

# Development, technological change and innovation: Schumpeter and the neo-Schumpeterians\*

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**Summary:** 1. Introduction; 2. Schumpeter on Schumpeter; 3. Schumpeter after the neo-Schumpeterians; 4. Modeling Schumpeter; 5. Season finale: how might growth theorists proceed further?

**Key words:** development; technology; technological change; innovation; imitation.

This review essay is devoted to a discussion of some central aspects of the Schumpeterian and neo-Schumpeterian approaches to the dynamic processes of development, technological change, and innovation. This essay is organized in two parts. In the first, Schumpeter's insightful distinction between circular flow and development is discussed. In the second, some central elements of the neo-Schumpeterian interpretation and extension of Schumpeter's views are critically outlined, special emphasis being placed on some recent attempts to formalize several of his insights on the cyclical dynamics of the processes of technological change and innovation. It should be stressed that due to space constraints primary focus will be upon macrotheoric issues, and only secondary attention will be paid to the neo-Schumpeterian literature on the microeconomics of technological change and to the burgeoning empirical developments along those lines.

Este ensaio-resenha discute criticamente alguns aspectos centrais das abordagens schumpeteriana e neo-schumpeteriana dos processos dinâmicos de desenvolvimento, mudança tecnológica e inovação. O ensaio está organizado em duas partes. Na primeira, a sugestiva distinção entre fluxo circular e desenvolvimento formulada por Schumpeter é discutida. Na segunda, alguns elementos centrais da interpretação e extensão da visão schumpeteriana empreendidas pela vertente neo-schumpeteriana são criticamente analisados, com destaque especial para várias tentativas recentes de formalização de visão schumpeteriana sobre o caráter cíclico dos processos de mudança e inovação tecnológicas. Vale ressaltar que este ensaio focaliza essas questões por um prisma primariamente macroteórico, o que significa que atenção apenas secundária é dispensada tanto à enorme literatura neo-schumpeteriana sobre aspectos microeconômicos desses processos quanto a estudos empíricos sobre os mesmos.

## 1. Introduction

This review essay is devoted to a discussion of some central aspects of the Schumpeterian and neo-Schumpeterian approaches to the dynamic processes of development, technological change, and innovation. Indeed, its title is supposed to capture the general content of the narrative that follows. For Schumpeter, while development is first and foremost a process of technological change, the latter ultimately takes place through innovations carried out by entrepreneurs.

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The essay is organized as follows. Section 2 presents Schumpeter's insightful distinction between circular flow and development, as well as the paramount role played by technological change in Schumpeter's view of capitalist dynamics. Section 3 is devoted to a critical outline of some central elements of the so-called neo-Schumpeterian interpretation and extension of Schumpeter's view.

Section 4 is then intended to discuss some neo-Schumpeterian attempts to formalize several of Schumpeter's insights on the cyclical dynamics of the processes of technological change and innovation. But I should stress that mine is not an exhaustive account of the neo-Schumpeterian approach. More precisely, due to space constraints I will focus primarily upon macrotheoretic issues, thus paying only secondary attention to the large neo-Schumpeterian literature on the microeconomics of technological change and innovation and to the burgeoning empirical developments along those lines.<sup>1</sup>

Finally, section 5 is devoted to a tentative evaluation of the extent to which a post-Keynesian approach to cyclical growth and distributional issues would benefit from the incorporation of some Schumpeterian insights into a Kaleckian framework.

## 2. Schumpeter on Schumpeter

Schumpeter's distinction between circular flow and development was worked out in his *The theory of economic development* (1912), whose main purpose was to outline the basic characteristics of the flow of economic activities through time.<sup>2</sup> As a first and crude approximation, economic life is conceived as a circular flow in which the total of all goods produced always finds a market. The notion of circular flow implies that somewhere in the economic system a demand is ready awaiting every supply, and nowhere in the system are there goods without complements, that is, other goods in the possession of people who will exchange them under determined conditions for the former goods. In the circular flow, there is no gap between receipts and disbursements, and money has no other role than that of facilitating the circulation of goods.<sup>3</sup> Schumpeter (1912) began by describing economic life from the standpoint of a well-behaved circular flow, running on in channels essentially the same period after period, in a similar way to the circulation of blood in an animal organism. Such circular flow describes economic life from the standpoint of the economic system's tendency towards an equilibrium position. This tendency gives us the means of determining prices and quantities of goods, and may be described as an adaptation to the conditions prevailing at any time.

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<sup>1</sup> An excellent critical survey of recent empirical developments in neo-Schumpeterian theory can be found in Freeman (1994), which concentrates on those topics where the results have been most impressive and where they have presented the greatest challenge to established theory. The main part of the paper concentrates on the results of microlevel studies of innovations and their diffusion at the firm and industry level. In Brazil, some recent contributions based upon several neo-Schumpeterian concepts include Canuto's (1991) analysis of technological change in late industrialization, the empirical study of the carrying out of innovations within Brazilian manufacturing industries conducted by Ferraz, Rush and Miles (1992), and, to a lesser extent, the study of the competitiveness of the Brazilian industry coordinated by Coutinho and Ferraz (1994), and Nakano's (1994) analysis of the prospects for the Brazilian industry in light of the ongoing process of globalization of the world economy.

<sup>2</sup> The book was originally published in German, in 1911, when Schumpeter aged only 28. In the preface to the English edition of 1934, Schumpeter mentions that while some of the ideas submitted in the book go back as far as 1907, all of them had been worked out by 1909.

<sup>3</sup> Elsewhere Schumpeter (1954:218) credited Richard Cantillon for being the precursor, circa 1730, in the development of a circular flow of income, while François Quesnay received the accolades for presenting Cantillon's ideas in a schematic form in the *Tableau Economique*. Murphy (1993), in turn, argued that John Law in fact preceded Cantillon by some 25 years in presenting the first outline of a circular flow of income.

But since this circular flow and its channels do alter over time, one must abandon, Schumpeter argued, the analogy with the circulation of blood. For even though the latter also changes in the course of the growth and decline of the organism, yet it only does so continuously, i.e., by steps which can be chosen smaller than any assignable quantity, however small, and always within the same framework.

Even though Schumpeter recognized that economic life experiences such changes too, he argued that it also experiences others which do not appear continuously and which change the framework, the traditional course itself, thus being unable to be understood by means of any analysis of the circular flow (1912:61). In this sense, the circular flow encompasses all the cases in which adaptative forces prevail in the economy, so that the static Walrasian equilibrium method may be satisfactorily applied. The circular flow is thus an adaptative system: experience shows that any quantity or price different from those of equilibrium causes a loss for everyone in the system. Indeed, exogenous factors (e.g. wars or earthquakes) may eventually cause such shocks as to disturb the stationary circular flow, even leading to cyclical fluctuations. Besides, certain slow and continuous endogenous changes in data (e.g. variations in population or saving) may well induce a gradual adaptation in the economic system. In both cases, though, the analysis can be safely carried out within the framework of an adaptative behavior: in the first case, because the circular flow affords a coherent apparatus of response; in the second, because the economy remains on an equilibrium path anyway.

According to Schumpeter, this is only apparently the general case in a capitalist system. There is just one exception, which, however, is so crucial as to require a profound modification of the analysis, such exception being the process of technological change, which elsewhere Schumpeter (1939:106) considered the *prime mover* of capitalist development. While the traditional analysis can deal with the consequences of changes in natural conditions or in non-economic social conditions, it fails where economic life itself changes its own conditions by fits and starts. For Schumpeter (1912:62-3), traditional analysis is not only quite unable to predict the dynamic consequences of discontinuous changes in the traditional way of doing things, but it also cannot explain neither the occurrence of productive revolutions nor the phenomena which accompany them; it can nothing but investigate the new equilibrium position after the changes have occurred. In fact, Schumpeter (1939:102) viewed evolution as a disturbance of existing structures and more like a series of explosions than a gentle, though incessant transformation, and it is just this occurrence of the revolutionary change that is the problem of economic development in a narrow and formal sense. By development, therefore, Schumpeter (1912:63) understood only the changes in economic life that are not forced upon it from without but arise by its own initiative, from within. To put it another way, development should be seen as a succession of discontinuous structural changes in the channels of the circular flow due to endogenous mutations of internal factors; it is an overwhelmingly complex and multidimensional process of spontaneous, endogenous, structural, dynamic and discontinuous transformation.<sup>4</sup>

Therefore, not every change in the equilibrium induced by a change in the functional structure of the economy implies a process of development in the Schumpeterian sense. In Schumpeter's (1939:73) view, for a given change to actually imply a process of development it must necessarily be triggered by the parameters of a Walrasian circular flow, namely,

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<sup>4</sup> In the first edition of the book, Schumpeter used the expression dynamics to refer to development. In the next edition of the book (1912), the term development is then used, Schumpeter's (1912:64) explanation being that his previous use of the term dynamics had been subject to a great deal of confusion and misunderstanding.

tastes, technology, and production factors. But while changes in tastes and in quantity, quality and distribution of productive factors are usually continuous and may be absorbed by adaptive forces, this is not the case with technical change, which is an essentially discontinuous process (1939:164). Therefore, technological change should be understood as a spontaneous and internal disturbance which produces a complex, non-adaptive response which will discontinuously and forever displace the prevailing equilibrium configuration. Development, unlike circular flow, requires that both the disturbance and the reaction of the system be internal, which implies that the structural change that characterizes development cannot be fully exogenous.

