Conceptualisation of family farms' flexibility

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Abstract— **Agricultural enterprises in transition countries face dynamic changes in the prevailing economic, legal and political conditions. The success of an enterprise depends on its ability to adjust its farming system in response to these changing conditions. To meet this challenge, flexible and adaptable production technology is required. Thus, the farm's choice of technology is an important decision which determines its future performance. Although the concept of a firm's flexibility is widely analysed in microeconomics literature, there is no comprehensive framework to facilitate the analysis of family farms' flexibility, especially considering market imperfections and other obstacles associated with the transition process.**

In this paper we formulate the theoretical framework for flexibility analysis in order to investigate the impact of farm-specific characteristics on optimal flexibility design and to explain the differences between farms using different production technologies. In a simplified formal model, a competitive risk-averse firm producing one product is assumed to face fluctuating demand under uncertainty. By choosing the level of flexibility, the decision-maker determines the technology of the firm, expressed by the cost function. The optimal level of flexibility will be found by backward induction in the two-stage decision-making process, including ex ante technology decision and ex post output level decision. Using comparative statics and existing theoretical literature, some hypothesis about the relationship between flexibility and other firm characteristics will be formalised. Some possible model extensions that account for specific characteristics of the family farm business in transition countries, as well as future empirical analysis are discussed.

Keywords— **flexibility, output price risk, family farms.**

I. INTRODUCTION

Agricultural enterprises in transition countries face dynamic changes in their prevailing economic, legal and political conditions. Indeed, the complexity of the agribusiness environment increases with ongoing liberalisation, globalisation and standardisation processes. We argue that an enterprise's success depends on its ability to adjust its farming system in order to respond to these changes. To meet this challenge, a flexible and adaptable production technology is required. Thus, the farm's technology choice is an important decision for determining its future performance.

The concept of a firm's flexibility has been widely analysed in microeconomics literature since its notion was introduced by Stigler [1], who considers flexibility to be an attribute of a cost curve, as far as its slope determines how responsive output decisions are to price fluctuations. Mills and Schumann [2] assume the existence of technologically diverse firms within an industry providing a trade-off between static and dynamic efficiency, the latter staying for flexibility. Thus, they argue that flexibility and firm size are inversely related, which has been confirmed by some empirical studies [3, 4]. Zeller and Robison [5] developed a flexibility model considering risk attitudes in the two-stage decision-making process. Thus far little work has been done on flexibility issues in the agricultural sector [6, 7]. To our knowledge, there exists no comprehensive framework to facilitate the analysis of family farms' flexibility, especially considering market imperfection and other obstacles associated with the transition process.

Based on the above considerations, the goal of this paper is to formulate the theoretical framework for flexibility analyses in order to i) investigate the impact of firm-specific characteristics on optimal flexibility design, and ii) to explain the differences between firms using different production technologies. Thus, in the next step, a simplified formal model will be discussed. Finally, we address possible model extensions to account for specific characteristics of the family farm business in transition countries, as well as future empirical analysis.

II. MODEL

In our model, a competitive, risk-averse firm producing one product is assumed to face an output price p_x under uncertainty. In the first stage, the firm chooses the level of flexibility α before the product price p_x is known. In the second stage after p_x is observed, the firm maximizes its profits by choosing the optimal output level x^*. Thus, there are two firms' decision variables, with α being the ex ante and x^* the ex post one. The costs of an ex post adjustment or the profitability of the ex post output decisions depend on the ex ante flexibility decisions.

Following Stigler [1], Marschak and Nelson [8] and Mills [9] we assume flexibility (α) to be a parameter of the cost function determining its convexity. However, we mitigate their strong assumption about costs being a quadratic function of output by formulating a generalised form of the cost function consisting of variable (C_v) and fixed costs (C_f).

Thus,

$$C_v = C_v(x,\alpha) + C_f(K,\alpha), \qquad (1)$$

where x is the produced output, and K the capital stock. By choosing the level of α the decision-maker determines the cost curve of the firm, and thus its ability to adjust output. Following the abovementioned flexibility literature, we assume that an increase in α reduces the rate at which marginal cost increases as output is expanded, making the cost curve less convex. Further assumptions are:

$$\frac{\partial C_v}{\partial x} > 0,\ \frac{\partial C_v}{\partial \alpha} < 0,\ \frac{\partial^2 C_v}{\partial x^2} > 0, \quad \text{and}$$

$$\frac{\partial C_f}{\partial K} > 0,\ \frac{\partial C_f}{\partial \alpha} > 0,\ \frac{\partial^2 C_v}{\partial x \partial \alpha} < 0.$$

The optimal level of flexibility can be found by backward induction in the two-stage decision-making process.

