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FINANCE, INNOVATION AND CORPORATE CHANGE

by

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FINANCE, INNOVATION AND INDUSTRIAL CHANGE

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1. INTRODUCTION

In a very general sense, innovation concerns processes of learning and discovery about new products, new production processes and new forms of economic organisation, about which, ex ante, economic actors often possess only rather unstructured beliefs on some unexploited opportunities, and which, ex post, are generally checked and selected, in non-centrally planned economies, by some competitive interactions, of whatever form, in product markets. However, in addition, and complementary, to product market competition, innovative efforts are shaped and selected also by the rates and critera by which financial markets and financial institutions, such as stock markets and banks, allocate resources to business enterprises. Irrespectively of whether resources are attributed to business units ("firms") or individual projects, allocative criteria and rates of allocation should plausibly affect the amount of resources which the real sector (call it the "industry") devotes to the innovative search, and also the directions in which the agents search.

This work is a tentative and highly conjectural investigation of these issues and discusses the impact that financial structures might exert on the rates of innovative learning, on the related dynamics of industrial structures and performances, and on the prevalent forms of economic organisation (such as, for example, the degrees of vertical integration and horizontal diversification of corporate units, the degrees to which they internalise research activities, etc). Section 2 will provide a brief assessment of a few findings, in both economic history and theory, on the relationships between finance and economic change. The scope of such a discussion is clearly much broader than

the central topics of this paper, mainly concerned with some implications of financial structures in terms of microeconomic processes of innovation and industrial evolution. Still, it is a useful, quite general, starting point. In section 3, I shall discuss in greater detail some features of those environments which are permanently characterised by technological and organisational change. In particular, I shall recall some features of learning processes and selection processes which, I suggest, are crucial ones in non-stationary economies. Section 4 will advance some hypotheses on the relationship between the financial domain and ("real") economic evolution. Finally, in Section 5, I shall explore some implications of the whole argument in terms of theory of the firm and its (changing) boundaries.

2. FINANCE, INFORMATION AND ECONOMIC CHANGE: HISTORY AND THEORY

Let me introduce the analysis that follows by straightly focusing on one of the fundamental issues of financial economics (and economics in general), namely: do financial institutions (including the forms of organisation of the financial markets, the particular channels through which savings finance investments, the corporate patterns of investment financing, etc) matter in terms of levels and changes in real aggregate variables (eg rates of innovation - were we able to measure them with precision -, rates of investment, productivity and output growth, etc)?

As known, there has been a rich, insightful, tradition in economic history, especially concerned with comparative economic development, which has emphasised the importance of specific financial institutions and modes of corporate financing for the observed patterns of national growth. It is obviously impossible to give a fair treatment here to such a wide and quite heterogeneous literature. I shall just recall some findings and interpretations.

First, it has been argued, the development of particular financial institutions (or lack of it) may foster, or be an obstacle, other things being equal, to long term economic development (see for example, Cameron et al (1967); Kindleberger and Laffargue (1982); Kindleberger (1983) who also cites Schumpeter (1954) who cites also Adam Smith). In this respect, one brings forward rather convincing - although necessarily indirect - evidence on the role that particular financial institutions, eg banks, emerging stock markets, central banks, clearning houses, etc, did (or did not) play in the development

play in the development of the manufacturing sector and the growth of its modern part, especially in the early phases of industrialisation. Second, the nature of financial institutions appear to have influenced also the criteria of allocation of resources (eg to government versus private non-industrial employments versus industry; and also among industries and amongst different types of firms).

Third, even today, one observes significant inter-national differences in modes through which industrial growth is financed. In particular, Rybczynski (1974) and Zysman (1983) have put forward a broadly similar taxonomy which distinguishes between "market-based" and "institution-oriented" (or "credit-based") systems. In a stylised representation of the former, stock markets, equity issues and, more so, bonds and retained profits are the dominant forms of corporate growth; bank loans serve mainly short-term purposes; allocation criteria are typically non-discretionary (...if you have a good past profitability profile and good expected profitability, I will sell or buy your stock according to my expectations and alternative investment opportunities, irrespectively of whether you are firm A or B...). Certainly, empirical examples nearest to the "market-based" archetype are the USA and the UK.

Conversely, in an equally stylised credit- (or institution-) based system, long-term bank loans and long-term ownership titles by banks, other financial institutions and/or governments, represent the major sources of corporate growth; allocation processes are much more discretionary (even when they do not depend on direct political objectives, they are likely to depend also on the history of the institutional relationships between particular firms and particular banks, etc...).

Fourth, at a general level, it is argued that particular (obviously, history-specific) forms of organisation of ownership, production, finance, economic exchanges have influenced and influence allocations and performance outcomes, even for the same set of economic incentives (see, for example, Gerschenkron (1953), Zysman (1983); an assessment of this proposition with somewhat more detail than it is possible here, is in Dosi (1988)).

Underpinning all these historical interpretations there has been the (explicit or implicit) general hypothesis that institutions, in our case here financial institutions, affect (i) the rates at which resources are accumulated, (ii) their employments, and (iii) the economic efficiency of their uses.

Conversely, a significant stream of theoretical (and also applied, econometric) literature has purported the claim that specific financial institutions do not matter in terms of real aggregate dynamics, because the latter is led by a largely exogenous dynamics of the "fundamentals" of the economy (technology and individual preferences) and because individual rationality is sufficient to guarantee the exploitation of all available opportunities (equated, in some sense, to all available information) at any single point in time. In this respect, the Modigliani-Miller theorem is a beautifully elegant theoretical argument on the irrelevance of financial structures to real allocative processes. (Modigliani and Miller (1958)).

Even more so, this is claimed in the "strong" versions of market

efficiency/rational expectation models, generally with much less awareness of the heroic nature of the restrictions imposed ex-hypothesi for the conclusions to hold. (Again, here one cannot do anything more than scattered referencing: for arguments mainly supporting such an hpothesis, see for example Jensen et al (1978); a critical discussion is in Summers (1986); some other critical remarks which concern more directly industrial analysis are in Teece (1983); the underlying theoretical model is also discussed in Coricelli and Dosi (1988)).

Note that one is talking here about models which generally assume stationarity (that is, technology and tastes do not change). Still, it is well recognised, such results on the irrelevance of institutional structures for macroperformances do not withstand the relaxation of any of the most demanding and empirically unplausible restrictions on the nature of the agents and the informational structure of the economy. A few, quite different, modelling methodologies agree at least on the broad conclusion that imperfect/asymmetric information implies/requires some sort of institutions governing information transfers, incentives, resource allocation: this applies ranging from "mechanism design" models a la Hurwicz, to Akerlof's "market for lemons", principal-agent models, all the way to Williamsonian transaction costs. However, given these findings the theoretical focus may easily bifurcate.

On the one hand, one may search for those institutions which, under given information constraints and under the assumptions of the models, are the most efficient ones - with or without adding the conjecture

that the empirical evidence is going to approximately match such theoretical results. Alternatively, one may wonder how institutions themselves affect information, incentives, and patterns of resource allocation of any one economy, implicitely leaving aside the enormously complex question of whether empirically observed institutions are the outcome of some process of institutional convergence toward, loosely speaking, the "constrained-best" (given "fundamentals" and information imperfections), and not the other way round, or possibly a yet to be determined coupled dynamics between fundamentals, information mechanisms and institutions.