It is in this sense that Schumpeter's notion of development can be seen as one of the earliest attempts to highlight the limitations of the Walrasian equilibrium system, Schumpeter's (1954:827) often-quoted claim about being Walras the greatest of all economists notwithstanding. Schumpeter constructed his equilibrium model of resource allocation as a prelude to his dynamic model of economic development precisely to illustrate that economic development depends on a disruption of the tendencies toward an equilibration of supply and demand. Indeed, Schumpeter's circular flow is the Walrasian theory of the market economy that forms the microfoundations of modern neoclassical economics. In focusing his analysis on the theory of economic development, Schumpeter clearly showed what cannot be explained by the Walrasian system, namely the fundamental phenomenon of entrepreneurial activity which results in endogenous innovation. For Schumpeter, though, the theoretical excursion into the complex realm of economic dynamics could start from a static system of Walrasian equilibrium: one being seen to complement rather than to negate the other.<sup>5</sup>

As far as the technical details of production are concerned, Schumpeter conceived the process of production as constituting the combination of productive forces with a view to generate a given amount of social product. In other words, to the extent that to produce means to combine materials and forces within our reach, development in the Schumpeterian sense should be viewed as the carrying out of new combinations, i.e., the carrying out of innovations. For Schumpeter (1912:66), the concept of innovation, in turn, covers the following cases:

- a) the introduction of a new good or of a new quality of a good;
- b) the introduction of a new method of production;
- c) the opening of a new market;
- d) the conquest of a new source of supply of raw materials or semi-manufactured goods;
- e) the carrying out of the new organization of an industry, like the creation of a monopoly position or the breaking up of a monopoly position. At this juncture, it is worth emphasizing that while Schumpeter's notion of development is much narrower than the currently prevail-

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<sup>5</sup> As Morishima and Catephores (1988:41-2) pointed out, it is in fact not unreasonable to suggest that Schumpeter's view of the development of the capitalist economy might have been influenced by Walras' own analysis: "It is generally believed that Schumpeter's hallmarks were the terms 'entrepreneur', 'innovation', and 'new combination'. However (...) these phrases were incorporated in an idea that had already been strongly emphasized by Walras and were, if anything, a direct extension of Walrasian concerns with the importance of the entrepreneur". The indispensable Walrasian starting point of Schumpeter's analysis is also identified in Schefold (1986). For Hodgson (1993), in turn, Schumpeter's work is in fact an extraordinarily and ultimately unsuccessful attempt to reconcile statics and dynamics; it forms an adjunct of Walrasian equilibrium, and represents an ostensible but ultimately unsatisfactory attempt to reconcile general equilibrium theory with notions of variety and change.

ing one, his notion of innovation is much broader than the prevailing one. As Vercelly (1991:205) pointed out, from a Schumpeterian standpoint circular flow encompasses not only the stationary state, but also steady growth, the reason being that, in the latter, Schumpeterian structural change is absent and the dynamic behavior of the system is continuous and exogenous.

Besides, it is worth recalling that Schumpeter (1912:74-5) used the term entrepreneur in a quite precise sense, namely, to refer to those economic agents who actually carry out innovations. While capitalists that do not innovate are not to be considered entrepreneurs, workers could, provided they performed the task of carrying out innovations. When characterizing Schumpeter's entrepreneur, therefore, one has always to keep in mind that his theory of the entrepreneur is part of a theory of the process of capitalist development. Schumpeter's entrepreneur is not placed within a static theory of equilibrium or disequilibrium; entrepreneurs are seen as economic agents whose functions are the carrying out of new combinations, the creative destruction of equilibria, thereby preparing the ground for a superior state of equilibrium.<sup>6</sup> Central to Schumpeter's view of the capitalist economy is thus the cogent notion of the dynamics of the market process, the market being something more than a signaling device for the efficient allocation of scarce resources. Rather, the market is a *locus* of radical change that pushes firms to innovate, and the economy to grow and change structurally. It is in this sense that market competition is the very realm of creative destruction in which firms grow, survive, or die; firms that are able to innovate or adapt will grow or survive, while others will be superseded and dethroned.

Finally, unlike the circular flow, money and credit play a quite essential role in the process of development. In particular, Schumpeter (1912:69) underlined that credit is primarily necessary to new combinations or innovations, so that it is from these that it forces its way into the circular flow. The reason is that credit creation makes possible a rapid redistribution of resources in favor of innovators, thus enabling them to withdraw the resources which they need from their previous employments (1912:106). In stationary circular flow, savings, interest and profits are absent, and since the economic process is synchronized, there are no stores of money, and credit may be neglected. As Schumpeter (1928:380-1) detailed elsewhere, money affects production, therefore, only in the context of the development process, and only in the restricted sense of credit creation for financing innovations. In the circular flow, not only the role of money but also the role of credit would be a subordinate one, for everything fundamental about the economic process could be explained in terms of goods, money merely giving a different aspect to phenomena whose analysis would be complete even without its intervention. In that case, production could and would be financed substantially by current gross revenue, and only small discrepancies would need to be ironed out. The process of development, in turn, would be inconceivable without credit creation, for as "innovation, being discontinuous and involving considerable change and being, in competitive capitalism, typically embodied in new firms, requires

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<sup>6</sup> In Schumpeter's (1939) contribution to the theory of business cycles, it is argued that technical innovation is not a separate phenomenon, but, on the contrary, is a crucial factor in the explanation of business cycles and the dynamics of economic growth. Indeed, Goodwin (1993) sustained that Schumpeter was the pioneer in the analysis of the dynamics of the modern industrialized economies. For Goodwin, when Schumpeter noted that the cycle is simply the form that growth takes, he made one of the most profound contributions to the understanding of the vicissitudes of contemporary societies.

large expenditure previous to the emergence of any revenue, credit becomes an essential element of the process" (1928:380).<sup>7</sup>

To put it more precisely, Schumpeter began with an economy in a state of stationary equilibrium in which all production factors are fully employed, neither net investment nor net saving take place, and the interest rate as well as the profit rate equal zero. Now some clever people, dubbed entrepreneurs, find out that profits may be reaped by introducing some new combinations different from those currently in use. Such entrepreneurs must have rare properties, such as alertness, determination, and strength to overcome resistance against innovations. But the most important thing they need is capital to introduce the new combinations by reshuffling the flows of current resources use; and in an economy based on the division of labor and on private property such transfer is caused by a squeeze of the purchasing power held by old producers. Once entrepreneurs have the needed capital, the reshuffling of the direction of resource flows is readily done by diverting resources, through pressure of market competition, from their current use in stationary equilibrium. This capital, however, cannot be squeezed out of the stationary economy, for there is no planned net saving, so that the only way to endow those entrepreneurs with the necessary capital is by means of fiduciary credit created by the banking sector. Therefore, the introduction of new combinations inevitably brings about a concomitant process of credit inflation and thereby forced saving, for those entrepreneurs are additional demanders of resources without immediately contributing to the economic pie; the greater quantity of means of payment is not readily, but only in a second stage, covered by a new production.

