The Journal of Interdisciplinary Economics, 1988, Vol. 2, pp. 307–320
0260-1079/88 $10

The Methodology of Cartesian Economics: Some Thoughts on the Nature of Economic Theorising

R.J. Anderson

Department of Sociology
Manchester Polytechnic

J.A. Hughes

Department of Sociology,
*University of Lancaster**

W.W. Sharrock

Department of Sociology,
University of Manchester

Abstract
The arguments advanced in this paper raise some questions to do with the character of conventional economic theorising, its metaphysical underpinnings and its relationship to 'real world' activities. At the heart of what is termed Cartesian Economics is a conception of science which stresses the criterial status of mathematics in the formulation of scientific theories. This is embodied in the methodology of 'inductive axiomatics' by which theoretically pure types are connected to 'real world' events through successive relaxation of theoretical axioms. However, it is argued here that the mathematical character of Ecomomics is a metaphysical stipulation not a discovery and raises again the question of Economic's empirical reference.

INTRODUCTION

The ideas offered in this argumentative discussion paper on the methodological character of 'conventional' economic theorising, and the general framework of presuppositions in which it is embedded, have been provoked by a study the authors' are completing on entrepreneurial decision-making.[1] The paper itself will make little or no reference to the empirical aspects of this work but, instead, concentrates on discussing

**Address for Offprints:* Dr J.A. Hughes, Reader in Sociology, Department of Sociology, University of Lancaster, Bailrigg, Lancaster, England.

some ideas on the relationship between economic theorising and 'real world' economic activities: a relationship, we argue, which formulates Economics as a mathematised science. In arguing this we want to raise again, as it has been raised again in a number of other social sciences, particularly Sociology, the question of Economic's empirical grounding.[2]

When measured against the standards and achievements of the 'hard', so-called, natural sciences, the 'soft' social sciences have much to do. This is more or less a sttandard and uncontentious view. The difficulty, and the disputes, arise over the significance of the disparity. Are, for example, the social sciences forever condemned to be less than scientific or is their current status symptomatic of, say, a 'pre-paradigmatic phase' which will be put behind us when we have discovered the way forward? Though there is as yet no satisfactory way of answering questions such as this, at least in the sense that most would agree about the way forward, the argument is often offered that *within* the social sciences some disciplines are exhibiting more progress toward closing the gap on the 'hard' sciences than others. Economics and Psychology, it could be said, in being more formalised than, say, Sociology are thereby further along the road to a fully-fledged scientific status. However, it seems to us that although it is undoubtedly true that Economics (leaving aside Psychology) are certainly more formalised than Sociology, the significance of this is worth looking at again. Not, we hasten to add, for the purposes of interdisciplinary merit tables but because it raises the central methodological question which has to be faced by all the social sciences, and which no amount of formalisation and operationalisation can set aside, namely, the relationship between theorising and 'real world' activities.

In some respects the question we want to raise for discussion will sound odd or, worse, wilfully ignorant. After all, Economics is a well-established empirical, policy oriented discipline. The consequences of its theories have had as much, if not more, impact on our lives as those of Computer Science, Optics, Microbiology, Mechanics and many, many more. However, this is irrelevant to the claim we are making. We are not claiming that Economics is non-empirical nor that its theories have no relationship to the 'real world', but that it is unclear just what this relationship is. The question of Economic's empirical grounding is still an open one.

A moment ago we introduced the vague not to say ambiguous notion of 'real world' and what we are interested in exploring is how far current theoretical practices could claim to be descriptive of what we will term, 'real worldly economics'. However, for the moment we want to leave the idea on one side to see, first of all, what sort of problem it nominates and begin with a summary sketch of two contrasting views on the nature of Economics: the orthodox one and a dissenting one.

From the turn of the century and what is often referred to as 'the marginalist revolution' (of which we will say more later), the 'conventional wisdom' has been that Economics is an *a posteriori* discipline. Its theories are inductively validated by test against real economic events, a procedure which facilitated the formulation and testing of economic predictions. However, and familiarly, such conventional wisdom was by no means universally acclaimed. Indeed, a group of dissidents under the leadership of Ludwig von Mises denied that economic theories were empirically testable and that Economics was an empirical discipline.[3] In their eyes, valid economic theories were *a priori* true and not confirmable or validated against 'how things are'. Empirical data, if it is to be had, is irrelevant to the truth status of economic theories.