For the topics discussed here, I shall deal mainly with the results of the latter methodology, comforted also by the fact that these appear to be no general demonstration in sight of stability of one (or few) institutional architectures of the economic system which could "optimally" withstand empirically plausible classes of informational imperfections, even with technological stationarity. (For an assessment of the theoretical state-of-the-art on these issues, cf Groves, Radner and Reiter (1987)). In this respect, the "information and economics" literature (cf for reviews in somewhat different perspectives Stiglitz (1984) and Williamson (1985)) is a powerful point of departure for the argument that follows, in that it shows, under otherwise quite restrictive assumptions, the theoretical possibility of (a) the dependence of allocation patterns upon the institutional set-up of each system (eg, hierarchy versus decentralisation, etc); (b) equilibria that, given decentralised decision processes, may be informationally efficient, incentive-compatible, but less than optimal in terms of resource allocation; (c) institutions which affect incentives and performance (eg

sharecropping versus other forms of land tenure); (d) equilibria that might still involve resource rationing; (e) equilibria depending on the sequences of information flows and agents' beliefs (and, thus, plausibly, on the institutions shaping both); (f) learning processes leading to (increasing) non-convexities in the technology sets and also possible non-existence of equilibria (on all these points, cf, eg, Sah and Stiglitz (1985), Stiglitz and Weiss (1986), Aoki (1986), Arthur (1983), Hahn (1987), Atkinson and Stiglitz (1969), David (1975) and (1985), Arrow (1987)). All these results bear three major implications.

First, they imply at least some de-linking between patterns of resource allocation, on the one hand, and the "fundamentals" of the economy, on the other: the former, and, thus, the possible sequence of equilibria that an economy reaches must depend also on the particular informational and incentive structures of any one economy. As a consequence, institutions - in our case, in particular, financial institutions - governing information and incentives, do matter in terms of micro resource allocations and aggregate performances.

Second, any empirical evidence - even when properly and successfully detected - on "financial market efficiency" must, therefore, be interpreted simply as a corroboration of the "weak" hypothesis that on average financial agents try to make the best use of the information that they have, but this imperfect and possibly asymmetric information is not independent from the institutional "architecture" of that particular system (Sah and Stiglitz (1985)), and is not sufficient, either, to corroborate the hypothesis that agents adjust to some underlying "real" equilibrium uniquely determined by fundamentals (Summers (1986)).

Third, if actual patterns of resource allocation are allowed to exert an influence on the future dynamics of the "fundamentals" themselves, eg technology, then any stationarity assumption, or even the theoretical separability between market processes and the dynamics of fundamentals turns out to be rather doubtful.

Of course, all these analytical conclusions stand also as a vindication of the theoretical soundness of the "historical" approaches to the interpretation of the relationship between finance and real dynamics, mentioned earlier. It is also a good start for the analysis of those environments which are explicitely assumed to be non-stationary and whereby a few other restrictions of the "information and economics" literature are relaxed. In this respect, the conclusions of the latter on the theoretical importance of specific financial institutions can be taken as an "...even more so..." proof, which a fortiori holds in permanently changing, complex, innovative environments.

I shall now turn to a characterisation of these environments by briefly outlining some broad (although not uncontroversial) "stylised facts" (ie empirical generalisations) together with some theoretical hypotheses that I consider to be promising ones in their interpretation.

3. INNOVATION AND ITS THEORETICAL REPRESENTATION

Let me start by discussing some of the features of environments which are explicitely non-stationary (technologies and, possibly, organisations and preferences change over time) and wherein agents try to exploit "opportunities", that I shall define shortly, which they believe - rightly or wrongly - that "are there", or might be created by their own actions.

In the broadest sense, an "opportunity" is a chance of getting a "better" product - in terms of some price weighted performance characteristics -; a more efficient production process (given ruling inputs costs, or even better, irrespectively of relative prices); a more efficient organisational set-up (for example, new organisational networks which increase the completeness of information for the relevant decision makers, without affecting the incentives facing organisation members, or, alternatively, increase incentive compatibility without affecting the quality of information flows, etc). Of course, an "opportunity" will be pursued if agents believe that the cost of doing that will be lower than the expected economic benefit from its successful exploitation.

Well, in order to represent this process, a theoretical strategy with a noble pedigree is to work, so to speak, "backward", from probability distributions of notional states-of-the-world, to actions and expected pay offs (cf on this methodological point, Arrow (1983)). Add to this also the assumptions that agents will (a) try to estimate as accurately as possible the "true" probability distributions, and (b)

push up their search costs until they equalise the expected returns discounted by some risk factor. One gets at the end some equilibrium representation of innovative efforts whereby all the economically exploitable opportunities are actually exploited. Clearly, the caveats, restrictions, properties of these equilibria - stemming from imperfect information and the institution-dependence of specific information flows and incentives, briefly recalled in the previous section - still apply. However, on analytical grounds, one may still use such class of models as heuristic devices which help in interpreting observed performances by separating some sort of "drift" in opportunities available at each time, and the equilibria that rational agents could achieve at such times, given the incentive- and information-architectures in which they operate. On normative grounds, one can also explore the properties of different "architectures" and their efficiency properties.

Possibly, the exploitation of an oil field is a good example. Once its existence is known (or even if agents simply believe in its possible existence) - ie an "opportunity" emerges - rational agents will try to "tap" it. The ways in which they will try to do it will depend also on their belief-ridden expectations, on institutions (eg property rights), on information flows. Of course, important analytical questions would then concern the nature of such information flows and of the competitive incentive which would allow the efficient exploitation of that oil field, and also the information and incentives which their potential financial backers would require in order to support their search endeavours. In all this, obviously, oil fields are there, whether we know about their existence or not, and any new "opportunity" can be reasonably represented as improved

information about a "true" state of the world which, as such, is stationary (any omniscient God-like agent would have the complete map of world oil fields, which were the same also a thousand years ago...). The non-stationarity is only the characteristics of economic environments composed of less than perfectly informed agents who are, so to speak, "shocked" by any novel piece of news adding to their previous knowledge. Relatedly, throughout such an information-augmenting process the actions of the agents can be neatly separated from the "true" states of the world.

Here, however, I would like to pursue a different line of enquiry and investigate some properties of environments whereby previously unknown states-of-the-world are themselves the result of the actions of the agents. To put it paradoxically, I shall focus on environments wherein the very existence of an oil field depends on the process of searching for it: it is created a few thousand metres below the earth surface by the very process of thinking about its existence, planning for its exploration, setting up the drilling equipment, and, finally, tapping it... It is obviously absurd for an oil field, but, I suggest, it captures a fundamental feature of contemporary processes of technological and organisational innovation. To put it another way, what is believed to be possible to achieve, what is in fact achieved, and the capabilities of achieving it are likely to be dynamically coupled in ways that do not allow any easy separation between "opportunity drifts" and "economic adjustments". Relatedly, I suggest, actual states of the world ("events") and agents' behaviours might not be separable, even in principle.

In the interpretation that I am proposing here, innovations are more akin to Newton's and Leibniz' development of differential calculus than the discovery of oil fields, iron mines and, even less so, to gambling on a lottery. Alike the development of a new mathematical theorem or a new physical theory on the Big Bang, and unlike Las Vegas casinos, innovations can be hardly represented, or even "rationally reconstructed", simply in terms of information gathering and allocation processes, based on degrees of risk aversion and probabilities distributions about events which could be - in principle, at least - known ex-ante.

