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NOTICE INTRODUCTIVE

Les circonstances de l'élaboration et de la publication de cet article de Jean-Paul Fitoussi et Nicholas Georgescu-Roegen constituent un événement significatif dans la trajectoire des deux auteurs, important aussi dans l'histoire du BETA.

Pour Jean-Paul Fitoussi, il s'agit de sa première publication internationale, insérée dans un volume consacré à une conférence de l'*International Economic Association* qu'il a co-organisée en 1978, au Bischenberg, avec le président sortant de l'Association, Edmond Malinvaud. C'est le premier pas vers une brillante carrière internationale, dont je n'évoquerai ici que les prolongements immédiats de cet épisode. Jean-Paul Fitoussi est alors à la veille de son départ à l'Institut universitaire européen de Florence, où il organisera une autre conférence de l'Association, dont il va assumer le secrétariat général à partir de 1984 et jusqu'en 2008.

Pour Nicholas Georgescu-Roegen, cet article est l'occasion d'un retour à des préoccupations qu'il avait reléguées depuis quelque temps à un deuxième plan, en faveur de sa contribution à l'économie de l'environnement. Il s'agit surtout de la réflexion méthodologique initiée dans la partie introductive et originale de son ouvrage[1] de 1966 et poursuivie dans son ouvrage de 1971, ainsi que d'une critique cruciale de la modélisation conventionnelle du processus de production, développée principalement dans le chapitre IX de ce dernier ouvrage.

Pour le BETA, cet article est la consécration du travail de recherche poursuivi en collaboration, en son sein, par le premier des grands économistes ayant séjourné parmi nous. Ce travail est d'autant plus significatif que Nicholas Georgescu-Roegen était, avant même son séjour de deux ans à Strasbourg, un des auteurs ayant le plus marqué quelques-uns des membres fondateurs du laboratoire.

Si l'on revient à l'article lui-même, le premier constat est celui d'une facture inhabituelle, surtout d'après les standards d'aujourd'hui, avec un corps de 21 pages (bibliographie comprise) et une annexe de 40 pages, traitée en fait comme un article autonome. Cette facture invite à s'adonner au jeu des identifications (qui des deux auteurs a écrit quoi) mais cela ne fonctionne que partiellement tant leurs deux pensées convergent, même si l'on peut identifier aisément les sources de maints passages.

Sur le fond, le corps de l'article développe une théorie du chômage involontaire qui en impute l'émergence et la persistance à des changements qualitatifs structurels induits par le flux d'innovations mis en évidence par Schumpeter. Ce point de départ est intéressant en soi pour au moins trois raisons, que j'énoncerai un peu dans le désordre. Nicholas Georgescu-Roegen a entamé sa carrière d'économiste dans le cercle de Schumpeter, après son arrivée à Harvard en 1934. L'article se réclame de Schumpeter une décennie avant l'éclosion des théories néo-schumpetériennes, dont la version appliquée à la croissance par Philippe Aghion et Peter Howitt à partir de 1987 est celle qui s'est le plus largement répandue. L'association ainsi esquissée entre macro-économie et innovation et la cohabitation sous-jacente des deux figures tutélaires que sont Keynes et Schumpeter pourraient presque servir d'image de marque au BETA des années 1980.

[1] Les références de cette notice figurent dans la bibliographie donnée dans le corps de l'article.

L'idée que l'économie est façonnée par un flux d'innovations à la fois créatrices et destructrices est évidemment au centre de la théorie schumpetérienne empruntée par les auteurs, qui soulignent toutefois la différence entre la conception cyclique du phénomène, avec des innovations intervenant par grappes, qui avait été proposée par Schumpeter et celle qu'il convient selon eux d'adopter après la deuxième guerre mondiale, dans un monde où la production d'innovations s'est en quelque sorte industrialisée et transformée ainsi en un processus continu. Ce processus modifie en permanence la structure de la demande et engendre en conséquence un chômage structurel persistant parce que continuellement recréé.

Pour rendre compte de ce chômage persistant, point n'est besoin de faire appel à la modélisation en termes de prix fixes initiée par Barro et Grossman au début de la décennie et qu'Edmond Malinvaud venait de promouvoir en 1977. Une des principales faiblesses de cette modélisation, pointée par les deux auteurs, tient au fait que les prix y sont purement exogènes, hérités d'une histoire qui reste inexpliquée. La modélisation faisant appel à la concurrence imparfaite, avec des entreprises décidant de leurs prix, va tenter de corriger cette faiblesse mais un peu plus tard seulement, au début des années 1980. L'approche des deux auteurs se base quant à elle sur une dynamique d'ajustement des quantités offertes (et corrélativement des prix de marché) où l'asymétrie des réponses aux excès d'offre et de demande joue un rôle essentiel, déjà exploité dans la thèse de Jean-Paul Fitoussi (1971).

En effet, si les quantités offertes (et produites) sont plus réactives aux excès d'offre qu'aux excès de demande, à la baisse plutôt qu'à la hausse, un simple déplacement d'un marché à l'autre d'une dépense globale croissant à un taux constant tend à ralentir la croissance réelle et à intensifier l'inflation. Dans sa critique de l'article, Franco Modigliani a exprimé sa méfiance à l'égard des asymétries en général et de celle postulée par les auteurs en particulier. Mais c'est la non-linéarité qui est en cause : la stricte convexité de la fonction d'ajustement des quantités en réponse à la demande excédentaire crée le même effet de ralentissement de la croissance et d'intensification de l'inflation à la suite d'une plus forte dispersion de la demande excédentaire. Un flux d'innovations recomposant en permanence la demande tend donc à engendrer en même temps des tensions inflationnistes et du chômage structurel persistants.

L'annexe de l'article est consacrée à une critique détaillée des fondements des théories du déséquilibre, laquelle peut cependant être aisément étendue à une grande partie de la modélisation conventionnelle. Je ne m'appesantirai pas sur les considérations générales issues des réflexions méthodologiques antérieures de Nicholas Georgescu-Roegen déjà mentionnées, y compris celles qui portent sur les fonctions d'utilité et de production. Un point mérite cependant qu'on s'y arrête : les auteurs dénoncent avec force la confusion opérée par la modélisation conventionnelle entre la main d'œuvre employée et le travail qu'elle effectue au cours de la période concernée, entre le *fonds* et le *service* qu'il rend (pour utiliser les concepts de Nicholas Georgescu-Roegen) ou encore entre la *force de travail* et le *travail* lui-même (pour utiliser ceux de Karl Marx).

Cette confusion fait disparaître une variable endogène essentielle qui est la durée du travail, efface la question de l'organisation du travail en équipes opérant sur des tours successifs (à laquelle est consacré plus d'un cinquième de l'annexe) et ne permet pas de tenir correctement compte de l'existence du chômage partiel. Lorsqu'ils abordent la discussion des règles de rationnement postulées par les théoriciens du déséquilibre, les auteurs observent en effet que le rationnement de la durée de travail n'est jamais envisagé. A la suite de cet article, j'ai moi-même essayé un moment d'introduire une durée endogène de travail dans un modèle à prix fixes et d'en analyser les implications, mais ce programme de recherche a avorté au bénéfice du projet d'endogénéisation des prix par la concurrence imparfaite qui s'est vite révélé plus prometteur.

Au-delà de cette critique générale des fondements des théories du déséquilibre, l'annexe s'engage dans l'examen détaillé des résultats analytiques obtenus dans le cadre du modèle de Malinvaud. La démarche surprend, tant on est alors loin de la théorisation proposée dans le corps de l'article, mais elle permet en tout cas de montrer que le fonctionnement du modèle est plus complexe que ne l'avait laissé apparaître son auteur – une complexité qui a été également mise en évidence à la même époque par d'autres économistes, parmi lesquels Werner Hildenbrand, dans un article de 1977 co-écrit avec son frère Kurt, cité par les auteurs et présenté à Strasbourg cette même année.

L'article ne connut qu'un retentissement discret. Il est arrivé à un tournant marqué par l'étiolement des théories du déséquilibre discutées dans son annexe et par l'éclosion, en 1982, du modèle d'équilibre général dynamique stochastique, qui allait coloniser la théorisation macro-économique en laissant peu de place au type de modélisation exploité dans son corps. Mais il est intéressant de le revisiter aujourd'hui pour ce qu'il exprime de ce tournant et pour ce qu'il illustre des trajectoires dont s'est faite l'histoire du BETA.

Rodolphe Dos Santos Ferreira, mars 2022

8 Structure and Involuntary Unemployment*

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> It is therefore misleading to reason on aggregative equilibrium as if it displayed the factors which initiate change and as if disturbance in the economic system as a whole could arise only from those aggregates.
>
> Joseph A. Schumpeter, *Business Cycles*

I INTRODUCTION: ARITHMOMORPHISM VERSUS DIALECTICS

Involuntary unemployment is a product of the industrial revolution. As a cyclical phenomenon, it existed until roughly the end of the Second World War. Some fluctuations still exist, but they are small and not as regular as during the earlier period dominated by business cycles. Moreover the problem appeared to have been solved by macroeconomic regulation of the Keynesian type. The unemployment which continued during the greater part of this period was considered as the 'full employment level of unemployment'. But the worsening of the phenomenon since the end of the sixties has shown that chronic unemployment remains the most relevant social problem. Hence, though the worsening of unemployment can be pin-pointed in time, its existence is a permanent characteristic of the industrial economic system.

But cyclical unemployment has recently become chronic unemployment.

* This is a revised version of the paper presented to the Conference. The authors wish to thank R. Dos Santos Ferreira for his comments and valuable suggestions concerning an earlier version, and to acknowledge the useful information provided by T. Aldrich Finegan.

The following tables – retracing the series of the low and the high rates of unemployment in the US since 1892[1] emphasise this conclusion.

Year	*Low*	*High*	*Year*	*Low*	*High*	*Year*	*Low*	*High*
1892	3.0		1918	1.4		1956	4.2	
1894		18.4	1921		11.7	1958		6.8
1902	3.7		1926	1.6		1960	5.5	
1904		5.4	1933		25.2	1961		6.7
1906	1.7		1944	1.2		1969	3.5	
1908		8.0	1949		5.9	1971		5.9
1913	4.3		1953	2.9		1973	4.9	
1915		8.5	1954		5.6	1975		8.5

	Before 1954	*After 1954*
Average low	2.5	4.5
Average high	11.9	6.7
Range	9.4	2.2
Average wave length	8.1	4.8

From this series, one can see the striking difference between the oscillation of unemployment before and after 1954, in two periods of industrial change. A fundamental question thus presents itself: what is the cause of this historical change?

The answer we propose in this paper is that both the emergence of unemployment, now and in the past, and its permanence in recent times are due to qualitative structural changes. For this reason we must point out from the outset that to deal with qualitative changes – whether in economics, biology, political sciences, or even astrophysics[2] – one must necessarily resort to the dialectical method. Furthermore, the nature of all actuality is dialectical, and this characteristic is especially pronounced in the case of

[1] The tables were calculated by continuing the series constructed by Lebergott (1964, pp. 512, 522).

[2] The most important notions forced upon us by a continuously changing actuality are dialectical: e.g. workable competition, tastes, long-run, short-run, democracy, good justice, valuable contributions, etc. Species, for example, is a dialectical concept precisely because the species, not the individual, is the vehicle of biological evolution. For the doubting arithmomorphic enthusiast, let us also mention 'a sufficient number of observations', a notion that cannot possibly be chased away from the foundations of probability (Georgescu-Roegen, 1971).

unemployment.[1] This is why most economists who in the past have tackled the problem of unemployment in a serious way – from J. B. Say, T. R. Malthus, D. Ricardo and Karl Marx to J. A. Schumpeter, A. C. Pigou, G. Myrdall, A. H. Hansen and Lord Keynes – have done so primarily through dialectical reasoning. But in more recent times economists have turned to using purely arithmomorphic models instead – as is now the fashion in modern economics. Undoubtedly, such models play a very important role in all sciences. To use an arithmomorphic simile for verifying already developed dialectical reasoning is an absolutely necessary methodological step (Georgescu Roegen, 1966, 1971). In economics this methodology was used by none other than the propounder of dialectical economics, Karl Marx, and over years has been used by many others, Lord Keynes in particular.[2] But it is an elementary truth, although we usually prefer to ignore it, that arithmomorphic models cannot incorporate the emergence of the novelty. If they could, nothing would prevent us from printing out the entire evolution of our whole planet until the end of eternity.

[1] The economic specialists who composed the USA President's Committee to Appraise Employment and Unemployment Statistics (1962) began their report by explicitly stating that 'there is no single definition of the labour force or of unemployment which is obviously *the* correct one'. In considering the question 'how shall we define the state of being unemployed?', they simply mentioned one case after another to prove that the concept slides into its opposite through an inextricable dialectical penumbra. To cite here only two illustrations: There is, first, the case of the unemployable (another dialectical quality). Second, there are individuals who *might* like to have a job but are not looking for one because they *believe* that they cannot find one. Are they 'unemployed'? And how can we discover who is such a 'discouraged worker'? (Finegan, 1978). Is, for example, a retired professor a discouraged worker because he believes that he could not find any job to his liking?

[2] It may not be superfluous to belabour the evidence. Keynes' *General Theory* contains only one diagram (p. 180), and an extremely elementary one at that. The famous work at the same time abounds in dialectical expressions. One can cite at will: approximate statistical comparisons of incommensurable collections based 'on some broad element of judgement rather than on strict calculations' (p. 39); expectations 'foreseen sufficiently far ahead' (p. 48); existing facts 'known more or less for certain' (p. 147); decisions 'taken as a result of animal spirits . . . , and not as the outcome of a weighted average of quantitiative benefits multiplied by quantitative probabilities [but reflecting] the nerves and hysteria and even the digestions and reactions to the weather [of their authors]' (p. 161f). Also, outside some spotty simple algebraic expressions, only the first section of Chapter 20 contains an argument cast in mathematical form, which, symptomatically, Keynes considers superfluous (see also note 9, below). Patinkin (1976, p. 22f), who quotes Keynes' blunt denunciation of the 'symbolic pseudo-mathematical methods', is completely right in his verdict that Keynes' merits lie 'in his creative insights about fundamental problems', not 'in rigor and precision'.

Certainly, if we are interested only in anonymous actions that simply repeat themselves – to which Pareto wanted to confine the domain of economics – mathematical models can be very enlightening. This is no longer true if things do not keep repeating themselves. Pareto's analogy of the navigator who does not need to take account of geology is ill-conceived: a navigator would have to take account of geology if the shores of the oceans changed as often as economic life.

The prevailing unlimited confidence that economists have in arithmomorphic models is responsible for many fallacies and unwarranted claims that still make the rounds. Take the loud claims that disaggregated dynamic economic models are the best blueprints for a development planner. These models cannot explain even purely quantitative growth – as immediately becomes apparent if one tries to see what corresponds in actuality to the paper-and-pencil symbolism (Georgescu-Roegen, 1974).

II UNEMPLOYMENT AND DISEQUILIBRIUM THEORIES: EQUILIBRIUM VERSUS DISEQUILIBRIUM IN THE MARKET PROCESS

Especially in recent times, arithmomorphic models have been the choice of most writers on unemployment. Reference is made to the school of thought that has proposed to study disequilibrium instead of equilibrium. Some of the disequilibrium models have a definite value as similes of some dialectical reasoning – the best achievement in this respect being Keynes's famous model of his *General Theory*. But on occasion the analytical models of disequilibrium that are accompanied by claims of greater penetration involve shortcomings of various natures.[1]

Even those models that would hold water throughout offer only a description of how an economic system may live with market disequilibrium. To explain how this is possible, special rules are thought up so as to bring about the desired result. We will take a closer look at this kind of model in the Appendix to this paper by examining the Analytical Foundations of Disequilibrium Theories. But at this juncture three important shortcomings of the disequilibrium theories deserve unstinted emphasis.

