THE PARADOX OF THE SYNONYMY OF "INCREASING RETURNS" AND ECONOMIE OF SCALE

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ABSTRACT

It is common in literature for the notion of "increasing returns" and economie of scale to be accepted as synonymous. This gives rise to a paradox however when considered in the context of real conditions of industrial production. This paper demonstrates the paradox, proceeds to its resolution, and briefly, in conclusion, outlines the main implications of the solution.

Key Words: *Increasing Returns, Economies of Scale, Constant Returns, Theory of Equilibrium, Concept of Unity of Technical Operations*

ÖZET

"Artan verimlilikler " ve ölçek ekonomi kavramları literatürde genellikle özdeş olarak kabul ediliyorlar. Bu özdeşlik, sanayi üretimi koşullarında telakki edildiği zaman bir paradox yaratıyor. Makalemiz önce bu paradox'u ortaya koyuyor, sonra bu paradox'a çözüm getiriyor, ve sonuç olarakta, çok kısa bir şekilde, çözümden en başlı çıkarsamaları belirtiyor.

Anahtar Kelimeler: *Artan Verimlilikler, Ölçek Ekonomi, Sabit Verimlilikler, Genel Denge Teorisi, Teknik İşlemler Ünitesi Kavramı*

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Introduction

The notion of "increasing returns" is frequently employed as a fundamental concept in several important areas of economic analysis. At the same

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time, however, it raises important issues (not least for the theory of value) that have been preoccupying economists for over a century.[1]

In this paper we address a particular aspect of "increasing returns", whose closer analysis may shed light on -or at least help to reformulate- a significant number of the issues raised and discussed in this context.

We refer to the use of term "increasing returns" as synonymous with economies of scale. There exist numerous examples of these terms being used interchangeably both in microeconomics literature in particular, and in areas where marginal analysis tools are utilized. The understanding is that these terms are synonymous, signifying one and the same phenomenon. This is sometimes made very explicit.[2] This synonymity, however, leads us to a paradox when considered under real economic conditions - in the domain of industrial production of material goods at least, to which the analysis put forward in this paper is limited.

We will first demonstrate the paradox and then proceed to its resolution. Finally, to conclude our analysis, we will point to some of the implications arising from our resolution of the paradox.

1. The Incompatibility of "Increasing Returns" with the Theory of Equilibrium in Perfect Competition

There is a generally considered fundamental incompatibility between the phenomenon of "increasing returns" and the theory of equilibrium in perfect competition (referred to in this paper as the TPC). The argument traditionally put forward runs essentially as follows: "increasing returns" imply diminishing costs leading to a position of monopoly, and this is incompatible with the conditions of equilibrium under perfect competition.

a) Although it is not explicitly declared or admitted, this incompatibility is accepted, implicitly, as being of a formal or logical nature. Pareto makes

[1] It was doubtless to acknowledge the fertility of this notion as far as raising issues is concerned (a fertility that has once again brought it to centre-stage) that BUCHANAN endowed his work with its so eloquent title: J.BUCHANAN, Y.YOON (eds.) [1994] *The return to increasing returns*, University of Michigan Press.

[2] For example, P. DEHEZ writes: "Economies of scale and increasing returns are synonymous" [1988, p.779].

interesting points on this issue: whilst refuting the notion that a monopoly can maintain its existence over time (although capable of occurring sporadically), Pareto nevertheless admits the (logical) coherence of the link between "increasing returns" and monopoly conditions. He claims:

> "If the unit cost of a good falls constantly as the quantity of that good produced rises, there is advantage to be gained in concentrating the production of all such goods in a single firm.
> This is admitted by those writers who believe that this would result in a monopoly. They have not, however, given sufficient attention to the difficulties of managing such a firm. The difficulties are such that, generally speaking, firms reach a certain limit, beyond which they find that the unit cost of production will rise rather than fall. There have hardly ever been any monopolies established, leaving aside rare and special exceptions, under conditions of free competition." (Pareto 1964, Vol. II, p. 89)

Pareto bases this argument on a hypothesis that has cropped up regularly ever since: Any increase in the size of a firm will lead to an increase in costs, following the U-shaped curve of average costs. Pareto's reasoning is his implicit approval of two propositions: On the one hand, the link between "increasing returns" and monopoly and on the other, as a consequence of the former, the incompatibility between the notion of "increasing returns" and the conditions for perfect competition. His refutation is based not on the logical coherence of the propositions (with respect to TPC), but on the question as to whether a firm can ever in reality achieve a real and long -term monopoly state- and this for reasons other than that of "increasing returns".

