

E (S (SK))

Puzzles and Problems

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This is a paper written by an economist on the production of scientific output and on the scientific belief-forming process. The fact that it is written by an economist should not automatically make it a paper on the Economics of Scientific Knowledge (ESK). However, if the latter is the application of well-developed economic tools to the understanding of the production of scientific output or beliefs, the paper could certainly be so classified. I will be using the venerable Solow growth model to explore some well-defined issues such as the applicability of this kind of model, which almost completely abstracts from individual rationality, or matters of scientific policy, including its public/private nature. There are, however, two features of ESK that will not be used quite properly even though they both seem, or ought, to be the staple diet of ESK. Although I will be making extensive use of the notion of equilibrium, I will be ignoring rationality and expectations completely. I find no use for individual rationality except in a cursory way. And as for expectations, a feature that one would expect to loom high in ESK, I just assume all the time perfect foresight, a simple case of rational expectations and a clever way of not letting in the very rich play of expectation-forming.

Without leaving the realm of ESK proper, I can ask myself some metaquestions on the pros and cons of this Solow model vs the usual game theory approach based on the notion of Nash equilibrium¹ or the issue relating to the humanity or inhumanity of scientific production. These latter types of issue are not quite the same as those encompassing ESK and they could be classified under the S (E (SK)) metaheading.

I have been interested in what I have called ESK or S (E (SK)) for many years, and more specifically in science, so the transformation of puzzles (or enigmas) into problems and puzzles is a conundrum that bothers and challenges me. A problem only challenges me. The challenge posed by a problem is the challenge of solving it. The challenge I feel when facing a puzzle is to convert it into a well-defined problem. Solving problems is a delicate, albeit decisive, task and I will therefore be considering it in this paper as automatically making problems and solutions equivalent.

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My old interest in puzzles and problems was driven by policy matters as how to organise scientific institutions to produce science. More recently, I have come into contact with the Sociology of Scientific Knowledge (SSK) and with the death of the subject or the bracketing out of both the subject and the world, rather esoteric issues for an economist which in any case shift our attention from the production of scientific output to the scientific belief-forming process. In this process, the notions of input and output are not clear cut. One way of understanding them is to think of pairs like Heidegger's things and objects, or Latour's matters of fact and matters of concern. My recent interest in these notions and in processes relating them in a constant flow has a dual origin. IN the first place, I want to explore how I can apply economic reasoning to their understanding, and to what avail. Here, for instance, I will try to capture the importance of the visual representation of science. But, secondly, I also want to use my own mental category to clarify some of the categories, examples and rhetoric used in SSK, such as relativism, conductivism or the broadening of empiricism that Latour is apparently demanding. All these issues could be stamped as E (S (SK)) in the sense that they pertain to SSK, but are going to be approached from an economic point of view. So the paper is certainly centres on (SK) but rambles from E(SK) to E(S(SK)) and S(E(SK)), taking S(SK) as an interesting object of observation. The epistemology is somewhat veiled in the background on this *pot pourri* but I will attempt to bring it to the forefront in unconventional ways.

Putting together the different issues I have already mentioned is not an easy task which I will attempt to accomplish according to the following programme. In the next section, I will be presenting the Solow model together with the notions of the golden rule of accumulation and the period of adjustment. In section 3, I turn my attention to the production of scientific output which I understand through a simple minded application of the Solow model. Contrary to some E(SK) practitioners, I claim that this understanding is quite appropriate and not so different from the underlying understanding in SSK. I show that it can be used to understand the role of visual representation in science and I argue in favour of the inhumanity of research strategy in the field. This particular way of looking at the production of science is particularly appropriate to face a particular aspect of the issue of the public or private nature of science. In section 4, the model is translated into the language of SSK in order to be able to understand and contribute to SSK. Here, the proliferation of things and objects that can be shown to occur through the scientific belief-forming process is interpreted as

an epistemic issue and as an explanation of the broadening of empiricism at which Latour aims, barely disguised as a possible mid-life crisis. In the final comments, I recap and make some brief remarks on conductivism and relativism.

2.- The Solow model

I begin by introducing the Solow model in its own terms and with a notation which I will not bother to modify when chafing its interpretation and/or applications. I begin with the supply side. Let Q stand for output, the same kind of stuff as capital (K). This stuff is produced by this capital K together with labour L . I will take the production function to be Cobb-Douglas with constant returns to scale from the very beginning. That is:

$$Q = K^{\Pi} L^{1-\Pi} = F(K, L)$$

where:

$$\Pi = \frac{F_K K}{F(K, L)} \quad \text{and} \quad (1 - \Pi) = \frac{F_L L}{F(K, L)}$$

are the corresponding participation ratios of capital and labour respectively, given that $F_K = \partial F / \partial K$ and $F_L = \partial F / \partial L$ are the corresponding marginal productivities.

