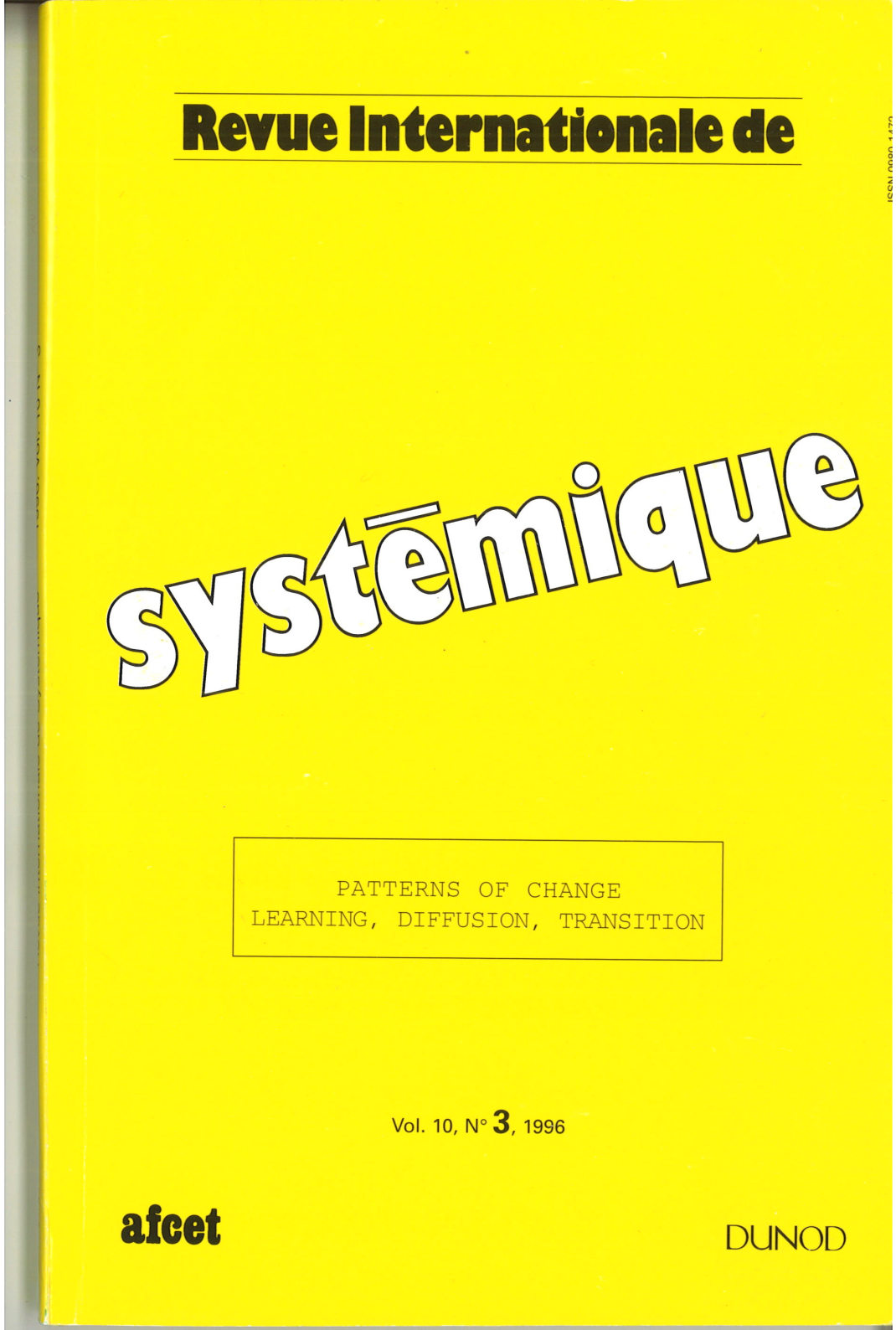

AFSCET

Revue Internationale de systémique

Revue Internationale de Sytémique

volume 10, numéro 3, pages 323 - 346, 1996

Sustainable differentiation

Ehud Zuscovitch

Numérisation Afscet, août 2017.

REVUE INTERNATIONALE DE SYSTÉMIQUE
Vol. 10, N° 3, 1996, pp. 323 à 346

SUSTAINABLE DIFFERENTIATION

Ehud ZUSCOVITCH [1]

Abstract
This paper tackles the issue of economic viability of Information-Intensive production Systems from a long run perspective. The relationship between capital, division of labour and economic development is analysed in the context of the new opportunities for product variety, opened by the wide dissemination of information technologies on the supply side, and the demand for such variety by countries with high per capita income. It is argued that a new form of industrial organisation, network structures, emerges to deal with problems of resource allocation in monopolistic-competition type of economic coordination, just as oligopolistic structures coordinated the capital-intensive industries of the post World War II era. Networks, because of their ability to internalise externalities, offer a flexible organisation solution for joint specialisation, provide some protection for property rights of intangible assets and, more importantly, alleviate the capital accumulation constraint on the division of labour and growth. As in other types of imperfect competition, the social loss of welfare from coalition behaviour may be offset by the networks' increased ability to generate and diffuse innovative activities.

Résumé
L'article aborde la viabilité économique des systèmes productifs d'information intensive. Les relations entre l'accumulation du capital, la division du travail et le développement économique sont analysées dans le contexte de nouvelles opportunités de différenciation des produits et

1. BETA-CNRS and economics Department, Ben Gurion University of the Negev, Beer Sheva. A previous version of this work was presented at the Münster conference of the International Joseph A. Schumpeter Society. I enjoyed and benefited from stimulating discussions with Robert Boyer, François Chesnais, Moshe Justman, Morris Teubal, Bengt-ame Vedin and Ulrich Witt. I gratefully acknowledge the support of the Commissariat au Plan and the Ruben Rausing Foundation.
Correspondence to : Ehud Zuscovitch, Economics Department, Ben Gurion University of the Negev, POB 653, 84105 Beer Sheva, Israel. Tel. : 972-7-472296, Fax : 972-7-472941, e-mail : ehudz@bgumail.bgu.ac.il

Rev. intern. systémique. 0980-1472 Vol. 10/96/03/ $ 4.00/

de qualifications ouvertes par la transformation industrielle en cours. Les réseaux sont présentés dans ce cadre comme une nouvelle forme d'organisation industrielle dont la dimension temporelle est irréductible. Ces structures apparaissent comme une forme de régulation industrielle dans un régime de concurrence monopolistique de la même manière que les structures oligopolistiques étaient adaptées à la production de masse de l'après-guerre. Par leurs capacités à internaliser des externalités les réseaux offrent une solution flexible à la spécialisation jointe, en même temps qu'elles permettent d'apporter une certaine protection aux droits de propriété particulièrement problématiques dans le cas d'actifs intangibles et finalement d'alléger la contrainte que l'accumulation du capital exerce sur la spécialisation et la croissance.

