

# Solving Marshall's Problem with the Biological Analogy: Jack Downie's Competitive Process

---

**John Nightingale\***

---

## **Abstract:**

The paper suggests that Marshall's text failed to explore the questions that naturally arose out of the 'biological analogy' that he was so strongly advocating. Instead, his mathematical background, and the already existing tradition of focussing on determination of market price and output, led him to the diagrams and mathematics of the footnotes and the Mathematical Appendix to make analytical sense of the story that he was telling. In essence, his theory of the firm, biological in nature, was left hanging in the air, without a solid analytical link to the market theory.

It was left to Andrews, following MacGregor, to elaborate a theory of price to go with Marshall's text, while it was Downie who took this framework of 'realistic' analysis (which for some reason he did not acknowledge as Andrews') to devise a theory of market process that relied on diversity and discontinuity for economic progress. It was Downie, in direct line from Marshall, who found the link between the theory of the firm and the market process that Marshall lacked, and that current authors now elaborate.

## **Marshall's *Principles of Economics* and Tension Between the Biological and the Mechanical Analogy.**

Alfred Marshall was the first notable writer to give the firm a central place in theory, as Philip Williams (1978) so clearly demonstrated. He went beyond merely discussing the role of the entrepreneur, analysing the 'representative firm' in detail, its origin, its supply function, its growth and decline. Moreover, he popularised the tools of analysis that were to become the fundamentals of neoclassical theory. The internal consistency of his theory has long been a matter of controversy<sup>1</sup>. The very purpose of having an explicit theory of the firm also gives rise to question. Is his theory of the firm a necessary prerequisite for his theory of market and industry performance? Or is it really an irrelevancy, institutional padding to make the 'real' theory more palatable, easier to assimilate? Any thoroughgoing neoclassical economist would have to consider the latter very seriously indeed.

The fundamental shape of modern neoclassical partial equilibrium microeconomics was set by Marshall's work. Not only did he write at length of the analysis of all the problems of production and its distribution, he also presented diagrammatically the most important elements as footnotes to his text, and he set out their mathematical foundations in a concise appendix (pp.838-858 of the eighth edition and the *Variorum*).

The problem he created for later theorists was that his text espoused one theory while his graphical and mathematical notes required another. This inconsistency, seized upon by Paul Samuelson (Samuelson, 1967), and struggled with by scholars such as O'Brien and Loasby (eg. O'Brien, 1987, Loasby, 1989 & 1991), may have a resolution in the work of Jack Downie. Downie was educated at Oxford in the Marshallian tradition, imbibed the Cambridge economics of Joan Robinson, and rejected the latter to replace it with his own synthesis which, had it been taken more seriously as theory, could have led to a more progressive microeconomics of markets some 30 years earlier than is now emerging in the schools of evolutionary institutionalists and post-Schumpeterians. The central concept that gave Downie a key to the problem was that of diversity of firms, the driving force that leads markets' performance and structure in an ever changing pattern of, in Downie's view, progress.

### **The Darwinian World of the Firm in Marshall's Text.**

Marshall explicitly built his theory on what he called "economic biology" (p.xiv). "...the central idea of economics, even when its Foundations alone are under discussion, must be that of living force and movement" (p.xv). The conclusion to Book IV, its chapter XIII, is the clearest statement of the economic biology of the firm. He gives a biographical history of the firm (pp.315-7), using the unincorporated firm as his norm. Central to his history is the ability of the undertaker or owner-manager and this person's goals in his (not her) business life. However, he does not neglect the joint-stock company. This he sees as being liable to stagnate rather than die. The reasons are what we would now call agency problems. The older and larger firm will have so lost "its elasticity and progressive

force, that the advantages are no longer exclusively on its side in its competition with younger and smaller rivals" (p.316).

The biographical history of the firm:

an able man gets a firm footing in the trade; he works hard, lives sparsely, his own capital grows fast, etc; as the scale of his business increases, so do the advantages which he has over his competitors, this lowers the price at which he can afford to sell<sup>2</sup>.

This process may go on as long as his energy and enterprise, his inventive and organising power retain their full strength and freshness, and as long as the risks which are inseparable from business do not cause him exceptional losses; and if it could endure for a hundred years, he and one or two others like him would divide between them the whole of that branch of industry in which he is engaged.

Here follows the parable of the trees of the forest as they struggle upwards through the benumbing shade of their older rivals (from pp.315-7).

Brian Loasby (1989) explores Marshall's methods and the context of his *Principles*. He sees Marshall as attempting something quite different from that which his orthodox successors imagined. He was not articulating a theory of value for the sake of determining the nature and conditions for equilibrium. He was setting out a theory of progress, in the tradition of Smith (Loasby, op cit, pp.48, 51-7). The terms he used were both those common to the then new neoclassical school of Walras, Jevons and so on, and innovative, in which case they were taken over by that school in the early part of this century. For this reason the story Marshall told was a mixture of real examples and theoretical analysis and of less rigour and elegance than the stories developed by the neoclassicals. In particular Loasby demonstrates Marshall's use of these concepts, showing that the modern usage is narrower, and often inconsistent (Internal and external economies, pp.57-60). Loasby does not labour Marshall's use of biological analogy, but he sees clearly the connection between Marshall's ideas and those of the modern evolutionary theorists (p.56). Moreover, Loasby argues that Marshall's industries were not the perfect competition constructs of the later theorists but were instead the competitive but oligopolistic industries whose analysis was later developed by both Andrews and Downie. The problems perceived by writers such as Samuelson, problems of failing to follow analysis to logical conclusions, asserting the importance of increasing returns in competitive industries, and so on (p.48), were then the product of errors of interpretation (pp.63-68). Their errors stemmed from the use which Marshall made of the mechanical analogy and of the equilibrium concept within that analogy.

Hodgson (1992, pp.6-8) argues that Marshall's biological analogy did not draw mainly from the influence of Darwin, but rather from Herbert Spencer. Spencer's version of biological thought, in Hodgson's view, is reductive and atomistic rather than 'organic', emphasising the typical or ideal and not the individual differences that Darwin's selection theory required. The representative firm concept, in Hodgson's view a Spencerian concept, avoids the central ideas of diversity of members of a population. Instead its focus is on the typical characteristics of the entity. Thus, on this argument, the use Marshall made of the biological analogy was

crippled by the perspective from which he approached it. The small place accorded to diversity as a concept of theoretical importance is evidence of Marshall's leaning toward Spencer in his *Principles*<sup>3</sup>. Despite this, Marshall saw Darwin and his principle of gradual change as sufficiently important to make it his motto for the *Principles*.