This production function can be represented as in Figure 1a. In this figure, a map of isoquants is depicted together with a ray from the origin. Since I am assuming constant returns to scale, the ray from the origin is the loci of points (one in each isoquant) with identical marginal rates of substitution (MRS) between capital and labour. This MRS is given by:

$$\frac{dK}{dL} = - \frac{\partial F / \partial L}{\partial F / \partial K} = \frac{F_L}{F_K}$$

and it gives the social valuation of capital in terms of labour. Note that along any isoquants the MRS diminishes southwest.

Constant returns to scale enable us to rewrite everything in per capita form:

$$q = \frac{Q}{L} = f(k)^{k^{\Pi}}; \quad f' > 0, \quad f'' < 0, \quad \text{where } k = K/L$$

$$F_K = f'(k) = \Pi k^{\Pi-1}$$

$$F_L = f(k) - kf'(k) = (1 - \Pi) k^\Pi$$

$$MRS = \frac{f(k) - kf'(k)}{f'(k)} = \frac{(1 - \Pi) k^\Pi}{\Pi k^{\Pi-1}}$$

and all these notions can be represented in figure 2a.

I can now return to the demand side of the model, specifying the consumption function. Let consumption C be given by:

$$C = Q - sQ = (1-s) Q$$

Where S can be a function of other variables and not necessarily a constant. In per capita terms we can define $c = C/L$ and write:

$$c = (1-s) f(k) = (1-s) k^\Pi$$

in the case of the Cobb-Douglas.

I can now introduce a public sector as the agent able to modify the savings rate. Let a be the % of capital owned by the State and let t stand for the tax rate imposed on any income. Look first at capital income. This income is given by $Y_k = (1-a) F_k K$ since private capital owns only $(1 - a)\%$ of this capital income. And since it is taxed, disposable capital income is given by

$$Y_{kd} = (1-t)(1-a) F_k k, \quad 0 < t < 1, \quad 0 < a < 1$$

Similarly, disposable labour income is given by

$$Y_{bd} = (1-t) [F(K, L) - F_k K]$$

where the expression between brackets corresponds to labour income, Y_L .

On the other hand, the public sector has revenues corresponding to taxation and income from property and expenses in the amounts required to maintain their share of capital.

$$D = R - E = a F_k K + t(Y_k + Y_L) - aK$$

Given these notions, I can now turn to saving. Private and public saving is given respectively by

$$S_{pr} = s(Y_{kd} + Y_{Ld})$$

$$S_{pu} = a k$$

We can now write that private saving is a proportion S of $F(K, L)$ given by

$$\begin{aligned} S &= s[(1-t)(1-a)F_k K + (1-t)[F(K, L) - F_k K]] \\ &= s[(1-t)(1-a)F + (1-t)(1-a)F] = s(1-t)(1-a)F \end{aligned}$$

And since total saving is given by $\dot{K}$, we can write

$$\dot{K} = S F(K, L) + a \dot{K}$$

and substituting the previous expression here, we find that total saving is given by

$$\dot{K} = \frac{S F(K, L)}{(1-a)} = \frac{s(1+a)(1-a)F}{(1-a)} = S'(a, t) F(K, L)$$

and it can be immediately verified that

$$S_1 > 0 \quad \text{and} \quad S_2 < 0$$

We can now finally turn to dynamics and equilibrium.

The dynamics are immediate. Denote by $\dot{x}$ the rate of growth of any variable

($\dot{x} = \dot{x}/x$, where $\dot{x} = dx/dt$) and assume for simplicity that $\dot{L} = n$. Then,

$$\dot{K} = \frac{S(a, t) F(K, L)}{K} - n$$

Therefore,

$$\dot{K} = S(a, t) f(k) - nk = S'(a, t) k^\alpha - nk$$

in the case of the Cobb Douglas. Quite intuitively, we say that a given k is an equilibrium if $\dot{K} = 0$ for this k . It is obvious that the k of equilibrium is a function of (a, t) .

In figure 2b, the saving function and the equilibrium k have been introduced. The following proposition is easy to prove and intuitively understood just by looking at figure 2b.

THEOREM 1: For $S_0^1 = s(a_0, t_0)$, the equilibrium k , such that $k^0 = S_0 K_0^\alpha - nk_0$ (i) always exists, (ii) it is unique and (iii) globally stable.

Proof: see...

All this has been well known for the last 50 years and I only need to make a couple of remarks for later purposes. The first is related to the notion of equilibrium. It is a long-run equilibrium and I have avoided referring to the short-run equilibrium with which at any time the factor ratio (W/r) equals the MRS so that both markets are in equilibrium. The second remark is that figure 2b is, together with the D/S scheme or the IS/LM diagram, one of the best icons of Economics. I will be turning to the general subject of scientific iconography in a moment.

Before moving on to the analysis of science, it is convenient to introduce two additional topics which will facilitate the exposition later on: the golden rule of accumulation and the period of adjustment.