I. BACKGROUND

Economic development relies on increasing specialisation that goes through a new threshold of complexity due to the tremendous potential of product variety made possible by the rapid dissemination of information technologies. It brings the more advanced part of the economic system towards a monopolistic competition-type of economic coordination rather than the oligopolistic one that prevailed since the World war II. Oligopolistic structures were an inevitable consequence of the industrial concentration brought by the increasing returns of standardised commodities production processes. In facing the challenge of increasing variety there is a need for different type of industrial structure, a flexible one and this is where networks come into the picture.

Networks are constellations of firms which are linked to each other by partnership arrangements to confer mutual advantages on participants. From a hierarchical point of view, networks represent an intermediate form of governance between spot transactions on the one hand, being the "purest" form of clearing deals in market economies, and a full integration in a firm organisation, on the other hand. In network organisations firms preserve their identity and the basic liberty to operate on the various markets but it is to their advantage to maintain long run relations with their partners. Hence, there is a strongly recurrent element in this relation as well as confidence building mechanisms and cooperative practices.

Credit, both in its trust and monetary dimensions is essential to its functioning and both dimensions require time to coordinate individual incentives during their interdependent specialisation. Time is therefore a distinct feature of networks and the reason for which the markets-hierarchies

transaction costs perspective is ultimately unsuitable for its analysis. A joint specialisation, or more precisely a partner-contingent specialisation-increase the mutual benefits and ultimately the joint profits but at the same time it increases the individual risk. It must therefore include a risk reducing device. In a way it is a limited liability type of industrial structure as participants share risks of specialisation up to a given extent and tend to establish patterns of exchange of information and hence internalise the knowledge and technology transfers within the network. This limited liability practice bears a strong resemblance to the original one (raising funds through limited liability mechanism) and we shall come back to this point later.

I have thus far defined networks in a very broad sense without attempting any sectional or inter-industry classification or type of benefits to be derived from cooperation, or the various architecture in which they take place. At this point it is more important to understand the fundamental drive behind networks formation over the last years and to explore the rationale and impact of this tendency within the context of managing technical change and sustaining growth.

Firm cooperation is not a new phenomenon; our first task is therefore to better understand why cooperation has increased over the last decade. In our view, it is strongly related to the gradual transformation of the industrial structure into what can be termed as an "Information Intensive Production System" (IIPS) [1]. This transformation is driven by information technologies and other key components of the new technical system such as advanced materials and bio-technologies. A dominant feature of Information Technologies, in addition to the efficiency gains associated with previous forms of mechanisation and automation, is to increase the flexibility of the response of the production tool and, more generally, of the firm to changes in its environment. Actually it can be phrased differently. Unless there are changes in the variety of products, design, functional properties, and so on the ability to change *per se*, the flexibility, does not mean much. Hence it is the essence of this type of technologies to try and differentiate, every time further, products and needs on both the supply and demand sides.

Differentiated products call for highly differentiated skills and if, for example, instead of some basic variety of plastic material you produced before, you have to meet a whole variety of very specific demands you need to cooperate in order to better define with the industrialist and the end user the specific use characteristics. Hence there is a growing increase in both variety and complexity that involve many types of knowledge and no one can control –let alone develop by himself the different ingredients that

are involved in his *own* business. We shall develop later on this tendency, but as micro markets multiply together with the globalisation of business, each micro market in itself is a world of detailed trade regulations, technical requirements, environmental considerations and we have not really gone into strategic considerations of competition on market shares and related issues. A growing information and knowledge intensity is a major driving force behind cooperative agreements.

The position I take in this paper is that the network organisation is not simply a passing metaphor or a transitional mode in reseach but rather a new form of industrial structure that tackles the fundamental challenge of simultaneously increasing variety and efficiency. The term that I choose for this purpose is *sustainable differentiation*. The set of new technologies that appeared in the early eighties and are being gradually developed and diffused, stimulate product and skill differentiation and the issue of viability arises then immediately. Indeed, we know since Adam Smith that division of labour is a function of the size of the market, and so, stronger differentiation must come along with growth, otherwise something may go wrong, and in some sense it does.

For some years now, productivity measures (and more generally the national accounts) have failed to represent the strong qualitative change that takes place due to the diffusion of new technologies and in particular information technologies. This has been termed the Solow Paradox, *i.e.* we see computers everywhere except in growth accounting (OECD, 1991). This is not to say that growth does take place and we just underestimate it because we use incorrect measures (although we do experience substantial quality improvements in many products and processes). We are still in the phase where creative destruction is violent and older industrial species are replaced by new ones without any serious addition to growth. It is quite possible that we are progressing but for the moment the massive job destruction and social tension related to human suffering from unemployment create doubt about the marvels of technical progress.

Growth relies on technical progress but it must be built into a surplus creation principle. This is why the literature on endogenous growth as well as the one on industrial economics have recently focused on issues such as increasing returns to scale, network externalities, knowledge spill-overs, public goods etc. There must be a super-additivity to fuel growth otherwise we are back to decreasing returns (where equilibrium usually prevails but this is comfort to analytical minds only). Such a principle exists for the mass production regime when standardisation and scaling up generate increasing

returns. In the new information-intensive production system some of the same logic may apply in the form of informational returns to scale but on the whole the new system is based on more variety and there surplus must come from a different type of mechanisms to which the cooperative dimension is essential.

There is also another dimension of increasing specialisation which is related to capital accumulation. Since the Physiocrates we know that (circulating) capital is primarily an advanced subsistence for workers. Therefore, if we need to specialise further, we must necessarily increase capital. If, for reasons related to new technologies, we need to create more differentiated skills that cater to micro-market requirements, this must be supported by the economy in relation to the size of capital. Think of the capital-specialisation relation as a sort of input-output process that must accompany the development of markets and growth. In the 19th century, the capital accumulation constraint was much more related to the input side of this process and subsequently the limited liability principle was established. Capital physical indivisibility was compensated in fund raising through sharing ownership and risks. Strong specialisation and increasing differentiation, the output of the development process, involve also considerable risk-bearing. Cooperative mechanisms are set in order to share these risks. So the problem is in the link between capital and specialisation and networks are a social way of dealing with this problem.