Moreover, the new combinations do not replace the respective old combinations at once, but establish themselves beside the old combinations and compete with them. Now, as soon as goods are produced under the new combinations, prices and profits are comparatively high, thus inducing more entrepreneurs to imitate the new combinations, which increases competition and forces prices down. Furthermore, as soon as entrepreneurs get financial receipts from the new production, they are able to repay their debts. This means the reduction of fiduciary credit and thus causes a credit deflation which reinforces the decrease in prices; therefore, a deflation is nothing else than an accompanying phenomenon of the economy approaching a new equilibrium in which prices again just cover costs. This process of deflation eliminates not only the old combinations, whose costs rose during the boom and whose returns fell during the depression, but also the entrepreneurial profits themselves. In the new equilibrium, the latter accrue to the owner of primary factors (workers and landlords) either directly, as higher factor remunerations, or indirectly, as lower equilibrium prices leading to increased purchasing power of those remunerations. In Schumpeter's view, this process of creative destruction is essential for the performance of capitalism, in the sense that it is an inherent attribute of the increase of economic efficiency over time.<sup>8</sup>

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<sup>7</sup> For Vercelli (1991:202), both Schumpeter and Keynes based their attack against monetary orthodoxy on a fundamental dichotomy. In Schumpeter's case, the opposition was between circular flow and development, whereas Keynes focused on the distinction between cooperative economy and monetary economy. In both cases, the first term is meant to define the scope of validity of the received view; the validity of the monetary orthodoxy is not altogether denied, but it is restricted to the concept of circular flow or cooperative economy. A fuller discussion of Keynes' distinction between cooperative economy and monetary economy can be found in Lima (1993a). Such similarities notwithstanding, Skidelsky (1992:704), in the second volume of his admirable biography of Keynes, mentioned that Schumpeter and Keynes thought each other a bit of a charlatan!

<sup>8</sup> As Bellofiori (1985) cogently suggested, Schumpeter in fact broke with the traditional view in a much more fundamental way. Using the argument that interest is zero in the circular flow, Schumpeter cut the relationship, posed by Austrian economists like Böhm-Bawerk, between time and interest. Schumpeter defined capital not as a means of production, but as a fund of purchasing power which can be created *ad hoc*. Interest, therefore, could no longer be seen as a real but as a monetary phenomenon.

### 3. Schumpeter after the neo-Schumpeterians

Having outlined Schumpeter's distinction between circular flow and development, I now turn to the interpretation and extension of Schumpeter's approach that has been developed by several authors associated with the neo-Schumpeterian school. The natural place to start is the classic work by Nelson and Winter (1982), which, more than any other single work, triggered off a modern discussion around Schumpeterian issues. Overall, the book can be seen as a frontal attack on the hard core of the neoclassical method, and a suggestion of an evolutionary, neo-Schumpeterian alternative. Nelson and Winter (hereafter NW) dispensed with all components of the standard maximization model, namely the global objective function, the well-defined choice set, and the maximizing choice rationalization of firms' actions.

For NW, the economic system is dynamic in character, and dynamic processes are inherently uncertain with regard to their outcomes. This makes it impossible for a firm to approach decision making with the intention of maximizing some static function, such problem of uncertainty being even more evident when making decisions regarding innovation and technical change. Instead, NW depict a firm's regular and predictable behavior as routines that play the same function for the business enterprise as genes do for the biological organism (1982:14). Hence, decision making on the firm level is, to a large extent, caused by routines that are actually the result of learning processes over time. As such routines are used in the daily practice of the firm, they are apt to undergo change, which means that the characteristics of the prevailing routines may be understood by reference to the evolutionary process that has molded them.

In fact, NW themselves inherited a body of knowledge from previous economists. From Herbert Simon they acquired the notions of bounded rationality and satisficing, which they used to build models of search and selection. From Schumpeter they acquired a workable framework for structural change. Adding the essential ingredient of routines, they were then able to construct models and theories of evolution. The better routines, which are introduced first as innovations, are selected by the environment and then propagated by replication (within a firm) and imitation (interfirm), thus leading to differential survival (via profitability) of firms. Through the process of market competition, the better rules survive, routines thus providing the analytical link between Simon and Schumpeter. In a word, routines function as the coordinative element in a firm, in this way allowing its continuity in an environment that undergoes incessant change.

It is noteworthy, however, that the target of their attack on the hard core of neoclassicism is circumscribed, for even though they disagree with casting firm behavior as the outcome of a global constrained maximization, they do not comment on the appropriateness of the characterization of the consumer (Mirowski, 1988:161). Their indictments of maximization are:

- a) processing information is itself costly;
- b) perfect knowledge of the underlying structure of the economy is unrealistic;
- c) all behavior that is fully preplanned is not consistent with free choice;
- d) maximization ignores firm decision-making structures;
- e) global probability statements cannot analytically encompass novelty and surprise.

As Mirowski (1988:162) cogently pointed out, even though neoclassical economists already have well-developed responses to this sort of criticism (e.g., Boland, 1981), a much more

damaging indictment of maximization, is delivered by NW: the defense of maximization, based on the notion that there is some form of selection that weeds out firms that do not behave as if they maximize, cannot be undertaken on purely logical grounds. For NW, one can conceive many plausible situations in which the mean survivor need not be a maximizer, or even particularly efficient from some global standpoint. In fact, Iwai's (1984b) interesting contribution to this literature (to be discussed later) is, among others, the delivery of a carefully developed mathematical model showing that when firms are allowed to innovate in their technology, the selective force of market competition is no longer capable of weeding out the less fit even in the long run.<sup>9</sup>

Another valuable contribution by NW is an extension of Schumpeter's notion that competition is a dynamic process. For Schumpeter, a central aspect of dynamic competition is that some firms deliberately strive to be leaders in technological innovations, while others attempt to keep up by imitating the success of the leader. Following Schumpeter, the evolutionary approach developed by NW conceives the economic problem in a way fundamentally different from the neoclassical one. The latter views choice sets as known and given, so that the economic problem is to pick the best possible production and distribution, the function of competition being to get the signals and incentives right. In NW's evolutionary approach, in turn, choice sets are not given and the consequences of any choice are unknown. Although some choices may be clearly worse than others, there is no choice that is clearly best *ex ante*. In this context, competition emerges as a selective process, one of its functions being to reward and enhance the choices that prove good in practice and to suppress the bad ones.

In order to formalize some of Schumpeter's insights, NW devised a simple model to discuss some of the ways by which market structure and technical progress are linked to other aspects of industry performance. In their model, firms may differ in their policies toward innovation and imitation, which are defined in terms of expenditure on these kinds of R&D per unit of capital. Both kinds of R&D are modeled as a two-stage random sampling process. The probability that a firm may take a draw on the set of innovation possibilities or on the set of imitation possibilities is proportional to the firm's average expenditures on these kinds of R&D. While an innovation draw is a random sampling from a probability distribution of technological alternatives, an imitation draw will, with certainty, enable the firm to copy the prevailing best practice.

An interesting conclusion derived by NW is that a more competitive industry structure does lead to a poorer productivity performance than does an industry that is more concentrated, but the reason is not the one commonly associated with the so-called Schumpeterian hypothesis — that best-practice technology evolves more slowly in the more competitive case than in the more concentrated case (Schumpeter, 1942).<sup>10</sup> Rather, it is that there is a larger

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<sup>9</sup> An interesting outline of the key neoclassical idea that evolutionary selection will favor maximizing agents or firms can be found in Hodgson (1990), who concluded that it would be rash to assume that natural selection will usually lead to fitter, more efficient and maximizing firms. Indeed, the very conception that maximizing behavior does provide the core notion of a single, all-encompassing microfounding framework for macroeconomics is highly problematic on methodological grounds. A fuller discussion of this issue is found in Pereira and Lima (1995).

<sup>10</sup> Rigorously speaking, the so-called Schumpeterian hypothesis states that monopoly firms are eventually more likely to be innovative. Such hypothesis was effectively set out in a few key chapters of Schumpeter (1942), even though there are undoubtedly hints in Schumpeter (1939) and in a 1934 review of Joan Robinson's *The economics of imperfect competition*. In Schumpeter (1942:101), for instance, it is suggested that "there are superior methods available to the monopolist which are either not available at all to a crowd of competitors or are not available to them so readily: for there are advantages which, though not strictly unattainable on the competitive level of the enterprise, are as a matter of fact secured only on the monopoly level, for instance, because monopolization may increase the sphere of influence of the better, and decrease the sphere of influence of the inferior, brains, or because the monopoly enjoys a disproportionately higher financial standing".



gap between best practice and average practice in the case where industry capital is fragmented than there is in the case where it is more concentrated. Other interesting conclusions from Nelson and Winter's model are:

- a) already concentrated industries remain concentrated, although the actual exercise of market power by the larger firms may be an important factor in tending to limit the growth of concentration in the industry;
- b) relatively concentrated industries provide a better shelter for R&D than atomized industries do;
- c) industries with rapid technical progress ought to be marked by high average R&D intensity and, as the industry matures, by a more concentrated industry structure than industries in which technical progress is slower;
- d) skilful and aggressive imitators can compete successfully with innovative R&D performers.<sup>11</sup>