However, by accepting the two propositions as logically true in the context of and in relation to TPC, Pareto implicitly acknowledges that TPC has its limits - it cannot be held up as a general theory. It should be stressed that the limits in question are of a formal or logical nature. The question as to the content of the notion "increasing returns", or the actual pertinence of the link between these "returns" and the position of monopoly, is neither raised nor addressed.

b) This has continued to be true for all the work and debate on TPC. Most of the economists seeking to establish the general validity of the theory have addressed the question of its incompatibility with the notion of "increasing returns", implicitly discussing it in logical terms. There is one relative exception, of major significance however, in so far as it generated an upsurge of discussion and reflection, albeit on a theoretical level. This is Clapham's "provocative" paper (Pigou's term) on the "Empty boxes" (1922). It would be useful at this point to briefly recall the context of Clapham's contribution, as this will move us on in our discussion of the incompatibility of "increasing returns", from Pareto to Marshall.

This question is in fact directly linked to the solution that MARSHALL had envisaged for reconciling "increasing returns" with TPC, with a view of ridding the theory of this limitation. Marshall's solution is of course well-known. It involves viewing the notion of "increasing returns" -in the context of a firm- in the light of two distinct types of "economies": "external" and "internal economies". It was not until many years later however, in the twenties in fact, that economists started to take an interest in the potential of this approach - even if Marshall himself had given the impression of not being completely convinced by his own proposal. It is probable that Pigou's ideas and Knight's contribution (Risk, uncertainty and profit, (1921)) were influential in launching this debate. The discussions finally evolved into what became known as the "cost controversy", into which CLAPHAM made his appearance in 1922 with his famous article. The "cost controversy" raged over ten years or so; besides CLAPHAM it featured KNIGHT (1921, 1923) PIGOU (1922, 1927), ROBERTSON (1924, 1930), SRAFFA (1926) and YOUNG (1928).

This controversy was a fertile one. Both Chamberlain's theory of monopolistic competition and Leontief's input-output analysis in particular are considered to owe their existence to it. It nevertheless failed to provide an answer to the question raised by CLAPHAM as to the meaning and content of the notion of "increasing returns", and offered no satisfactory solution to the question of the incompatibility of that notion with the TPC. To this day economists continue to seek a solution, trying now to place the notion of "increasing returns" per se within the theory itself.[3] The incompatibility between "increasing returns" and the TPC therefore presents a significant limitation to the theory.

c) Given this incompatibility, the synonymy of "increasing returns" and economies of scale directly implies the incompatibility also between economies of scale and one of the fundamental hypotheses of the TPC: Constant returns to scale. Now, in the industrial production of material goods with which we are here

[3] See for example: P.BEATO [1982], J-M. BONNISSEAU [1988, 1992], J-M. BONNISSEAU, B. CORNET [1988], B. CORNET [1988], P. DEHEZ [1988], P. DEHEZ, J. DREZE [1988]

concerned, the incompatibility between constant returns and economies of scale cannot bear scrutiny - it is in fact their **compatibility** that is observed. It is to this that we now turn.

2. The Compatibility between Constant Returns and Economies of Scale

In order to demonstrate the compatibility between constant returns and economies of scale we will first look more closely at the notion of **returns to scale**, at different types of return and the corresponding types of production costs. We will then proceed to the definition of economies of scale. We will base this on quantitative observations commonly made in studies on cost evaluation for industrial production. Finally, applying these notions in an analysis of industrial production, based on a concept that we will propose: the concept of **Unity of Technical Operations**, we will see how constant returns to scale and economie of scale are in fact entirely compatible.

