
Economic Theory and Technical Progress

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Abstract

Economists' recent outburst of interest in technical progress follows upon a widespread feeling of inadequacy of current economic theory. This paper traces the origin of this inadequacy back to the historical circumstances that led an influential group of English economists in 1815 to put forward the 'law of diminishing returns' to land cultivation, jointly with the theory of rent. It shows how technical progress, though not denied in principle, was eliminated by assumption for analytical reasons. That choice - it argues - arose from historical circumstances specific to a particular country in a particular time. Yet it has influenced the development of economic theory ever since. Later on, neoclassical economists have further exacerbated the effects of that initial choice. The paper argues in favour of going back to the origin and reversing the Classical choice.

1. Introduction: the roots of the problem

For almost two centuries, since Adam Smith's *Wealth of Nations* (1776), only in rare, exceptional cases has technical progress played any role in economic theory.

This is by itself astonishing. The 'Industrial Revolution', that started in England roughly at the time of publication of Adam Smith's masterpiece, was precisely due to the practical

applications, on a mass scale, of the new technologies that had been discovered and to the social conditions that made such applications possible. Yet technical progress has remained extraneous to the core of economic theory.

The picture has changed since the end of World War II. The economic literature of the post-war period, at first slowly but, then at an increasing pace, especially over the past two decades, has given the impression of an explosion of concern for, and interest in, the economic consequences of changes in technology, with particular attention being given to the spread of innovations and the dissemination of knowledge. This unprecedented interest in technical progress is of course fully justified, if somewhat belated. It has happened under the strong, persistent impact of external macroscopic events. Facts, rather than a spontaneous development of economic theory, have forced economists to open up their analyses to the widespread effects of technical change. Yet there is no disguising the apparent incongruity between the new concern for technical progress that has been imposed by external events and contemporary economic theory, as at present it stands. To begin with, most of the new contributions on technical progress originated, and continue to develop, on tracks that are quite outside the established body of

economic theory. At the same time, those contributions that have insisted on taking mainstream economics as their starting point have remained limited in scope (mainly in macro-economic terms) and have turned out to be extraordinarily complicated.

Quite plainly, the economic theory which we have inherited from both Classical and Neoclassical (and also, by the way, from Marxian) economics has revealed itself to be unsuited to the investigation of phenomena connected with technical progress.

In the present paper, I contend that the roots of the appalling inadequacy of modern economic theory to investigate technical progress lie in a peculiarly perverse cumulation of misjudgments made by the economic profession at crucial junctures in the development of economic theory when, for analytical reasons, a choice seemed necessary between equally possible, but alternative, lines of investigation. The first of such choices was made in 1815, in England. The 'corn question' provided the historical context at a time when Adam Smith's theoretical framework had to be opened up to more analytically grounded investigations. A second choice took place (and on this occasion on a larger scale) at the end of the nineteenth century. It had the effect of further exacerbating the consequences of the previous choice.

If the 1815 choice was a kind of 'original sin' of economic theory, it seems unlikely that we will be able to rectify it, unless we revisit reassess and understand the circumstances of the time.

2. *A remarkable February 1815*

The year 1815 - besides being the start of long-lasting changes in the history of the Western world - has also become famous to historians of economic thought for the publication in London of five pamphlets: two

by Malthus, the others by West, Torrens and Ricardo. All of them appeared in the remarkably short period of three weeks, in February 1815. According to Piero Sraffa's (1951, p. 5) careful reconstruction, the chronological succession was as follows:

Malthus, *Inquiry into Rent*, 3 February 1815,

Malthus, *Grounds of an Opinion*, 10 February 1815,

[West], *Essay on the Application of Capital to Land*, 13 February 1815,

Torrens, *Essay on the External Corn Trade*, 24 February 1815,

Ricardo, *Essay on Profit*, 24 February 1815.

These five essays are often cited as a major example of simultaneous discovery in economic theory. They all have in common the differential (sometimes, improperly, called 'Ricardian') theory of rent - both in its extensive and (with the exception of Torrens) in its intensive version - and the 'law of diminishing returns' to land cultivation.