An interesting theoretical approach to technical change which takes the NW analysis further is that of Dosi (1984). While sharing the NW view of the firm, Dosi goes further in stressing the importance of private appropriability in innovative activities. In his view, private appropriability and technological opportunities are the two most fundamental conditions of innovative activity of capitalist firms. Dosi's is a theoretical analysis of the patterns of technical change in modern economies with an illustrative case study on the semiconductor industry. Its general task is the explanation of the complex determinants, procedures and directions of technical change, and its effects on industrial performance, structural change and international trade. To that end, Dosi introduces the interesting notion of technological paradigms, which define clusters of technological trajectories of progress. In this view, scientific advances together with several institutional factors contribute to determine the timing and the nature of new paradigms, while market competition in fact plays the role of an important selection mechanism.<sup>12</sup>

As a consequence, innovative activities display varying degrees of private appropriability and determine the patterns of lags and leads between firms, such technological asymmetries between firms playing a paramount role in explaining industrial performance. For Dosi, a reversal of the assumptions of traditional industrial economics is thus in order: instead of starting from an assumption of identity between all firms and then introducing oligopolies as a complication, one should rather begin from the opposite assumption. As technical change makes every firm markedly different, a competitive environment is that particular case

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<sup>11</sup> Though the contribution by NW has, more than any other, triggered off a modern revival of Schumpeterian analyses, reference should be made to the contemporaneous work by Rosenberg (1982), which also helped to set the research agenda for later neo-Schumpeterian contributions. Based upon Schumpeter's distinction between invention, innovation and diffusion, Rosenberg (1982) forcefully argued that many improvement inventions and innovations take place during the process of diffusion itself, as a result both of user experience and of competition between suppliers. Moreover, Rosenberg (1976) had already investigated the effect of different patterns of technical change on the evolution of industrial structures along Schumpeterian lines.

<sup>12</sup> Dosi credits Freeman (1979) with being the first to suggest independently an analogy between science and technology in Kuhnian terms. Indeed, Dosi's is also a further elaboration of the notion of natural trajectories of technological progress advanced in Nelson and Winter (1977) and of the notion of technological regime advanced in Nelson and Winter (1982).

whereby the forces of technological diffusion are powerful enough to wither away innovation-based asymmetries. Dosi's formulation therefore constitutes a frontal attack on the neo-classical theory of the firm, in the sense that it clearly shows that it is both empirically unsound and theoretically untenable to start from the naive assumption that all agents are equal in their access to technology and in their capacity to carry out innovations. On the contrary, any satisfactory model of firm behavior must start from the assumption of a markedly high degree of inequality and variability, in addition to the pervasive uncertainty about the future, already recognized in the seminal work by NW discussed earlier.

More recent conceptual contributions to the neo-Schumpeterian literature can be found in the volume edited by Dosi et alii (1988). The work is presented by the editors as an exploration of a new, evolutionary approach to economic theory, capable of incorporating technical and institutional change into the mainstream of economic analysis and policy-making, rather than treating it as part of the rag-bag of residual or exogenous factors. The main features of this new, evolutionary approach is then summarized as follows. First, technological change is a fundamental force in shaping the patterns of transformation of the economy. Second, there are some mechanisms of dynamic adjustment which are radically different in nature from those allocative mechanisms postulated by the orthodox theory. Third, these mechanisms have to do both with technical and institutional change or the lack of it. As regards the former, it is suggested that it is both disequilibrating and a source of order for the directions of change and the dynamic adjustment processes. Finally, the social-institutional framework always influences and may sometimes facilitate and others retard a given dynamic process of technological and structural change; these acceleration and retardation effects relate not simply to market imperfections, but to the very nature of the markets themselves.

Even though the authors included in the volume recognize that the main source of intellectual inspiration for their work has been the pioneering contribution by Schumpeter, they argue that the latter, his quite insightful contributions notwithstanding, was indeed only partially successful in his endeavor, and this was so for the following reasons. First, he made rather poor use of economic statistics and, as he himself was at pains to emphasize, he only made the first attempt to open up some of the major problems. Second, he paid little attention to what would now be called the Third World. Although he certainly stressed the role of technological competition, he did not really extend his analysis to the case of international trade or international diffusion of technology. Third, he never formalized his models, which may well have helped the richness of his theory but did not help the exploration of the coherence and consequences of his propositions. Fourth, although he pioneered the study of the relationship between technological revolutions and long cycles of economic development, he did not really develop any satisfactory theory of depressions. Fifth, Schumpeter had little to say about government policies for industry, technology and science, or the relationship between industrial research, universities and government institutions and development. Finally, it is hard to reconcile Schumpeter's views on innovations, economic dynamism, and partial monopolistic appropriation of technological advances with his other view that equilibrium could still be defined in Walrasian terms. In this context, it is argued that though a constructive critique of Schumpeter is the starting point of the works contained in the volume, they have tried to go well beyond him in many respects.

In that volume, particularly interesting is the contribution by Dosi and Orsenigo (1988). They are concerned with the inherent uncertainty associated with technical innovation and argue forcefully against any theory which is predicated upon "hyper-rationality" on the part of representative agents. Following the distinction suggested by Heiner (1983), they argued

that due to the specific features of the innovation process, one should expect to find innovative environments showing both an information gap (imperfect information) and a competence gap, in that the capability of efficiently processing the available information is heavily constrained by the complexity of the causal links characterizing the environments to which the information refers.<sup>13</sup> In their view, though, technical change, the great diversity of its sources and dynamic implications notwithstanding, is not a purely random process. More precisely, there are regularities in the pattern of technical change which have been analyzed in empirical studies and which may account in part for the relatively stable pattern of growth.

Following Dosi (1984), they referred to the existence of technological trajectories and technological paradigms which provide opportunities for innovative investment and growth of new markets over relatively long periods, along rather well-defined paths of development and diffusion. At the microlevel, order in this context refers to the characteristics of learning processes and the properties of a sort of Evolutionary Hand. Like the competitive Invisible Hand, it entails a competitive market process which relates prices to costs of production and moves economic resources from low-return to high-return employments. However, the classic Invisible Hand, under the conditions of rather fast technical change, increasing returns, environmental complexity, *inter alia*, is quite crippled and too weak to keep the system in some sort of order while it grows and changes. The Evolutionary Hand, in turn, also selects and orders the diversity always generated by technological and institutional change. Moreover, it is more powerful because it is not entirely invisible, but is forged within visible (indeed often dominant) technologies and institutions: it not only selects *ex post*, it also teaches and guides *ex ante*.

As regards the idiosyncratic nature of the innovative processes, an interesting contribution to the neo-Schumpeterian paradigm was provided by Dosi (1988), in which innovation is broadly seen as concerning the search for, and the discovery, experimentation, development, imitation and adoption of new products, new production processes and even new organizational set-ups. In his attempt at organizing and interpreting an increasing empirical evidence on the sources, procedures and microeconomic effects of technical change, Dosi detected the following stylized facts on innovation processes.

First, what is searched for cannot be known with precision *ex ante*. Certainly, whenever innovation is undertaken by profit-motivated agents, it must involve also some sort of perception of yet unexploited opportunities. However, such perceptions and beliefs rarely entail any detailed knowledge of what events will happen to be, thus rendering innovation an inescapably uncertain process.

Second, a distinctive property of contemporary innovations is an increasing reliance of new technological opportunities on advances in scientific knowledge.

Third, the increasing complexity of technological research and innovative activities militates in favor of more formal organizations (universities, government laboratories, firms'

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<sup>13</sup> It is worth noting that Solow (1994:52), in assessing some recent developments in neoclassical growth theory, underlined the large uncertainty that surrounds many research projects and innovative activities as follows: "it is possible that some of this uncertainty is not probabilistic: if 'Knightian uncertainty' shows up anywhere, it could be here. If so, then appropriate analytical techniques are lacking". In the same vein, Griliches (1994:18) admitted that though the rate and direction of inventive activity, and the diffusion of innovations, are subject to economic influences and analysis, "the outcome of inventive activity is not really predictable. True 'innovation' is an innovation. If it were knowable in advance, it would not be one, and the innovators would not be able to collect any rents. In that sense it is futile to expect that we could control it fully or predict it well". On my part, I would argue that the presence of fundamental uncertainties in innovation activities should not be taken to imply that we are unable to derive its *ex post* macroeconomics implications in terms of growth and distributional dynamics. Indeed, neither Dosi and Orsenigo nor Solow nor Griliches seem to be suggesting such a nihilistic position.

R&D laboratories etc.) as opposed to individual innovators as the most conducive environment to the production of innovations.

Finally, empirical evidence seems to suggest that the patterns of technological change cannot be described as simple and flexible reactions to changes in market conditions:

- a) despite significant variations with regard to specific innovations, it seems that the directions of technical change are often defined by the state-of-the art of the technologies already in use;
- b) quite often, it is the nature of technologies themselves that determines the range within which products and processes can adjust to changing economic conditions;
- c) it is generally the case that the probability of making technological advances is, among other things, a function of the technological levels already achieved by them; in a word, technical change is a cumulative activity.