2.1. The Notion of Returns to Scale and Types of Production Costs

2.1.1. The Notion of Returns to Scale and Constant Returns to Scale

The term "constant returns" (or "increasing returns/"decreasing returns") is commonly to be found in the literature without always the explanation that this in fact refers to constant returns to scale (or "increasing/decreasing returns to scale"). It is presumably considered that, as these terms are well enough understood by all economists, there is no risk of ambiguity if the term '**to scale**' is dropped without explanation. Nonetheless, in our opinion it is necessary to mention the term '**scale**' whenever these concepts are used. This helps to distinguish very clearly the general concept of returns to scale from three different ways in which it is actually used, and also from the concept of "factor returns", which carries a different connotation.

In contemporary writing, the concept of returns to scale is used very precisely. In the New Palgrave, J. EATWELL (1987) gives the following definition:

> "Returns to scale:
>
> The technique of production of a commodity may be characterized as a function of the required
> input x_i :
>
> $$y = f(x_1, x_2, ..., x_n)$$

> If all inputs are multiplied by a positive scalar, t , and the consequent output represented as t^s y, then the value of s may be said to indicate the magnitude of return to scale.
>
> If s = 1, then there are constant returns to scale; any proportionate change in all input results in an equiproportionate change in output." (1987, p.165)

This definition reoccurs with more or less precision in all microeconomics texts. PICARD for example (1990) writes:

> "It would therefore be interesting to consider the variation in production that would result from a quantitative increase in equal proportions of all factors. How would production change if we envisaged for example a doubling in the quantities of all factors employed?
>
> ... there would be constant returns to scale if production just doubled. Mathematically, if λ is any number strictly superior to 1,... returns to scale are held to be constant if:
>
> $f(\lambda z_1, \lambda z_2,..., \lambda z_n) = \lambda f(z_1, z_2,..., z_n)$" (1990. p.138)
>
> (with z_1 being the **<u>physical quantity</u>** of factor i)

2.1.2. The Different Types of Return to Scale and of Costs of Production: Their Difference and Relationships

a - Given Eatwell's definition of **returns to scale** and Picard's definition of constant returns to scale, the three different types of return to scale below can be established:

Consider production function f (x_1, x_2) where x_1 and x_2 are physical quantities of the number λ such that λ>1

and a number

$$[\, f(\lambda x_1, \lambda x_2) = \lambda f(x_1, x_2) \,] \Rightarrow (CR)^4$$

[4] We will use the following notation for the different types of return to scale and the production costs associated with them:

$$[f(\lambda x_1, \lambda x_2) > \lambda f(x_1, x_2)] \Rightarrow (IR)$$
$$[f(\lambda x_1, \lambda x_2) < \lambda f(x_1, x_2)] \Rightarrow (DR)$$

By defining returns to scale as:

$$RS = [f(\lambda x_1, \lambda x_2)] / [\lambda f(x_1, x_2)]$$

we can establish that :

$$(RS = 1) \Rightarrow (CR)$$
$$(RS > 1) \Rightarrow (IR)$$
$$(RS < 1) \Rightarrow (DR)$$

b) The notion of production costs corresponding to returns to scale is defined in all the microeconomics literature as:

$$CS = AC / MC$$
$$= [TC / q] / [\partial TC / \partial q]$$

We can therefore establish the three types of production costs:

$$(CS = 1) \Rightarrow (CC)$$
$$(CS > 1) \Rightarrow (DC)$$
$$(CS < 1) \Rightarrow (IC)$$

RS : Returns to scale
CS : Production costs corresponding to returns to scale
CR : Production with constant returns to scale
IR : Production with increasing returns to scale
DR : Production with decreasing returns to scale
CC : Constant production costs
DC : Decreasing production costs
IC : Increasing production costs
TC : Total cost of production
q : Physical quantity of production
AC : Average cost
MC : Marginal cost

c) Hence, given known and fixed input (or factor) prices, the relationship between the different types of return to scale and production cost can be expressed as follows:

$$(RS = 1) \Leftrightarrow (CS = 1) \Rightarrow (CC)$$
$$(RS > 1) \Leftrightarrow (CS > 1) \Rightarrow (DC)$$
$$(RS < 1) \Leftrightarrow (CS < 1) \Rightarrow (IC)$$

Having thus clarified the main notions linked to returns to scale, we must now turn to a definition of economies of scale.