We shall also argue that the very way in which specialised demands are matched calls for cooperation in the search and definition of new needs and that learning is done collectively in such a fremwork. Our basic answer to the viability issue is that, to some extent at least, physical increasing returns of standardisation may be partially compensated by another type of increasing returns, of an informational nature, through the creation of externalities, and networks are structures that are set to appropriate them by a limited number of interrelated economic agents.

There is yet another important motivation for the growing interest in network configurations and it is the strong performance of some economies, the main case being Japan naturally, where a govemment/private sector coordination and cooperation was particularly efficient in promoting quick adoption of new technologies together with a rather articulated strategy of foreign market conquest. This dimension, very appealing, does not concern us here directly as we try to deal with the theoretical issue of the link between network as industrial structure and economic development, yet in some sense we shall try to explain the success of this form of organisation by economic arguments of trust and long run risk sharing that are probably behind the long run cooperative attitude present at all social and economic strata in Japan.

One more comment is due. As it may have already appeared, our basic premise is to relate networks and progress to the overall learning and development processes, (and more precisely to technological knowledge creation and dissemination). We argue here that networks are basically an organisational device to promote learning through the combination of private and group (or coalition) incentives. This is not a secondary dimension but a primary one. Networks functioning, as any coalition behaviour, necessarily involves a potentially strong dimension of imperfect competition. If it includes only a priority-to-memebers mechanism it introduces inefficiencies and welfare loss. From a social welfare perspective this is "justified" only if the inconvenience is compensated by efficiency gains, as in abetter capacity to differentiate skills and products and to contribute hence to economic growth.

If collective learning is a key feature of this system it is also due to the appropriation of innovation, and of development activities in general. Innovation comes either as an informational good which can be dissociated from the good to which it is incorporated or as an embodied entity in which case separability is not simple, because part of the production practice may remain tacit. In development processes the skills, properties and goods differentiation remain partly tacit. In an IIPS the need to permanently generate new combinations makes the development phase much more important than before. A larger part of the firm material and immaterial resources must be spent on development activities which really become a part of the production system. Since the competitive edge of the firm relies much more on its intangible human capital, a problem of access to technological information arises. If the firm needs specific high-tech skills (and the larger the diversity of such skills the more difficult it is) it can not have direct access to them on the market because they are too firm-specific. Furthermore there must be a considerable adaptation of the skill to the firm requirements. In such a case it is much more reasonable to enter into long-run cooperative arrangements than to purchase them directly since skilful personnel loses some of their attributes en route. Network functioning meets both dimensions of simple scale sharing facilities (using some skills more rationally) and of network externalities, that is the ability to have access to his integrated environment through the network experts.

The structure of this paper is as follows. We first study the problem of sustainable differentiation comparing viability conditions under the scale intensive context and the information-intensive one. Then we try to establish in which sense network functioning provides some answers to the viability problem: through risk sharing and credit mechanisms on the one hand and learning through reactivity and interaction on the other. We finally offer a tentative analysis of collective learning and innovation appropriation in such an industrial structure.

II. SURPLUS CREATION AND ECONOMIC DEVELOPMENT

Surplus creation is a fundamental subject in economics and it is not pure chance that economics as a scientific discipline emerges approximately at the same time as the industrial revolution. Allocation problems arise when there is something to share, *i.e.* when surplus is created, and a stationary economics offers no stimulating perspective in this respect. As a matter of fact this complementarity between development and allocative forces is clear in the writings of both Adam Smith and Joseph Schumpeter. In Smith's theory, the invisible hand as a metaphor for the discussion of resource allocation (or the exchange coordination problem) which arises because of the specialisation (division of labour) and the surplus it generates. In Schumpeter (1934), the tendency towards equilibrium occurs after the first of the two-phase of the analytical business cycle, where development forces are dominant. Unfortunately, it is the allocative dimension and not the creation or development of resources that was increasingly explored and, with the marginalist revolution and the subsequent neo-classical focus on the short run and the role of the marketplace, economics was practically identified with concerns of efficient allocation.

In recent years the discipline tends to go back to a more classical (in the sense of the classical school) preoccupation of explaining and managing growth. In this context the surplus creation mechanisms are essential as something must fuel growth. Most of the recent contributions study the implications of increasing returns, which are in most cases assumed to be related to the division of labour (Romer, 1986, 1990) but there are also micro foundations-type works that try to better explain the source of surplus resulting from specialisation, as for example in Borland and Yang (1991, 1992) and Edwards and Starr (1987), following earlier contributions by Houthaker (1956) and Rosen (1976). Neo-schumpeterian approaches appear natural in such a context and present innovation as a source of endogenous growth, either as in Nelson and Winter (1982), Dosi *et al.* (1988) in an evolutionary tradition, or, more related to the mainstream practice, as in Helpman and Grossman (1991).

The issue of a more turbulent environment as the context for such a growth is common to the evolutionary approach and modelling efforts of

several research traditions. One finds contributions more focused on non-linear dynamics, chaos and alike as in Sylverberg (1992) as well as direct modelling of the creative destruction as in Aghion and Howitt (1992). The broader aspect of the Schumpeterian tradition is that surplus creation is strongly related to both innovation and the perturbation and successive adjustments it introduces into the market structure (and subsequently into the macroeconomic level). Other strands of the economic literature, such as the work on productivity measures in relation to technical change (Griliches, 1979, 1990) or on innovation and market structure in the industrial organisation models (d'Aspremont and Jaquemin, 1988) and Crepon *et al.* (1992) focus on spill-overs of knowledge and technology dissemination as a source of surplus.

We have described several metaphors by which we try to explain surplus creation principles and mechanisms. I shall try to suggest here a unifying principle to surplus creation starting with basic considerations relating surplus creation to specialisation. It will help us then to compare the viability conditions under the mass production regime with what I have termed the information intensive production systems.

In the pre-classical economic theories surplus comes from the land, and land fertility is the key factor behind development. It is clearly the case with the Physiocrates who described the economy in agrarian terms and less so with writers like Sir James Steuart for whom the industry takes the lead in development as its products stimulate the farmers to produce more food. In classical economic theory, land and subsistence continue to be a major concern but surplus creation is attached to industry. The views about what drives industrial dynamics and the principle of surplus creation are not uniform. Smith claims it is the division of labour, Marx, the part of the labour which exceeds what it takes for reproduction and Schumpeter believes it is the change from one system to another that generates temporary surplus. However it is interesting to notice that once each presents his viewpoint on the "main" explaining factor, all the other "secondary" dimensions are gradually introduced.

