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Integration of Production and Financial Theory in Analysing Farm Firm Behaviour

INTRODUCTION

Important changes have occurred in the financial and economic environment facing agricultural producers world-wide. Increased price volatility for both inputs and products has resulted in significantly higher risk. Price changes on land and other inputs have created capital gains and losses that have sometimes overshadowed current income from production in agricultural decision-making. High interest rates on borrowed funds combined with the increased use of leverage or debt capital in many farm businesses have increased the financial vulnerability of a number of firms. Government policy in the form of subsidized credit, price supports or constraints for agricultural commodities, and tax treatment of farm investments in agricultural production have become a significant dimension of the environment in which farmers must make their production, marketing and financial decisions.

Given these significant changes in the production environment for agriculture, the theory of the firm, which is used as the conceptual base for most production economics studies of farm firms, must be re-examined. As traditionally developed in most microeconomic or farm management textbooks, this theory does not encompass some of the major dimensions of the farm firm's decision environment including financing strategies, capital gains and losses, liquidity problems, risk, and tax considerations. A more complete theory of the firm that integrates production theory and investment-financial theory is necessary to explain producer behaviour and the adjustment processes of the farm firm.

The purpose of this paper is to develop a broader theoretical framework of farm firm behaviour that encompasses production, financing, and investment-disinvestment decisions with explicit recognition of cash flow, liquidity, capital gains and losses, rate of return, and tax considerations. The discussion will proceed by first identifying the important characteristics of the farm firm decision environment. Then an explicit model of an integrated theory of the firm will be developed. Implications of this integrated theory of the firm for optimal input use, optimal product mix, optimal investment and disinvestment behaviour, optimal financing strategy, and optimal firm size will be discussed. Finally, policy considerations will be reviewed.

THE DECISION ENVIRONMENT

The modern decision environment for the farm firm includes some important new dimensions as well as a renewed awareness and focus on 'old' dimensions that have been previously recognised, but not adequately reflected in farmers' decisions in recent years. The old dimensions include the multiplicity of enterprises or products that can be produced and inputs that can be used in the production process. This basic and well recognised dimension of the decision environment is increasingly important for two reasons. First, the focus of much of the expansion of agriculture in the developed countries during the 1970s has been on specialised agriculture which required capital-intensive technology resulting in capital-labour substitution and reduced diversity. Higher capital charges and increased financial and business risk in agriculture attributable to more price volatility and higher leverage ratios suggests that the trends to more specialisation and capital-labour substitution should be re-evaluated. The conceptual framework must be sufficiently robust to evaluate the benefits in terms of efficiency compared to the cost in terms of higher risk and reduced flexibility or adaptability to a changing environment of specialization and technology that embodies a high capital-labour ratio.

A second dimension of the production response phenomena that must be tractable in any theoretical model and should be recognised in empirical work is the twofold response function for such production inputs as fertilizers, chemicals and growth stimulants of various forms. These 'non-traditional' inputs generate two important outputs, a 'good' in the form of increased yield of grain or livestock products, and a 'bad' in the form of a residual that may result in environmental degradation. Most farm management-production economics studies have not recognised these residuals or have treated the residual response function as an externality. With increased consciousness of the environmental degradation and social cost of such residues, these externalities must be internalised and response functions that explicitly recognise both products (the agricultural commodity as well as the environmentally degrading residual) must be included in the empirical analysis of optimal enterprises choice and input combinations.

A third important dimension of the modern decision environment is that returns can be obtained in the form of annual flows of income (losses) *and* in the form of capital gains (capital losses). The capital gains or losses have typically occurred in the form of price appreciation or declines on farm real estate, but such gains or losses could be associated with any asset. Various researchers have speculated about the impacts of capital gains on production decisions. Bhatia argued that in a world of perfect capital markets and equal taxes on all types of income, unrealised capital gains would be a perfect substitute for current income in wealth of the individual, and hence there is justification for including at least a part of the capital gain in the current income stream of an individual. Plaxico and Kletke (1979) formalised this wealth approach by recognising a fraction of capital gain as income, while deferring the remaining gain and the taxes on the gain to the end of the holding period.