2.2 - Economies of scale: The Phenomenon and its Description[5]

In project evaluation and cost analysis, economists and engineers have often observed that the increase in production capacity of plant or equipment (or a set of equipments) in different industrial sectors is not proportionate to variations in the cost of the plant or equipment in question.

These observations, or at least those reaching publication, were systematically made in the fifties for equipment designed for the oil, petro-chemical and chemical industries. They were applied later to several other sectors involved for example with steel, aluminium or cement production or the manufacture of components for the automobile industry.[6]

The data available does not cover all industrial sectors, but it is derived from an area sufficiently broad to justify a general description of the phenomenon of economies of scale.

Economies of scale refers to a reduction in unit costs per capacity of the plant or equipment (or set of equipments) of a factory, as the capacity of

[5] See H. ERDEMLI [2001], Elements of Global Industrial Economics: The concept of economie of scale and the trade theory.

[6] See for example on the oil, petro-chemical and chemical industries: R. S. ARIS and R. D. NEWTON [1955], H. C. BAUMONN [1964], C. H. CHILTON and R. H. PERRY [1973]; for the steel industry: B. GOLD [1974, 1979], F. PECO [1971], United Nations [1980]; on aluminium: United Nations [1967]; mechanical (but also chemical): C. F. PRATTEN [1971,1991]; for the automobile industry and household electrical goods: N. OWEN [1983] .

production of the same rises.[7] We propose formulating this phenomenon of cost in the following manner.[8]

$$([(\Delta K / K) / (\Delta Y / Y)] \in] 0, 1 [ ) \Rightarrow (E)$$

The effect of economies of scale must therefore necessarily be expressed as:

$$\Delta (K / Y) < 0$$

It should be noted that not all increases in production capacity result in economies of scale. There are limits.

2.3 - The Industrial Production of Material Goods, Returns to Scale, and Economies of Scale

2.3.1 - Industrial Production and the Concept of Unity of Technical Operations

[7] An example from the steel industry will suffice as an illustration:

Completely integrated production unit

Production capacity 10^6 tons / year	Unit cost of equipments per capacity $ / ton of steel	Unit cost of equipment per capacity Index
1	240	120
1.5	200	100
2	180	90
3	160	80
5	140	70

F. PECO [1971], p. 136.

[8] Where :

K : The total cost of the plant or equipment at current prices

Y : The capacity of production of the plant or equipment in **physical units** (number, tons, m^2, m^3 etc.)

E : Economie of scale.

The industrial production of material goods consists of the transformation of manufactured components, or of raw materials of organic or inorganic origin, through one or more physical, chemical, or physico-chemical processes, into products destined for the direct or indirect use of other economic activities, if not directly by consumers. Assembly is considered as the transformation by any physical process. We will refer to these transformation processes as techniques of production.

In order to analyse industrial production in terms of physical quantity, or in real terms[9] (rather than in terms of value), we propose the concept of **Unity of Technical Operations (UTO).**

UTO associates through its qualitative (technical) relations the following elements of production: The production equipment, human labor (not always necessary), and the materials to be transformed. The qualitative relations between these elements determine their quantitative relations (technical coefficients).

The UTO concept is as valid for a single workstation as it is for a workshop or factory.

a - The UTO, technique of production and the principle of complementarity.

The technical and quantitative relations between factors of production, upon which the concept of the UTO is based, require that the composition of these elements be quantitatively fixed, i.e. that the factorial composition be fixed in physical terms - this is the principle of complementarity.

