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FORECASTING THE IMPACT OF TECHNICAL CHANGE ON EMPLOYMENT : METHODOLOGICAL REFLEXIONS AND PROPOSITIONS FOR RESEARCH

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ABSTRACT

This report starts with the observation of the existence of two different methodologies which are only slihtly related. The macro-economic method led to precise measurements but nonetheless encountered a series of difficulties : theoretical difficulties concerning the nature of unemployment, empirical difficulties concerning the description of international competition, and econometric difficulties regarding measure of technical change. By the same token, applied technological studies enhanced transitions which were foreseen in the organization of production and the creation of new products. These studies explained the economic and social stakes which were connected to strategies used by unions, business firms, or state institution, and which were determining factors in the diffusion of technical change. However the major portion of these studies never established a clear linkage with macro-economic methods tested in the past.

As a reaction to this, this paper proposes to integrate certain determinants of technical progress in a macro-economic model which describes medium term growth in five european industries. This model demonstrates the contribution of certain variables, which account for innovations and of other variables which are connected to traditionnal tools of economic policy.

This third approach has its own evident limits which are derived from the difficulties of measuring innovations as well as measuring differences stemming from divergent growth patterns and heterogeneous institutions which shape that growth in each of the national economies.

INTRODUCTION

The rise of unemployment at the end of the sixties, and the incapacity of most economic policies to check that event, as well as the enlargement of technological changes, led a certain number of economists to favour a structural interpretation to contemporary problems of unemployment, emphasizing the role played by investment and technical innovations.

In this context, our paper developes a set of questions on the methodological aspects of forecasting the impact of technological change on employment. The first section illustrates the inherent limits of traditionnal macro-economic projections ; these limitations are all the more reinforced if one takes into account the hightened transformations of the productive process which are connected to the current crisis. A second section sheds light on the most interesting aspects of direct research and its inquiry into the effects and ramifications of new productive techniques on employment.

It should be mentioned, however that available works in this field encounter a certain number of methodological obstacles, one of which is the absence of a macro-economic framework.

Finally a third section suggests an alternative approach which aims towards establishing certain determinants of technical progress in a macro-economic framework model based on international cross-sections data. This framework allows us to a simulate downwards trends in employment and productivity.

THE MACRO-ECONOMIC APPROACH

At an elementary level, macro-economic findings deduce employment tendancies from a comparison of perspectives between per capita production and total annual production. The productivity variable summarizes the effect of technical change , which is equivalent in this case to greater efficiency in the productive process.

In fact, recent econometric models have enabled us to treat the subject in a more sophisticated manner. Nonetheless, these models have encountered at least three types of difficulties in analysing relations between technical change and employment, which are elaborated below.

Demonstrating the connection between technical change and employment: some theoritical and empirical difficulties

The history of economic thought is replete with diverse positions on the effects of technical progress on employment : the same kind of diversity exists in recent macro-economics litterature. Certain economists, observing the evolution of economic development in the U.S, claim that a slowdown in

productivity is associated with a strong growth in employment.

Others taking the example of Japon (or the lesser case of West Germany) take the contrary position and contend that increases in productivity prevent increases in unemployment.

The problem however is to determine the conditions under which are based one or the other of the above arguments.

The first argument implicitly assumes the independance of effective demand in relation to technical progress under limited conditions of foreign trade competition. The second states that foreign competition is the essential determinant of economic growth and therefore of employment. It follows that one would not know the impact of technical change without either taking into account theories on the origin of unemployment and taking into account empirical caracteristics of the economies in question.

More precisely, the significance of the relationship between technical progress and employment is conditionned by two types of considerations.

From a theoretical point of view (Annex 1), for a closed economy, an increase in technical progress leads to a rise in employment if unemployment is of the classic type (i.e if it is due to insufficient productivity in relation to real wage). On the other hand an increase in technical progress implies a decline in employment if on the contrary keynesian unemployment prevails (i.e connected to the weakness of effective demand).

It is clear that these contrasting results are not only derived from opposite theoretical conceptions (keynesians versus neo-classicals) ; but it is also important to verify underwhich conditions one of these conceptions best fits the economy in question.

From an empirical point of view, the divergent interpretations regarding employment and productivity can be reduced to estimates of exposure to foreign competition. From the very simple model given in annex 2, one can derive an important conclusion : an increase in productivity is favorable to employment if it acts in an economy where foreign trade is price elastic, on the other hand it is unfavourable to employment if that economy is more monopolistic and therefore exports are less sensitive to price changes.

Besides the improvement of the productive process itself technical progress also involves the creation of new products (which engenders a monopolistic situation during the first phasis of development). It follows from our earlier point that if innovation in products during the first phase favours employment growth, a subsequent innovation in the productive process will have a dampening effect on employment growth. Whereas

ANNEX 1

THE IMPACT OF TECHNICAL CHANGE ON EMPLOYMENT DEPENDS ON THE NATURE OF UNEMPLOYMENT

Recent works (Barro, Grossman, 1971, Benassy, 1975, Malinvaud 1978) helped to figure out a model which synthetizes the traditionnal opposition between Classicals and Keynesians.

