Introduction

This book concerns the full, long-run reaction of the firm and the industry to a price shock, be it autonomous or determined in a predictable way by productivity increase, by a change in taxation, or by a change in the conditions of international trade. By full reaction we mean the adjustment of the input mix and of the output(s), under the condition that net profits are null, both before and after the shock, in every industry. For simplicity, we ignore firm heterogeneity; we also ignore the possibility of external economies or diseconomies and leave aside the impact of the shock on the size of the industry and the number of firms.

Within this field of investigation, the most familiar tools of analysis in the economist's toolbox are no doubt the partial equilibrium 'laws' of input demand and output supply. Our central message is that too often economists expect from these 'laws' more than they can give: in relevant economic circumstances they are too simple to provide correct predictions. The zero-net-profit condition, in particular, requires a more articulated analysis that sometimes yields qualitative results contrary to those of the familiar 'laws'.

We recognize, of course, that a cavalier, simplistic use of the 'laws of input demand' has been criticized during the Cambridge capital theory debates. However, such criticisms were focused on the economy as a whole or on vertically integrated sectors, not on individual industries. Their central finding was that a change in the rate of interest may modify the *aggregate* capital/labour and capital/output ratios in a direction opposite to that expected on the basis of a simple 'law of input demand' (a contribution giving a distinct flavour of those debates is Garegnani, 1970). By contrast, we are concerned here with 'micro' productive choices and often assume an identically zero rate of interest.

Almost 30 years ago, when the intellectual appeal of the debates was perhaps declining, one of the present authors (Steedman, 1985, 1988) presented an early analysis of the input use/input price relationship in

an industry belonging to a Sraffa-type system characterized by many primary inputs and a zero rate of interest. In a series of examples, it was found that at a micro level there can still be unconventional comparative statics *for both* primary and produced inputs *and without* any interest being paid on capital. This perhaps unexpected result raised a series of questions that stimulated further articles (Steedman, 1998, 2005, 2006; Opocher, 2002; Opocher and Steedman, 2008a, 2009, 2011) and, eventually, shaped the present book. If not interest and capital – which are notoriously tricky matters – what *is* responsible for the violation of a simple law of input demand at the micro level, where it is generally believed to be most reliable? Is the comparative statics of firms whose maximum profit is null qualitatively different from the conventional partial equilibrium comparative statics? Is a consistent zero-net-profit comparative statics more interesting for the applied microeconomist than a crude partial equilibrium analysis? What relevant applications can be built on that theoretical basis? In answering these questions, we share with the canonical Sraffian literature the assumption of many industries which earn zero net profits, have input–output relations and have some inputs in common. As compared with that literature, however, we pay more attention to the presence of many primary inputs and less attention to the presence of a positive and variable rate of interest. We also lean towards the conventional description of production by assuming in most of the book twice-differentiable cost functions and U-shaped average cost curves; we do this simply in order to make it clear that our findings do *not* derive from the rejection of these conventional assumptions.

Our search for an elementary 'sufficient reason' (to use one of Sraffa's favourite phrases) explaining why the law of demand referred to an individual firm is a crude representation of reality led us to reconsider, in the light of our findings, a long tradition of mainstream literature, including the so-called long-run theory of the firm mentioned in the Preface. A microeconomic analysis of production which was less partial than that implied by the conventional demand and supply curves surfaced many times and in many different ways in a vast literature, owing to the fact that a shock hitting the industry can hardly exhaust its effect by changing just one price.

Despite the frequent simplifications in textbooks and in applications, the theory of multi-input use by the firm and the industry is extremely varied and rich. One might even question the existence of single 'laws'

of input demand or of output supply: different waves of studies specified the *ceteris paribus* stipulation, the relationship between the firm and the industry, and that between the industry and the economy in different ways, according to different judgements as to which indirect, collateral effects may reasonably be ignored.

The microeconomics of production developed in London and Chicago at the end of the 1930s (Hicks, 1937, 1939; Allen, 1938; Mosak, 1938; also Samuelson, 1947, had been drafted at the end of the 1930s) refined a strict partial equilibrium method as a sensitivity analysis of productive choices in reaction to an individual price change; it also adopted a bottom-up conception of the industry in which the equilibrium of the firm was completely independent from that of the industry. The resulting analytical kernel, so simple and elegant, has been very powerful and influential in the subsequent decades – becoming indeed *the* fundamental tool of partial equilibrium analysis.