First, the point of departure is a given constellation of prices that remains invariable throughout the period under consideration. 'In the beginning there were the prices', one might say, thinking of the familiar Biblical verse.

Second, no explanation whatsoever is offered of how these prices came

[1] See Appendix. Here, as elsewhere in the text, 'disequilibrium model' refers to the kind of model using the fix-price method. In fact such models, as Malinvaud rightly points out, are equilibrium models. They are based on the assumption that quantities react significantly faster than prices. Nevertheless we refer to them as disequilibrium models, because in some sense supply and demand differ in them.

about. As Schumpeter used to say in discussing the possibility of unstable equilibrium, perhaps an angel from the sky called them out.

Third, the disequilibrium theorists have been so concerned with explaining how an economic system can live with a given disequilibrium that they have ended up with a theory which implies that any given disequilibrium must continue forever.

This new development represents a complete *volte-face* from the explanation of the market process propounded by Léon Walras and, in an even more cogent way, by Alfred Marshall. To recall, they taught that, if no exogenous factors intervene to change the preference or the technical parameters, any disequilibrium between demand and supply will ultimately disappear. In a nutshell appropriate for the present discussion, the basic idea is as follows (cf. Patinkin, 1956, p. 37). The Monday markets open with some quantities offered for sale; the quantities have been determined by previous decisions (say, those made on the preceding Saturday). On these markets, some prices will be established by a partly random process that will also take into account the reasons that governed the previous decisions. There is no claim that these prices will clear all the markets. But Marshall's argument (in particular) does not stop with Monday's outcome. The economic process, indeed, continues on Tuesday, with new quantities and newly formed prices. Only by a miraculous coincidence will the Tuesday markets clear completely. But unless we deny to all consumers and producers the ability to learn from past experience, the new configuration of prices and quantities must normally be nearer the equilibrium than that of Monday. Such an adjustment, involving both prices and quantities, will day after day bring the system nearer and nearer its equilibrium defined on the basis of the prevailing economic behaviour. And even though the exact equilibrium may not be reached within a finite duration, the tendency of the system to move toward it is always at work. The only reason why this tendency may be disturbed is the emergence of some innovation in the broadest sense of the term.

In contrast with the neo-classical explanation of the market process, the disequilibrium approach deals only with what happens on Monday and stops there, as if there were no Tuesday, Wednesday, and so on. This, and not the fact that the disequilibrium approach focuses on another element of the market process, is the fundamental difference between the two schools of thought. In the disequilibrium theory, prices are unexplained parameters; they come from the past and completely dominate the market; quantities simply adapt to these fixed prices. Moreover, there is no tâtonnement at all; the adaptation is instantaneous (a one-day affair). This is the basis for the new school's explanation of the chronic unemployment of our own era.

The disequilibrium theory thus emerges as a theory of static disequilibrium, a disequilibrium that perpetuates itself because the Tuesday market is just a repetition of the Monday market. To be sure, some supporters of the disequilibrium theory mention that prices cannot remain constant as time goes by (e.g. Malinvaud, 1977). But if they mean that both prices and quantities adapt themselves even in the absence of any innovations, they must necessarily imply that the market configuration must tend toward equilibrium. Obviously, if this is the case, there can hardly be any claim of a true revolution with respect to the neo-classical teaching, nor even of a Keynesian counter-revolution.

Thus, by introducing the idea that, given time, prices also adjust so as to reduce any excess supply or excess demand, we parry the objection that disequilibrium theories are theories of static disequilibrium. But the price to be paid for this defence is the very relevance of those theories *vis-à-vis* the old equilibrium doctrine.

The proper approach, the most fruitful in economic theory thus far, emerges from Marshall's teachings. This is to start with a system in equilibrium, look for the causes that may throw it into disequilibrium, and study their possible effects. Once this is done, we must try to find out the reactions by which the system tends towards the new equilibrium. For to any disequilibrium there is always a corresponding conceptual equilibrium. Disequilibrium theories simply begin with a certain disequilibrium and end with it.

The only snag in Marshall's teachings on how the system moves toward equilibrium, first through short-run adaptations and later through long-run adaptations, lies in a misinterpretation of his methodology. Many economists came to believe that long-run adaptations to a given disequilibrium always operate and actually bring the system into equilibrium. However, Marshall never taught this inept interpretation of theoretical reasoning in economics; otherwise, he would not have insisted on the irreversibility of the long-run supply curve. Keynes's famous protest against the long-run equilibrium missed the core of the matter. The important thing for the economic process is not that 'in the long run we are all dead' – which is an undeniable fact. What is important is that the proper long-run adaptations (in the sense in which this term is used in economic theory) have little chance to begin working. Short though our lives may be in comparison with the time dimension of the economic process, one disequilibrium comes after another in such rapid sequence that we may seldom witness pure long-run forces at work. Before a new form enters the field, some innovation comes to introduce a new production function. This is particularly true of the modern industrial age – as we shall argue presently.

III UNEMPLOYMENT AND EVOLUTIONARY CHANGE

In a somewhat imprecise way the problem of unemployment may be represented by the following parable. At the great feast provided by nature and prepared by the community, some people are seated at the table and enjoy in varying degrees their meals. Others, however, can find no place at the table and must be content with the usually scanty leftovers. They cannot partake of the ordinary meal, they are told, because they have not contributed in any way to the preparation of the feast. To which they retort that they have tried very hard to do so by offering to work in the kitchen, but that there was no place for them there either. The problem now is to explain how such a situation may have come about.[1]

One possible answer is that there are not enough 'pots and pans' to permit the employment of all would-be workers. This case may be identified with 'overpopulation' in a special sense, namely when the marginal productivity of labour is zero. Obviously marginal pricing cannot work then; other rules for distribution must be adopted that conceal this kind of unemployment. The situation is characteristic of many agrarian economies, where through various institutional arrangements many people can earn a subsistence income greater than their individual contribution to the national product (Georgescu-Roegen, 1960). But the case deserves special attention because it reveals the influence that a continuously growing population, or even a sudden swelling of the labour force with women and youth, can have on industrial unemployment in western countries.

Whereas in the overpopulated agrarian countries the hidden unemployment can be imputed to the extremely low productive capacity per capita, the opposite condition was used by Karl Marx to explain the unavoidable increase in unemployment to such a level that it will ultimately bring about the downfall of capitalism. As he argued, capitalists contribute to a continuous structural change, because they invest a steadily increasing proportion of surplus value in constant capital, that is, in the physical capacity for production (Georgescu-Roegen, 1960a). Marx's implicit assumption was that under capitalism constant capital not only increases (a fact that by itself would rather increase employment), but also becomes continuously more efficient. Better machines replace men – an idea that goes back to Ricardo and to a large extent is perfectly valid.

We owe to Schumpeter, however, a far more refined and more penetrating structural analysis of unemployment under capitalism. As we remember, Schumpeter attributed the phenomenon of general disequilibrium – hence of unemployment – to a steady flow of novelties that arise from within the economic process itself (provided this process is not identified exclusively with what happens on the markets).

Schumpeter's point of departure was that the economic process feeds upon the product of the inventive idle curiosity that constitutes a main character-

[1] In what follows we shall ignore the suggestion that some individuals are not entitled to a seat because they have kept moving around the kitchen hopin all the time to find a 'better' job. It cannot be denied that some people remain unemployed because of their 'job-searching', but the phenomenon has only a marginal relevance.

istic of the human species: this is the source of the flow of the inventions of new things or of new ways of doing things. It is incontestable that such inventions have occurred continually but without any regularity, not even a stochastic one. Incontestable also is the fact that ever since the Industrial Revolution they have become far more frequent.

Naturally, not all technical inventions can find an immediate practical application; and those that do are not of equal importance. Schumpeter argued that as unused inventions accumulate over time, some entrepreneur will base his venture on one or another invention that seems to present a greater chance of economic success. Then many others will imitate the initiator(s). A movement of the economic system away from the previous situation will thus be produced by novelty or, as Schumpeter preferred to say, by innovation. Certainly, this movement implies a powerful disturbance, with workers being drawn from the older activities by an increase in new labour demand designed to provide future production. The disequilibrium that occurs during the first stage could be represented by the situation to which Malinvaud (1977) referred as 'repressed inflation'.

But entrepreneurs would not be entrepreneurs if they were not over-enthusiastic about their ventures. In the end, it will emerge in the new markets that the new captains have created a productive capacity too large for the final demand facing it. A large part of the capacity will become idle and unemployment will soar – a delayed result of the novelty that has been incorporated into the economic system.

Now, if this were all, we would expect the system ultimately to reach a new equilibrium. To be sure, that would take a rather long time, because decumulation is a far slower process than accumulation. A pair of shoes may be produced in a day, but we must walk miles on end to decumulate them in the proper sense of the term (Georgescu-Roegen, 1968; 1971; 1974). So, before long, new entrepreneurs embark upon another batch of innovations that have emerged from the continually produced inventions. The story (i.e. the cycle) thus repeats itself. (Needless to recall, Schumpeter did not include only technological novelties among innovations; for our own epoch we must take into consideration the novelties created by new fiscal rules, new economic developments, and new international contacts as well.)

Briefly, it is the steady emergence of novelties, bringing about structural changes, that prevents the economic system of modern times from reaching a Walrasian equilibrium. As a matter of fact, two of the greatest economists have explained the cause and the maintenance of economic disequilibrium by a structural analysis – Marx by referring to the structure of capital investment, and Schumpeter, to the structure altered by the perennial flow of innovations. However, the temper that now prevails in orthodox economics is to regard only work taking the form of mathematical models (the more mathematically complex, the better) as important. Even the structural studies of Marx and Schumpeter are belittled as 'vague and impressionistic', which is the verdict of Baumol (1970).[1,2]

In spite of this verdict, we propose to continue in the same furrow and argue with additional points that the permance of unemployment in this epoch is due to a continuous structural change brought about by novelties. This proposition means not that only one kind of unemployment – structural unemployment – is worth studying, but that at the source of any unemployment one finds structural change. Such an explanation is both particular and universal. Particular, because change always has an area of application. Universal, because evolution results from an ongoing process of change. 'Novelty' is, in effect, multidimensional; it can be expressed by innovation – a change of taste or of technique, the expansion of markets – or by institutional evolution – alteration of fiscal rules, unemployment compensation, the length of the work week. It can also be brought about by the transformation of a country's international relations and new economic developments. In short, it can manifest itself in many areas and cannot by its nature be constrained by a taxonomy. Hence the concept of 'innovation' that we shall consider must be understood in the broadest sense of the term. This sense, we should note, includes also any new measure instituted by the government with the intention of eliminating some undesirable aspect of the prevailing equilibrium, a phenomenon that has become quite frequent during the past forty years or so.

But although we have been inspired by Schumpeter's theory, our position differs from his. This does not mean that we find his theory inadequate. On the contrary, we believe that Schumpeter's theory of business cycles is one of the truly great economic contributions of all time, comparable only with those of Adam Smith, Ricardo and Marx. What we claim is that if Schumpeter arrived at the conclusion that the flow of novelties produces the cyclic fluctuation of unemployment, it was only because the economic reality which he had witnessed was such that the incorporation of novelties into the economic system was a bandwagon phenomenon. As John Theophilus Desaguiliers wrote in 1744, the inventors of the steam engine were not 'philosophers to understand the Reasons or mathematicians enough to calculate the Powers, and to proportion the Parts; [they] . . . luckily by

[1] Structural studies being thus *praeoccupatio non grata*, we economists have lost contact with actual phenomena in a dangerous measure. One salient case is the phenomenon of inflation, towards which the prevailing teachings based on a mechanistic description of aggregated coordinates are totally impotent. (For a structural analysis of inflation see Georgescu-Roegen, 1968 and Fitoussi, 1971.)

[2] A different verdict exists, however. A salient illustration is given by Francois Perroux, who insisted in his work on the necessity of a structural analysis of the economic process.

accident found what they sought for'. (Cited by Dickinson, 1963).[1]

This situation has completely changed since the Second World War. Enterprises no longer produce only products in the strict sense; they now produce inventions as well. Inventions no longer have to accumulate until some 'leaders' feel that it is about time to convert an invention into an innovation. The temper of the business world is nowadays geared to producing invention and using innovation as fast as it can get them. We live now by R & D, one of the greatest innovations, whose influence upon the structure of business activity has been recognised by many authors (including Schumpeter himself).

One consequence is that innovations come up now with such dazzling frequency that the economic system is constantly maintained in disequilibrium, with a persistent unemployment.[2] The main reason is familiar. Any successful innovation causes older activities to shrink or completely interrupt their production (since complete decumulation demands an utterly impractical long time under adverse circumstances). This creates what is known as structural unemployment, which in the usual literature is considered to have only marginal importance. We maintain, however, that in our own epoch, most unemployed workers represent structural unemployment. But it is not legitimate to think that macroeconomic disequilibrium and structural disequilibrium are mutually independent. The former can be – and *is*, according to Schumpeter – the consequence of a structural change. Conversely, the impact of macro-disequilibrium acts very selectively, in clearly circumscribed regions of a system of partial markets: decentralised economies are characterised by a system of markets that are not perfectly co-ordinated. Hence the distinction between structural and deficient demand unemployment is not always relevant. Moreover, there are also several aggravating factors that characterise the new structure of the world's economic system.

First, because modern technology requires increasing specialisation, it becomes increasingly difficult for many unemployed people to find new jobs. The just-adopted innovation generally requires new skills, which is responsible for the fact that jobs are begging although chronic unemployment may be high.[3] Unemployment thus lasts longer.

Second, enterprises no longer tend to gather together in a few centres. We do not find only Manchesters or Pittsburghs any more. Unemployed people from one location may find it difficult to know about vacancies in other locations, and even if they know, they may not always find the change of place a convenient solution. Structural unemployment thus meets with still another friction.

[1] We may also mention that the inventor of another important energy convertor, the electrical dynamo, was a workman, without any R & D facility.

[2] On the frequency of innovation, see Lebergott (1964).

[3] A survey by *Business Week* revealed that shortages of highly skilled workers are becoming increasingly common (*Business Week*, 5 June 1978).

Third, it is in the nature of the process itself to generate excess capacity (in the physical sense). The plasticity of the structure of demand comes up against the relative rigidity of the structure of production. Hence investors are likely to overreact to any increase in demand regardless of its structural origin. This means not that adaptations in capacity are systematically oversized with regard to the supplementary demand which generates them – the converse may be true – but that the duration of the supplementary demand is generally difficult to evaluate. Nor does this mean that the entrepreneurs are always wrong in their expectations of effective demand. But two factors aggravate the difficulty of forecasting. The first is obviously obsolescence, a phenomenon which has some connection with novelty. The second is competition. Competition is not a state but a process. As a process it often has the effect when the market shrinks of developing excess capacity (Gaffard, 1979). The time horizon of the investment coincides only by chance with that of demand. This problem certainly has some relevance when the optimal scale of new investment is high. Thus, when the automobile industry in the United States was faced in the late 1950s with a sudden increase in demand caused by peoples' sudden desire (a novelty, to be sure), to have a second car in the family, its managers reacted by building a capacity to satisfy that additional demand within a few years. After the temporary excess demand was satisfied, the industry ended up with too large a capacity, for they now must satisfy only the replacement demand and whatever increase may be attributed to the population growth. The result is that, because of technological and financial advantages, the industry now works near capacity during only part of the year.[1] If decumulation were a simple affair, this disequilibrium would vanish quickly.[2]

The tendency of the managers to overinvest may also result in building more than one plant. After the air clears, the superfluous plants have to be closed because of well-known laws of returns to scale of operations.[3]

Fourth, it is by now a well-known fact that one fateful novelty of post-Second World War has been the development of many underdeveloped

[1] For the reasons why a firm may choose between two alternatives – to work with a given capacity and vary the working time, or to keep this time constant and vary the capacity used – see Georgescu-Roegen (1971a).

