THE CURRENT FACTORS WHICH MAKE SCIENCE A PRODUCTIVE FORCE AT THE SERVICE OF THE CAPITAL – THE FOURTH STAGE IN THE PRODUCTION ORGANIZATION

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Review « Innovations, Cahiers d'économie de l'innovation », INNOVAL – L'Harmattan

Abstract

The historical context determines for most part the order of priority of the scientific phenomena to study, the techniques (methods and tools) to use, as well as the social use which will be made of the results. Karl Marx highlighted three stages in the transformation of the production forces of capitalism: meetings of workers isolated under the same management, followed by the division of the work and the differentiation of the tasks, then by the clear separation between intellectual and manual work.
This paper presents the fourth stage in the productive organisation: an organisation based on the spatial devolution of the achievement of this production and on decisional, financial and informational centralisation that the applications of contemporary science allow. Concerning the organisation of the work, this fourth moment is characterised by the combination in the same group of staff paid by the company itself and a salaried staff paid by other organisations, but appropriated by the company which makes use of the said group. This fourth stage is the one of the unprecedented marketability of science, organised as a network by enterprises and states in a clear technological aim.

From the idealization to the instrumentalisation of science (in stages , sometimes long, sometimes short , by strong hesitations or by weak scruples) 23 centuries have passed.
Plato in his République identifies science with dialectics. It consists of supreme undoubted knowledge: knowledge, he said, begins with supposition, progresses to faith, then to thought and finally to science. St Thomas of Aquinus and later, Kant put into perspective the immutability of the "upper step of knowledge" (the anglo-saxon pragmatists went even as far as to consider that science is only a simple means for mankind to achieve its purposes). We will consider the opinion of P. Papon (1983, p.23) founded primarily on the dialectic relationships which science maintains with the social organization : the objective of science is "the critical knowledge of reality". "Implying a mastery of nature, it provides the means to act upon phenomena, controlling them or modifying the progress". Thomas Kuhn explains the forming and the surpassing of "scientific paradigms" (a set of beliefs, of recognised values and techniques common to the members of a group of scientists) by the systemic relationships peculiar to the scientific community: "...if Greek science had been less based on deduction and less susceptible to dogma, heliocentric astronomy would have been able to begin and to develop eighteen centuries earlier than it did . But , this would ignore the whole historical context" (Kuhn, 1983 p.44).

If research into the essence of things, in the sense that "all science would be superfluous if the appearance and the essence of things became confused"(Marx, 1976, Volume III , p.739), is generally commonly accepted as being the aim of the scientific activity, the historical context determines for the most part, the order of priority of the things and the phenomena to dissect, to understand and to know, the techniques (methods and tools) to use to penetrate the essential, as well as the social usage which will be made of the essence extracted. At the

moment in time when, according to Marx (1977, volume II, p.220), "industry has already reached a very high level(...), invention becomes a branch of business, and the application of science to the immediate production determines the inventions, at the same time as soliciting them". Then, for Habermas (1973, p.43), "with the arrival of industrial research on a large scale, science, technique and exploiting found themselves part of the same system". Capitalism provided the framework for the systematic application of science to production, which in turn gave impetus to the development of scientific knowledge concerning laws of nature and the world. Capitalism redirects, in accordance with a productive end, a reserve of scientific and technical knowledge built up, making science a productive strength at the service of capital. "Giving a scientific character to production is therefore the tendency of capital..." (Marx, volume II,1977, p.187).

The point here is not to argue whether scientific work is partial or impartial. Impartial science in a society of salaried workers, of private property of production resources and of profit is inconceivable. But, it is interesting to reconsider some aspects of the current debate on science, technology and competitiveness through the method of analysis that Marx left us, in order to better understand the subtle changes in methods of appropriation and the marketing of science in clearly global commercial and industrial objectives. We will propose first of all a reading scale of innovation, or of the application of science to production, in today's capitalism. We will compare the parts of the thinking of Marx which seem to us the most revealing on the systemic relationships between science, innovation and the society, to the recent developments in free thinking to show that the economists supporting the plausibility of the market, incorporate into their theory larger and larger chunks of classical ideas. We will defend subsequently, using these contradictory debates between Marx and his peers, the idea of the "fourth moment of the organisation of the capitalist production"; an organisation based on the spatial devolution of the achievement of this production and on the decisional, financial and informational centralisation that the applications of contemporary science allow. We will attempt at the same time to study in particular the controversial thesis of the "economy based on information or on knowledge".

The second part of this paper will be devoted to demonstrating certain particularly important, current processes in the application of science to production. Innovation is an economic act whose success depends on the involvement of a large number of public and private institutions. But the role of the state has never been so explicit in the constitution and organisation of the required means for the application of scientific knowledge to production. We will refer first of all, to the theoretical justification of the economists supporting the heavy involvement of the state, in the transformation of general knowledge into production knowledge to discuss the appearance and application of a new accumulation context. These theoretical theses and the proposals as far as economic policies which result from them are concerned, will lead us to present several forms of these accumulation contexts and to argue the economic and social limits which the device for systematic instrumentalisation of science encounters.

1. The myth of innovation : from the formation to the private appropriation of production resources .

Science, in the same way as technique, is always historical. But in capitalism, science is considered as a fount of knowledge from where technique feeds (see the excellent Nef, 1953). It is considered as a resource of production strengths because the work process has become "a technological application of science" (Marx, 1977, Volume II, p.220). The growth in the

size of the company and the amount of capital held or raised has furthered the enrollment of science in immediate production. a) The domestic markets of the big industrial and international countries are getting bigger, b) the narrowing social division of work and the rising overheads that the companies, fighting to compete, must bear, as well as c) the external savings[1] they can make and the opportunities for profit appearing here or there, by pure chance or intentionally, for the bigger companies amongst them, become catalysts or barriers for the accumulation of private capital, but also of social capital in general. The application of science to the economic activity of such and such a company or group of companies, makes innovation the main function of growth and commercial strength .