Both the exponents of what we have called the 'conventional wisdom' and the dissidents represented by von Mises, argue that Economics is, or might be, a scientific discipline but differ over what they take this to mean. For most scholars it is the natural sciences, particularly Physics,[4] which are the model for Economics to follow. For von Mises, on the other hand, the models to follow are the mathematical sciences and Logic. At its simplest, the upshot of the 'conventional wisdom', on the one hand, is the presumption that economic theories are putative empirical generalisations and, on the other, for the dissidents, the presumption that they are deductive inferences premissed in axiomatic systems. For conventional wisdom' it was the 'economic world' which determined the truth, or otherwise, of economic theory while for von Mises it was the deductive rigour of the reasoning. Crucially, the difference between the two conceptions of economic science is over the role of empirical evidence and its relation to theory. For the conventional view, empirical evidence is all important and the determinant of the truth status of theories, whereas for von Mises empirical evidence is irrelevant. No one would expect a mathematician to collect 'data' on various geometrical forms, such as table tops, box files, pizzas, and cricket balls, to validate mathematical statements about the properties of rectangles, cubes, circles and spheres. Such statements are about 'mathematical objects' not about the ponderous and inelegant objects we find 'in the world'.

However, there are two qualifications we need to add to the overly neat distinction we have established so far. Many Economists who subscribe to the 'conventional wisdom' would argue that Economics is mathematical in character. But, far from subscribing to a von Mise-ian view of Economics, what is being claimed here is that Economics deals with quantifiable phenomena,[5] which is not what von Mises is arguing at all. Moreover, as recent work in the Philosophy of Natural Science strongly suggests, it is far from clear that such a simple dichotomy can now be sustained and that there is no single, unamibiguous relationship between theories in the natural sciences and how things are 'in the real world'. The complex interpenetration of theory, data, experimental methods and measurement systems is now well attested to.[6]

Nevertheless, the crux of the dispute between the two conceptions of Economics is over what it is to be an empirical science and whether Economics can lay claim to that status. The issue is a deep and difficult one, as we know from Sociology, and it is not our intention to even begin to explore let alone resolve it. We raise it because one orientation to it forms to bed-rock of what we have termed the 'conventional wisdom' in Economics; an orientation which constitutes the methodology of what we can think of as Cartesian Economics.[7]

INDUCTIVE AXIOMATICS

The methodology of Cartesian Economics is one which we can call, 'inductive axiomatics'. Under this procedure, a phenomenon is defined *a priori* as a pure type with a number of delimited and definitive characteristics. Once the pure type is defined, reference to activities in the 'economically defined real world' is secured by means of a step-by-step relaxation of the axiomatically defined parameters. To take a familiar, and general, example, the unitary economic actor acting in the market place; that is, a single buyer or seller, or a firm acting as a single unit which is defined as a utility maximising device. In positions of choice, such an actor will always seek to achieve outcomes which maximise utility. Such maximising behaviour is programmed by means of a stipulative psychology consisting of (a) a predisposition to rank preferences in order of utility, and, (b) the possession of perfect knowledge of the market place, along with a set of economic institutions which provide a measurement system which can be applied to all economic transactions, and the perfect liquidity of resources. In such an environment the psychology set out above allows the *homunculus* called the 'economic actor' to act in economically rational ways.[8]

It is important to note, even if fairly obvious, that while we can recognise features of our ordinary economic activities in the things the economic actor does, the constitution of the homunculus is not achieved by gathering together instances of ordinary economic activities, comparing them, and distilling out the essence of economic life. Far from it. Indeed, the opposite strategy is used. The essence of economic life, that is, utility maximisation, is defined *a priori* and it is this which is laid against the activities we ordinarily carry out. This procedure is accomplished by a step-by-step relaxation of the stringency of the axioms. Constraints such as the possession of perfect knowledge, the perfect liquidity of resources and with them the impossibility of there being two prices in one market, or a monopoly of supply and demand, and so on, are set on one side. At the same time, non-economic relevances are introduced. Purely economic calculations are held to be affected by moral, political and social factors and, as far as the economic system is concerned, economic activities become a condensate of economic, moral, political, psychological, cultural factors. It is this additive, building block approach to the description of economic activities which we call 'inductive axiomatics'.

It is this general methodology on which we want to focus. At its heart is a particular conception of theory and theorising. The role of theory is to provide the definitions of the pure type *and* the means by which an increasingly better fit can be obtained between the pure type and the 'phenomena encountered in the real world'. What should be dispensed with, and when, is the business of theory.