Industrial development is a dynamic process in which specialisation leads to increasing returns to scale through successive reorganisation, resource reallocation and competition. These reorganisations may be of an incremental innovation type and more endogenous to economic forces à la Schmookler (1966) or of a Schumpeterian nature, of a more exogenous nature with jumps and discontinuities, but again, in both cases the surplus appears as a function of reorganisation. When moving to a more efficient technology or production

method not by any method by itself. Surplus is generated when one structure is superposed on the other and the agents have to adjust and integrate novelty a lot of (productive) energy is spent. This way of looking at the principle of surplus creation offers a unified view of specialisation as the result of both division of labour and innovation. I take here a more Schumpeterian view but I don't that Smith would reject this view either. All other types of surplus creation as spillovers and externalities fit in. Indeed information transfers are just another type of creating wealth by facing the existing firm structure with a new information/innovation. In most cases this reallocation does not preserve the inputs proportions of previous production organisation otherwise development would consist of a mere replication. The competitive dimension of this process should not be minimised as it entails a change in market structures etc., but we shall come back to that later.

It is also important to distinguish between surplus creating principles from increasing returns. The existence of surplus does not ensure automatically increasing returns. Specialisation in the form of goods and skills differentiation increases the efficiency and generates surplus during the overall process but the magnitude of the change does not systematically imply a process that can sustain growth in the way experienced by the western economies after the second world war. The ability of increased efficiency to lead to increasing returns depends on the magnitude of the efficiency gains of every sequence of reorganisation, on demand and income elasticities and on the extent to which both sides trigger a chain-reaction of development processes. In the next paragraph we shall describe this process in the case of the mass production regime in relation to standardisation. We shall then analyse the variety issue of information intensive production and we will claim that while the surplus creation principle does exist it is not followed, at least automatically, by an explosive process.

III. THE VULNERABILITY OF THE MASS PRODUCTION REGIME

The continuous process of reorganisation and technological change that sustained economic growth from the beginning of the industrial revolution knew an important acceleration after the second world war. This is due to several factors. There was of course a demand triggering in the great need to civil reconversion in the US and the tremendous challenge of reconstruction in Europe; the fact that science has truly become a part of the production process and induced a stream of innovations, coming from R&D departments of big firms; the perfectioning (much accelerated in the war) of mass production techniques due both to Taylors' scientific organisation of work and Fords'

chain production principles; and no doubt the availability of cheap energy. It is hard to attribute the growth potential to any single factor. The division of labour principle was certainly not enough to produce such a drive alone. There were some major innovations such as the development of synthetic materials, that have shown also strongly physical returns to scale in the upgrading of their production units from several thousands tons per year ethylene units to several hundred thousands such tones only twenty years later. The same Kilogram of Polyethylene worth went from ten kilos of beef to several grams at most over the same period. Plastic is a good example since the process of replacement of natural raw materials with synthetic ones was very powerful. On every efficiency gain and price reduction a new horizon for substitution of a whole range of products opened up. Yet even in the case of such capital-intensive industries as refining and the production of oil-based commodities the weight of successive innovation of improvement was found to dominate the initial "radical" innovation (Enos, 1962). This is only to say that, as Schmookler suggested much of the impact of technical change eludes the layman who identifies technical progress and radical innovation.

Analytically speaking the overall process of increasing returns under the mass production regime could be summarised as follows. After an initial exogenous increase in demand, the production units adjust first in moving to two or three shifts but then are obliged to increase capacity. This gives birth to reorganisation of processes together with some process innovation and tend to increase efficiency. The firm will the typically try to increase its market share by lowering price and consequently the average price of the goods under question decreases. Demand for this good, other prices being given, increases as the product has become cheaper comparatively to others and demand rises now *endogenously* and will push for another cycle and another. Subject to convenient efficiency gains and demand elasticities we have just defined a type of reorganisation process whose envelop curve will exhibit increasing returns. As we all know from our elementary textbook a production function with increasing returns covers more than what it takes to pay the factors of production and this growing profit will create an incentive never to stop before the quantitative saturation of the market. Prices continues to fall and quantities increase. As the excess of profits over factor remuneration is transformed into more purchasing power distributed in the economy this develops further the demand and triggers more and more such processes in other sectors of the economy. This truly resembles a chain-reaction process where the decomposition of one nucleus trigger others. I have elsewhere analysed this in more detail (Ayres and Zuscovitch, 1990) but with different

emphasis it matches other descriptions or models of growth such as Salter virtuous circle (1960) or the Kaldorian technical progress function. The originality here is related more to the interdependence of such increasing returns processes in a chain-reaction manner.

Although such a chain-reaction process is very powerful, and I do believe that such a process was behind the post-war years of rapid growth, its own efficiency tends to make it highly unstable. Indeed when prices reach low levels they become highly sensitive to any change in the components of cost be it raw materials, energy, transport costs etc. This was the case with the oil crisis, and it may be the case for the steep decrease in computer components nowadays. Furthermore the process of capacity accumulation doesn't stop so quickly because when demand falls, the firms get often into capacity increasing to get some efficiency gains and save their market share. (See Gaffard, 1979). By doing so they make the crisis still worse off. The mass production regime produces the reasons of its own fragility.

When instability increases to the point where the overall profitability is subject to violent fluctuations with every small change of relative prices the firms will naturally try to diversify their product portfolio in order to compensate for cyclical fluctuations. This is one of the major motivations to increase product variety. One should add to that the historical context of the late seventies and the early eighties' uncertainty as to the nature of emerging technologies and the increasing competitive pressure of low wage countries and particularly the new industrialised ones. This is certainly not the only one. A richer society whose basic needs were already fulfilled asks also for more product variety. The demand for higher variety was there both from the production side and the consumer side and when the information technologies enter the scene in the eighties the ground is ready for a quick development of higher variety. One last remark at this point. We should not forget that the pattern of mass production increased welfare and income per capita very substantially. Yet in the present time of environmental concerns we have to admit that this scaling up with decreasing prices brought upon a significant level of pollution not only because of neglect of the environmental aspects but also intrinsequely, by its very nature. When the price of plastic bag approaches zero the cost of its recuperation exceeds by far the price of its production.

IV. SUSTAINABLE DIFFERENTIATION

Information technologies both on the production sites with CAD/CAM, robotics, and in general flexible manufacturing, and at the office level,

personal computers, telecommunication networks etc., tend to increase the capacity of the system to deal with variety. The cost of switching from one series to another and sometimes from one product to another decreases and one can see in some extreme cases on the same production chain one different model after another. This is not just a metaphor for production ; the logic is one of competition. If standard goods can be easily copied and produced elsewhere with cheaper labour, it is quite natural that the industries of western countries lose their relative advantage in producing commodities. In such a case, as suggested in a previous section, the industry will try to introduce more substantial variety and will tend to rely on a strong market segmentation with specific properties.