Let us briefly characterise the optimal equilibrium path. What we want to discover is what savings ratio $S^o(a^o, t^o)$ will generate a k of long run equilibrium k^0 at which per capita consumption is maximised. Per capita consumption C_1 is given by $(1-S) f(k) = (1-s) k^\Pi$. In the long run equilibrium defined by $\dot{k} = 0$ we have that $S^1 f(k) = s k^\Pi = nk$, i.e.

$$S = \frac{nk}{k^\Pi}$$

Therefore, in the long-run equilibrium, we can write per capita consumption as a function of S :

$$C(G) = \left[1 - \frac{nk}{k^\Pi} \right] k^\Pi = k^\Pi - nk$$

In order to maximise C , we have to implement a savings ratio, s , which corresponds to a k such that

$$f'(k) = \Pi k^{\Pi-1} = n$$

Given the condition of optimality, we find the optimal savings ratio

$$S = \frac{nk}{k^\Pi} = \frac{\Pi k^{\Pi-1} k}{k^\Pi} = \frac{\Pi k^\Pi}{k^\Pi} = \Pi$$

the so-called golden rule of accumulation. We denote it by S^0 and note that it corresponds to the capital participation ratio, Π . The corresponding long-run equilibrium k is denoted by k^0 and shown in figure 2c.

Let us finally introduce a much less known topic, that of the period of adjustment which tells us something about dynamics between equilibria. As a simple mathematical implication of the Solow model, one may ask about the period of adjustment. This concerns how long it would take to go from an initial equilibrium k_0 (related to an initial S_0) to a final equilibrium capital/labour ratio corresponding to a higher, say, savings rate. To be precise, let us assume that the economic system moves from its initial position k_0 to a final equilibrium position denoted by k^0 due to a change from $S_0 < \Pi$ to $S^0 = \Pi$ implemented formally by a change in a or t (note that both variables are independent or can be understood as such). Given the nature of the differential equation $\dot{k} = f(k) - nk$ it will take an infinite number of periods to obtain exactly k^0 . What we then ask is how long it takes to attain a particular k_α arbitrarily close to k^0 . Under the usual interpretation what we have in mind is the following. When moving from S_0 to S^0 , $S^0 > S_0$, consumption diminishes initially but after a certain period of time during which output has increased, consumption regains its initial value and from then on it becomes larger than it initially was. Whether the move from k_0 to k^0 is worth then depends (putting aside the rate of future discount taken as given

consumption) on the time it takes to attain k_α , where α is called the relevant adjustment, the one which enables us to attain initial consumption. It is given by $S^0 f(k) = n$ or, in the case of the Cobb-Douglas production function, by $S^0 \Pi k^{\Pi-1} = n$ as reproduced in figure 1.

Denote now by t_α^a the relevant period of adjustment required to reach, we can establish the following proportion:

THEOREM 2:

Let $s(a_0, t_0) = S_0$ be the initial savings ratio. Let $s(a^0, t^0) = S^0$ be the final savings ratio. Let $\bar{t}_a^k$ be the relevant period of adjustment. Then:

$$1.a. \quad \frac{\partial t_a}{\partial a_0} > 0 \quad \text{and} \quad \frac{\partial t_a}{\partial t_0} < 0 \quad \text{for } k_0 < \underline{k}$$

$$1.b \quad \frac{\partial t_a}{\partial a_0} < 0 \quad \text{and} \quad \frac{\partial t_a}{\partial t_0} > 0 \quad \text{for } d_0 > \underline{k}$$

Proof: see....

Let us consider the usual case of underdeveloped countries. In these countries, k_0 is very small and below $\underline{k}$. We can then say that the relevant period of adjustment is larger for these underdeveloped countries which have initially a greater use of the public sector and/or a lower tax rate. Note that Theorem 1 is just a mathematical implication of the model and therefore cannot be directly related to any conventional knowledge about the influence of the public sector on development, but it could easily be empirically tested. However, we will make use of it to discuss matters related to the production of science and the scientific knowledge process which will be raised by different interpretations of the Solow model.