The theory of rent has been taken as the source of the marginal principle, which survived Classical economics in the theory of production and income distribution, and, by being interpreted in a different form, was extended and applied to all factors of production (not only to land). The principle of diminishing returns has become one of those ideas that have influenced economic theory ever since.

3. *No coincidence*

It is worth stressing at the outset that, in spite of appearances, the publication of the essays in those three weeks was not due to chance.

As all authors explicitly state, their pamphlets were published in anticipation of, and as a contribution to, the discussions on the Corn Bill, which was before the House of Commons. The Parliamentary debate was tabled to begin on February 17, 1815. The new Corn Law was actually passed on March 15.

There can be few doubts as to the crucial relevance of trade in corn - for a country such as Great Britain during the second decade of the nineteenth century. The Industrial Revolution was under way, population was growing at an unprecedented rate and corn was the major item in food consumption of the working class.

The price of corn, over the previous few decades, had increased enormously (and so had rents), though with substantial fluctuations. To give an idea of order of magnitude, the *average* price of corn, which was 45 shillings per Winchester quarter in the 1770s, rose to 82 shillings in the 1800-1809 decade and peaked at approximately 150 shillings in 1812! But in 1813, owing to a huge harvest, it fell dramatically to about 70 shillings and continued to fall in 1814, owing to expectations concerning the consequences of the end of the war.² Quite understandably, the landlords were alarmed and were crying out for import protection.

In the previous years, the high price of corn and increased rents had rendered the landlords an unpopular class. Both the House of Commons and the House of Lords had appointed Select Committees to investigate the problem of the high price of corn and their reports which had become the subject of heated discussions were before Parliament.

The five essays listed above are part of that debate. The authors admit great haste and apologise for imperfections of exposition, due to the necessity of quick publication. Malthus

even adds a preliminary advertisement to his first pamphlet warning the readers that events 'have induced me to hasten its appearance. It is the duty of those who have any means of contributing to the public stock of knowledge not only to do so, but to do it at the time when it is most likely to be useful' (Malthus 1815a, p.i). Even Torrens, who was publishing a 350-page book, which must have been in progress for some time, expresses in his *Preface* 'the hope of contributing something to the right decision of a question... which has come before the legislature'; adding that 'the vital interest of the whole community, rendered him not unwilling to depart from... his original design and to conjoin controversial detail with general disquisition' (Torrens, 1815, p. xv).

West begins by stating that he had been 'reading lately the reports of the corn committees', and that 'a correct understanding... of the corn question has induced [him] to hazard this publication before the meeting of Parliament' (West, 1815, p.1). We know that Ricardo, on his part, made a great effort, especially given his admitted great difficulties in expressing himself in writing, to bring out his essay on time. He wrote it as a reply to, and in open polemics with, Malthus, hoping to bring support to the cause of unconditional free trade (in opposition to Malthus's qualified recommendation for protection).

So in February 1815 there was no accidental coincidence in discovery. Rather, we witness a determined effort on the part of all authors to take part in a contemporary debate with the intention of influencing a Parliamentary decision reputed to be of great importance to the nation.

4. *The beginning of Ricardian economics*

The imminence of an important parliamentary debate thus explains the publication of the five pamphlets in February 1815. But simultaneous publication does not necessarily imply any sudden discovery. Their authors had been thinking about the problems under discussion for some time - perhaps for many years. Malthus - certainly a most authoritative writer - thought it expedient to convey his arguments in two separate pamphlets. The first, *Inquiry on Rent*, is a typically academic essay, centred on presenting a theory of rent. He states explicitly that he is using notes, which had been the basis of his lectures at East India College. In the essay, the theory of rent is the central subject, while the idea of diminishing returns enters as a consequence of a dynamic application of the theory of rent to a situation in which land is in fixed supply and population is growing. The second pamphlet, by contrast, is an open statement of policy. Malthus draws on arguments in yet another of his previous pamphlets, 'Observations on the Effects of the Corn Laws...', published in Spring 1814, and openly states his position, giving his 'grounds of an opinion' in favour of a partial restriction on the importation of corn.