[2] Incidentally, graduate schools in the United States adopted exactly the same policy as the automobile industry when the universities were confronted (around 1960) with the sudden increase in the number of applicants for admission to college. As a result, the greatest difficulties of many graduate schools stem from their present excess capacity (Georgescu-Roegen, 1975).

[3] If one were willing to pay more attention to facts than to mathematico-imaginative endeavours, one could see from the press wires that this case is sufficiently frequent. For example, Bulova Watch, which maintained three plants (two in the United States and one in Switzerland), recently closed its New York plant in order to maintain the operation of the Swiss plant at a profitable level (*The New York Times News Service*).

countries and the spectacular development of others, such as Japan. In most cases, the newly created industries adopted the latest techniques and were far more efficient than the old physical plants in the western world, which, without any possibility of being decumulated, eventually had to close down.[1] The situation in the electronic, apparel and shoes industries is common knowledge.[2] World employment suffered a structural displacement because a great amount of hidden unemployment from formerly non-industrial economies was attracted into new industrial activities operating at a lower real wage-rate, in efficiency terms, than those prevailing in the old advanced economies.

IV STRUCTURAL DISEQUILIBRIUM AND ASYMMETRICAL ADAPTATION

We have mentioned so far only what we believe to be the main categories of structural change in the super-industrial era. Even a more extensive study probably could not exhaust all causes. For, as Schumpeter (1939, p. 11) observed, 'it is obvious that the external factors of economic change are so numerous and important, that if we beheld a complete list of them we might be set wondering whether there is anything left in business fluctuations to be accounted for in other ways'. But, also with him, we believe that innovations are the main causes of disequilibrium, whether on the labour market or on other markets. Great novelties have emerged in the economic world since Schumpeter's time, and they are responsible for the change in the western world from wide fluctuations in unemployment to persistent unemployment.

Thus, in a mobile, perpetually changing economy, consumer habits and the industrial pattern alter continuously. Change may be external to the partial system on which one is reasoning, but it is inherent in economic evolution itself: e.g. change of tastes and behaviour, new technologies and new products, and changes in social conventions. These continual structural shocks require that microdecisions be adapted constantly and assure the permanence of market disequilibrium. Certain factors provide the basis for the permanent existence of market disequilibria. They explain why prices and quantities do not have and cannot have an infinite speed of reaction. This is precisely why the adaptive process of the various economic agents becomes lasting and produces redistributive effects (we shall call the dispersion of partial disequilibria around their macroeconomic average 'structural

[1] What to do with obsolete plants is a far more important economic problem than it appears from this angle. Take an absolute economic planner. What ought he to do if one day he finds on his desk a blueprint that renders obsolete, say, all existing steel plants, which still have a useful life of some thirty or forty years?

[2] To cite an example for this phenomenon, too: some 700 workers lost their jobs when one Genesco plant in Huntsville, Alabama, closed because of 'outdated facilities and competition from imports' (UPI wire).

disequilibrium'). The first of these factors is the high level of uncertainty in the present world, in which something novel is likely to occur almost every day. The second is the great difficulty, almost impossibility, of knowing what is actually happening in a world which, because of structural novelties, has reached a crushing complexity, and which, in addition, often changes before information reaches the inquiring individual.[1] The third is the friction exercised on the adaptations by several institutional rules which have come into being on the basis of the idea that some price rigidities would help prevent disequilibria associated with novelties.

But if the adaptations of the economic agents were symmetric, structural disequilibrium would not have macroeconomic effects. Now, asymmetry characterises nearly all movements in the economic space, and yet is usually eluded in theoretical representations or reduced to the status of an epiphenomenon. It is, however, the manifestation of a constraint essential for the understanding of economic and social phenomena, i.e. irreversibility. The manifestations of asymmetry are numerous – precisely because they represent the local application of a more general principle – and reflect objective or subjective constraints, but none of them is irrational (Fitoussi, 1979). Asymmetry is in particular the medium through which structural disequilibrium produces its consequences in terms of unemployment and inflation.

The first asymmetry we shall speak of has been evoked in the preceding section. It concerns the pair accumulation-decumulation. For a basic asymmetry governs the domain of material production: while a stock of natural resources can be decumulated as fast as one wishes, this is not true of the stock of industrial equipment. Each kind of equipment has its specific decumulation time. These specific times retard structural changes. It follows that the differential evolution of various sectors, induced by structural disequilibrium, will clash with a countervailing trend; the result of this clash will probably be a worsening of unemployment, since it is reflected in a loss of capital, i.e. abrupt disinvestment. Thus, the delay imposed by decumulatio on structural changes is generated by the relative inertia of industrial structures. If one adds to the problem of the physical stability of industrial structures that of the tendency toward stability of organisations, this delay becomes multidimensional. The plasticity of structures thus comes up against an objective obstacle – the internal decumulation delay – and an institutiona obstacle. For the structural pattern of an economy itself produces the institutions responsible for maintaining it, i.e. stabilisation policy, development of the public sector, concerted practices and coalitions, pressure groups etc.

[1] We do not deal with the issue of information because some substantial work has already done (e.g. Phelps *et al.*) so that the imperfection of informa provides a theoretical basis for the imperfect flexibility of prices is demonstra e.g. by Gordon and Hynes (1970).

But asymmetry not only affects the pair accumulation-decumulation, but by way of corollary is reflected in the behaviour of the managers of existing plant. In spite of the fact that for the reasons shown in this paper we maintain that price rigidity is not the cause of persistent unemployment, we do not intend to deny that in the western world some prices are sticky. There are, above all, the institutions that in western countries regulate salaries and wages. Nor do we intend to deny that price rigidity increases the friction of adaptations, that is, it aggravates the duration of the unemployment generated by innovations. A series of substantial papers have concentrated on the relation between price rigidity – especially, of wage-rate rigidity – and unemployment.[1] Some of them are based on a fully choice-theory approach. There is no longer any need, therefore, to invoke the hypothesis of an institutionally determined wage, or monetary illusion, to justify imperfect regulation by the price system.

Hence, the second application of the general asymmetry principle concerns the domain of prices and quantities. Pure adjustment by prices and pure adjustment by quantities delimit a spectrum within which all combinations are possible. In this continuum we hypothesise that the adaptations gravitate closer to prices with regard to upward adjustments, closer to quantities with regard to downward adjustments. These two types of adjustment are in any event simultaneous, since the asymmetry of price movements has for corollary an asymmetry in the opposite direction of movements of quantities. This result may be derived in a number of ways. For example, Galli (1978) argued, on the basis of the existence of production adjustment costs, that the movement of prices relative to that of quantities is greater in the case of an increase in demand than in the case of a decrease. Dieffenbach (1977) derived the same result in combining the Marshallian dynamic with the voluntary exchange hypothesis. The argument implies that one assumes that the elasticity of supply is much greater than the elasticity of demand.

We incline towards another explanation, which is that the asymmetry reflects rather the behaviour of economic agents under the conditions of continuous uncertainty that now prevail in western countries. Between the two possible modes of adaptation to an increased demand – increased prices or increased quantities – a manager will naturally reject that which represents a course difficult to reverse – which is to increase the present capacity or, if

[1] Two kinds of approach provide a theoretical basis for this rigidity. The first starts from the Keynesian hypothesis that wage-earners resist a fall in their relative wages and introduce into the utility functions the set of relative wages (e.g. Trevithick, 1976; Annable, 1977). The hypothesis has also been amended to take into account 'the real wage rate resistance' (Hicks, 1974). The second (Azariadis, 1975; Bally, 1974; Gordon 1976) base the relative rigidity of wages on the existence of implicit contracts between employers and employees whereby real wages remain stable in the presence of stochastic fluctuations of demand. But this second approach concludes that unemployment is always voluntary.

this is not fully used, to hire more workers on the basis of the typical conditions of the labour contracts (Fitoussi, 1971, 1974).

That such an asymmetrical behaviour towards the structural changes generated by a novelty necessarily leads to an increase in unemployment is a point which has some roots in Keynes' *General Theory*. But the point may be presented in a framework that is both more general and more precise. We start with the reasonable assumption that for small displacements supply varies proportionally to excess demand. The asymmetry of the managerial behaviour is then translated by the formula

$$\Delta S_i = s_{i,t+1} - s_{i,t} = \lambda_i X_{i,t} \quad i \in [n], \tag{1}$$

where s_i is the supply of commodity G_i, X_i is the excess demand and

$$\lambda_i = k_i + h_i \Delta_i,\ k_i, h_i > 0, \text{ with} \tag{2}$$

$$\Delta_i = 1 \text{ if } X_i < 0,\ \Delta_i = 0 \text{ if } X_i > 0. \tag{3}$$

These conditions imply that when price changes, entrepreneurs will not fully adapt to their short-run supply curve, SS^1, because they are not certain about the durability of the change. Instead, they follow a course of adaptation under uncertainty, Ea′ if prices increase, and Ea if they decrease. It follows that there is a kink at point E (Figure 8.1).

Hence if p_i is the price of G_i and if we put $Y_i = p_i X_i$ and introduce the notation $F^* = -F$ whenever $F < 0$, then

$$S = \Sigma pi \Delta s_i = \sum_1^n k_i Y_i - \Sigma h_j Y_j^*, \tag{4}$$

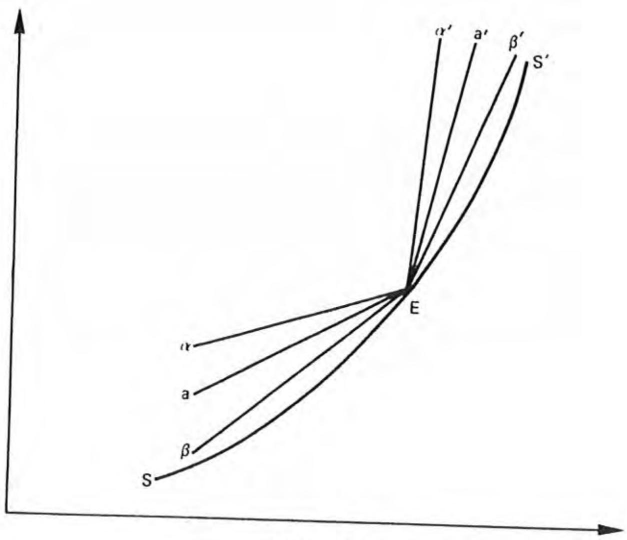

Fig. 8.1

where the last sum extends only over the negative excess demands. This relation shows that the aggregate supply is subject to an influence that can be decomposed into two main components: one related to the aggregate excess demand and one related to the aggregate negative excess demand (Fitoussi, 1971). The implications of this result are highly relevant. Let k and h be the arithmetic means of $[k_i]$ and $[h_j]$, respectively, and let

$$k_i = k + a_i,\ h_j = h + b_j \tag{5}$$

Relation (4) may be written

$$S = k \sum_1^n Y_i - h\Sigma Y_j^* + \sum_1^n a_i Y_i - \Sigma b_j Y_j^*. \tag{6}$$

Further

$$T = \sum_1^n a_i Y_i - \Sigma b_j Y_j^* = \Sigma a_p Y_p - \Sigma a_q^* Y_q - \Sigma (a_r + b_r) Y_r^* + \Sigma (a_s + b_s)^* Y_s^* \tag{7}$$

and if a = Max $[a_i]$, b = Max $[b_j]$, the last relation becomes

$$T = \alpha[a\Sigma Y_p + (a+b)\Sigma Y_s^*] - \beta[a\Sigma Y_q + (a+b)\Sigma Y_r^*], \tag{7a}$$

for some values $\alpha, \beta > 0, \alpha + \beta = 1$,

Now, if a and b are of the second order of importance with respect to k and h – which is a reasonable supposition – the last two terms of relation (6) may be neglected. Hence

$$S \simeq k \sum_1^n Y_i - h\Sigma Y_j^*, \tag{7b}$$

which proves that, if the aggregate excess demand is null, supply decreases approximately in proportion to the aggregate negative excess demand. Relation (7) always leads to (7b) if – as portrayed in Figure 8.1 – the cone $\alpha' E \beta'$ representing all possible Ea′ lines has no common element with $\alpha E \beta$, the cone containing all possible Ea lines.

More generally, relation (7b) signifies that the variations of production undergo a twofold effect: a macroeffect operating in the usual direction, and a structural effect – the effect of the dispersion of microeconomic disequilibria – which generates a slowing down of the growth of output. In any case, an aggravation of the structural disequilibrium is likely to be followed by a decrease of the rate of growth (if the economy has been growing aggregatively). The same relation also proves that an explanation which pays attention only to aggregate equilibrium cannot bring to light important phenomena due to structural changes, i.e. to structural disequilibria.[1]

If we consider this result together with the asymmetrical reaction of wages and prices, the result is that any aggravation of the structural disequilibrium causes an increase both in the level of unemployment and in the inflation rate. We have in this an explanation for the curious and troublesome situation of inflation accompanied by an intolerable level of unemployment (Fitoussi, 1971).[2]

V SUMMARY AND CONCLUSIONS

In this paper we defend the thesis that the cause of economic disequilibria, and hence of the phenomenon of unemployment, is the novelties that punctuate the evolution of the economic process. This is Schumpeter's theory of economic development. But we amended his theory by arguing that in the period following the Second World War some fateful novelties have changed the picture to which he referred. These are, particularly, the momentous innovations of R & D, and the communication established between the labour markets of western nations and those of the developing countries. Novelties that impose structural changes are produced from within the economic process itself. A steady flow of inventions is now produced by R & D and immediately converted into actual innovations. There is no time, therefore, for adaptations to soften the disequilibrium caused by one novelty before the next novelty comes on the scene. Hence the resilient persistence of disequilibrium, and implicitly, of unemployment. The second fateful innovation falls in line with Schumpeter's theory. We need only add that since development of the formerly undeveloped nations is a continuous process, its repercussions on the labour markets of the western nations are also a persistent phenomenon.

Our analysis therefore establishes unemployment as a structural phenomenon. The principle of the explanation is as follows: if it is true that any evolution of effective demand is accompanied or produced by a modification of its structure, transfers between markets and between sectors will characterise economic evolution. There is thus constant pressure towards the modification of production structures which generates the simultaneity

[1] Needless to add, in the case of complete Walrasian equilibrium all $X_i = 0$; hence (1) becomes idle. But that formula is not intended for analysing Walrasian equilibrium.

[2] The argument has also been developed by Archibald (1970) and Tobin (1972), but the main objective was to explain the price co-ordinate and the equilibrium component of unemployment. For Archibald, e.g., the problem was to explain short-run movements around the Phillips curve. Our model, however, explains why one may have a simultaneous aggravation of inflation and unemployment.

of the isolated processes of accumulation and decumulation. It is then easy to understand that structural disequilibrium – i.e. the differential evolution of the structures of demand and production – produces unemployment because of the impossible mobility of installed capital and the asymmetry of movements in prices and quantities. Because structural disequilibrium and macroeconomic disequilibrium are linked, the structural/conjunctural dichotomy loses its relevance.