3.- Some simple analytics of the production of science

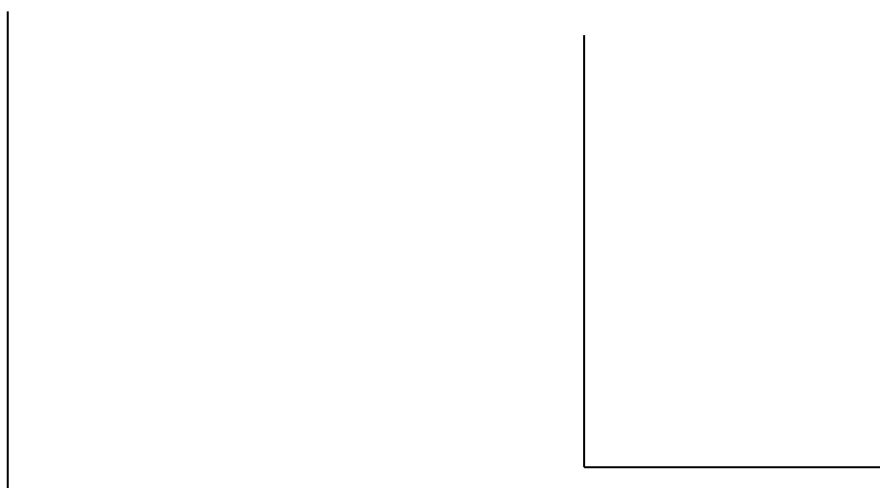
A simple application of the Solow model can help to say something related to certain issues in $E(SK)$, $E(S(SK))$ and $S(E(SK))$. Take L as the number of scientists, K as the scientific resources they can use in their work and $F(K, L)$ as scientific products. Some of these products are consumed immediately and others increase the resources available to the scientists. A vaccine, for instance, might be consumed immediately. A new molecule that has been isolated cannot be consumed right away as it goes back to the production of scientific output as a resource available for scientists to produce others.

The first application of this interpretation of the model pertains to what I have called E(S(SK)). SSK has closely studied iconography, or the role played by visual representation in science. The production of scientific output according to the Solow model offers an extremely good opportunity to look at this matter in the field of and with the aid of Economics. Go back to figure 1a in which a map of isoquants was depicted together with a ray from the origin which represented a particular k and united points of identical MRS. In the next figure, I offer two panels. On the left-hand side the Solow trajectory starting at k_0 has been represented as originally in his paper, namely as convex towards the ray (which has been taken to correspond to k^0 brought about by the golden rule of accumulation). Solow justifies this particular shape by the fact that the convergence from any k towards k^0 is monotone, something that is implicit in Theorem 1. However, it is not difficult to show that the true trajectory is like the one shown on the right-hand panel, which is also consistent with monotonicity of convergence from any k towards k^0 .

THEOREM 3:

The Solow trajectory is concave to the k^0 ray.

Proof: see Urrutia ().



This theorem elicits some comments related to the visual representation of scientific results. Firstly, note that just by looking at figure 2d, we already know that the trajectory in figure 1 has to be connected to the increasing nature of the MRS of resources for scientists, a feature of the model which seems to fit the reality of a world in which scientists are increasingly scarce and valuable. But this feature is common to both the trajectories shown in the two panels of figure 1b, the false (idol) and the true (image). The perils of visual representation are now obvious in at least two directions.

In the first, we observe a kind of proliferation which is not present in panel a. Look at L , the number of scientists. Also, the true trajectory is the difference between the number of existing scientists and the optional one seems to decline. But the opposite is true. The same applies to scientific resources. I call this proliferation and the true image does not disguise this. The number of scientists that each year have to be endowed in the system in order to obtain a “better” equilibrium in the production of science increases by 1. So does the amount of resources applied to science. The second direction in which visual representation is dangerous in this particular case is the velocity of adjustment. In this respect, the true Solow trajectory is deceitful because it gives the wrong impression that the adjustment is quick. However, the period of adjustment, as we have already seen in the previous section, is not an easy issue and can certainly not be ascertained graphically. In this sense, the impression given by the true trajectory is also deceitful. This example is sufficient for it not to be as iconophilic as Latour claims we should be.

Let us now turn to $S(E(SK))$. Here, I have three comments to make. The first is related to the optic of Latour/Woolgar does not object directly to the constructive nature of science, but mainly to their conception of the product of science as if it were in the economic system. He describes the model that an economist will accept and in so doing he leans unconsciously towards microeconomics and game theory. Here I have presented a completely orthodox economic model which (i) is not microeconomics and not that different from the one used by Latour and Woolgar. From my model it does not follow, however, that scientific results are cooked up in order to obtain more revenue through a better reputation. The increase in revenue comes structurally, so to speak. The second comment is related to the debate between Woolgar and Latour on the role played by human agents in the research strategy of science. The word structure above has been

chosen to underline that the analysis does not need to introduce human beings. Economics is not a humanism. I have, in fact, hardly mentioned the markets for scientists and scientific issues and definitely not the rationality of scientists.

I turn finally to $E(SK)$ and more specifically to matters of scientific policy and to the discussion about the public/private nature of scientific effort. Given the way in which I have presented the Solow model in the previous section, it is easy to suspect, and it was in fact implied, that the public sector can implement the golden rule of accumulation. I can actually prove it now. We call optimal intervention to any pair (a^0, t^0) which, given s and Π , produces $S = S^0 = \Pi$. Given the definition of S , we obtain this locus as given by

$$a^0 = \frac{s(1-t^0) - \Pi}{S(1-t^0)\Pi - \Pi}$$

Given Π and s , the optimal size of the public sector is $a^0 < 1$, satisfying the above condition for $0 < t^0 < 1$, which can always be obtained provided $S \leq \Pi$, as seems to be the general case. Now, the public sector deficit can be written as follows:

$$D = t F(k, L) + (1-t) a F_k K - \frac{a}{1-a} s (1-t)(1-a\Pi) F(K, L)$$

and it is obvious that for $t = 1$, there is superavit. By continuing it can easily be shown that there is always a certain t that generates a superavit together with the corresponding

a. As an example, $0 < t = \frac{as(1-a\Pi)}{as(1-a\Pi) + (1-a)} < 1$ generates a superavit of $(1-t) a F_k K$.