If this interpretation is correct, first, "events" did not properly "exist" before their very discovery. In that, there is a fundamental analogy between, say, the transistor, the electrical motor, the zipper, on the one hand, and the theories of gravitation, Brownian motions, etc, on the other. (Note, in this respect, that the fact that both sets of discoveries are grounded on some natural phenomena is irrelevant for the argument here: the process that led to their discovery is generally largely independent from the ex ante perception of the underlying natural properties or "laws"; indeed, the latter emerge together with the discoveries themselves).
Second, there is a fundamental problem-solving feature of innovative activities, based also on uncodified, tacit, cumulative elements of knowledge (cf Nelson and Winter (1982) and Dosi (1988a)). Loosely speaking, innovative activities both "pose the problem" and try to solve it, and the uncertainty about its solution does not relate only to imperfect information but to the inherently "ill-structured" nature of the problem itself (more on this topic in Simon (1982)). Let me put it more provocatively. In a fundamental sense, the economic

profession is generally inclined to represent decision problems as trivial ones. They may be computationally very complex but they are still trivial: a powerful computer could handle them equally well or better than any human actor (on this point, cf Stiglitz (1984)). Conversely, innovation-related problems could not in general be handled by any computer, irrespectively of the information that we feed into it, falling short of any complete information about the solution itself (a more detailed argument on these topics, and some theoretical implications are in Dosi and Egidi (1987)).

Third, the foregoing conjectures - if empirically corroborated - add further weight to the hypothesis that innovative processes are path-dependent and institution-dependent (Arthur (1983) and (1988), David (1985) and (1986), Dosi and Orsenigo (1988)). It may well be that where an agent searches depends on where one has already found something in the past and on where its knowledge is. Moreover, past successes and failures of individual agents and, more so, of whole groups of them can plausibly feed back upon the incentives to search in some directions and not in others, irrespectively of the notional opportunities that might exist elsewhere (Arthur (1983) and (1988), David (1986)). In other works (Dosi (1984) and (1988a)), broadly in line with a growing literature on the economics of innovation (cf Freeman (1982), Rosenberg (1975) and (1982), Nelson and Winter (1977) and (1982)), I have tried to conceptualise these processes of innovation in terms of what I call technological paradigms and technological trajectories, based on specific bodies of knowledge and search heuristics; and showing varying degrees of opportunity, cumulativeness of technological capabilities, appropriability of innovation-based economic advantages. An important implication of all

this for the present discussion is that innovative processes are intimately associated with persistent non-convexities in what are commonly called production possibility sets. (In this respect several innovation studies corroborate and extend an earlier conjecture of Atkinson and Stiglitz (1969). See also David (1975) and Stiglitz (1986)).

Fourth, an important theoretical corollary of innovation, so defined, is that something crucial is missing when we represent the innovative process as some sort of "hill-climbing", whereby the "hill" is postulated to be already there from the start, and agents - Bayesians or not - try to get to the top, that is, to converge to some equilibrium (equilibria) notionally independent from their own actions (1). Rather, innovative patterns might be more accurately represented by those non-ergodic increasing-return processes whereby, metaphorically speaking, (a)...the more you have got in the past along any one direction (in terms of 'trajectories' of innovative search) the more you are likely to get...; (b) the more you are successful on any one path the more you will have an incentive - with the exception of major technological revolutions - to pursue it further; (c) the more you search/learn on the grounds of any one set of technological criteria, procedures, tasks (that is, on any one "technological paradigm"), the more you will also improve your capabilities in doing so in the future, but often at the expense of neglecting or even "erasing" the capability of searching in other directions (more rigorously, on all this, cf Arthur (1983) and (1988)).

I shall now turn to the discussion of the implications of all the foregoing features of innovation with respect to the central concern

of this paper - ie the relationship between financial structures, innovation and industrial change.

It should not be surprising, given the argument so far, that I propose a theoretical representation of non-stationary environments, cum technological and organisational change, as evolutionary systems. In general, I define the latter as systems where (i) agents are explicitely allowed to search, make mistakes, sometimes obtain unexpected successes, and try to learn throughout such processes; (ii) product- and financial markets operate also as selection devices amongst different firms and different technologies; (iii) notwithstanding any generic economic motivation ("...make as much money as possible..."), agents' behaviours have to be further characterised by empirically-based and context-specific decision rules; and, finally (iv) aggregate performances (measured on whatever yardstick, eg rates of innovation, productivity growth, etc) and patterns of change over time emerge as results of self-organising (collective) properties of the interactions amongst diverse agents which can be presumed to permanently show disequilibrium behaviours (2). In short, I propose that innovative environments are characterised by the twin fundamental properties of learning and selection. Relatedly, I suggest that differences in structures (eg firms' size, levels and distributions of technological capabilities, etc), performances, and patterns of change can in principle be mapped in different underlying relative balances between learning and selection processes and into the rates and modes by which these processes occur.

Thus, the question of the influence of financial structures on innovation and industrial dynamics turns out to concern essentially the influence that financial structures and the related criteria of resource allocation exert on the rates and modes at which firms learn (I shall come back later to a detailed definition of what I mean by that) and the rates and criteria on which particular environments (including, of course, financial institutions themselves) select among firms and among technologies.

In general, there is no evidence - either empirical or theoretical - which would suggest that the major conclusions achieved in the "imperfect information" literature, cited earlier, would not apply to evolutionary environments, with the characteristics just mentioned. Indeed, a fortiori they apply to the latter. For example, non-stationarity adds further factors which, most likely, make rationing a permanent phenomenon (Stiglitz and Weiss (1986)). The subtle combination between imperfect/asymmetric information and possible incentive incompatibilities (eg moral hazard and adverse selection) (cf Williamson (1985), Radner (1987)) is obviously enlarged by the permanent existence of innovation activities about which, by definition, contracts cannot be completely specified and performances cannot be completely monitored (Teece (1988)). The continuous emergence of unknown events (after all, innovations are also that) deepens the uncertainty facing decision processes and magnifies the importance of the particular institutions guiding behaviours (A pertinent argument on the relationship between institutionalised behaviours and uncertainty is in Heiner (1983) and (1988)).

However, in addition to all that, when analysing evolutionary environments with the features briefly sketched above, one must also explicitely consider the effects that current patterns of finance allocation have on the future innovative capabilities of individual firms and, more generally, on the future capabilities of any one economic system to generate, and adjust to, new events (innovations), at present largely unpredictable.

One thing is to monitor existing contracts; achieve varying degrees of efficiency in the allocation of resources amongst currently available employments; select amongst firms on the grounds of their current performances. A quite different thing is to foster the capabilities of individual firms in developing at some future date new products and processes; select those firms that are more likely to be able to successfully adapt to future (currently quite unknown) environments; provide the general allocative patterns which will favour, tomorrow, a relatively high aggregate economic performance - on whatever criteria it is measured - in an environment which is going to be different from the present one.

The next section elaborates on these points.

4. LEARNING AND SELECTION: FINANCE IN ECONOMIC EVOLUTION

The theoretical analysis of "evolutionary" environments (as from the foregoing, quite broad, definition) is still at a rather exploratory, if exciting, stage. Much more so, the role of the financial domain in economic evolution, in this perspective, is still largely undetected. There appear to be intuitive and "impressionistic" convergences between evolutionary/"self-organisation" approaches to the theory of economic dynamics and the historical interpretations of economic development, of which few have been mentioned earlier in section 2, but one is still well behind any satisfactory interpretation - let alone a reasonably general theory - of the links between finance and real variables in non-stationary set-ups.