1.1. Science and externalities, or the social contribution to private capital.

The liberal and neo-liberal economic thinking has, only very recently, been able to find some arguments to justify forming, in the aim of making them available to private firms, scientific and technical resources. The liberal economists are quick to thank R. Solow [1956] who started new methods of research into the links between technology and growth.

Firstly, as a residual factor of growth,[2] new techniques have become a very popular subject of research with the neo-liberals, especially since W.J. Clinton and A. Gore (and with them the democratic modernists) reached the top of the American nation . Since 1992, the American administration, at the same time as launching very ambitious technological civil programmes, was using very elaborate theoretical explanations to justify the setting up of a complicated economic, financial and legal device for the transfer of scientific resources from the public to the private sector.(see Clinton and Gore,1993).

The standard neo-classic growth model was changed drastically by the introduction of technical progress and innovation in the liberal approaches to accumulation. To consider for example, that the supply activities of technical and scientific information have a positive impact (in terms of creation of wealth and profits) which is greater on the scale of a group (a large number of companies) than on a company taken individually (which is all the more frustrating when the company which issues the information in order to use it in its innovating activities, makes others benefit from it) is a significant advance compared with the mechanical and ahistorical balance of the original model. The question of economic repercussions on the community, of individuals' actions (especially concerning scientific production and commercial development) points us towards the socio-holistic approach to the economy applied successfully (and according to the political and ideological tendancy) by the classical authors. Innovation, more particularly, defined by J. Schumpeter (1935) as a new "combination of productive resources", corresponds to a process of generation and private appropriation of a group of resources (scientific, technical and financial) which, combined by the company or a group of companies, results in new products and the opening of new markets. "The conception of new products is a very important element in innovation. It is

[1] The usual term is that of externalities which can be defined (with A. Marshall, 1906) as being positive or negative effects, which involve an activity of an economic agent outside this activity or that the agent is subjected to from outside. The most attractive for a company is to achieve, in a setting favourable to investment, substantial external savings, without having to bear the slightest cost that its activity creates for the community as a whole (pollution or various nuisances). It is important therefore, to underline, that taking private property for granted, the private agent will create various effects on the local community, but in return, he will expect from the community means and opportunities to enlarge his property (assets) or where necessary, to defend it.

[2] As a residual factor, technical progress contributes to the part of economic growth which cannot be explained by the evolution in the volume of the production factors (capital and labour).

here that the large firms, with huge resources at their disposal, have a great advantage. They can fund research teams and experiment with a large number of innovations in the hope that one of them will stand out from the crowd", wrote J. Robinson in 1977 (Robinson, 1977). The supply creates its own demand thanks to the insight and the fighting spirit of the entrepreneur, then of the large firm. The second stage of the innovation process (appropriation) prevails these days over the second one (the generation). The company tends to take advantage of its environment rather than to invest in it, for instance, in all the stages of technological creation; which can be explained by the fact that the investments in the acquisition (appropriation) of production resources are less costly than those devoted to the training in these resources. Which also makes the neo-liberals say that the collective cost-effectiveness of the capital can be high, whereas the private cost-effectiveness can become insufficient.

If the liberal economists struggled to get out of their model's dead end, a long time ago Marx himself and the economists who applied his method showed, as did L. Karpik (1972), that science, which since the 19th century "is no longer only likened to the discovery of hidden links between given phenomena", but which is also "promotion of a natural order", becomes the foundation of industry; it is in this way that "heteronomous science" (which corresponds to the research applied to both the experimental development of new techniques and production methods and to finished goods) marks time on "autonomous science" (let's say fundamental research with no recognised private profit-making aims). The production process therefore determines the appearance of new techniques and defines their use. To do this, it directs the application of the scientific knowledge and stipulates the fields of scientific research. An organic relationship is thus created between science , the technique and the firm (in the case of those who bring together the capital and the employees and who are defined and changed by conflictual class relations and inter-capitalist competition) and it is in this that technology (and innovation), as a transformation of knowledge into production and accumulation knowledge, is a social fact.

Let us look at Karl Marx's reasoning. The first theory: capitalism (and to be more precise, the middle classes) "cannot exist without revolutionising constantly the production tools, and therefore the production relations, that is to say all the social relations". The labour input required to produce the different goods (destined for consumption or for production), after they have been adapted and used for private purposes to be transformed into capital, tells us a lot about the state of the social relations. "The quantitative expansion and the efficiency with which the capital is developed as fixed capital, broadly indicates to what extent the capital is developed as capital, as being the power over the living work and to what extent it is subjected to the production process in general" (Marx, 1977, volume II, p.187). The technological use of science is the essential factor in the development of fixed capital ; this being an "index which shows to what extent the universal social knowledge has become a direct productive strength". The development of (fixed) capital enlarges the scale of production at the same time as prompting this enlargement, requiring in parallel the specialisation and the overlapping of different work forces which are more and more complicated : simple work/complex work, living work/dead work, socially necessary work, collective work... Salaried work, and the salaried class as a capitalist norm of participation in the accomplishment of production and the social organization (or ...disorganization) (Boutillier, 1999-1), becomes the driving force behind accumulation.

Second remark: the general development of the production forces is the development of all the means (material and immaterial) that science in the hands of the capital, injects into the production, natural forces, in the form of means of production, enabling higher usage value

with less work (Marx, 1976, Book I, p.231 and onwards). Science becomes capital under the pressure of the competition and possible political and social disputes. The authority of the capital and the power on the market of a given company depends on its potential to make profits, to accumulate. Innovation is therefore essential in the daily battle that firms undergo to avoid the numerous hurdles (lack of demand, increase in price of production resources, emergence of new competitors, social problems, restricting regulations , etc.) which can block the road to prosperity. Science is therefore called upon more and more ; the new technology which it will create must be more efficient (allowing a greater mastery of the work process) and must achieve new exchange values (i.e.guarantee accumulation) The speed of the renewal of the capital is dependent on the accumulation barriers which play a major role in defining the integration of science into both production and the general development of the forces of production.