In the main text as well as in the Appendix we take a position against those disequilibrium theories that explain the existence of unemployment today by the fact that there was unemployment the day before and that base their analytical models on the assumption of price rigidity. However, there can be no valid explanation of one phenomenon if we just begin and end with that phenomenon or if we explain its existence today by its existence yesterday. For, as Schumpeter was often heard to protest against the purely monetarist theories of business cycles (which, to recall, argue that one prosperity grows out of the previous depression), such theories boil down to the notion that the cause of business cycles was the overproduction of apples in the Garden of Eden.

To explain a phenomenon, we must reduce it to a proximate cause, to something more general and also more elemental. This does not mean that all phenomena can be so reduced. Many are brute fact. Indeed, a theory is intellectually satisfying only when it rests entirely on brute facts. The inquisitive activity of the human mind, which is responsible for the inventions of all sorts which influence the economic process, is not a brute fact, but can be regarded as a valid proximate cause of innovations.

The great physiologist, Claude Bernard, set up a very interesting rule for deciding whether an explanation or a statement suggesting a relation between two phenomena is sound. The rule is that each valid explanation requires not only some proof but also a counterproof. Following this stringent rule, we would like to mention the counterproof of our thesis. Before the Industrial Revolution paved the way for the capitalist system, in no part of the world did unemployment of the sort prevalent under that system exist. And it did not exist simply because inventions occurred extremely rarely, and even when they occurred they did not always attract the interest of producers. Those societies were served by a practically invariable technology. Basically, they were in a non-evolutionary state.[1] That is why they had no involuntary unemployment.

[1] During the Middle Ages, for example, the overwhelming majority of people spent their budgets in a practically invariant pattern. That explains why economists then were unable to arrive at the notions of demand and supply schedules (Georgescu-Roegen, 1967).

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Appendix: An Examination of the Analytical Foundation of Disequilibrium Theories

Jean-Paul Fitoussi and Nicholas Georgescu-Roegen

1. The necessity of analytical similies and the usefulness of specific models

As we noted in the main part of the paper, the use of an arithmomorphic simile to verify an *already developed* dialectical reasoning is a necessary step in economic methodology. Some problems, however, are so complicated that they can be represented to some degree of satisfaction only by a highly complex system of the same general nature as Walras' or Pareto's. The inherent mathematical difficulties of such general systems make it extremely difficult to arrive at logically firm answers to the most relevant questions. To verify the claims associated with a general model – or, in its absence, to verify the correctness of the initial dialectical reasoning – only one means seems available: to replace the general simile by a simple, yet completely specific model. Such a step is just as fruitful methodologically as its predecessor – that of using an analytical simile to verify a dialectical reasoning. One of the most important applications of this methodological procedure is Malinvaud's recent monograph on the disequilibrium theories of unemployment (1977).

The problem to which Malinvaud addressed himself is of primary importance for both theory and policy. The old Keynesian idea that some aggregate disequilibrium is responsible for unemployment took a specific form with the work of Patinkin (1956) and subsequently and in broader perspective with that of Clower (1965). Recently, several authors, beginning with Barro and Grossman (1971) have cast this idea into some simplified but unspecified models. Slightly different though these models are, they all tend to explain how a complex system may live with any disequilibrium. Instead of ultimately disappearing if exogenous factors do not intervene – as Walras and, in a more cogent way, Marshall taught – disequilibria may be perpetuated indefinitely. That is why – the new school asserts – chronic unemployment as we have it today exists. The new theory being, in its strictest formulation, a theory of static disequilibrium, it cannot possibly offer any physiological analysis of the market. Its characteristic model offers only a mechanico-descriptive view of that process (Georgescu-Roegen, 1966).

2. Disequilibrium theories: general observations

The main analytical claims of the disequilibrium theories – claims that, in addition to their simplicity, account in large part for the growing popularity of those theories – are two (Malinvaud, 1977, pp. 12f, 78):

P_1. To absolutely every constellation of money-prices $(p_1, p_2, \ldots, p_j)$, there corresponds *one and only one* specific type of disequilibrium. In other words, the type of disequilibrium, DIS, is a point function of the price constellation:

$$\mathrm{DIS} = \mathrm{DIS}\,(p_1, p_2, \ldots, p_j). \tag{1}$$

P_2. For each type of disequilibrium, there exist some rationing procedures that allow the disequilibrium to persist at the given price constellation.

In this paper we propose to show that within the usual framework of disequilibrium theory there are some disturbing exceptions to these claims. However, contrary to what Hildebrandt and Hildebrandt (1977–78) have recently maintained, there is no ambiguity involved in the determination of the disequilibrium patterns, provided the *purely analytical* solutions that have no economic relevance are set aside (as they should be in any model of actuality). But as we shall show, for substantially frequent constellations, the analytical models of economic disequilibrium break down completely. Still more important, rules for rationing if there is shortage may fail to achieve their aim (Section 13).

In view of the fact that, as far as the cause and nature of unemployment are concerned, swords have been crossed over Walrasian versus non-Walrasian economics, we thought it instructive to examine the Walrasian explanation of equilibrium from the same viewpoint adopted by the disequilibrium analysis (Section 9). We have recalled an older result that refutes the current belief in the general existence of a Walrasian equilibrium and hence in the notion that the Walrasian system is applicable to any economic condition. That counter-example reflects the case of 'overpopulation'. This time, we have added still another counter-example, which reflects 'overcapitalisation' and is equally pertinent to chronic unemployment (Section 12).

A special feature of this paper is the fact that we have taken into account the essential difference between labour time and labour power. The distinction – introduced and used only by Karl Marx – is important in many problems, for example, in that of the utilisation of existing physical plants. But for any analysis of employment its importance is paramount. Yet the authors of unemployment models have followed the practice used in the standard theory and have clung to an analytical representation of the production process, that ignores the distinction. We thought the occasion very opportune for exposing this old, deep-rooted fallacy (Section 5), the verdict being that not only the analytical models of unemployment but also the production theory limited to the behaviour of a single firm have still, so it seems, a long and thorny way to go.

Since Malinvaud's re-examination embodies the main ideas developed by the previous contributors, it appeared natural to refer the following analysis to the framework made numerically explicit in his essay.

3. A review of analytical assumptions

The logical way to begin the proposed re-examination of the disequilibrium models is by listing the general assumptions made, explicitly or implicitly, by practically all writers on disequilibrium. For even if one shares the philosophy widely popular among large circles of economists which is that we should not quarrel about axioms, one should none the less be aware of as many as possible that are involved in an argument.

A. *The period for which the market process is described is so short that (i) the size of the population remains constant and so does the size of the labour force, which consists of N individuals; (ii) the tastes of the population are invariable; and (iii) there exists a constant number, P, of production units operating with unchanging technical recipes and constant material scaffolds.*

B. *During the same period only one trading act takes place in each market.* This means that during that period workers are hired only once and they also buy their good only once. The closest correspondence to such a duration in actuality is obviously the day. We may therefore refer hereafter to this period as 'the day.'[1]

C. *The price constellation is an economic element that cannot be affected by the behaviour of the economic agents – consumers, producers, government. Consumers seek to maximise their ophelimities and firms seek to maximise their profits by adjusting the quantities they but or sell to the given price constellation. The government simply spends some given funds at the given prices.* There also are some special assumptions that are usually adopted in order to simplify the demand and supply schedules. Some of these assumptions are made for the sole purpose of obtaining structures amenable to simple algebraic manipulations. Malinvaud was right in adopting this procedure. For as long as one's approach is confined to a mechanical description of a given process, a specific algebraic model is an excellent didactic tool.

D. *In addition to money there are only two commodities: a homogeneous labour and a general consumer good, hereafter called 'commodity'.* The fact that capital is not recognised as a commodity does not mean that capital equipment *per se* does not exist. In a completely integrated process, capital equipment may be maintained constant within each production unit as a part of its normal activity. A capital market, therefore, is not necessary. However, the situation is different for natural resources. Even in a completely integrated process there must exist some material input flows. It is true that during one

[1] Barro and Grossman (1971, p. 84) propose the label 'week'. But this term may be misleading, since it does not convey the strong restriction assumed by the models.

'day' there cannot be any appreciable increase in the scarcity of natural resources. Also, royalties are manmade; nature does not have check-out counters. Yet in an actual market economy royalties are part of cost, side by side with wages. But the authors of the models under discussion have followed the traditional practice of standard economics, which is to ignore this issue.[1] The curious outcome is that, although their authors do not seem aware of the fact, these models represent a pure labour theory of value in a sense not intended perhaps even by Marx.

E. *All individuals and all firms are identical.* In other words, all individuals have the same ophelimity function and all firms operate according to the same technical recipe and possess the same type of physical facilities.

4. A critique of structures: the ophelimity function

The most debatable of all these assumptions is certainly that concerning the price-quantity relationships (assumption C). However, the same assumption raises a different kind of issue, which concerns the analytical structure of both the ophelimity function and the production function.

These two concepts have acquired their present currency only by a repetitive, almost automatic, use. As a result, the issue of whether they are valid analytical representations of the corresponding phenomena has received little attention, and some correlated aspects of those concepts have even received none. As far as analytical representation is concerned, we are to a large extent justified in assuming simple structures – linear, quadratic, etc. – in our specific illustrative models. But it would be a fatal mistake to leave out, whether by neglect or for reasons of simplification, any essential feature of reality.

Let us deal first with the ophelimity function. Unless we assume that the world ends at the end of the day, this function must depend on money. The justification is simple. Not only boiled, baked, fried, etc. potatoes but also raw potatoes must be included in the ophelimity function for they *can be converted into the former at some specific rates.* That is, raw potatoes have an 'indirect' utility. Similarly, money has an indirect utility because it can be converted into direct utilities at some specific, albeit somewhat uncertain, rates in the future (Hicks, 1939, p. 33). Obviously, this is true for money as well as for raw potatoes only as long as there will be a tomorrow, however uncertain that tomorrow may be.

That is not all. Once we introduce money as a store of value into the ophelimity function, the thorny issue of whether the arguments of that function should be stocks or flows comes up in full force. Indeed, the ophelimity pertaining to a day – which is assumed not to be the last one –

[1] This is usually done by simple silence. Malinvaud (1977, p. 33) seems to be an exception, as he justifies the omission by explaining that a three-commodity model cannot have room for natural resources as well.

must be a function of *all flows consumed during that day as well as of all stocks existing at the end of the day.* 'Consumed' is used here in the strictest sense. Accordingly, one cannot consume money. One can only exchange it against goods, which may be consumed or held as stocks. The important point that not all flows come from or go into a stock is established in economics by leisure.

The ophelimity function must therefore have the form

$$U = U(x, l; s, m), \tag{2}$$

where x is the flow of the commodity consumed during the day; s is the corresponding stock at the end of the day; $l = B - L$ is leisure (with L being the work time performed and B the biosociological maximum of working hours that can be performed during the day); and m is the amount of money at the end of the day.[1] The price of the commodity and the wage rate being p and w respectively, the budget of the individual is

$$I = ps_0 + wB + m_0 = p(x + s) + wl + m, \tag{3}$$

where the subscript zero indicates *stocks* at the beginning of the day.[2] Hence, its optimal distribution is determined by the additional, but not too familiar equation

$$\frac{U_x}{p} = \frac{U_l}{w} = \frac{U_s}{p} = U_m. \tag{4}$$

This argument shows that by using for the ophelimity function the simple formula

$$U = 2 \log x + \log (B\text{-}L) + \log m, \tag{5}$$

one implicitly assumes that the individual has no initial stock of the commodity and consumes all that he buys during the same day.[3] Explicitly

F. *Households do not stock the commodity.* If we also assume (which by now seems quite natural) that 'in the morning' the identical individuals have

[1] Most authors make the ophelimity function depend on 'real money', i.e. on m deflated by the price of a physical unit of the commodity. However, if one takes this price as money unit – as Barro and Grossman (1971, p. 84) do – then the deflation of m is only a necessary transformation, not a structural aspect of the ophelimity function. See also the following footnote.

[2] To our knowledge, only Bushaw and Clower (1957) have considered a utility function that depends on both flows and stocks. But they assumed that both consumption and trading go on continuously, an assumption that compelled them to introduce an additional relation between flows and stocks different from the natural one, which is so clearly shown by a discrete framework (such as that assumed here).

[3] With this form of the ophelimity function – used by, among others, Malinvaud (1977, p. 41) and Benassy (1978, p. 522) – it is immaterial whether we make it depend on m or on m/p, as long as p is assumed constant.

the same amount of liquid money m_0, the supply of working hours, the demand for the commodity, and the final money balance are

$$L = (3Bw - m_0)/4w, x = (Bw + m_0)/2p, m = (Bw + m_0)/4. \quad (6)$$

These formulae, however, are valid on the assumption that there are no constraints to the individual's reaching the maximum of this ophelimity and that

$$m_0 < 3wB. \quad (7)$$

If $m_0 \geqslant 3wB$, the individual is too rich to want to work, in which case the solution of (4) is a corner solution:

$$L' = 0, x' = 2m_0/3p, m' = m_0/3, \quad (8)$$

with $x' \geqslant x$ and $m' \geqslant m$.

5. *A critique of the standard production function: funds, flows and working hours*

The form of the production function used by the models under discussion raises far more complicated issues. In fact, that form involves perhaps the greatest fallacy of standard economic theory. To recall, in 1894 Philip Wicksteed introduced the concept of production function by simply stating that the equation

$$q = F(x, y, z, \ldots) \quad (9)$$

represents the relationship between the product and the factors of production – with the current vapid terminology, between output and inputs. During the almost hundred years elapsed since, economists have made no attempt to see whether Wicksteed's simple formula represents a production process adequately. To recall only the salient points of a previous analysis of this issue, Wicksteed's formula, now the standard one, omits two cardinal aspects of the production process.[1]

The first omission concerns the *essential* difference between fund and flow factors, that is, between the agents of the process (labour power, capital equipment and Ricardian land) and the materials transformed by them.

[1] Georgescu-Roegen (1976, chs. 2, 4, 5). Endeavours have been made to specify at least the dimensionality of the symbols in (9), some writers arguing that the symbols must represent quantities, others, that the symbols must represent flow rates with respect to time. The two views still circulate as two completely equivalent descriptions of one and the same phenomenon. Yet they would be equivalent only if all production processes were indifferent to size – an idea that cannot possible be accepted.

Because of this distinction, the analytical representation of any such process requires at least two relationships:

$$q = \Psi(H, K, T), \tag{10}$$

$$q = \Psi(x, y, z, \ldots, v), \tag{11}$$

where H, K, T represents (generically) the amounts of labour power, capital and Ricardian land, and q; x, y, z, . . . ; and v represent the flow rates of the product, of the ordinary inputs, and of waste.

The second element omitted by the standard theory is the duration of the process, specifically, the number of hours, $t \leqslant 1$, the process is in operation every day (the day being taken as the unit of time). It is important to note that this duration should not be confused with the working hours of one shift; t may cover several shifts and also include overtime. Since the *daily* production is $Q = tq$, (10) and (11) become

$$Q = t\Psi(H, K, T), \tag{12}$$

$$Q = \Psi(tx, ty, \ldots, tv). \tag{13}$$

This representation brings to light several important problems. One is the idleness of capital in development planning; another concerns the structure of the cost of production. But the new representation reveals the elementary fact that, if $t < 1$, the daily output can be increased without necessarily increasing the agents, not even the labour power.