Another approach to the value of unrealised gain is to argue that unrealised gain is a substitute for equity in the financial negotiation – unrealised gain increases the financial base for acquiring credit and reduces risk for borrower and lender. Thus, Lins and Duncan argue that because appreciated value of land holdings provides a base for additional purchases, capital gains have resulted in incentives for farm expansion. They also suggest that rising land prices encourage greater reliance on debt financing; in an attempt to reap the benefits of capital gains, farmers buy sooner and go further into debt than they would in a stable price environment. Davenport et al. (1982) suggests that the preferential tax treatment of capital gains has exacerbated the farm expansion trend by offering high income land owners tax shelter incentives for purchasing more land. Castle and Hock argue that farm land capital gains reduce incentives to adopt land saving practices and technologies and may help explain the increase in acreage per farm, the use of larger machinery and the relatively low growth of land productivity in the 1970s. Thus, a complete theory of farm firm behaviour must explicitly recognise capital gains and losses as well as annual income flows as important dimensions of the decision environment.

Taxation is one of the irritants of the real world that has become increasingly important in the decision environment of the farm firm. Numerous recent studies indicate that the optimal product mix and input utilisation is substantially altered by the tax treatment of various inputs and products. Differential tax treatment of capital compared to labour under the US tax law, which reduces the cost of capital but increases the cost of labour, would be expected to alter the utilisation of these two inputs. Investment credits and rapid depreciation allowances have also contributed to adoption of capital intensive technologies and capital-labour substitution (Davenport et al., 1982). Differential tax treatment of 'capital gains' compared to 'ordinary income' have encouraged the production of those products that will generate the more favourably taxed capital gain income. Tax sheltering which is part of the tax code in the United States and many other countries whereby income can be sheltered from taxation through judicious use of deductions, exemptions and credits has significantly affected investment behaviour and expansion as well as contraction strategies. The institutional structure of the tax rules cannot be ignored in analysing farm firm behaviour – in fact, it would appear to be a major determinant of individual production, investment-financing, and marketing strategies for many farmers.

A fifth dimension of the decision environment is the significant impact that financing has on the optimal input mix and product choice. The traditional thoery of the firm assumes that adequate financing is available to purchase inputs in the optimally desirable quantities and that the financing institutions will not implicitly or explicitly differentially ration funds for different enterprises. But Vickers and Baker have clearly indicated that financing arrangements do affect optimal firm behaviour. Through differential interest rates or credit constraints for various inputs and products, which are more a function of cash flow rather than net income considerations, lenders can alter the relative net prices (market price plus or minus implicit finance charges) of various products and inputs, and thus optimal input mix and product choice. Explicit recognition of finance charges and the money capital constraint must be part of a robust theory of firm behaviour.

Furthermore, recent innovations in financing the production process, in addition to the traditional funds sources of retained earnings and debt, suggests that the choice of a particular financing arrangement is much more complex than has traditionally been the case. The theoretical model must include alternative equity sources including retained earnings, family transfers and non-farm equity, as well as non-equity sources of debt and lease capital with various terms and maturities. In fact, in the current high interest rate, high risk environment, the optimal financing arrangement may be as important as the optimal enterprise choice and input mix for the successful farm business, and these two decisions are clearly interrelated.

A final dimension of the current decision environment which must be explicitly recognised in the conceptual framework and empirical work is the significant element of risk in agricultural production and the interrelatedness of the financial characteristics of the farm business and new concepts of risk in agriculture. Most previous analyses have utilised the widely accepted concept of risk as the variation in income that results from variable prices and yields. Consequently, the results traditionally have been represented in the framework of expected income and the standard deviation, variance, absolute deviation or coefficient of variation of expected income. More recent studies have focused on cumulative probability distributions for income and evaluated those distributions using stochastic dominance techniques (Barry). But the financial stress of recent times has focused attention on a second concept of risk – that of the probability of firm survival as an entity. For a large number of producers, the focus of risk management is not on controlling or managing the variability in income, but protection from failure or termination of the firm.