Third remark: For Marx, competition "requires a continual increase in capital and imposes pervading laws of capitalist production as external coercive laws to each individual capitalist" (Marx, 1976, Book I, p.241). To limit the risk of disappearing (through over-investment in relation to the solvency of the market in question), the firm must innovate and at the same time grow. Depreciation and centralisation go hand in hand . Innovation links the two together: it allows the depreciation of the already old capital whose cost-effectiveness has slumped; it creates a favourable climate in which to make further investments, it furthers by "creative destruction" (Schumpeter) and the involvement of finance, the merging of capital (centralisation) forming huge companies so that: "the capital and its development appear as the starting point and the end, like the motive for and the objective of the production.(...)". For this reason, the capitalist economy tends to "develop its production forces as though it only had the absolute power of the company as a limit". But this tendency enters into "permanent conflict with the restricted objective, taking advantage of the existing capital" (Marx, 1977, volume II, p.213). The periodic crises mean the abeyance or the "destruction of part of the existing production forces"[3]. The resumption of accumulation after the said destruction, will not be possible without thorough modification of the foundations and the norms of accumulation (new social organization of work, new competition rules, ... new technology , new institutional forms of management and economic regulation).

1.2 The fourth stage in the capitalist production organization

As soon as the capital takes over the social production, the technical progress reflects the more or less significant changes (marginal or radical) in the techniques and the production methods, together with the social organization of the working process and thereby the historical type of company (Marx, 1976, Book II, p.51). The three stages in the transformation of the production forces of capitalism highlighted by Marx (meetings of workers isolated under the same management, that of the holder of the capital, followed by the division of the work and the differentiation of the tasks with the setting up of a salaried management team in the factories, then by the clear separation between intellectual and manual work which determined the status of the staff from the scientific and technical knowledge compared with the immediate commercial objectives of the production process) have a conceptual link to the constitution and the evolution of the "collective worker".

[3] About a century later, J. Schumpeter was to describe as "creative destruction" the process of destroying old capital by new productive combinations which create, from their introduction to the market, new opportunities for profit and investment (Schumpeter, 1979).

Capital instigates cooperation among the workers for the accomplishment of a given production assignment . It creates in this way collective work all the while depriving the staff of any role in the organization of their work, and of any control over their contribution (added value) to the production, finally of any role in evaluating the usage value that their workforce represents for the capital. A. Smith's spirit lurks : the machine was created by the division of labour. He also remarks that the specialisation of labour will lead the worker to discover sooner or later the means to reduce the difficulty of his task. But these "minor innovations" are not the only ones; according to A. Smith, other inventions are a consequence of the work of scientists which consists in observing distinct physical and technical processes (A. Smith, 1976). These inventions, when marketed, will represent the major innovations of the future.

Capital clouds the issue (by class and salary segmentation and a strong differentiation of status and remuneration of the jobs proposed) so that (in the case of given production forces) part of the work community are unable to realise (and therefore under estimate) individually and, where possible collectively, their contribution to the production process (and the profits related). How can a research scientist, shut away in his laboratory under contract, have the same notion of team work or group destiny as a worker on the production line on the other side of the world, or be compared to the salesman paid primarily with profit-sharing or commission on volumes sold (or new business he lands or contracts he signs,...)?

The stages of the capitalist production organization therefore precede the technical transformations and transform science into a productive force and define technology as production knowledge. Innovation and more particularly, technology, said J.K. Galbraith (1967), undergoes a major organizational effort, but it is also the result of the organization. This Marxist basis of perception of the evolution of production forces under the constraints of accumulation has inspired some of the liberal economists. The positive externalities, the increasing returns or even the human capital are the concepts which illustrate in different words the state of the collective work and the state of the socialization of the capitalist production such as it has been noticed since the beginning of the eighties. The current phenomenon of an "economy founded on knowledge" (see for example, Foray, 2000) is the continuation of the formalization of the scientific and technical knowledge and of the organization of science as a domain for accumulation whose origins date from the middle of the 19th century. Indeed, with the creation of schools and specialised publications, knowledge and all sorts of scientific and technical information is distributed. "We go therefore progressively from an series of empirical results, logically organized, to a strictly scientific knowledge which results from experiments willingly carried out, not more uncertainly endured" (Gille, 1978, p.785).

However, what we must emphasize is that the explanation that the superiority of the social return on investment in research and in innovation in companies in comparison to the return on the individual capital, lies in the increase in the number of factors determining the profit-making potential in a given company. These factors (education, environment, health, finance, inter-industrial relations, communication, requirements and aspirations, ...) of a general nature influence the marginal cost of a company or an operation and with everything equal, have an effect on the return on the capital invested. The firm, in a competitive situation, be it apparent or latent, must appropriate these factors or, at least monitor their impact on the profitability, or even better, take advantage (abundant production resources which could be taken over, the opening of new markets) the non-commercial logic which these factors generate and reproduce (and nowadays this is how innovation is defined).

The firm, by investing in research and experimental development, or by taking over small innovative companies, or by collaborating with other companies as strong as themselves (joint research programmes, cross licensing,...) or with government research bodies (universities, for instance), appropriate knowledge which is the essential factor of competitiveness. Large companies consider that "the knowledge which is vital for competitiveness entirely covers fundamental knowledge and insist that the university research institutes, with whom they sign research partnerships, accept their own criteria on who should be considered as 'public' or 'private'" (Chesnais, 1986).