To appreciate the full import of this view of Economics for the conception of 'real world economic activity' we have to realise that it furnishes us with a way of seeing economic activities but in its terms. In Euclidian geometry, to take a parallel case for an example, the theorems and demonstrations are sufficient to allow the axiomatic scheme to be

one which we can call,
phenomenon is defined *a*
delimited and definitive
reference to activities in
d by means of a step-by-
parameters. To take a
nomic actor acting in the
r a firm acting as a single
ice. In positions of choice,
itcomes which maximise
rammed by means of a
predisposition to rank
ie possession of perfect
t of economic institutions
ch can be applied to all
y of resources. In such an
lows the *homunculus* called
tional ways.[8]
vious, that while we can
activities in the things the
omunculus is not achieved
iary economic activities,
of economic life. Far from
sence of economic life, that
is this which is laid against
edure is accomplished by a
e axioms. Constraints such
rfect liquidity of resources
two prices in one market,
on, are set on one side. At
are introduced. Purely
y moral, political and social
n is concerned, economic
, moral, political, psycho-
lding block approach to the
call 'inductive axiomatics'.
want to focus. At its heart
ising. The role of theory is
nd the means by which an
een the pure type and the
What should be dispensed

ew of Economics for the
we have to realise that it
ctivities but in its terms. In
r an example, the theorems
he axiomatic scheme to be

extended over all planar objects. In a planar world Euclidian geometry would be complete. And yet, without the geometry we could not see that world as a planar one. It is the geometry which provides us with a way of looking at the world, not vice versa. The same is true of the axioms, theorems and demonstrations used in Economics. In an economically given world, economic theory is complete and without Economics we could not see what economic activities would be like. Thus, the tests, the validations, the demonstrations, the measurement systems which determine the goodness of fit between 'the phenomenon as given in the world' and the 'phenomenon as defined in the theory' are all rooted within the methodology of inductive axiomatics. Just as we cannot step outside a geometry to see what geometrical objects are really like, so we cannot step outside the framework of our economics to see what economic activities are really like.[9]

At this point it is worth stressing once again that this is not a veiled critique of Economics we are offering even though what has just been argued runs against some of the defences of Economics that presuppose the possibility of theory neutral description and the measurement of the correspondence between theory and theory neutral descriptions. But, it should be noted, such defences are arguments made on behalf of Economics and offer justifications which are independent of it. Dismissing this line of defence would still leave Economics intact. But it is also important to see what we are advocating. First, suggesting that the presuppositions of Economics be examined *as* presuppositons and, second, seeing what alternatives might be at hand and whether a 'gestalt switch' from Cartesian Economics to some other form is likely or even possible.

One way in which such an exploration might begin is by taking up the notion of empirical reference and thinking about how it can be achieved. This would force us to ask ourselves what we know about the activities of the 'real world' referents of the pure types? How do specific types of actors behave in actual economic situations and environments? Looking at matters in this way makes apparent the slack between the pure types and any of its empirical instantiations. An actual entrepreneur, for instance, corresponds hardly at all to the lineaments of the economically rational actor of the pure type, even though, in the theory, entrepreneurs are protopically motivated by pure economic considerations. Nor is this disparity merely of an ordinal character. True, the entrepreneur may be able to rank only a few of his preferences and on any specific occasion unable to determine what his 'best' interests are in a transaction, but, equally, the differences are dimensional. Profit may not be treated as a return for risk bearing but as a measure of relative efficiency or relative success. Administrative rationales may override entrepreneurial ones. The upshot of these observations, and their like, could well be the transformation of the logic underpinning entrepreneurial activities in the theoretical accounts or a transformation of an entrepreneur.[10]

CARTESIAN ECONOMICS

It is at this point that we can turn back to the logical character of economic theorising and the general framework of presuppositions in which it is embedded. Earlier we said that most economists regard economic theorising as mathematical in character even if they differ over whether the guarantee of the truth of the mathematically formulated propositions is their fit with how things are as opposed to their deduction from *a priori* true axioms. Mathematical tools and models pervade the discipline and if we leave aside the arguments of von Mises, then what we are left with is the identification of mathematization with scientificity. The business of a science is to describe the laws operating within the realm under investigation and such laws will be of a mathematical character. As we shall see below, these two claims are crucial but for the moment let us see how this is achieved within what we have called Cartesian Economics.

In 1871, Jevons published *The Theory of Politcal Economy* in which he claimed to show how what had previously been regarded as a descriptive discipline might be made amenable to mathematical analysis. At the time Jevons was one of a number of economists working on the theory of marginal utility which, as the marginalist revolution, was to cast the mould for economic theorising. More precisely, it borrowed a mould from the natural sciences and used it to set the form of subsequent economic theorising. In essence the procedure was simple, though major in its consequences, and consisted in the use of graphical representation and the application of analytical geometry to the graphs so derived. Because it was Descartes who first demonstrated how graphical forms could be expressed as a system of equations, we have termed this style of thinking *Cartesian Economics*.