By contrast, West's pamphlet focuses on the *law of diminishing returns*: 'a principle of political economy - he writes - which occurred to me some years ago', and which he found 'confirmed by many of the witnesses... on reading lately the reports of the corn committees' (West, p. 1). In a 55-page essay, the theory of differential rent comes only in the last 7 pages. The exposition of the theory of rent is clear, but the focus of the essay is on diminishing returns. Sraffa (1951, p. 6) states that West's presentation of the theory of rent was independent of Malthus's. Yet, it does not seem inconceivable to me - as West's essay was published 10

days after Malthus's widely publicised *Inquiry on Rent* - that the last seven pages on rent might have been added at the last moment, after reading Malthus's essay, at the end of an almost ready pamphlet basically devoted to diminishing returns.

It is also conceivable that something similar might have happened to Torrens's essay, where a theory of differential rent, in the extensive version only (as he considers, in succession, first-rate quality land, second-rate quality land, third-rate quality land, etc.) only appears in the last chapter (Torrens, 1815, pp. 315-325).

The case of Ricardo's paper is less uncertain. As he had mainly been a businessman, he was, in a sense, a novice to discussions of economic theory. Up to 1813, his letters and writing had been concerned with currency questions. But in 1813 and 1814 he had passionately begun to apply his mind to the relation between the growth of capital and the rate of profits. It is in this connection, i.e. with reference, and *only* with reference, to profits that he had been applying the principle of diminishing returns to land cultivation. Sraffa (1951, p.7) is convinced that, in this form, he had applied the principle as early as 1810 or 1811 (in his *Notes on Bentham*). But rent had not entered his arguments before February, 1815. Quite clearly, when he read Malthus's *Inquiry on Rent*, he must have been, so to speak, struck by light. He read both of Malthus's essays voraciously. According to Sraffa's reconstruction (Sraffa 1951, p.5), he had read them by February 6, and by February 13, respectively. One can imagine how Ricardo could see all parts of his work over the previous years at last coming together. The theory of differential rent must have appeared to him as the final missing piece that he needed to complete his mental scheme.

He read the other papers too, but after the publication of his essay (West's by March 9, and Torrens's by March 14, according to Sraffa's reconstruction; see Sraffa 1951, p.5). In them he only found confirmation of his own ideas. As the whole picture had, so to speak, clicked together in his mind, he openly acknowledged Malthus's contribution on rent. (When, later, he read West's, he also added West to Malthus as deserving recognition of priority on the theory of rent - see the Preface to his *Principles*).³

If one reads all these essays from the distance of almost two centuries, one is struck by how remarkably Ricardo's essay towers over those of the other authors. Malthus's essays are ably laid out and finely argued, but they concentrate on rent. West's and Torrens's essays contain competent arguments on the issues at stake; yet with their concern for diminishing returns and for the corn trade they are clearly dated. Ricardo's essay is quite different. It really is remarkable for the completeness of the underlying theoretical framework from which his arguments are developed. He begins with rent, which is immediately linked to profits; he continues with the growth of population and of capital, and links these to diminishing returns. He succeeds in bringing the pieces together in a complete, logically consistent theoretical structure, in which the various elements appear as coherent parts of a whole scheme of a working economy. Though the details were to become much clearer only two years later in his *Principles* (1817), one can see here already a theory of production, a theory of income distribution, a theory of relative prices (agriculture versus manufactures) and most notably a dynamic theory concerning the movement through time of a capitalist economy.⁴

It is this remarkably complete model that

leads him to the sad conviction that there is a tendency towards a stationary state. And it is this eventuality that leads him to argue powerfully and passionately for free external trade of corn, as the only way to avoid an otherwise gloomy course of events in which the growth of population, the increase of rent, the fall of the rate profits, and the compression of wages towards subsistence could only lead, in the long run, to the misery of a stationary state.

The importance of Ricardo's essay is unquestionable. It was the beginning of an intense correspondence with contemporary economists, who urged him to be more exhaustive. From the intention of writing a second edition of that essay sprang his major work, the *Principles of Political Economy and Taxation* (1817).