It is a question of the fourth stage of the capitalist production organization: the combination in the same group of staff paid by the company itself and a salaried staff paid by other organizations, but appropriated by this company which makes use of the said group. The company keeps control of the group which is itself composed of productive capacity , trained and employed in various areas and by various social production entities (Laperche, Uzunidis, 1999). This deconcentration of the constitution and the management of the private work groups affects all organizations. The diversification of the canals we use to transfer scientific and technical knowledge and information from public training centres for production resources (e.g. universities) towards the companies is proof of this; the refinement of the legal and financial system for the appropriation of the value constituted in the public sector by the company is further proof of this; the multiplication of the different levels of social status and salaries of the salesmen of all sorts of manual and intellectual competence is yet more proof.

The large controlling firm (or on a joint basis several large companies) constitutes the crux of the deployment of the production process. Having concentrated its means of production, defined and divided up the production tasks and put together directly controllable working groups, it is becoming these days a decentralised organization and management centre for its production resources. Capitalist production operates at the moment as though the influence on the company's market (and the coordination of the functions and activities that it can impose on it) is a factor of economic power (and of centralization of the ownership of the capital) which is more important than the influence bestowed upon it by its own assets (scientific, technical, industrial and financial).

But this is forgetting that this firm's strength is a result of its financial capacity (financial assets and property and capital raised) and of its potential concerning information. By "information" we mean scientific, technical, industrial, financial, commercial, political, sociological, etc. which a company has access to and can transmit to the market. Information and finance together, enable the constitution and management of working groups which are geographically dispersed and remote (investment in interindustrial cooperation relations, in protecting the technological assets, in the appropriation of scientific knowledge and the creation of new products, in the coordination, using telematic means, of the different activities, etc.) (see Uzunidis and Boutillier, 1997; Laperche 1998).

Technological innovations are today the outcome of this centralising deconcentration process. They also provide the possibility for the process to work and to prove itself more efficient (concerning the costs incurred in raising large amounts of capital) than the huge factory which employs hundreds of people. The debates on the "networks" that we will look at afterwards focus as much on the flexibility (to create or destroy production capacity according to the economic climate) that the large firm's decentralized management of the production provides, as on the increase in the firm's capacity to appropriate a large quantity of resources

without investing in their formation. We can easily notice that the rapid development, for example, in information technology and communication is founded on the setting up of the new social organization of the capitalist production [4]: multiplication of the salary and social status of the workers which is ultimately tending towards the integration of the individual into the society in general, into the work and particularly the production.

The worker-entrepreneur, the technician-entrepreneur, the executive-entrepreneur, the researcher-entrepreneur, the student-entrepreneur, the consumer-entrepreneur…, these days, the word entrepreneur signifies the result of the individualised social treatment of the person in question (or all the people in question!) (see Boutillier and Uzunidis, 2001-1). The use of the word "entrepreneur" is as abusive as that of the word "associate": the workers (wage-earners or fee-earning consultants), just like the suppliers, the customers and the sub-contractors have become for the management (and the shareholders) "associates" or "partners" with no distinction; which shows that, unless there is a social conflict where the staff are considered as enemies undermining the interests of their bosses, the large firm has turned into a centre of concentration of the production resources, but also of formation and flexible coordination of working groups, depending on the accumulation requirements and the fluctuation of the markets . It calls for cooperation and goes on towards this convergence by applying the strategies of growth and integration.[5]

This coordination and innovation process, both flexible and evolutionary, imposes on the firm the pressing need to be provided with the different types of technological and intellectual means to acquire and combine uninterrupted flows of material and immaterial resources. The "knowledge theory" applied to the company says : the ability to adapt and the efficiency of the company depends on its cognitive categories, on the interpretation codes of the information itself, on the tacit skills and its procedures in solving the problems it encounters (Dosi, Nelson, Winter, 1999). The task of "technostructure" consists therefore of finding the balance between managing the "partnerships" and developing the internal instruments of organization.

On the other hand, the scientific and technical powers of the automatic means of production and communication enable the capital to extort the human knowledge, very often to reconstruct it in documents (patents) or automatic processing systems (software to assist with production and decisions, specialised software, etc…). In doing so, the firm pursues its objectives of controlling its workforce and depriving them of power, including the power given to the scientists because of their knowledge (Jorda, 1999). It highlights the fact that the

[4] The circulation of information should become the main cementing function of the current capitalist society, broken up into its fundamental and founder activities : production, exchange and accumulation. Internet is a network for the circulation of consumer information which is accessible to a large public made up of existing and potential consumers ; intranet uses the information to cement the enlarged space of a company (only its staff, depending on their status and position, can have total or partial access to it) ; extranet cements the relationships that a company has with its suppliers, customers, bankers,… Information socialises and at the same time, centralizes the decisions and strategy of companies ; the large firm presented as a centralized network of positions is integrated into a network of more or less independent firms. It is in this way that its influence on the market can be strengthened while avoiding investments which require the opening of new production facilities.

[5] To grasp the entire current theoretical ideas of the liberal economists, it is important to bring together certain ideas that they propose. For example, the theory of knowledge and skills must be associated with those of the "government of enterprise" (A. Schleifer, W. Vishney, 1997) which describes the strong involvement that (financial) institutional shareholders have, in the day-to-day running of a large firm …of a substantial proportion of its capital. The profitability in the short and medium term of the capital committed by these is the most common evaluation criterion of the president and of the technostructure which has the decision-making power in this company. Exercising this power requires numerous business skills (A. Chandler) judged themselves by the managers' ability to take advantage of the group of "living strengths" of the firm and by their aptitude to integrate external elements.

scientific, technical and industrial information as a system of knowledge which is articulated, formalised and likely to be communicated or transferred, is a means of production, identifiable as such (Laperche, 2001- 1) the use of which provides innovation for the economic process and the accumulation of capital.

2. Marketability of science and the new accumulation context

By accumulation context, we understand the forms, the methods and the means of competition and of cooperation between the economic players which enables the carrying out of the production process, i.e. the setting up of similarity between the social relations of production with the productive forces (Uzunidis, 2000).

