MATHEMATICS UNDERSTANDING OF ECONOMY BY THE GENERAL PUBLIC IN THE ECONOMIC DEPARTMENTS

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Abstract: Some implications for the public understanding of economics are considered here. The paper is completed by considering two case studies of the use of mathematics in economics, both of which focus on the economic effects of education. The first case study considers growth theory, which analyses the effect of education on rates of economic growth, i.e. at the macro level. The second focuses on the micro level, considering the effect of education on individual earnings. These case studies will be used to illustrate the effect of mathematics on the content and public understanding of economics, respectively.

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1. INTRODUCTION

Mathematics is thus increasingly important in terms of the expression and communication of ideas in economics. This in itself is a matter of interest, particularly with respect to the public understanding of economics. Further, to the extent that public understanding of mathematics is limited, so too will be the public understanding of economics. This applies at a variety of levels, from school pupils making subject choices to policy makers' understanding of policy advice.

Economics has been undergoing technical change, employing more mathematics and more sophisticated statistical techniques, which have improved the productivity of the discipline; the change in content is thus one of undoubted improvement. But concerns have been raised that mathematisation has proceeded at the cost of attention to matters which cannot be expressed mathematically, i.e. the alternative modes of communication can actually allow analysis in areas closed to mathematics.

2. OBJECTIVES

The issue is thus the fundamental one of what we understand by the discipline of economics and what it can achieve. This issue too feeds back into the issue of the public understanding of economics *as a discipline.*

But we turn now to consider this issue in a rather different light, namely how mathematisation impacts on the public understanding of economics, considering first policy makers, then students and then the general public..

3. METHODOLOGY

The mathematical basis for much of economic policy advice was most evident in the heyday of the large econometric macro models. The UK government was advised on economic policy by the 'Seven Wise Men', most of whom were associated with one or another macro-econometric model. The predictive power of each model was a matter for public discussion. Monetary policy is now the responsibility of the independent Bank of England's Monetary Policy Committee, the minutes of whose monthly deliberations are published. The Bank staff input on the basis of mathematical models, as discussed in the *Bank of England Quarterly Bulletin,* is clearly significant. Now the Bank has published a volume which explains the nature and use made of mathematical models (Bank of England, 1999) [2].

Perhaps the most significant element of the policy-maker's understanding of economics, as it is affected by the extensive use of mathematics, is the understanding this conveys about the nature of economics and its capacity for generating predictions. For all the *caveats* (*ceteris paribus* effectively means the economic structure remaining as it was during the estimation period, and no exogenous shocks occurring), an impression is given by mathematical models that they are scientific and constitute the economists' best basis for prediction. The use of models in the policy-making context thus serves a rhetorical purpose in accord with the aim of putting economics on a par with the physical sciences (McCloskey, 1986) [6].

The large multi-equation models of the 1980s did not predict well; even though they were not complex in the formal sense of allowing a significant degree of interaction between agents, they were complex in terms of scale. Whitley (1997) explains the rationale behind a greater emphasis in the Bank of England on a range of partial models. Bank policy is now based on an inflation forecast which incorporates predictions on the basis of a range of models. The forecast now takes the form of a fan-chart which effectively ranges the forecasts each within the narrow fan of its own stochastic range, the outcome being a large fan; the width of the fan reflects the level of 'uncertainty' attached to the forecast range; note that this uncertainty is quantified.

An agency like the Bank collects a wide range of intelligence, much of which must remain within the category of 'vague': the sense of the markets, the propensity to innovate, the mood of public sector unions, etc. Yet these matters are of central importance to any inflation forecast. The latest Bank document explains that survey data are fed into the decision-making of the Monetary Policy Committee, alongside formal projections, as a check for the consistency of those projections. Thus, while the 'official rhetoric' form of the inflation forecast suggests quantifiability, the 'unofficial rhetoric' of actual policy-making incorporates unquantifiable elements of judgement, as the subject-matter dictates

4. ANALYSES

It is no wonder that the public have a conflicting impression of economics as, on the one hand, scientific and, on the other hand, indecisive. There is a range of hackneyed jokes to this effect. Because the official rhetoric implies a degree of precision which is unattainable in practice, economics disappoints. Economists feel themselves misunderstood. The *caveats* are there; the economy is too complex a system to reasonably expect accurate forecasts; there are bound to be differences of opinion. Yet the public expects economists to agree on scientific results in the same way as physicists. I would suggest that it is no accident that this increase in public misunderstanding of economics has coincided with the increased mathematisation of the discipline.