However, I believe we have got to the stage where one can at least suggest some notionally testable conjectures, attempt theory-guided generalisations on micro evidence and tentatively extrapolate from simulation results. This is what I am going to do in the following.

Finance, Diversity and Evolution

A seemingly robust hypothesis about non-stationary environments - which applies when exogenous "shocks" appear, and, more so, when changes in economic fundamentals are endogenously produced - is that diversity amongst agents, in terms of technological competences, behaviours, expectations is positively correlated with the "resiliance" and long-term performance of any one economic system (see, for example, Eliasson (1986), Dosi, Orsenigo and Silverberg (1988), Silverberg, Dosi and Orsenigo (1988)). In turn, this implies

some crucial and quite subtle demands on the allocative criteria of the financial system.

Of course, a rather weak and general criterion of efficiency of resource allocation by the financial system is that it should not be biased, at the very least, toward firms and "projects" which, given all the available information, have shown and are expected to show a future economic performance worse than others. Indeed, by positively biasing allocations on the grounds of actual and expected performances, any financial system operates as a selection device. It does obviously so when it is a direct source of financial resources to individual industrial actors, but, indirectly, it does it also when an overwhelming role in such a system is played by capital markets, whose main function - it appears - is the exchange of ownership titles. Yet, it can be reasonably claimed that, still, it exerts a "disciplining" influence on management behaviours and performances. In fact one may conceive also financial systems in which allocative selection operates against efficiency (3). However, for the time being I shall assume that financial selection satisfies the weak efficiency criterion, just defined, and ask, loosely speaking, whether "more efficiency" necessarily implies also "better evolutionary performance" (eg more innovation, more productivity growth, easier adjustment capabilities, in the long term). Indeed, the crucial and somewhat counterintuitive point, here, is that, under non-stationarity (innovation is an obvious case) long-term aggregate performance might not be monotonic into the efficiency of the selection rules by which financial investors, on the grounds of all presently available information, discriminate among alternative employments of their funds. This is a possible outcome of the characteristics of innovation

discussed earlier: efficiency on the grounds of past/present performances and past/present technologies might not be necessarily taken as an unbiased predictor of future performances - at the levels of both single firms and aggregates of them. Allen's point (Allen (1988)), on a somewhat analogous biological equivalent to this problem, is a revealing illustration: greater average "fitness" - it can be shown - in any one environment may still imply a lower dynamic "fitness" vis-a-vis some other species that, on average, are "worse" - require more environmental resources in order to survive, have a lower rate of successful reproduction, and make more "mistakes" in their genetic transmission. Still, despite the skewdness in the frequency distribution of "mistakes" and revealed "improvements" (biased in favour of the former), species which are ecologically "less efficient" at any one time might turn out to be dynamically "fitter" than species which, so to speak, are better at optimising within any given environment. I certainly do not want to draw any one-to-one correspondence with social sciences or even over-emphasise the metaphor. However, in analogy with these examples, I do suggest that some departures (of magnitudes which still wait to be theoretically assessed) from the technological and economic efficiency revealed on the grounds of past and present environments are necessary in order to ensure future innovativeness and adaptiveness (4). After all, one is dealing with worlds made of agents who are trying to be as "strategic" as possible, but are still less informed that Leibniz' God (who could possibly predict future trajectories even when bifurcating singularities appeared). Such economic (and, more generally, social) systems can plausibly build their long-term survival upon the generation of enough diversity in competences and behaviours which

allow them to internally produce, and also cope with, largely unpredictable changes.

Facing all that, financial markets may well face a permanent, quite tricky, trade-off between efficiency - as assessed on the grounds of all available information - and evolutionary viability - defined here by (a) the probability that some innovation will emerge at a future time t, which will turn out to be "fitter" in the t-environment, and (b) the probability that the system will rather smoothly adjust to any shock at any such future time. I shall briefly elaborate on this point which is rather crucial to my argument. Quite independently, Eliasson (1986) and the author (Dosi (1988)), broadly in line with Nelson (1981) and Nelson and Winter (1982), have tried to define the nature of the trade-offs between "static efficiency" (roughly, the opportunity cost of given resources at any one time), on the one hand, and "Schumpeterian-" and "growth-" efficiencies, on the other, related to the varying potential for future explorations of technological and market opportunities which current patterns of allocation entail/foster/hinder. (The reader should notice that, here and throughout, "dynamic" or "Schumpeterian" efficiency is defined in terms of the capabilities of economic organisations or systems to continuously generate innovations and adapt to unforeseen changes, but does not carry any normative implication, eg on whether a greater innovativeness is also normatively "better", etc).

In the context of this discussion, the tighter the discipline which financial institutions exert on business firms (implying also a quicker reactiveness of the former to current performances of the latter), the higher, of course, "static efficiency" will be. In fact,

in market economies, such discipline is the result of the way financial structures - irrespectively of their specific institutional features - operate as a selection mechanism. For example, they set boundaries to the revealed distribution in production efficiencies and market competitiveness of firms within each industry (that is, on what I call in Dosi (1984) the "degree of industrial asymmetry"); set limits to the length of time during which "lame ducks" are given the last chance to adjust in their technology and organisation; etc.

Thus, arguably, for any given informational and incentive "architecture" of a system, improvements in "static efficiency" increase the mean and decrease the variance in the performances of micro units (again, on whatever criterion performance is judged). However, in an evolutionary perspective, remarkably, the mean performance of the system at some future time t, other things being equal, may not be monotonic into its mean performance at time zero, but, possibly into its time zero variance. Note, moreover, that any increase in the variance may well imply a lowering of the mean (given "deviant" behaviours heavily biased toward "mistakes"). Hence, we have here one of the grounds of the fundamental trade-offs introduced above.

In order to illustrate this point, following Silverberg (1987), suppose that the fundamental competition/selection process in the product markets results in changes of market shares of individual firms, such as

$$\dot{f}_i = A\left(E_i - \bar{E}\right) f_i \qquad (1)$$

where the dots stand for the rates of change; f_i is the market share of firm i; E_i is the "competitiveness" of the i-firm and $\bar{E}$ is the "average competitiveness" of the industry (= $\sum_i f_i \cdot E_i$). For the purposes of this work suppose also that the competitiveness of each firm is linear in its "performance", which, in turn, is some combination of the elements of a vector $\vec{\mu}_i$ describing its process technology, product performances, organisational set-ups, learning economies, etc. Of course, other things being equal, any criteria of allocation of financial resources which is positive in the E_i's satisfies "static efficiency", as defined above. However, "Schumpeterian efficiency", will depend also on the transition probabilities in the μ_i's. Interestingly, with <u>complete</u> cumulativeness of technological progress, no trade-off between "static" and "Schumpeterian" efficiencies would emerge: the technological winner(s) today would also be the winner(s) tomorrow. Conversely, in a dramatised version of the "early Schumpeter" (Schumpeter (1934)), today's winners are going to be tomorrow's losers and the financial system (the "banker") is permanently facing a dilemma between making the best out of what is revealed by experience, and some sort of "heroic trust" in unexplored opportunities. In this respect, the "optimistic irrationality" of the Schumpeterian entrepreneurs requires a symmetric counterpart amongst "bankers".