The 1815 essay was the beginning of Ricardian economics.

5. Impact on economic theory

Quite apart from the beginning of Ricardian economics, which was an event in its own right, there can be no doubt that the impact of those five pamphlets on the development of political economy was enormous.

Ever since, the theory of differential rent has remained a milestone in the history of economic analysis. Adam Smith had been confused, and even contradictory, on the subject of rent. By 1815, all influential economists became convinced that political economy had at last been enriched by a sound theory of rent. No longer did rent appear as a sort of 'monopoly price', as Adam Smith had called it, but a necessary consequence of the fact that high-quality land is scarce, and that in general the given natural resources, for technological reasons, have different productivities and yield differential gains.

It must be pointed out, however, that this theory of rent was not original. James Anderson, in his work, *Inquiry into the nature of the Corn Laws with a view to the new Corn Bill for Scotland*, published in 1777, had anticipated it, and very clearly so.

His famous passages have been reprinted in many places: for example, in McCulloch's edition of the *Wealth of Nations* (McCulloch, 1828, p. 45) and in Cannan (1903, pp. 371-372). They are too long to be reproduced here. It may however be interesting to reproduce yet another passage of James Anderson's on rent, from another of his works: *Observations on the means of exciting a spirit of National Industry*, also published in 1777:

In every country there are various soils, which are endued with different degrees of fertility; and hence it must happen that the farmer who cultivates the most fertile of these can afford to bring his corn to market at a much lower price than others who cultivate poorer fields. But if the corn that grows on these fertile spots is not sufficient fully to supply the market alone, the price will naturally be raised in that market to such a height as to indemnify others for the expense of cultivating poorer soils. The farmer, however, who cultivates the rich spots will be able to sell his corn at the same rate in the market with those who occupy poorer fields; he will, therefore, receive much more than the intrinsic value for the corn he rears. Many persons will, therefore, be desirous of obtaining possession of these fertile fields, and will be content to give a certain premium for an exclusive privilege to cultivate them; which will be greater or smaller according to the more or less fertility of the soil. It is this premium which constitutes what we now call rent, a medium by means of which the

expense of cultivating soils of very different degrees of fertility may be reduced to a perfect equality. (Anderson, 1777, p. 376).

It is interesting to note that this passage was part of a criticism that Anderson directed at Adam Smith. Yet he did not explicitly point out that Smith was incorrect, and Smith (who must have seen Anderson's criticism, as Cannan perspicaciously points out - see Cannan p. 221) did not correct his theory. James Anderson's remarkable theoretical contribution was thus simply missed.

The theory of differential rent remained dormant, only to be re-discovered and hailed as a great contribution in 1815, when it was presented in conjunction with the law of diminishing returns.

An important point to stress is that James Anderson had always been a strong opponent of the idea of diminishing returns to cultivation of land! His opposition was not based on theoretical arguments; it came from personal experience. He was a farmer and an experienced agriculturalist. Like all farmers, he was in favour of protection, but in his case this was based on the grounds of an unusual argument. He thought that protection would indeed force inferior lands into cultivation, but these inferior lands would eventually - by careful tending - be made as productive as the other (originally more fertile) lands. He was a strong believer in agricultural progress and indefinite increasing returns! The point is worth mentioning as it shows, incidentally, that the theory of differential rent and the law of diminishing returns are separate theories. Neither implies the other.

When Malthus published his *Essay on the Principle of Population* (1798), James Anderson was among his strongest critics (see Anderson, 1801). Malthus had presented his *Principle of Population* on a rather weak

theoretical ground, namely on the ground that there is an inconsistency between a natural geometric progression of population growth and a factual arithmetic progression of the means of subsistence. It was precisely in replying to Anderson's criticisms, in the second edition of his *Principle of Population* (1803), that Malthus developed,⁵ in a rather casual way, an argument that implied the principle of diminishing returns, but applied in reverse.⁶ It took some time before the idea crystallised clearly in his mind.

The same must have happened to West, Torrens and Ricardo, though at various stages and times, before 1815.