With a view to provide an interpretation of the complex relationship between technical innovation and scientific advances and market structures, Dosi then further elaborated on the twin concepts of technological trajectories and technological paradigms introduced by him in 1984. While a technological paradigm defines contextually the technical needs that are meant to be fulfilled, the scientific principles utilized for the task in question, and the material technology to be used, a technological trajectory is the activity of technological progress along the economic and technological trade-offs defined by a paradigm. It is noteworthy that Dosi admitted that this does not imply the complete irrelevance of the inducement mechanisms to changes of techniques stemming from the levels and changes in relative prices, or from changing demand conditions. On the contrary, he argued that these factors are likely to be fundamental, influencing both the rate and direction of technological progress, but within the boundaries defined by the nature of technological paradigms.<sup>14</sup>

Moreover, Dosi argued that such an interpretation of the innovative process is useful to the understanding of the inter-industry differences in the modes and degrees of innovativeness. Dosi's main conclusion is that the observed differences, over sectors and over time, in the rates and modes by which innovations are generated, diffused and used, trace them back to both inter-sectoral and inter-temporal differences in the opportunities of innovation that each paradigm entails, the degrees to which firms can obtain economic returns to various kinds of innovation, i.e., the degree of appropriability of innovation, and the patterns of demand that firms face.<sup>15</sup>

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<sup>14</sup> Based upon Dosi's (1984) original notion of technological paradigm, the broader notion of technological regime was recently proposed by Malerba and Orsenigo (1993) to define a specific combination of opportunity and appropriability conditions, degrees of cumulativeness of technological knowledge, and characteristics of the relevant knowledge base. Building on this broader notion of technological regime, Dosi, Malerba and Orsenigo (1994) develop an interesting analysis of evolutionary regimes and industrial dynamics.

<sup>15</sup> More recent and rather specifics-oriented contributions to the evolutionary view appear in the volumes edited by Dosi, Giannetti and Toninelli (1992), and Foray and Freeman (1993). The former present several pieces dealing with the microeconomics of industrial development through technological change and with some sectoral and national evidence on the links between the process of technological innovation and the institutional changes in the form of corporate organization. The latter, in turn, present pieces discussing topics such as: the role of basic research in national competitiveness as well as in the general advance of worldwide technology; the role played by structural interdependencies in the dynamics of invention and innovation; and the relationship between technological trajectories and organizational structure, in particular as far as so-called national systems of innovation are concerned. On the latter notion, which is an analytical device intended to portray the distinct national flavor of different countries' technological basis, see also Lundvall (1992) and Nelson (1993).

#### 4. Modeling Schumpeter

Having outlined some neo-Schumpeterian, evolutionary conceptual extensions of Schumpeter's framework, I now turn to some recent attempts to formalize some of those insights on the dynamics of technical change and innovation. The natural place to start is the interesting contribution by Iwai (1984a, 1984b), which is devoted to the development of a simple evolutionary model of innovation and imitation along the lines suggested by NW. More precisely, Iwai's (1984a) main purpose is to analyze how dynamic interactions between the equilibrating forces of imitation and the disequilibrating forces of innovation are likely to mold the evolutionary pattern of an industry's state of technology. His major conclusion is that in such a Schumpeterian, evolutionary environment, an industry will never approach a neoclassical equilibrium with perfect knowledge even in the long run.

Basically, the disequilibrating forces of innovation come from the fact that it generates a temporary market power (and a corresponding monopoly profit) for those who carried it out. The equilibrating forces of imitation, in turn, come from the fact that once imitation by competitors starts taking place, those monopoly profits start being wiped out, thus driving the system back to a stable trajectory. Meanwhile, though, new innovations are carried out, thus keeping the system in a permanent state of disequilibrium. In other words, while firms' imitation activities constitute an equilibrating force of technology which tends the industry's state of technology (not uniformly but logistically) toward a neoclassical equilibrium in which all the firms have full access to the most efficient production method available, the function of innovation lies precisely in upsetting that equilibrium tendency. Indeed, it is shown how the opposite forces of innovation and imitation will work hand in hand to generate a certain statistical regularity in the way in which the relative configuration of the distribution of efficiencies across firms develops itself over time.

Thus, Iwai's (1984a) framework for discussing the evolutionary process of creative destruction places the phenomena of innovation, imitation and growth, not as equilibrium outcomes of the far-sighted choices of optimizing economic agents, but as dynamic processes moved by complex interactions among firms which are permanently striving for both survival and growth by their competitive struggle against each other. Indeed, underlying Iwai's work is the notion that, even for the analysis of such long run phenomena, it is fundamental to begin with the study of disequilibrium processes working at the microlevel of firms and then to trace out carefully the manner in which they interact with each other and cause the aggregate economy to move from one position to the next. It was this framework, on the other hand, that led Iwai (1984a) to conclude that the state of technology of an industry will be in perpetual dynamic disequilibrium under the Schumpeterian hypothesis of innovation and imitation.

Iwai (1984b), in turn, introduced the notion that firms successful in innovation and imitation grow relatively faster than less successful ones, and studied how the interplay of the process of firm growth and the process of technological innovation mold the evolutionary pattern of the industry's state of technology. As I mentioned earlier, the doctrine of economic selection insists, by means of the analogy to the biological theory of natural selection, that only the most efficient firms will survive the long run competitive struggle for capacity growth; indeed, if neither innovation nor imitation is possible for firms, a firm or group of firms which is lucky enough to start with the most efficient technology will outgrow all the other firms in the long run. But as Iwai (1984b) pointed out, once the possibility of technological imitation is allowed for the firms, the industry will settle down to a static equilibrium of perfect technological knowledge, not by the success of the most efficient firms in their striving for the higher growth rates, but by the success of the less efficient in their effort to imitate the others.

In other words, as soon as the possibility of technological imitation by relatively high cost firms is taken into account, the logic of economic selection loses much of its effectiveness. It is true that the lowest cost firms will monopolize the whole productive capacity in the long run, but the force of technological imitation will eventually allow all the existing firms to join the rank of the lowest cost firms. Indeed, it is the very expansion of the productive capacity of the lowest cost firms — their own success — which necessarily invites the vigorous imitation activities of the less fortunate ones and betrays their own bids for the dominance of the whole industry.

Besides, when firms are also allowed to innovate in their technology, the selective force of market competition is no longer capable of weeding out the less fit even in the long run, for a spectrum of production methods with diverse unit costs will forever coexist in the industry, which means that not only the fittest but also the second, third, forth..., actually the whole range of the less fit will survive in the long run. The force of economic selection working through the differential growth rates among firms with different unit costs is constantly outwitted by the firms' imitation activities, so that the processes of growth, imitation and innovation will interact with each other and work only to maintain the relative configuration of the industry's state of technology in a statistically balanced form in the long run. Indeed, Iwai's model shows that the dynamic interplay of the processes of innovation, imitation and growth not only will keep the industry's state of technology from settling down to the static equilibrium, but will reproduce in the long run a relative dispersion of efficiencies across firms in a statistically balanced form.

Soete and Turner (1984), in turn, emphasized that the complex process of diffusion of innovation is as important as its occurrence. In their view, the fundamental reason for delay in adopting an innovation — the so-called retardation factors — is related to uncertainty and lack of information about the new technology and the often proprietary nature of the new technology. Unfortunately, they maintain, most of the literature on growth theory has ignored the strategic contribution of technology diffusion on the rate of technical progress. Even though technological change is no longer treated as an unexplained residual, the actual diffusion is simply assumed to be instantaneous across total capital, or, in the best case, limited by the investment rate, as in the vintage growth models. In this context, Soete and Turner's purpose is to attempt to deduce from the readily understandable concept of technical progress at the microlevel, i.e., the adoption and diffusion of new technologies, the more nebulous concept of the rate of technical progress.

To put it directly, what their model shows is that there are two contributions to this rate, one is the weighted average of the microdisembodied technical progress, whilst the second represents the contribution of the diffusion of innovations. The latter's contribution, in turn, is found to be a function of the distribution of the rates of return of the different technologies in use. As regards the dynamics of such a system, the main conclusion derived by the authors is that if diffusion is rapid, and new innovations occur only once this process is completed, then the economy can indeed be thought of as "more or less" in a position of equilibrium. On the other hand, if the diffusion process is slow and new innovations are more or less continuous, then equilibrium will rarely occur.

