manitoba	6.35	2.60
Saskatchewan	.239	.815
Alberta	-3.24	1.30
British Columbia	- .176	.869

Net Stock Demand for Farm Machinery

The sign and significance of estimates obtained from Eq. 2-12 are presented in Table 6. As far as the hypothetical sign conditions are concerned, least squares with first order autoregressive schemes provide expected signs. However, the equation with the smallest standard error is chosen for further discussion. Least squares with first order autoregressive scheme again provide better estimates for Prairie provinces.

The model presented here is based on stock adjustment model and therefore the next task is to pick up the adjustment coefficient and determine the long-run elasticities of net stock demand as well as short-run elasticities. These elasticities for individual regions are shown in Table 7.

As shown in Table 7, the elasticity with respeft to factor price ratio of Eastern provinces ranges between -.2 and -.4 while the elasticity of net stock with respect to the factor price ratio is less than -1.0, except for British Columbia.

On the other hand, the stock demand elasticities with respect to the ratio of output price to price of machinery in Atlantic and Quebec provinces are negative while in other provinces the elasticities are positive.

In British Columbia the situation may be that farmers are attempting to increase the capital labor ratio to meet labor movement from agricultural sector to the other sectors.

TABLE 6. Net Stock Demand for Farm Machinery

	P_m/P_L	P_y/P_m	Y_{t-1}	F_t	S_{t-1}	R^2
Canada	− (**)	− (**)	−	− (*)	+	.98
Atlantic Provinces	− (*)	+	−	− (*)	+ (**)	.80
Quebec	−	+	−	−	+ (*)	.94
Ontario	− (*)	+ (**)	+	− (*)	−	.96
Manitoba	− (*)	+ (**)	+ (*)	+ (**)	− (**)	.92
Saskatchewan	−	+ (**)	+	+ (*)	− (**)	.95
Alberta	−	+ (**)	+ (**)	+ (**)	− (**)	.98
British Columbia	−	+	+	− (**)	+	.99

* and ** put on denote that the estimate is statistically significant at 5 percent and 1 percent confidence level respectively.

TABLE 7. Long and Short-Run Elasticities for Farm Machinery Interests

Elasticity with respect to	P_m/P_L		P_y/P_m	
	short-run	long-run	short-run	long-run
Canada	- .974	- .955	-.281	-.275
Atlantic	- .380	-1.13	-.019	-.057
Quebec	- .365	-1.34	-.074	-.271
Ontario	- .243	- .705	.114	.080
Manitoba	-1.36	-1.29	.015	.014
Saskatchewan	-1.03	- .942	.204	.187
Alberta	-1.13	-1.05	.110	.102
British Columbia	.089	.087	.256	.250

CHAPTER V

Conclusions

As we discussed and hypothesised previously investment behavior of farmers with respect to economic variables are quite different in Eastern and Western Canada and in individual provinces.

Several existing models for the demand for farm machinery based on CES production function were estimated with Canadian data between 1960 and 1974 both at national level and at the provincial level. A part of the results have been discussed and compared at regional level.

Generally speaking the important variables are relative price of machinery to labor, relative price of product to machinery, lagged net income and average farm size. Above all average farm size takes a role as an explanatory variable of economies of scale, although the change of the variable over time is quite slow.

Difficulties underlying in this kind of study is measurement of capital equipment, farm machinery, and how to cope with technological changes in farm machinery, labor and production of agricultural products. It may be said that models presented here are based on theoretical production function where some special type of variables such as weather and institutional control are omitted. Since we assume that these factors are negligible or cancel out, as a matter of fact they are not, and exclude the variables, thus our estimates may be biased. Therefore we have to take the results discussed here with a grain of salt.

In this study especially in adjustment model some special assumptions which are hard to believe are employed. They are: (i) adjustment period and observation period are coincident, (ii) all types of farm machinery have uniform adjustment lag period and all farmers have the same economic expectations, although there are no rationale to believe so. As discussed in Chapter 4, aggregation errors are not properly treated in this study.