### **The Mechanical Analogy of the Footnote Diagrams and Mathematical Appendix.**

This is the theory with which we are familiar, the demand curve facing the industry, the supply curves, supply price, equilibrium price and output of the firm, internal and external economies of scale (the latter in post Pigovian writing is not quite what Marshall had in mind, but is something relentlessly logical instead<sup>4</sup>), all these and more were developed and presented as the means of expressing his ideas in precise form.

It is not the case that the mechanical analogy is confined to these places, there are many parts of the text where his exposition is essentially of the mechanical kind. He apologises for using mechanics rather than biology, excusing this as being due to his inability to use the latter. The Preface to the Eighth Edition makes this point plainly (p.xiv). An example is in his use of the idea of equilibrium which he singles out for attention as suggesting mechanics rather than biology: demand price = supply price. Marginal utility analysis and the aggregation of individual demands into market demand with no consideration of the possibility of interdependence of demands is another. Normal supply price is defined as a representation of the real cost of production, analysed into the efforts and sacrifices required to make the good being supplied (p.347). His discussion of the principle of substitution suggests the businessman carrying through mechanical calculations (Bk V, Ch IV).

On the other hand, he uses the biological analogy explicitly and implicitly when presenting historical analysis or the 'stylised facts' of some market or other institution of the economy. A good example is in Bk IV, Ch XII, § 5- § 12 where he discusses the development of business management in the alternative legal structures that have evolved to cope with differences in scale of operation. But this discussion ends with an analysis of the supply price of business ability which forces his analysis to focus on an equilibrating process in which this supply accommodates to the demand for it (p.313). It can be argued that Marshall's theoretical purpose is not clear. Is he intending to create a theory of market equilibrium or is he creating a theory of the firm in the market?

It is the former which captured the attention of his successors. The Pigovian synthesis took his market analysis and imposed a logic upon it, yielding neoclassical partial equilibrium theory as we know it today. It is the latter which the post Marshallian<sup>5</sup> writers attend to, emphasising the population dynamics of firms supplying a market. In this their links are to classical economics, of production and growth, rather than to the economics of exchange which neoclassical theory develops.

It is argued here that Marshall himself was consciously or unconsciously, attending to what are now two different research programmes. The one was what

became the neoclassical programme, in which the focus of attention was on equilibrium price and output, on the market outcomes that can be observed, daily in the case of the produce markets. The other, what is the now burgeoning field of economic population dynamics, cried out for a focus on the evolution of market structures and performance outcomes. The biologists did not seek mainly to set down conditions for equilibrium population size, density etc, but instead tried to explain the emergence of differentiated species and their co-existence. In the same way the biological analogy used so enthusiastically by Marshall should have been the vehicle for the analysis of the rise and decline of firms within markets and industries, thereby explaining the progress of prices and outputs over time, and the obvious diversities within industries and how they lead to progress or decline. His inability to use biological analogy was not due to lack of logical and mathematical skills in analysis, it was due to attention being focussed on inappropriate theoretical goals, the goals of explaining equilibrium, its stability, and what became comparative statics. These goals are discussed in Clark & Juma (1988, pp.45-50), and also in Hammond (1991).

Marshall believed that both the mechanical and the biological analogies were useful and valid in their right place. What might be thought strange is that he found the notion of analogy so powerful in focussing theoretical development. Rather than inducing theory from the phenomena at hand he appeared to seek analogies with other scientific fields, and use their analyses. This was not an unusual feature of 19th century science (Clark & Juma, pp.203-6 for a discussion of the power of Cartesian/Newtonian mechanics in the thought of 19th century economists), nor of contemporary science, and perhaps reflects a faith in reductionism, and in the hierarchy of science, from physics at the top, to social sciences somewhere near the bottom.

Selection 14 of Pigou's *Memorials of Alfred Marshall* (1925) is "Mechanical and Biological Analogies in Economics". In this piece Marshall explores the limits of the mechanical analogy in coping with dynamics, concluding "Thus, then, dynamical solutions, in the physical sense, of economic problems are unattainable... It has been well said that analogies may help one into the saddle, but are encumbrances on a long journey... (I)s there... (a) serviceable analogy between the later stages of economic reasoning and the methods of physical dynamics? I think not. I think that in the later stages of economics better analogies are to be got from biology than from physics; and consequently... economic reasoning... should gradually become more biological in tone" (*Memorials*, pp.313-4). That being said, the substance of this little paper was directed at the use of the mechanical analogy, while noting both early in the paper (as quoted) and late in it, that the biological analogy would become necessary. The impression still remains, after taking this paper into account, that Marshall did not know how to employ that analogy beyond the exposition in Book IV of industrial organisation (see Book V, Ch 1, § 1). He wanted to journey to the Mecca of the biologist, but was unable to make that journey himself, hoping that those who followed would do so. The concept of equilibrium, whether in its mechanical or its Spencerian manifestation, held too strong a sway with him, and with those who followed<sup>6</sup>.

## Post-Marshallian Economists, and their Attempts to Keep Alive the Essence of Marshall's Text.

The post-Marshallians can be defined as those who held back from Pigou and Robinson in their logical extensions to Marshall's partial equilibrium analysis. Perhaps the most notable post-Marshallian was Philip Andrews, a man who saw himself as retrieving the real essence of Marshall from the depredations of the Pigovians. The clearest statement of Andrews' purpose is to be found in "Industrial Analysis in Economics" (1951). His task here was to show that the concept of industry as Marshall had used it was important to empirical work in industrial economics. Andrews had been educated in the modern Cambridge theories of monopolistic competition, in the 'microequilibrium' method, but had been forced to devise his own theory of the individual business and to then find that Marshall's theory of the competitive industry became of immediate and clear relevance to his own. "... (I) t was now possible to think consistently in terms of individual business, whereas Marshall did not push individual analysis beyond a few limited generalisations. The theory of the equilibrium of a competitive industry as presented by Marshall seemed meanwhile to take on the firmness which it must have had for him" (ibid, p141). Andrews defends Marshall's abstraction that suggested to the Pigovians that competition implied identical products by arguing that his long run price was the only requirement of the 'competitive market', that firms in such markets were never thought to be in a situation to sell any quantity at that price, and that reference to particular industries and his 'realistic asides' (p.143) was indication that industries consisted of firms selling non-identical products, and indeed, any firm would typically be selling many products (ibid). The subsequent neglect of this aspect stemmed from failure to appreciate Marshall's concepts of industry and market, one which Andrews saw as central. "The Marshallian industry will consist of businesses with a sufficiently common technical equipment, knowledge, experience, & s., for them to be able to turn over to making any 'range' of the given commodity or any of the particular commodities within the 'range'. Further, the business men can be assumed to be sufficiently 'in' the general market to be aware of the prices secured by producers of other types of commodities within the market" (pp.143-4).<sup>7</sup>