Obviously, empirical environments are likely to fall somewhere in between these two extremes (for more precise taxonomies, see further on). However, the possibility of a tension between static allocative efficiency and evolutionary performance continues to apply. In a way, this is so because of a sort of "amplification effect" that non-

stationary (innovative) environments exert on some system properties also analysed - as mentioned - in the imperfect information literature. Of course, technological information is generally asymmetric; innovations cannot be properly assessed until when, and if, they are actually developed; technological and organisational innovations imply various sorts of externalities and increasing returns; technological knowledge is partly tacit and can hardly be stated in "blueprint" form, let alone assessed by external financial agents. Moreover, in evolutionary environments, innovative explorations are likely to involve many more mistakes than successes, a lot of resource waste, duplication of efforts, inevitable sponsorship of losers. As one tries to show elsewhere (Dosi, Orsenigo and Silverberg (1988) and Silverberg, Dosi and Orsenigo (1988)), part of the "mistakes" and "losses" turn out to be indeed a positive externality on which the whole economy learns and improves its performance. However, it still holds that, given the characteristics of innovation as from the foregoing section, ceteris paribus, the evolutionary viability of any one system may be positively related to the diversity of its trial-and-error processes of search, its (sometimes "useful") mistakes, its diversity in competences and expectations (More on these points in Nelson and Winter (1982), Winter (1971), Eliasson (1986), Metcalfe (1986), Gibbons and Metcalfe (1986), Silverberg (1988), Dosi and Orsenigo (1988)). As a consequence, any financial system which is evolutionarily viable (with whatever degree of ex post revealed success in fostering the long-term system performance) must allow for the possibility of rather numerous "gambles" on unexplored opportunities, about which little is known ex ante, but which can be reasonably expected to be, on average,

failures. This is the other side of the possible trade-off between "static efficiency" and "Schumpeterian"/"growth-" efficiencies. With largely imperfect information and a probability one that some currently unknown events will emerge at some future date, the higher the selective efficiency of financial allocation to firms and technologies that are "optimal" in a certain environment, the higher also may be the probability of a future "dynosaurs syndrome". (I have purposely used the conditional tense, since such theoretical possibilities do not necessarily apply in all circumstances, for reasons that will be briefly discussed below).

Historically observable financial systems differ also in the ways they seem to trade-off "static efficiency" for "evolutionary viability" and also in the apparent success in doing so. In this respect, the empirical taxonomies cited at the beginning of this work are also relevant. I propose that those historical conjectures mentioned earlier on the importance of financial structures for long-term economic performance are strictly consistent with the following propositions, derivable from the foregoing discussion, namely: (a) different institutional set-ups, governing the exchange of ownership claims on real assets and the channels of corporate finance, embody also different balances between "efficient selection" and innovative search, and (b) the institutional modes by which financial allocations occur affects both "static" and "Schumpeterian" efficiencies.

I shall now turn to these issues.

Financial Institutions and Innovative Learning: A Taxonomic Exercise

As briefly noted elsewhere (Dosi and Orsenigo (1988a), on which I partly draw in the following), there seems to be a curious paradox in several practically-oriented (and also theoretical) discussions of merits and limitations of different contemporary financial systems. On the one hand, it is often lamented that in "market-based" systems, the stock markets tend to be "short-sighted" in their allocative rules and, thus, tend to penalise risky long-term innovative efforts (5). On the other hand, for example on the European continent, it is not uncommon to hear complaints about the "conservatism" of the banking establishment and their diffidence toward new innovative projects. By lack of any more discriminating analysis, one would thus be tempted to accept a rough equivalence of the two archetypical systems with regards to innovation-related risk-aversion and judge them on the comparative merits in "static" allocative efficiency. However, on the grounds of the foregoing framework, something more specific can be said on the dynamic properties of the two stylised ("market-based" and "credit-based") financial systems.

First, as a premise, one may recall that "market-based" systems tend to be relatively biased toward "impersonal" exchanges of ownership titles; and "credit-based" systems toward more "institutionalised" ownership/control relationships and/or information flows specific and restricted to particular suppliers and users of financial resources. In this respect, Zysman (1983) applies Hirschman's dychotomy and argues that the former mainly rely on entry/exit mechanisms of selection, while the latter rest on "voice" mechanisms, - that is, explicit purposeful intervention and guidance (Hirschman (1970)).

Second, the features of innovation, briefly suggested earlier, lend

support to Pelikan's conjecture that the processes of financial allocation themselves involve specific (and possibly, cumulatively built) competences (Pelikan (1988)). Allocative criteria do not depend only on any given incentive structure and information availability, but also on competences, cognitive structures (and also beliefs) which logically pre-exist information detection and guide its processing.

As a consequence of both points, it is plausible to suggest that "specialised institutions" would choose, (hence, allocate resources) more competently, and incrementally develop specific knowledge on particular firms and industries - including their organisation, efficiency, market prospects, technological opportunities, etc. Thus, in the terminology of this paper, learning is going to be relatively more important than selection. A crucial corollary of this, however, is that the "paradigmatic" nature of knowledge (see earlier) generally implies that "learning" entails a powerful exclusion effect: specific competences and "visions" in a certain domain may well make it harder to see things in other directions. This is a property often found in individual behaviours and is even more likely in collective organisations where "knowledge" is also stored in repeated and rather sticky organisational routines (Nelson and Winter (1982), Winter (1987)): there may well be a trade-off between, so to speak, the "width" of the information set that is processed in allocative decisions and the "depth" of processing competences (Williamson (1975), Dosi and Egidi (1987)). Relatedly, one may expect some trade-off between the evolutionary efficiency of allocations by specialised financial operators - such as business-managing universal banks - along rather established technological trajectories versus their

capability of allowing highly uncertain experiments on new technological paradigms (6).

Conversely, "market-based" systems may be more conducive to the exploration of new technological paradigms whenever (a) innovative opportunities are high, and, jointly, (b) innovative competences are quite diffused throughout the economy.

These asymmetric allocative properties of financial systems may be possibly illustrated in the following way. Suppose that the environment is non-stationary, and consider two extreme possibilities.

In environment A, learning by individual firms and by the financial operators which allocates funds to them is negligible. In turn this implies that, given non-stationarity, the skills, innovative capabilities and, hence, economic performances of any one firm will, sooner or later, become worse ("less fit") than some other newer firms. Thus, the evolutionary dynamics is led by a sort of pure selection process whereby the mean performance of the system at any one time is a function of the efficiency at which selection (also financial selection) occurs; and performance dynamics is a function of the rate of entry of new firms and the distribution amongst them of fruitful innovations and "mistakes". All this involves the purest "market-based" mode of financing. Only common, and low, knowledge is available to financial investors and they can only assess incumbent companies by their past/present performances. No assessment at all is possible on entrants; investors may as well throw a dice on deciding whether to support them: they can only spread risks by diversifying

their portfolios (Of course, one must assume also that investors know that on large numbers the success of some companies, although quite unlikely, will eventually reward their total investment).