Starting from a very simplified version of that model, one can demonstrate that technical change can have opposite effects on employment whether the economy happens to be in a state of keynesian unemployment (insufficient effective demand) or in a state of classical unemployment (excess of real wage in relation to productivity).

Let the following model of a close economy, where investment $\bar{I}$, real wage $\bar{w}$ and level of active population $\bar{N}$ are exogeneous :

(1) $D = C + \bar{I}$ formation of effective demand

(2) $C = c\,Q$ consumption function

(3) $Q = F(N)$ represents the constraints of production

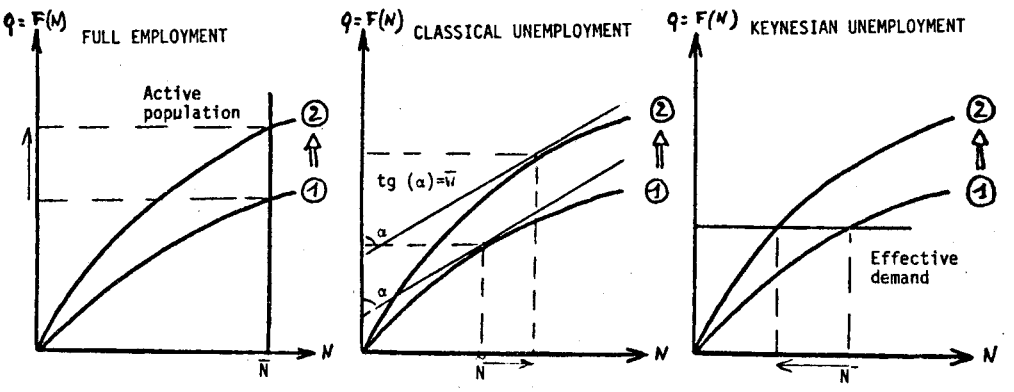
(4) $\tilde{N} = N(\bar{w})$ so that $\frac{\partial F}{\partial N} = \bar{w}$ defines the profitable level of employment

The production of equilibrium Q is the minimum of the profitable production $\tilde{Q} = F(\tilde{N})$, of the effective demand D and of the production of full employment $\bar{Q} = f(\bar{N})$. Thus :

(5) $Q = \text{Min}\{\tilde{Q} = F(\tilde{N}),\ D,\ \bar{Q} = F(\bar{N})\}$

The three figures below show respectively the case of full employment ($Q = \bar{Q}$), the case of classical unemployment ($Q = \tilde{Q}$) and the case of keynesian unemployment ($Q = D$).

If a technical change improves the efficacity of production (which translates the production function from ① to ②) one can notice, according to the case, that employment grows (under classical unemployment), stays invariant (under full employment) or decreases (under keynesian unemployment).



In conclusion, the effects of technical change (which is there reduced to a rise in production when employment and capital are constant) on employment depend essentially on the type of equilibrium which prevails.

Effect of technical change on	Type of equilibrium	Full employment	Classical unemployment	Keynesian unemployment
Production		↗	↗	-
Employment		-	↗	↘

As a matter of fact it is rather difficult to diagnosis the nature of present unemployment.

Nevertheless from a methodological point of view, these opposed effects of technical progress on employment show how limited are the "monist" explainations (optimists as well as pessimists) and thus how inadequate they are to analyze the present situation. This conclusion is reinforced in an open economy (see Annex 2).

when production is routinized and put to common use, the speed in the adoption of new methods of production will have a positive effect on employment.

One can generalize from the lessons of macro-economic models and be tempted to advance the proposition that the effect of technical progress on employment depends essentially on the type of specialization that characterizes a particular national economy.

In conclusion the link between technical progress and employment is far from evident and lends itself to varying interpretations by different currents of thought which are either optimist or pessimist. Neither the optimistic or pessimistic vision should be based on a-priori theories, but on empirical specifications. Nonetheless it is difficult to clearly define these characteristic, especially those which deal with international competition. For example the uncertainties affecting price elasticity in international trade are sufficient to obfuscate the direction of the relationship between technical progress and employment. This problem is all the more exacerbated by a second uncertainty, which affects the treatment of technical progress in the macro-economic model.

The measure of technical change : a considerable uncertainty

Very generally, technical change is assumed by the given of an exogeneous variable namely the productivity of labour (under a rigourous complementary hypothesis) or the total productivity (under an hypothesis of substitution between labour and capital). For example in the Cobb-Douglas production function, the growth of labour productivity results from the mingled effects of the substitution between capital and labour and from an autonomous trend of technical progress. For the vintage models, technical progress is characterised by a series of parameters which specify if technical progress is embodied or not embodied into capital, or if it improves the efficiency of capital or of labour.