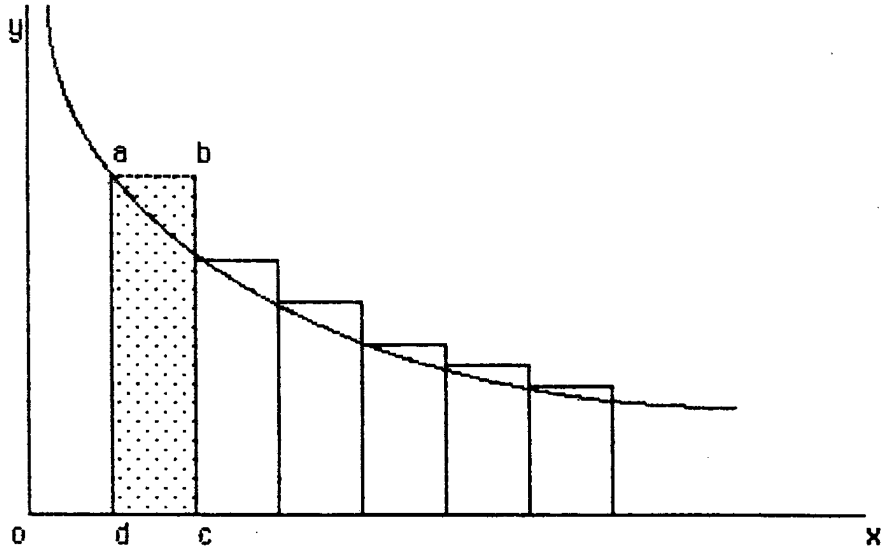
Imagine, says Jevons, the store of food a person eats in a day.[11] If the food is divided into 10 equal portions and we reduce the whole by 1 portion, then the discomfort an individual feels will be minimal. Remove a second portion, however, and the discomfort increases. Remove a third and a fourth and the discomfort increases even further but the *marginal increase* in discomfort is not linear. The individual 'needs' the fourth portion more than the third, and the third more than the second is 'needed'. If we represent the distribution of 'needs', or the utility gained, graphically, the point is easily demonstrated. The area of the rectangle a,b,c,d, represents the utility which that portion of food provides for the individual. The total utility for food is, therefore, the sum of the rectangles between o and x.

Once we are thinking in graphical terms then the important move made by Jevons concerns the relative utility of the various portions. Utility may be considered as varying in two dimensions, intensity and quantity. The quantity will be scaled along the OX axis and the intensity along OY. So, the graph in figure 1 is now an indirect representation of utility. The second important move concerns the portioning of the food. The earlier division into 10 was arbitrary and could just as well have been 100, or 1000. But, as we increase the number of rectangles so the utility

k to the logical character
ıl framework of presup-
rlier we said that most
mathematical in character
rantee of the truth of the
ıeir fit with how things are
true axioms. Mathematical
ınd if we leave aside the
ɛft with is the identification
business of a science is to
m under investigation and
ter. As we shall see below,
ment let us see how this is
ıian Economics.
'olitcal Economy in which he
en regarded as a descriptive
natical analysis. At the time
working on the theory of
·evolution, was to cast the
ısely, it borrowed a mould
ɛt the form of subsequent
e was simple, though major
of graphical representation
to the graphs so derived.
:rated how graphical forms
we have termed this style of

erson eats in a day.[11] If the
we reduce the whole by 1
ɛls will be minimal. Remove
:t increases. Remove a third
en further but the *marginal*
lividual 'needs' the fourth
l more than the second is
ıeeds', or the utility gained,
. The area of the rectangle
ion of food provides for the
herefore, the sum of the

then the important move
y of the various portions.
ı dimensions, intensity and
e OX axis and the intensity
ı indirect representation of
the portioning of the food.
could just as well have been
· of rectangles so the utility



GRAPH 1 The Marginal Decrease in Utility with Increased Portions of Food

they represent can be more and more easily conceived as being represented by a continuous curve. At the limit of an infinity of subdivisions, the utility represented by the food will be expressed by the area under the curve in graph 1.

Once we have begun to think of the variation of utility as curvilinear, then it is but a small step to using the reasoning involved in the differential calculus.

> "...if we increase x by the small quantity [dc], or x, the utility is increased by the small rectangle [abcd], or u; and since a rectangle is the product of its sides, we find that the length of the line [ad], the degree of utility is represented by the fraction $\Delta u / \Delta x$.[12]