Conversely, consider environment B, wherein knowledge is quite specific and cumulative on both sides of firms and investors. Firms are so good that possess powerful "meta-rules" of innovative search which let them efficiently cope with non-stationary environments (or they may even generate non-stationarity themselves). Financial investors know that, and, in fact, share part of that knowledge and steadily help in building it up. Unlike the previous case investors will not "select" allocations only or primarily on the grounds of current performances. Indeed, they may well see any current performance failure as "bad luck", or as a learning investment for the future, or else as "management mistakes" which call them to step in and take positive actions. Moreover, the relevant knowledge, highly idiosynchratic and path-dependent is specific to these agents. At the extreme, this is a pure "learning mode", wherein variety and selection among agents would become redundant. In fact, it would be a sheer resource waste.

How would one judge the relative efficiency of different combinations between the two "learning" and "selection" modes? Obviously a thoroughly satisfactory answer is enormously difficult to give. More modestly, let me simply consider some properties of these processes.

First, the more knowledge is asymmetric, appropriable, and "scarce", the more also "institutionalised" processes of finance allocation will be conducive to "evolutionary viability". Knowledge specificity and

asymmetry are, in fact, plausibly higher in catching-up countries, and in the early phases of industrialisation. Indeed, rather formal bank-industry relationships have historically appeared to be the general case in industrialising countries, which often require long-term commitments of resources to the accumulation of technological competences, often despite absolute and comparative disadvantages and despite unfavourable short-term profitabilities, especially in the newest technological paradigms (Dosi (1988)).

Second, I suggest that a necessary (but not sufficient) condition for the "Schumpeterian efficiency" of a "market-oriented" system is that it must operate in a country which is on, or near, the "technological frontier". In these circumstances, current efficiencies of business units, as revealed by their economic results, may on average be a roughly unbiased predictor of their future learning potential within the technological paradigms whose knowledge they embody and, moreover, current profits may generally be sufficient to finance substantial innovative efforts.

Finally long-term dynamism requires also the continuous exploration of new potential paradigms, new "trajectories", new products. In that, variety, trial-and-error processes of exploration are an important ingredient of technological progress. In fact, in some "market-led" systems processes of resource allocation based on selection of "revealed efficiency", and processes of allocation to innovative search, insofar as the latter involves novel firms, have increasingly

become institutionally separated and that largely corresponds to the separation between stock markets and venture capital markets.

The development of the latter is, in this light, an institutional innovation which augments the allocating competence of "specialised" investors; reduces innovative uncertainty by spreading risks over investment portfolios; and institutionally separates, so to speak, allocation-by-selection among revealed performances and part of the allocations-to-learning which the economy does.

In other industrialised countries (more "credit-based" ones), the financing channels are much less split-up. Banks are much more important with respect to both processes, but still allocative criteria may differ and much higher requirements on collaterals may be required for new innovative ventures. (I come from a country, Italy, where it is not surprising to know that an innovative venture has been financed by mortgaging the houses of uncles and grandmothers...). Yet in other countries (eg Japan), the exploration of new products, processes and organisational arrangements is, to a good extent, inbuilt within the organisational routines/strategies of established companies (cf, for example, Iwai (1988) and Baba (1988)), and "virtuous loops" have often appeared between innovativeness and static efficiency.

Third, irrespectively of whether a national financial system is nearer the "credit-based" or the "market-based" archetype, an overwhelming part of business-performed innovative search goes on in established firms. In turn, these firms normally access financial resources as whole entities and not with respect to individual projects. In

different systems they may rely more on bank-loans or, alternatively, on bonds, or retained profits, etc, but still, it is, eg General Motors, Siemens, ICI, etc which acquire a certain amount of financial resources on the grounds of their global performance. In relation to innovative learning, there are particularly good reasons for that, since part of the economic value of a successful search is precisely in that it remains private and appropriable (7). As a consequence, there is no a priori reason to expect that a "universal banker" (say, of the German type) who has both a vested institutional interest in the long-term viability of a particular company and also asymmetric information about the company's specific learning activities should allocate financial resources any worse - in terms of "Schumpeterian efficiency" - than a market which can only allocate on the grounds of average performances and common knowledge.

In the varying combinations between learning and selection which permanently characterise evolutionary environments, one may well find at any point in time a small number of different institutional relationships between financial structures and industry which turn out to be roughly equivalent in terms of "Schumpeterian efficiency". Among them, of course, there might be cases similar to the American one, whereby specific market institutions (eg venture capitalists) intermediate financial resources and spread risks, thus allowing a plurality of technological/commercial trial-and-errors to surrogate the possible incompetence of individual investors. There are also other institutional set-ups (eg more similar to Japan; to a good extent, Germany; and, for the little knowledge I have of them, the Scandinavian countries) whereby the evolutionary process is, to to speak, more "Lamarkian" (as opposed to the relative "Darwinian" bias

of market-based systems) and rests much more on the cumulative knowledge of both financial investors and industrialists.

Irrespectively of the institutional archetype, the "Schumpeterian efficiency" of any one system requires that financial institutions operate a relocation of resources toward the new activities much quicker than that which would normally occur through the product markets (after all new technologies often start by occupying small but rapidly growing markets) (Pavitt (1981)). Different institutional set-ups appear to do it in quite different ways, ie in market-based systems by quickly capitalising future revenues in the current stock exchange valuation; in credit-based systems, by an explicit targetting of resources. Again, opposite examples in this respect are the USA and Japan.

Moreover, the taxonomy of systems of financial allocation based on the relative importance of learning versus selection; voice versus exit; discretional versus non-discriminatory allocative rule may also be applied to intra-national differences. For example, irrespectively of whether a country tends to be more "market-based" or "credit-based", it seems plausible that bigger firms, quoted on the Stock Exchange, can have more access to non-discriminatory "impersonal" channels of finance, and that smaller firms (eg partnerships) ought to rely more on discretionary relationships with their providers of financial resources (eg banks or individual investors) and on "voice" mechanisms of control.

On the Evolutionary Properties of Different Financial Systems

Needless to say, an enormous amount of theoretical and historical work is still needed in order to analyse the general properties and performances of evolutionary environments cum financial institutions. However, it is likely that unequivocal statements on the welfare properties of different institutional architectures of the finance-industry links will be shown to be impossible, even in principle. Among other reasons, this is likely to be so, I conjecture, because of the characteristics of innovation discussed earlier. Indeed, if one were to represent innovative opportunities, in the earlier metaphor, as a given "oil field", about which agents simply have imperfect information, one could, for example, compare the performance of a financial system which allows a multitude of agents to "tap" it on the basis of the general information available at any one time, with another one which, say, hooks the resources to the repeated trials of particular agents. I do indeed believe that these types of exercises are instrumental in exploring particular properties of, eg information imperfection, appropriability, etc. I also believe, though, that they fall well short of a positive characterisation of contemporary innovative activities. The interpretation of innovation suggested here is centered on cumulative, specific, irreversible learning processes, within a domain of notional opportunities mostly unknown and quite large (for all practical purposes, an infinite one): then, one of the implications is also that one can hardly resolve in general the dilemma between processes of allocation which foster path-dependent learning on particular "trajectories" and the seemingly "wasteful" exploration of other ones. The former process - as Arthur shows - may well present increasing returns, strengthen the microeconomic incentives to go further down the path, but, most likely, may also lock-in the system onto that path. The crucial issue

is that no one knows precisely what there could have been on another path without actually walking a bit on it or at least getting near it. In terms of the foregoing discussion, there are "paths" of different width, separated by hills of different heights - some not separated at all - and with different opportunities of economically exploiting them - some are very promising, a few are dead ends. Some of these paths characterise entire industries (what I refer to as "technological paradigms and trajectories"); others are narrower and specific to the history of technological and organisational development of individual firms (Pavitt et al (1988)); yet others are quite broad and may characterise entire economies and historical periods (Freeman and Perez' "techno-economic paradigms" or "regimes", such as electromechanical automation with standardised mass-production, etc).