This concern about financial failure has stimulated a new emphasis on the cash flow and liquidity characteristics of the firm and its asset base. Each asset or input in the farm business has five financial characteristics of importance in economic analyses. Four of these – net income, net cash flow, capital gains, and collateral value – have been commonly recognised. Furthermore, the uncertain nature of the first three of these is frequently acknowledged, but the uncertain nature of the collateral value has seldom been considered in modelling the farm firm. The fifth characteristic, which we will refer to as the asset's liquidity value, has typically been overlooked because models have seldom considered the possibility of asset liquidation as a survival strategy. These liquidation losses, which may be larger and more variable for some assets than others, have had an important effect on the economic viability (including survivability) of farm firms. A more complete understanding of farm firm behaviour is possible if these important and significant dimensions of the decision environment are explicitly recognised in the conceptual framework.

AN INTEGRATED THEORY OF THE FIRM

A theoretical model that encompasses most of the characteristics of the modern production environment for the farm firm is summarised in the following set of equations. Ideally the model should maximise expected utility considering price, production and financial risks. This approach has been used elsewhere with a specific focus on survival (Robison and Lev). The approach used here is a simpler lexicographic model which maximises the expected value of the firm subject to a probabilistic constraint on firm continuance.

As suggested by Vickers, the entrepreneur is assumed to maximise wealth, which can be stated as:

$$V = \frac{E[\pi]}{\rho} - K = \{\sum_{t=1}^{\infty} E[\pi]/(1 + \rho)^t\} - K \tag{1}$$

where V is the expected value of the firm, $E[\pi]$ is the expected annual stream of income and capital gain, and ρ is the capitalization rate. The expected annual stream of income and capital gain is specified as:

$$E[\pi] = E\left[\left\{Pf(X, L) - \gamma_1 X - \gamma_2 L - r\left(\frac{D}{K}\right)D\right\}(1 - \tau) + \phi_1\delta_1 L + \phi_2\delta_2 X\right] \tag{2}$$

where P is a vector of output prices; X denotes non-durable inputs or products that contribute to production and are consumed or sold during the production period; L denotes durable inputs that contribute to production over time and may increase (decrease) in value resulting in capital gains (losses); f(X, L) is a strictly concave multiproduct production function with f_X, $f_L > 0$, f''_X, $f''_L < 0$ for all products; γ_1 and γ_2 are the cash prices of inputs X and L respectively (the price of non-durable inputs is easily determined; the price of durable inputs is calculated as the annualised cost of the services rendered and is frequently estimated as the explicit or implicit rental cost per unit of service); D is debt funds used to finance the production process; K is equity funds; $r(D/K)$ is the debt supply function with $r' > 0$ and $r'' > 0$; τ is the average tax rate; δ_1 and δ_2 are the rate of capital gain or loss on non-durable and durable inputs; and ϕ_1 and ϕ_2 are the portion of unrealised capital gain or loss on non-durable and durable inputs substitutable for income. The formulation of equation (2) does not explicitly recognise the differential taxation of capital gains compared to ordinary income, although such a distinction has been accommodated elsewhere (Lowenberg-DeBoer).

The capitalisation rate is specified as a function of firm size and financial leverage:

$$\rho = a - \theta_1 (K + D) + \theta_2\left(\frac{D}{K}\right)^2, \tag{3}$$

where a is a constant, θ_1 is the firm size parameter of the capitalisation rate function, and θ_2 is the leverage parameter of the capitalisation rate function (Vickers). The specification of equation (3) recognises that as firm size increases the marginal productivity of capital and thus the capitalisation rate declines, but that increased leverage and thus higher financial risk results in an increase in the capitalisation rate.