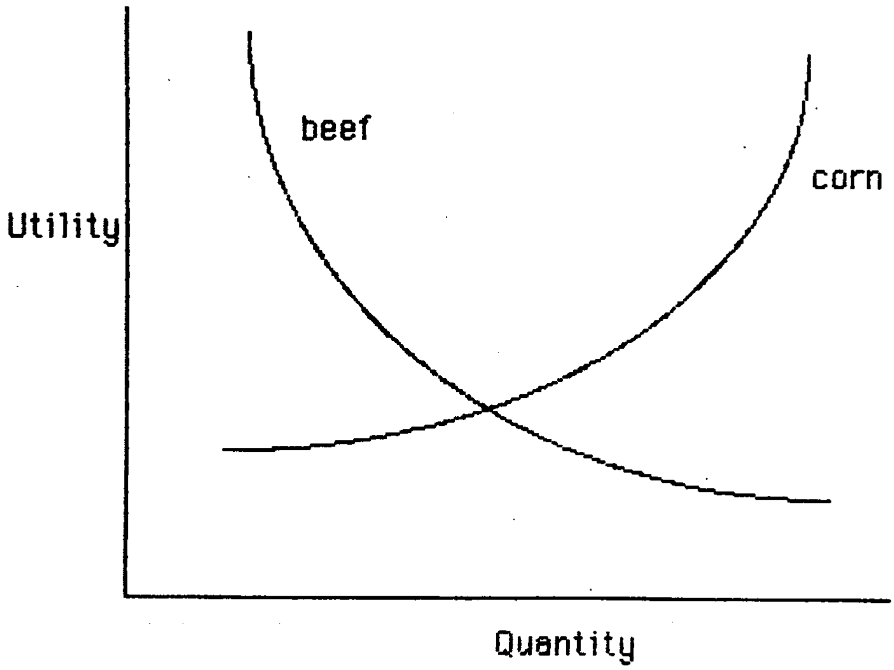
At the limit of infinity, that is where the size of the rectangles are infinitely small or where there are infinitely many increments of food, the instantaneous rate of change of utility for x is expressed as the derivative du/dx which, obviously, is a function of x. By this means Jevons achieved the possibility of summarising the representations of economic factors as non-linear functions in systems of differential equations. All that was required was to develop the appropriate measurement systems for the utility of capital, labour and land. As Jevons concluded,

> "From these axioms we can deduce the laws of supply and demand, the laws of that difficult conception, value, and all the intricate results of commerce, so far as data are available. The

final agreement of our inferences with *a posteriori* observations ratifies our method".[13]

For the purposes of our argument we can ignore the difficulties in the way of ratification. Jevons himself was aware of most of them. Our concern is with the general strategy. Following Bentham's utilitarian psychology, Jevons supposed that the primal drive of human beings is to achieve happiness and avoid pain. Achieving happiness is equivalent to maximising utility. But utility cannot be scaled uniformly nor measured directly and without a scaling and a measurement system, the mathematisation of economics would be impossible. The marginalist revolution's achievement was in the representation of utility as a graphically depictable continuous variable, and in the development of scaling and measurement systems. And with mathematisation would come the possibility of an Economic Science. But to achieve that Jevons had to develop a means by which utility could be continuously transformed into a directly observable and measurable variable to allow for the manipulation of symbolic representations without recourse to clumsy graphical forms. This needed breakthrough was provided by the theory of exchange.

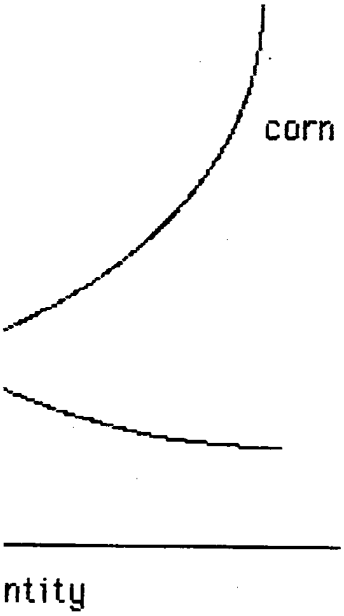
As before, Jevons begins with the simplest imaginable case. The market consists of two individuals wishing to exchange two goods, beef and corn. Following the analogy of the utility function for food depicted earlier, the functions for the two commodities can be sketched thus:



GRAPH 2 Two utility functions mapped on one graph

ignore the difficulties in the
vare of most of them. Our
ɔwing Bentham's utilitarian
l drive of human beings is to
g happiness is equivalent to
led uniformly nor measured
measurement system, the
mpossible. The marginalist
resentation of utility as a
and in the development of
ith mathematisation would
. But to achieve that Jevons
ity could be continuously
neasurable variable to allow
:ations without recourse to
hrough was provided by the

plest imaginable case. The
o exchange two goods, beef
y function for food depicted
ies can be sketched thus:



If the market consists only of beef and corn, using the logic of the theory of utility, the exchange will continue until the marginal utility of one good is equal to that of the other. At this point, total utility will have been maximised; a situation represented by the device of reversing the utility function for one good and superimposing it upon the other. The next step is to express the graphical relationships in symbolic terms. Jevons proceeds by making the following definitions:

x = the quantity of beef exchanged
y = the quantity of corn exchanged
Δx = the marginal unit of beef
Δy = the marginal unit of corn