His *Manufacturing Business* (1949) takes themes familiar from Marshall and gives them an elaborate alternative price and market theory, based on the method of Marshall's text. In his later work, *On Competition in Economic Theory* (1964) he presented a detailed critique of the Pigovian system, and showed that his alternative was capable of dealing with all the orthodox questions, albeit without the formal elegance of the neoclassical models. Andrews did not, however, use biological analogies explicitly<sup>8</sup>. He did not mention them. Nor did he use any type of evolutionary dynamics to explain the time paths of industry structure or performance. The references for his theory were in the language of the world of manufacturing business as he knew it in England of the 1930s and 40s. Andrews integrated into economic theory the concepts of margin of profit, mark up over

direct cost and full (more correctly, normal) cost pricing. He also gave the concept of cross entry, entry from adjacent industries, which were later developed in an explicitly neoclassical style by Baumol, Panzar and Willig, in their *Contestable Markets and Industrial Structure* (1982)<sup>9</sup>. The influence of these ideas was not as direct as he would have wished, but the use of the cost concepts in aggregative theories is now widespread, due to the simplicity and tractability of the mathematics of mark ups, and to their power to yield good predictions in macro models.

The major effort that Andrews made was directed against the notion of microequilibrium, the insistence that each and every firm be identical, and in equilibrium, before equilibrium of the industry could obtain. This effort took the larger part of *On Competition...*. His argument ran along the lines that Marshall had put forward 70 years previously, that firms were unique entities, possessing commonalities from common techniques of production, or, less importantly, common markets. The analysis upon which he embarked was essentially a refinement of Marshall's *Principles* and *Industry and Trade*, using the representative firm concept to bring back the determinate price and output. However, instead of supply curves dependent on marginal decisions, as in Marshall, he had normal costings and a vaguely defined competitive pressure (presumably on returns on funds invested) setting the costing margin that was able to be established within the industry. Andrews' theory accounted for observed changes from exogenous shocks, from cyclical or random fluctuations of demand, but in the static sense of setting the new equilibrium, for the industry, but not for the firm. Andrews' attack was on microequilibrium, not on the notion of equilibrium itself. Change and technical progress in particular remained outside Andrews' analysis. This was despite his own claim that differences in efficiency were the essence of competition "on any dynamic view" (p.145). While he laid open the processes of pricing and choice of product and market within the industrial culture of early to mid 20th century England, he did not go the further step to explore the dynamics of the processes. Instead, he saw innovation as "unsystematic" (*ibid*), relevant to the businesses doing the innovating, but not to the general picture of the industry. In other words, Andrews followed Marshall in failing to see the full significance of diversity within the population of firms in his industries, failed to see that diversity itself was the source of change in performance and structure of industries, the source of the secular fall of real costs and prices of especially manufactured goods.

It fell to Jack Downie to show that diversity was the engine driving the competitive system, and that population dynamics opened a new set of questions to explanation. In his one contribution to economic theory, a major but neglected one, Downie developed a model of industry (in the Andrews' sense of firms with a common technical capacity to produce) behaviour and performance. In this model it was precisely the differences between firms that drove the system through time. The industry then was seen to be following an evolutionary pathway, punctuated by revolutionary shocks of innovation whose origin was endogenous, though stochastic in timing and identity.

His model has many thoroughly contemporary insights. Examples to be explored include his notion that there needs to be 'grit in the system' to allow profit seekers to

expect to enjoy benefits from a venture before they are competed away; the path dependence of his industries' history and 'destiny'; its non-ergodic nature in that a small change such as a firm's successful innovative effort can transform its industry, changing the time path of industry price, output and market structure<sup>10</sup>.

Downie's book, *The Competitive Process* (1958) was written while he was at the Oxford Institute of Statistics, on leave from the Treasury where he spent almost the whole of his working life. His work was explicitly on the question of reform of monopoly and restrictive practices law, an exploration of the significance of the 'rules of the game' as he called them, for the efficacy of competition. This work was apparently quite different from his Treasury tasks, which in the latter part of his short career were monetary policy questions, and, from 1961, at the OECD where he was assistant secretary general in charge of the department of economics and statistics (*The Times*, Aug 13, 1963, p12)<sup>11</sup>. Apart from the book, his only other publication of relevance is his paper "How Should We Control Monopoly?" (1956), one of three bearing that title in a symposium in that issue.

### Why did Downie Write *The Competitive Process* ?

When we put together the book and the *EJ* paper it can be seen that Downie saw monopoly policy as the reason for his research. Both the Preface and Introduction to the book make it clear that it is the effect of the regime of regulation on the working of competitive processes that is central. Is it the American anti-trust legislation that has allowed American industry to flourish (pp.11-2)? Is the common law and historic doctrines such as the restraint of trade doctrine efficacious, or is statute law required? But he saw the reason for asking the question in a quite different light to that of standard theory. Instead of the static efficiency arguments in the tradition of Harberger, his first and dominant concern was the effect of legislation on the diversity which he saw as the path to progress.

He saw his theory as a development of Marshall. "...in a sense I have done no more than try to rescue Marshall's notion (Downie specifically cites the trees in the forest analogy) from the damage it suffered when Mrs Robinson pointed out that pike in a pond might be a better analogy" (p.7). He went on immediately to note that "(i)n concentrating on growth and change rather than equilibrium I am swimming with the main stream of post-war economics and, of course, I have drawn much food for thought from Schumpeter. J. Steindl's book on *Maturity and Stagnation in American Capitalism* contains a model of the competitive process which is very like my own, although he places more emphasis on market imperfections..." (pp.7-8).

What is remarkable from the perspective of the 1990s, in the latter stages of the neoclassical hegemony, is that he thought he was in the mainstream. We now know that his work was largely ignored because it was far from the mainstream of either industrial economics, public economics or microeconomics in general. Mrs Robinson's *Imperfect Competition*, Professor Chamberlin, and American static micro-equilibrium theorists, were to dominate monopoly policy, going with the unimpressive productivity results which make the title of Steindl's book prophetic. He also apparently believed that his theory would be so unexceptionable (in the mainstream) that it did not require more than the relatively perfunctory exposition in



the book. No journal articles of any kind appeared, let alone the heavily theoretical equivalent of Andrews' *On Competition...*, to draw the lines clearly around his theory, and exclude the neoclassical alternatives.