As far as international trade is concerned, Schumpeter's contention that technological competition is more important than price competition, with invariant conditions of production, has found increasing confirmation from empirical and theoretical work in the sphere of international trade. In this context, reference should be made to the innovative contribution by Dosi, Pavitt and Soete (1990), which discusses the role played by the dynamics of increas-

ing returns, particularly those associated with production technology and innovation, in international trade. Their evolutionary analysis starts from differences of technological capabilities and innovativeness and then focuses on the effects of such differences on international patterns of trade and growth. Their purpose is to develop a model of international trade in which the fundamental feature is the existence of international technology gaps, by which are meant differences in innovative capabilities, in the sources and uses of innovations, in corporate strategies, and in institutional conditions that contribute to determine these gaps.

According to this interesting formulation, technological gaps are of fundamental importance in explaining the participation of each country in international trade flows as well as in international differences in income levels. Moreover, Dosi, Pavitt and Soete present empirical evidence showing that the both wide and persistent differences in per capita income stem primarily from the joint effect of international differences in the degrees of capital accumulation and in technology, rather than from differences in relative prices only (or distortions in the price mechanism), as it is the case either in the Heckscher-Ohlin pure trade model or in the so-called new trade theory (e.g., Helpman & Krugman, 1989; Krugman, 1990). Technology gaps are therefore of paramount importance in determining the participation of each country in international trade flows and, through that, the maximum levels of income that each country can attain, compatible with the foreign balance constraint.<sup>16</sup>

Silverberg (1988), in turn, attempted to enumerate the various concepts of the overarching self-organization framework, while forcefully arguing for their relevance to the analysis of economic development and technological change. To put it briefly, the theory of self-organization deals with complex dynamic systems open to their environment in terms of the exchange of matter, energy and information, and composed of a number of subsystems. The behavioral environment and the individual subsystems are seen as undergoing a process of mutual coevolution which may admit a determinate joint outcome. Within certain domains, specially in the neighborhood of a structural instability, these complex interactions can often be represented at an aggregate level by a small number of order parameters which summarize the net result of the complex of feedbacks constraining the behavior of the subsystems.

Furthermore, many such systems have been demonstrated, both experimentally and theoretically, to lead to the quite spontaneous emergence of coherent macroscopic structures from the seemingly uncoordinated and erratic behavior of the component parts at the microscopic level. Among the reasons that make the concept of self-organization of interest to the analysis of economic development and technical change, Silverberg mentioned the growing recognition on the part of economists that both the mathematical richness and the empirical realism of the study of dynamical systems in fact increase immeasurably when the focus shifts to intrinsic non-linearities. In addition to self-sustaining cycles, non-linearity introduces the very possibility of systems with multiple equilibria, bifurcation of solutions of various types, and deterministic chaos, all features that in turn play an essential role in the mathematical theory of self-organization and evolution.

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<sup>16</sup> Soete's (1981) is an early empirical confirmation of the neo-Schumpeterian notion that neotechnology theories have much greater explanatory power in relation to international trade performance than the standard Heckscher-Ohlin factor proportions theory. Indeed, the neo-Schumpeterian casts some doubts on the natural selection argument through international competition. To what extent such liberating neo-Schumpeterian message has been ignored as Brazil submits its arrangements to natural selection via greater international exposure, this is an issue that goes beyond the scope of this review essay. See Fagerberg (1994) for an excellent theoretical and empirical survey of the fundamental role played by technological progress and technology diffusion in the persistence of international differences in growth rates.

Along more neoclassical lines, Aghion and Howitt (1992) developed a model of endogenous growth in which vertical innovations, generated by a competitive research sector, constitute the underlying source of growth. In their model, equilibrium is determined by a forward-looking difference equation, according to which the amount of research in any period depends upon the expected amount of research next period, and one source of this intertemporal relationship is creative destruction; that is, the prospect of more future research discourages current research, by threatening to destroy the monopoly rents created by the latter. More precisely, each innovation consists of a new intermediate good that can be used to produce final output more efficiently than before, research firms being motivated by the prospect of monopoly rents that can be captured when a successful innovation is patented. But those rents, in turn, will be destroyed by the next innovation, which will render obsolete the existing intermediate good.

In this context, the average growth rate and the variance of growth rate are increasing functions of the size of innovations, the size of the skilled labor force, and the productivity of current research, as measured by a parameter indicating the effect of research on the Poisson arrival rate of innovation; and decreasing functions of the rate of time preference of the representative individual. The main conclusion derived by Aghion and Howitt is that under *laissez-faire* such growth rate may be more or less than optimal because, in addition to the appropriability and intertemporal spillover effects of other endogenous growth models, which tend to make growth slower than optimal, the model also has effects that work in the opposite direction. In particular, the fact that private research firms do not internalize the destruction of rents caused by their innovations introduces a business-stealing effect similar to that found in the partial-equilibrium patent literature. Moreover, when the size of innovations is endogenized, it is found that business stealing also makes innovations too small.<sup>17</sup>

Given the research agenda to be sketchily suggested in the next section, it is also worthy of critical outline the neoclassical analysis of the relation between market concentration and growth recently developed by Smulders and Klundert (1995). Their analysis is put forward by applying some ideas developed in the new growth theory literature, in particular the notion that investment generates knowledge, which in turn can be used in generating further innovations. For instance, investment in the form of R&D expenditure may lead to improvements in existing production processes or product quality, as well as to an increase in experience (knowledge capital), which raises the productivity of future R&D expenditure.

Where these authors deviate from the mainstream view is that they assume, following the neo-Schumpeterian approach, that the accumulation of knowledge is an in-house activity of firms, which is not to deny that firms can learn from each other, but rather that the core of knowledge is firm-specific. Appropriability of firm-specific knowledge can take different forms, but the basic element is some form of tacit knowledge, which is tied to the organization rather than to individuals belonging to these organizations. If R&D is primarily an in-house activity, each

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<sup>17</sup> Also along traditional lines, Caballero and Hammour (1994) investigated the response of industries to cyclical variations in demand in the framework of a vintage model of creative destruction, their premise being that the continuous process of creation and destruction of production units that results from product and process innovation is essential for understanding business cycles. But though they recognize the Schumpeterian pedigree of their model, they do not go so far as to adopt Schumpeter's view that the process of creative destruction is itself a major source of economic fluctuations, as in the equally traditional contribution by Shleifer (1986), for instance. An excellent survey of recent neoclassical models of endogenous technical progress may be found in Grossman and Helpman (1994). For a well-formulated non-neoclassical model of endogenous technical change, the reader is directed to You (1994), who recaptures this important idea from the neoclassical world of intertemporal utility maximization and puts it into the classical-Kaldorian (and more realistic) world of class-based economic behavior.



firm has to do its own share. If there are many firms in an industry, and firms have to compete for the factors of production on an economy-wide scale, each firm will end up with a limited capacity to innovate. As a consequence, there may be a positive relation between growth and concentration on a macroeconomic level even if there is a learning externality which varies positively with the number of firms. However, the number of firms in industry is itself a variable, so that the pace of economic growth and the level of market concentration are interdependent.

More precisely, the specific form of the relation between concentration (i.e., a decline in the number of firms) and the rate of growth depends on the net result of four different effects. First, aggregate consumption expenditure is spread over less products as the number of firms decreases, and this *scale effect* implies a higher rate of return to product-specific R&D investment, for the fixed cost of innovation can be covered by a larger volume of sales. On an economy-wide level, a smaller part of the labor force has to be employed in research activities, so that the economy faces a smaller amount of fixed costs necessary for improvement of the basket of consumer goods. Second, in a more concentrated market structure, firms may have less competitors from which they can learn, which implies that the average productivity of labor employed in R&D, and consequently the rate of return, is lower (*public knowledge effect*). Third, a smaller number of firms also implies that the relative importance of spillovers declines, which means that the learning-by-watching opportunities decline relative to opportunities to learn from own innovations. As a result, the private rate of return for a given rate of innovation is larger, for the firm's own innovative efforts have a larger impact on the total knowledge base (*learning-by-watching effect*). Fourth, concentration may lower the perceived price elasticity of demand by increasing the market share. In a more concentrated market structure, an own price change has a larger impact on the sectoral price index and thus on demand, so that to maximize profits, firms set higher markup rates (*monopolization effect*). Therefore, concentration and growth are linked by three channels, namely concentration impacts the incentive for innovation by affecting the volume of sales per firm (scale effect), by influencing general knowledge spillovers (public knowledge effect and learning-by-watching effect) and by changing competition and markup rates (monopolization effect).