Several authors have explained the importance of this principle in understanding the phenomenon of industrial production.[10] PICARD (1990) writes on this subject:

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[9] The analysis of industrial production in physical terms is particularly compatible with the notion of returns to scale in this area, which, as we have seen, is also defined in physical terms.

[10] See, for example, A. BARRERE [1959], R. FRISCH [1963], J-L. GAFFARD [1995], R. W. SHEPHARD [1970].

We should also recall in this context Pareto's definition of complementarity: "Complementary goods are those economic goods that need to be associated, in order to produce, directly or indirectly, particular ophelimities. This would include, for instance, a stove and the coal to be burnt inside it, or a lamp, and its wick and oil. Capital goods are in general complementary, as they can with difficulty be employed on their own. This is what certain economists mean when they say

> "Factors of production are indeed complementary. Suppose for example that a firm produces 10 units of goods, using 10a units of labour and 10b units of capital. If the quantity of labour falls to 9a units of labour, the total production possible will be equal to or less than 9, whatever the quantity of capital. No increase in the amount of capital can offset the fall in the quantity of labour to maintain production at 10 units." (1990, p. 146)

The concept of Unity of Technical Operations is entirely compatible with the principle of input (or factor) complementarity, which is an intrinsic property of any production technique and can be observed on a daily basis in the industrial production process.

b - The UTO and the concept of capacity of production.

The maximum output –in real terms– obtainable from a UTO in a given period of activity (generally a year) is referred to as its production capacity. Capacity of production is always expressed in physical quantity. This definition is largely based on the definitions of production capacity to be found in R. Frisch (1963) L. Johansen (1972), and G.J. Stigler (1972) with the addition of those elements specified above.[11]

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that capital is "sterile" without labour. But there is nothing particular in this, and we might just as readily say that labour is "sterile" without land and movable assets" (1964. Vol. 1, p. 42).

[11] The definition preferred here is sometimes considered as the definition of "technical production capacity". BOURLANGE and CHANEY [1990] explain this term as follows: "Generally two main notions of production capacity, or production potential, can be distinguished. The first refers to the **maximum** level of production that is possible to achieve, taking into account short- term factors of production, i.e. typically the stock of capital... We are referring to the **technical** production capacity." [1990, p.55]

The second understanding of production capacity, that of **optimal** production capacity, is "...the level of production which maximises profits or minimises costs". However this does not correspond to production capacity as defined above; it concerns rather the level of output to be achieved given a specific capacity of production.

It is often found incidentally that the notion of production capacity is understood as applied in national accounting at a sectoral or even macroeconomic level. At this level the difficulties of definition and measurement become extremely serious, and have, incidentally, been well identified. (See on this: D. BOURLANGE and E. CHANEY [1990,], G. CETTE [1990] , G. CETTE and D. TADDEI [1995], S. MAYO and M.. REYNAUD [1995])

Our -technical- definition based on the concept of the UTO has the advantage of not raising the difficulties presented by an analysis at macroeconomic or sectoral level.

c - The UTO and the rate of capacity utilization.

The rate of capacity utilization of a UTO describes the relationship between the actual output of UTO and its capacity of production. This is the definition generally upheld by economists. C. Corrado and J. Mattey (1997) for example define it as follows: *"Capacity utilization is a ratio of the actual level of output to a sustainable maximum level of output or capacity."* (1997, p.152)

Likewise, R.A. Nelson (1989):

> "Capacity utilization is usually defined as a ratio of actual output to some measure of potential output. Some studies employ an engineering approach, in which potential output represents the maximum output that may be produced given a firm's short- run stock of capital." (1989, p. 273).

Finally we can cite the example given by G. Cette and C. Waysan (1996) as a good illustration of the concept:

> "If for example a vehicle assembly line produces forty vehicles per hour although it has a maximum capacity of fifty vehicles, the utilisation rate of its production capacity is 80%."

It should be noted that this example is entirely in line with our definition of production capacity in physical or real terms, and it thus clearly illustrates our understanding of the notion of utilization rate.

d - The variation in output of a UTO.