In any case, it is only with the publication of the five February 1815 pamphlets that the Law of diminishing returns to land cultivation becomes a clear, explicitly stated principle of political economy. Again we might ask: why was it that this conviction took hold precisely in February, 1815? As explained above, the five pamphlets were all published in February 1815 in order to contribute to, and to influence, a decision that was about to be taken by the House of Commons. Now we may look at the other side of the coin. All these authors had read, very carefully, the Reports of the Committees of Inquiry on the corn question. From these Reports, one can see very clearly what had happened in England in the previous decades. The Industrial Revolution had been associated with an unprecedented growth of population (in fact, more than in a geometric progression!). This, coupled with the Napoleonic wars and the inevitable difficulties of importation of corn, had caused a rapid increase in the demand for food, which had led to an expansion of agricultural production, through the passing of a succession of enclosure acts, in order to extend cultivation to formerly uncultivated lands. The obvious consequences

had been a higher price of corn and higher rents.

To see diminishing returns in this process was simply a rationalisation of historical events - actually of an historical circumstance, which was typical of a specific country (England) and of a specific period of time (the late 18th - early 19th centuries).

Incidentally, but very significantly, it must also be noticed that, from a purely analytical point of view, the principle of diminishing returns suited Malthus's theory of population very well. In the place of the earlier weaker arguments of geometric versus arithmetic progressions, a scientific principle could be presented which allowed Malthus to assert that, as the number of people increases, it is true that 'a pair of hands comes with every mouth', but while the new mouths require as much food as the old, the new hands produce less and less. Ricardo promptly turned this into a powerful argument against protection. Free trade in corn would stop extension of cultivation to less productive lands and hence divert production potential to manufactures, where all agreed that diminishing returns would not apply. Factual historical evidence and analytical convenience seemed to go hand in hand.

The theory of differential rent - which had been ignored as long as it had been proposed (by James Anderson) within a static framework - became a powerful analytical tool when it was applied within a dynamic scheme, in which the extension of cultivation of land is coupled with diminishing returns to scale. For the emerging science of Political Economy this marked a turning point.

6. The 'law' (or pseudo-law?) of diminishing returns

But how accurate, or how reliable, or how meaningful is a 'law' of diminishing returns?

One has a pretty good idea of what is meant by a law in physics. The law of gravitation, for example, is a universal law expressed by a formula that describes how bodies fall in ideal conditions of no attrition. Of the law of diminishing returns, no one would say that it expresses how an economy behaves in any ideal condition. It rather expresses how an economy moves in *hypothetical* conditions. The hypothesis is that technology does not change, or changes at a speed that is insufficient to prevent a fall in productivity, as production is expanded.

In fact, not one of the authors we have considered asserts that diminishing returns represents a universal principle. To begin with, they present it only for agricultural production. This is a crucially important point. They all imply that, in manufacturing production, the opposite is the case, namely that productivity is increasing. Moreover, they admit that technical progress goes on in agriculture as well; but not at a sufficient pace to offset the fall in productivity.

Ricardo is the most logically consistent of them all. He is always careful *not* to deny that 'improvements might take place in agriculture' (p. 11); but at the same time he is convinced that they would not proceed at a sufficiently speedy pace. Therefore (quite remarkably from an analytical point of view), he explicitly states that, for clarity, he leaves them aside. He cuts short all hesitations: 'We will, however, suppose that no improvements take place in agriculture, and that capital and population advance in the proper proportion' (p. 12). In this way, the absence of technical progress in agriculture becomes an explicit *assumption!* Once this assumption is granted, even the simple two-commodity version of Ricardo's model (with an agricultural good and a manufactured good) is by itself sufficient⁷ to show how all of Ricardo's conclusions logically follow, as 'capital and

population advance in the proper proportions'. He obtains in logical succession: lower-fertility lands brought into cultivation, higher rents, a lower rate of profits, a higher price of corn, a movement towards the gloomy conditions of a stationary state, with wages compressed to subsistence, profits at their minimum and rents at their highest. He concludes:

It follows then, that the interest of the landlord is always opposed to the interest of every other class of the community... High rent and low profits, for they invariably accompany each other, ought never to be the subject of complaint, if they are the effect of the natural course of things. (Ricardo 1815, p. 20).