This tendency calls in turn for a massive incorporation of science and technology in specific configurations to match this increasing variety. This is a very natural strategy as most industrialising countries lack a broad scientific and technological knowledge base and the risk of imitation by them is reduced. We should also mention here that other new technologies conform to this tendency to define micro-markets products in their specific functional properties. Both new families of advanced materials and biotechnology rely to a large extent on scientific progress that tend to explain functions on the basis of the microscopic properties of matter (see Cohendet *et al.*, 1988).

It is worth emphasising that the mass production regime relies *in an essential way* on standardisation. A considerable R&D investment is required for standardization. Yet, as the most important thing to achieve in such a setting is the construction of an production device, capable of reaching high process efficiency around the standardised goods, it does not fully exploit the scientific and technical abilities of the firms' R&D departments. Now, when substantial variety is called for, the ability to use this knowledge in a differential way become vary important. This is why the production regime based on information technologies is intensive in knowledge and information. Technical knowledge is not enough naturally. The very definition of specific applications calls for cooperation with users and it follows that the firms must develop learning abilities in general and discriminating capabilities in particular, on both the supply and the demand sides (see Teubal and Zuscovitch, 1993). As a matter of fact every micro- markets is defined as a complete environment of its own and calls as such for numerous specialities. Elsewhere we have termed this type of production an information-intensove production system (IIPS, see Willinger and Zuscovitch, 1988).

This type of production systems immediately raises a problem of viability and it is easy to see why. The efficiency of the mass production regime

relied on standardisation. Consumers and users were not used to express individualistic preferences because of the high expense involved. Standardised products compensated them with a cheap commodity. In this context no real variety exists, the most one can hope for is "functionalised commodities". The real competencies and skills one had to develop were a function of the few brands that were actually produced and with a convenient division of labour the firm could be practically independent, at least in the areas that it considered strategically vital (*e.g.* the engine for the car producer).

Nowadays, with the increasing number of specifications, one needs to master an ever increasing number of bodies of knowledge in order to adjust the products to the functional properties of the different applications. It turns out that the cost of switching from one product to another may fall but the characterisation and design of a variety is very expensive. Two issues are at stake. The first is how to make available all the special skills that the firm needs in order to function under an IIPS and the second related question if such a functioning is economically viable, *i.e.*, whether it is capable of generating surplus and whether it offers some compensation for the lost economies of scale that were available in the mass production regime. To summarise, an IIPS requires a much higher differentiation of skills and capabilities and it is not clear what conditions should be met in order to make such a differentiation viable. Before attempting an answer the relationship between capital and specialisation has to be addressed.

The farmers, said the physiocrates, must have their productive and private consumption in advance. This was termed "advances" and represented the fundamental flows in the "Tableau Economique" and is one of the first versions of the notion of primitive accumulation that many classical authors share as a condition for industrialisation. If one introduces this intermediate in the Smith correspondence between the size of the market and the division of labour, things can begin to clarify. If, expecting an increasing market size the entrepreneurs wish to further differentiate their skills, they need to increase their capital in order to feed the extra workers during production time (for simplicity we assume circulating capital only).

As economic development occurs, increasing specialisation through division of labour and innovations requires more and more capital and as it becomes more and more difficult to get such capital from any single source, the limited liability mechanism is established in the 19th century and the collection of funds is made divisible through what fundamentally is a risk sharing mechanism. Under *standardised production*, when the variety of goods and skills is limited, the specialisation is viable since the firm can

afford to maintain and develop specific skills (given the infrastructure of general education) to protect its competitive advantage. Under IIPS this no longer holds because in order to supply increasing diversity of specialised needs, the firm has to possess many more specialities in any field ranging from R&D to marketing. If returning to the plastics case, a different functional requirements are needed from materials which enter the components of T.V. sets and of a PC's, the plastics firms need, in order to compete in the relevant markets, to better understand and thus to effectively *interact* with electrical appliances producers.

A differentiation of goods calls for a differentiation of skills that is very hard to address for all firms, even industrial giants. To come back to the capital and differentiation relationship. If capital raising was made social, specialisation was kept firm individual (and secret if possible). This was possible because of the limited variety. Now it seems that specialisation itself must be shared. When instead of a standardised commodity the firms produce many specialities, they must define the goods/services packages in cooperation with the end-users or industrial users and the specific requirements needed for each application often call for many specialists that are not available in the necessarily limited skills of one's enterprise and for which exterior skills must be contracted. So *Partnership is therefore a condition for viability.* it enables partners to develop skills in a mutually contingent way, *i.e.*, I specialise if you specialise and we agree to share our learning according to some modality. If a pin-pointed skill must be developed, it is possible that there will never be sufficient work for the specialists to survive. A highly specialised skill can only be maintained if competence is shared among many users. This is basically why we may think of networks as a new industrial organisation. It renders specialisation essentially a social process and creates the same separation between specialisation and ownership as did the limited liability device on the fund raising level. We must go now beyond this basic level and understand the motivation and incentives of such an industrial organisation. We shall do so by first studying the incentives and then the learning dynamics.

V. NETWORKS INCENTIVE STRUCTURE, INTERACTION AND LEARNING

a. Individual incentives and incentive compatibility

There are several basic motives for which a firm enters a cooperative agreement. The first is to have access to a skill, competence, or service which

is not directly available. This is a simple principle of sharing indivisible factors and services, such a sharing a representing agent in Brazil for a firm which has only limited activity there. Other arguments go along the same line : reaching a critical mass in some capability enables both firms to reach new markets or technologies which require a minimal scale ; avoiding research duplication in several firms, etc. Aside from indivisibility there is a whole range of complementarities that firms agree to share for their mutual profit (see Milgrom and Roberts, 1990).

There are different ways of structuring the partnership arrangements according to the type of complementarity and we shall not go deep into classification matters here. But, there is very clearly a large difference in the situation when cooperation is established between competing firms in the same market to undertake together pre-competitive R&D (horizontal cooperation), from the one where firms from different sectors resolve together mutual problems of product definition (vertical cooperation). User-producer is another type of cooperation having yet another set of constraints and incentives (see Lundvall, 1988). We shall neither deal here with the strategic implications of cooperation which encompasses the entire area of game theory nor shall deal with the strategic behaviour for cooperative R&D (see Katz, 1986 and d'Aspremont and Jacquemin, 1988 for that purpose). The whole issue of defining rules for partnership is very interesting and includes such topics as : industrial organisation considerations of structure and stability of cooperation in various industries, business practice rules for success or failure in joint ventures, legal aspects of finding optimal forms and categories of balancing rights and duties for each significant mode of cooperation etc. A comprehensive picture of the types of individual incentives and compatibility is not within the scope of this paper (see Shachar and Zuscovitch, 1993).