Given the principle of complementarity, it is clear that the capacity of production of a UTO is determined by the capacity of equipment or set of equipments of which it is composed, and that this capacity determines in turn the total amount of labor, material (based on technical coefficients) and utilities required for production. The concept of production capacity is therefore indeed synonymous with scale of production, as discernible in Eatwell's definition of returns to scale quoted above.

A UTO's volume of production or output (in physical quantity or real terms) will thus vary – either through variations in its capacity or scale of production, or through variations in the rate of utilisation of its production capacity (for a given scale or capacity). In general the variation in capacity will be analysed in discrete terms and the variation in volume of output, given a production capacity, in continuous terms.

2.3.2 - Constant Returns to Scale and Economies of Scale in Industrial Production

Given the principle of complementarity and the notions of production capacity and capacity utilization rate which underlie the UTO concept, it is easy to understand that for industrial production the relationship between the quantities of inputs (or factors) and the quantities of output is linear.

a - If we consider the definition of returns to scale in the light of the explanations above for these elements underlying the UTO concept, the strict correlation between the variation in a UTO's capacity or scale of production and constant returns to scale becomes evident.

In fact, if the production capacity of a UTO is increased by a factor of 2 for instance, with no change in production techniques, the scale of production is increased by a factor of 2 also. In order to maintain a capacity utilization rate or a scale of production of 100% it will also be necessary to increase the quantity of all factors by the same amount, exactly as required by Eatwell and Picard's definitions of returns to scale cited above.[12] The notion of constant returns to scale can therefore be entirely confirmed in industrial production.

b- This property of industrial production does not exclude the achievement of economies of scale. As we have seen for a UTO, it is in fact the production

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[12] A practical example. An automobile assembly unit has an annual production capacity of 500 000 vehicles of a given model. With output at 100% capacity there will be a requirement for 500 000 chassis, motors, etc. and 2 million wheels, tyres, etc. If the scale or capacity of production is doubled, the quantity of these inputs required will of necessity also double, and only double, given a utilization rate of 100% using the same technique of production for the same model of vehicle. The relation between the quantity of inputs and outputs can therefore be defined as follows:

$$[\, f(\lambda x_1, \lambda x_2) = \lambda f(x_1, x_2)\,] \Rightarrow (RS = 1)$$

It should be noted that in this example we do not take into account the quantities of inputs such as chassis, motors etc. which may be rejected; it is assumed that these are delivered conform to technical specification.

capacity of the plant or equipment that determines both the scale of production and the quantities of other factors / inputs required for the quantities of output, at a utilization rate of 100%.

As a consequence, under constant returns to scale, it is perfectly possible to achieve a relative reduction in the unit cost per capacity of plant or equipment as the production capacity of the plant or equipment in question rises. In other words, it is perfectly possible to achieve economies of scale under constant returns, since the increase in the scale or capacity of production remains proportional to the increase in the quantity of all the other inputs required to achieve it. Economies of scale are therefore entirely compatible with constant returns to scale, and vice versa.

It is clear therefore that the use of the notion “increasing returns” as synonymous with economies of scale results in a paradox - to which we now wish to propose a solution.

3 - The Resolution of the Paradox

The paradox we have just demonstrated above is not insoluble. The solution proposed is in two parts. The first involves the distinction on formal grounds between economies of scale and the notion of “increasing returns”. The second requires the demonstration that constant returns to scale are not only observable in industrial production (as we have seen) - but that they are also the **only** returns to scale possible in this domain.

3.1 - The Necessity of Distinguishing between the Notion of “Increasing Returns” and the Phenomenon of Economies of Scale

The paradoxical situation outlined above is destined to persist as long as “increasing returns” continue to be confused with economies of scale, and vice versa. Once however these are considered as separate and different phenomena, to be distinguished at a formal level, the paradox will cease to exist, on this level at least. Such a distinction is all the more defensible given the differences observable between the phenomenon of economies of scale and the notion of "increasing returns" as they have been defined above. It will be sufficient here to indicate the more salient differences.