The relevant point to note is that technical progress in manufactures, *however pronounced it may be*, does not make the slightest difference to Ricardo's conclusions. It is the process of production of the agricultural good that acts as a bottleneck. The way out, for Ricardo, is free external trade. If corn is imported, the country will specialise in manufactures, and the process of diminishing returns (as it only affects agriculture) will be brought to a halt! The argument is incontrovertible; but it stands on the crucial hypothesis of no (or in any case insufficient) technical progress in agriculture. This can hardly be said to be a 'universal law'. In spite of what some interested witnesses might have said in their testimonies at the Corn Committees, many - and James Anderson was one of them - would claim that it was not even the case in England at that time. Cannan (1903 p. 152) remarks that diminishing returns may be seen as denied even in some statements of the Chairman of the Committee (Sir Henry Parnell).

Unlike the theory of rent, the law of

diminishing returns in agriculture did not attain general acceptance, even at the time it was presented. Notable examples of a strong critique are those by Thomas Chalmers (1832), in England, and by H.C. Carey (1837), in the United States. Chalmers, in his *Political Economy*, argued at length that 'The doctrine or discovery... promulgated by Sir Edward West and Mr. Malthus... that the land of greatest fertility was first occupied... is not accordant with historical truth' (Chalmers, 1832, chap. I, pp. 2-6). Carey, in *Political Economy* (1837), insisted on pointing out that precisely the way in which the law of diminishing returns was illustrated by both West and Ricardo, namely by the process of cultivation starting on the most fertile land in a newly settled country, was contradicted by historical facts. Certainly that was not the way in which things happened in the United States. Yet, in spite of criticism and opposition, the law of diminishing returns immediately became one of the cornerstones of 19th century mainstream political economy. James Mill, in his *Elements of Political Economy* (1821) expounds the law of diminishing returns as a general rule, neglecting even to mention the possibility of new discoveries or improvements. And when his son, John Stuart Mill, wrote what came to be considered as the synthesis of Classical economic theory - his *Principles of Political Economy* (1848) - he presented the 'law' in a chapter headed 'Of the Law of the Increase of Production from Land', warning that 'This general law of agricultural industry is the most important proposition in political economy. Were the law different, nearly all the phenomena of the production and distribution of wealth would be other than they are' (Mill, 1848, 1st ed. vol. I, p. 212). But John Stuart Mill must have felt uneasy, and not at all on solid ground, for he kept on continually modifying

his presentation of the law in the subsequent editions of his *Principles*. In examining the succession of John Stuart Mill's many qualifications and exceptions, Edwin Cannan points out that Mill ends up by admitting a surprisingly high number of exceptions, and he is baffled:

... we should be at a loss to conceive why Mill should be at the trouble of developing a law which: 1) does not operate in the very early date of the history of society; 2) is liable to temporary supersessions; and 3) has been made head against by an antagonizing principle, namely, the progress of civilization, throughout the whole known history of England. (Cannan, 1903, p. 177).

But what kind of 'law' can this be? No wonder Cannan (1903) ends up by calling it 'the pseudo-scientific law of diminishing returns' (p. 181), pointing out that it is based on 'pseudo-historical characteristics' (p. 175). Yet it became generally accepted. One of its effects was to generate unjustified pessimism concerning the future of industrial economies. Interestingly enough, this unjustified pessimism, which characterised the political economy that came out of the Malthus-West-Torrens-Ricardopamphlets, was better perceived by external observers than by the internal practitioners of the new science.⁸ Thomas Carlyle, the Scottish poet and writer, was quick to notice a contrast between the actually vast possibilities of progress and the gloomy conclusions of the economic profession. His epithet, defining political economy as the 'dismal science', has become famous.

7. A theory of profits (and of capital) as an extension of the theory of rent

The idea that technical improvements would

not be strong enough to overcome the terrible curse of the scarcity of natural resources, particularly of land, shaped the minds of economic theorists for the whole of the nineteenth century.