In this case, labour productivity rises in mid term, if the replacement of former capital speeds up and not simply in the event of a growth in the formation of capital. Nonetheless technical progress remains exogeneous and economic activity has a marginal affect on the diffusion of more modern equipment in the productive process.

ANNEX 2

THE IMPACT OF TECHNICAL CHANGE ON EMPLOYMENT IS DIFFERENT ACCORDING TO THE INTENSITY OF INTERNATIONAL COMPETITION

Such is the conclusion that one can draw from most macro-economic models at disposal. For the sake of exposition, we present the simplest model which leads to that result.

(1) $\dot{q} = \dot{EXP}$ the growth of exports fixes that of production (which simplifies a keynesian multiplier effect)

(2) $\dot{EXP} = e_1 - e_0(\dot{p} - \dot{p}_{ext})$ exports depend negatively on internal prices

(3) $\dot{p} = \dot{s} - \dot{\pi}$ internal prices derive from wage costs through the application of a margin profit rate

(4) $\dot{n} = \dot{q} - \dot{\pi}$ employment results from the comparison between productivity and production trends.

All variables are expressed in term of rate of growth.

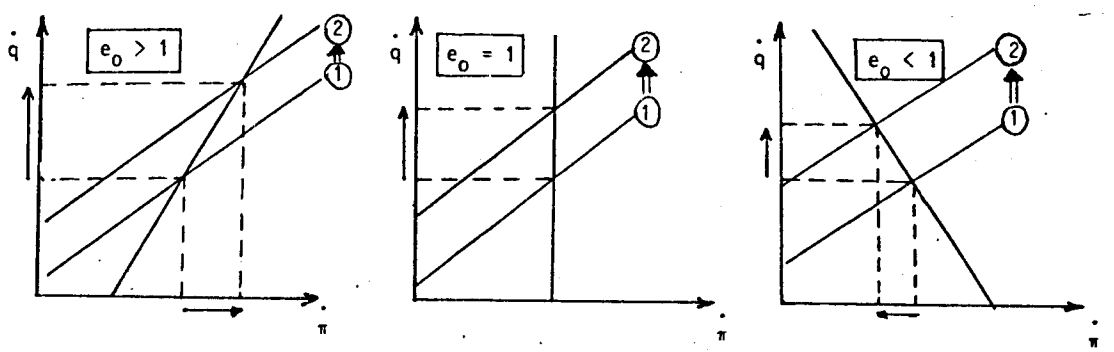
If we suppose that the rate of growth of wage $\dot{s}$, of external prices $\dot{p}_{ext}$ and of productivity $\dot{\pi}$, are exogeneous, production and employment growth rates are given through the following equations :

(5) $\dot{q} = e_0 \cdot \dot{\pi} + \{e_1 + e_0 \cdot (\dot{p}_{ext} - \dot{s})\}$

(6) $\dot{n} = (e_0 - 1) \cdot \dot{\pi} + \{e_1 + e_0 \cdot (\dot{p}_{ext} - \dot{s})\}$

In consequence the effect on employment of a same progression of productivity depends on the situation of each economy regarding international competition. Three different cases appear according to the value of the elasticity e_0 of exports in relation to internal prices (in equation (2) e_0 is suppose to be positive).

The figures below show that if e_0 is less than 1, a technical change (which translates the equation (4) from (1) to (2)) induces a decrease in the rate of growth of employment whereas the employment growth rate is increased through a technical change if e_0 is greater than one.(If e_0 equals 1, employment is not affected).



In conclusion, the effect on employment of a productivity gain, which derives from the diffusion of a technical change turns out to be positive if a 1 % decrease in internal prices allows a greater increase of exports (the case of an open economy in a world of strong competition).

Inversely, this effect is negative when export growth is less elastic to prices changes (which is particularly the case in monopolistic situations).

Effect of technical change on	Degree of external competition	Monopolistic situations $e_0 < 1$	Critical value $e_0 = 1$	High competition $e_0 > 1$
Production		↗	↗	↗
Employment		↘	-	↗

Thus one cannot determine a priori -i.e before studying the characteristics of the concerned economy- the orientation of the effect of technical change on employment.

In theory one could outline the technical conditions of production with greater precision at finer levels. However in practice, the estimation of employment (or production) functions on a two-digits basis does not allow one to resolve the methodological obstacles which were mentionned earlier (INSEE, 1980).

Very generally then macro-economic models only treat the consequences of technical progress, the origin of which is not described. It is then assumed that economic variables have no bearing on technical change. This is an hypothesis that seems to contradict a great number of findings on technical progress (Rosenberg,1971 and 1976,Pavitt 1979,Mansfield 1968,OCDE 1980).

In addition the production-employment productivity "block" in a model is one in which the econometric estimation is very weak. Thus "vintage" models for French industry undergo an important uncertainty, because available estimates correspond to a very large number of parameters (Benassy, Fouquet, Malgrange, 1975) so that, when they are simulated, their properties can be very different.