Further study may be suggested as follows. Models discussed in this paper are aggregate model in terms of farm machinery, and as mentioned above it cannot be assumed the uniform composition of farm machinery and uniform adjustment lag, thus disaggregate model should be analysed. The other possible expansion of this study may be the development of distributed lag model based on disaggregate model in order to fully analyse the adjustment behavior by type of farm machinery and by regions, since we found out significant difference in adjustment behavior of different regions.

APPENDIX A

Data sources and major variables

The data and the major variables

I_t : Farms gross capital expenditures on farm machinery in 1961 dollars. The undeflated data are from Farm Implement and Equipment Sales, (Cat. no. 63-203 Annual, Statistics Canada).

S_t : Net stock of farm machinery in 1961 dollars. The data are based on 1958 Farm Survey Report No. 3 (CDB), Farm Net Income, (Cat. no. 21-202 Annual) and Census Reports (1961, 1966 and 1971, Statistics Canada).

$(P_m)_t$: Index of price of farm machinery. The source is Prices and Price Indexes, (Cat. no. 62-002 Monthly, Statistics Canada).

$(P_L)_t$: Index of price of agricultural products. (Statistics Canada Cat. no. 62-002).

Y_t : Realised farm net income in 1961 dollars. Statistics Canada Farm Net Income, (Cat. no. 21-202).

L_t : Number of workers employed in Agriculture. Canada Census Reports in 1961, 1966 and 1971 are refered.

F_t : Average farm size measured by acreage per farm. The data are from Census Canada issued in 1961, 1966 and 1971.

In this study the stock of farm machinery is measured in terms of dollars, and thus the measurement of quality of farm machinery becomes serious. Does the value of stock take into account the quality change in farm machinery? Rayner suggested the use of quality price index in order to deal with the problem and Griliches suggested that, "The deflated series of expenditures on tractors does take into account quality changes for which a price is paid". (6,11)

However, it is hard to say that changes in price reflect all the quality changes in farm machinery. Even if we use total horse power as a measure of stock of farm machinery, we may not reflect all possible quality changes in farm machinery. These omitted quality changes may correlate with other independent variables to some extent, thus we may have biased estimates in our regression. In particular the effects will be appearing on estimates of price elasticity.

APPENDIX B

TABLE B.1 Farm Machinery Investment Equations for Canada (1960 - 1974)

Dep. Var.	constant	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	41.66 (5.01)**	-9.88 (2.93)*	2.08 (4.11)**	-.714 (6.87)**	.024 (1.17)	-.041 (3.51)**	.97	48.11**	2.49
Eq. 2 $\ln I_t$	50.59 (2.64)*	-2.72 (1.63)	.131 (.322)	-5.20 (4.12)**	.049 (.041)	-5.66 (1.99)	.93	22.77**	1.82
Eq. 3 S_t	67.48 (8.24)**	-19.69 (5.93)**	-2.69 (5.39)**	.139 (1.36)	-.009 (.456)	-.072 (6.22)**	.98	103.44**	2.11
Eq. 4 $\ln S_t$	13.49 (3.49)**	-.974 (2.91)*	-.281 (3.43)**	-.021 (.082)	-.010 (.407)	-1.75 (3.05)*	.96	37.52*	1.68

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/K			.380 (**)	-.540 (**)			.62		.32
Eq. 6 ln S/L		.260					.06		.93
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	.006				.815 (**)	-.003	.99		.71

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE B. 2 Farm Machinery Investment Equations for Atlantic Provinces (1960 - 1974)

Dep. Var.	constant	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	.769	-.323	.026	-.142	.018	-.002	.90	14.97**	2.29
	(4.48)**	(3.91)**	(1.73)	(1.14)	(.736)	(2.60)*			
Eq. 2 $\ln I_t$	19.12	-3.58	.055	-2.02	.009	-4.28	.93	21.97**	2.55
	(3.35)**	(5.29)**	(.414)	(2.65)*	(.112)	(3.88) **			
Eq. 3 S_t	.864	-.328	.007	.802	-.076	-.002	.80	6.55**	2.13
	(3.54)**	(2.78)*	(.348)	(4.50)**	(2.20)	(2.40)*			
Eq. 4 $\ln S_t$	2.68	-.380	-.019	.665	-.036	-.543	.77	5.33*	2.18
	(2.00)	(2.40)*	(.622)	(3.72)**	(1.82)	(2.10)			