Relatedly, from the point of view of the criteria for financial allocation, the dilemma comes down to whether the universe of all firms is rewarded/penalised on the basis of their current performances in a non-discriminatory way or whether a few of them are, so to speak, "positively discriminated" and allowed to move faster along the trajectory, ie learn faster. One of my earlier conjectures was indeed that within rather established industry-trajectories, the latter mode is likely to be more conducive to technological change. This, in fact, does not require the related financial institutions to "know much more than the market" in terms of long-term perspectives of particular technologies. It simply requires them to know more about the internal competences, innovative projects, etc of individual firms, which they are likely to do.

On the other hand, whenever there are plenty of (actual and perceived) opportunities around, and diffused capabilities of economically exploiting them, non-discretionary patterns of allocations are likely to be instrumental in exploring yet unknown "paths". Or, seeing it from the opposite angle, the more a "credit-based" system needs to explore new paradigms, the higher must be also the technological competences and strategic flexibility of both its firms and its inter-linked financial institutions. In essence, firms are required to "simulate" internally to their organisations at least part of those processes of trial-and-error which in "market-based" systems generally occur via much more "decentralised" search endeavours, often associated with the emergence of, and market selection amongst, new "Schumpeterian" firms. In this respect, a good illustration of these points is the case of Japan as compared to the USA (On the Japanese firm as an "innovation laboratory", cf, for example, Baba (1988), Aoki and Rosenberg (1987); such differences in the patterns of development of new technologies is corroborated by industry case studies, eg microelectronics (Dosi (1984)).

In this perspective, one may also reinterpret the often-heard claims on "stock-market short-sightedness". Given market expectations inevitably based on past/present performances and common knowledge, "shortsightedness" does not necessarily require the inability of the market itself to correctly forecast future corporate performances. One may plausibly think of corporate behaviours, which are "rational" - given the institutional context - and which try to avoid any trade-off between current profitability and long-term innovativeness by systematically neglecting all the most daring innovative opportunities involving high current learning costs. If all firms do that, then the

market is indeed "forecasting correctly", but this simply means that a sort of structural shortsightedness has become self-fulfilling in the system. (For some empirical evidence along these lines, in a UK-Germany comparison, see Prais (1981)). Conversely, broadly in line with Odagiri (1980), one may plausibly conceive financial set-ups whereby evolutionary "far-sightedness" is precisely the outcome of the imperfection of capital markets. That "imperfection" may force upon financial institutions the burden of learning about the specific conditions under which financial resources are employed, and also impose a long-term commitment to the "Schumpeterian viability" of industrial actors whose future is interlinked with the future of the lenders themselves. Of course, there is no intrinsic necessity for financial markets to be always "short-sighted", in the evolutionary sense in which the term is used here, meaning a relative incapability to finance and reward the exploration of future innovative opportunities. However, in the perspective of this work the degrees of "short-" or "far-sightedness" are unlikely to depend on the nature of the relevant common knowledge - plausibly quite low in any case -, but rather on the nature of common beliefs (for example, it often happens that drug companies are allowed quite high price/earning ratios because in these cases the general view embodies a belief in high innovative opportunities; or, the reader could also think of the changing fashions by which the stock market reacts to varying propensities to invest in R & D by different companies and/or in different countries...).

I have argued so far that different institutional arrangements governing the allocation of financial resources, entailing different

balances between learning - internalised within individual organisations -, on the one hand, and more decentralised processes of experimentation - relatively more biased toward ex-post market selection -, on the other, may indeed turn out to show roughly comparable degrees of overall "Schumpeterian efficiency" of the respective industrial systems. Of course, one can also find plenty of empirical examples where such a rough equivalence does not seem to be there. For instance, based on little more than an "informed guess", I would pick the Italian and the British cases as illustrations of the worse of both ("credit-based" and "market-based") worlds. In the Italian case, a pattern of finance mainly based on discretionary allocations by banks does not seem to have fostered the development of particular competences of the latter (if there are special competences, they do not concern innovation and production efficiency, but, rather, more political goals, on the one hand, and the safeguard of the "old boys' club" of long-established business groups, on the other) (8). Thus, one has here the disadvantage of weak "static efficiency"/weak selection processes, without the advantages of cumulative allocative competences of financial institutions. In the British case, a market-based financial structure, while revealing all the dangers of "shortsightedness" that such an arrangement entails, has not developed to any satisfactory degree mechanisms of allocation to innovative search, neither - until recently - to new ventures, nor through the internal rules of allocation of established firms (In this respect, the case of cash-abundant GEC is a good example).

In any case, the very fact that in each institutional arrangement the modes of learning and selection differ must plausibly have some microeconomic implications in terms of the strategies by which firms

cope with change and the boundaries between what is internalised within individual organisations and what is left in the markets.

In the section that follows, I shall suggest some tentative hypotheses on these issues.

5. FINANCE, THE CORPORATION AND ITS CHANGING BOUNDARIES

Most of the central topics discussed so far with reference to industry dynamics, not surprisingly, re-appear in relation to the internal organisation and strategies of individual firms. In fact, when dealing with possible conflict between "static" and "Schumpeterian" efficiencies, market-selection versus organisational learning, etc, one is actually assessing also the degrees to which decentralised processes of interaction can surrogate the "fallibility" of individual decision makers. Individual organisations essentially face the same dilemmas, but they must also make allowance in their decision rules for the possibility of making mistakes, correcting them, and, more generally, have strategic rules that are robust enough to let them succeed in a non-stationary environment.

Let me start by briefly characterising the functional structure of each firm. For the purposes of this work, a firm can be described as embodying (a) rules for resource allocation; (b) an information structure; (c) a pattern of incentives; (d) procedures for control/performance assessment; (e) a learning structure. With regards to points (a) to (d), again, most of the conclusions achieved in the literature on imperfect information, incentive compatibility, transaction costs etc, can be easily carried over to the description of business units that operate in innovative environments. As remarked earlier, several properties (eg on contract incompleteness, adverse selection, bounded rationality, etc) turn out, indeed, to be magnified by innovation and non-stationarity. However, the explicit consideration of the latter phenomena adds a further dimension to corporate organisation and strategies. After all, each firm, too, must embody procedures which makes it as efficient as possible in

allocating resources to currently known employments, monitor current transactions, etc, but also procedures which allow it to adapt to future (currently unpredictable) changes in the environment and produce these changes itself, by innovating. Since, as argued throughout this work, no simple relationship can be postulated between current efficiency and innovative learning, each firm is likely to embody a permanent tension between the different functions just mentioned. In particular, it is likely to embody different combinations between organisational procedures which "make it good at doing what it is already doing", and procedures aimed at the discovery and exploitation of new opportunities, ie "doing new things", or "doing the same things in different ways".

In a work, currently in progress, by D Rumelt, D Teece, S Winter and the author, on which the following is partly based, we try to explore the relationship between the forms of knowledge incorporated in each firm, its behavioural rules and its changing boundaries (9).