In the discussion of the theory of utility, we saw that Jevons argued that $\Delta y / \Delta x = y/x$ for commodities which were homogeneous, in that the ratio of exchange (x/y) did not vary. At the limits, as we saw, the derivative $dy/dx = \Delta y / \Delta x$. By simple algebraic manipulation we get

$$\frac{\Delta y}{\Delta x} = \frac{y}{x} \Rightarrow y = \frac{y}{x} \Delta x$$

Jevons introduces exchange by considering the system from the point of view of two individuals, call them Wilf and Jack. If Wilf held a amount of corn and Jack held **b** amount of beef, then after the exchange, the relative positions would be

Wilf would hold $(a-x)$ corn and y beef
Jack would hold x corn and $(b-y)$ beef

For Wilf, utility is maximised at the point where $dy/dx = \partial_1(a-x)\beta_1 y$. But since dy/dx is defined as $\Delta y / \Delta x$ and is identical to y/x then $\partial_1(a-x)/\beta_1 y = y/x$. The same line of reasoning is applied to Jack. His utility is maximised where $dy/dx = \partial_2(x)/\beta_2(b-y)$. Since for Jack, on the reasoning we have just indicated, $dy/dx = \Delta y / \Delta x = y/x = \partial_2 x/\beta_2(b-y)$ then it follows, $\partial 1(a-x)/\beta_1 y = \partial_2 x/\beta_2(b-y)$, which is the general theory of exchange. Complexities are introduced simply by adding more variables, either more goods or more individuals, but in all cases the expressions remain functionally interrelated.

What is required now is a metric by which measurement of utility can be achieved for both simple and complex cases. And, despite all the caveats, despite the problems of variation in the utility of money as a consequence of Giffen goods, Jevons suggests that price is the only measure possible.

> "We cannot really tell the effect of any change in trade or manufacture until we can express the laws of variation of utility numerically. To do this we need accurate statistics of the quantities of commodities purchased by the whole population at various prices. The price of a commodity is the

> only test we have of the utility of a commodity to the purchaser; and if we could (know) exactly how much people reduce their consumption of each important article when price rises, we could determine, at least approximately, the variation of the final degree of utility—the all important element in Economics."[14]

Armed with these measures, Economics looks set on a course to become a fully-fledged mathematically-based science, no different in kind, though different in scope and complexity, to physics, astronomy and the rest. The achievement of the marginalist revolution was the redirection of Economics along this course. To be sure, the mathematics of modern Economics is far more subtle and sophisticated than that used by Jevons, nonetheless, it is still premissed on the two principles we have ennunciated: first, the Cartesian transformations of graphical representations for algebraic ones; and second, the use of the price metric as the measure of utility and the guide for rational choice. The price metric allowed for the measurement of the observable to stand for the non-observable, namely, utility. This procedure of 'indirect measurement' in combination with the first principle is the cornerstone of Cartesian Economics as a mathematised science.

THE GALILEAN REVOLUTION AND MATHEMATISED SCIENCE

Jevons, of course, did not address the question of whether mathematisation was necessary for a discipline to attain scientific status. This was simply taken for granted as a principle, a stipulation rather than a contingent fact of scientific life, that mathematical forms were essential to science. However, as studies of scientific development in the 16th and 17th centuries suggest, this had not always been the case.[15] What took place during this period was a methaphysical shift in the outlook of a small number of intellectuals which has since percolated throughout Western European culture. The shift was originally associated with the 'mathematization of nature' by Galileo and others, and only afterwards extended to the field of the moral sciences. In general terms, the claim is that the mathematisation of nature is a philosophical stipulation and not a scientific discovery. Once the stipulation is in place and its consequences worked out, that the scientific discovery of the quantifiable laws of nature is possible.

The claim can be illustrated through Koyré's discussion of Galileo's contribution to the development of experimental science. Take, for example, the critical concept of motion. For Galileo, a body is indifferent to the state of motion it is in. Motion cannot, of itself, change an object. Further, unless acted upon by some external force, a body in a state of motion will continue in that state, as will a body in a state of rest. Thus, for Galileo, motion and rest were equivalent ontological states. To his contemporaries, this was an extraordinary claim and they rejected it, not because they were unscientific, but because they could not accept the

The Journal of Interdisciplinary Economics, 1988, Vol. 2, pp. 321-334
0260-1079/88 $10

equivalence of rest and motion among other things. For them continuous motion was an impossibility, at least here on earth. It might be possible to speak of the external motion of the cosmos, but the laws of the cosmos did not hold terrestially. As Koyré puts it,

> "No wonder the Aristotelian felt himself astonised and bewildered by this amazing attempt to explain the real by the impossible—or, which is the same thing, to explain real being by mathematical being, because . . . these bodies moving in straight lines in infinite empty space are not real bodies moving in real space, but mathematical bodies moving in mathematical space".[16]

Galileo had said famously, that the "book of nature is written in geometrical characters" and this apothegm summarised the differences in outlook between himself and most of his contemporaries. In Koyré's view, the differences can be represented as two alternate conceptions of the position and importance of mathematics for science.