Thus it is not surprising that reestimates have led to different coefficients, (M.Raoul , 1980) which perhaps explains the weakness of these projections.

Even more, if one adopts the simplest form (Boyer, Petit 1980), it is particularly difficult to operate econometric tests concerning the stability or instability of these functions before and after 1973. Although certain productivity series show a noticeable drop in most nations since 1973, one cannot determine with precision if this change is a lasting or simply transitory (Dubois 1980).

That uncertainty affects the credibility of medium term projections. For example the VII Plan projections associated with the VII French plan led to an anticipation of continuous productivity gains even in a period of slow growth (Vignon , Villa 1976). Although it might be difficult to make a rigorous comparison between forecast and results between 1973-1980 (1), it seems that one has overestimated those productivity gains, as can be seen in the most recent results (INSEE, 1981).

This leads us to point up a third gap in the macro-economic approach.

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(1) Mainly because of changes in the statistic basis.

The failure to take into account the determinants of technical change

Generally speaking, macro-economic theory contains difficulties in treating the hypothesis of structural unemployment advanced by specialists in the field of technical progress (Freeman 1978,Mensch 1978 and 1980).

Essentially macro-economic models treat technical progress as a reduction in costs, without analyzing the introduction of new products that might be the catalyst in the development of new leading sectors in the economy. In the same way the dissemination of new methods of production is assumed to be strictly an economic phenomenon which never intervenes in institutionnal or social processes. Moreover,in view of economic and social planning it seems necessary to enlarge those institutionnal reforms which are connected with business management, the organization of unions or state actions and which would butress a harmonization between technical progress and the return to full employment. On this essential point macro-economic models are silent.

In conclusion in order to forecast the impact of technical change on employment the macro-economic approach provides a valuable quantification, but is lacking in other aspects because it is essentially based on the extrapolation of past trends and does not treat technological transformations which are in process. This observation leads us to examine a second approach using a completely different methodology.

DIRECT PROSPECTIVE STUDIES : POSSIBILITIES AND LIMITS

Insights on the diffusion of new technologies

Althought technical progress might be a continuous activity in time as well as in space (it more or less deals with the ensemble of production and products)it is often reduced to transformations generated by a clustering of major innovations. This view is confirmed by the relative similarity between lists of foreseen innovations. This consensus on these lists stems from the fact that there is a relatively small number of new invention which in term act as a catalyst and basis for future innovations.

Thus the perspectives that were taken by the VIII French plan (CGP 1981) concerning new technologies remain close to the forecast on innovations (in information, new energy sources, bio-technology) made thirteen years earlier by Gabor or Kahn and Wiener (1968).

In fact it is on the forecast of expansion of new technologies that differences appear between studies. These differences will affect the foreseen impact of new technologies on employment.

Following Missika (1980) we can distinguish two types of impact studies. The first of these studies, called application studies, begins from a new technology defined with lesser or greater precision and assesses its affects on all types of existing employment. The second called sectors studies poses questions on the affects of all foreseen technological transformations on employment in given sectors such as banking or printing.

These application studies, which resemble marketing studies, allows to assess the potential size in the dissemination of new techniques which are well defined. Thus they contribute to the elaboration of strategies of choice regarding innovations by decision makers in business, unions and the state (1).

In effect these application studies allow to understand what is new and specific in each innovation but taken separately they can lead to contradictory forecasts regarding employment. This explains the thrust to synthetise determinants which lie at the base of sector studies. This thrust is evident in sectors where potential productivity gains might lead either to a drastic reduction of employment when demand grows moderatly (printing) or to a transformation in types of growth when growth is supported and diversified (insurance and banking) (2).

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(1) Cf. the significant interest stimulated by the study for SIEMENS on the office complex in 1990. (Intersocial 1979). That study affirmed that a higher proportion of office work could have been standardised (43 %) or automatised (25-30 %) by the introduction of new technologies (telecopy, text treatment, automatic reader...)

(2) The Nora-Minc report (1978) estimated thus that in ten years the diffusion of electronic technology will contribute to a 30 % growth in labour productivity in these sectors in France. Taking into account perspectives of growth in those branches, employment will stagnate, putting an end to the role of these sectors in creating employment, as they have done in the last twenty years.

It is usually at the level of the sector that unions define their strategy to confront the "abuses of progress" (1).

In effect, technical change no longer appears as an exogeneous trend imposed on the strategies of businesses or workers, or of the state but in great part as the outcome of their mutual struggle and their eventual accord. As business firms seek to reduce their costs and improve their competitive position, so too do the unions and the state respond in order to control the rythm and the growth of the changes which affect employment. It is an essential interest of some direct application studies to explain unions strategies and assess their impact on the rythm of employment change brought about by innovations (cf.Scholz and Wolf 1981).

The consequences of these innovations on employment however will in the first place depend upon macro-economic conditions,but the imposition of this macro-economic perspective remains problematic.