We should also bear in mind that cooperation is not necessarily a bilateral relation. In network structures the gains from partnership formation may be higher in the same way multilateral trade is superior to the sum of bilateral trade as the quid pro quo constraint is not imposed on any single trade. This calls for the creation of a form of credit that we discuss later. The more difficult point to analyse is not when the "club" of the participating firms agrees on a common language, standards or norms of trust but when numerous bilateral agreements have a more diffuse nature, since then the coordination problem becomes insoluble and Arrow's impossibility theorem on the intransitivity of priorities fully applies.

When the of definition of markets and transactions grows finer, contracts become very complicated to define and transaction costs inevitably increase.

In hierarchical organisations such as firms the priority setting is then settled by an authoritative principle. In partnership and network arrangements there is no such authority. Therefore coordination of priorities is potentially more difficult. The only solution for a smooth functioning without insurmountable detail solving is the institution of trust and credit, indeed discussion of individual motives, shared or not is not enough. If we want to go beyond that we have to understand better the time dimension involved in confidence building mechanism.

b. Priority reciprocity and credit

Partnership relations involve time in an essential way. Transactions are repeated over time, become routine, and withdraw from this regularity is a sort of *causus beli*. Indeed partners, or participants in network introduce a norm of behaviour which is essential to the stability of the coalition. They must build confidence if transactions are not cleared instantaneously. The word credit here has a double meaning. The first is that partners give recit to each other in the sense of norms of behaviour, reputation and confidence, in which one party is willing to offer systematic priority as long as, on average he is not losing from this fact.

Trust is atacit agreement in which the buyer is willing not to look systematically for the best opportunity at every instant but over a longer time interval, as long as his traditional partner does not go beyond some mutually accepted norm. The buyer saves some on search costs, the seller the insurance costs of protecting himself against uncertainty, since now, when demand decreases, he has a captive buyer who will give him systematic priority. Compared with a seller who is not in the network his financial costs are reduced so he is immediately more competitive. if he skilfully uses the credit he receives from his buyer(s) he can also make some efficiency gains through R&D for example, and come after a while and pay back. There is also here a reciprocity arrangement in case of excess demand. We should elaborate here more on that since this dimension of reputation and credit mechanism is very important.

Fundamentally, there is a strong correspondence between credit, imperfect competition, and time. The same coalition measure reflects by how much the supplier can withdraw from the current efficiency price. Therefore it becomes a measure of apparent short-run inefficiency and of imperfect competition. This is not necessarily so because on the average *over time* no one can really deviate. But local deviations are possible and are in a way the purpose

of the game. Agents use this possibility to locally deviate, to establish a competitive advantage. This credit arrangement defines also the time horizon for the economy. The greater the credit the partners allow themselves, the longer is the time horizon of their economy and the better is the advantage they have over external economic agents.

From this point of view, the firm's goodwill appears as an essential asset that enters like any other into its asset portfolio and where the usual economic rules of management apply. When interest rate rise in the economy, the competitive pressure increases because it becomes more expensive for suppliers to grant purchasers credit and the latter may be induced to go out of the "clientele" of the former. Where goodwill ceases to be an asset like any other is in respect to it's transferability simply because a reputation effect must be gained –it cannot be simply transferred as in a normal transaction. The same is true for the technological facet of these assets as they are very often only partly transferable. We shall come back to this point when we discuss appropriability. The arguments we have put forward, whether on the basis of individual incentive or on credit mechanism that appear in network relationship, are useful for understanding the consistency of partnership behaviour. Yet, we have not dealt with the issue of surplus creation in networks and the way the various credit arrangements and, more generally, how the risk sharing mechanisms affect the problem of specialisation.

c. Sustainable differentiation again: credit and specialisation

Credit, trust, and risk sharing are necessary conditions for specialisation to take place in a network and particularly an information-intensive one. As product variety expands, coordination can become extremely difficult. The standard industrial economics prognosis is to integrate the agents within a single firm and solve, in an essentially authoritative way, two problems. The first is the problem of mismatching priorities and the second is the enormous definition and transaction costs that arise inevitably in the context of strong differentiation.

The hierarchical solution to these two problems is what defines the Williamson's Transaction costs approach (1975, 1985). In the context of increasing differentiation this may not be an adequate solution. Under IIPS the number of skills is such that it is impossible to integrate them all. One may wish a flexible organisation structure in which specialisation is much broader within the system but is not appropriated by a well defined entity. Since, on the one hand, it is no longer possible for the firm to *totally* set the

priorities for all the required skills, and on the other hand it is not satisfactory to have no priority at all in a market spot contractual relations, a flexible organisational form should allow for the modulation of priorities according to the strength of the partnership agreement (be it contractual or tacit).

If functioning under a network arrangement seems to guarantee such flexibility the problem of coordination is not automatically solved. The second problem, *i.e.* the need of defining a detailed contract for each of an unlimited number of states of nature, still remains. This is precisely where the credit in the sense of trust becomes relevant. In business language, trusting somebody means that you define a line of behaviour from which the partner will not deviate because of the potential risk of severing the confidence tie. This trust is precisely what makes it possible *not* to define in a contractual way the all the possible configurations that might arise under numerous highly specific circumstances and to let the general sharing principles of the network guide decisions in conflict situations.

Risk sharing of specialisation is another important aspect of cooperation and it is in our view an important trust mechanism in network functioning. Specialisation is a risky business. One very often loses a "horizontal" ability to satisfy various demands in order to gain "vertical" efficiency that will guarantee better profits, if targeting is correct. Any specialising firm accepts this risk, network or not. A risk sharing mechanism is essential because while aggregate profits for participating firms may indeed be superior to a previous situation where all firms were less specialised, the profit distribution may be very hazardous. To make specialisation worthwhile, the 0-1 individual outcome must be smoothened somehow by a cooperative principle of risk sharing.

On a more general level networks introduce a new notion of cooperation in relation to specialisation –a limited liability principle. Under the standardised production regime raising funds was made divisible but the firm's specialised assets and skills were not shared. This is no longer adequate. if the firm wishes to specialise further it must interact in many sub-markets with other producers and with users to produce tailor made solutions for higher added-value products and thus the *specialisation itself is becoming increasingly shared.*

To this new dimension one can very naturally add the more familiar argument of sharing indivisible resources. A pinpointed specialisation even if it was originally developed within a given firm for some specific application or skill, cannot be fully exploited unless shared or sold under some convention for other specifications of completely different products that need such a

skill. Typical for this case are new materials which have specific military applications but are much too expensive to produce unless some civil applications support the development as well. When specialisation is shared risk is also shared, and this is done under different forms of conventions or trust related mechanisms.