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			-.056	-.178			.13		.28
Eq. 6 ln S/L		-.225					.14		.65
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	-.08				-.252	-.016	.88		1.97
	(*)				(**)	(*)			

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE B. 3 Farm Machinery Investment Equations for Quebec (1960 - 1974)

Dep. Var.	constant	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-.074 (.061)	-.013 (.026)	.250 (2.25)*	-.244 (1.39)	.096 (1.92)	.005 (.836)	.90	14.60**	1.80
Eq. 2 ln I_t	-8.35 (.725)	-.126 (.117)	.523 (1.63)	-1.70 (1.62)	.372 (1.86)	1.81 (.780)	.89	13.30*	1.83
Eq. 3 S_t	2.92 (1.47)	-1.15 (1.45)	-.081 (.449)	.864 (3.03)*	-.063 (.775)	-.008 (.774)	.94	25.40**	2.21
Eq. 4 ln S_t	2.47 (.940)	-.365 (1.47)	-.074 (1.02)	.727 (3.04)*	-.022 (.473)	-.432 (.818)	.94	25.57**	2.32

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			.725 (**)	-.902 (**)			.74		.30
Eq. 6 ln S/L		N/A					N/A		N/A
Eq. 7 ln $\frac{S_t}{S_{t-1}}$	-.023				.540 (**)	-.027 (**)	.99		2.19

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5% and 1 % level respectively.

3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE B. 4 Farm Machinery Investment Equations for Ontario (1960 - 1974)

Dep. Var.	constant	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	s.w.
Eq. 1 I_t	-1.34 (.453)	.696 (.642)	.905 (3.90)**	-.214 (.519)	-.043 (.741)	.023 (.653)	.94	26.81*	1.78
Eq. 2 $\ln I_t$	-45.08 (1.23)	1.47 (1.36)	1.13 (3.69)**	-.314 (.113)	.094 (.427)	8.94 (1.33)	.94	25.39**	1.77
Eq. 3 S_t	23.14 (4.30)**	-2.06 (2.68)*	.706 (4.30)**	-.456 (1.56)	.009 (.210)	-.087 (3.44)**	.96	36.71**	2.17
Eq. 4 $\ln S_t$	13.53 (2.78)*	-.243 (1.68)	.114 (2.78)*	-.419 (1.12)	.002 (.054)	-2.19 (2.44)*	.94	24.01*	1.47
Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			.829 (**)	-1.07 (**)			.83		.28
Eq. 6 ln S/L		N/A					N/A		N/A
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	-.008				.604 (**)	-.012	.99		1.66

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE B. 5 Farm Machinery Investment Equations for Manitoba (1960 - 1974)

Dep. Var.	constant	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-7.04 $(3.44)^{**}$	2.80 $(2.99)^{*}$	.809 $(2.65)^{*}$	.330 (1.70)	.071 (.919)	.007 $(2.90)^{*}$	.75	4.70^{*}	1.32
Eq. 2 $\ln I_t$	-58.92 $(3.89)^{**}$	6.35 $(3.96)^{**}$	2.60 $(3.29)^{**}$	1.05 (1.35)	.338 (1.27)	9.39 $(3.84)^{**}$	.82	7.38^{**}	2.12
Eq. 3 S_t	-6.24 $(2.74)^{*}$	2.57 $(2.47)^{*}$	.767 $(2.26)^{*}$	1.16 $(5.40)^{**}$	-.016 (.188)	.006 (2.19)	.89	13.05^{*}	1.12
Eq. 4 $\ln S_t$	-10.19** $(3.33)^{**}$	1.22 $(3.78)^{**}$	.538 $(3.37)^{**}$	1.10 $(7.01)^{**}$	-.004 (.072)	1.66 $(3.37)^{**}$	.94	23.85^{**}	1.60
Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			.153	-.246 (*)			.01		.48
Eq. 6 ln S/L		.318					.03)		.74
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	.012				.631 (**)	.009	.95		.94

