4

Topics in production economics

4.1 *Introduction*

This chapter deals with four subject areas of importance to the analysis of production and supply. In public debates about growth and development it is common for reference to be made to (i) differences in efficiency among sectors of the economy, and to (ii) differences in efficiency in agricultural production among countries, regions, farm sizes and tenure systems. The concept of *efficiency* in economics is a complex and difficult one. Section 4.2 below presents a brief examination of the problems and the usefulness of certain measures of efficiency.

One of the principal engines of economic growth is *technological change*. The tools presented in Chapter 2 provide the basis for the cxplanation and definition of technological change which is set out in Section 4.3.1. Section 4.3.2 discusses the *sources of technological change*, and this is followed (in 4.3.3) by a discussion of *adoption and diffusion of agricultural technology* and its impact in the so-called Green Revolution.

Reference has already been made in Chapter 3, in the context of the need for a dynamic treatment of supply response, to the importance of *risk and uncertainty* upon farmers' decisions. Section 4.4 pursues this in slightly more detail, and indicates the implications of risk aversion in the face of uncertainty for resource allocation at the farm level and for supply response to price in general.

Fourthly Section 4.5 deals with a special topic in production (and consumption theory) which is covered by the term *duality*. The essence of this topic is that there are alternative ways of expressing the resource allocation problem for the competitive firm, which contain all the same basic technical and behavioural information. This is important at the level of empirical analysis, since it establishes the possibility of alternative approaches to the same problem. It also helps explain why, in textbooks on economics, discussion often switches rapidly from profit maximisation to cost minimisation, since these turn out to be the dual specification of each other. Duality is a fairly difficult concept, and some readers may prefer to skip this section.

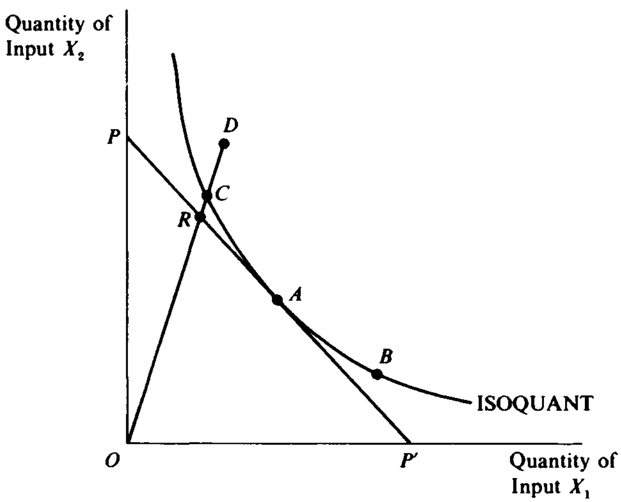
4.2 *Efficiency of resource use*

A measure of producer performance in response to economic incentives is often useful for policy purposes and the concept of *economic efficiency* provides a theoretical foundation for such a measure. Using the analytical tools presented in Chapter 2, the term 'efficiency' can be defined with some precision and it is this definition which has been taken as the basis for much empirical work on the subject. Nevertheless it should be noted at the outset that the validity of the concept has been questioned by a number of authors. We will therefore try to assess its usefulness in the light of some of these criticisms.

4.2.1 *Technical, allocative and economic efficiency*

Much of the literature on efficiency is based, directly or indirectly, on the seminal work of Farrell (1957), who argued that efficiency could only meaningfully be gauged in a relative sense, as a deviation from the best practice of a representative peer group of producers. He also introduced the distinction between *technical efficiency* (where maximum

Fig. 4.1. Farrell's efficiency indices.



output is obtained from a given set of inputs) and *allocative efficiency* (where, given input prices, factors are used in proportions which maximise producer profits). These concepts will be explained with reference to Fig. 4.1.

The diagram shows the efficient unit insoquant for a group of farms using inputs X_1 and X_2. Farms located on this isoquant use the least amounts of these inputs to produce a unit of output. If points *A*, *B*, *C* and *D* denote farms which are producing one unit of the product, then farms *A*, *B* and C, being on the isoquant, are technically efficient but farm *D* would be judged to be technically inefficient. A measure of technical efficiency for farm *D* is given by OC/OD, i.e. farm *D* could reduce both inputs by a proportion OC/OD and still produce the same level of output. Given relative input prices, the isocost line PP' indicates the minimum cost of producing one unit of output and so overall economic efficiency is greatest at the point *A* on the unit isoquant. Noting that point *R* has the same level of costs as *A*, Farrell proposed that overall economic efficiency of farm *D* could be measured as OR/OD, with OR/OC representing allocative efficiency, or the divergence between the minimum cost point and the costs incurred at point *C*. The overall economic efficiency measure can be decomposed as follows:

$$OR/OD = OC/OD \times OR/OC$$

or

$$\text{economic efficiency} = \text{technical efficiency} \times \text{allocative efficiency}$$

Given these definitions, farm *A* would be economically efficient, farms *B* and *C* would be technically efficient but not allocatively efficient, and farm *D* would be neither technically nor allocatively efficient.

