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AN ENDOGENOUS GROWTH PROCESS

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Novembre 1990

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INTRODUCTION

1. Much has been written on developing countries particularly in the eighties. Their indebtness position has strongly deteriorated as well as their macroeconomic performances. Most of the related countries located in Africa and Latin America have undertaken structural adjustment processes recommanded and supported by the World Bank and the I.M.F. Such processes are built on the law of comparative advantages as it appears from the price version of the Heckscher-Ohlin's approach. Accordingly under free trade a country relative price reflect in its specialisation based on the abundancy of its production factors (i.e. capital and labor). In that framework Samuelson's theorem establishes that factor cost tend to equalize so that through international competition purchasing power parity prevails at least for tradable goods. Consequently countries determine demands and suplies at given factor cost or price the latter one being natural forces introduced on the markets by an Invisible Hand.

2. The Heckscher-Ohlin's approach has been widely used. It has given birth to well known paradoxes through the works of Leontief and others (1). Consequently, it has been shown that for many countries as the U.S., Japan, Canada, India... it failed to explain the export commodity structure, i.e. what sorts of goods are supplied on foreign markets. Accordingly it has been extended to the case of more than two factors of production. Therefore its"trade" predictibily has increased strongly.

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1 For instance :
Baldwin R.E. : "*Determinants of the Commodity Structure of U.S. Trade*", A.E.R. 61, march 1971
Mitchell D.J.B. : "*Recent changes in the labor content of U.S. International trade*", Industrial and Labour Relations Review, April 1975
Stern R.M. and Markus K.E. : "*Determinants of the structure of U.S. foreign trade 1958-76*", Journal of International Economics, May 1981

It worths to remember that Leontief's results were criticed by
Leamer E.E. : "*The Leontief paradox reconsidered*", Journal of Political Economy, June 1980
Brecher R.A. and Choudhi E.U. : "*The Leontief paradox reconsidered*", Journal of Political Economy, August 1982

3. Basically and at the opposite of Ricardo, the Heckscher-Ohlin's approach neglects technology assuming a same production function for a given set of countries. With this respect growth means trade and vice-versa at least as long as market demand has not been saturated. Countries' growth impulse contradict the Heckscher-Ohlin's statement in the long run for growth is not supported by trade as long as innovation matters. Asian macroeconomic performances particularly in the case of Japan present a strong case for governments to adopt strategies focussing on innovation. Therefore growth is no more an exogenous phenomenon linked to exogenous to markets prices and therefore falling like manna from heaven. It is the result of an innovation diffusion process and its accompanied policies. As long as developing countries have not a normal access to invention, the first step to innovation and cannot pay for more technology related to their specialisation so as to carry the first one into practice they would not reach a stable level of development in the long run not being able to catch-up with developed countries in terms of factor productivity and demand pattern.

I - INNOVATION : A MICRO LEVEL PHENOMENON

4. Innovation relates to product and process. Often it is difficult to distinguish between both notions. Simply stated, it can be said that a process innovation changes the existing input-output coefficients for a given list of products while a product one modifies consumption pattern both in range and quality. So given, a process innovation improves efficiency in physical and economic terms. It affects economy mainly through cost reductions and the enlargement of markets through price elasticities of demand. The product one depend on income elasticities (2).

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2 An illuminating discussion of the definition to be given to a product or a process can be found in O.E.C.D. ; D.S.T.I./S.P.R. 82.44 - Workshop on patent and innovations statistics, 28 th-30 th june 1982, 29 p.

5. At the micro level each innovation whatever it is i.e. product or process has a life cycle or curve which indicates how it develops over time measured as the output accounted for by that innovation. The life curve comprises four main phases namely the pioneer, growth, maturity, saturation or decline ones. It is usually assumed to be S-Shaped up to their decline phase with gradually decreasing growth rates of output. While various interpretations and applications of the S-Shaped growth curve exist, they can be reduced to two main types : limited possibilities for further technical improvements given a certain state of technology, versus the limited possibilies for further market penetration given a certain rate of penetration. Usually the two aspects will be interrelated : cost-reducing improvement innovations can increase the rate of diffusion of a product ; market saturation will be a strong incentive for product improvement, to prevent or postpone a decline in sales.

6. The decline phase should be considered an open-ended phase. Absolute decline resulting in complete replacement, is but one of the possible courses of an innovation following its maturity. Several variations to the standard life cycle pattern exist, representing the different ways industries may react when faced with saturated markets. Little can be said about the length of the various phases of an innovation life cycle. Innovations are too diverse in nature and area of application to allow any generalization with respect to the length of their lives. Also the market conditions at the time and place of introduction will vary considerably. Despite uncertainty, about the duration of an innovation life cycle, the question of life cycle length is very important for growth for the latter one depends strongly, among other things, upon the phase of the life curve. Insight into the duration of various phase would give insight into the growth potential of an economy.