The value of the firm is maximised subject to the financing and survival constraints. The financing constraint is specified as:

$$K + D - \alpha X - \beta L \geqslant 0 \tag{4}$$

where α and β are the amount of financial capital absorbed in the acquisition of the non-durable and durable inputs respectively; these parameters may not be equal to the purchase price of the input if special financing arrangements reduce the capital absorbed in the acquisition process. For example, leasing arrangements or concessionary financing used as a sales tool by farm equipment manufacturers can reduce the capital required to acquire such equipment. Equation (4) indicates that the acquisition of inputs requires and is constrained by the availability of equity (K) and debt (D) capital. Equity capital is comprised of proprietor's contributions and retained earnings, as well as equity funds contributed by outside investors. Thus, the equity capital base is not presumed to be constant since the entrepreneur's equity can be augmented with outside equity.

The final constraint is a liquidity or survival constraint. It recognises that assets have a net cash flow and/or a liquidity component that can be used to meet the firm's minimum requirement for cash. Given the uncertainty associated with the cash and the liquidity components, this is specified as a constraint which must be met with a specified probability:

$$PR\left[\left\{Pf(X, L) - \gamma_1 X - \gamma_2 X - r\left(\frac{D}{K}\right)D\right\}(1 - \tau) + \lambda_1 X + \lambda_2 L - C \geqslant 0\right] \geqslant Z \tag{5}$$

where λ_1 and λ_2 are the after-tax liquidity coefficients per dollar of nondurable and durable inputs (which is one minus the liquidity loss), respectively, C is operator withdrawals and Z is the minimum probability with which the constraint must be met. Equation (5) might be termed the 'survival function'. It reflects the cash flow requirements that the firm must meet to continue in business. Production inputs and capital assets typically contribute cash earnings; while others, such as stored grain awaiting sale, commonly contribute cash through liquidation. However, the constraint recognises that durable and non-durable inputs can be liquidated to meet cash needs, even though such sales are expected to significantly impair the long-run income-generating capacity of the firm. The formulation specified here assumes that assets are liquidated only at the end of the production cycle; however, such an assumption is not essential if the model included a more detailed time specification. In a dynamic context, with changing debt and equity levels, the liquidity constraint could include a more detailed specification of financial plans, including principal payments.

The decision variables in the model include non-durable inputs (X), durable inputs (L), debt, and equity (K). The multiproduct nature of the production function [f(X, L)] implies that the optimal values of these decision variables will result in an optimal product mix as well as an optimal size of farm.

IMPLICATIONS

The comparative statics properties of this model are complex to develop analytically, particularly given the probabilistic nature of the survival constraint (equation (5)). Lowenberg-DeBoer has derived comparative static properties for the model excluding the survival function. As a step in the development of a more general model, the discussion here will draw upon and augment that earlier work by examining the implications of adding the survival function to the model.

The implications of this integrated model for optimal input use and product mix are significant. Lowenberg-DeBoer indicates that ignoring the survival constraint the optimal mix of durable and non-durable inputs is not only a function of the relative prices (γ_1 and γ_2), but also the finance charge coefficients (α and β) and the capital gains parameters ($\phi_1\delta_1$ and $\phi_2\delta_2$). Using his approach, the marginal rate of input substitution is defined as:

$$\frac{f_X}{f_L} = \frac{[\gamma_1 + \alpha\,(r + r'\,(D/K))]\,(1 - \tau) - \phi_1\delta_1}{[\gamma_2 + \beta\,(r + r'\,(D/K))]\,(1 - \tau) - \phi_2\delta_2} \tag{6}$$

where f_X/f_L denotes the ratio of marginal products of durable for non-durable inputs.

As is typical of the Vickers' formulation, the marginal rate of substitution is equal to a factor or input cost ratio which includes after-tax relative input prices, plus relative 'finance charges'. These relative finance charges reflect the interest payments on funds borrowed to buy the inputs, as well as the implicit or explicit collateral constraints imposed by lenders as reflected in specific lending limits that restrict the use of credit in acquiring various inputs. Because these lender-imposed collateral and funding constraints are more a function of cash flow and liquidity characteristics of various inputs rather than relative prices, it is typically the case that the relative finance charges will not be equal to relative input prices.