This case requires state intervention which promotes and guarantees the explicit drawing up of coherent rules in order to organize public and private economic activity and, in our case to facilitate the industrial application of science. The property relations and the antagonisms between capital and work must be redirected (or reconsidered) to be in phase with the development of technology, of scientific and industrial knowledge, of skills and of qualifications. The organization of work and of the economy on the whole must change, in order to be able to respond to the need for the capital to be renewed rapidly and in return, to allow the firm to absorb or digest (depending on the usual commercial criteria), the progress of science and technology. If the institutional transformation of regulation is not enough to make market relations, of profit and of property, correspond with the scientific strength of production “the capitalist envelope bursts” or “the walls crumble away” (Schumpeter).

2.1 Socialisation of the production and innovation “networks”.

The role of the state in the socialisation regulation of the capitalist production for private purposes of innovation and accumulation is essential and specific. State intervention has already gone beyond the very traditional fields of application and funding of a scientific and technical policy, in the middle of which, we find on the one hand, public centres of learning and research and on the other hand, the production of arms. The behaviour of the state regarding the issue, resembles more and more that of the big financial and industrial groups and the strong links of interdependence between these influential bodies justify the transfer of resources from the public to the private sector. This is possible if the state draws up a policy of innovation, i.e. the promotion of all scientific means of research, of development of application and of technological choice to allow the creation of new products and new procedures in the industry, founded on the socialisation of the costs and the privatisation of profits.

This dual accumulation process, jointly produced by the public and private sectors has enlightened the liberal economic thinking for twenty years to the point where it restored to favour state intervention in the sectors which generate resources which can be appropriated and are crucial for realising private profits: e.g. in research and development, where the stock of knowledge does not depreciate and where the production of each firm can benefit from all the available knowledge; in the training of the “human capital” also, where the qualifications and the skills of certain staff are of benefit to others and to the employers.

State intervention in the socialization management of the capitalist production for private accumulation purposes can take different forms: financial assistance for activities which

generate resources which can be taken over individually or collectively by private interests; creating devices allowing the private reappropriation of the return on the investment in research and development (e.g. patents which do not hinder the distribution of innovations); the application of cooperation procedures between public and private bodies with the objective of funding the feasibility of a private investment project likely to have wide-scale economic repercussions (see Lucas,1988; Romer, 1990; Barro,1990; for a clear and synthetic presentation of the theories of "endogenous growth" Guellec and Ralle, 1995 ; Aghion and Howitt , 1998).

Faced with the complexity of the private innovation process, M. Castels (1996, 1997, 1998) went as far as to maintain, quite cleverly, that the fundamental unit of the economic system is no longer the entrepreneur, the family, the firm or the state, but the network composed of different organizations. Regarding innovation, the division of work and the very refined specialisation of skills in scientific research and experimentation, remove any possibility of autarkical organization of the technological production. The network unfolds as a private form of organization of the instrumentalization of science. Partnerships between companies and between state research bodies and companies, and a whole panel of technical, financial and commercial contributions, illustrate the theories of the traditional economists (e.g. A.Smith and K. Marx) for whom as fast as the capital takes over the social production (and enlarges its market by appropriating the resources at the time), we witness technical transformations and changes in the social organization of the production. Nowadays, the analyses in terms of network often ignore the balance of power that the big firms exercise on simple and complex work, on smaller ones and on public bodies for scientific and technical production.

The technological progress in information and communication facilitate the decentralization of the forming of capital and the carrying out of the production and guarantee the centralized management of the firms. They also provide economic advantages to those among the workers who can accumulate specialist knowledge to integrate the entrepreneurial networks on a permanent basis. Small innovating firms, those set up by engineers or scientists are generally integrated (either by buying up, or by licensing, or even better, by assistance, via capital risk, at the very beginning) in the economic and financial domain of innovation of a larger firm (Uzunidis, Boutillier, 2001). Public research, under the cover of its valorisation (in the case of private use for commercial purposes), is subjected to the rules of profitability: in the US first of all (in the eighties), then in all the countries with advanced capitalism, the governments put in place technological policies of innovation founded on the improvement of supply. Such a policy applied to public research must on the one hand, reduce the costs of investment and management borne by the State and on the other hand increase the quantity of innovation resources constituted by the community in aid of the private firms.

The creation of a pool of productive capacity able to be appropriated at any time by companies, is considered by the liberal economists to be the fundamental aspect of state intervention in accumulation. Let us look at the thinking of Branscomb and Keller (1998): stating that creating and circulating information improves the results of an national economy (and the large firms that it is made up of), they put forward the idea that the traditional scientific and technological policy (centred on the funding and the realization of major programmes in research and development, primarily in the areas of defence, energy, space or medecine) has been replaced by one of research and innovation. In order to be fruitful in terms of competitiveness, this policy has to target as much the realization of public research programmes (or ones receiving public funding) as the circulation of their results to the "users" (the competitors). The state has to guarantee the efficiency of the privatization procedures (the

"valorization") with regulations (protection of patent rights, anti-monopoly measures, etc.), fiscality, the budget, etc. in order to favour the accumulation of "social capital". With this term, American economists, close to the democratic party conceptualize the process of transferring value from one company to another, from public bodies to private concerns (without explicit reference to the effects of domination and inequality, except in the case of a monopoly, i.e. in the commercial field. They agree to discuss the discriminating and restricting positions linked to innovation, in line with the size and mobilization of capital); they also conceptualize creating a "stock" (pool) of resources which are shared under this many-sided, multi-functional cooperation which involves several partners.