First, however, a preliminary remark: We have seen in our review of the different types of return that the notion of "increasing returns" is defined in real terms - in terms of physical quantity - and is not based on measures of value. The corresponding notion in value terms would be that of "decreasing production costs". Hence even on a terminological level one cannot strictly consider "increasing returns" defined in physical terms to be synonymous with economies of scale, which is a phenomenon of cost in value terms. Furthermore "increasing returns" can lead to lower costs only if input or factor prices remain constant. Under economie of scale, however, the price (or cost) of the plant or equipment is not at all constant. Economies of scale are in fact conditional upon variations in the price of the equipment.

These are sufficient grounds to justify the requirement to distinguish the notion of "increasing returns" from economies of scale. At the very least on a formal level therefore we can avoid the paradox that ensues if these terms are used synonymously, as is frequently the case in economic analysis. In order to offer a full solution to the paradox, however, we will also demonstrate that constant returns to scale is the **only** type of return to scale possible in industrial production.

3.2 – The Demonstration of the only Type of Return to Scale Encountered in Industrial Production: Constant Returns to Scale

The arguments we have put forward establishing the reality of constant returns to scale in industrial production suggest very clearly that such returns are in fact the only returns possible in this domain. To be strict, we admit a hypothesis of no major consequence, which we explain below and which is relatively easily accepted.

We will therefore now demonstrate that the notion of "increasing returns to scale" has no real meaning in industrial production. This follows from the application in this domain of the notion of returns to scale as defined and generally accepted in literature (See Palgrave's definition cited above).

In fact, if, following the definition of returns to scale, we increase the quantity in physical terms of all the elements (or factors) of a given production operation by factor λ the output -in physical terms- can only rise by the same factor λ, given a capacity utilisation rate of 100%.

It is true that it is not uncommon to record "wastage" at production level, although this is becoming less and less important today on some production lines, thanks to the use of computers. Some industrial manufacturing also allows production of by-products. The result is that the material balance may reveal a discrepancy between the total quantity of inputs in the composition of a product and the total output. Today, however, improvements in recycling techniques and the production of by-products (which have always been traditional) are helping not only to establish constant returns in real terms, but are also contributing to development of new economic activities.

Thus, setting aside the wastage and / or rejection factor (our hypothesis), if a UTO's capacity or scale of production doubles, total output can do no more than double at the most -it cannot possibly achieve a total output greater than capacity. And given a 100% rate of capacity utilization, no increase in capacity or scale can lead to a reduction in production, assuming our hypothesis. In other words, **Industrial production can present neither "increasing returns" nor "decreasing returns": the only returns of scale possible in this domain are constant returns to scale**.

The paradox of the synonymy between "increasing returns" and economies of scale can thus be entirely resolved; both by distinguishing these two notions on a formal level, and by demonstrating the entirely artificial nature of the notion of "increasing returns" in industrial production. However, the resolution of the paradox and the points we have raised to achieve it, have important implications. We shall pay a rapid visit to some of these by way of conclusion.

4. By Way of Conclusion – A Brief Look at some of the Implications of the Resolution of the Paradox

It would be impossible in the context of this paper to offer a full analysis of the implications, direct and indirect, of the resolution of the paradox, given their importance and number. We will therefore content ourselves here with a rapid look at some of the main **direct** implications.

1 - Above all it is clear that economies of scale and the notion of "increasing returns" must be strictly and formally distinguished, and also that account must be taken of our conclusion, namely that the notion of "increasing returns" is an entirely artificial notion with no real significance (for industrial production at least).

2 - Such an artificial notion can thus in no way limit the equilibrium theory, at least as far as industrial production is concerned, as it has no real content. If the theory continues to show limitations as an aid to understanding processes in this domain, they cannot be put down to “increasing returns”.

We may therefore legitimately ask to what extent the work currently being carried out to reconcile the notion of "increasing returns" with TPC – and thus rid it off its limitations – is capable of ever achieving any significant conclusion representing advancement in economic thought on the issue. This immediately begs a second question: Can economies of scale, which are perfectly compatible with TPC’s hypothesis of constant returns, be consistent with any other hypotheses of the theory?