7. Life cycle also exists for innovations on an international basis. During each phase, both production and distribution costs favour specific countries. Respectively the innovative and the imitative ones, i.e. firstly the semi-industrialized and secondly the developing countries. This indicates that both international trade and capital flows are linked to the innovation life cycle given an international market diffusion model (3). This model is not given once and forever. It depends upon many parameters amongst which countries' policy towards invention, profitability, and training and re-training of labour. Well known examples are Japan and Germany.

II - GROWTH : A MACRO LEVEL PHENOMENON

8. At the macro level the life curve transforms into a curve of saturation of the milieu. It represents the diffusion of the innovation to the whole economy (bandwagon effect) in the form of creation of new industries tending to exploit a wide range of applications supplied by the innovation and as such changing the household demand pattern both in range and quality. The phases of the saturation curve are featured by interacting growth forces or dynamic interdependencies between macro supply and demand i.e. resource allocation and income distribution. The forces depend upon the allocation of the productivity and/or quality gains due to innovation between the capital owners, consumers and workers of the innovative country on the one hand and between the latter and its competitors on the other.

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3 For more, see :
Kuznets S. : "*Economic change*", W.W. Norton, New-York, 1953
Posner M.V. : "*International trade and technical change*", Oxford Economic Papers, 1961
Hufbauer G.C. : "*Synthetic materials and the theory of international trade*", London 1966
Krugman P.R. : "*A technology gap model of International trade*", march 1982
Vernon R. : "*International investment and international trade in the product cycle*", Quarterly Journal of Economics, 80, May 1966
Vernon R. : "*The product cycle hypothesis in a new international environnent*", Oxford Bulletin of Economics and Statistics, 41, november 1979
Hirsch S. : "*Location of Industry and International Competitiveness*", Clarendon Press, Oxford, 1967

9. Growth or diffusion dynamics is mainly constrained by :

- ***The input availability and specificity***

The first one means domestic versus foreign supply. It reflects both the capacity of a country's industrial structure to achieve user-supplier coordination and barriers to innovation at the international level. The second one is related to product/process interaction and production system complexity.

- ***The product/process interaction*** refers to the extent to which differentiation of the final product involves that of crucial inputs, components and manufacturing equipment which may constrain delivering firms.

- ***The production system complexity*** refers to the technical interdependence of equipment, operating practices and procedures both within and between the various stages of manufactures. The more complex a production system, the greater the constraints to changing any of its component parts. These constraints are in part material : if the different physical components of the system are interdependent or are to interact, each component must be adjusted to the particularities of the others, for example, in terms of speed, precision, tolerances, interfaces and so on However, these constraints also arise from operators and engineers' acquisition over time of specific knowledge of system behavior e.g. of how to organize maintenance and fix "bugs" Changes which make the knowledge obsolete are likely to prove costly, in that a new cycle of "learning by using" will be needed before full effectiveness is obtained. As a result, in industries with complex production systems, major new inputs must be tailored to the constraints imposed by each firm's existing set-up ; and these later ones are likely to diverge over time, as firms differ in their expansion paths, product strategies and learning behavior. The constraints imposed by the "systemicity" of the production process are particularly clear in the industries with managed large scale physical networks, such as electricity and telecommunications (4).

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4 Notes extracted from Ergas H. : "The inter-industry flow of technology. Some explanatory hypothesis", OECD, DSTI/SPR 83-85

- The speed of diffusion

It is not given. Several reasons may be put forward. When information is costly to acquire, as it is, and the innovation typically has several technical attributes, firms can resort to an indirect form of "learning by doing" i.e. learning by observing the experience of existing adopters. At any point in time, firms view differently the advantages offered by the innovation to their own operations, but, over time, the process of adoption involves a gradual convergence of viewpoints as all adopting firms acquire a common perception of the innovation's worth. Another important aspect of the speed of diffusion is profitability. This aspect is a two-sided problem as not only profitability for potential adopters matters, but also as is it perceived by the producers. So, the speed of diffusion depends on supply-side constraints, just as much as it does on constraint to adoption. In other words, profitability influences the speed of diffusion but equally the latter one will influence profitability. Both adoption and supply constraints of the diffusion process therefore diffusion itself, vary over time because the environmental framework of the innovation is changing. Indeed, improvements to the innovation either in the production technology or in the utilization one or both, international catching-up process, general economic growth and policy, changes in relative commodity and input prices, in other complementary or competing innovations and expectations of future technological change can be expected to occur during diffusion. All of the factors will affect the innovation and consequently its growth process.