The underestimation of uncertainties and of global interdependancies

The strategies of employers, who want to adopt a new technology, are too frequently perceived as wishing only to diminish employment and reduce costs. Nonetheless it is not at all certain that automation will be translated into a loss of employment and not into a change in services rendered which is usually the case in the tertiary sector (2).

All the same, the direct role of the State in the genesis as well as in the first phasis of diffusion of innovation (Freeman, 1966 ; Masse 1967) is difficult to assess insofar as the effects of innovation on employment are concerned.

The question remains of how the state decides its actions, in regulating the labour market, by braking or accelerating the diffusion of technical progress, and finally chooses between employment to day and employment tomorrow.

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(1) See collected studies on sectoral analysis on the impact of technical progress edited by the Federation of French Unions C.F.D.T (1977).

(2) Referring to two different sources, Rothwell and Zegweld (1979) observed that there was a slight rise in employment in offices where text treatment epuipment was used. There was an expectation however that such equipment should have halved the number of people employed. the reason why such employment was not halved was that there was a great diversification of tasks which accompanied the introduction of the new technology.

During the phasis of a large diffusion of innovations, union strategy seems clear (although it varies according to the given country), but their margin of action vis a vis their mandates remain largely undetermined.

All the more,difficulties are added to these strategies by the inherent uncertainty of innovation regarding lags in adaptation, obsolscence, and renewal (Jantsh, 1967).

It is consequently difficult to see on what basis direct prospective studies, which more often deal with macro-economic perspectives as fixed, make their assessment regarding the size of the diffusion of innovation (as to explain divergences -see annex 3).

In effect, whatever might bring on new technologies of production, their diffusion is very much connected to growth of demand of the product concerned. All the same the extension of markets for new products depends on the rythm of growth of the whole economy.

Moreover the state of world demand and the conditions of competition between nations, which influence the level of internal activity of economies (largely tied into a system of international exchanges) play a determining role in the perspectives for new products and new productive processes.

First of all the increases in employment brought about by the fabrication of a new product are limited in time, because the extension of markets induces a delocalisation of sites of production (with varying degrees of rapidity), according to the situation of the world economy.

Otherwise competition between countries, which have different social systems and economic institutions can bring about an innovation which leads to a strong reduction in employment. In effect, all rigid opposition to rationalizing measures of innovation can bring about either a diversion of demand towards countries where that rationalization has been accepted, or a delocalisation of production towards countries where wages are weaker (1).

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(1) A study on the transfer abroad in the production of German textils explains the significance of the gap within wage costs (in a ratio of one to five) and the modernity of capital equipment used in these new sites. (Fröbel, Heirinchs, Kreye, 1980).

MICROELECTRONICS AND EMPLOYMENT : SOME OPPOSITE FORECASTS

from Zavis P. Zeman (1980)

	The optimists	The pessimists	The ones insisting on uncertainty
Example	Arthur D.Little Inc (ADL) : "Strategic Impact of Intelligence Electronics in U.S.and Western Europe : 1977-1987" Londres, 1979	Barron i. et Curnow R.C. (Science Policy Research Unit SPRU) "The Future with Microelectronics : Forecasting the Effect of Information Technology" Londres-Frances Pinter Publ. 1979	D. Lamberton "Social Costs of change, Employment, Professionnal Skills and Curricula" OCDE Paris 1978
Thesis	Microprocessors constitute on innovation, which transform the division of labor within sectors, as it has been the case for previous innovations. On the whole, it will benefit employment growth.	Microelectronic allows a sharp productivity increase specially in the tertiary sector, where enrolment was high. Beside the electronic industry is already highly automatised and thus won't enlarge employment.	The uncertainties, coming from the new type of society (brought about by microelectronic) give a decisive importance to public policy choices.
Estimation of effects	For the all four studied countries, on the 1977-1987 period the diffusion of micro-processors will bring about 30 to 35 milliards of dollars of supplementary incomes, the distribution of which is difficult to foresee.	The authors forecast an employment decline of 18 % within 15 years, mainly concerning employment in the tertiary sector.	The effect on employment will depend upon the social innovations or the policies to adapt which will be undertaken.

It should however be recognized that, if one takes into account this tendancy towards delocalisation of production brought about by the differences between labour costs, rationalizing innovations will contribute to the slowdown of the transfer of production.

Quite apart from the above mentionned factors, the relative autonomy of multinational firms brings about other constraints concerning the diffusion of technology. These constraints act to maintain entrance barriers, and they create monopolistic technological network which fosters a restrictive system of licences (1).

State and unions in order to define their strategy regarding innovative techniques must appreciate the advantage in the long run of competitive research for enhancing employment. The answer to this question cannot be provided by direct technological studies where everything is treated as if the plans of the firms were made independantly of economic conditions.

One is thus obliged to look at the macroeconomic level in order to appreciate effect of various innovation strategies on employment.