We have suggested some links between credit and specialisation. Analytically speaking, we have to understand each of the above dimensions more precisely and also be able to articulate the different forms together in a global explanation of the relation between network credit and specialisation. Practically, if network functioning involves a limited responsibility mechanism it is probable that some legal and jurisdictional innovation is called for. It is true that in recent years some new forms of public and private associations, appear under various conventions and institutional forms. It is possible that we have to re-assess more radically the principles of property rights to adjust to this basic conflict of allocation that arise when creation is collective and property is private.

The issue we are dealing with is sustainable differentiation. Thus far we have focused on viability from the standpoint of economic networks functioning. Now we have to consider the relationship between specialisation and surplus under IIPS and thus to try to tackle the issue of a macroeconomic or system viability. Under various forms, differentiation leads to an extremely high potential of cross-fertilisation. Much of the recent work on genetic algorithms deals with the issue of viability at this level. In principle such gene combinatorics are very creative.

Transposed to economic terminology, skills combination may stimulate creativity and productivity. In our discussion on surplus creation we have argued that surplus results from reorganisation is generated when two different structures are confronted. The need to "digest" the novelly is a primary drive as any manager recognises. The introduction of new management religions every couple of years is not so much related to the intrinseque value of the novelly as such but because it regenerates competition and creativity through the successive waves of adjustment. Since higher differentiation ultimately means an acceleration of the emergence and development of new and different structures the potential for surplus creation from is high.

To the other question relating specialisation and growth I have no clear-cut answers. In order to generate growth the surplus creation, which relies here on dynamic economies of scope, must trigger a chain reaction of the kind we have previously described. It is hard to see how this can come about. Although as we explained before every specialisation must rely on a

widespread use and create the potential for a wider diffusion it is hard to see how a massive triggering of demand, leading to cost and price reductions, can take place as long as demand comes in small parcels. Growth must probably rely on some combination of both standardisation and differentiation of information. Informational returns to scale of standardised algorithms must, at least partially, substitute those related to physical capital. Our specific contribution in this paper to the viability issue was to suggest that network functioning can generate increasing returns because it alleviates the capital accumulation constraint on specialisation.

d. Learning and appropriation

In the previous paragraph, we have characterised the network as a flexible organisation in terms of specialisation and the ability to learn in a collective manner is what lies at the heart of the entire issue. In order to make progress in our understanding of the relationship between network, differentiation and surplus creation we have to thoroughly understand the principles of interactivity (see Le Bas and Zuscovitch, 1992, 1993). There are numerous levels for grasping interactive effects. There are some innovation-innovation type of effects as in technological complementarity, production bottlenecks and evolution along technological trajectories. There are agent-agent types of interactivity such as externalities and there are innovation-agent interactions as those that occur during diffusion.

Interactivity can be apprehended at the intra-firm level when focusing on learning and on an inter-firm level when dealing with spill-overs. One can also link intersectoral technology transfers and the interplay between technologies. It is impossible to develop this further here but it is clear that if surplus results from interactivity, a comprehensive analysis of network learning should re-interpret much of our current concepts of interaction in a network framework. We will follow a more modest objective focusing on learning in a more restrictive sense. In a previous paper, Teubal and Zuscovitch (1993) classified the relationship between networks and learning in the following way. Knowledge differentiation process occurs in networks of firms in which a prime contractor coordinates the functioning of sub-contractors. We refer to it as a generalised learning by doing process and emphasised the strong organisational dimension of such networks and its specific role in assigning standard performance in terms of minimum quality requirements. This is a typical behaviour in construction type industries such as the automobile or the aircraft and space industries. Recently we were also

able (see Zuscovitch and Cohen, 1993) to establish that the role one fulfils within the network tend to influence the nature of its technological learning.

The second type of learning is a generalised learning-by-using that occurs in capital good industries where the producer incorporates the users' collective learning in the innovation process. This process occurs very often in the market development stage before standardisation. In the same paper we have finally tempted a learning-by-interaction analysis taking the supply and demand differentiation process as given. Our purpose was to analyse how at each stage of technology and market building, a qualitative residual is generated and stimulates further differentiation and creation of successive levels of sub-categories. Increasing discriminating capabilities from both producer and user perspectives yield, under different configurations either a converging process where variety is limited, or a divergent process of increased variety. Here also we must limit our discussion and tackle the last issue of bridging learning and innovation appropriation.

Under different forms we have suggested in this paper that network is a new type of industrial organisation capable of dealing with learning (and differentiation in general) when information intensity increases. One of the most important reasons for this tendency is that innovation appropriation occurs differently under IIPS. The basic reflex in innovation appropriation is due to Arrow in this seminal article (1962). Arrow stressed that the informational nature of the innovation is a major source of market failure. This, was true not only because of the general nature of scientific knowledge but also because production was perceived within a standardised regime. When product variety is limited any leakage of information may incur very serious losses simply because total output is affected. All subsequent analysis and policy implications followed automatically from this information nature of innovation and derived from the fact that information was understood to be easily and costlessly transferable.

Under increasing variety the situation is completely different. Increased differentiation drives the system towards a multiple micro-markets situation where imitation is much harder as it calls for multidimensional specifications for each of the individual design configurations. The problem is actually much more complicated. When intensive information is embodied in the products both through a wide variety of user needs and massive incorporation of science and technology properties, the firm tends to rely much more on intangible assets to establish their competitivity. The real side or the "book value" decreases in importance. These intangibles that represent the accumulation of human capital by the firm are much less transferable. This

limited transferability is due partly to the tacit dimension of technological practice and also to the collective nature of these assets. The cumulative nature of learning makes these assets even more local, more specific. If information cannot be efficiently transferred through markets even with the "right" incentive then the only way to transmit such experience is by sharing its production. Networks represent a mechanism for innovation diffusion through collaboration and the interactive relationship becomes not only a coordination device to create trust but an essential vector of technical progress.