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is signifivant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE B. 6 Farm Machinery Investment Equations for Saskatchewan (1960 - 1974)

Dep. Var.	constant	P_m/P_1	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-11.34	4.35	1.22	.055	.078	.009	.59	2.27	1.39
	(1.53)	(1.54)	(1.68)	(.240)	(1.00)	(1.29)			
Eq. 2 ln I_t	-62.67	5.08	2.00	.083	.318	9.44	.63	2.67	1.86
	(1.76)	(2.03)	(2.11)	(.090)	(.936)	(1.77)			
Eq. 3 S_t	-12.68	5.49	1.30	.890	.038	.009	.95	31.90**	1.55
	(1.63)	(1.86)	(1.72)	(3.72)**	(.466)	(1.23)			
Eq. 4 ln S_t	-15.79	1.39	.589	1.02	-.001	2.40	.97	57.46**	2.08
	(2.25)	(2.82)*	(3.16)*	(5.58)**	(.016)	(2.28)			

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			-.183	.176			.10		.67
Eq. 6 ln S/L		.660					.10		1.54
Eq. 7 ln $\frac{S_t}{S_{t-1}}$	.033				1.12 (**)	-.273	.98		.82

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE B. 7 Farm Machinery Investment Equations for Alberta (1960 - 1974)

Dep. Var.	constant	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-.636	.415	.594	-.078	.086	.0006	.70	3.69*	.69
	(.093)	(.199)	(1.03)	(.184)	(.783)	(.099)			
Eq. 2 $\ln I_t$	-30.27	2.07	1.45	.272	.254	4.51	.62	2.61	1.11
	(.828)	(.833)	(1.43)	(.158)	(.460)	(.825)			
Eq. 3 S_t	2.66	-.228	.527	.724	.006	-.003	.97	56.03**	.86
	(.455)	(.127)	(1.07)	(2.00)	(.063)	(.523)			
Eq. 4 $\ln S_t$	-2.97	.268	.375	1.03	-.039	.453	.97	56.40**	1.27
	(.426)	(.566)	(1.94)	(3.14)*	(.372)	(.435)			

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			-.286 (*)	.135			.51		.70
Eq. 6 ln S/L		N/A					N/A		N/A
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	.153				.693 (**)	.053	.988		.98

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE B. 8 Farm Machinery Investment Equations for British Columbia (1960 - 1974)

Dep. Var.	constant	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	.750 (4.21)**	-.131 (2.20)	.105 (3.20)*	-.613 (4.17)**	.075 (4.23)**	-.001 (3.37)**	.98	90.93*	2.80
Eq. 2 $\ln I_t$	11.00 (1.75)	-.176 (.250)	.869 (1.57)	-3.76 (3.20)*	.688 (3.31)*	-2.27 (2.35)*	.96	43.31**	2.26
Eq. 3 S_t	.115 (4.51)**	-.158 (1.85)	.079 (1.67)	.093 (.439)	.015 (.603)	-.002 (4.09)**	.99	214.88**	1.75
Eq. 4 $\ln S_t$	4.39 (2.90)*	.089 (.524)	.256 (1.91)	-.026 (.092)	.068 (1.36)	-.883 (3.16)*	.99	138.04**	1.82
Dep. Var.	**P_L/P_m**	**$(P_L/P)_m$**	**P_L**	**P_m**	**L_t/L_{t-1}**	**$(S/L)_{t-1}$**	**R^2**	**F-ratio**	**d.w.**
Eq. 5 Ln S/L			-.506 (**)	.152			.88		.65
Eq. 6 ln S/L		N/A					N/A		N/A
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	.162				-.326 (**)	.027 (**)	.96		2.03

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

APPENDIX C

TABLE C. 1 Farm Machinery Investment Equations estimated by Least Squares with the first order auto-regressive scheme for Canada (1960 - 1974)