Further evidence of his beliefs can be found in his (*EJ*, 1956) paper. He defined the public interest (undefined in the legislation under discussion), quite unselfconsciously I would argue, as consisting in the two issues at the heart of his investigation. These were first, "the extent to which efficient and inefficient, low-cost and high-cost, firms co-exist in different industries. The second is the rate at which efficiency - now usually summarised as productivity - increases over time. ... (this) suggest(s), therefore, that we should take the public interest to be the securing of the minimum intra-industry dispersion of efficiency which is compatible with economic progress" (*ibid*, p.574). Note the complete absence of any concern for the traditionally acknowledged results of 'the monopoly problem', the efficiency criteria of orthodoxy.

It can be seen that Downie's public policy orientation created the demand for his theoretical work, and the theoretical work gave him the key to dealing with his public policy concerns.

### **The Significance of Downie's Theoretical Work.**

There are many levels on which this question can be taken. At the least interesting, the extent to which it was directly seminal for further theoretical development can be measured by citation. The result, I suspect, would be to show it was not very influential. This paper is focussed on the place it has in the Marshallian tradition and its congruence with later Schumpeterian writing. Further papers will explore the extent to which Downie anticipated that later writing.

### **Downie and the Concepts Used by Orthodoxy**

In his first theory chapter, Chapter II of the book, Downie reviews the orthodox theory and finds it wanting in relevance to the problems that he sees as central. Indeed the existence of his phenomena, i.e., differing efficiencies, persistence of those differences, and slowness to react to innovation, is denied by orthodoxy (pp.20-1). "The main preoccupation of the theory of the firm has been with aspects of economic performance where the quantitative effects of different rules of the game are likely to be small. The tolerance of the economic system for differences in efficiency and the rate of growth of efficiency over time... have received very much less attention" (p.24). The point he is making here is that relevant economic performance measures are not going to alter significantly with variation of variables seen as significant to orthodox theory.

He then disposes of the notion that the orthodox method of analysis might be worth saving (pp.24-9). Using argument reminiscent of that of Andrews' critique (Part I of *On Competition...*) Downie shows that the attempts to save the notion of the firm in equilibrium in the face of falling cost curves (Chamberlin) and horizontal long run demand curves (J.M. Clark) were in vain, or mutually incompatible. The static equilibrium criteria of orthodoxy have no meeting with the observable world.

Moreover, the efficiency criteria which fall out of the orthodox analysis are incompatible with the efficiency criteria of significance to firms, households and governments, namely, the progress of productivity over time.

Most significantly for our purposes, Downie recognises that the orthodox concept of equilibrium implies that "the path by which equilibrium is reached, and the speed with which firms move along it, have no influence on the nature of the equilibrium which is achieved or tended towards" (p.28), it is path independent and ergodic. To the contrary, inter-temporal efficiency depends on attempts to change what would have been the static conditions, on uncertainty about what objective conditions in the marketplace will be in the face of determined efforts to change them, on attempts to catch the market before opportunity has disappeared. Downie therefore set himself to the task that Marshall had failed to address. He concludes the chapter "we must start again, by abandoning the concept of equilibrium as defined in the theory of the firm. This is easy. Building a new set of concepts is not so easy. To this I now turn" (p.29).

### **Downie's Normative Concerns: the Problem of "efficiency"**

Downie chose a difficult path in creating a single variable called "efficiency". He was attempting to quantify in a single measure his central normative concern with technical progress, an index of that progress which he wanted to relate to differing sets of 'rules of the game'. This is explicitly not a measure of the factors which affect a firm's relative market success, the success which sees firms growing rather than shrinking. Dozens of alternative measures are available in the productivity measurement literature. His choice may not be the best for this purpose, but alternatives will not alter the nature of the theory, merely its realisation.

With his background in practical statistics, evident in his early publication (1952), it is no surprise that his concern is with identifying an easily obtained statistic of firm performance. The measure is the ratio of costs to output for each firm. The costs measure is the sum of current costs (assuming that input prices are a good representation of relative scarcity) and the cost of capital (i.e., finance costs, defined as "the product of the value of the capital employed (as measured by the firm) and the average rate of profit in the industry" p.40). The output measure is, if anything, more problematical. His solution is to assume many firms produce any specific product, and all firms produce many products. Then to compare two firms' outputs (of different products), an index of quantity times all producers' average cost of each product is used for each firm. This works only where there are no common costs, and where no firm is "preponderant" (p.43). Because there are common costs, the next best solution is to use average price of each product, the worst to use the prices the firm charges, or obtains, in the market. The assumption here again, is that the market price, or the price charged by the firm, is a good representation of average total costs.

His efficiency measure, the ratio of cost to output, is influenced by both technical efficiency (current input cost and usage, funds employed), and by market performance (returns of funds, prices obtained). This he regards as a defect (p.44).

But it is not clear that it is, if the goal is a single measure on which to judge the socially important elements which do include both technical and market factors. A rise of prices, while input costs remain constant will be an increase of measured efficiency all round. So as well as falling input costs increasing efficiency, rising margins of prices over cost also increase efficiency. Perhaps this is why Downie was less than satisfied that a single index conflated technical and market efficiency, as the firm's market efficiency is indicated by a high margin, but it is technical efficiency that yields economic progress. But is this really so? Improved products gain market share at the expense of less desirable ones. The Transfer Mechanism (see below) deals with both in taking profit levels as the source of funds for investment in capacity. It can hardly be argued that economic progress is not furthered by improved product offerings. Nonetheless, rising prices are not a generally observed characteristic of technically progressive industries whether those industries are improving their products or simply lowering their costs.

His index allows inter-firm differences to be seen even where industry average prices are used in the index. Differences in firms' employment of funds will cause their efficiencies to differ. The reason is that the price change alters the average rate of profit, which in turn enters the efficiency index as the price of funds. So firms using more funds will be restricted in their rise in efficiency compared to firms using less funds (pp.46-7). This is indeed as it should be, given that *ceteris paribus* holds.