It is with reference to the public understanding of economics that Krugman (1998) [4] in fact makes his case for mathematical formalism. He argues that formalising arguments, eg within an accounting framework, yields useful results which do not seem to be intuitively clear to the media. Indeed he argues that economics can *only* progress with the aid of mathematics. But, as a separate issue, he argues that economists should put more emphasis on translating the result of mathematical theories into lay terms in order to communicate more effectively with the public.

In the UK the matter of attitudes among economics students has only been addressed relatively recently. The latest issue of the *Newsletter* of the Royal Economic Society contains an account of a survey of A-level students which indicates that students with mathematical ability are more inclined to choose to take economics at university in preference to Arts subjects, but not Science subjects. But otherwise there has been little study of this area. In the UK, unlike the US, course content and methodology are monitored, but not transparently. Thus, for example, the university monitors postgraduate provision, and has the ability to influence programmes through the allocation of its student awards. At the undergraduate level, the new quality assurance system will effectively be influencing how economics is taught. But so far there has been only limited public debate.

We turn now to consider two related areas of economics for illustration of the arguments developed so far.

These studies have suggested that the state of technology is empirically important (i.e. labour and capital did not fully explain growth rates), putting a focus on technological change, something which had been treated as exogenous to the closed, formal system representing the economy. In other words, the requirements for mathematical tractability had required that something which is difficult to represent deterministically, and indeed to measure, was excluded from the analysis.

More recently, attention has shifted from trying to endogenise technical change in general (i.e. independent of capital and labour inputs) to endogenising the other contributors to productivity, notably labour productivity. This is the post-neoclassical endogenous growth theory to which Gordon Brown has expressed allegiance (see Aghion and Howitt, 1998) [1]. Its policy significance is that, while technological change in the long-run is available to all economies (so that all economies' growth rates would be expected to converge as technological change is globalised), labour productivity is something which is amenable to policy manipulation, allowing different growth rates across economies. Thus the empirical assessment of the relative merits of the two approaches rests on the empirical judgement as to whether international growth rates are converging or not. The fact that there is not a consensus on this judgement illustrates the intrinsic difficulties of empirical testing in economics.

According to the endogenous growth approach, labour productivity may increase because of learning-by-doing (i.e. as a by-product of employment), or it can increase through education outside employment. A series of mathematical models has been developed, which can be grouped around the idea that education provides a one-off increase in labour productivity, raising the rate of economic growth, or the idea that it also increases the capacity to absorb technological change into the production process. The aim is to determine the optimal level of education expenditure in terms of which would yield the highest rates of economic growth.

The models inevitably require a series of assumptions to be made. Thus, for example, the Lucas (1988) [5] model portrays education as an investment decision by the individual on a par with capital investment; time spent in education means time not in employment (just as capital expenditure precludes consumption expenditure). Education yields the same increase in productivity across the board, and at all levels of education. The decision is based on a rate of time preference and a co-efficient of risk aversion, but, since these are unidentifiable in aggregate, empirical application simply focuses on the coefficient of the labour variable in the reduced form equation. Other models have attempted to increase the degree of realism relative to the Lucas model, allowing for example for example for decreasing returns to education, interplay with the coefficient of technological progress and inequality between education levels of workers. Inevitably this has increased the complexity of the mathematical model. But measurement difficulties mean that these finer points cannot be assessed empirically. Aghion and Howitt (1998) [1] point out that:

"*formal theory is ahead of conceptual clarity. . . . The real question is one of meaning, not measurement. Only when theory produces clear conceptual categories will it be possible to measure them accurately.*"

The presumptions then are formalist. Once the meaning of terms is agreed, it is fixed; theory can then be tested against the facts which can be measured as long as the definition is clear. There is no room for analysis outside the formal mathematical model.