We start with the hypotheses that (i) corporate learning involves organisational rather than individual skills; (ii) a good part of the knowledge that learning generates resides in organisational routines; (iii) corporate learning is supported by strategies (or "meta-routines") that make provision for "looking in new directions", and "breaking the rules"; (iv) each firm is likely to have one or more "core businesses" defined by the technological/market trajectories it has experienced.

We, then, proceed to interpret the varying boundaries of the firm (eg

its degrees of diversification, the interrelatedness of the activities in which it is engaged) in terms of three fundamental dimensions, namely (a) the learning opportunities offered by its core business(es); (b) the degrees of path-dependency/cumulativeness of such learning; (c) the "toughness" of the selection environment(s) in which the firm operates.

Some of the predictions of the model are that with rapid learning and tight path-dependency, one should expect single product firms growing rapidly; that with high learning and low path-dependency one should observe firms which diversify across the activities where their knowledge is applicable and also some "hollow corporations"; that conglomerates may exist where there is a low path-dependency, low learning and a weak selection environment (10).

What do patterns of finance allocation have to do with all this? Some properties of different 'stylised' financial systems are outlined in Figure 1.

First, financial structures affect the selectiveness of the environment of the firm. Inevitably, firms, as characterised here, embody varying degrees of "efficiency slack". Some of this slack may be "progressive" in evolutionary terms in so far as apparently "wasteful" activities are instrumental in the exploration of new market opportunities, provide useful technological knowledge for other activities in which the firm is involved, etc. Some slack is sheer inefficiency, shielded, so to speak, behind the "indivisibility" of the firm. Well, one could expect that the more a system is "market-

FIGURE 1. A TAXONOMY OF FEATURES AND PROPERTIES OF 'STYLISED' FINANCIAL SYSTEMS

Systems / Properties	"Market-based" Systems	"Credit-based" Systems
Selective pressure on the grounds of revealed performances	higher	lower
Trial-and-error processes through birth of new firms	higher	lower
"Voice" versus "exit" processes of change	exit	voice
Opportunities of cumulative learning	lower	higher
Discretionality of allocative processes	lower	higher
Specialisation of competences by financial allocators	lower	higher
"Specialisation" versus diversification of incumbent firms	more specialisation	more diversification

based", the more it allows easy transfer of ownership claims, the more also it will increase environmental selection. Thus, over-diversified companies will be weeded out, firms with below-average competitiveness will be more rapidly taken-over by other ones, etc. This is, in my view, part of the story behind the recurrent waves of mergers and take-overs in the USA and other countries, probably favoured by financial innovations such as securitisation, etc. In turn, as argued by Carlsson (1988), mergers and take-overs appear to have often led to disintegration, selling-off of non-core business, specialisation. However, this may only be part of the story, since an increased volatility of ownership (ie a higher "perfection" in the market for industrial assets) may also imply more ambiguous evolutionary effects.

This leads to my second point. The potential conflict between selection/static efficiency, on the one hand, and "Schumpeterian efficiency", on the other, discussed above with reference to whole industries, may also apply at the level of individual companies. There are two clear cases in which this sort of trade-off occurs, namely (a) whenever the protection of a certain ownership structure is amongst the management objectives, so that the firms employ resources simply to protect itself, and (b) whenever learning costs depress current profitability and the market is unable/unwilling to capitalise future opportunities. Under these circumstances high levels of financial discipline may in fact jeopardise the long-term viability of a company or lower its future learning potential.

Third, and more generally, one would expect that, other things being equal, in credit-based systems, industrial growth will occur more via diversification of existing companies, while in market-based systems

the pressure to specialise in highly profitable activities will be greater (11).

Can one draw at this level straightforward normative conclusions on "better" and "worse" corporate structures?

Again, in my view, most of the earlier remarks remain valid. In evolutionary environments, each corporate structure embodies necessarily "sub-optimal" compromises between possibly conflicting interests and functions (Nelson and Winter (1982), Nelson (1987)). Relatedly, also the vertical and horizontal boundaries of firms vary. Particular systems of finance allocation and ownership exchange affect such boundaries by affecting the selective pressure confronting each firm, the levels of attention that it must pay to current profitability and the resources available for, lato sensu, learning activities. One can presume that, in general, the more capital markets matter and the more "efficient" they are, the higher also will be the pressure against uncompetitive activities and uncompetitive firms. However, from the point of view of long-term performances this higher market efficiency is not a sufficient ground for normative judgements. An evolutionary theory of corporate structures tells a story in which firms' boundaries change with change in the selection environment, technologies and learning conditions. Most likely, there is more than one pattern of corporate structure that is evolutionarily viable and such viability cannot be presumed to bear a monotonic relationship with the "perfection" of the markets in which the ownership titles of the companies are traded.

6. CONCLUSIONS

In this, largely exploratory, work, I have tried to suggest some conjectures on the properties of financial institutions in environments where innovations continuously occur, where "opportunities are always there", and where the degrees to which agents actually exploit them are primarily constrained by their own capabilities. In turn, I have argued, the performance of financial systems must be assessed on the grounds of the double, and possibly conflicting, roles of selecting resource employments based on revealed relative efficiencies and fostering the learning capabilities of individual agents and/or of the system as a whole. In these non-stationary environments several of the properties identified by the economic analysis of information imperfection, incentives, etc apply and are indeed amplified. Other properties emerge as the outcome of innovative activities and of the paramount importance that in them have learning and selection processes. In general, the importance of particular financial institutions in terms of economic growth, suggested by economic historians, is abundantly vindicated in this analysis.

Also puzzling issues emerge. For example, if innovative activities present the features that I have tried to outline here, no simple relationship can be established between the revealed efficiency of any one allocating system and its evolutionary performance (its "Schumpeterian efficiency"). The current state of the theory does not allow one to go much further than suggesting plausible taxonomies and empirically testable conjectures. In fact, the relationship between

financial structures and industrial evolution remains one of the most challenging, difficult, largely unexplored, fields in dynamic analysis. After all, finance is a crucial bridge between the present and the future, between what "has proved to work" and the exploration of "what is possible". In this respect, the present work has tried to highlight some features of such tension between continuity and change, mistake-ridden explorations and efficiency, cumulative learning and discrete ruptures, and the importance of financial structures in all this.

FOOTNOTES

1. Incidentally, note that such an account of environmental dynamics might turn out to be misleading even in biological environments that, plausibly, present much higher structural stability than social ones: cf Allen (1988).

2. On these points, cf Nelson and Winter (1982), Iwai (1984), Day (1984), Eliasson (1986), Silverberg (1987) and (1988), Dosi, Orsenigo and Silverberg (1988); Silverberg, Dosi and Orsenigo (1988).

3. There is indeed some evidence espeically from centrally-planned economies but also from Western ones, that this can be empirically plausible. However, this issue cannot be pursued here

4. This is also an implication of the model suggested in Amendola and Gaffard (1987).

5. Cf, for example, Lorenz (1979), Carrington and Edward (1979), Crotty (1985).

6. See also Ergas (1986).

7. The clarification of the importance of this point with respect to the modes of business finance is also the result of discussions with S Winter.

8. More on the Italian case in Ciocca (1982) and Nardozzi (1986).

9. Some preliminary results have been presented in Dosi, Teece and Winter (1987).

10. Corroborating evidence can be found in Pavitt (1987), who independently developed a broadly similar interpretation.

11. Some evidence showing the higher degrees of diversification of European and Japanese companies as compared to American ones is in Mariotti (1987).

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