Even Marx, the theorist of historical change and the inspirer of heretical thoughts on the consequences of changes in technology, was nevertheless unable to escape from such an idea. Unlike Classical economists, he (unconvincingly) rejected the theory of differential rent; he mixed rent and profits together and considered them all as being parts of surplus value and exploitation. Rather than avoid the problem of diminishing returns, he let it enter his analysis in disguised form. Paradoxically, his concept of an 'increasing organic composition of capital' led him into the trap of applying diminishing returns to capitalist accumulation in general. In a Marxian context, the law of diminishing returns re-emerged in the shape of a 'law of the falling rate of profits', which turned out to be one of his major blunders.

Curiously enough, in this respect, the marginalist economists, at the end of the nineteenth century, fell into exactly the same trap. They converted the marginal principle, which the Classical economists had applied to land only, into a general principle, to be applied to all factors of production.

This is something that the Classical economists would never have done. In their elaborations - as is evinced most clearly by Ricardo's scheme - the theory of differential rent served the purpose of separating the effects of extension of production on land (where diminishing returns were supposed to prevail) from those of extension of production in manufactures (where constant, or increasing, returns were taken for granted). By extending the marginal principle outside the processes of land cultivation, the marginalist economists automatically and

imperceptibly carried beyond such processes precisely those characteristics that the Classical economists had carefully confined to land.

The consequences of this extension were of paramount importance. In the second part of the nineteenth century, as the process of industrialisation began to spread from England to Western Europe and to the United States, the emphasis of economic theory was bound to shift from agricultural production to industrial production. Capital accumulation, rather than extension of land cultivation, became the focus of economic investigation. It deserved and should have received appropriately invented tools of analysis, suited for its specific characteristics. What it obtained instead was an extension of ready-made analytical tools that had been invented for the analysis of the process of land cultivation.

Böhm-Bawerk, the principal theorist of capital, conceived capital accumulation as an increase in the 'roundabout methods' of production, which he tried to express in terms of an increase of the 'average period' of production. In this version, the marginal principle and the principle of diminishing returns became indistinguishable parts of the same conception.

This approach put into motion a series of analytical adaptations, which proceeded from two opposite sides. On the one side, the principle of marginal land had to be shaped in such a way as to suit the characteristics of all other factors of production; which led to the application of the marginal principle only in its intensive version. The principle of diminishing returns was thereby shaped in the form of diminishing returns to changing proportions, associated with variations, in the opposite direction, of factor prices (the growth of capital, relatively to labour, being associated with a fall in the rate of profits).

This was interpreted as expressing the - no doubt important - process of *substitution* of capital for labour, which is at the root of any process of economic growth. But such a conception of the substitution process should have appeared as peculiar, as it presupposes a constant state of technical knowledge.⁹

On the other side, a series of *assumptions* were introduced in order to assimilate the characteristics of all factors of production (and, most of all, of capital) with the characteristics of land. Knut Wicksell, adding rigour to Böhm-Bawerk's theory of capital, enshrined the relation among all the factors of production in what later became known as the neoclassical production function, in which all factors enter production on exactly the same footing. The clearest and perhaps most ingenuous expression of this approach is that of John Bates Clark (1899, pp. 194 ff.), who explicitly, and even with a touch of pride, uses precisely the diagram representing the varying proportions of labour and land to represent (by simply changing the name of the fixed factor) also the varying proportions of labour and capital.¹⁰ Then he could even abandon land altogether, concentrating on labour and capital only, with diminishing returns to changing proportions.

This conception of production, which has come to dominate economic theory, up to our own day, required an *analytical* (not a factual!) distinction between two types of changes of returns: i) changes due to variation in the *scale* of production, at constant factor proportions; and ii) changes due to variations in the proportions among the factors of production (supposed to represent the process of substitution of capital for labour). In theory, the first process of variations might yield constant, decreasing or increasing returns; but in general increasing returns were excluded, by *assumption*. The second process

of variations had to be conceived as going in the direction opposite to changes in factor prices, again, by assumption, owing to the requirement that convexity of the production function is - not an observed fact! - but a necessity of the theory. The theory of income distribution was associated - without any explicit justification - *only* with the second process of variations (i.e. with the variations in the factor proportions).