In the ex-post decision, the decision-maker chooses a profit-maximizing output level x^* by given flexibility (α) and product price (p_x). Profit is given by:

$$\pi = p_x x - C_v(x,\bar{\alpha}) - C_f(K,\bar{\alpha}) \ . \qquad (2)$$

Solving the first order condition

$$\frac{\partial \pi}{\partial x} = p_x - \frac{\partial C_v(x,\alpha)}{\partial x} = 0 \ . \qquad (3)$$

provides the optimal output level x^* as a function of p_x and α:

$$x^* = x^*(p_x,\alpha) \ . \qquad (4)$$

Ex ante decision: At the time the decision-maker chooses α, the price p_x is unknown and profit is a random variable. Only expected value $E(p_x) = \bar{p}_x$ and variance of the product price, $Var(p_x) = \sigma_p^2$ are known. Hence, the decision regarding the optimal flexibility level can be described as a maximisation problem under risk. We assume a risk-averse decision-maker with a constant absolute level of risk aversion λ. Then, the certainty equivalent of the risky profit π_{CE}, measured as the expected value of profit minus the risk premium, will be maximized with respect to flexibility α.

Substituting the optimal output (4) in the expected profit function provides:

$$\pi_{CE} = E(\pi) - \frac{\lambda Var(\pi)}{2} = \\ = \mathrm{E}\left[p_x x^* - C_v(x^*,\alpha) - C_f(K,\alpha)\right] - \frac{\lambda}{2} x^{*2} \sigma_p^2 \rightarrow \max! \qquad (5)$$

The optimal level of flexibility, solved by the first order condition of $\partial \pi_{CE} / \partial a$, delivers

$$\alpha = \alpha(\bar{p}_x, \sigma_p^2, K, \lambda, x^*). \qquad (6)$$

Based on the comparative statics, some individual effects could be derived. The theoretical findings, however, differ slightly with regard to the assumptions made due to the cost function. Indeed, assuming that the cost function is quadratic, we could identify a

positive impact of expected output price and capital on the flexibility level. This assumption conforms with the findings of Marschak and Nelson [8] and Mills (among others).

However, Hiebert [10] argues that the assumption of a quadratic cost function might be too restrictive while dealing with the analysis of decision-making under uncertainty, and hence lead to ambiguous effects. The effect of the output level is also unclear. On the one hand, Mills and Schumann [2], Zimmermann [4] and Das et al. [3] provide evidence on the inverse relationship between flexibility and output level or firm size. On the other hand, following the arguments of Zeller and Robison [5], higher capital costs of a flexible technology cause higher flexibility levels for larger firms. Intuitively, we expect a positive relationship between risk aversion and flexibility, since flexibility is usually attributed to the ability to cope with risks. However, Zeller and Robison [5] argued that a more risk-averse decision-maker would prefer less flexible technology due to the higher capital investments required by flexible technology. Thus, further research is needed.

III. FURTHER RESEARCH

A. Theoretical framework

It is left to future work to extend the theoretical model to make it more suitable to adequately address the issue of flexibility of family farm businesses in transition countries. Some of the future research and extensions might include:

- The introduction of additional variables in the theoretical model such as factor price fluctuations in the variable cost function in order to analyse their impact on the choice of the flexibility level.
- Extending the analytical framework to analyse a multi-product firm to account for the ability to switch between different outputs.
- Further literature research to derive hypotheses on the impact of various family farm characteristics, such as socio-demographic variables (i.e., family size, age and education of the head of the farm, farm succession) and organisational characteristics of the farm (commercialisation, integration degree of labour, capital markets, etc.).
- Discussion of the possible objectives of a family farm (profit orientation, cash income, ensuring family farm income and self-sufficiency, etc.).
- Consideration of market imperfection on the product, input, labour and capital markets.

However, accounting for different goals and market imperfections in transition economies would call for a formal, complex farm-household-model.

B. Empirical analysis

Using the above outlined analytical framework as a basis, further empirical work will focus on flexibility issues in Polish family farms during the transition period between 1994 and 2001. We will utilise data from the annual survey of a sample of 562 farms, which contains both farm-specific accountancy information and socio-demographic variables.

First empirical results of the econometric estimations reveal a negative relationship between farm size (output level) and flexibility. Firms with a high share of variable costs were more flexible. Access to off-farm finance has a positive effect on a farm's flexibility. Some socio-demographic factors (age, education) have a significant influence on farms' ability to adjust.

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