Instead of using (12) and (13), the usual models of market disequilibrium are based on some highly simplified form of the standard production function

$$Q = F(Z), \tag{14}$$

where $Z = tH$ is *the amount of labour services*. There seems to be no exception to this practice.[1] Take the particular form used by Malinvaud (1977, pp. 51, 63), which with our notations is

$$Q = (\sqrt{1 + 2aZ} - 1)/a. \tag{15}$$

If the representation of a reproducible production process by (14) is to comply with the truth that *doubling the working time of any given set of factors doubles the output*, F must reduce to $Q = AtH$, where A is a constant determined by the existing material funds. However, in the analytical models

[1] See Patinkin (1956, p. 128); Barro and Grossman (1971, p. 85; 1976, p. 11); Korliras (1978, p. 480); Benassy (1978, p. 522); and Negishi (1978, p. 504), although this author simply speaks of 'labor'. Some authors – e.g., Negishi (1972) – do not even allow us to know whether they have in mind labour power, H, or labour services, since their argument is carried out in abstract symbols of 'labour inputs'.

of disequilibrium the usual assumption is that decreasing marginal returns prevail for all scales;[1] hence for any Z

$$F''(Z) < 0. \tag{16}$$

Occasionally, one hears the argument that if the output were not a function of labour services we could not account for the fact that managers may substitute between working hours and labour power. But the idea is a superficial interpretation of facts (as we shall see presently in some detail), and is related with the practice of using 'employment' to mean labour services. A salient illustration is offered by Keynes himself: in one place he defines 'the quantity of employment' as the ratio between the total wage bill and the wage rate of 'ordinary labour' (1936, p. 41). The dimension of the co-ordinate thus defined is that of labour *services*, man-hours, not of labour *power*, which is measured in men.[2]

6. *Further remarks about the production function*

For any given production unit – with K^0 and T^0 given – the *scale* of operation is determined only by the size of the labour force employed, H. The daily output is then proportional to the operating day of the production unit,

$$Q = t\Psi(H, K^0, T^0) = tf(H) \tag{17}$$

From all we know, the curve represented by this function of H is S-shaped. For t = 1 (a full working day) the curve is represented by $OQ^iQ^mQ^*$ in Figure 8.A1.[3] There is an inflexion point H^i such that $f''(H^i) = 0$ and

$$f''(H) > 0 \text{ for } 0 < H < H^i, f''(H) < 0 \text{ for } H^i < H < H^*, \tag{18}$$

where H^* corresponds to the maximum scale of operations

$$Q^* = f(H^*), \tag{19}$$

with

$$f'(H) = 0, \text{ for } H \geqslant H^*. \tag{20}$$

[1] This practice is, again, general: Barro and Grossman (1971, p. 85; 1976, p. 11); Korliras (1978, p. 480), Negishi (1978, p. 504); Benassy (1978, p. 522). Malinvaud's formula obviously satisfies (16).

[2] A most curious fact, which apparently has not aroused attention: the basis of Keynes reasoning on this matter is purely dialectical, essentially identical to that by which Karl Marx argues that any concrete labour represents some general, abstract labour.

[3] There is no danger in using from now on the same letter to denote both the amount of a co-ordinate and the corresponding point in a diagram, and the diction will be greatly simplified thereby.

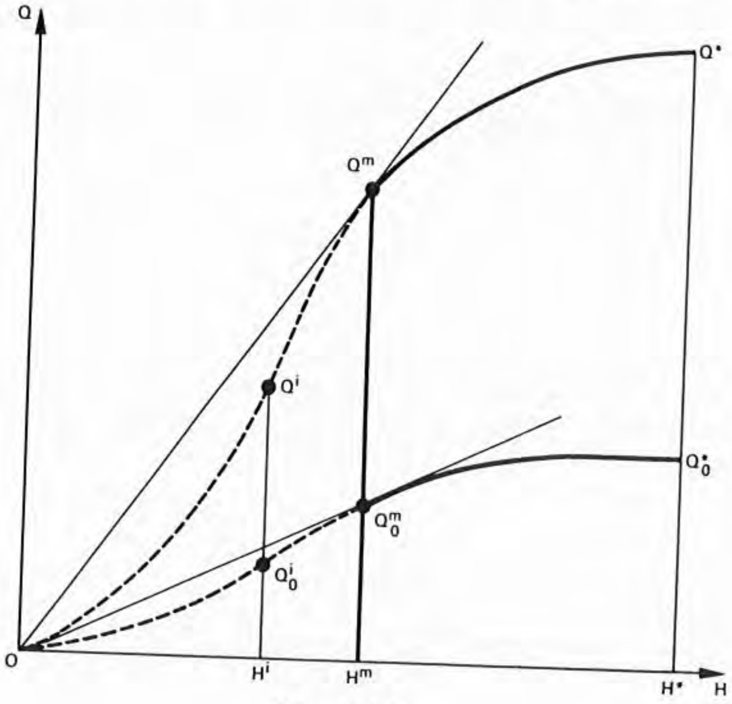


Fig. 8.A1

There is also an optimum scale of operation H^m for which f(H)/H is a maximum. For analytical convenience, we shall also assume (as is ordinarily done) that the third derivative $f'''(H)$ exists.

As an instructive illustration, we shall occasionally use

$$f(H) = -H^3 + 6H^2 + 3a\,(a + 4)H,\ 0 \leqslant a, \tag{21}$$

which yields

$$H^i = 2,\ H^m = 3,\ H^* = 4 + a. \tag{22}$$

Before proceeding to examine the problems raised by the shape of f(H), let us point out still another incongruity of the standard literature, where the production function is frequently represented by

$$Q = F(Z, K), \tag{23}$$

even in works dealing with crucial problems (e.g. Patinkin, 1956, p. 128; Solow, 1957, p. 313; Barro and Grossman, 1976, pp. 105 and 107). The incongruity becomes obvious if we note that Q and Z, in contrast with K, involve the time dimension. In fact, whenever labour cost is equated with the product of the wage rate by the amount of 'employment', alternatively, by 'labour', there is a confusion between the amount of a fund factor and the amount of its services.

7. The case of several labour shifts

In continuation our analysis must consider the case of several shifts. There are two situations to be distinguished.

The first is that when working hours of a shift, $t_0 \leqslant B$, are exogenously determined. In this case, the daily output of a shift is $Q = t_0 f(H)$, and is represented in Figure 8.A1 by the curve $0Q_0^iQ_0^mQ_0^*$, whose ordinates are in the ratio t_0 to those of $0Q^iQ^mQ^*$. However, the production unit may work with any number, n, of shifts, such that $nt_0 < 1$. The possible combinations are

$$Q = t_0 f(H_1) = 2t_0 f(H_2) = \ldots = nt_0 f(H_n), \tag{24}$$

where H_k is the size of the shift for k shifts. The problem is to find which k maximises the average return, Q/kH_k, alternatively $f(H_k)/H_k$, for a given Q, $0 < Q < nt_0 f(H^*)$. Obviously, $H_1 > H_2 > \ldots > H_n$. On the other hand, for an S-shaped production function, $f(H)/H$ increases in the interval $[0, H^m)$ and decreases in the interval $(H^m, H^*]$. Hence, for any $Q < t_0 Q^m$, the solution is $k = 1$. The second shift will be introduced only after H_1 reaches the level H' determined by the condition

$$f(H') = 2f(H'/2). \tag{25}$$

This equation admits a solution $H' < H$ if and only if

$$2F^*(H/2) > Q^*. \tag{26}$$

Alternatively, if the *second* solution ${}^1H$ of

$$Q/H = Q^*/H^*, \tag{27}$$

which always exists, satisfies the condition,

$${}^1H < H^*/2. \tag{28}$$

Otherwise, the second shift will be introduced only after H_1 reaches the maximum level, H^*.[1]

To clarify this point, let us now take the working hours of a shift as the unit of time and denote by δ the new measure of the day. Let us also assume that (21) represents the daily output of a shift. The solution of (25) is $H' = 4$. Hence, for $0 < Q < Q' = 12a^2 + 48a + 32$, one shift provides the optimum solution, a result that is represented only by the section $0Q'$ of the production curve $0Q^*$ (Figure 8.A2). A change occurs at $Q = Q'$, when a second shift may be introduced. The third shift will be introduced only after the size of the

[1] It may be well to remember that not all scales of a production function are necessarily used in business practice. Thus, even if (26) is not satisfied, the production unit will pass from one shift to two shifts without first using H^*.

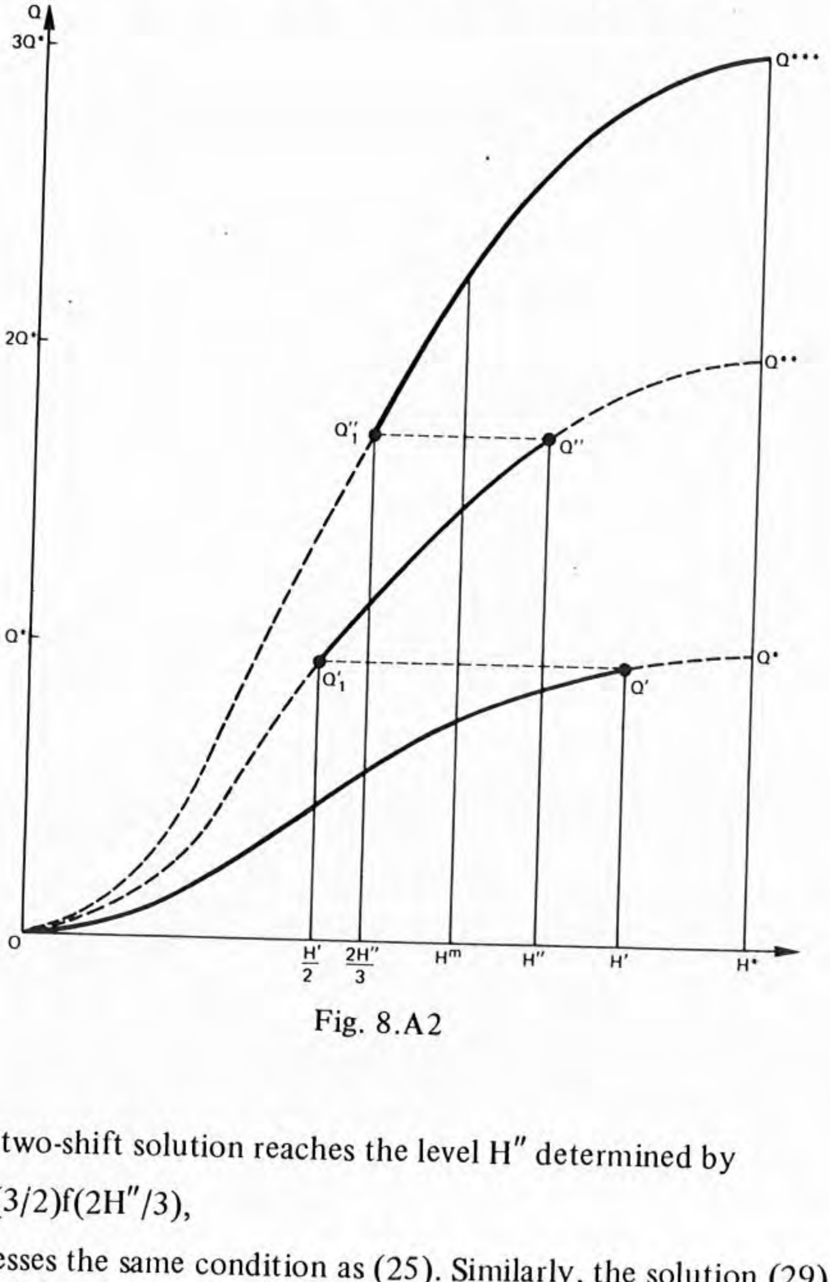


Fig. 8.A2

shift in the two-shift solution reaches the level H'' determined by

$$f(H'') = (3/2)f(2H''/3), \tag{29}$$

which expresses the same condition as (25). Similarly, the solution (29) exists if and only if the second solution ${}^2H$ of

$$f(H)/H = Q^*/H^* \tag{30}$$

satisfies

$${}^2H < 2H^*/3 \tag{31}$$

In the case of our numerical illustration, we have $H'' = 18/5$ with $Q'' = 2F(H'') = 21.6a^2 + 86.4a + 62.2$. After Q exceeds Q'' the optimum operation requires three shifts.

We may continue in the same way for another and another shift. However, for the object lesson of our illustration it is not necessary to go further. We may thus assume that $3 < \delta < 4$, so that no more than three shifts should be possible. Graphically, the relationship between the daily output and the labour services, Ƶ = kH_k, is represented by a curious curve made of the three broken segments 0Q′, Q_1'Q″, and Q_1'', Q***. A more convenient way to represent the same relation is shown in Figure 8.A3, where the curves 0Ƶ*, 0Ƶ**, 0Ƶ*** are the inverse functions of 0Q*, 0Q**, 0Q*** of Figure 8.A2. The segments 0Ƶ′, Ƶ′Ƶ″, Ƶ″Ƶ*** correspond to the thick segments of the other diagram. Let Ƶ (Q) be the inverse function of f(Ƶ) = Q. Then,

$$
\begin{aligned}
&Ƶ = Ƶ(Q) \quad \text{for } 0 < Q < Q' \\
&Ƶ = 2Ƶ(Q/2) \text{ for } Q' < Q < Q'' \qquad (32)\\
&Ƶ = 3Ƶ(Q/3) \text{ for } Q'' < Q < 3Q^*.
\end{aligned}
$$

A few observations are now in order. First, it would be wrong to think that the diagram of Figure 8.A3, because it shows that the daily output is a function of labour services, Ƶ, justifies formula (14). We have chosen a different notation, Ƶ instead of Z, precisely to emphasise that Ƶ is not the same concept as Z. The latter does not distinguish between 8 men working 1 hour, 1 man working 8 hours, 4 men working 2 hours, etc. In other words, Z is not associated with a definite length of the working day whereas Ƶ is. If,

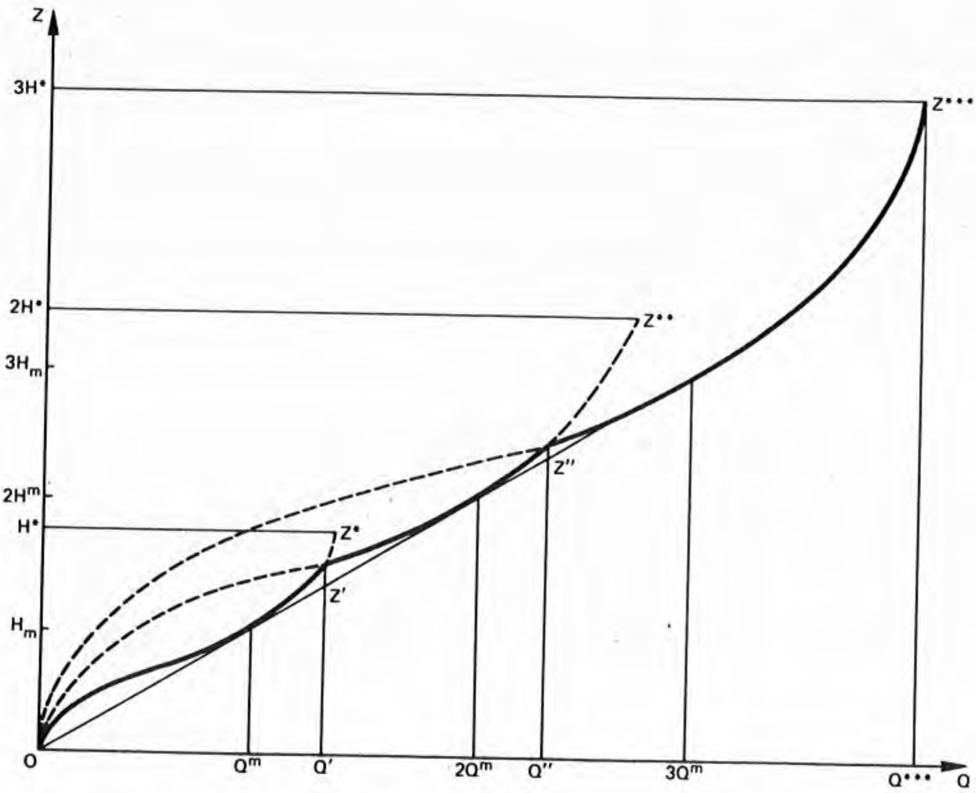


Fig. 8.A3

for example, $Z' < Z < Z''$, the working day is twice the working time of one shift.