Unlike the usual Vickers' model, the input cost ratio also includes an argument reflecting differential capital gains or losses on durable and non-durable inputs. Typically, capital gains or losses on durable inputs will exceed those on non-durables; in fact, the capital gains or losses for non-durables will frequently be zero. Assuming that capital gains on non-durables are zero ($\delta_1 = 0$), but that capital gains on durables are positive ($\delta_2 > 0$) and that part of these gains are substitutable for current income ($\phi_2 > 0$), the capital gains will tend to offset part of the cost of acquiring the durable inputs. Capital losses would have the opposite affect; they would tend to increase the cost of durable inputs. Thus, the optimal input mix is not only a function of relative factor prices, but also relative finance charges and relative capital gains or losses.

The recognition of capital gains and losses and finance charges will also have an impact on the choice of outputs. Lowenberg-DeBoer introduces two production functions [g(X, L) and f(X, L)] into the model, and when input prices are the same for both enterprises the marginal rate of substitution equation is as follows:

$$\frac{f_X}{f_L} = \frac{g_X}{g_L} = \frac{\{\gamma_1 + \alpha[r = r'\ D/K]\}\ (1 - \tau) - \phi_1\delta_1}{\{\gamma_2 + \beta[r + r'\ D/K]\}\ (1 - \tau) - \phi_2\delta_2} \tag{7}$$

Both the marginal rate of substitution for the f production function (MRS_f) and marginal rate of substitution for the g production function (MRS_g) will be larger than is traditionally the case because of the presence of capital gains on durable inputs. But, if one production function has a lower marginal product of durable inputs than the other, the output and use of durables in the production of that commodity will be curtailed. For instance, assume g describes the production of fruit and vegetables such that at some relatively small amount of land g_L becomes small compared to g_X, that is the marginal product of land becomes small compared to the marginal product of other inputs such as fertilizer, labor, pesticides, etc. Assume f describes the production of grain; the marginal product of land in grain production can remain relatively high even if substantial amounts of land are already in use. Under these conditions MRS_g would be equal to the input cost ratio at some low level of land input, but a much larger level of land input would be required to equate MRS_f and the factor cost ratio.

As capital gains increase, the input cost ratio increases and the output which lends itself to land-extensive production assumes a larger share of the output mix. It may be the case for some levels of capital gain and some production functions, that the land input for g must be made so small to achieve equality (7) that the production of output g drops to zero. It should be noted that this does not suggest that the most land extensive output is always favoured. Rather it indicates that the favoured output in the presence of capital gains is one in which the production process is relatively land-extensive and the marginal product of land remains relatively high even when the firm uses large amounts of land. For capital losses the opposite effect occurs and enterprise choice tends toward land-intensive options.

The discussion thus far has not recognized the impact of liquidity and cash flow differences in the choice of optimal durable and nondurable input use as encompassed in the survival function of equation (5). If the lender's perception of cash flow and liquidity characteristics of durable and non-durable inputs as reflected in the finance charges are an accurate reflection of the actual values of these coefficients as experienced by the farmer, then explicit recognition of these characteristics as in equation (5) will have little impact on the optimal input mix. However, if cash flow and liquidity characteristics as actually faced by the farmer differ from those of the lender, then the addition of these parameters will influence optimal input use. Specifically, non-durable inputs are typically more liquid and generate more cash flow on a per unit basis than durable inputs, which would suggest a larger quantity of nondurable inputs in the optimal input mix.

With respect to investment behaviour, the optimal mix of durable and non-durable inputs as well as the optimal type of durable input to acquire is influenced by the net income, net cash flow, capital gains, collateral value, and liquidity parameters in the fashion noted earlier. The disinvestment behaviour, as noted elsewhere (Boehlje and Eidman 1983) is a function of the same parameters; the owner would prefer to sell those assets that possess the characteristics of high liquidity, low net income and cash flow, low capital gains, and limited collateral value.