It should be evident that technical efficiency (maximum output from given inputs) refers only to the physical characteristics of the production process. It can therefore be taken to be a universal goal in that it is applicable in any economic system. On the other hand allocative efficiency and overall economic efficiency presume that the entrepreneurs' goal is one of profit maximisation.

BOX 4.1
Efficiency of peasant agriculture

Schultz (1964) and others have argued that, given their access to resources, peasant farmers combine inputs in a manner which yields maximum profits; peasants are 'poor but efficient'. This view has been

influential in the design of development strategies and has prompted, notably in the 1970s, a number of empirical investigations of farmers' efficiency in developing countries. For example, Lau and Yotopoulos (1971) compared efficiency on small (< 10 acres) and large farms in India in the period 1955–57. They demonstrated that small farms perform with greater economic efficiency than large farms but that the farm types are equally allocative efficient. The advantage of small farms is thus attributed to their greater technical efficiency. Sidhu (1974), again using Indian data but for a later period (Punjab, 1967/8–1970/1) drew somewhat different conclusions. His results indicate that small and large farms, as well as tractor-mechanised and non-mechanised farms, are not significantly different in terms of relative economic efficiency, allocative efficiency or technical efficiency. An explanation offered by Sidhu for the apparent divergence with the preceding analysis, is that his sample was taken at a time when agriculture in the region was being modernised (new seed varieties, fertiliser, irrigation etc.) and since larger farms had more immediate access to the modern inputs, they had the opportunity to catch up with small farms in terms of efficiency.

This type of empirical evidence, if it is accepted, suggests a picture of peasant agriculture which is much more optimistic than the typical caricature of a stagnant and unco-operative sector. At the same time it gives rise to some concern that there are substantial economic costs to the distortions of incentives (product prices and input subsidies) which at present are offered to farmers in developing countries.[1] However it must be stressed that the definition of economic efficiency is not unambiguous and that the measurement of efficiency is not a straightforward matter. Some of the conceptual and empirical problems are discussed in the next section.

4.2.2 '*The myth of efficiency*'

The controversy about the interpretation of efficiency measures concerns both the validity of the efficiency standards used and the accuracy of the empirical measures obtained. Pasour (1981) suggests that a level of performance which is achievable only under ideal conditions of perfect knowledge is not an appropriate standard against which to measure real world performance. In a similar vein he argues that performance standards derived on the assumption of profit maximisation should not be used to measure the performance of entrepreneurs whose objective functions include elements other than profit. A third area of controversy raises questions about the accuracy of empirical measures. In particular it is argued that observed inefficiency may be due solely to our inability to measure inputs accurately. For example quality differences in land and labour are often difficult to record, while the problems of measuring capital inputs and management expertise are further complications. Another pertinent argument suggests that the notion of efficiency is relevant only within the narrow confines of the perfectly competitive equilibrium and hence irrelevant to real world problems. Specifically, allocative efficiency assumes that market prices are a true measure of relative scarcity but when prices are distorted by governments or monopolies (defined in Chapter 9) or where goods remain outside the market system, the role of prices in resource allocation is greatly impaired. As a final criticism we can add the difficulty of interpreting a static efficiency measure in the dynamic setting of agricultural decision-making. Since a firm's resource allocation decisions are based on expectations over several production periods, any performance standard over a single period may be misleading. For example a farm which has installed irrigation equipment may appear to be using too much capital[2] if surveyed in a year of unusually high rainfall.

When confronted with this lengthy catalogue of criticisms, a number of authors (e.g. Rizzo (1979)) have concluded that the concept should be abandoned. At the very least great caution is urged, when reviewing empirical work on the subject. However, on a more positive note, we could accept the proposition[3] that it is valid to try to estimate producers' performance in terms of *technical* efficiency, since to a large extent the latter would avoid many of the criticisms levied upon more general efficiency concepts. In particular, measures of technical efficiency rely less heavily on the assumptions of perfect knowledge, perfectly competitive markets and the profit maximisation objective.

4.3 *Technological change*

4.3.1 *Technological change in economic modelling*

Economists usually define *technology* as a stock of available techniques or a state of knowledge concerning the relationship between inputs and a given physical output. *Technological change* is an improvement in the state of knowledge such that production possibilities are enhanced. In other words, through technological change the production function will shift over some range such that

(i) more output can be produced with the same quantity of inputs
(ii) the same output can be produced with a smaller quantity of inputs.