- The market evolution of competing enterprises

Theirs goods are substitutes to those produced by the innovating sector of which competition increases. If the competing enterprises do not innovate there will be a loss of market share at given cost and selling price. That will initiate a depressing effect transmitted to the whole economy via input-output relationships.

- ***The macroeconomic technology framework and the preventing stance of economic policy, their expected evolution, the expectations of future technological change and by social, managerial and training changes.*** All of these variables interact. For instance the social, managerial and training changes may be enabling and facilitating circumstances permitting the potential applications of innovation in many sector (diffusion) to be realized in practice while the speed of diffusion also favours these requisite changes.

10. The macro growth process related to innovation vary according to innovation being of wide rather limited adaptability, having a long time span, being interrelated and simultaneously appearing. In that case one speaks about a new technology "system". When simultaneously appearing basic innovations converge in energy sources, transport, tools (or the production goods industries) and in manufacture and there is a reservoir of labour the growth process picks up with the blossoming of industrial revolutions supported by leading sectors. Further the growth process is also influenced by natural trajectories of some technologies, i.e. technological advances which seem to follow other ones in a way that appears inevitable. This concept due to Nelson and Winter (5) may featured either specific technology or a wide range of these. In the 20th century there were two still opened up natural trajectories i.e. the exploitation of understanding of electricity and the resulting creation and improvement of electrical and later electronic components and the similar developments regarding chemical technologies. It is apparent that industries differ significantly in the extent to which they can exploit the prevailing general natural trajectories and that these differences influence the rise and fall of different industries and technologies.

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5 In search of useful theory of innovation, Research Policy 6, North Holland, 1977

III - SCHUMPETERIAN DYNAMICS (6)

11. The innovation based growth process is an evolutionary one. That means that enterprises are always innovating and imitating although at varying speeds. So an innovator's monopoly position is only temporary. As soon as an innovation is made "the spell is broken", and the way for others to imitate is opened up. A bandwagon is set in motion. Schumpeter called that process the one of creative destruction. The evolution of the state of technology in a capitalist economy is determined by the interaction of these two dynamic forces. The tendency towards technological uniformity among firms is bound to be upset by a sudden introduction of a new and better production method (product) by one or several firms. So innovation is note a single-shot phenomenon. By nature it is a recurrent process. Consequently the state of technology is a state of constant flux.

12. Under the joint pressure of imitation (diffusion) and innovation the industry will not reach a neoclassical equilibrium supported by a price vector with perfect technological knowledge even in the long run. While new technological knowledge constantly flows into the industry, actual production methods of a majority of firms always lag behind it and a multitude of diverse production methods with a wide range of efficiencies (cost gap) will co-exist forever. Indeed, it is merely the statistical regularity of the relative pattern of these microscopic disequilibrium that characterizes the long run of the industry and permits to shape it as a well known smooth bell curve skewed to the left.

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6 Notes issued from ***K. Iwai*** : "*Schumpeterian dynamics. An evolutionary model of innovation and imitation*", Journal of Economic Behavior and Organization 5 (1984) pp.159-190

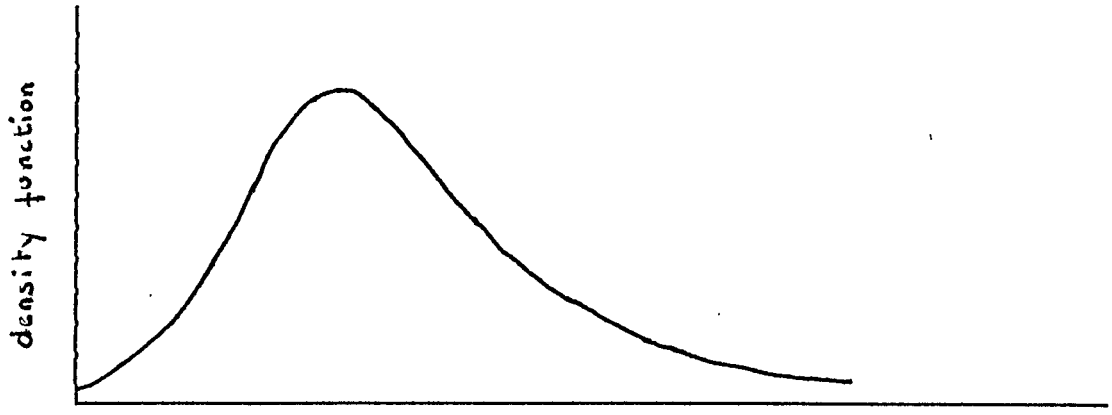

Fig. 1 : The theoretical long-run average density function of efficiency (i.e. cost gaps) due to K.Iwai