The network, created in this way can be a cause but also the consequence of the socialization of the production which must be achieved thanks to various contributions, and in times of high rotation of capital, to a continual flow of information and scientific and technical knowledge. According to these economists, the state must encourage the creation of networks to maintain innovation and competitiveness among firms. The consecutive reduction of investment and transaction costs for large firms and of the risk associated with the possible wrong choice in the taking full advantage of scientific capital (made by the combined investments of the firms making up the "network") are the two arguments which justify the state's involvement and the creation of a new accumulation context. But these arguments are concealed in the neo-liberal thinking by macro-economic factors of competitiveness. The competitiveness of a national economy, measured by its ability to create clusters of innovation, depends mainly on its scientific, technological, financial and commercial links which are components of networks (see above). The said networks must be coordinated by their own initiatives and by the institutional accumulation context put in place for them. Getting further away from the original theory, the fashionable economists offer us the concept of a "national system of innovation" which can be described, according to S. Metcalfe (1995), as the group of different bodies who contribute jointly or separately to the development and to the circulation of new technology and who create a setting in which the governments devise and apply measures destined to encourage the process of innovation. What it is in fact, is a group of commercial and non-commercial organizations undertaking to apply science to production and to do all the "incidental" jobs linked to the realization and circulation of technology; the whole of this being coordinated by the state in the aim of public interest and the increase in the general well-being.

But what credit should be given to this version of liberal thinking proposed leaning against the systemic analysis which passes over in silence the power struggles which build up at times of private appropriation of scientific resources, of the creation of "new productive combinations", of the generation and distribution of profits? Would it not be as plausible to get back to the debates on monopolies and on the externalities which they involve or benefit in order to discuss the "gap" that the financial influence of firms has created in the neo-classical theory (J.Robinson, 1976, p.172)? The fact is that the new accumulation context favours the expansion of the technological capital of the large firm in the same way that it guarantees its improvement and its productivity (innovation, opening new markets, profits) on a national and international scale.[6] This is probably the reason why the link (with many

[6] The OECD measures innovation "globalization" a) by investments in R&D and the taking out of patents by the foreign subsidiaries in a given country; b) by the technological alliances between companies on an international level which can be in the form of a simple exchange of licenses or setting up joint research subsidiaries; by publishing articles and holding patents for international collaboration (OECD,1999). Networks, or the socialization of the production of scientific or technical knowledge, along with their application to productive purposes follow and provide the trend towards the international centralization of capital. "Small countries" (to use the OECD terminology), which are very active in scientific matters (Ireland, the Netherlands, Switzerland) turn their "innovation device" into one of the main assets in attracting forign

theoretical and ideological consequences) between marketing the research and centralizing the capital through these so-called networks has not been clearly established in the contemporary neo-liberal theory.

The economists agree in saying that capitalism is a system which cannot bear rigidity and stagnation; also many people say that the slowdown of the accumulation is due to a lack of flexibility (in the use of production resources and the making of profits) in the system. During the transitional period (the 70s), from the national logic of capitalism (keynesianism, the welfare state, Bretton Woods) to the logic of global expansion and integration of the national capitalist systems, the economists warned us: "capitalism works when it is flexible, but self-destructs when it is not. Its greatest virtue and the secret of its past success lie in its adaptability, which it takes from the automatic forces of the market" (Scitovsky, 1980); "Post-industrial society, whether it is technectronic or informational… will be overwhelming for those who have not mastered it…" (Lorenzi and Le Boucher, 1979, p.273) ; here is what is at stake: the developed capitalist countries …will only come through the crisis by applying the new forms of accumulation…" (Lorenzi, Pastré and Toledano, 1980, p.379). Flexibility and the "modernization" of the exploitation were achieved by applying the ideas of the "questionability of the markets" (Baumol,1982): opening up public markets to competition, reducing the hurdles to international exchanges, privatizations, redundancies, relaxing work regulations, unification of financial markets, etc. Massive depreciation of surplus unproductive capital, which is a source of inflation provided the possibility to the large firms to open up new markets, to increase their financial and economic power and to experiment before imposing new productive combinations. Under their pressure and then under their control, the softening economic measures in their favour meant the appearance of innovation networks that the governments still have to consolidate and integrate into the national system of innovation for fear of lacking credibility on the financial markets.

2.2. Modes and prospects of marketability of scientific research

The OECD, after convincing itself that we are heading towards a "knowledge economy" based on permanent innovation, itself dependent on the networks and cooperation, "notably between science and industry", emphasizes that policies of innovation in large industrial countries favour the funding of research carried out under the supervision and control of industry, reform their university systems to make them compete so as to improve the of scientific and technical services on offer to firms, encourage the mobility of researchers and their involvement in business (OECD,2000).

In all big countries, basic research is mainly carried out in universities and research centres financed by the state. To make the university logic compatible (the researcher's career and ambition, the teaching, scientific evaluation of the results of the research,etc) with that of industry, the new accumulation context applied to science (Uzunidis, 2001 (a)) consists of the following characteristics: a) the reduction in public funding and the contractualization of the research, where the criterion of "return on investment" determines the choice of project and the follow up of the work carried out; b) the creation of centres to valorise research in universities, where the "centres of excellence" look after the contracts, patents, termination of licenses and the creation of technological companies; c) the drawing up of a private status for

technological investments. "Large countries", helped by their financial markets, give an essential nature to these partnerships in the evaluation of the competitiveness of their economies and any other national economy (Uzunidis, 2001(b)).

the researcher who wishes to integrate a research team or to leave one to set up his own business, take advantage of "his" patent (or that of the centre which employs him) or change jobs; d) the development of financial institutions for innovation and for the creation of innovating firms to a capital risk or capital investment type (which must attract speculative capital and divert thim from being unproductive, but…).