Yet that analytical kernel by no means exhausted the variety of questions addressed before, during and after this sudden upsurge of studies. The short-run relationships between input demand and the output market (the so-called 'derived demand' theorized by Marshall and Pigou) were analysed, for instance, by Hicks (1932), Allen (1938) and by later authors such as Saving (1963), Winch (1965) and Heiner (1982). The long-run tendency to zero net profits (or uniform normal profits) due to competitive forces – which featured so prominently in both the classical and the early neoclassical economists – was (re-)introduced against the background of the Hicks–Mosak–Samuelson theory by such authors as Ferguson and Saving (1969), Bassett and Borcherding (1970a), Silberberg (1974), Braulke (1984, 1987), Chavas and Cox (1997); see also Steedman (1998).

These contributions theorized their own input use–input price relationships, involving a specific list of what was given and what changed along with an 'original' price change. It perhaps did not aid clarity that these different relationships have all been called 'input demand curves', like that of the conventional theory.

No less varied are the analyses under the heading of an 'output supply curve'. The old Marshallian theory of supply incorporated many connections between an industry's output level and the supply prices of a variety of inputs and outputs (e.g. Marshall, 1920, pp. 371, 415; Pigou, 1928; Harrod, 1930). Within this broad tradition, we find different supply curves, each involving that many prices changed

at once, as in Barone (1992 [1894]), Robinson (1941), Viner (1953), Samuelson (1971).

All these contributions are good examples of the wisdom of Schumpeter's remark that there is no sharp borderline between partial and general equilibrium methods (Schumpeter, 1954, pp. 990–98). They also confirm how far-reaching were Sraffa's famous 1925 and 1926 articles, pointing precisely to the fact that a movement along an upward-sloping supply curve involves a change in many prices; equally far-reaching was his research programme on the 'production of commodities by means of commodities', initiated in 1927, which implied long-run price interdependence outside any rigid scheme of either partial or general equilibrium.

This book reflects our own judgement about the connections between the firm, its industry and other industries that no micro analysis, we think, should ignore. An aspect on which we particularly insist is the great importance of intermediate inputs. We completely agree with the 'long-run theory of the firm' on the fact that a (nominal) change in a wage rate determines, by long-run adjustments in the industry, also a (nominal) change in the output price; but it affects in a like degree the prices of other commodities too, including perhaps the produced commodity inputs of the firm/industry under consideration. All such effects must be taken into account simultaneously. We also insist on the presence of a variety of primary inputs, which are taken to be either land and labour, as in much theoretical literature, or different kinds of labour, as in many applications.

An outline of the book

Chapter 1 introduces the reader to our definition of a full industry equilibrium (FIE) and to the general properties of an FIE comparative statics. We also make it transparent how our FIE analysis relates to both the mainstream 'long-run theory of the firm' and the Sraffian 'long-period theory of production'. In the next chapter we lay some analytical foundations of FIE with reference to a hypothetical isolated industry, as if all inputs could be primary and industry-specific. We first present the main analytical findings of the 1970s long-run theory of the firm; our main reference here is Silberberg's (1974) 'dual' version based on the firm's minimum-average cost-function. The only refinement that we make to this version consists in shedding full light on the underlying

structure of relative prices; to say that a parametric increase in an input price is accompanied by an endogenous increase in the output price is, in a sense, to remain on the surface of the phenomena brought about by competition, the deeper roots consisting of a changing relative price structure. Our shift of emphasis also paves the way to further developments in which the change in relative input prices is more complex than that implicitly considered by the above-mentioned literature. Then, remaining in the simple context of Chapter 2, we introduce some issues which were absent in that literature but which play a significant role in the rest of this book, notably the presence of produced inputs and of discontinuities in profit-maximizing input use. Concerning the first issue, the simple case of 'own input use' suffices to generate some peculiarities of produced input use (as opposed to primary input use) in relation to the input price; later chapters generalize the argument to more realistic multi-industry contexts. Concerning the second issue, we shall here step outside the traditional 'smoothness' assumption by admitting that the cost function may be *almost* everywhere twice-differentiable; this single modification is enough to generate significant qualitative changes in the input price–input use relationships, which, again, later chapters will place in the setting of more complex models. The appendices to Chapter 2 present two digressions from the main argument: one deals with some alternative concepts of Hicksian input substitution, while in the other we point out that some long-established results of trade theory are in fact examples of FIE analysis.