Even if meaning were clear, however, measurement issues would not be insubstantial. There is a more general issue of the capacity of econometric techniques to discriminate between theories. The endogenous growth theories are put forward as an alternative to neo-classical theories on the basis of the pure theory model which precedes the econometrics. But since the econometrics consists basically of correlation analysis applied to a reduced form of the theory which involves a similar range of variables to neo-classical theory it is not at all clear what can be distinguished. The *doyen* of the neo-classical approach, Robert Solow (1994) [7] argues that his treatment of technical change as exogenous does not mean that it cannot be analysed (his model is partial rather than general) and that such analysis must take account of the unquantifiable uncertainty associated with the innovation process. He sees the extraction of workable hypotheses from case studies as a more promising avenue than the endogenous-growth theory foundation on the intertemporally-optimising representative agent. The endogenous growth theories are constructed in aggregate terms, referring to the aggregate 'representative' individual (as having a particular degree of risk-aversion, for example). But they draw on micro-foundations based on the axioms of rational (optimising) individual behaviour. We turn now to consider a literature which focuses on this behaviour (without being concerned with its implications for economic growth).

4.1 Critical

The micro-economic basis of endogenous growth theory refers to the individual decision about the degree of education to undertake (see Willis, 1986) [8]. This choice is based on an assessment of earnings foregone during education relative to the increase in earnings which would result from education, i.e. a form of present-value calculation. The benchmark is long-run competitive equilibrium, where supply and demand for workers at each schooling level are equated and no worker wishes to alter her schooling level. For each worker in equilibrium, the present value of education represents a return equal to the alternative return on foregone earnings, the interest rate.

While the theory is developed mathematically in the standard terms of individual optimisation, the empirical literature is explicitly couched in different terms, but carrying forward many of the assumptions of the theoretical literature. Thus, for example, in building up his exposition of the literature, Willis (1986) posits an earnings function, whereby earnings are shown as a function of years of education and years of employment over a lifetime. Rather than deriving from theory, the functional form is arrived at as the best statistical fit. The residual term has mean zero, so that, on average, earnings are fully explained by the education and employment periods. As well as all the assumptions underpinning the use of these two variables, it is assumed that the data sample are taken from a population in long-run equilibrium. Willis explains the elaboration of theory as efforts are made successively to relax these assumptions, and the interplay between theoretical formulation and statistical estimation. This interplay is primarily one of confirmation, since the statistical limitations on dealing with micro-level diversity are significant. The conclusion is that empirical work supports the human capital approach to education choices (the same approach which underpins endogenous growth theory).

But two significant *provisos* need to be specified about what this tells us about human capital theory. One is the specific point about rational choice theory which is that it does not readily adapt to disequilibrium expression; Second, the empirical analysis is essentially based on correlation, and thus tells us nothing about causation.

5. CONCLUSIONS

We have discussed how the use of mathematics has increased significantly in economics, and the issues this has raised. There are issues at the level of communication of ideas, among economists, and between economists and policy-makers, the general. For public and students communication is of great importance. But communication is based on a shared view of the nature and scope of the discipline.

There is therefore a more fundamental issue about whether and in what way mathematisation has changed the nature and scope of economics.

Mathematical tools have allowed many advances in economic theory. But at the same time, the difficulty in combining pure theory with applied economics has allowed the two strands to proceed according to different agendas. Even so, there are elements in common (presumption of equilibrium, fixity of meaning of terms and of the objects of measurement, etc) which provide the basis for mathematical treatment, but which nevertheless are controversial. Much of this issue boils down to the question of how far a study of complex social systems is amenable to the (mathematical) methods of analysis adopted by the physical sciences.

Critical thinking is an active and purposeful thinking process that is required to perform contemporary accounting and auditing tasks. Several task characteristics (e.g., task novelty) were identified as those that require critical thinking. It was also noted that several action- oriented attributes such as meaning imposition are necessary to understand the tasks and to perform them effectively.

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