The impact of technological change can be illustrated with reference to the factor–product, factor–factor and product-product diagrams introduced in Section 2.2 of Chapter 2. Consider the introduction of a new wheat seed variety which increases the output response to fertiliser usage. The adoption of the better quality seed input into the production process will shift the total product curve upwards (Fig. 4.2) so that with fertiliser usage f_0, output can be increased from OA to OB. Alternatively, a given output level, say OA, can now be obtained with a reduced level of fertiliser usage (Of_1 instead of Of_0). In this factor-product case, all inputs other

Fig. 4.2. Technological change and the total product curve.

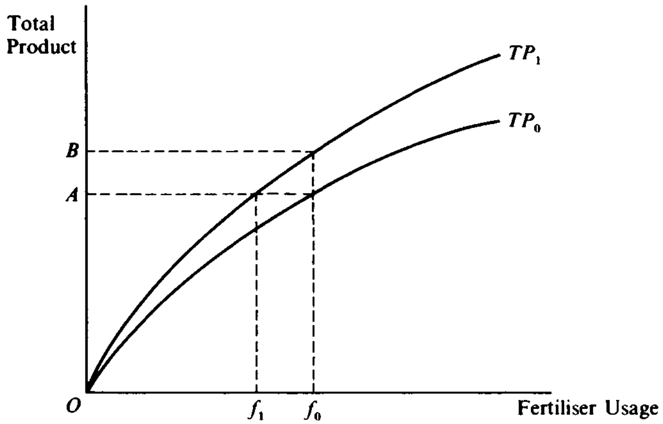
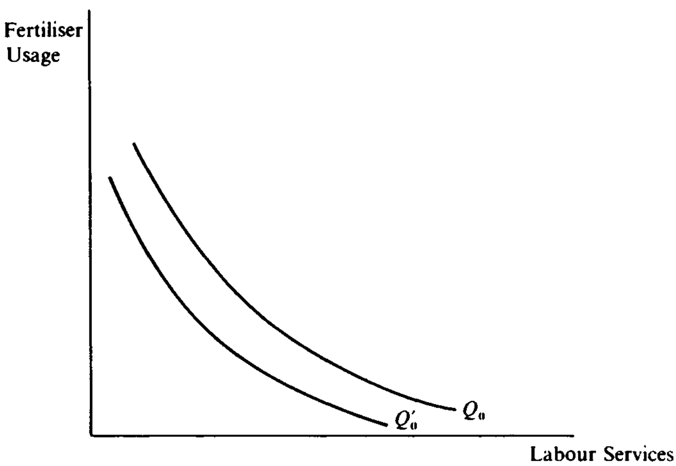


Fig. 4.3. Technological change and the isoquant.



than fertiliser are held fixed. The factor–factor diagram in Fig. 4.3 allows us to illustrate the case of two variable inputs, say fertiliser and labour. In Fig. 4.3 the isoquant for output level, Q_0, depicts the various combinations of the variable inputs which yield that output level. However, under the new technology the *same* output can be obtained with less of the variable inputs i.e. the new isoquant (Q_0') for output Q_0 shifts towards the origin.

Finally, suppose the farmer produces two products, wheat and maize. The production possibilities frontier (PPF_0) in Fig. 4.4 indicates the output combinations which are available, given a set of inputs. However, since the introduction of the improved seed variety in wheat production allows more wheat to be grown with the same quantity of inputs, the frontier swivels to PPF_1. (Note that as maize inputs have not been changed

Fig. 4.4. Technological change and the production possibilities frontier.

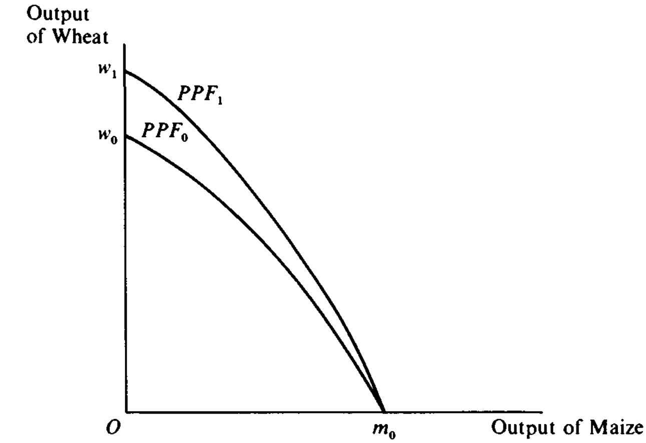
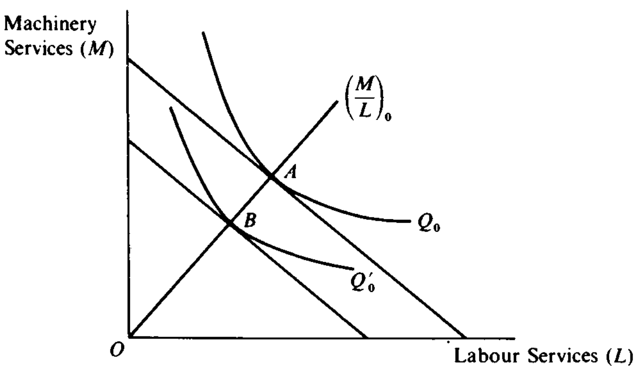


Fig. 4.5. Neutral technological change.