Second, as one should have expected, the optimum average return is the same for any number of shifts. In actuality, however, there is a new complication. A regimen of several shifts involves some additional costs. Hence, when the diagram of Figure 8.A3 is used to represent the total cost, some discontinuous jumps must separate the three segments at the points corresponding to Q' and Q''. The optimum average return is therefore not the same for all shift regimens.

We may now consider the case in which the working hours of a shift may vary freely up to a maximum, t_0. A given output Q, $Q < Q_0^* = t_0 Q^*$, of a single shift may be obtained in an infinite number of ways by variation of the working hours and the labour power employed. The optimal combination is that which will minimise the variable cost. But since in the case under consideration labour is the only *variable* factor, for the optimal solution we have to minimise only the input of labour services, tH, *without any regard for the level of the wage rate.*[1]

For the labour services, we have

$$s = th(Q/t), \tag{33}$$

where h is the inverse of f. The minimum of s involves the sign of

$$ds/dt = h(Q/t) - h'(Q/t)Q/t. \tag{34}$$

On any interval of free variation of the argument Q/t, this familiar expression changes its sign from negative to positive for $Q/t = Q^m$, provided this value is compatible with the constraints of the problem. But $Q/Q^* \leqslant t \leqslant t_0$, hence that solution is acceptable if and only if $Q < t_0 Q^m = Q_0^m$. In this case, the optimal solution consists of the optimal scale, H^m, used during

$$t = Q/Q^m. \tag{34}$$

If $Q > Q_0^m$, ds/dt is negative over the entire interval of variation of t; hence the minimum of s corresponds to using $H = h(Q)$ for the maximum number of working hours, t_0.

The optimal solution as Q varies from 0 to Q_0^* is represented by the kinked line $H^m Q_0^m Q_0^*$ (Figure 8.A1), again a quite unorthodox result.[2]

However, since the unit may now choose the working hours of a shift, it does not necessarily have to move into decreasing returns even if $Q > Q_0^m$. If

[1] The variable cost of any given output must always be minimum. In the case of more than two variable factors the condition leads to the scale line whose equation involves the price ratios of all these factors. Naturally, in that case the optimum solution depends on prices (Georgescu-Roegen, 1976, ch. 2).

[2] Obviously, if $Q > Q_0^*$, no solution exists with a single shift. And if $Q > Q^*$, an additional plant is needed.

$Q \leqslant Q^m$, the unit may use enough optimal shifts, H^m, of $t \leqslant t_0$, so that the daily output be Q. Only if $Q^m < Q \leqslant Q^*$ must the unit operate in the region of decreasing returns. The final result is that, if the working hours of a shift are not pre-determined, the relation between the daily output and the labour services (properly determined) is represented by $H^m Q^m Q^*$ (Figure 8.A1). By inversion, we obtain a representation analagous to that of Figure 8.A3, which is

$$Z = (H^m/Q^m)Q, \text{ for } 0 \leqslant Q \leqslant Q^m, \qquad (36)$$
$$Z = h(Q), \qquad \text{for } Q^m \leqslant Q \leqslant Q^*.$$

Here again we must note that Z is not just a number of man-hours. For the first interval, the size of the labour power employed is given, H^m; for the second interval, the working day is given, $t = 1$. An even more important observation is that for the first interval the number of shifts is indeterminate; hence we cannot say how many members of the community are actually employed. Even if $Q < t_0 Q^m$, the unit may employ any number of shifts. The upshot is that even though relation (36) is much simpler than that obtained for the condition in any general model assumed in the preceding section, its use in a general model may lead to greater analytical complexities. The point is that although the wage bill is the same regardless of how many shifts are used to produce $0 < Q^m$, the income distribution and hence the demand for the commodity and the supply of labour do vary with the number of shifts.

8. *The optimal scale of production*

In the preceding sections we have considered the purely technical problem of a production unit called to produce a given daily output with the least cost. One point for the thesis developed in those sections deserves emphasis at this juncture. The optimal solution does not consist in minimising the 'labour input', tH, as such, in which case it would be possible to substitute t for H and *vice versa*. Even when the labour regimen allows the production unit to choose its operating hours freely, for every Q there is only one optimal t (determined by the optimal H). This should also be true when the production unit comes to adjusting its market behaviour optimally.

Turning now to consider this problem, we shall adopt the simplifying assumption – implicit in all standard models, whether of equilibrium or disequilibrium – that only one shift can be used. The question now is what t, $t \leqslant B$, maximises the unit's profit.

For our purpose it is now useful to consider the total cost function

$$T(Q) = T_F + twH = T_F + twh(Q/t), \qquad (37)$$

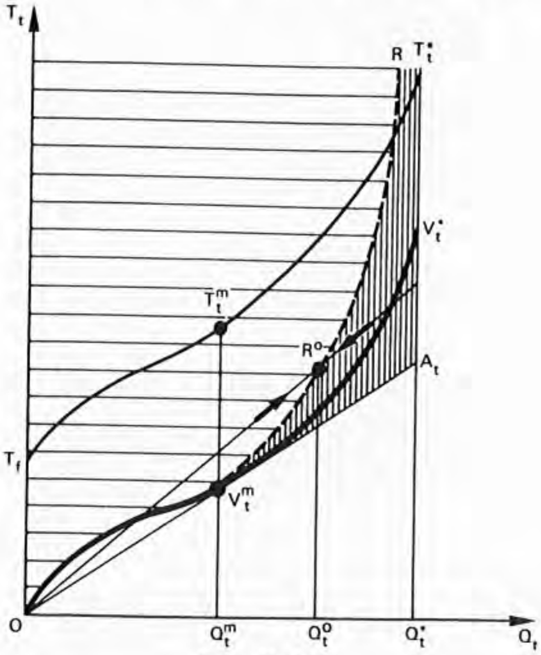


Fig. 8.A4

where T_F is the fixed cost and w is the wage rate.[1] If w is assumed constant, T(Q) is represented by $T_F T_t^*$, and the variable cost, $T_V = twh(Q/t)$, by $0V_t^*$ (Figure 8.A4).[2]

If p is the price of the commodity, the profit is

$$\Pi = t[pf(H) - wH] - T_F. \tag{38}$$

Since Π is a linear function of t and the coefficient of t is always positive (in acceptable conditions), it follows that for whatever H, Π is an increasing function of t. Profit is then maximised when t has the greatest possible value. The conclusion is that the value of t that maximises profit is t = B, provided the production unit can choose it so.[3]

[1] We must not gloss over the fact that the fixed cost represents the earnings of the services of the material agents. Interest is counted even in communist economic systems. The disequilibrium models usually ignore this co-ordinate; e.g. Benassy (1978); Barro and Grossman (1971). In their 1976 volume, Barro and Grossman include the capital fund in the production function, but use a different formula from (37). The omission not only vindicates the point made earlier – that such models reflect a pure labour theory of value – but also does away with the condition in which firms must close down (thus contributing to involuntary unemployment) for the reason that receipts are smaller than the fixed cost.

[2] The inverted S-shape of $0V_t^*$ follows from (18), and from (20) it follows that the marginal cost for Q_t^* is infinite.

[3] The point recalls Karl Marx's objection against the argument of Nassau Senior that profit is earned in the last hour of the working day. Formula (38), however, vindicates Senior.

Analytically, there are two situations worth considering. In the first, the working hours are determined by the workers' utility maximisation; in the second, the working hours are institutionally determined by law.[1] But whatever the actual situation, an important proposition follows from (38):

The optimal employment, H^0, is independent of the number of working hours, t. The only condition H^0 must satisfy is

$$pf'(H^0) = w.^2 \tag{39}$$

The optimal *scale* of operations, Q^0, given by

$$wh'(Q^0) = p, \tag{40}$$

determines the daily output $Q_t^0 = tQ^0$.

Maximum profit does not imply the absence of loss, but if the loss is greater than T_F the production unit must close down in order not to lose more than the unavoidable loss. Because of the shape of $0V_t^*$, it is obvious that the unit must close down if

$$p < V_t^m/Q_t^m. \tag{41}$$

Hence, the *analytical* solutions of (39) and (40)[3] are valid if and only if

$$H^0 \geqslant H^m, \ Q^0 \geqslant Q^m. \tag{42}$$

The case that distinguishes the disequilibrium models is that in which the production unit is rationed. This means that it can sell at most a given $\bar{Q}_t$, such that $\bar{Q}_t < Q_t^0$. For a general picture, let $V_t^m R$ be the locus of the point (Q_t^0, pQ_t^0) representing the receipts for the optimal output as p varies. From (40) it follows that the equation of $V_t^m R$ is

$$R_t(Q_t) = wQ_t h'(Q_t/t), \tag{43}$$

and we shall write $\bar{R}_t = R_t(\bar{Q}_t)$. If $(\bar{Q}, p\bar{Q})$ is in the domain shaded vertically in Figure 8.A4 – $RV_t^m A_t$ with $V_t^m R$ excluded – the unit can increase its profits by producing less, namely, Q_t^0. This is no longer possible if that point is in the closed domain $T_t 0 V_t^m R$, shaded horizontally. To produce less than $\bar{Q}_t$ would decrease the profit available at that output. Finally, if $(\bar{Q}, p\bar{Q})$ is in the domain below $0V_t^m$ and $V_t^m A_t$, the firm must close down.

[1] Malinvaud (1977) is apparently the only author to consider in detail both these situations.

[2] Let us not fail to note that there is only a formal similarity between this relation and the ultra familiar one of the standard theory. The latter, when it is not written in an incongruous form, is $pF'(Z) = w$. Cf. Malinvaud (1977, p. 52).

[3] By *analytical* solutions we mean those solutions that may satisfy an equation without complying with the restrictions of the model involved.

The optimal output of the unit is

$$Q_t = \bar{Q}_t, \text{ if } pQ_t \geqslant \max[\bar{V}_t, \bar{R}_t], \tag{44}$$

$$Q_t = Q_t^0, \text{ if } \bar{Q}_t > Q_t^m \text{ and } \bar{V}_t \leqslant p\bar{Q}_t \leqslant \bar{R}_t, \tag{45}$$

$$Q_t = 0, \quad \text{if } (\bar{Q}_t < Q_t^m \text{ and } p\bar{Q}_t < \bar{V}_t) \text{ or } (\bar{Q}_t \geqslant Q_t^m \text{ and } pQ_t^m < V_t^m). \tag{46}$$

For the particular production function (21), we have:

$$Q_t^m = (9a^2 + 36a + 27)t, \; V_t^m = 3wt. \tag{47}$$

9. A map of Walrasian disequilibria

A few object lessons can be derived by applying the preceding results first to the Walrasian equilibrium. To this purpose, we shall use the simple diagram devised by Edgeworth and subsequently adopted by Hicks for the analysis of multimarket equilibrium.[1] For the system that involves only labour and a general commodity, we may consider the value of the wage rate, $w = \alpha(p)$, that would clear the labour market when the participants act on the knowledge that the commodity price is some given p. As we shall see presently, the function $w = \alpha(p)$ is always linear. Hence, if S_L and D_L are the Walrasian supply of and demand for labour, respectively, the locus of the pairs for which the excess supply of labour $\Sigma_L = S_L - D_L$ is null, is represented by the straight line 0b (Figure 8.A5). This line divides the plane into two domains; above 0b, $\Sigma_L > 0$; below 0b, $\Sigma_L < 0$.

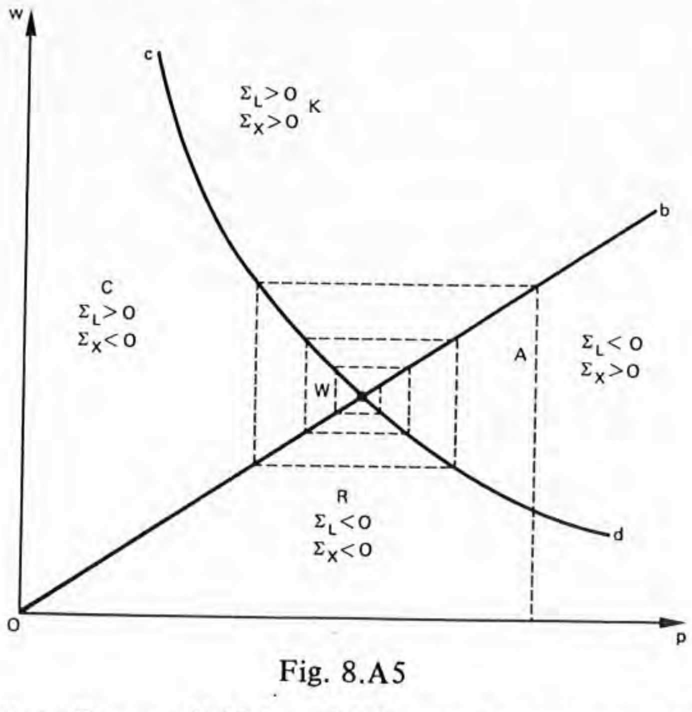


Fig. 8.A5

[1] Cf. Georgescu-Roegen (1976, p. 365). Some diagrams used by Malinvaud (1977, Sec. III) and Benassy (1978) are Edgeworth's diagrams.

Similarly, we can define a function $p = \beta(w)$, along which the excess supply of the commodity, $\Sigma_X = S_X - D_X$, is null. The curve cd, represented by this function, also divides the plane into two domains; $p > \beta(w)$ where $\Sigma_X > 0$, and $p < \beta(w)$ where $\Sigma_X < 0$.

A priori, we may expect that the plane (p, w) should thus be divided into four distinct domains (as shown in Figure 8.A5), each one associated with a particular type of initial disequilibrium:

(K) Keynesian:	$\Sigma_L > 0, \Sigma_X > 0$
(C) Classical:	$\Sigma_L > 0, \Sigma_X < 0$
(R) Repressed inflation:	$\Sigma_L < 0, \Sigma_X < 0$
(A) Anticlassical:	$\Sigma_L < 0, \Sigma_X > 0$

The terminology is that used by Malinvaud (1977, pp. 30f) with the exception of the last (A), which he discards from the outset as 'uninteresting' (which is not true in general).

The idea of Edgeworth and Hicks is that one can explain the movement of prices toward their Walrasian equilibrium by an algorithm based on Figure 8.A5 instead of by the more controversial *tâtonnement*. Successive adjustments may proceed from one market to another in a cobweb fashion, as shown by the interrupted lines. The algorithm will bring the price constellation nearer and nearer the Walrasian equilibrium, W, represented by the intersection of the two lines, $\Sigma_L = 0$ and $\Sigma_X = 0$, (provided that they intersect and also have a 'nice' shape).