The 160 billion dollars that the governments of the member states of the OECD invested into scientific research and technological development in 1998 (Guellec and Van Pottelsberghe, 2000) only represents about a third of the total investments into R&D.The average proportion of basic research in university research is in the region of 50% in the OECD countries but is decreasing progressively. On the other hand, companies are funding less and less fundamental research projects, banking on what the universities can bring in. A vicious circle of tendential degeneration of science. However, firms are funding a major proportion of innovation but they also benefit from favourable statutory and fiscal measures, mainly for the application of networks of innovation. We notice "a drop in the number of research projects with intellectual curiosity as their sole motivation" (OECD, 1998). Those who defend the idea of "networks" maintain that universties can find them beneficial in so far as they guarantee career openings for their future graduates and obtain financial assistance; firms benefit from the network by improving their access to better- trained human resources and to sources of new ideas. The OECD underlines that certain hurdles remain for the network's efficiency to be complete: the status of civil servant which many researchers have, the evaluation of the public research which is still done on the basis of work published and not on what contribution the researcher has made to industry… For the marketabilityof science to become a compulsory norm of innovation, the OECD (often using the example of the US), having acknowledged that "the state powers" are not in a position to create networks ex nihilo, proposes to the states "setting up support programmes for the networks in the long term…" (OECD,2000, op. cit.) Will these programmes be capable of countering the damage done by the waste of scientific and technical resources that we see nowadays?

This type of policy proposing scientific production resources to companies in effect, goes beyond a simple transfer; it reduces the chances of survival of "independent science" exhausting without renewing – which is not in the interest of companies – the pool of future productive forces! We have in fact seen with the help of Marx that science is historical and so are its applications. The economic adjustment using the networks and the social management of the fourth stage of the capitalist production organization brings flexibility to the markets and to the innovation process, but makes the systematic application of science detrimental in the long term: Is there not a danger of accumulation hitting a snag regarding the scarcity of potentially productive fundamental knowledge which has not been directed? It is true that "in the long term we will all be dead" (Keynes), but the financial logic which dominates the creation and improvement of technological capital (associating scientific and industrial knowledge and innovation engineering) helps the large firms to select those scientific applications which could have the highest profitability in the short term; these firms speculate in this manner, leaving aside knowledge to lie fallow. Fluctuations on the stock market illustrate this: the "technological values" have lost between 40% and 60% from the spring of 2000 to the summer of 2001, depending on the industrial country (the US, the EU, Japan).

Having been a long-time believer in the success of the new "informational paradigm", the experts in economics have under-estimated the natural trend of capital to destroy all it undertakes if, on the one hand the capital committed is superior to the profits made, but also to the profits anticipated, and if on the other hand the profits raised without industrial work

are superior to those coming from a normal production process (all the more so since this one is partly covered by the state and private "partners" of the "network"). The trends of financial commitment in biotechnology (another promising sector) are no different: the speculation concerning the genetic make-up of humans, animals and vegetables, as in all communication and information technology, will increase the surplus capital, which due to lack of appropriate remuneration, will result in considerable scientific feats being abandoned and will force many start ups, founded on knowledge, into bankruptcy. The result is that the speed at which the capital must be renewed in a centralized economy, rich in underused and volatile resources, means that it hardly bothers about scientific applications. They are left to perish even before (due to profitability) being effectively turned into innovations. We are therefore in an economy based on a lack of knowledge[7], because in draining the scientific pool, the firm (or the network), even in the case of a monopoly, does not have the time to establish its influence through customer loyalty for a certain time (as long as possible) for a sufficient clientele (keeping the customer informed and making its product indispensable); another firm, anticipating the movement, injects into the market its own "technological values", it destabilizes the system, which overloads on capital, takes refuge in finance. This lack of knowledge limits the scope of the market solvency and represents a barrier to finding cost-effective alternatives.

Will the targeted innovation programmes, defined (and financed) jointly by the governments and the large firms, be able to restore hope in seeing a come-back in a long term accumulation process and avoid "the dilemma of stagnation"? By having a pool of scientific and technological knowledge, industrially formed, intending to be applied over a longer period than that required by the rival sectors, arms production in big countries tells us a lot about the role the state plays in encouraging and creating networks. During the "cold war" years, the industrial policies of the US, Great Britain and France were based on the creation of new technology within the framework of the big arms programmes. The relaxing of the regulations governing the innovation linked to the defence and decompartmentalization of the "militaro-industrial complex" created a new concept (at the same time that the American administration was being convinced of the importance of the circulation of knowledge to rival industries from fundamental knowledge sources – universities and armaments): the "industrial and technological basis of defence" (OTA, 1991). This is defined as "the group of people, organizations, technological know-how and production capacity involved in the design, the development, the production and the maintenance of arms and defence equipment…".

The preservation and consolidation of this "innovation-arms network" are probably the best equipped in industrial equipment in an open and economy in the hands of financiers (Bellais, 2000). This network facilitates long research and technological experimentation under the cover of competitive and financial "short termism" ; it arranges domains for the investment of public and private capital and creates vectors for the transfer of scientific and technological resources to rival industries. It is true that many start-ups at the beginning were created in information technology thanks to the special relationship that the American army had nurtured with certain big universities and companies in the country. The increase in the

[7] Lack of knowledge and not ignorance …, in the sense that no device of social understanding or evaluation of new technology is allowed (which requires, through education , individuals to take a conscious stand, faced with the problem in hand) ; so as not to jeopardise the structure of the new flexible and discriminating context of accumulation. But in fact what has happened to the neoclassical market transparency for the supporters of the "economy of knowledge, know-how and information"? unless it is a question of general knowledge of mankind, subjected to a compulsory purchase and left to lie in fallow, of the creation and funding of knowledge capital, of free access to company secrets by a few initiated shareholders, or even of the spectacular advertising addressed to masses of previously briefed consumers ! "Lack of knowledge is worse than ignorance" (Socrates).

defence spending at the beginning of the century in the large arms-manufacturing countries confirms the importance that the state grants the military regarding technology. American firms and their shareholders rely on the "anti-missile shield" and "spy satellite" federal programmes to redeploy their unused saving in the "new economy".