I can conclude that an optimal scientific policy can be implemented by the public sector. However, if we ask whether this optimal policy should be implemented the answer is not obvious. The first difficulty involved whether the private sector would possibly behave better. This difficulty has no direct answer in the present framework. What can be said in this framework is only whether it pays to reduce the public sector, reducing a and/or t , in terms of the period of adjustment. If we look at Theorem 2 in the previous section and we interpret its constant, we would claim something like the following for advanced countries in scientific terms. Those countries should diminish

the size of the scientific public sector and increase the tax rate, t . First the country should be advanced in scientific terms.

4.- Some further remarks concerning $S(S(SK))$

What I want to do now is to use the Solow model conveniently translated as an instrument to really understand what is the picture of the scientific process as depicted by SSK and especially by Latour. This author has recently written a very interesting piece trying to refuel what he calls critique through a rhetoric pretension of a false mid-age crisis. So he begins by pretending that the deconstruction of scientific beliefs through the detailed construction of the bargaining process through which this scientific belief is accommodated, might have gone too far when faced with wars of all kinds, from scientific wars to the Iraq war, or with failures like the Challenger or Columbus one. As expected, this crisis ends as a recommendation to broaden the scope of empiricism to cover all these “states of affairs”, covering not only “matters of fact” but also “matters of concern”, or using a different terminology, not only objects but also things.

So, in this section I will try to simply translate the Solow model to accommodate both the increase in scope of empiricism and to understand economically what SSK appears to understand as the process of science. I will then present a possible way of making sure of the real “mid-age crisis” which might underline the one used rhetorically. This section is therefore an exercise in $E(S(SK))$.

Before I proceed to an ad hoc translation of the Solow model, let me turn poetic for a moment. Roquentin felt anguish and nausea when contemplating a simple root completely detached from any natural project. This root is an object in itself, which cannot be used except to bump into it and the significance or meaning of which we cannot reach from the void. The only experience I have has close to such nausea turns out to be the contemplation of the object that falls to the floor when I cut my toenails, completely deformed by psoriasis. I feel this object is absurd, but only until I discover that my psoriatically fattened toenails show how they, like a dolomite rock, can be divided into finer layers of corneous matter. Then what stood as a disgusting object turns into the intelligible implementation of an uncoordinated body process full of

meaning and a clear source of understanding about my own being. Immersed in this mesmerising thought, I discover (in spite of Latour, I must admit), the distinction made by Heidegger between objects and things. According to Latour, Heidegger understands that an object, a jar for instance, is something that be unconsciously come up against. A thing, however, like a car for instance, is closer to a coordinated dominion of several judges closing a cause (chose, cosa) or a cooperative solution of a political assembly (thing). As I have just said, my psoriatic toenails are more things than objects. But this personal and existential experience becomes an interesting research enigma if, following Latour, we associate Heidegger's objects (and the root) to matters of fact (or simply facts: incontrovertible proven facts) and Heidegger's things, like mugs (or my psoriatic toenails) to matters of concern (or ways of caring about certain things or enigmas or problems. Whoever elaborates a theory is someone who cares about ideas and helps to transform them into facts. These facts, as time goes by, detach themselves from their origin and become the unproblematic objects we come up against or which are used as weapons in intellectual wars. This fact or this object might mean to recover its "awe" and remember that it was once subject to the caring effort of many people. In sum, science and thinking in general is a return ticket to travel between objects and things, between facts and th.....?, between matters of fact and matters of concern. Is this travel everlasting? Can we think about it? Can we say something about it? These are the questions I next want to explore.

This digression leads me to the ad hoc translation I want to make of the Solow model. What I have said in my digression can be presented in a better way. Let G stand for a function transforming objects into things. Let M represent the transformation of things into matters of concern and E transform these matters of concern into matters of fact which are nothing but objects. However, part of these objects can be transformed through E^{-1} into matters of concern or enigmas. Consider the following artistic example. The function G transforms a heavy sound into music, g (sounds). This new music can be for instance required. Then M "transforms" this new instrument into a new form of concerto: e (instrument 1). Part of this new form of concertos might be transformed into a new required? instrument. Now, three functions can be composed into a single function F , going from sounds to concertos and another function S going from concertos to instruments and new sounds. Then the translation of this process of science which SSK wants to explore (bracketing out the subject and the world) can be represented by the previously presented Solow model. Let L stand for enigmas or