Smulders and Klundert then examined separately the implications, in terms of growth, of increases in concentration due to an exogenous shock, to an endogenous process of free entry in response to international integration, and to mergers among firms. Their model showed that an increase in concentration is, in most cases, associated with a rise in the rate of growth. Starting from a rather high level of concentration, though, further increases in concentration may well harm growth because monopoly power of firms increases significantly, thus reducing the private incentives for innovation relative to profitability of current profits.<sup>18</sup> But however interesting this formulation may eventually be, its focus on intertemporal

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<sup>18</sup> Indeed, there is a neoclassical industrial-organization literature on leapfrogging among firms, the key concern being with the possibility that established monopolists may systematically have less incentive to innovate than potential rivals, and thus may eventually cede technological leadership. In this literature, which was not taken up by Smulders and Klundert, no externalities are usually assumed to exist, in the sense that firms are presumed to be able to establish full proprietary control over any new technology they develop. However, leapfrogging can still arise because of the so-called replacement effect according to which an established monopolist has a somewhat reduced incentive to innovate because he or she is earning rents from the old technology (Tirole, 1988:391-2). Gilbert and Newberry (1982) showed that, in spite of this effect, an established monopolist in a world of complete certainty would still innovate ahead of potential rivals; but Reinganum (1983) has shown that, in the presence of uncertainty, established monopolists may indeed make less innovative effort than their potential rivals, preferring to cash in on the rents from their established position even though they know that these rents will eventually disappear.

allocation in a world of continuous full employment makes it somehow unable to analyze the effective demand effects that are crucial to an understanding of the relation between concentration and growth. The short-run market equilibrium, for instance, requires that total consumption expenditure equals total income from wages and profits, while labor market equilibrium requires that the total (fixed) supply of labor is employed. Besides, the lack of an independent investment function and the assumption that agents have perfect foresight stand in sharp conflict with a neo-Schumpeterian analysis of the role played by innovation in the relation between concentration and growth.

Finally, an issue which is worthy of some discussion regards the extent to which Schumpeter can be looked upon as an evolutionary theorist.<sup>19</sup> As shown above, Schumpeter, of course, looms large in the neo-Schumpeterian, evolutionary literature of today; Nelson and Winter (1982:39), for instance, pointed out that it could reasonably be argued that they are evolutionary economists for the sake of being neo-Schumpeterians. But as Hodgson (1993, ch. 10) forcefully suggested, the invocation of Schumpeter's name by neo-Schumpeterian economists is both misleading and mistaken. In contrast to Schumpeter, the work of these evolutionary modelers is based on a natural selection analogy either of a Darwinian or of Lamarckian kind. For instance, Schumpeter was not concerned with any discussion of why and for what reason certain firms are more able to innovate than others; that is, to what extent firm-specific routines, to use the concept by Nelson and Winter (1982), might be used in this context and perhaps also inherited over time.

In fact, Nelson and Winter interpret those routines as being quite analogous to genes, adopt the idea from Lamarckian biology of the inheritance of acquired characters, draw an analogy to mutation in economic systems, and set up selection mechanisms in their evolutionary economic models. For Hodgson, Schumpeter, in turn, eschewed the natural selection analogy for economics and adopted an entirely different conception of evolution in social science. If there is an implicit natural selection analogy in Schumpeter's writings, in the process of competition for instance, then it enters only by the backdoor, for it is contrary to Schumpeter's explicit intention. Instead, Hodgson goes on, the exciting evolutionary ideas that have emerged with the neo-Schumpeterians have much more to do with Thorstein Veblen and the old institutionalism than with Schumpeter himself.

## **5. Season finale: how might growth theorists proceed further?**

In any case, it is fair to suggest that the neo-Schumpeterian approach is the strand of the non-neoclassical economics that has been paying more systematic attention to the importance of technological change for the dynamics of a market economy. Although there is no complete agreement among their members regarding the actual importance of technical change and innovation — i.e., whether they are the fundamental determinant or an important element of capitalist dynamics —, one should recognize that the neo-Schumpeterian approach has been providing interesting insights about the dynamic implications of endogenous processes of innovation and technological change. In my view, two of these insights deserve careful examination on the part of those interested in providing an adequate explanation for the process

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<sup>19</sup> I am indebted to Phil Mirowski for having suggested me to give some thought to this issue.

of growth and distribution in capitalist economies, and I close this review essay with some comments on them.

First, I would argue that the implications of the Schumpeterian hypothesis are worthy of further theoretical exploration, particular attention being paid to the circumstances under which a more concentrated market structure is actually conducive to higher levels of technological change and growth. An important question that arises here regards to what extent, if any, and under what circumstances, if any, this innovation effect can potentially reverse the correlation between growth and distribution obtained in the Kalecki-Steindl, neo-stagnationist models originally developed by Rowthorn (1981) and Dutt (1984 and 1990), in which an income redistribution toward capitalists is highly deleterious to growth.<sup>20</sup> Even though *prima facie* that hypothesis suggests that innovation effects can eventually reverse that negative correlation between growth and distribution, an important element to be considered is Steindl's (1952) notion that not only is the diffusion of consumer goods dependent on the level of income and its advance, but equally the diffusion of new equipment and production methods in fact depends on effective demand. Needless to say, to sustain that effective demand matters does not mean that we should embrace some naive demand-pull approach to technological change, in which the prime mover is some supposed recognition of needs by the production units in the market, to which their efforts follow in order to fulfill those needs through their technological activities. That such a view is foreign to a neo-Schumpeterian approach is straightforward.

On the other hand, allowing effective demand to play a role would imply to consider the cases of excess and full capacity. In this context, it would be worth trying out the specification of an innovation function which incorporates the impact of excess capacity on the propensity to innovate. Also, it would be worth working out the possible cyclical implications of a non-linear innovation function specifying that the propensity to innovate is higher for either low or high levels of capacity utilization, thus giving a neo-Schumpeterian flavor to the neo-stagnationist view. For low levels of capacity utilization, capital-using innovations would be higher, capital-saving innovations being the case for high levels of capacity utilization. In the same vein, another non-linearity in such innovation function which might eventually lead to some interesting cyclical behavior would be to specify it in a way that makes firms' propensity to innovate low, for either low or high levels of markup.

These two specific non-linearities are suggested by a more general non-linearity, namely one specifying that the propensity to innovate is low for either low or high degrees of market concentration and thus monopoly power. In fact, the rationale for such a non-linear specifi-

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<sup>20</sup> Truly enough, the notion that inequality may eventually be harmful to growth has been recently formalized in the mainstream literature as well. Persson and Tabellini (1994), for instance, combine insights from the theory of economic endogenous growth and the theory of endogenous policy in an argument that runs as follows. Growth is largely determined by accumulation of capital, human capital, and knowledge usable in production, and the incentives for such accumulation hinge on the ability of the individuals to appropriate privately the fruits of their efforts, which in turn depends on what tax policies prevail. In a society where distributional conflict is important, political decisions produce economic policies that tax investment and growth-promoting activities in order to redistribute income. It is argued that the model's implications are supported by the empirical evidence by showing that both historical panel data and postwar cross sections indicate a significant negative relation between inequality and growth. However interesting such contribution might be, it should be noted that income inequality is assumed to be harmful to growth not for intrinsically economic reasons, as in the Kaleckian tradition, but rather due to its political implications. It is the perverse way the political system, rather than the economic sphere, is organized that is to be blamed for inequality being harmful to growth; distributional issues matter, but not for intrinsically economic reasons.

cation would be the following. It is reasonable to assume that as the monopoly power of a firm increases, so does its financial (meaning higher markup rate) and technical (meaning larger scale of production) ability to introduce technological innovations. However, once an optimal level — for the lack of a better word — of market concentration is reached, further increases in the degree of monopoly power of a firm are likely to decrease its urge to update its technical knowledge and its propensity to innovate. On the other hand, a lower markup, to which a higher real wage would correspond, may eventually lead to labor-saving innovations, the demand impacts of which may well reverse the standard neo-stagnationist result that a lower markup increases the growth rate (Lima, 1995).

Indeed, non-linearities of this kind are suggested by the (ambiguous and thus inconclusive) results obtained in the burgeoning empirical literature on the relation between market structure, firm size and technical change. For instance, the empirical literature on the subject in the 60s and 70s tends to boil down to such general statements as there is a market structure intermediate between monopoly and perfect competition most conducive to technological change and innovation. In other words, whether or not a change in the markup rate will lead to the standard neo-stagnationist results now becomes dependent not only on the direction of that change, but also on the prevailing levels of market concentration and thus of markup.

Besides, the inherent formal difficulties associated with a reasonable modeling of the complex relation between market structure and innovation are compounded by some empirical evidence showing that market structure (meaning both firms' size and concentration ratio) cannot be considered as an independent variable, for it is a function of the patterns of technological change as much as the latter is a function of the former. Indeed, it is the incessant process of creative destruction itself, by means of changing the relative balance between firms, which brings about the endogeneity in the degree of monopoly.