Dep. Var.	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-.790 (.262)	2.49 (2.30)*	-.032 (1.35)	.038 (1.12)	.0041 (.536)	.78	8.18**	.99
Eq. 2 $\ln I_t$	.131 (.711)	1.28 (5.52)**	-.169 (1.03)	.327 (1.79)	.391 (15.37)**	.71	5.47*	2.80
Eq. 3 S_t	-10.17 (1.32)	3.05 (1.81)	-.070 (1.84)	.035 (.652)	.102 (3.79)**	.86	14.20**	1.063
Eq. 4 $\ln S_t$	-1.04 (4.76)**	-.038 (.687)	-.015 (1.02)	.0076 (.425)	.574 (68.82)**	.96	58.80**	1.41

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			.806 (7.49)	-.964 (8.93)			.96	271.54**	1.59
Eq. 6. ln S/L		.165 (.426)					.077		1.33
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	.308 (1.71)				.820 (139.37)**	-.005 (.170)	.99	17487.3**	1.334

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE C.2 Farm Machinery Investment Equations extimated by Least Squares with the first order auto-regressive scheme for Atlantic Provinces (1960 - 1974)

Dep. Var.	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-.025 (.610)	.022 (.921)	-.014 (.566)	.033 (1.0)	.0006 (2.33)*	.68	4.82*	1.53
Eq. 2 ln I_t	.333 (1.45)	1.92 (8.01)**	.457 (.595)	-.149 (1.00)	-.194 (9.11)**	.88	16.07**	2.02
Eq. 3 S_t	-.076 (.543)	.057 (2.06)	.002 (.066)	.003 (.088)	.006 (6.00)**	.63	3.79*	1.12
Eq. 4 ln S_t	-.103 (4.16)**	-.031 (1.16)	.442 (4.98)**	-.007 (.429)	-.024 (9.36)**	.74	6.49*	2.08

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			1.36 (2.80)*	-1.88 (3.31)**			.89	101.19**	.92
Eq. 6 ln S/L		-.405 (.506)					.36		1.47
Eq. 7 ln $\frac{S_t}{S_{t-1}}$	-.044 (1.81)				-.245 (12.33)**	-.012 (2.51)*	.93	72.68**	1.39

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE C. 3 Farm Machinery Investment Equations estimated by Least Squares with the first order auto-regressive scheme for Quebed (1960 - 1974)

Dep. Var.	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-.144	.190	-.017	.061	.002	.83	10.92**	1.75
	(1.97)	(1.32)	(.569)	(1.12)	(1.75)			
Eq. 2 $\ln I_t$	-.277	1.38	-.038	.138	.075	.80	8.79**	2.16
	(.866)	(3.20)**	(.278)	(.543)	(3.60)**			
Eq. 3 S_t	.233	.362	-.029	.025	.016	.92	24.66**	.872
	(.973)	(1.31)	(.626)	(.324)	(7.73)**			
Eq. 4 $\ln S_t$	-.230	.021	-.004	.005	.217	.91	23.27**	1.12
	(2.07)	(.184)	(.148)	(.132)	(47.09)**			

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			.739	.015			.95	250.88**	1.06
			(.345)	(.048)					
Eq. 6 ln S/L		.405					.097		1.43
		(1.13)							
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	.0004				.540	-.025	.99	4771.44**	1.92
	(.028)				(101.96)**	(5.69)**			

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE C. 4 Farm Machinery Investment Equations estimated by Least Squares with the first order auto-regressive scheme for Ontario (1960 - 1974)

Dep. Var.	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-.494	.365	-.004	.020	.005	.88	16.92^{*}	1.57
	(1.76)	(1.29)	(.127)	(.397)	(2.05)			
Eq. 2 $\ln I_t$	-.096	1.46	.120	.013	.185	.81	9.86^{**}	2.38
	(.637)	$(5.93)^{**}$	(.764)	(.060)	$(11.45)^{**}$			
Eq. 3 S_t	1.15	1.18	-.016	-.009	.023	.87	15.13^{**}	1.43
	(1.28)	$(3.58)^{**}$	(.500)	(.168)	$(3.50)^{**}$			
Eq. 4 $\ln S_t$	-.049	.179	-.006	.0002	.364	.90	21.23^{**}	1.83
	(.267)	$(2.78)^{*}$	(.346)	(.006)	$(41.51)^{**}$			