3 - No response to this question can be given without according central importance to the concept of UTO. The UTO concept brings within a single conceptual framework three essential elements: the principle of complementarity and the two notions of capacity or scale of production and rate of capacity utilization. It also implies that returns to scale in industrial production are necessarily constant.

Although such an implication may demand changes in the way we view and analyse industrial production, this is in fact only natural. After all, in real terms or in terms of physical quantity, isn’t industrial production just a physico-chemical transformation of matter (as it is often defined, incidentally), and as such subject, ultimately, to physical laws?

3.1 - Clearly, the fact that returns to scale are necessarily constant in industrial production will again raise the problem of production coefficients in economic equilibrium theory. This is a problem that raised major doubt and discussion when theory was being elaborated.[13]

3.2 - But this issue should also be given serious attention in research currently being carried out with a view of reconstructing economic analysis around an interpretation of the division of labor and the notion of “increasing returns”.[14]

3.3 - Similarly, the notion of “increasing returns” is a central element in theory of endogenous growth put forward relatively recently.[15] The question is evident: To

[13] See on this S. VON ROTEN [1977]

[14] For example X. YANG, Y-K. NG [1993]

what extent is it wise to try basing a theory of economic growth on a notion with no real content, at least in the domain of industrial production (which nevertheless represents the lion's share of all economic activity in the world)?

3.4 - Finally, a great deal of research has been carried out since the 1970s on international trade theory and to this day research aims at an improved understanding of international trade conditions currently being observed - research which in fact shows up the limitations of traditional theory in this field.

The proposals made up to now in this respect, mainly of a theoretical nature, give significant space in their analyses to the notion of "increasing returns". In so far as this research focuses particularly on the exchange of industrial goods it remains relatively limited in its reach. If we accept the urgent need for new theoretical analysis in this area -and this is evident to most economists- it would be pertinent, at least as far as the exchange of industrial goods is concerned, to exploit the potential offered by the reality of constant returns. This would of course require a review of a number of hypotheses considered sufficiently well-established, without for all that imposing a return to the H-O theory.

4 - We now wish to draw attention to another series of implications of the resolution of the paradox, starting with that concerning the relations between the types of return to scale and types of production cost. As we made clear in paragraph 2.1.2 c, there is a correspondence in marginalist analysis between the different types of return to scale and production cost. This correspondence, however, is not always explicitly declared and acknowledged, in microeconomics literature in particular, nor is it systematically observed.

According to the relationships made explicit above, constant returns to scale imply constant production costs for any given input or factor price. Now we also saw that economies of scale are perfectly realizable under constant returns to scale. We are therefore faced with a difficulty: If, in industrial production, we admit economies of scale, we can no longer affirm that constant returns to scale have as a necessary corollary constant costs of production, since for one factor of production at least -the equipment- we have decreasing costs. We can no longer

[15] See in particular P. ROMER [1986, 1987, 1994] and G.M. GROSSMAN, E. HELPMAN [1994].

claim a correspondence between constant returns to scale and constant costs of production.

5 - This leads us a further implication, which actually resolves the difficulty above. That is, in the case of industrial production it is necessary to distinguish very clearly analyses in real terms from analyses in value terms. This resolves our difficulty, since, given constant returns to scale, it is entirely possible to record increasing, decreasing, or constant costs of production.

The relationships described in paragraphe 2.1.2 c between different types of returns to scale and of costs of production therefore no longer hold: Constant returns, the only really significant type of returns to scale must be set against costs as follows:

PRODUCTION IN REAL TERMS	**PRODUCTION IN VALUE TERMS**
RS = 1	**RC = 1**
	RC < 1
	RC > 1

The main direct implications arising from the resolution of the paradox, as presented in the four points above, do indeed indicate a need to reformulate and re-examine a number of important issues, both in economic analysis in general and in production analysis in particular. We nevertheless believe that this requirement also promises to improve our understanding of the economic phenomena and processes in question.

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