For instance, firms that have been successful in innovating tend to grow more rapidly and increase their market power relatively to laggard firms. In addition, changes in the cost of production of the innovating firms are likely to disrupt the very basis upon which the previous distribution of produced quantities among firms was organized, thus putting the innovating firm in a more favorable position to increase output and market share by means of price reductions. In this connection, Iwai's (1984a and 1984b) notion of an industry's state of technology — in which different production methods and therefore costs are distributed across firms — is an alternative that deserves consideration. More precisely, one might consider the possibility of assessing the impacts of innovations on growth dynamics through their cost-reducing influences on markups.

In fact, in Iwai's (1984b) model of the firm growth there are basically two causal mechanisms through which successful innovations lead to the growth of the firm. First, a successful innovation or imitation, by leading to a cost reduction, allows the firm to lower the price of its product. Indeed, the firm may choose to keep the profit margin constant and reduce the price proportionally to the cost reduction, thus lowering the price of its product relative to the less fortunate one, so as to promote the growth of its sales. Second, a successful innovation may allow the firm to increase its profit margin earned on each sales dollar and thus raise the rate of profit on the existing productive capacity.

Such increase in profit rate in turn stimulates the firm's investment in productive capacity, either by influencing the expected profitability of investment projects or, to the extent that capital markets are imperfect, by directly providing an internal fund for investment projects. It is in this sense that I would suggest that there is a great deal of possibility of endowing a neo-stagnationist growth model with a Schumpeterian, cyclical dynamics via such mutual

feedback effects between market structure and firms' propensity to carry out innovations. Under what circumstances such cyclical behavior would lead the system to alternate between wage-led and profit-squeeze growth regimes is another issue worth looking at.

Second, what is also worth working out is Schumpeter's notion that money affects production only in the restricted sense of credit creation for innovation. In Schumpeter's model of economic development, credit-money plays a crucial role, for bank financing of production is a necessary condition if entrepreneurs are to introduce innovations into the economic system. Real and monetary analysis cannot be split in the Schumpeterian system, for the process of economic development can only be started by an *ex novo* creation of purchasing power, an endogenous change in money supply being a very necessary monetary complement to innovation activities. As I detailed elsewhere (Lima, 1992), one of Keynes' major contributions was the notion that market economies are essentially monetary economies, which means that money is not neutral either in short period or in the long period. Hence, a macro-theory of growth along Keynesian lines must necessarily take that notion into account.

A puzzling question that arises here, however, regards what would be the rationale behind a non-neoclassical monetary theory of growth, or, what amounts to the same thing, in which sense money is not neutral in the long period. What seems to be at stake here is through which channels, if any, money affects capital accumulation, so that the question to be addressed is how to ground money non-neutrality on the dynamics of some real variables that are directly crucial for the path of accumulation. As I detailed earlier, one of Schumpeter's major contributions was his emphasis on the importance of technological change for the dynamics of a capitalist economy. His primary emphasis on technological change notwithstanding, Schumpeter also noted that money affects production only in the restricted sense of credit creation for innovation. Hence, while the long period non-neutrality of money is somehow "hanging in the air" in Keynes' analysis, Schumpeter provided an insightful hint for those interested in endowing a non-neoclassical monetary theory of growth with a coherent and consistent story about the mechanisms through which money may not be neutral in the long period.

Sketchily enough, a formal model which could possibly analyze the logical connection between credit-money and innovation is one in which an endogenous mechanism of credit creation through a forced redistribution of income in favor of entrepreneurs makes possible a higher rate of innovation, and a possible alternative would be to use an innovation function in which a higher markup would speed up innovations along the lines of the Schumpeterian hypothesis. But as I argued above, a crucial issue here is to what extent, if any, such a positive effect of a higher markup could offset its negative demand impacts in terms of redistributing income from a low-saving propensity class. In fact, a crucial element to be taken into account is that both the carryout and diffusion of innovations depend not only on the availability of finance, but also on effective demand. Another possibility would be to make decisions of investment in innovations dependent on the debt position of the firms, thus providing a link between those decisions and the rate of interest in the context of a model with endogenous money. More precisely, such a model would capture the idea that a higher markup, by increasing prices, would cause a redistribution of income from creditors (e.g., rentiers) to net debtors (e.g., entrepreneurs) by lowering the real interest rate, given an exogenously fixed nominal interest rate.

In this model, it might be useful to incorporate a rentier class whose real stock of wealth grows according to its rate of saving, which implies that the mechanism of forced saving just described would redistribute income from rentiers to those entrepreneurs who carry out in-

novations. Indeed, Goodwin's (1967) dynamic framework would be a quite natural candidate for modeling a situation in which conflicts of interest between innovative entrepreneurs and rentiers could lead the economy to behave in a cyclical way; in fact, one might well consider the possibility of formalizing the Schumpeterian process of creative destruction itself using a Goodwin-type of limit cycle framework.

To that end, it might be useful to assume that firms in fact make two kinds of investment, namely replacement and innovative investments, and that to each of them corresponds a different strategy of funding. While the former would be financed by retained profits or external funding, the latter is crucially dependent on the availability of external funds. Indeed, this assumption is essentially intended to capture Schumpeter's idea that an innovation, being discontinuous and involving considerable change, requires large expenditure previous to the emergence of any revenue, so that credit becomes an essential element of the process of innovation.

A more inclusive macromodel could also incorporate some imitative investment function, to which specific technical and financial determinants would correspond, and a natural question to address here regards to what extent, if any, investment decisions so determined would still be subject to Kalecki's (1937) principle of increasing risk, which asserts that firms can or are willing to borrow only limited amounts, related in turn to their previously accumulated internal funds. Certainly, a detailed analysis of this complex issue would require the model to incorporate the behavior of the banking system and other financial institutions, in particular their policies with respect to granting external funding, which in turn depends whether we are dealing with a macromodel with exogenous or endogenous money. It is in this sense that I would suggest that the extent to which, if any, and the circumstances under which, if any, a post-Keynesian, monetary theory of growth and cycles can be grounded on the connection between technological change and money is an issue that deserves careful examination.<sup>21</sup>

In this monetary context, a final prospective issue which is also worth looking at regards the extent to which the neo-Schumpeterian approach to innovation processes, when applied to the financial sector, can be conceived as supporting the post-Keynesian view that money supply is endogenous. In a nutshell, the standard post-Keynesian view of endogenous money can be presented as follows: money is credit-driven; loans make deposits; deposits make reserves; the supply of and the demand for credit money are interdependent; the money supply curve is horizontal; the rate of interest is an exogenous monetary variable; and the control instrument of the central bank is not a quantity, but a price, namely, the rate of interest. Hence, the crucial aspect of such view is the causation which runs from loans to deposits to high-powered money, banks making loans first and searching for the reserves later (Lavoie, 1992:203).

In this sense, the occurrence of financial innovations reinforces the theory of endogenous money as it reveals how money can be endogenous in the long run despite the constraints imposed by the central bank; that is, money endogeneity is a structural feature of a modern market economy endowed with a well-developed financial system. Financial innovations have two major effects: they allow the public to economize on money balances and they allow the financial system to economize on reserve requirements. In both cases, financial innovations

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<sup>21</sup> Some quite preliminary and sketchy elaborations on how money can be incorporated into a post-Keynesian, monetary theory of growth and how monetary issues can be incorporated into a post-Keynesian, monetary theory of cyclical growth can be found in Lima (1993b) and Lima (1994 and 1995), respectively.

cause the demand for money function to shift unpredictably through time, which implies that the central bank can know by much only after the fact. Indeed, central banks may thus precisely control interest rates or even the monetary base in the long run; but they have little control over the money stock and the amount of bank loans. To a large extent, therefore, the flow of reserve-economizing financial innovations will be determined by the magnitude and the duration of the attempts by the central bank to eventually impose restrictive monetary policies, for banks, other financial institutions and all non-financial institutions will look for means to avoid the stranglehold of the monetary authorities and thus circumvent their quantitative or legislative constraints (Lavoie, 1992:210).<sup>22</sup>

Hence, to the extent that an endogenous creation of purchasing power is a necessary monetary complement to the carrying out of innovation activities, as Schumpeter so suggestively put it, one cannot but conceive the multidimensional connection between endogenous money and technological change and innovation as providing an interesting research agenda for those in search of an account of economic fluctuations capable of consistently integrating both monetary and real phenomena.

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<sup>22</sup> Interesting neo-Schumpeterian discussions of the process of financial innovation may be found in Artus and Boissieu (1988), and Viñas and Berges (1988). Though these contributions are not primarily intended to discuss whether money supply is exogenous or endogenous, they clearly support an endogenous view.

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