CONCLUSION

We have attempted to show that *sustainable differentiation* or the ability of the industrial structure to manage a large product variety to depend upon various forms of confidence building mechanisms such as risk sharing, trust and credit. We argued that these mechanisms replace authority in hierarchical systems and allow for specialisation to transcend the frontiers of the firms. If, as we claim this is a new form of limited liability device the purpose of which is to disconnect specialisation from ownership, the same way as ownership was disconnected from fund raising, then the economy is potentially reaching a higher level of efficiency on the Smithian road to increased division of labour. We have suggested that such an economy has a surplus potential because it is innovative in a Schumpeterian sense by continuously stimulating new combinations. While we have provided a mechanism of increasing returns to growth, arguing that networks loosen the constraint excerts by capital on the division of labour through a cooperative mechanism, the ability of such a system to sustain growth remains uncertain and is surely linked to other macroeconomic conditions, such as aggregate demand and income distribution.

Notes and references

1. See Willinger and Zuscovitch (1988).

P. AGHION and P. HOWITT, A Model of Growth Through Creative Destruction, *Econometrica*, 1992, 60, pp. 323-351.

K. ARROW, Economic Welfare and the Allocation of Resources for Inventions. In *The Rate and Direction of Inventive Activity*, edited by R.R. Nelson. Princeton, NJ, Princeton University Press, 1962.

C. d'ASPREMONT and A. JACQUEMIN, Cooperative and Noncooperative R&D in Duopoly with Spill-Overs, *Am. Econ. Rev.*, 1988, 78, pp. 1133-1137.

R. V. AYRES and E. ZUSCOVITCH, Information, Technology and Economic Growth: Is There a Viable Accumulation Mechanism in the New Paradigm?, *Technovation*, 1990, 10(3), pp. 163-183.

J. BORLAND and X. YANG, A Micro-Economic mechanism for Economic Growth, *J. Pol. Econ.*, 1991, 99, pp. 460-482.

J. BORLAND and X. YANG, Specialization and a New Approach to Economic Organization and Growth, *Am. Econ. Rev.*, 1992, 82(2), pp. 386-391.

P. COHENDET, M. J. LEDOUX and E. Zuscovitch, *New Advanced Materials*, Berlin, Springer-Verlag, 1988.

B. CREPON *et al.*, Cooperative, Noncooperative R&D and Optimal Patent Life, *INSEE Conference on Technology Appropriation*, Paris, June, 1992.

G. DOSI *et al.*, *Technical Change and Economic Theory*, London, Frances Pinter, 1988.

B. K. EDWARDS and R. M. STARR, A Note on Individibilities, Specialization and Economics of Scale, *Am. Econ. Rev.*, 1987, 77, pp. 192-194.

J. L. ENOS, Invention and Innovation in the Petroleum Refining Industry. In *The Rate and Direction of Inventive Activity*, edited by R.R. Nelson, Princeton, NJ, Princeton University Press, 1962.

J. L. GAFFARD, *Efficacité de l'investissement, croissance et fluctuations*, Cugas, 1979.

Z. GRILICHES, Issues in Assessing the Contribution of Research and Development in Productivity Growth, *Bell J. Econ.*, 1979, 10, pp. 92-116.

Z. GRILICHES, The Search for R&D Spillovers, *Scandinavian Journal of Economics*, 1992, 94, S29-47.

G. M. GROSSMAN and E. HELPMAN, *Innovation and Growth in the Global Economy*, MIT Press, 1991.

H. S. HOUTHAKKER, Economies and Biology : Specialization and Speciation, *Kyklos*, 1956, 9(2), pp. 181-187.

M. JUSTMAN, M. TEUBAL and E. ZUSCOVITVCH, *Technological Infrastructure and Economic Growth*, The Jerusalem Institute for Israel Studies, 1993.

M. L. KATZ, An Analysis of Cooperative Research and Development, *Rand J. Econ.*, 1986, 17, pp. 527-543.

B. A. LUNDWALL, Innovation as an Interactive Process-From User- Producer Interaction to the National System of Innovation, In *Technical Change and Economic Theory*, edited by G. Dosi *et al.*, 349-369, Frances Pinter, 1988.

Ch. LEBAS and E. ZUSCOVITCH, Formes d'interactivité et formes de progrès technique, *Economie Appliquée*, 1992, Tome XIV, 1, pp. 23-52.

Ch. LEBAS and E. ZUSCOVITCH, Apprentissage Technologique et Organisation, *Economies et Sociétés*, Série "Dynamique technologique et Organisation", W., n° 1, 5, 1993, pp. 153-195.

P. MILGROM and J. ROBERTS, The Economies of Modern Manufacturing Technology, Strategy and Organization, *Am. Econ. Rev.*, 1990, 80(3).

R. R. NELSON and S. G. WINTER, *An Evolutionary Theory of Economic Change*, Belknap-Harvard, 1982.

P. ROMER, Endogenous technological Change, *J. Pol. Econ.*, 1990, 98, pp. 871-102.

S. ROSEN, Substitution and the Division of Labor, *Economica*, 1978, 45, pp. 235-250.

W. E. G. SALTER, *productivity and technological Change*, Cambridge, Cambridge University Press, 1960.

J. SCHMOOKLER, *Invention and economic Growth*, Cambridge, MA, Harvard University Press, 1966.

J. A. SCHUMPETER, *Theory of Economic Development*, Oxford : Oxford University Press, 1934.

M. SHACHAR and E. ZUSCOVITCH, Industrial and Technological Partnerships - A Characterization from a Business Economics Standpoint, In *Technological Infrastructure and Growth*, edited by M. Justman, M. Teubal and E. Zuscovitch, The Jerusalem Institute for Israel Studies, 1993.

G. SILVERBERG, Modeling Economic Dynamics and technical Change : Mathematical Approaches to Self-Organization and Evolution, in *Technological Change and Economic Theory*, edited by G. Dosi *et al.*, 531-559, Frances Pinter, 1988.

G. SILVERBERG, G. DOSI and L. ORSENIGO, Innovation, Diversity and Diffusion : A Self-Organization Model, *Economic Journal*, 1988, 98, pp. 1032-1054.

J. STEUART, Sir, *An Inquiry into the Principles of Political Economy*, London, Oliver and Boyd, 1966.

M. TEUBAL and E. ZUSCOVITCH, Knowledge Differentiation and Demand Revealing through Network Evolution, In *Patterns in a Network Economy*, edited by B. Johansson, Ch. Karlsson and L. Westin, Berlin, Springer-Verlag, 1993.

M. WILLINGER and E. ZUSCOVITCH, Towards the Economics of Information-Intensive Production Systems : The Case of Advanced Materials, In *Technical Change and Economic Theory*, edited by G. Dosi *et al.*, 239-255, Frances Pinter, 1988.

E. ZUSCOVITCH and G. COHEN, Network Learning of High- Technology : The Case of the European Space Program, Presented at the Manchester Conference on Technology Collaboration, Networks, Institutions, and States, April 1993.