> "If you claim for mathematics a superior status, if more than that you attribute to it a real value and a commanding position in physics, you are a Platonist. If, on the contrary, you see mathematics an abstract science which is therefore of lesser value than those—physics and metaphysics—which deal with real being; if, in particular, you pretend that physics needs no other basis than perception and must be built directly on perception, that mathematics has to content itself with the secondary and subsidiary role of mere auxiliary, you are an Aristotelian."[17]

For Koyré, Galileo was a Platonist. Whether Galileo would accept this description is neither here nor there, but he was certainly committed to the mathematization of science and, indeed, one could plausibly go as far as Husserl and say that work done under this conception is Galilean Science.[18] Because many of the forces 'discovered' by the new science could not be directly experienced, and hence directly measured, what Gurwitsch calls an "indirect mathematisation" was necessary.[19] Descartes, of course, in his analytic geometry provided the means by which spatiotemporal representations could be cast in mathematical form. The net result of this accomodation of qualitative phenomena within the mathematising format was to extend the scope of Physics. It became the method by which all of Nature (and from there all phenomena) was to be described and explained. To quote Gurwitsch again, the principle was established that

> "Nature as it really is (in contrast to its perceptual appearance is a mathematical structure, perhaps a plurality of such structures, and it matters little whether the structures are comparatively simple, as in the early phases of modern science, or extremely complex and abstract, as in contemporary physics".[20]

Indirect mathematization was achieved in physics through the use of Cartesian analytic geometry. Spatiotemporal geometric representations could be cast into algebraic form, abstracted, formalised and compared and, eventually, integrated into general laws. The same strategy is on view in Jevons' transformation of utility functions into the price metric. Such a transformation is seen as the crucial step on the way to formulating economics as a science.

However, the Galilean proposal about the essentially mathematical character of the laws of nature, and hence of natural phenomena, is not a discovery but a stipulation and, as such, constitutes a metaphysics. Only by losing sight of this feature enables us to feel free to generalise the mathematization of nature to social life. It might well be the case that the institution of modern science is predicated on the application of mathematical procedures to furnish generalised, formal descriptions of its phenomena, but the success it has had in providing such descriptions is not, of itself, a guarantee that the strategy is exportable to other arenas and phenomena. The possibility of mathematization might be a contingent and not a necessary fact about the natural world.[22] If it is a contingent fact of nature that natural phenomena are relatively easily describable in mathematical terms, then we can infer nothing at all from this about social phenomena. What is needed is an argument which shows either that social and natural phenomena are essentially mathematical in form or an argument which secures their direct isomorphism. In the absence of either kind of argument we are left to wonder why it should be supposed that social and economic activities are even adequately rendered in mathematical terms. As we said earlier, the invocation of an assertion that they deal with quantified values is certainly insufficient if only because the induction of quantified variables into economic and social theorising, as opposed to their common or garden use in daily economic and socal life, was a consequence of indirect mathematization not its precondition.

The question to be asked, therefore, is not whether it is possible to represent economic activities in mathematical terms, but what is to be gained by so doing? Do we understand economic activities any better? Or do we find the mathematical character of the descriptions becoming 'disconnected' from their putative empirical base? Are the mathematical discoveries, consequences and implications of more interest and value than what can be said about 'real world economic agents'?

CONCLUSION

The apparent success of Galilean science cannot be taken as indicative of the generalisability of the principles upon which it is based. It is a social fact about our society that the Galilean conception of science, predicated as it is on the indirect mathematization of nature, has come to dominate. It has permeated the modern consciousness, so to speak. And an important aspect of this is the way in which the mathematization principle has been taken over by other disciplines in their search for rigour and scientificity. One such annexation of the principle was the marginalist revolution in economics. Qualitative phenomena, for instance utility, were represented in spatiotemporal terms and subjected to mathematical transformations and indirect measurement. But the increasingly sophisticated character of these mathematical transformations and their degree of predictive precision should not blind us to the metaphysical commitment Cartesian Economics entails. It is a commitment which cannot be validated by appeals to 'the data', just as Galileo's conception of the equivalence of motion and rest could both be validated by appealing to experimental results. What is measurable, what is discoverable, what is an economic phenomenon in the first place, are all defined within Cartesian Economics.