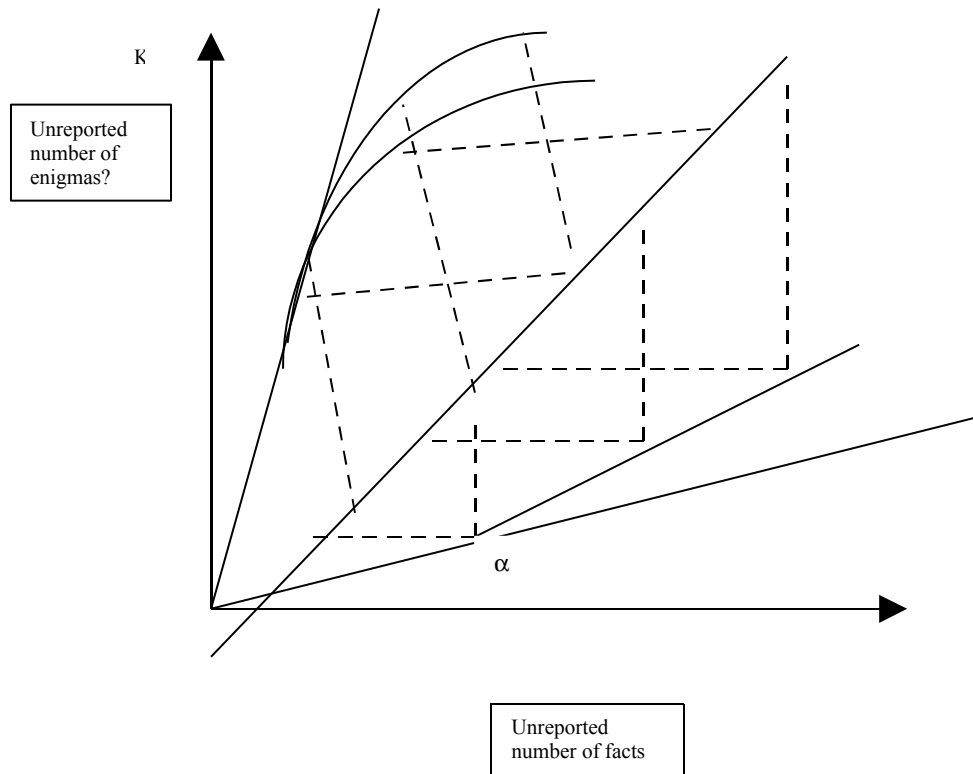
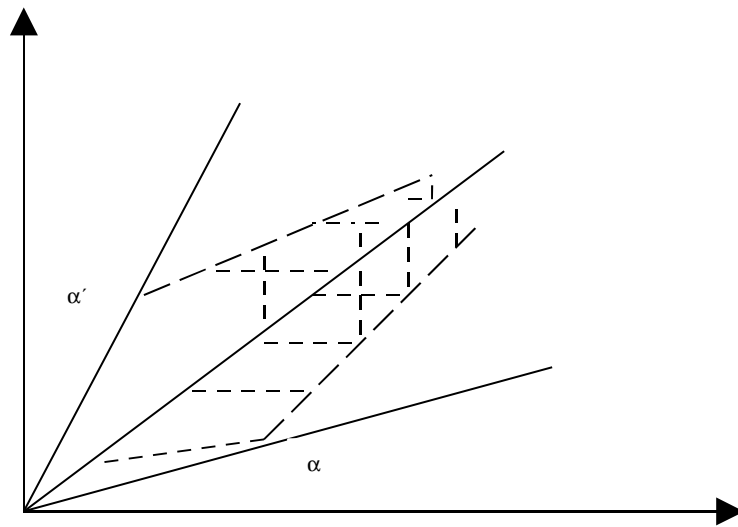
puzzles which flow at a constant rate of n . Let K stand for the problems (which can be taken to be transformed into solutions on a one by one basis) and let $F(K, L)$ be the problems produced by the enigma and the solutions already obtained. Let $S(a, t)$ stand for the ratio of solutions which are not consumed at a given time and feed back to the production of more solutions. In this interpretation, I might represent the number of problems or solutions that are necessarily not consumed if we want to maintain a constant stock of problems usable for the functioning of the (scientific) process. In a way, the saving function and $(1, t)$ are the mediators between the (bracketed away) subject and world. I will assume that there are only attainable (a, t) pairs, something that cannot be proved in the context of this translation. And given this assumption, I will take $S(a^0, t^0)$ as the golden rule of accumulation of solved problems that can be used to obtain knowledge, or more facts.