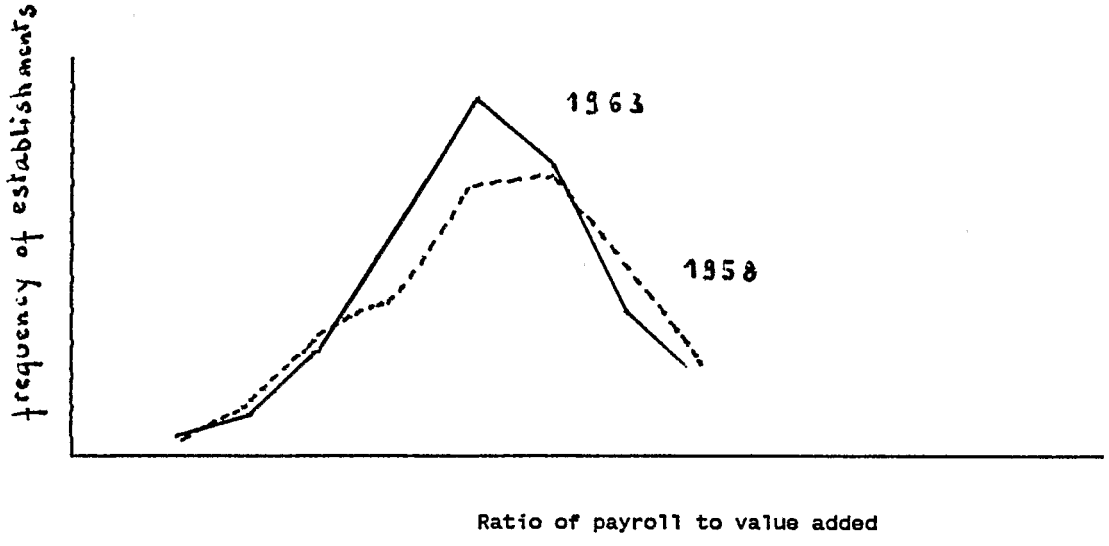

Fig. 2 : Applied long-run average density function of ratio of payroll to value added in the U.S. metal stamping industry (*)

(*) K. Iwai found similar patterns in Japanese cotton-spinning industry and Norwegian fish-food products and non-electrical machinery industries.

CONCLUSIONS

13. As Schumpeter mentionned innovation produces a creative destruction process that incessantly revolutionizes the economic structure **from within**, incessantly destroying the old one, incessantly creating a new one. The orthodox theory of competitive equilibrium consists of assuming this fundamental fact about capitalism away. So trade matters, it prevails over production. In such a framework participants to the market take price (or cost gap) as given and determine demands and supplies accordingly. There is thus no one within the system who has any motivation to change the reached position, not to mention the one who strives for creation or destruction. Indeed, from the perspective of the orthodox analysis, the existence of entrepreneurial profit (i.e. a change in the cost gap position) which arises from successful innovation must be treated as an example of the imperfection of competition ; the wave of imitations which relentlessly follows the first success must be classified as an externality to markets and the entire process of creative destruction is merely an adjustment process which transfers the economy from one equilibrium to another. What Schumpeter considered to be the essential fact about capitalism is regarded as an aberration from the competitive equilibrium_a slip of the Invisible Hand.

14. At the international level a focus on innovation is missing when discussing macro policies to be implemented in developing countries. Behavioral prerequisites assume a trade price equilibrium mechanism based on countries comparative advantages once and forever given. That is fully irrelevant in the framework of growth impulses for which innovation and related diffusion process matter. Accordingly growth does not fall like manna (trade) from heaven. It is an endogenous process embodied in the economic structure. **Macro Policy should treat it consistently i.e. as an endogenous production factor.**

15. Although preceding analysis illuminates specifically the industrial dynamics it has become a powerful tool too to investigate the agricultural one. Indeed the efficiency within the economic structure of the latter one tends to be strongly affected by genetics in developed countries. The latter one influe deeply on crops productivity through modified genes and prerequisited agricultural pratices (changes in pesticides and fertilizers consumption). And though unmodified genes come mostly from the south developing countries are gradually losing their related market share. Indeed investment to modify genes are mainly due to Northern firms which tend the more and more to protect their markets with barriers to entry amongst which patenting seeds, i.e. price increase. So even in agriculture the catch-up productivity mechanism has been constrained by innovation.

16. And finally a last example relevant for indebting countries. At given price and factor cost biotechnology or the use of micro organisms to produce permits to recuperate 30% of normal oil losses due to oil viscosity.