Our next question must be the advantage of defining a specific efficiency variable that is somewhat removed from the variable the capital market is supposed to rely upon in making judgements about whether to supply new funds to a firm, i.e., rate of profit on funds. First, as Downie says, "the latter (rate of profit) will...usually provide a fair guide" to the efficiency index ranking (p.46). In the absence of large changes of production processes over time, and in the absence of large differences between firms at any time, rate of profit may be enough for ordinal comparisons. But not always. Where the capital/output ratio differs very greatly between firms the efficiency ranking may differ from their profit rate ranking. Second, the efficiency index is one possible measure of total productivity, and so has the normative significance Downie required whereas rate of profit is without such significance, except in the most unusual conditions, that is of perfect competition in a world of no exogenous change.

It is not at all clear that the most efficient firms, in Downie's sense, are the most able firms in the relative growth sense of economic selection. Growth depends on both the ability to increase market share, or size of a market, and on the ability to command new funds. The latter is thought to be related to rate of profit for both internal and external funding. The former can depend on keen pricing relative to rivals, reducing the level of his efficiency index, while rate of profit may or may not be reduced by such behaviour.

## The Transfer Mechanism

It is the Transfer Mechanism (TM) which marks Downie's contribution to economic theory, by which he lays claim to creating a link between Marshall and Schumpeter, or at least, the modern population dynamics school.

The verbal argument he uses to support his theory is very reminiscent of the words of the other Marshallians, Andrews in particular. Reasons for his failing to cite Andrews at all could be sought, and a detailed linguistic analysis may also reveal common threads. But neither of these is the present task. What is distinctive is his focus on market and industry growth, on the path of investment that maintains capacity usage constant (which he calls equilibrium).

He argues that prices, except for "new" industries (p.68fn), are of limited importance for growth of market or industry demand, because price elasticities are not great, nor is there scope for much variation of relative prices, while national income is of great importance for disposable income of buyers. Price is important as the supplier of cash flow to finance production and the level of investment to sustain capacity growth. Price and rate of growth are therefore determined (p.69). But for each firm, these differ with both cost efficiency and market success of each firm's range of products, so giving rise to the transfer of market share that is at the heart of the TM.

The rule that drives his system is the investment/disinvestment relation. Under this rule, all profits are invested in purchasing capacity, and negative profits are recovered by selling capacity. There is no external funding. Then differences in costs per unit of output determine the distribution of capacity among firms, while rate of growth of demand determines market size. His selection variable is thus profit (or costs equivalently) per unit of output.

The examples he uses at pp.70-2 indicate the power of the mechanism to change market structure. While this mechanism is crude and simplistic it does encapsulate some of the behaviour of firms. More importantly, it is useful as a simple example of the sort of forces that drive a system. One can imagine many more complex sets of forces, perhaps implying more complex selection variables, some weakening the force of the simple model, but all driven by diversity. Downie's view was that elaborations of the TM would only strengthen it. "So long as profits are the main determinant of potential growth the system will always show a strong intolerance of cost differences" (p.75)<sup>12</sup>. In other words, structure will change rapidly towards one of small cost difference:

Whether this also means that the most efficient firms prevail is a slightly different question. Downie's answer is that this will be the case except in most unusual circumstances. In his general model (pp.76-9) he presents a simple mathematical representation of a system in continuous equilibrium (as he defines it) under constraints specified earlier, and additionally, identical and constant capital output ratios and no entry or exit. His mathematics explores the behaviour of the variance of efficiency over time<sup>13</sup>. He uses a two period analysis to explain the current period's price and efficiency variance in terms of last period's values. He finds that both price and dispersion of efficiency will fall the more rapidly the

greater the initial dispersion. So we have an intimation of the analogue of the Fisher relation (the rate of change of population average on the selection variable is proportional to the variance of that selection variable) appearing. But note that it is the dispersion of efficiency, and not the dispersion of profit per unit of output that he analyses. In other words, it is because efficiency is so closely related to the selection variable, profit, that this result appears. The complexity of the result, containing a third moment term, is probably the outcome of this choice. A future task is to use profits, the selection variable, in the formula, and note the emergence of the Fisher relation.

Does the TM exhibit path dependence? Does Downie claim anything that might be interpreted as path dependence for the process of the TM? Path dependence means that the state of the system depends on the path that it has followed in its history. Where a system might find some kind of equilibrium, that equilibrium will differ depending on the path followed in reaching it. The second question can be answered in the negative. Downie saw that equilibrium as a steady state path of growth of capacity, determined by the rate of growth of demand, almost completely exogenous to his system (pp.67-8). No matter what the initial state, he saw the path converging on that growth equilibrium. The first question is more difficult. The path at any point in time is dependent on its history, but that does not make the 'final' state path dependent. Whether that is the case is unclear from my understanding so far. Further formal analysis will be required to establish this property. What can, perhaps, be said is that the TM model is one for which history is clearly important, with a possible diminishing of that importance where conditions for steady state growth remain constant for many years. One difference between this and neoclassical growth models is that this model can run happily 'out of equilibrium' whereas the others are in some difficulty due to the nature of the production relations they require, i.e., the requirement of equilibrium for individual producers. The TM model assumes specifically that firms are not in any state which could be called 'equilibrium' by neoclassical theory.

What Downie has shown in his TM is that efficiency of the industry will increase if market share is able to be transferred to the more efficient and away from the less efficient. This is the main, and routine, means by which technical (and market) efficiency is translated into socially beneficial progress. Rules that impede this transfer are to be avoided, while arrangements that promote the success of the efficient firms relative to the inefficient are to be encouraged. What we see him to have achieved is an analysis of the dynamic change of market structure in response to selection pressures imposed by the market. Thus, Marshall's biological analogy has been completed, in a thoroughly gradualist Darwinian manner by Downie. However, what Downie proceeds to suggest goes well beyond the constraints of a Darwinian process. Nature is seen to jump.

### The Innovation Mechanism

This mechanism is formally exogenous to his TM model. However, it is essentially part of the whole model, one which we can call 'punctuated equilibrium' following Mokyr (1990 and 1991). For a Darwinian model of population ecology, such as the

TM model, innovation represents purposive mutation that occurs randomly as far as the TM model is concerned. The innovation, when it is successful, transforms higher cost firms into lower cost firms. As an example, imagine a Poisson distribution of events that effect only one firm each event, only firms in the lowest  $x\%$  of the distn of efficiency,  $e$ . The outcome is a new distn of  $e$ , and a new trajectory of relative growth for each firm, thus a new pathway to concentration and lower industry average cost.