But is the basis of defence really a defence against the marketability of science, is it not more of a crisis shock-absorber and a step up to new capitalist adventures? It could be the same with health (the state system allowing future commercial applications for genetics) or with the environment (the state system creating opportunities for improving ecology). What is important though, is the network i.e. the device, in the new accumulation context, for the socialization by the market (contract) and for the coordination by the big firms and the state, for productive and profitable purposes of the scientific research activities.

The network not only monopolizes the inventiveness of science , but also guides it depending on its accumulation restrictions and objectives. For example "standardization using anticipation" (Foray, 1990; Laperche, 2001). To control the pace of technological applications of science, big firms which dominate a market, in association with research institutes, create technical norms before the technology is really operational. Alternative technology is therefore eliminated, competitive barriers consolidated and reinforced and the centralized property safeguarded. In this case, the dominating firm or firms lean on the network, not to impose or declare their technological and financial power, but most often to express it in costly and very risky sectors. Whether they are in information technology (software, components), telecommunications (mobile phones) or genetics (interpreting genes), the big firms, by adapting, combining and protecting the scientific production knowledge and by standardizing their use, exercise their technological and financial power over the scientific activity : they direct, according to their plans, the choices and the research projects and look after their future valorization. Defined and constituted in this way, the supply has to create its own demand. The support that the state gives to the network also aims to guarantee it markets; to discreetly involve the public or private consumer in the concept of profit-making (schools, hospitals, the authorities, public transport and communications, the army, the police… does this not mark out the way towards "consumer-citizens"?) Once again, only the state can save capitalism!

CONCLUSION

To reach this recognition of the state's responsibility for the management of the socialization of the capital, the liberal economists lost precious decades and the critical economists often lost their way in the mazes of a polymorphous capitalism. The first ones, bound for a long time to equilibrium in general, succeeded however in revealing the contradictions in their beliefs. Even though they give a lot of weight to the market mechanisms, they acknowledge the need for arrangements outside of the market and praise state interventionism at the very beginning of accumulation : there where potential innovations and profits are created. The second ones thought the progress in science and technology represented the coming of a new era : that of the "information society" or "the economy of knowledge" defined as much by the new capitalist production standards (requiring large quantities of specialised knowledge and information to access this knowledge and to integrate it into a process of scientific research and innovation) as by the speed of circulation (being informed to produce and consume and to know how to produce and know how to consume). The fact is that the current metamorphoses of capitalism show that the change is fundamental. The new era of capital is not so much

apprehended by the technological progress, but by the new way in which the production process is organised and developed. The industrial applications of science are the result of this, but also what prompts accumulation, the means to succeed and the cause of crises. “the real barrier of capitalist production, is the capital itself …The means – the illimited development of the productive forces of society – enter into permanent conflict with the limited aim, the improvement of the existing capital” declared Marx in The Capital.

We have proposed the idea of the “fourth stage of the organization of capitalist production” and have spoken on “the new accumulation context” which is linked to it. Starting with Marx’s analysis and with a particularly critical view of the past and present liberal thinking, we have noticed that this opinion is making enormous progress thanks to the see-saw effect: free enterprise on the one hand, state intervention on the other. Marx (but also Schumpeter and numerous other economists inspired by Keynes’ ideas) has left us with a method which allows us to consider the development of the market as a whole, the socialization of the production and the centralization of the capital. The current theories of networks, externalities, competition and innovation are based on an acquired principle: the benefits of the market, and on common finding that: the market, must not only be developed, organized and regulated, but that it must also be created and preserved. We are not far from thinking that these theories bring the ideas of Marx back into line with current thinking.

The socialization of capitalist production has indeed taken on such dimensions that from now on, the appropriation of the technological elements gathered by the large companies is less costly than the raising of capital for their formation. The big firms are becoming, using relations of power and exploiting, convergence centres for science and techniques, which they combine to supply their innovation process. To get from the stage of the concentration of production to the current stage of the contractual integration of the centralized property, capitalism has invented a new accumulation context; the economic policies of “contesting the monopolies”, privatization, flexible work management, international financiarization and integration have to a certain extent succeeded in depreciating the old capital, but they have also created the context of securitization and marketability of all individual and collective assets (science is of course part of this). In these conditions how can we be surprised by the regulatory power of finance? The system works by trial and error, finance facilitates the task. But in doing so, it directs the applications of science to production, it becomes a selection criterion to the research programmes and at the same time it weakens the potential for radical system innovations.

We described the current stage of capitalism in previous publications (Uzunidis, 2000) as “managerial”, because the power of decision of the improvement of capital was entrusted to the employees, managing both the economy and public affairs. The age of the “captains of industry” is a bygone era. State management of innovation which the liberal economists are calling for, shows that on the one hand that the appropriation of scientific resources by companies is considered as one of the State’s main economic reasons and on the other hand that the obstacles to accumulation become insurmountable without the organizing and planning role of the state. The introduction of commercial logic into scientific research falls within the scope of an innovation policy; but more surprisingly, so does the economic efficiency of the “network”.

But this “network economy” will not benefit the social group : on the one hand, the size of the markets (with rapid and costly renewal) and the profit opportunities seem pathetic compared with the masses of accumulated capital; on the other hand, the growing extent of

centralization of wealth limits the development of the scientific and technological and more widely, the economic potential. It is therefore obvious that the new accumulation context, laid out by the marketability of everything which can be considered as socially public or collective, can not engender a period of generalised prosperity. In their study of the history of long movements of the development of capitalism, Freeman and Louça are categoric on this subject: "institutional change, technical change, transition, crisis: this is how the economic reality develops…Technological and social innovation is the key player in the understanding of the dynamics of the long periods in the dominant economies… The crucial question of a historical analysis is this: how do these economies, whose mode of development is exhausted, pick up over time?… Being incapable of predicting the future, history has helped us to understand and "take action in the present and the future… It is essential to make choices" (Freeman, Louça, 2001, p.371-372).

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