Most of the book, including Chapter 2, concentrates for simplicity on single-output firms/industries. Yet, as it can hardly be denied that firms are in fact generally multiproduct, we should at least indicate how our analysis can be extended to joint production; besides, both contestable markets theory and Sraffian theory have devoted much attention to this case. This is done in the starred Chapter 3*, which presents a full-length zero-net-profit comparative statics of multiproduct firms; we shall show that the case with one input and many outputs yields results which exactly mirror those for a multi-input, single-output firm and that some theorems of the long-run theory of the firm can indeed be generalized to the multiple-output, multiple-input case. We retain the isolated industry framework by assuming all *outputs* to be industry-specific, but it should not be too difficult for the reader to envisage the additional complications that non-disjoint groups of commodities would involve.

In the remaining chapters we revert to the single-output case. In Chapter 4 we place a particular industry into its wider industrial context, in which there are input-providing industries as well as industries which compete for the use of the same inputs, both primary and produced. All industries will be assumed to yield maximum net profits of zero. In short, the zero-net-profits comparative statics of a firm belonging to a certain industry should take into account an economy-wide adjustment which provokes a complex change in the structure of relative prices. In order to facilitate the analysis, we assume smooth cost functions, everywhere twice-differentiable, and the absence of input complementarities throughout this chapter. We consider the effect of two main shocks: a change in one primary input price relative to all the others and a change in the rate of interest (while the proportions between primary input prices remain constant); in both cases, *commodity* prices adjust relative to each other and relative to primary input prices, under the forces of competition. The main message of the chapter is that, irrespective of the shock considered, primary inputs and commodity inputs react very differently; the former obey the qualitative restrictions which would be predicted by conventional partial equilibrium analysis, the latter do not – and it is indeed very doubtful that any significant input use–input price relationship can be formulated for produced inputs.

Chapter 5 removes the assumption of everywhere-twice-differentiability and focuses mainly on *primary* input use per unit of gross output in an industry which has relations with other industries; in most of this chapter the rate of interest is assumed to be null. It is shown that labour use per unit of output in a particular industry may be positively related to the real wage; interestingly, this may happen even though we have a conventional inverse relationship at the semi-aggregate level of the vertically integrated sector. This is found in many different specifications of the industrial structure – whether Wicksellian, or of the 'corn-tractor' (Samuelson-Surrogate) variety, or characterized by general input–output relations. We remark that even a single 'jump' may undermine the regularity in primary input use that was obtained in Chapter 4. This finding is particularly relevant in all cases in which a small change in the structure of input prices prompts a change in the very nature of the commodity inputs that are used; the inputs included in some technologies and not in others will be referred to as 'on/off inputs'. The subtitle of Chapter 5, 'Some aftershocks

from capital theory', may encourage the reader to find connections with the Sraffian critique of marginalist theory and, of course, it is not coincidental that we have employed a series of models which featured prominently in the famous capital theory debates. Our main interest here, however, is *not* in capital theory paradoxes as such, but in the general properties of FIE comparative statics, of which such paradoxes are, perhaps, simply a particular aspect.

The next three chapters are devoted to some applications of FIE analysis. A given price change can normally be traced back to a specific shock either in the industry under consideration or in other industries. In particular, we analyse some price effects of a change in taxation and productivity increase (exogenous changes in the 'terms of trade' are analysed in the second Appendix to Chapter 2). Our main endeavour will be to relate the industrial patterns of the two 'shocks' to the changing structure of relative prices and real wages, under the assumption that the relative wages of different kinds of labour remain constant; on the basis of our results, we provide a rational method for separating an observable change in a real input price into two components, one due to the direct impact of the shock, the other due to an induced change in relative wages.

As indicated above, our FIE analysis is intended to be a further step in a long theoretical evolution. Rather than supplementing each individual chapter with a series of footnotes on historical matters, we present a compact historical narrative in Chapter 9. Some general conclusions are set out in Chapter 10.

1 *Taking seriously the tendency to zero net profits*

The tendency of firms to earn zero net (or 'pure', or 'extra') profits is a salient feature of a capitalist, market economy, for a firm can hardly make permanent losses, unless it is subsidized; nor can it indefinitely make net profits, unless it enjoys legal protection. The regulating effect of competition in a market regime tends to eliminate profits and losses in a variety of different cases. The traditional long-run theory of Wicksell (1934) [1901], Flux (1923) [1904], Edgeworth (1913) and Pigou (1928) tells us that free entry and exit at the margin of the market ensures that output prices are always such as to allow for maximum net profits equal to zero, there being numerous firms, each operating as a price taker at the bottom of its U-shaped long-run average cost curve. The limit-cost pricing theory originated by Bain (1956) predicts that the mere threat of entry may lead firms to set a price equal to average cost; the contestable markets theory of Baumol (1982) and Baumol *et al.* (1988) [1982] describes the industrial structure in terms of efficient firms earning zero net profits, the number of firms (perhaps only one) depending on the size of the market. Game theory (Tirole, 1988, pp. 209–11) tells us that, in oligopoly, price competition among the existing firms may lead to an equilibrium with properties similar to equilibria with free entry and exit (Bertrand equilibrium). Needless to say, finally, the early theorizations of the classical economists argued for the same tendency, in terms of inter-industry capital movements and vanishing deviations from a uniform rate of profit.