Mokyr (1990) suggests that a taxonomy of technological change can be set up by analogy with genetic evolution. Phenotypical changes are equivalent to movements around known technologies; changes in gene dispersion are equivalent to Downie's TM, and to the many alternative formulations of this phenomena, that give rise to analogies of Fisher's Law; mutation is the equivalent of emergence of new ideas, but the Lamarckian aspect must be added in, as economic mutation is usually directed by goals and informed by learning<sup>14</sup>; speciation is equivalent to the rare event of an invention that transforms economic possibilities, Schumpeterian long cycles are set off by them, with the steam engine the most clearcut example. Mokyr calls these latter 'macroinventions' (ibid, p352). The Mokyr 'macroinventions' that lead to discontinuous change are of a much higher degree of discontinuity than Downie's innovations. That is, in the context of an industry, an innovation that transforms a firm's level of costs (or transforms a firm's market demand in a heterogeneous market) is not a Schumpeterian cataclysm for the economy as a whole. The industry's structure will be changed by a firm innovating as Downie suggests, but the industry's place in the economy may not be changed in any important respect. Downie's Innovation Mechanism (IM) fits into the Mokyr taxonomy as a mutation. Mokyr argues that this should be regarded as Darwinian, and continuous, rather than being a discontinuity. And from the macroeconomic viewpoint this may be appropriate. Nonetheless, we still have a discontinuity at market level, where the gradual process of concentration, and convergence upon best practice via the TM is disrupted. If, as Downie supposed, this disruption, though unusual, is quite certain in a statistical sense<sup>15</sup>, then his analysis provides a means of understanding why concentration does not proceed toward the extreme, and why the leading firm does not maintain its position for more than a relatively few years (and why Robinson's 'pike in the pond' metaphor is rejected). But where an industry is constantly being upset by innovation, the TM process fails and another means of analysis must be sought. Downie himself notes (p.94) that these two sources of change, selection (TM) and mutation (IM) to follow Mokyr, may well operate "in a much more complex and continuous fashion than has been implied" (ibid). But his position remains at base one of separating the two clearly and of expecting the two to appear cyclically. As he concludes the analysis of the IM:

"Nevertheless, the cyclical form in which I have found it most simple to expose the process may have more than merely pedagogic value. It is plausible to suppose that in reality also there will be periods of what may be called ingestion, during which the structure of efficiency-relatives is broadly undisturbed and the strong are engaged in consuming the weak, and that these will be followed by periods of revolution, when technique is in the

melting pot, old kings are being dethroned and new ones are coming to the fore. We should at least bear this in mind when confronting empirical material" (ibid).

A way of dealing with innovation that is quite consonant with Downie, but at odds with Mokyr at least on the surface, is that developed by Cyert and March using Simon's organisation theory (Cyert and March, 1963, but see also Cyert and March, 1956). Here the firm is stimulated only by failure to achieve targets. The firm attempts to reduce costs, eliminating organisational slack or pushing back the bounds of the firm's own knowledge, when it finds its profit goal underfulfilled, or its market share falling 'too much', 'too fast'. It is, of course, this set of ideas that Nelson & Winter (1982) took up in their model, a model which will be argued in another paper to have reinvented a number of Downie's ideas.

It is clear that the IM implies non-ergodicity. Success or failure of a particular innovation, the occurrence of an innovation at all, can lead to change of the path taken by the industry in the future. Even if the innovation is small in impact on best practice costs, it will change that pathway, rather than being absorbed into an old pathway. Thus a departure even from one of his steady state growth paths will change the course of history. It also implies path dependence, which is a weaker condition than non-ergodicity<sup>16</sup>. The two mechanisms together thus demonstrate these two qualities that are characteristic of population dynamics models. The significance of history is assured.

One of his conclusions to the analysis of both mechanisms is not unlike that of Edith Penrose (1959), that there is nothing in the analysis of the competitive process that bears on the optimum size of the firm (p.95). His other conclusions are that progress consists in the tendency of cost dispersion to be eliminated, therefore no optimum dispersion can be determined; that there is no ideal rate of progress; that any relation between 'slow' progress and 'the rules of the game' must be explored by examination of the effect of these rules on such things as penalties for failure to innovate, rewards for efficiency, freedom to experiment, and the rate of diffusion of innovation.

## Entry and Exit

It is here that Downie intersects with both Andrews and Penrose. Like Andrews, Downie sees entry as generally being by existing firms, moving into markets which their technical expertise can serve. Andrews called this 'cross entry'. Like Penrose, but unlike Andrews, Downie saw 'cross entry' as a phenomenon of large corporations seeking outlets for underused or inappropriately used resources. He saw it also as the dominant form of entry. But unlike both of them, his analysis of the effects of such entry is in terms of its effects on technical progress. The entrants are relatively efficient "largish" (p.101) and thus technically resourceful firms who believe their rate of growth can be improved by entering the new industry. This depends on the profitability which can be expected, on average, in the industry being entered, and on the relative advantage the firm expects in that industry (p.103). The latter he expected to be more important, as efficiency differences are greater than differences in average rates between industries. The industries from

which entrants come will be those in which the dispersion of efficiency is no longer great, mature industries in other words, dominated by a few large firms. In such industries the innovations will be biased toward large scale methods, restricting the power of the mechanism to counter the concentrating effects of the TM (p.106). The capital export industry will not be as subject to the TM as without such export, as the efficient firms are moving capital elsewhere. This also weakens the IM as firms are under less pressure in that industry (p.107). But in the "colonised" (ibid) industries the effects will be the reverse, both mechanisms will be pushed harder by the inflow of capital of seemingly efficient firms. However countering the progressive effects of this capital inflow will be the market power of the new entrants, protected from the market's forces by the financial strength of the parents. Rates of profit may be no guide to selection (p.108). While Downie entitles this chapter (VIII) "On entry and exit", exit is not mentioned.

The contribution Downie makes in this chapter is the link between maturity, in terms of concentration and dispersion, and the relative rate of progress of the industries. His view of the success of entry by large existing firms is probably far too optimistic given the experience of merger in the past 40 years. His attempt to put the entry process in the context of diversification and link it to the selection and mutation processes of the market is still ahead of current model builders, probably because he was not confined by formality. This comment also applies to his final theoretical contribution, on the setting of prices and outputs through time, with emphasis on strategic behaviour by firms in an industry.