Misgivings about the consequences of considerations such as these have begun to be voiced within the community of professional economists.[22] The issue becomes most sharply focussed in determining what it means to call Economics an empirical discipline. From what we have said in this paper, it would seem that, by itself, mathematization is not sufficient. This might mean one of two things. First, that von Mises was right all along and that Economics is a deductive science with the same relationship to 'real world economic activities' as logic has with the grounds on which we frame and evaluate arguments in daily life. Both are 'pure' sciences not 'descriptive' ones. Or, alternatively, it might be that we would have to rethink the commitment to Cartesian Economics and its metaphysics and, if possible, reconceptualise economic activities outside the conventional framework.

FOOTNOTES

1. The grant was awarded by the ESRC (ref: F00232213), 'A Sociological Investigation of Entrepreneurical Decision-Making'.
2. We do want to stress that what follows is *not* an attack on Economics. The issues we try to raise are generic ones for all the social sciences. Also, we would like to note that our concern in this paper is analytic rather than historical even though we do draw on materials from the history of Economic thought.
3. cf. the contributions to Part 1 of Bruce Caldwell's (1984), *Appraisal and Criticism in Economics*, London, George Allen and Unwin.
4. In a series of provocative papers, Philip Mirowski has argued that the Marginalists simply took over the mathematical approaches of 19th century physical theories of the conservation of energy and applied them to the notion of a production function. They were able to do this simply by virtue of their misunderstanding of the techniques they borrowed. See his 'Physics and the Marginalist Revolution', *Cambridge Journal of Economics* (1984), 8, pp. 361–79, and 'Shall I compare thee to a Minkowski-Ricardo-Leontif-Metzler Matrix of the Mosak-Hicks Type?', *Economics and Philosophy*, (1987), 3, pp. 67–96.
5. This is Jevons suggestion. See his (1967) *Theory of Political Economy*, New York, Sentry Press. Originally published in 1871.
6. An excellent review of these issues is to be found in Ian Hacking (1983), *Representing and Intervening*, London, Cambridge University Press.
7. What we mean by 'Cartesian' here is not quite the same as Mirowski's in his 1987, *op.cit.*. There it is used to designate both a particular conception of formal reasoning and a psychology which has become endemic in Economics. This pairing he refers to as a 'Cartesian Vice'. *ibid.* p. 83.
8. The term 'homonculus' is that used by Schutz (1962) in his classic essay, 'Concept and Theory Formation in the Social Sciences', reprinted in his *Collected Papers*, Vol. 1, 'The

Problem of Social Reality', The Hague, Martinuus Nijhoff.

9. Certainly we can imagine a 'gestalt switch' enabling the development of different sorts of geometries and different sorts of Economics. What we cannot imagine is a description of geometrical objects which is independent of geometry or economic objects independent of Economics.

0. This argument is examined in our working paper, 'Cartesian Economics and the Entrepreneur' and extended in a draft manuscript provisionally entitled, *The Opportunists*.

11. W. Stanley Jevons, *op.cit.* p. 45.

12. *ibid.* p. 50.

13. *ibid.* p. 18.

14. *ibid.* pp. 146-7.

15. See, for example, A Koyré (1986), *Metaphysics and Measurement*, London, Chapman and Hall. Doubt has been cast on Koyré's interpretation of Galileo's notebooks and memorabilia by M.A. Finocchiaro (1980), *Galileo and the Art of Reasoning*, Dordrecht, Reidel.

16. Koyré *ibid.* p. 34.

17. *ibid.* p. 36-7.

18. E Husserl (1970), *The Crisis of European Sciences and Transcendental Phenomenology*, Evanston, North Western University Press.

19. A Gurwitsch, *Phenomenology and Science and the Theory of Science*, (1974), Evanston, Northwestern University Press, ed. Lester Embrace. "Indirect mathematization of qualities requires that they be correlated with occurences which, because they are describable in spatio-temporal terms, are capable of direct mathematization". p. 54. The development of systems of indirect mathematization owe more to Descartes and Huygens than Galileo despite the fact that we tend to speak of the Galilean revolution in science.

20. *ibid.* p. 55.

21. This leaves on one side the difficulty of disentangling mathematical innovations from the use to which these innovations have been put in the natural sciences.

22. See, for example, E. Leamer (1984), 'Let's take the con out of Econometrics', reprinted in Caldwell, *op.cit.* p. 460-72. M. McAleer et al (1975), 'What will take the con out of Econometrics?, *The American Economic Review*, 75, pp. 293-307; C. Sims (1980), 'Macroeconomics and Reality', *Econometrica*, 48, pp. 1-27; E. Leamer and H. Leonard (1983), 'Reporting the fragility of regression estimates', *Review of Economics and Statistics*, 65, pp. 306-17; D. McClosky (1985), *The Rhetoric of Economics*, Madison, The University of Wisconsin Press.

(Received November 1987)