Since all P production units are assumed to be identical, the total daily output is

$$Q = tP\Psi(H/P, K^0, T^0), \tag{48}$$

where H is now the total *number of men* employed. P being constant in the case under consideration, it is harmless but greatly convenient to write this relation in the same form as that used in the preceding sections, i.e. as

$$Q = tf(H). \tag{49}$$

We now come to the crucial consequence of our new analytical representation of a production process, which is that *the Walrasian supply of labour power is completely inelastic*. Certainly, every man wants to be employed for his desired supply of labour time. It is only *this last supply that varies with the price constellation*. Moreover, as we have seen, the demand for labour power also is independent of the supply of working hours. There are two important conclusions.

First, in all circumstances,

$$Q = Lf(H), \tag{50}$$

where L represents the working hours, the individual worker is willing to supply in each particular situation.

Second,

$$\Sigma_L = N - D_L, \tag{51}$$

where D_L is given by (39), i.e. by

$$w = pf'(D_L), \tag{52}$$

provided receipts cover at least the variable cost. This last condition is $f(D_L)/D_L > f'(D_L)$, from which it follows that

$$D_L \geqslant H^m, \tag{53}$$

and hence

$$w \leqslant pf(H^m)/H^m = pf'(H^m). \tag{54}$$

The boundary of this *closed* domain is a straight line denoted by 0i in Figure 8.A6 as well as in our subsequent graphs.

Alternatively, (p, w) may belong to the complement of (54), which is the domain *above* 0i. Then, all firms must close down: $D_L = 0$, which implies $S_X = 0$. Relation (51) becomes $\Sigma_L = N > 0$ (a discontinuity that will prove to be quite relevant for the disequilibrium analysis, Section 10 below). Since in the domain above 0i, also $\Sigma_X < 0$, the initial pattern is classical in all cases.

For the subsequent analysis, the domain of (54) need only be considered. There are three distinct patterns that require separate handling.

(A): $H^m \leqslant N < H^*$. This is the 'normal' case on which standard models, whether of equilibrium or disequilibrium, are based.

Because of (52), $\Sigma_L = N - D_L = 0$ is equivalent to the linear relation

$$w = pf'(N), \tag{55}$$

represented in our graphs by 0b. From (54), it now follows that the slope of 0b is never greater than that of 0i (Figure 8.A6a).

Let L now be the *unrestricted* supply of labour time of the individual and x the *unrestricted* demand of the individual. The Walrasian total supply of the commodity is $S_X = Lf(D_L)$ and the unrestricted total demand $D_X = Nx + G/p$, where G is a fixed amount of money that represents the demand of the 'government' and must be spent entirely at any price p whatsoever. Hence, the commodity market clears if and only if

$$\Sigma_X = Lf(D_L) - Nx - G/p = 0. \tag{56}$$

If the ophelimity function has the form (5), this relation becomes[1]

$$3pEf(D_L) = 2w(NE + 2A), \tag{57}$$

[1] Especially when specific numerical structures are used, one should ascertain the dimensional homogeneity of all relations. In the case of the formulae derived from (21) one should take into account the fact that all the numerical coefficients in that expression have the dimension commodity/(time) (labour power)^i i = 3, 2, 1, respectively.

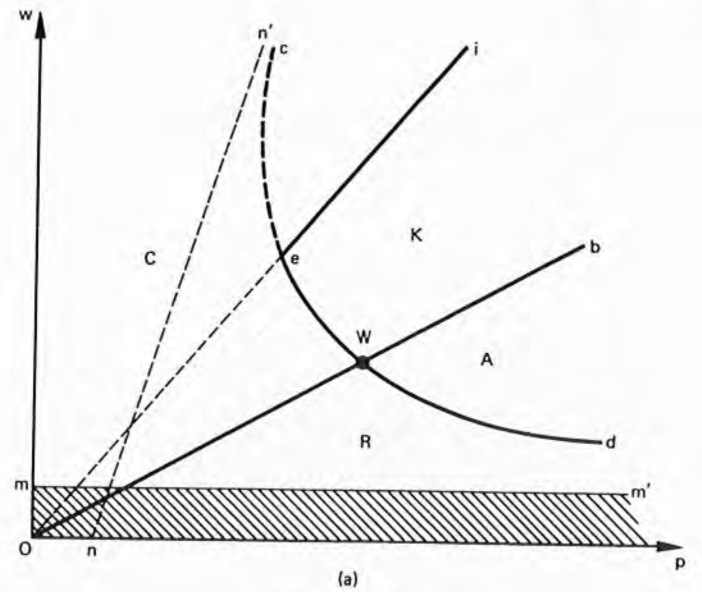


Fig. 8.A6a

where

$$E = 3Bw - m_0, \quad A = 2Nm_0 + 3G. \tag{58}$$

Within the non-negative orthant of the plane (p, w), (57) is represented by the curve cd. If

$$\Lambda(k) = 3f(D_L) - 2Nk > 0, \tag{59}$$

the intersection of cd with the line $w = kp$ corresponds to a unique $E > 0$. Indeed, Λ is a decreasing function of k for any k such that $f''(D_L) < 0$, as proved by the sign of

$$\Lambda'(k) = 3f(D_L)/f''(D_L) - 2N. \tag{60}$$

Therefore, cd intersects 0i at a point, e. It also has two asymptotes. One asymptote is mm′, which is represented by $E = 0$; it delimits the domain of unavailable price constellations (7). The second asymptote, nn′, is

$$w = kp - 4Ak^2/9Bf(D_L) \tag{61}$$

where k is given by $\Lambda(k) = 0$. Its slope is therefore greater than that of 0i.

Only the branch of cd below the point e is relevant for the economic model. To the east of the kinked line ied, $\Sigma_X > 0$; to the west of it, $\Sigma_X < 0$. The plane (p, w) is divided into the relevant domains K, C, A, R, as shown by the thick lines in Figure 8.A6a.

The Walrasian equilibrium constellation, $W(p_W, w_W)$, exists and is unique. By putting $D_L = N$ in (57) and noting that $w_W = p_W f'(N)$, we obtain

$$[3f(N) - 2Nf'(N)]\,E_W = 4Af'(N).$$

However, one curious feature must be remarked. The line ei is only one part of the boundary between the domains K and C; it is not part of the locus $\Sigma_X^0 = 0$. For values of w above e, *there is no value of p that clears the commodity market*. The cobweb approach to equilibrium cannot therefore work unless the initial price constellation does not differ too much from that of the Walrasian equilibrium. This analytical result is sufficiently surprising if viewed only from the general analysis of Walrasian equilibrium. But apart from this, it deserves attention because it represents a catastrophe situation stronger than that of the usual models of catastrophe.

(B): $N > H^*$. Since $f'(N) = 0$, the system may be rightly characterised as 'overpopulation'. It obviously cannot operate according to the principle of marginal pricing of Walrasian economics. We have here a striking counter-example to the position that Walrasian economics can work in all circumstances and that at least one Walrasian equilibrium always exists, a position which has acquired the status of incontestability through the famous theorem elegantly proved by Arrow and Debreu (1954). What is more, the relevance of this case is not purely academic only. Overpopulation in the above sense has been a far more dominant situation in history than that in which marginal productivity of labour is positive.

If there is overpopulation there is involuntary unemployment in an entirely different sense from the current use of the term. Employment is H^*, with, paradoxical though it may seem, a maximum working time (which now may be split between several individuals who thus share the 'unwanted leisure'). The resulting output satisfies first the demand of the 'government', D_G, representing some percentage, ρ, of the total output. The rest is shared among all consumers in the same ration, r:

$$Bf(H^*)(1 - \rho) = Nr. \tag{63}$$

Most of the distribution is achieved by transfers in nature outside any price system and according to a rationing rule analogous to that suggested recently by Malinvaud for the classical unemployment (Section 13 below).[1]

(C): $N < H^m$. In this case, the labour market can never clear. If $w > pf(H^m)/H^m$, we conclude as before that $D_L = 0$ and $\Sigma_L = N > 0$. And if $w \leqslant pf(H^m)/H^m$, then $D_L \geqslant H^m$; hence $\Sigma_L < 0$. If $D_L = 0$, then $\Sigma_X < 0$; and if $D_L \geqslant H^m$, the commodity market again clears only if (56) is satisfied.

The pattern is described by Figure 8.A6b, again by the thick, solid lines. No price constellation corresponds to the Keynesian case. What is more, *there is no Walrasian equilibrium*, for nowhere can we have $\Sigma_L = 0$. This is still another counter-example to smooth-sailing Walrasian economics. The situation may be described as 'underpopulation' or, perhaps more tellingly, as 'overcapitalisation'.

[1] The foregoing points form the substance of a 1960 essay reprinted in Georgescu-Roegen (1976, ch. 6).

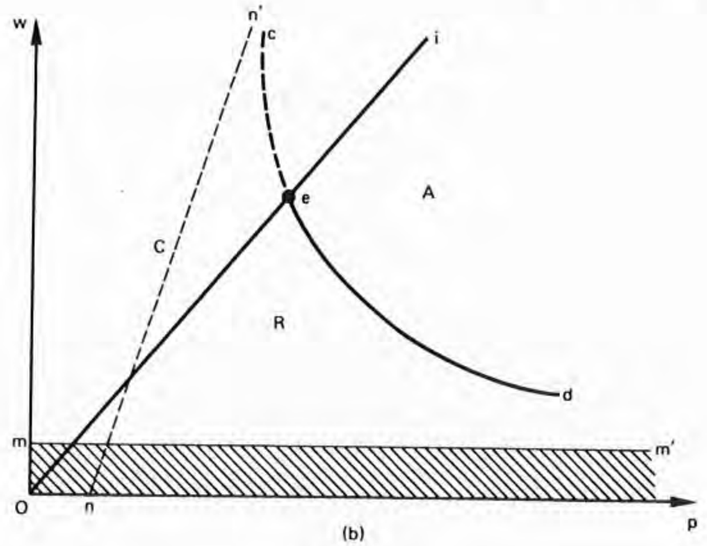


Fig. A6b

10. Preliminary considerations of disequilibrium theory

The idea that an economic system can live with disequilibria of some sort or other necessarily implies that the demand of some buyers or the supply of some sellers normally have to remain unsatisfied. This raises the thorny problem of determining which particular individual or which particular production unit will remain unsatisfied and to what extent.

The answers hinge on a series of factors, most of which are imponderable: the economic acumen of the individual (as a consumer, a worker, or a manager), his location, his eagerness to strike a contract, the chance of his finding a favourable partner, the amount of 'money' he possesses, etc. No analytical formula could possibly embrace all these variables for a positive answer in each case.

For purely analytical purposes, however, the issue can be circumvented by some expedient assumptions. The assumption that all people and all firms are identical (assumption E) comes easily to mind. But because of the Principle of Insufficient Reason, all buyers (or all sellers) should then come out of the market equally unsatisfied. Unemployment would then pertain to working hours instead of individuals. It would be a continuous attribute instead of a discontinuous one as is the case in actual conditions, in which an individual is either fully employed *for the day* or is not employed at all.

It is thus assumed, first, that in a market oversupplied with workers who seek employment a worker is satisfied either completely or not at all (e.g. Malinvaud, 1977). Because of the complete identity of the workers, who is employed and who is not must be decided by pure hazard – a curious assumption as far as the actual world is concerned. A second assumption is anti-symmetrical to the preceding one. On the commodity market, the unemployed individuals are always completely satisfied, whereas those who are employed may have to be rationed, in which case they share the balance of the effective supply equally.[1] In contrast with the rules for individuals, firms always share equally the demand for the commodity, and, hence, the supply of labour.[2]

We should also recall the novel idea of disequilibrium theory, namely, that prices are not affected by the behaviour of the economic agents – the production units and the households. These agents adapt only the quantities transacted at the given price constellation. The adaptation is based on what once was regarded as a tautology, namely, that the quantities bought must be equal to the quantities sold. But there also is an additional, not always explicit, idea, which is that the commodity market, not the labour market is the wheel of the adjustment.

Three basic ideas will aid the organisation of the otherwise entangled picture of disequilibrium theory.

(I): *First*, if (p, w) is the given price constellation, no unit can work with H workers unless

$$w \leqslant pf(H)/H, \tag{64}$$

and none could work at all outside the domain of (54).

(II): *Second*, the characteristic assumption of disequilibrium approach is that the excess supply of the commodity, $\Sigma(H)$, cannot be positive at the disequilibrium employment $H = N_1$. The excess supply is

$$\Sigma(H) = Lf(H) - H(x - x') - Y_m, \tag{65}$$

where x' denotes the demand of the unemployed worker and Y_m stands for the minimum necessary output, $Nx' + G/p$. We may also put

$$\Sigma_X^0 = \Sigma(N) = Lf(N) - G/p. \tag{66}$$

(III): *Third*, as we have seen in Section 9, if a production unit cannot employ D_L workers because $N < D_L$, in order to maximise its profit it must seek to employ as many workers as the preceding conditions would allow. This means that $\Sigma(N_1) = 0$. Hence,

$$D_L > N \Rightarrow N_1 \leqslant N. \tag{67a}$$

If $D_L \leqslant N$, $\Sigma(N_1)$ may be negative. And, as we shall see by an additional

[1] We may note in passing that this rule contradicts the common fact that individuals with higher incomes are ordinarily more efficient buyers than the others.

[2] Malinvaud (1977, pp. 50f) seems to be the only author who considers the case of non-identical firms. But, in the end, he adopts an aggregate production function which does not specify the share of each individual firm.

argument later on, the rule is

$$D_L \leqslant N \Rightarrow N_1 \leqslant D_L. \tag{67b}$$

Naturally, even in this set up, some sort of *tâtonnement* is indispensable for arriving at the disequilibrium scale that satisfies both (II) and (III). Yet disequilibrium theories disregard this necessity completely, and *pour cause*: since there is only one market during the day, one would have to fall back on contracting and recontracting (which would upset the whole apple cart).

11. The map of static disequilibria: first part

For a qualitative analysis that may pinpoint the details of the various situations, we shall again assume that the ophelimity function has the form (5).

The problem of which type of disequilibrium corresponds to a given price constellation hinges on the relative position of two curves in the plane (H, Q). The first is the straight line AB, representing the effective demand for the commodity,

$$Q_1 = H(x - x') + Y_m, \tag{68}$$

for the employment level H.[1] The second is $0Q^*$, representing the output of the commodity,

$$Q_2 = Lf(H), \tag{69}$$

for the same employment (see Figure 8.A10, below). In order to avoid the division of many of the subsequent analytical findings into cumbersome subcases, we shall include in the function (69) the extension $Q = Q^*$ for $H > H^*$.

Because $\Sigma(0) < 0$ and $\Sigma(H) < 0$ for any value of H greater than some ^0H (which may be zero), the equation $\Sigma(H) = 0$ has an even number of roots in the interval $(0, {}^0H]$. As we shall prove presently (although it is intuitively obvious from Figure 8.A10), this number may only be 0 or 2 (including the case of a double root).

Let us put

$$\phi(N; E, H) = 2w(HE + 2A)/3Ef(H). \tag{70}$$

[1] It may be natural to think that $x' < x$, which entails that the slope of AB is positive. However, whether that is so or not depends on the sign of the coefficient of dl in the relation $(U_{xx}U_m^2 - 2U_{xm}U_xU_m + U_{mm}U_x^2[w(U_{xm} - U_{mm}) + U_{ml} - U_{xl}]\,dl$, which cannot be ascertained in general. In the case of 'independence', however, that coefficient is always positive; hence, with increased leisure (decreased income from work), the demand for the commodity decreases, and $x' < x$. Curiously, however, in our case the specific formula of x' coincides with that established in (8) for an individual too rich to work!