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 $\ln S/L$			.281	-.365			.97	435.05^{**}	1.08
			(1.73)	(1.80)					
Eq. 6 $\ln S/L$		.580					.05		1.20
		(1.59)							
Eq. 7 $\ln \frac{S_t}{S_{t-1}}$	.020				.604	-.009	.99	5680.8^{**}	.96
	(.633)				$(109.84)^{**}$	(1.33)			

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5 % and 1 % level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also fo natural log. form.

TABLE C.5 Farm Machinery Investment Equations estimated by Least Squares with the first order auto-regressive scheme for Manitoba (1960 - 1974)

Dep. Var.	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-.653	.352	-.103	.099	.002	.77	7.37*	1.05
	(1.33)	(2.65)*	(2.23)	(1.64)	(1.61)			
Eq. 2 ln I_t	-1.10	1.52	.038	-.564	.003	.73	5.96*	1.52
	(.810)	(2.97)*	(.137)	(1.98)	(.960)			
Eq. 3 S_t	-1.48	.506	-.176	.165	.008	.92	26.77**	1.98
	(2.48)*	(3.82)**	(3.87)**	(2.83)*	(5.24)**			
Eq. 4 ln S_t	-1.36	.015	-.054	.076	.127	.93	130.09**	1.12
	(3.47)**	(.166)	(1.28)	(2.09)	(16.94)**			

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t/L_{t-1}	$(S/L)_{t-1}$	R^2	F-ratio	d.w.
Eq. 5 Ln S/L			1.27	-1.35			.79	46.33*	.87
			(4.14)**	(4.45)**					
Eq. 6 ln S/L		.535					.31		.90
		(1.32)							
Eq. 7 ln $\frac{S_t}{S_{t-1}}$	.856				.861	-.554	.98	287.19**	.80
	(3.16)*				(13.33)**	(3.10)*			

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5% and 1% level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

TABLE C. 6 Farm Machinery Investment Equations estimated by Least Squares with the first order auto-regressive scheme for Saskatchewan (1960 - 1974)

Dep. Var.	P_m/P_L	P_y/P_m	S_{t-1}	Y_{t-1}	$\bar{F}_t$	R^2	F-ratio	d.w.
Eq. 1 I_t	-1.05	.616	-.080	.057	.002	.70	5.20*	.96
	(.818)	(1.70)	(1.83)	(1.25)	(1.18)			
Eq. 2 ln I_t	.239	.815	-.505	.741	.177	.77	7.67*	2.52
	(.608)	(4.09)**	(3.04)*	(6.32)**				
Eq. 3. S_t	-2.00	1.41	-.186	.091	.010	.95	47.61**	1.58
	(.954)	(3.26)**	(3.50)**	(1.68)	(2.83)*			
Eq. 4 ln S_t	-1.03	.204	-.093	.045	.275	.96	56.43**	1.25
	(1.72)	(1.48)	(2.02)	(.945)	(16.45)**			

Dep. Var.	P_L/P_m	(P_L/P_m)	P_L	P_m	L_t'/L_{t-1}	$(S/L)_{t-1}$	R_2	F-ratio	d.w.
Eq. 5 Ln S/L			-.573	.571			.48	11.27**	1.03
			(1.68)	(1.66)					
Eq. 6 ln S/L		.594					.13		1.63
		(1.38)							
Eq. 7 ln $\frac{S_t}{S_{t-1}}$	-.217				1.14	.508	.99	482.06**	1.63
	(.795)				(29.79)**	(2.23)*			

1). Values in parentheses are t-statistic.
2). * and ** indicate the estimate is significant at 5% and 1% level respectively.
3). In the equation of which dependent variable is of natural log. form independent variables are also of natural log. form.

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