Ed Mansfield and the Diffusion of Innovation: An Evolutionary Connection

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ABSTRACT. The analysis of the diffusion of innovation was a central theme in Ed Mansfield's work over many years. In this essay I summarise his analysis of logistic diffusion processes and relate his work to earlier studies of industrial retardation and subsequent work on evolutionary economic processes. A distinction has to be drawn between the logistic law and the logistic curve, the latter being only one instantiation of the more general law which is itself a signature of evolutionary selection processes within a population of rival innovations.

Key words: innovation diffusion, logistic law, evolutionary process

JEL Classification: D23, O31, O32, O33

1. Introduction

Ed Mansfield was an acknowledged pioneer in the study of technological change and its wider economic consequences. Along with Zvi Griliches, Dick Nelson and Chris Freeman he was a premier source of inspiration to the generation of scholars who began to study technical change in the 1960s. In terms of the range of his interests, the sharpness of the questions he posed and his willingness to gather the detailed micro data that is needed to make sense of technological change, he had few peers in his generation. Others have written extensively about his work (Diamond, 2003; Scherer, 2005); in this short essay I want to relate his contribution to the wider framework of evolutionary economic analysis for, unwittingly or not, it is to this field that Mansfield made a major contribution particularly though his work on the spread of new technology. The connection to evolutionary ideas is through Mansfield's use of the logistic curve, one of a ubiquitous family of "S" curves to which scholars have turned to summarize the evolutionary dynamics of the spread of innovations. Less well known is the fact that behind the logistic curve lies a more general logistic law describing the relative diffusion of competing innovations in a population of technologies that serve some common economic purpose. It is the logistic law that predisposes population dynamics to generate logistic curves when the diffusion data are plotted over time. The logistic has for many years been a standard tool of analysis in evolutionary ecology (Kingsland, 1985) and in evolutionary economics it is a way of capturing the dynamic response of a market system to the opportunities opened up by economic variation in the form of sequences of innovations. In this brief essay, I shall explore two particular aspects of Mansfield's work on diffusion, in relation to the further developments in diffusion theory that it stimulated, and in terms of the longer sequences of evolutionary economics that pre-date and post-date Mansfield's work. It turns out that Mansfield's work is closely connected to wider questions subsequently studied by evolutionary economists, indeed that the logistic law, the logistic process and the logistic curve are characteristic signatures of competitive selection processes in the presence of economic variation. In short, I shall argue that logistic phenomena are deeply embedded in competitive evolutionary processes but that these processes do not generate in general a logistic curve when the diffusion data is plotted over time. The logistic law and the logistic curve must be separated conceptually, and only in special cases will the later follow

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from the former. Indeed the logistic curve is a very special case of the more general logistic law, which is perhaps why there exists a whole family of "S" curves, Gompertz, log-logistic, log normal etc., that can provide good competing, empirical summaries of the diffusion process. The deeper content of the logistic process it turns out is that it is a natural consequence of a population approach to evolutionary dynamics.

The modern literature on innovation diffusion is immense not only in economics but in marketing management and in technological forecasting and I don't propose to review it at all.[1] However, some brief assessment of the Mansfield approach will help the subsequent discussion.

2. Mansfield on innovation diffusion

Amongst the most influential of his papers are the studies of the spread of new technology, for as he put it "Once an invention is introduced for the first time, the battle is only partly won, since it must still gain widespread acceptance and use. The rate of diffusion is of great importance. The full social benefits of an innovation will not be realised if its use spreads too slowly" (1971, p. 133). Here Mansfield identifies themes of great importance in his future work; that the economic and social payoffs from innovations depend on the diffusion of those innovations, a problem in economic dynamics, that there might be an optimal rate of diffusion which ultimately would determine the private and social returns from investments in practical knowledge and in its more abstract underpinnings in science and basic engineering.

Here I propose to focus on the 1961 paper on the diffusion of innovation since most of his subsequent ideas and studies on innovation diffusion remain framed by this seminal paper. Mansfield begins with a question "Once a new technique is introduced into an industry by a firm how quickly will others make use it?" His answer is grounded in Schumpeter's distinction between the initial innovator and the subsequent swarm of imitators who carry the innovation to its full economic significance. By taking 12 innovations in 4 industries and using data gathered from major firms he observes that the rate of adoption is generally slow with wide variations across the innovations. Clearly this is a problem in dynamic adjustment, and Mansfield's general approach to the problem is that the spread of new technology is part of a market process which sets the dynamic context in which producers and users respond to new technological opportunities. He suggests it is a process of learning, and thus of the growth of knowledge in the market context, in which producers and users improve the innovations in focus and, when they are stabilised, then shift their attention to improving the associated process technology. This is a theme that has been explored in depth in the subsequent product and technology life cycle literature (Utterback, 1994) but it is clearly contained in Mansfield's general approach, albeit in a form subdued relative to the questions to which he devoted most attention. Among these questions the three most important are "What factors explain the different rates at which innovations spread?" "What factors explain the rates at which different firms adopt innovations at different times?" and "What factors determine the speed with which a given firm substitutes new methods for old in its operations?" The answer to the first question is of course a logical extension of the second and third although the three are often treated separately. In the 1961 paper, for example, the focus is on the first question and we find that it takes 5–10 years on average before half the firms in an industry begin using an important innovation and in many cases longer, although there are wide variations around the average. On the basis of this framework one is led to a number of important distinctions. The diffusion of innovation should be distinguished from the adoption of innovation, the latter relating to the decisions by firms to incorporate an innovation in their activities, the former to the economic importance of an innovation as measured by, for example, the proportion of the output of an industry that is produced with a given innovation. Adoption obviously influences diffusion but it is the latter that embodies the economic impacts of an innovation on employment, rates of return and the competitive process. Indeed, the wider significance of these phenomena is that they provide the link between innovation and productivity growth in particular and economic growth in general. Adoption between firms is distinguished