For very good reasons, then, the study of production under ideal conditions of vanishing net profits is a permanent item on the economist's agenda.

The long and multi-faceted theoretical work done in this field can perhaps be said to be conclusive concerning the characterizations of

given equilibria, but it is certainly still incomplete and open to debate concerning their *comparative statics*.

Whatever the market context, a fundamental problem arises when we compare different equilibria of an individual firm. Any single shock disrupting a given equilibrium necessarily creates either profits or losses; in order that a new permanent equilibrium be reached, the original shock must therefore be accompanied by some compensating changes. For example, an exogenous reduction in the wage of one kind of labour (say, due to selective immigration) creates profit opportunities and must be accompanied, as time goes on and competition exerts its full effects, by either a reduction in the output price, or by an increase in the wage of another kind of labour, or by an increase in the interest rate, or by yet another change. It is not possible in this case to follow through the simple logic of the familiar partial equilibrium analysis, because there cannot be a parametric change in just one variable under a strict *ceteris paribus* stipulation. At least two variables must differ as between alternative zero-net-profits equilibria. Or to put it more formally, two distinct equilibria on the zero level set of a profit function (i.e. maximum profit as a function of prices) can never differ in just one price. Consequently, the traditional qualitative restrictions concerning choices in the new equilibrium, as compared to the old, should be entirely reconsidered. (Of course, *constancy* of net profits would be sufficient to create the same problem, but we shall always focus on constant *and zero* net profits.)

This book coordinates and takes further different strands of literature which have done this kind of comparative statics, aiming at a unified framework, able to identify the regularities (and lack thereof) of the 'final' reaction of a firm to a given shock, when market mechanisms have eliminated profit opportunities or losses throughout the system. Such a framework of analysis we call 'full industry equilibrium' (or FIE). It should be remarked from the outset that we focus on the *consequences* of processes leading to vanishing profits rather than on the processes themselves. We do not commit ourselves, therefore, to any specific context, or market structure, or competitive process. For brevity, however, the general context leading to null profits will be referred to as 'free competition' and the time within which null profits tend to prevail will be referred to as the 'long run'.

1.1 The long-run theory of the firm, the industry and the economy

A series of articles in the late 1960s and 1970s, mainly in the *American Economic Review* (including Ferguson and Saving, 1969; Bassett and Borcherding, 1970a; Portes, 1971; Silberberg, 1974; Panzar and Willig, 1978), criticized the comparative statics of the classical works of Allen (1938), Hicks (1939) and Samuelson (1947) on the ground of the 'inconsistency of holding output price constant in the face of changing costs through changing factor prices' (Silberberg, 1974, p. 734). They shaped the fundamentals of a proper long-run theory of the firm and very explicitly introduced a comparative statics that was 'less partial', so to speak.

Many results in this book can be considered as further generalizations and extensions of this long-run theory of the firm. Because it can hardly be denied that the older (and simpler) comparative statics still prevails in economics courses, textbooks and applications, a few words of introduction on this strand of literature may be in order. (A more complete narrative of the making of this literature is presented in Chapter 9; its main formal results are discussed in Chapter 2.)

The topic which first aroused interest in the 'new' comparative statics was the long-run scale adjustment of the firm in the face of an exogenous increase in an input price. The older results were based on a distinction between 'normal' and 'inferior' (or 'regressive') inputs: in the former case, the marginal cost curve would shift upwards, thus leading to a reduction in the equilibrium output *at a constant output price*; in the latter case, counter-intuitively, marginal cost would diminish and output increase. The new theory extended the analysis to the *average cost curve* and proved that the minimum average cost always increases when an input price increases: if the firm was initially breaking even at the bottom of its average cost curve, then the shock would drive it out of business, unless the output price increased. A new permanent equilibrium is therefore at the bottom of the *new* average cost curve, at a correspondingly higher output price. But does this involve an increase or a diminution of the equilibrium output? It was proved that everything depends on the output elasticity of the input in question, not on its being normal or inferior (see Chapter 2 for details). This result became very valuable for the contestability theory (as far as single-output firms were concerned) because it provided a