It seems extraordinary that the theories of production and distribution should have proceeded on such important questions simply by a process of, bit by bit, extensions, and of assumptions added on the basis of analytical convenience, rather than on the basis of observation or logic.

This analytical process has proceeded a long way indeed, in spite of its going, quite clearly, against what Malthus, West, Torrens and Ricardo originally intended. It was no doubt strongly influenced and facilitated by the parallel development of the notion of marginal utility in the theory of consumption.¹¹

Now and then, there have indeed been criticisms and oppositions to such extensions, but, in spite of their solid grounds, they have not in the end been successful.

Piero Sraffa, in 1925, published a remarkable article (Sraffa, 1925), in which he carried out a punctilious analysis of the sources of the laws of returns in economic theory. With reference to Marshallian analysis, he argued that the 'diminishing' part and the 'increasing' part of the 'relation between cost and quantity produced' were in fact derived from altogether different and even mutually incompatible pieces of analysis, joined together as if they constituted a single relation, only because that is what was analytically required in order to obtain an elegant relation that could be symmetrical to

the demand schedule.

Sraffa was still moving within the century-old economic approach that had taken technology as given and constant. Technical progress had not yet dawned on the horizon of economic analysis. Within such a framework, his conclusions were perfectly consistent. The only assumption that could be logically compatible with economic theory - he argued - was the assumption of constant returns to scale.

Sraffa was not concerned with technical progress, even in his later work (Sraffa, 1960). Yet, his discovery of the 'reswitching' phenomenon in the choice of technique was basic to a criticism of the generalised application of the marginal principle. The controversy in capital theory that flared up in the 1960s did achieve important results. At the end of it, everybody had to agree that the assumption of diminishing returns to changing proportions, when applied to capital and labour, has no logical foundation. In general, there exists no monotonic association between variations in the *proportions* of capital to labour (or of capital to land or to capital to any non-produced factor of production) and the rate of profits. The implication is that the extension of the marginal principle to *capital* and labour (or to capital and land) has no logical foundation. More specifically, the assumption of a general 'well-behaved' (as it has been called) production function is totally unwarranted. (See Pasinetti *et al.*, 1966).

The results of the capital theory debate of the 1960s were therefore all against the generalisations of the marginal principle that had taken place in post-Ricardian economics. They should have provided a warning on the wrong directions that had been pursued; a sort of clarion call for an elimination of the excesses of marginal economic theory and a return to the point of departure of the Classics. One could have hoped then that at a

second stage, the choice that had been made by the Classics could have been reconsidered.

But this step failed to materialise. The results of the 1960s discussion on capital theory are nowadays generally ignored. Uncritical acceptance of diminishing returns to changing proportions as applied to capital and labour remains widespread. In most of the economics textbooks and in most of the papers appearing in today's prestigious economic journals, production functions involving Labour and Capital with decreasing returns to changing proportions are freely used, apparently without the slightest doubt as to their appropriateness, and most of the time even without giving the slightest warning or information on agreed outcomes of previous discussions.

For all this - it should be stressed - the authors of the 1815 Political Economy pamphlets bear no responsibility.

8. Technical progress versus limited natural resources

Ricardo could never have imagined that an innocent *assumption* ('We will, however, suppose that no improvements takes place in agriculture...', Ricardo, p. 12), that so well served the analytical purpose of isolating what he thought to be the field of diminishing returns (agriculture) from what he took to be the field of constant or increasing returns (manufactures), would generate such long lasting effects. His assumption was meant to be confined to production on land. Obviously he could not anticipate, even less prevent, the use that later economists would make of it.

But once the assumption of no technical improvement had been extended to production in general - and here I come to the main contention of the present paper - the effect was that, with the exception of a few isolated cases, technical progress disappeared from economic analysis for more than a century.