This has been a common objective of many authors who employ the direct approaches (see Pastre, Toledano 1979). The work of Scholz and Wolf (1981)has been at the leading edge of this movement. Starting with a large number of interviews of business leaders and experts on the tendancies and consequences of technical progress on the level of employment and the quality of work, these authors integrate a number of givens on the evolution of labour productivity within the framework of a macro-economic model.

This significant work permits one to analyze the effect of technical progress on employment by comparing expectations derived from the direct approach with expectations from an econometric model. The retroactive effect of the macro-economic context remains problematic and constitutes a limitation of this method.

Moreover the direct approach only deals with the future and one cannot discern the validity of that methodology in assessing the past.

This is not only a shortcoming which is limited to these authors, but pertains to much of the work by technical change specialists who are interested in employment.

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(1) For information on restrictive practices of multinational consult OCDE (1977).

Thus Freeman (1979) interprets the present situation as the declining part of a Kondratief cycle, tied to the domination of process innovations... without ever observing quantitative measures which would have allowed him to verify whether a substitution existed between innovations of process and innovations of product, as some theorists of long cycles claim. Apparently the works of Mensch (1979 and 1980) goes a way toward filling this gap by developping a testable formulation, but the macro-economic mechanisms leading to an equilibrium between full employment and underemployment are not fully explicit. Such a limitation hinders all discussion which seeks to assess the validity of these conclusions or which tries to correct social and economic policy.

From this fact it seems useful to complement the teachings of these direct approaches with a very different research approach which from the start explains a close interaction between macro-economic modelling and the incorporation of certain insights of the theory of technical change. .

THE THEORY OF TECHNICAL CHANGE AND MACRO-ECONOMIC MODELLING : POSSIBLE INTERACTIONS

Taking into account certain economic determinants of technical change

Very often studies evaluating the diffusion of technical progress do not link it to key factors such as : the speed of market expansion, the rythm of capital formation, the profitability, and the volume and nature of research-development expenditures.

However theoreticians have advanced a certain number of hypothesis which permit a partial endogeneization of the productivity increases and the speed of diffusion of demand for new products. We would like to briefly review some of these explicative factors.

.It is clear that the rythm of capital formation conditions the speed of adoption of new techniques and acts during medium term on the dynamic of labour productivity. Thus one can explain the differences observed between American and Japonese manufacture (Economic Report to the President, 1979).

.The existence of dynamic scale effects may be at the origin of a connection between productivity and growth advanced first by Verdoorn (1949) and reformulated by Kaldor (1966). The basic idea is that

for a group of economies at medium term(which arrive at the same stage of maturity) technical progress is directly conditioned by the speed of market expansion. In effect, most of the studies (Cripp; Tarling 1973 Cornwall 1978,...), making comparisons in international cross-sections, refute the hypothesis of independancy of productivity in relation to growth ... even if the origin of this connection remains largely unexplained (Rowthorn, 1975).

. Another set of ideas by a number of theoreticians (Fellner 1961, Black 1962 ; ...) have introduced the hypothesis that the intensity and the direction of technical change was conditionned by the division of revenue between wages and profits.

Taking into account the particularities of wage formation in contemporary economies (Eatwell et alii, 1974, Boyer 1979), the research of productivity gains would be as intense as the growth of real wage, following previously negotiated wage settlements.

. Finally since the end of the XIX century scientific and technical research has been characterized by an entanglement with current economic activity : new technologies far from being manna from heaven have resulted from previous effort in research and developpment, which were taken in accordance with their potential profitability.

As a consequence one cannot ignore the fact that new technologies and new products have come into being.This leads us to consider the effort of R.D as a partial conditioner of potential productivity gains, even if from methodological point of vue (Griliches 1980) such a connection is difficult to demonstrate.

Above all, it would be difficult for a macro-economic model to incorporate all the ideas that have just been roughly outlined.

One very simple model, which is mainly methodological, shows the possibilities of such an approach and permits certain clarifications concerning the respective effect of traditionnal economic policies and of actions which bear upon innovation.

Toward developing a model which considers the impact of technical change on employment : a tentative approach

The model which illustrates the macroeconomic approach, analyzes the growth of five european industries. Three factors of technical change are generated, namely the extension of demand, the formation of capital and research development expenditures.

The figure presented in annex 4 shows how these factors act on productivity and how they are interrelated.

The structural equations of the model, which are derived from the above figure,use variables which are quite common except for the research development variables where the two indicators are quite arbitrary.

According to the estimated parameters of the model, these variables which attempt to assess the orientation and the importance of innovations, appear in the past (1960-1976) to have had a negative affect on employment. That negative affect has a double component which consists of a direct action of the process oriented nature of innovations and of an indirect action through capital formation which is accelerated by the innovations stimulated by growth of research development expenditures. According to the simulations run with the model, the reduction of industrial employment (i.e the deindustrialization process) appears quite general after 1973. In fact, the rationalizing effect of the investment and technical progress is no more compensated by a rapid growth of both internal and external demand, so that the deinsustrialization is likely to continue, as far as the present world crisis will persist.