Ignoring the survival constraint, the financial structure of the firm can be characterised by solving the first-order conditions for equity and debt to yield an expression in the discount rate and leverage ratio as:

$$\rho - r' \left(\frac{D}{K}\right)^2 = r + r' \left(\frac{D}{K}\right) \tag{8}$$

The left-hand side of this equation is the marginal cost of equity capital, and the right-hand side is the marginal cost of debt capital, which generates the common financial result that in the optimal financial structure the marginal cost of all sources of capital are equal. Lowenberg-DeBoer indicates that if equity is not fixed, capital gains and losses do not affect the financial structure or the optimal debt-equity mix. However, if equity is fixed, the optimal use of debt must be found simultaneously with input levels. The result in this case is that capital gains or losses do impact debt utilisation; debt use increases (decreases) with higher levels of capital gains (capital losses).

In a more detailed specification of the model, D may be a vector of debt with various maturity and principal repayment characteristics. The optimal composition of debt is then a function of the cost of each debt source and its impact on the survival constraint through the debt servicing requirements. Debt servicing requirements are typically lower for current compared to long-term debt because of lower interest rates and scheduled principal reductions (assuming normal inventory financing). Consequently, with increased financial stress and cash flow problems, the optimal debt composition will include a larger quantity of long-term and a smaller quantity of short-term (current) debt. Equation (5) also suggests that, because of relative liquidity and cash flow characteristics as noted earlier, an input mix that contains a higher proportion of non-durable inputs will improve the probability of survival. Clearly lower levels of withdrawal and the substitution of entrepreneural and investor equity for debt will reduce the cash requirements for debt servicing and also increase the probability of survival.

In summary, the implication of incorporating capital gains or losses and finance charges (including liquidity and collateral coefficients) in the analysis for the use of durable and nondurable inputs and organisation of the farm firm are important. Since real estate is the most important durable input used in most farming operations, the farm size implications are also significant. In essence, the larger the capital gain on durable inputs (for example, the land price increase) or the smaller the finance charges, all other parameters constant, the greater the optimal use of durable inputs (farmland). Use of nondurable inputs is reduced if capital gains are larger or the fraction of capital gains substitutable for current income is greater. Capital losses and higher finance charges have the opposite effect; they tend to increase the cost of durables (land), reducing the factor or input cost ratio and hence reducing the use of durables (land) in the optimal solution while increasing use of nondurable inputs. Thus, in an environment of capital losses or higher relative finance charges, the decision-maker would tend to economise on durables (land) to avoid those losses or costs.

With specific reference to capital gains or losses, it is important to separate the effects of the price level of durable inputs compared to the rate of change in durables' prices. If the price of durable inputs is higher, the annualised cost of durables' ownership will be higher and there will be a tendency to use fewer durables. The price change in durables can, however, either offset or add to the cost of owning durable inputs, depending upon whether the price is rising or falling.

The analytical results suggest that at least part of the increase in the use of durable inputs and farm size in the United States in recent years may be a result of the almost continuous capital gains that have occurred. It also indicates that, all other things being equal, if capital gains during the period had been smaller or if those unrealised gains had been less substitutable for wealth, farmers would have invested in more non-durable inputs such as labour, fertilizer, pesticides, and improved seed. The analysis also suggests that farm size and the use of non-durable and durable inputs can be significantly affected by government policy. For instance, it is frequently argued that land prices are the capitalised value of expected future income from land ownership. If this expected future income is rising, capital gains are likely to occur. If a price support programme increases the rate at which future income from land is expected to rise, the analysis suggests that there will be a tendency for farm size to increase and for land use to become more extensive. Conversely, a weakening of government price support commitments which reduces income expectations, resulting in a lower rate of land price change, would tend to reduce the optimal farm size and encourage more intensive farming. Government tax and credit policies that have a differential impact on income, capital gains and finance charge coefficients for durable and non-durable inputs will affect the optimal input mix in like fashion.

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