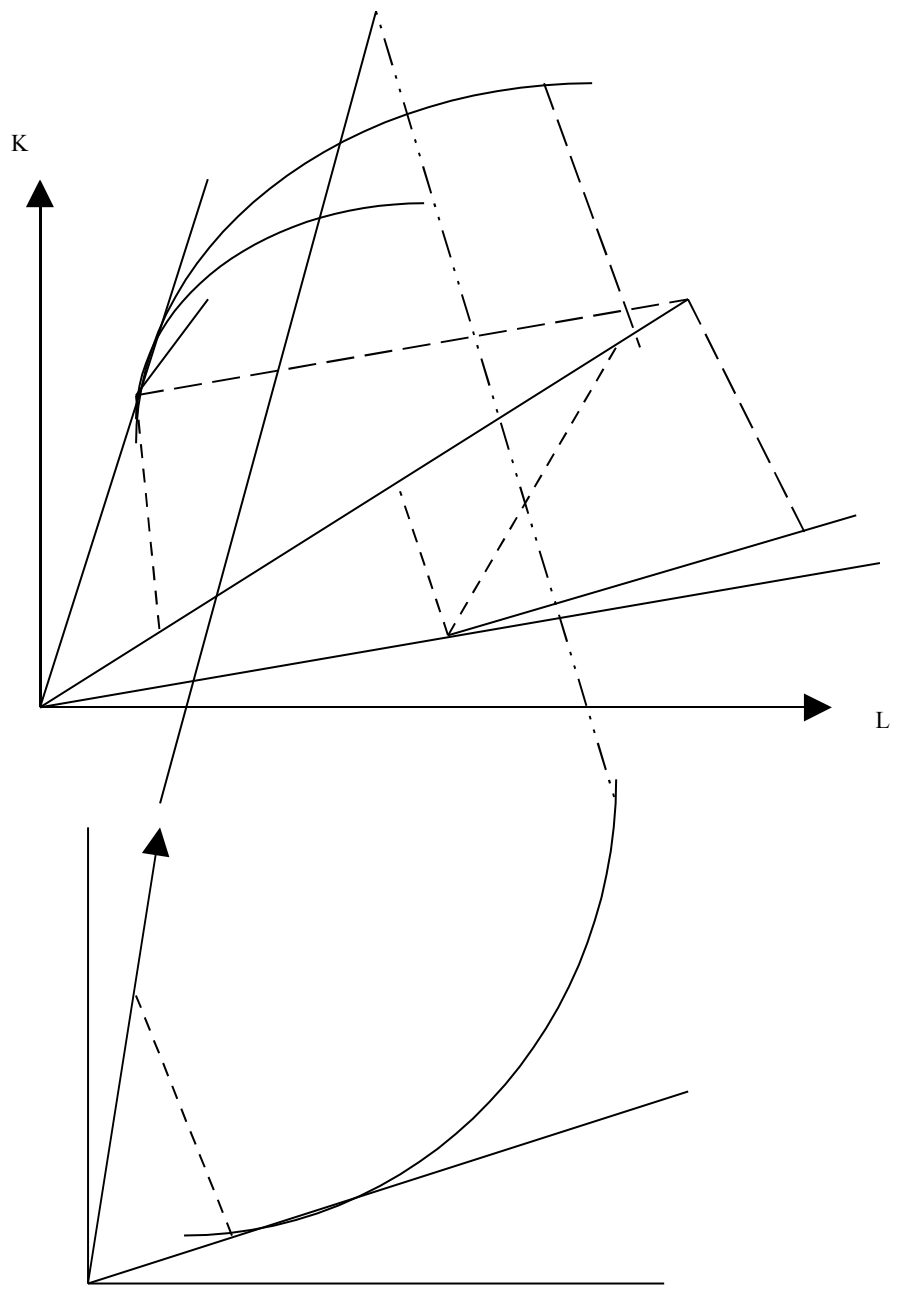
Let us look at this interpretation carefully. $F(K, L)$ is the number of things or problems (= solutions) that have emerged from L enigmas and K problems which have been reintroduced into the scientific process. Of $F(K, L)$, a certain percentage amounting to C is consumed. Consumption here is the number of the things produced which become objects, as many objects or facts and not useful for further advancing the scientific process. They are like branches of the evolution of the system which cannot be expected to grow new shoots. S , on the other hand, is the number of things produced which continue to be research potential and are refuelled into the scientific process. How the split between C and S occurs depends on a and t . This latter tax detracts? from $F(K, L)$ and goes immediately back to the process, a kind of forced saving of matters of fact which are then spared from becoming just absurd objects. The remaining $(1-t) F(K, L)$ can be consumed or fed back into the process. We can understand a as the % of things which are public in the Latour sense. Those public things are brought to the attention of the public and help to determine, in part, the amount of things, problems (= solutions) which, as matters of concern, contribute to the production of new scientific problems. The other part determining these new scientific problems may not be public in this sense but still useful in work with new enigmas.

This interpretation is compatible with other distinctions, more epistemic this time. C can be understood as the amount of truths in the correspondence sense that are added in each period to the stock of truths in this sense. On the other hand, if one

wishes, S can be understood as the amount of truths in the coherence sense produced in each period.