## How Equilibrium is Achieved

His concept of equilibrium, the matched growth of demand and capacity, implies concern that firms' decisions to change their outputs will be consistent, not suffering the Richardson problem of over- or under-shooting due to the radical uncertainty of what competitors are choosing before their choices become obvious. He solves this, in a manner similar to that of Richardson (1953, 1960 & 1971), by positing "grit in the system" (Downie, 1956, p.575) as he called it in a slightly different context<sup>17</sup>. The argument is rather Andrewsian, normal price "provide(s) an anchor, which tends to confine price changes within not too wide a range" (p.110), and this normal price "approximates reasonably closely to the equilibrium price as I have defined it" (ibid). In other words, the short term fluctuations of demand that might create sudden price changes, and profit changes, thence capacity changes, which might be unjustified in the longer term, these are damped by the natural caution of businesspeople who have seen it all before. In other words, Downie is positing an adaptive expectations view of price and capacity setting.

It is in this chapter that exit is dealt with. The failing firm may wind slowly down, negative net profits preventing the firm from maintaining its asset base, but still able to produce and make a contribution toward interest costs and suchlike fixed charges. Or a more efficient firm may buy the failing firm, or its assets, and put it out of its misery quickly. This has the advantage that the more efficient will increase their profits and growth rate. This increases the efficacy of the TM, whereas the alternative slows the transfer of market share toward the more efficient (p.114).



The other constraint on rapid change in the market is the goodwill factor. Like Andrews, Downie regards customers as being, to greater or lesser extent, committed to their current supplier. To change supplier is a major policy initiative, not done lightly. Firms intent on increasing market share will attempt to "detach" customers of the most vulnerable firms, and "attach" them as firmly as possible (p.116). Where this process is facilitated by negotiation and commercial secrecy the TM operates more rapidly than where prices are posted and deals public (p.117). So goodwill is both a force for smoothing fluctuations and for slowing the transfer of market share from the inherently inefficient.

The declining industry provides a particular problem, as capacity is eroded only by time or innovation. And innovation is rare in such an industry, in Downie's view (p.119). While the notion of the normal price may restrict firms from indulging in marginal cost pricing, the longer the slump, the more likely discipline will break down. Under such conditions it is not always the efficient firms that stay solvent longest. The TM is thus suspended during such a slump, or in the death throes of the declining industry (*ibid*).

Downie's analysis of equilibrium of capacity to demand is less complete than his TM and IM models might wish to have as complements. But it must be said that the problem of strategy has not yet been dealt with happily by the post Schumpeterians either. Downie relies on behavioural traits that will differ from one economy to another, and from one time period to another. Nonetheless, the attempt was made. The critical insight, that immediate and complete reaction to any change, in the manner suggested by rational expectations models, is destructive of maintenance of equilibrium, was reached. The mechanisms which slowed reaction in Downie's case are those which Andrews developed in great detail in his *Manufacturing Business* (1949).

G.B. Richardson's doubts about the possibility of rational choice under competition or oligopoly were not published until 1960. Was it a coincidence that two minds in the same institution at about the same time developed the same ideas, in great detail in Richardson's case, and as an important subsidiary element in Downie's<sup>18</sup>. This result was only recently derived formally in a neoclassical context by Heiner (1989). Schumpeter's argument in *Capitalism, Socialism and Democracy* (Schumpeter, 1942), Ch VII, "Monopolistic Practices", is a possible source of Downie's idea, but Schumpeter takes the notion of beneficent restrictive practices much further toward the 'destructive competition' line of thinking which sees the nature of investment in sunk capital as requiring protection from the forces of competition.

## Linking Marshall with Schumpeter

Downie's two mechanisms of competition can be seen as a formalisation of two sets of ideas, the Andrews post Marshallian ideas of the Oxford school that had its genesis in the Oxford studies in the price mechanism of the late 1930s; and Schumpeter's forces of creative destruction. While Schumpeter's focus was on the great movements of history that shaped modern industrial society, that of the post Marshallians was on the year by year passage of time and the evolution of markets and industries, their structure and performance. Where Andrews had failed to create a properly dynamic model, Downie used the Schumpeterian vision as a basis for his dynamics.

- 
- \* Department of Economics, University of New England, Armidale, NSW 2351. The present work was carried out while on a year's study leave from the UNE. During that time I was fortunate to discuss this paper with Stan Metcalfe, Brian Loasby, Denis O'Brien, Alec Gee, Neil Kay, Dominique Foray, Geoff Hodgson, George Richardson, Martin Fransman and Norman Clark. Their encouragement and comments are gratefully acknowledged. The comments of the referees of this Journal have also been of great help in clarifying some issues.

## Notes

- 1 Clark & Juma (1988) attempt to deal with Marshall's dilemma. However, they do not see that Marshall provided a substantial part of the basis for modern evolutionary thought, which is the burden of the present paper.
- 2 A theme important to Marshall, that of the long run tendency of real prices to fall with development of markets and techniques of production, can be suggested as the central idea with which the biological analogy is distinguished from the mechanical. This is to be explored in further work on Downie's contribution.
- 3 The relationship between the two analogies, and the full import of the biological analogy in Marshall can only be grasped by seeing *Industry and Trade* in the context of the *Principles*. The task of elaborating on this point is beyond the scope of this paper.
- 4 "Pigovian" is used to indicate work in which the full logical implications of the simple mechanical model is taken seriously. Whether Mr Pigou was the first, or whether Sraffa in his 1926 *EJ* paper (or his 1925 paper published in Italian) is really to blame is unclear to me. Loasby (1989), in his essay on the Cambridge economists' transformation from Marshall's economics to the timeless, ahistorical economics we accept as orthodoxy, "Joan Robinson's 'wrong turning'" (pp.71-85), notes that "with Pigou came an important shift of emphasis; historical development and the working of the competitive process faded into the background and formal analysis became more prominent" (p.75). See also pp.73-5 on increasing and decreasing returns, and Loasby, (ibid), Chapter 4, "Knowledge and organisation...".
- 5 Post Marshallians are writers such as MacGregor (see Lee, 1989) and Andrews, authors who resisted the Pigovian/Robinsonian synthesis, and maintained the need to see the business firm as a reality, and its behaviour as warranting explanation. As Andrews showed in his 1951 paper, the exit of many economists from the Cambridge orthodoxy in the first decades of the century was the beginning of the other business disciplines, at least in the UK.