In addition the estimation of the model furnishes an evaluation on the effects of economic policies which aim at sustaining industrial employment (annex 5).

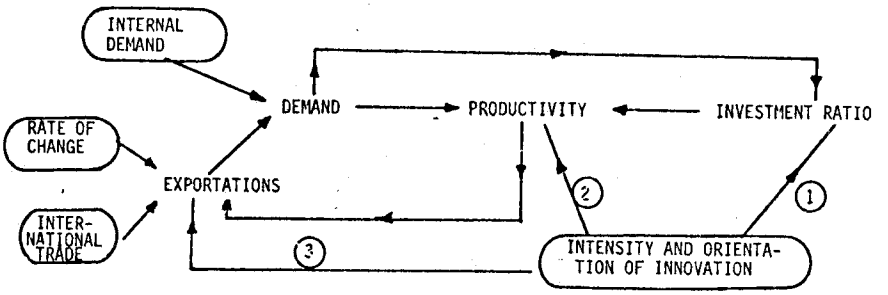
Thus a decrease in the rate of change produces at medium term an increase in employment, which is nevertheless too weak (1) to compensate for the declining trend in industrial employment without greatly endangering the equilibrium of the balance of payments. All the same a rise, in investment would be followed by an increase in industrial employment only if that supplement of investment has a high multiplier effect on internal demand. Finally, the estimation of the model underlines the importance

(1) A ten per cent devaluation would engender a one per cent increase in industrial employment.

ANNEX 4

MULTIPLICITY AND INTERDEPENDANCY OF THE MEDIUM TERM DETERMINANTS OF INDUSTRIAL GROWTH AND PRODUCTIVITY : THE EXAMPLE OF A MODEL FOR FIVE EUROPEAN INDUSTRIES

The causality network



The results for five european industries on four periods :

1960-1965, 1965-1969, 1969-1973, 1973-1976

$$\begin{cases} \dot{E} = \underset{(5.2)}{7.1} - \underset{(9.0)}{0.55} \times \left(\frac{I}{Q}\right) + \underset{(6.3)}{0.75} \times \dot{Q} - \underset{(3.4)}{0.036}\ \tilde{ORINNO} & (1) \\ \frac{I}{Q} = \underset{(12.5)}{11.7} + \underset{(3.3)}{0.44} \times \dot{Q} + \underset{(4.2)}{1.52} \times \tilde{INNO} - \underset{(5.6)}{2.6}\ R.U. & (2) \\ \dot{Q} = \underset{(2.7)}{-1.5} + \underset{(7.6)}{0.51} \times \dot{EX} + \underset{(8.4)}{0.46} \times \dot{D} & (3) \\ \dot{EX} = \underset{(2.3)}{2.2} + \underset{(7.4)}{1.28} \times \dot{PR} - \underset{(4.6)}{0.31} \times CHANGE & (4) \\ \dot{PR} = 100 \times \left[-1 + (100 + \dot{Q}) / (100 + \dot{E}) \right] = \dot{Q} - \dot{E} & (5) \end{cases}$$

ESTIMATION METHOD : Full information maximum likelihood method as given in TSP.

DEFINITION OF VARIABLES

. Endogeneous variables

$\dot{E}$: Growth rate of industrial employment

$\frac{I}{Q}$: Ratio of investment on added value in current prices

$\dot{Q}$: Growth rate of added value in constant prices

$\dot{Ex}$: Growth rate of volume of exports of industrial goods

$\dot{D}$: Growth rate of internal demand of industrial goods

$\dot{PR}$: Growth rate of productivity(added value in constant prices per man employed)

. exogeneous variables

$\tilde{ORINNO}$: Percentage of process innovations in the total of innovations, ten years before (common values for the five industries)

$\tilde{INNO}$: Ratio of R.D.expenditures(military excepted) to GNP (both in constant prices), fives years before

R.U : Dummy variable for UK industry, to account for the weakness of the investment ratio in that country

CHANGE : Growth rate of the exchange rate (i.e. the value of national currency in US dollars), this variable expresses partly the effect of the differences in financial capacities between countries

STATISTICAL SOURCES

O.S.C.E (1980) except for CHANGE and RD variables - see R. Boyer, P. Petit (1980-2)

of world growth, which is equally as important for employment and production as that of internal demand.

Thus this approach enables us to treat certain aspects of technical progress within a macoreconomic framework. However its limits are obvious and should be kept in mind.

An initial limitation of this approach comes from the difficulties of defining and measuring innovation variables.

The variables chosen are common indicators of intensity or of direction of the innovation process. On the other hand their explicative ability is loose (i.e the connection between research development expenditures and postwards innovations is not tight).

In addition alternative indicators exist (such as the flow of patents) and using them would change the results. All the more the very specificity of each innovation is ground to homogeneous conditions of time and space.

A second limit, which affects the results of the model, pertains to the econometric method which is used to estimate the parameters of the model.