I am now in a position to use the Solow model as interpreted to understand the broadening of empiricism intended by Latour as a leading figure in SSK and then to ascertain the epistemic content of this way of looking at the process of science. Remember THEOREM 3 and read it now according to this interpretation. Look at figure 1b, which is identical to figure 1c but where L stands now for enigma and k for things or problems. The scientific problem starting from a certain initial point moves along the “true” trajectory. In this trajectory, the ratio of solutions to enigmas increases all the time making enigmas relatively more and more sure as we said about initially in the previous interpretation. But this cannot be taken as good epistemic news but rather means that the unsolved enigma increases as time goes by until it reaches steady state. If we look at panel 1, we can think that the distance between K and L along the process and their corresponding ratios in the optimal process are continually decreasing. In other words, both $|k_t - k^0|$ and $|L_t - L^0|$ are continually decreasing: the empirical content diminishes and the number of enigmas also diminishes. However, the opposite is true. If we look at the other panel, the one which tries to be the case according to theorem 3, we find that the number of puzzles increases and that do does the number of problems and solutions. This can be read as a proliferation of thinks and objects which seem to be bad news from an epistemic perspective, but which seriously broaden the scope of different entities floating about in this model. Turning to literature or mythology, what is happening is that simultaneously the mountain that Sisyphus has to climb increases its height and the truth makes it more and more attainable at the summit, percentage-wise. The mountain (empiricism) increases and the truth attainable is greater and greater but smaller and smaller as a % of the total truth attainable.





We can define this strange nature of science as proliferation, a word that conveys certain disquieting effects, certain disorder and disgust. Therefore it seems natural to ask whether any society will ever make the effort to jump from an initial “state of affairs” corresponding to k_0 to the optimal state of affairs k^0 . The answer will depend once again on the rate of discount of the future, or impatience, and on the relevant period of adjustment. Go back to the content of theorem 3 and apply this interpretation. First take a society which is now at an equilibrium k_0 , which is greater than $\underline{k}$, the k that gives the same number of (“non-productive”) facts or truths S^0 eventually. Then making many things or problems as public solutions, reducing the relevant period of adjustment as would do to decrease the number of things which are found to be fuelled back to the problem. Now take a society where $k_0 < \underline{k}$. In this case, the reduction of the relevant period of adjustment occurs when the stock of things made public is small and forced saving increases.

According to this interpretation, no policy recommendation is possible. However, we can try to apply the last result to the understanding of Latour’s rhetoric crisis. At the beginning ($k_0 < \underline{k}$) it might be appropriate, in order to reduce the relevant period of adjustment, to have a small stock of matters of concern. But as k increases and if $k > \underline{k}$, then moving the stock of matters of concern into the process will be appropriate in order to reduce the relevant period of adjustment. Latour claims that critique has not been understood because it has been taken as an attempt to reduce the number of accepted facts when the case was rather that what critique was trying to do was to increase the number of matters of concern in such a way as to increase the state of affairs. What I am surmising is that according to my $E(S(SK))$, we might not take Latour’s words at their face value. After all, Latour is human and according to his all too human explanations, this might not be the right research strategy. As a matter of structure, my result can be more convincing in the sense that what he says is just the result of the passing of time.

Or, alternatively, to see everything as a problem is only a good research strategy in societies where $k > \underline{k}$, what we could call scientifically progressive societies.

Or, alternatively, still his experience ought not to be rhetoric but really sad. He should have wanted to see facts as problems (i.e. to increase a) until the society had

reached a point beyond k . Along these lines, his faked crisis can be understood as the opportunistic broadening of empiricism to matters of concern when it really helps.

5. Final comments

Let us recap and then add some additional comments.

As a paper on $E(SK)$, we have been able to understand the production of science as a dynamic accumulation problem which, modelled according to a simple growth model, has told us (i) that some particular kind of optimal equilibrium path can be implemented by the public sector and that (ii) the public/private nature of the production of science is a problem that can be enriched by the consideration of the period of adjustment in general and the optimal path in particular.

But the paper tries to add something to what I have been calling $S(E(SK))$. The particular modelling of the production of science that has been made tells us that (i) scientific research can be understood as having no relation whatsoever to the humane area and that (ii) there is an alternative to the conventional microeconomic way of representing the production of science.

Finally, the paper has tried to offer some results concerning what we might call $E(S(S, K))$. The first result is related to the perils of using visual representations of science. By way of an economic example, I have shown that this visual representation can be very misleading. The second result is a possible interpretation of the broadening of empiricism that Latour claims to be intending when rhetorically referring to the possible crisis of critique.

The final comment that I am obliged to add is of a different nature. They recognise that this “macroeconomic” way of looking at science in an evolving social system has not been able to say anything of interest concerning the constructivism and relativism of science. Is it then completely devoid of epistemic value? Not totally. On the one hand, it implies that iconophilia does not add to the epistemic value whatever its importance as “condensed ?” between the world and the mind. On the other hand, it should be clear that not all epistemic misconceptions can involve

errors. For instance, the false Solow trajectory of adjustment would have never inoculated any error in the calculations of the period of adjustment. I take this fact to be a form of relativism.

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