- 6 The picture of Marshall leaning first to biology, then to mechanics, and so on, is drawn by Brinley Thomas in his recent paper (1991). The paper is unfortunately too brief to sustain the argument fully, but is highly suggestive of the conflict in directions taken in Marshall's development of his *Principles*.
- 7 The present author attempted to clarify these concepts in light of later writing of Andrews in his (1978).
- 8 He did, however, see the statistical nature of modern physics as analogous with his micro non-equilibrium views (Andrews and Brunner, 1951, p15).
- 9 There is some suggestion that Andrews' year at Harvard in the middle 1960s may have given some impetus to the work of Caves, whose seminal paper of 1977 was quoted by Baumol et al. It is still common for Americans to keep their citations local. The folklore of the transmission of ideas may be fascinating but no more than a footnote.
- 10 The reader unfamiliar with these concepts may find a convenient entry to them in W.B. Arthur's piece in *New Scientist*, 6 February, 1993, in a special supplement on complexity, all of which is worth reading.
- 11 It should be noted, however, that his Treasury position gave him privileged access to data. His empirical work for the book was based on raw data from the Census of Production, not the Standard Industrial Classification aggregations available to other researchers. This made his a difficult act to follow and may have contributed to his later neglect. My own view is that it was his unconventional framework that was more important to the neglect.
- 12 See Metcalfe (1989) for a modern account of profit as the selection variable.
- 13 There are also a couple of typographical errors in this section, the major one being carried through in the mathematics to a contradiction of his conclusion, viz, that "the rate at which prices fall will be the greater the smaller the capital intensity of the industry and the rate at which demand for its products is growing" (pp.78-9).
- 14 But for a contrary view, see Hannan and Freeman, (1989) pp.22-3, 76-7.
- 15 in the same way that cyclones are unusual for any specific location, but certain up to a probability distribution.
- 16 An economic process may be path dependent without being non-ergodic, but non-ergodicity implies path dependence.
- 17 Richardson's concerns with imperfect information and its relevance to economic efficiency was first flagged in his 1953 paper, but not developed in the form familiar from his 1960 and beyond. It has been suggested that 'grit' is similar to 'slack' as means of stabilising markets. In this context it may well be advisable to consider both Leibenstein's X-inefficiency concept and Hirschman's Exit/Voice dichotomy, to explore their relationship with Downie's adaptive expectations approach.
- 18 Richardson (1960). Downie's strong views on regulation of competition, coming from his Civil Servant's practical concern with the need for "grit in the system", to give the enterprising firm a reasonable run at profit making before being cut down by followers, did not introduce Richardson to the dilemma explored in his book. Richardson had little contact with Downie and does not remember ever discussing matters such as this with him, or coming into contact with Downie's ideas at all.

## References

- Andrews, P.W.S. 1951 "Industrial Analysis in Economics" in Wilson T. & Andrews, P.W.S. *Oxford Studies in the Price Mechanism*, Oxford, Clarendon, pp.139-172.
- Andrews, P.W.S. & Brunner, E. 1951 *Capital Development in Steel*, Oxford, Basil Blackwell.

- Barkley Rosser, J. 1992 "The dialogue between the economic and the ecologic theories of evolution" *Journal of Economic Behaviour and Organisation*, 17, pp.195-215.
- Clark, N. & Juma, C. 1988 "Evolutionary theories in economic thought", in Dosi, G. et al, *Technical Change and Economic Theory*, London, Pinter, pp.197-228.
- Cyert, R.M. & March, J.G. 1963 *Behavioural Theory of the Firm*, Englewood Cliffs, NJ, Prentice Hall.
- 1956 "Organisational Factors in the Theory of Oligopoly" *QJE*, 70 pp.44-46.
- Downie, J. 1952 "A note on the demand for food", *Economic Journal*, LXII, #248, pp.936-9
- 1956 "How Should We Control Monopoly? II", *Economic Journal*, LXVI, #264, 573-7.
- 1958 *The Competitive Process*, London, Duckworth.
- Hammond, J.D. 1991 "Alfred Marshall's Methodology", *Methodus*, 3,1, pp.95-101.
- Hannan, M.T. & Freeman, J. (1989) *Organisational Ecology*, Cambridge, Mass., Harvard University Press.
- Heiner, R. 1989 "The Origin of Predictable Dynamic Behaviour", *Journal of Economic Behaviour and Organisation*, 12, pp.233-257.
- Hodgson, G.M. 1992 "The Mecca of Alfred Marshall" unpublished manuscript, University of Northumbria.
- Lee, F.S. 1989 "D.H. MacGregor and the Firm: a Neglected Chapter in the History of the Post Keynesian Theory of the Firm", *British Review of Economic Issues*, 11,24, pp.21-47.
- Loasby, B. 1989 "Knowledge and organisation: Marshall's theory of economic progress and coordination" *The Mind and Method of the Economist*, Aldershot, Edward Elgar, pp.47-70.
- "Joan Robinson's 'wrong turning'", pp.71-85 in *ibid*.
- 1991 *Equilibrium and Evolution*, Manchester, MUP.
- Metcalfe, J.S. 1989 "Evolution and Economic Change", in A. Silberston (ed) *Technology and Economic Progress*, Macmillan.
- Mokyr, J. 1990 "Punctuated Equilibrium and Technological Progress" *AERPP*, May, pp.350-4.
- 1991 *The Lever of Riches*, Oxford UP.
- Nelson, R. & Winter, S. 1982 *An Evolutionary Theory of Economic Change*, Cambridge, Mass, Belknap Press
- Nightingale, J. 1978 "On the Definition of Market and Industry", *Journal of Industrial Economics*, , pp.31-40.
- O'Brien, D. 1990 "Marshall's Industrial Analysis", *Scottish Journal of Political Economy*, 37, 1, pp.61-84
- Penrose, E.T. (1959) *The Theory of the Growth of the Firm*, Oxford, Basil Blackwell.
- Pigou, A.C. 1925 *Memorials of Alfred Marshall*, London, Macmillan.
- Richardson G.B. 1953 "Imperfect Knowledge and Economic Efficiency" *Oxford Economic Papers*, 1953, pp.136-56.
- 1960 and 1990 *Information and Investment*, Oxford UP, Oxford.
- 1971 "Planning versus Competition", *Soviet Studies*, 22, 3, pp.433-47, also in Richardson G.B., 1990.
- Samuelson, P. 1967 "The Monopolistic Competition Revolution" in Kuenne, R.E. *Monopolistic Competition: Studies in Impact*, New York, Wiley.
- Schumpeter, J. 1942 *Capitalism, Socialism and Democracy* New York, Harper & Brothers.
- Thomas, Brinley 1991 "Alfred Marshall on Economic Biology", *Review of Political Economy*, 3.1 pp.1-14.
- Williams, P.L. 1978 *The Emergence of the Theory of the Firm*, London, Macmillan.