The full-information-maximum likelihood (FIML) method, which applies to simultaneous equations models, takes into account interdependancies between the equations.

In return the results obtained by that method are dependant on initial values, which are given to unknown parameters. Besides the information employed is confined to five countries and four periods. This only provides us with a rough idea of the direction on some effects of technical progress.

Finally, on more theoretical grounds, it seems that only with great difficulty could such an approach integrate the whole set of determinants of technical progress which are mentionned in the literrature. Apart from factors which could be integrated in a more elaborate model, some national characteristics are excluded such as differences between countries regarding the importance of multinational firms or concerning the role of the unions or related to actions of the state. Now those characteristics imply for each country, different types of capital growth and capital distribution within their sectors, or different forms of public interventions in industry, or in the genesis of technical change, which (like the qualification regarding active population or other social or cultural institutions) introduce specific national determinants in the relation, between technical change and

ANNEX 5

THE REDUCED FORM OF THE MODEL : MULTIPLIER EFFECTS OF VARIOUS EXOGENEOUS VARIABLES ON THE MEDIUM TERM TRENDS OF INDUSTRIAL PRODUCTION, EMPLOYMENT AND PRODUCTIVITY

One can summarize the network of interdependancies, that represent the structural equations of the model (annex 4), through a series of reduced equation which expresses each of the endogeneous variable as a linear combination of the exogeneous variables and the constants. That reduced form allows to assess directly the multiplier effect on employment, production or productivity of a shift of either an exogeneous variable (rate of change, rythm of innovation, internal demand) or of the level of one structural equation (through a shift in the constant).

The table below gives in each case the estimation of these multiplier effects.

	$\dot{D}$	$\dot{DM}$	$\dot{CHANGE}$	$\Delta\dot{(\frac{I}{Q})}$			$\Delta\dot{N}$	INNO	ORINNO
Exogeneous variables		Shift in world market trade	Exchange rate	Shift investment equation			Shift in employment equation	innovation	
Endogeneous variables	Domestic demand			Without any increase of global demand	With an equivalent increase of global demand	With a multiplier effect of 2 on global demand		Level of RD expenditure / value added	orientation toward productivity
Production	0.68 (10.4)	0.75 (5.2)	-0.23 (-4.3)	0.52 (3.6)	1.06 (6.7)	1.6 (8.6)	-0.96 (-4.2)	0.80 (3.1)	0.035 (3.2)
Employment	0.34 (6.1)	0.38 (4.4)	-0.12 (-3.3)	-0.28 (-3.4)	0.01 (0.09)	0.27 (1.8)	0.51 (3.5)	-0.40 (-2.5)	-0.018 (-2.0)
Productivity	0.34 (5.4)	0.37 (3.9)	-0.11 (-4.1)	0.80 (6.7)	1.05 (7.1)	1.33 (7.5)	-1.47 (12.3)	1.2 (3.9)	0.053 (3.3)

The meaning of variables $\dot{D}$, $\dot{CHANGE}$, INNO, ORINNO is given in Annex 4.

The variables $\dot{DM}$, $\Delta\dot{(\frac{I}{Q})}$, $\Delta\dot{N}$ are respectively the constants of the equations of exportation, of investment, and of employment considered as parameters to simulate changes in the corresponding structural equations.

In the case of a shift of the investment equation, we have supposed successively that the multiplier effect of investment on internal demand was zero, one or two.

employment. To suppose that all nations follow the same model (where only a few exogeneous variables account for a multitude of national properties) may underestimate the difference between countries as well as neglect the importance of technological advance or backward positions in the process of diffusion of technology (Gomulka 1979, Maddison 1979).

In sum, the macro-economic approach we are presenting is a complement rather than a substitute for the other approachs.Put another way it offers a fuller and more appropriate macro-economic framework, where one can make use of the results of direct propectives studies (assuming that there is an adequate typology of innovations which has previously led to suitable indicators).

CONCLUSION

In the light of the preceding developments we shall sum up four of our main conclusions :

1/ From a methodological point of view, the present work, which is still in process, argues for a fuller articulation between the analyses of specialists of technical progress and those of macro-economics.

This seems to be an essential condition for understanding crucial factors regarding employment in the coming decades.

2/ On theoretical grounds,the preceding analysis is a plea in favour of the endogeneisation of technical change, the genesis and diffusion of which depends as much on economic activity as on social and institutional factors.

3/ Regarding european industries, the economic model leads to a forecast of a continuing decline in industrial employment, which began in some countries in the mid sixties and spread to all countries after 1973.

4/ As to the economic policies, which could counter that movement,one is obliged to conclude that devaluations or measures to stimulate demand have only limited effects.

Equally so, the stimulation of innovation, which is supposed to restaure or maintain competition, should have a persisting negative effect on industrial employment.

This conclusion, if it was supported by other works of the same kind would without doubt stimulate the search for brand new economic and social policies, in order to cope with the magnitude of disequilibria which have been accumulated.

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