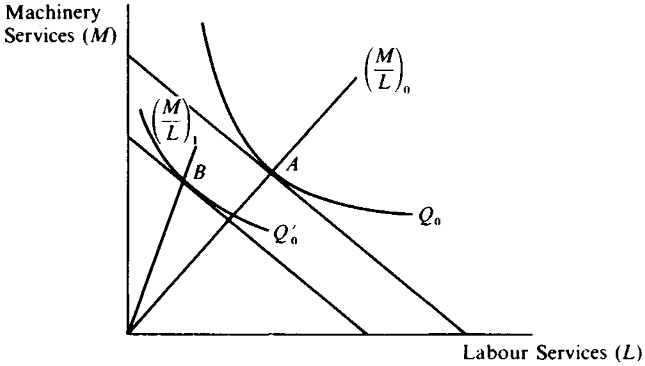
in any way, the maximum output of maize from a given set of inputs remains at m_0.)

It is often useful to distinguish types of technological change. Consider Fig. 4.5. Technological change has shifted the isoquant for a given output from Q_0 to Q'_0, in such a manner that *at constant factor prices* (of labour and machinery) both factors are saved in the same proportion as they were being used originally, and the optimal machinery to labour ratio $(M/L)_0$ remains unchanged. This type of technological change is termed *neutral*.[4]

Perhaps more frequently, technological change may be *biased*, in the sense that at constant factor prices it induces a change in optimal factor proportions. Suppose the relative marginal product of machinery services is raised by the introduction of a technologically superior tractor. If factor prices are constant, the optimal machinery–labour ratio will rise and the technological change is said to be *labour-saving*. This is illustrated in Fig. 4.6, where as the isoquant shifts, the optimal machinery–labour ratio rises from $(M/L)_0$ to $(M/L)_1$. The same level of output can now be produced by reducing labour usage more than capital usage.

Thirtle and Ruttan (1987, pp. 12–22) provide a lucid and extended explanation of neutrality and biasedness in technical change. As they note, while it makes sense to define as neutral technological change shifts which at fixed factor price ratios leave the optimal factor use ratios unchanged, this is not so at the industry level. For, whereas for the individual firm input prices are given, at the aggregate level it is more appropriate to consider factor endowments or availability as fixed; certainly that is so in the short-run. In that case a neutral technological change can be more appropriately defined as one which, with *given factor proportions*, raises the marginal product of labour in the same proportion as the marginal

Fig. 4.6. Labour-saving technological change.



product of capital. In that case the economic interpretation of bias is 'simple and appealing. A labour-saving innovation makes labour in some sense more plentiful relative to capital than it was previously, with the result that the marginal product of labour must fall relative to capital' (Thirtle and Ruttan, 1987, p. 15).

It should be noted that in most of the economics literature, the analysis of technological change is quite narrowly focussed, since it is concerned solely with changes in the physical production process. There is little or no reference to the impact of technological change on political and social structures, on institutional and administrative systems, and on the physical infrastructure. However, as we will see below, many agricultural economists are now taking a broader perspective. It is also the case that in orthodox economic theory, technology is viewed as a factor outside the control of the entrepreneur and of the industry and so technological change is simply an *exogenous* shift in the production process. Nevertheless, in a development context in which sustained economic growth is sought, it is pertinent to ask: where is the technological change to come from?

BOX 4.2
Characteristics of technological change in the agricultural sector

Technological change has occurred in every sphere of agriculture. Much of it has been embodied in capital, i.e. in machinery, drainage, irrigation and buildings, but there have also been significant advances in the form of high yielding varieties (HYVs) of crops, improved strains of livestock, better feeds, and more effective fertilisers, pesticides and insecticides. Moreover, technological progress has been evident in cultivation and husbandry methods and in the overall managerial skills of the farmer.

Much of the technological change which has taken place in the agricultural sector has been biased, often being labour-saving (in the case of most new machinery) or land-saving (as with the HYVs and fertilisers). This does not necessarily imply that less of these factors are used. For example, with a labour saving technological change, theory suggests that the producer will employ less labour, for a given output level. However, as the marginal cost of production has fallen, the producer will wish to increase output, in order to maximise profits, and so employ more of all factors of production. There will then be a tradeoff between the initial displacement of labour due to the technological change and the increased employment of labour due to the