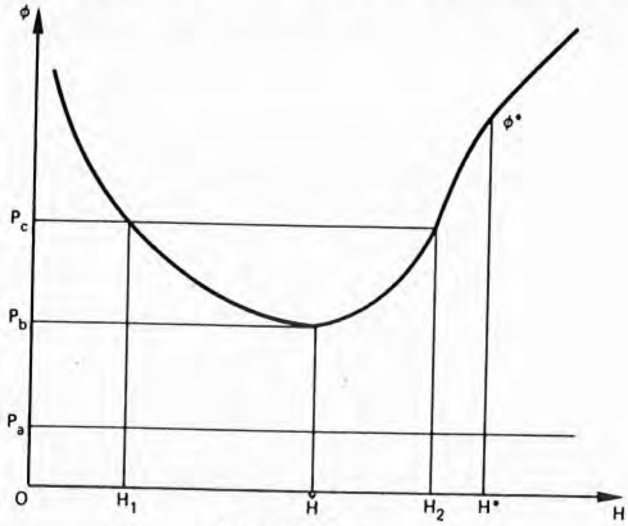


Fig. 8.A7

This sign of $\Sigma(H)$ is the same as that of $p - \phi$. For any given E, the shape of ϕ, regarded as a function of H, is that shown in Figure 8.A7. Namely, for $H = 0$, $\phi = \infty$, and for $H \geqslant H^*$, $\phi = 2w(HE + 2A)/3Ef(H^*)$. The function $\phi(H)$ also has one and only one minimum, corresponding to H determined by the equation:

$$\varphi(H) = f'(H)/[f(H) - Hf'(H)] = E/2A. \tag{71}$$

Let us note, first, that, because of the general S-shape of $(f(H)$, $\varphi(H) \geqslant 0$ if and only if $H \geqslant H^m$. Moreover, $\varphi(H^m) = \infty$ and $\varphi(H) = 0$ for any $H \geqslant H^*$. Finally,

$$\varphi'(H) = ff''(f - Hf')^2 < 0 \tag{72}$$

for $H^m < H < H^*$. It follows that for any given E, there is a unique $\check{H}$,

$$H^m \leqslant \check{H} = \check{H}(E/2A) \leqslant H^*, \tag{73}$$

for which ϕ is a minimum.[1] Conversely, to any given H not smaller than H^m, there corresponds one and only one value of E such that $H = \check{H}(E/2A)$.

Let us now put

$$p = \check{p}(E) = \phi(N; E, \check{H}). \tag{74}$$

In the plane (p, w), this function is represented by $\mathcal{H}$(Figures 8.A8 and 8.A9). It is immediately clear that $\check{p}(0) = \infty$ and $\check{p}(\infty) = \infty$. Therefore $E = 0$ is an asymptote of $\mathcal{H}$. There also is another asymptote, zz′, given by

$$w = 3pf(H^m)/2H^m - 2A/3BH^m; \tag{75}$$

its slope is greater than 0i.

[1] The concavity of ϕ does not necessarily remain always positive. ϕ'' might be zero for some H, $\check{H} < H < H^*$. But this does not affect the current argument.

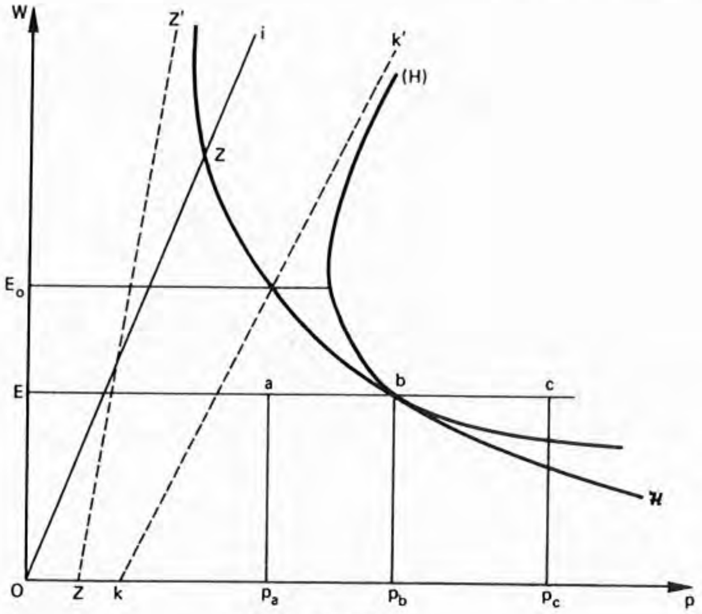


Fig. 8.A8

The sign of $d\check{p}/dE$ is the same as that of

$$\Delta(E) = \check{H} - 2Am_0/E^2. \tag{76}$$

Since $\Delta(0) = -\infty$ and $\Delta(\infty) = H^m$, $\Delta(E) = 0$ has an uneven number of roots. For the particular form (21), (71) becomes

$$EH^2(H - 3) = 3A(a + H)(4 + a - H) \tag{77}$$

by substituting $H = 2Am_0/E^2$, it is immediately seen that $\Delta(E) = 0$ has only one solution. It is analytically convenient to assume that the function f(H) is such that (76) has only one root, in which case $\mathcal{H}$ has the shape shown in Figure 8.A8. Perhaps this is true for all 'regular' production functions. However, for the strict argument, $\mathcal{H}$ has a somewhat equivalent property: a line $p = \lambda w$ that intersects $\mathcal{H}$ does not intersect it again. Let us assume that $p = \lambda w$ intersects $\mathcal{H}$, which means that

$$3\lambda/2 = (\check{H}E + 2A)/Ef(\check{H}) \tag{78}$$

has a solution $E > 0$. The derivative of the right-hand side with respect to E is simply $-2A/E^2 f(\check{H}) < 0$. Hence, (78) cannot have a second solution. In particular, 0i intersects $\mathcal{H}$ once, at Z. Since (71) and (74) yield

$$f(\check{H}) = 2w/3p \tag{79}$$

the value of $\check{H}_z$ corresponding to Z, is given by $f'(H_z) = 2wf'(H^m)/p$.

There exists a still more important property of $\mathcal{H}$. In the plane (p, w),

$$p = 2w(HE + 2A)/3Ef(H) \tag{80}$$

represents a one-parameter family of curves, the parameter being H. This

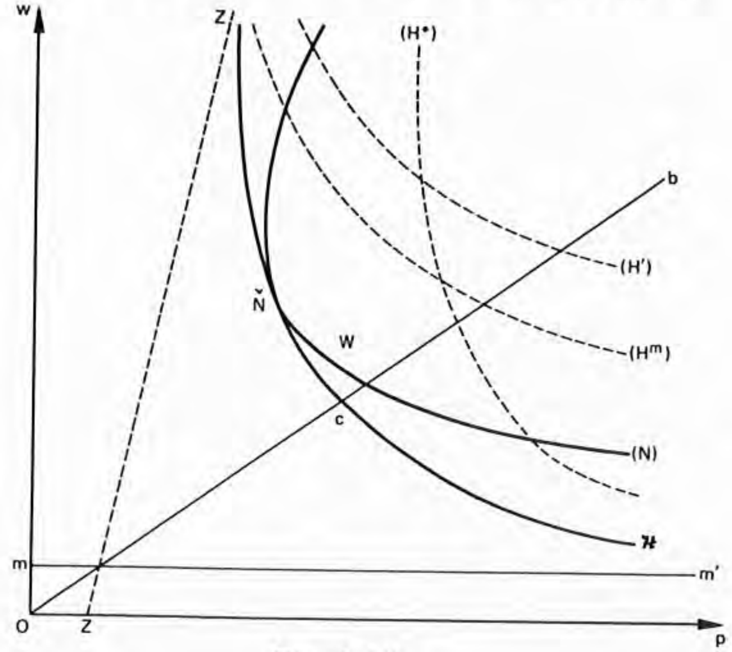


Fig. 8.A9

family constitutes the basis of disequilibrium analysis. Analytically, we shall allow H to vary freely from 0 to ∞.

Each curve (80), denoted thereafter by (H), has two asymptotes: E = 0 and

$$w = 3pf(H)/2H - 2A/3BH, \tag{81}$$

denoted by kk′. (The slope of kk′ is never greater than that of zz′.) The right-hand function of (80) has a unique minimum corresponding to

$$E_m(H) = \sqrt{2Am_0/H} \tag{82}$$

Moreover, (H) is convex toward the west, since $d^2p/dw^2 > 0$ (Figure 8.A8).

Next, we should ascertain whether the family of curves (80) has an envelope. If it exists, the envelope is determined by eliminating the parameter H from (80) and the derivative of that equation with respect to H. This derivative yields

$$3pf'(H) = 2w. \tag{83}$$

By substituting this value of H for $\check{H}$ in (80) we obtain the envelope of that family. But (83) is the same equation as (79); hence the function determined by it and (80) is $\check{H}(E/2A)$. Therefore, the envelope of the family (80) is $\mathcal{H}$.

However, $\mathcal{H}$ is tangent not to all curves (H), but only to those for which $H \geqslant H^m$. The reason is that (71) has no positive solution otherwise. If the last condition is satisfied, (H) is tangent to $\mathcal{H}$ at one and only one point (Figures 8.A8 and 8.A9). Indeed, if the same (H) were tangent in more than one point, it would mean that to the same $\check{H}$ there would correspond more than one value of E – which would contradict (79). This last condition implies that if E (of the tangent point) increases from 0 to $+\infty$, the parameter corresponding

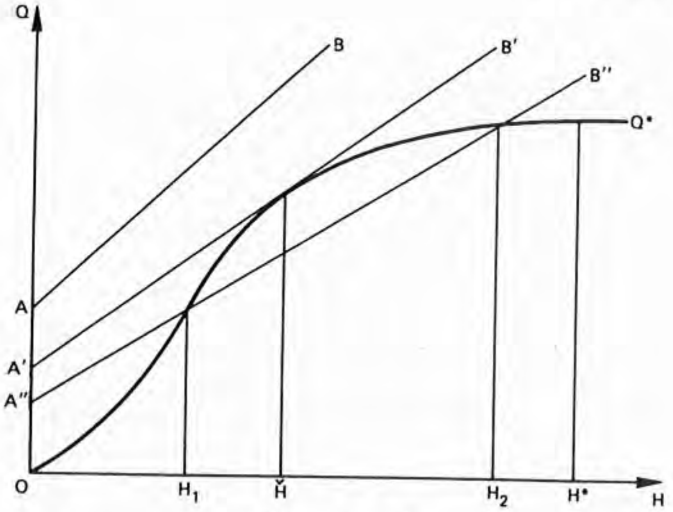


Fig. 8.A10

to the tangent curve decreases from H^* to H^m. The point of tangency of (H^*) is at $p = \infty$, and that of (H^m) at $w = \infty$ (as shown in Figure 8.A9). If $H' < H^m$, (H') does not intersect (H^m) and belongs entirely to the open domain east of (H^m).

The curve $\mathcal{H}$ divides the plane into two domains with crucial properties for disequilibrium mapping. If a price constellation (p_a, w) is represented by a point *a* belonging to the domain west of $\mathcal{H}$ (Figure 8.A8), then, as seen from Figure 8.A7, $p_A < \check{p}(E)$, and, hence $\Sigma(H) < 0$ for any H. AB does not intersect $0Q^*$ (Figure 8.A10).

If $b(p_b, w)$ is on $\mathcal{H}$ then $p_b = \check{p}(E)$, and $\Sigma(H) < 0$ except that $\Sigma(\check{H}) = 0$. A′B′ is tangent to $0Q^*$ at $\check{H}$ (Figure 8.A10). Through b passes *only one* curve of the family (80). This curve, which corresponds to the parameter H, is tangent to $\mathcal{H}$.

Finally, let us consider a point belonging to the east of $\mathcal{H}$, say, $c(p_c, w)$. From Figure 8.A7 it follows directly that in this case, the condition $p_c = \check{p}(H)$ is always satisfied for two and only two values of H, $H = H_1$ and $H = H_2$, $H_1 < \check{H} < H_2$. A″B″ intersects $0Q^*$twice, at point corresponding to H_1 and H_2 (Figure 8.A10).[1]

Therefore, through any point belonging to the domain east of $\mathcal{H}$ pass two curves of the family (80), (H_1) and (H_2), as shown in Figure 8.A9. The dual proposition, however, is not true: two curves do not always intersect each other, not even at infinity. If they intersect, the value of E^0 pertaining to

[1] For Figure 8.A10, we should note that if w remains constant, Lf(H) does not shift if p varies. As p increases, AB shifts lower and its slope decreases. Needless to add, H_2 may be greater than H^*, but that is only an analytical solution.

intersection must be non-negative and satisfy the equation

$$E^0[H_2f(H_1) - H_1f(H_2)] = 2A[f(H_2) - f(H_1)], \tag{84}$$

where (here and hereafter) notations are such that $H_1 < H_2$. If $f(H_2)/H_2 > f(H_1)/H_1$, the solution of (84) is positive; the two curves intersect and intersect only once. In the contrary case, $E^0 < 0$ and the curves do not intersect.

There are four distinct and exhaustive cases.

1: $H^* < H_1$. From (84) it follows that $E^0 = 0$, hence, $p = \infty$. The two curves meet at infinity.

2: $H^m < H_1 < H^*$. In this case, $0 < E^0 < \infty$. The two curves intersect at a finite distance.

3: $H_2 < H^m$. The two curves never intersect, since $E^0 < 0$.

4: $H_1 < H^m < H_2$: There are two subcases. First, the equation $f(H_2')/H_2' = f(H_2)/H_2$ has a non-trivial solution (which is unique if it exists). Second, this solution does not exist; we then put $H_2' = 0$. The two curves intersect at a finite distance if $H_1 > H_2'$, and at infinity if $H_1 = H_2' > 0$. If $0 < H_1 \leqslant H_2'$, the two curves never intersect.

We shall also need to know the relative position of a pair of curves (H). The sign of $p(H_1) - p(H_2)$ is the same as that of

$$-E[H_2f(H_1) - H_1f(H_2)] + 2A[f(H_2) - f(H_1)]. \tag{85}$$

If the curves intersect, this sign is positive for $E < E^0$, and negative for $E > E^0$. Hence, (H_1) intersects (H_2) from above and from the west. We must note that if $H^* < H_1$, (H_1) and (H_2) intersect at $E^0 = 0$, hence (H_2) is to the east of (H_1). If the curves do not intersect at all, then (85) is positive, which means that (H_1) is to the east of (H_2).

Another crucial element of the problem is the sign of

$$\Sigma_X^D = Lf(D_L) - D_L(x - x') - Y_m. \tag{86}$$

The associate curve, D, represented by

$$D(p, w) = E[3f(D_L) - 2D_Lf'(D_L)] - 4AF'(D_L) = 0, \tag{87}$$

is asymptotic to $E = 0$, since $f'(D_L) = 0$ implies $p = \infty$. For relevant situations, $H^m \leqslant D_L < H^*$, in which case the coefficient of E is always positive. Therefore, any line $w = \lambda p$, $\lambda \leqslant f(H^m)/H^m$ intersects D at a finite distance. In particular, D intersects 0i at a point c′ for which $E = 4A/H^m$ (Figure 8.A11).

12. The map of disequilibria: second part

As in Section 10, we shall being with the normal case of disequilibrium models.

A: $H^m \leqslant N < H^*$. We shall represent the family of curves (79) in Figure

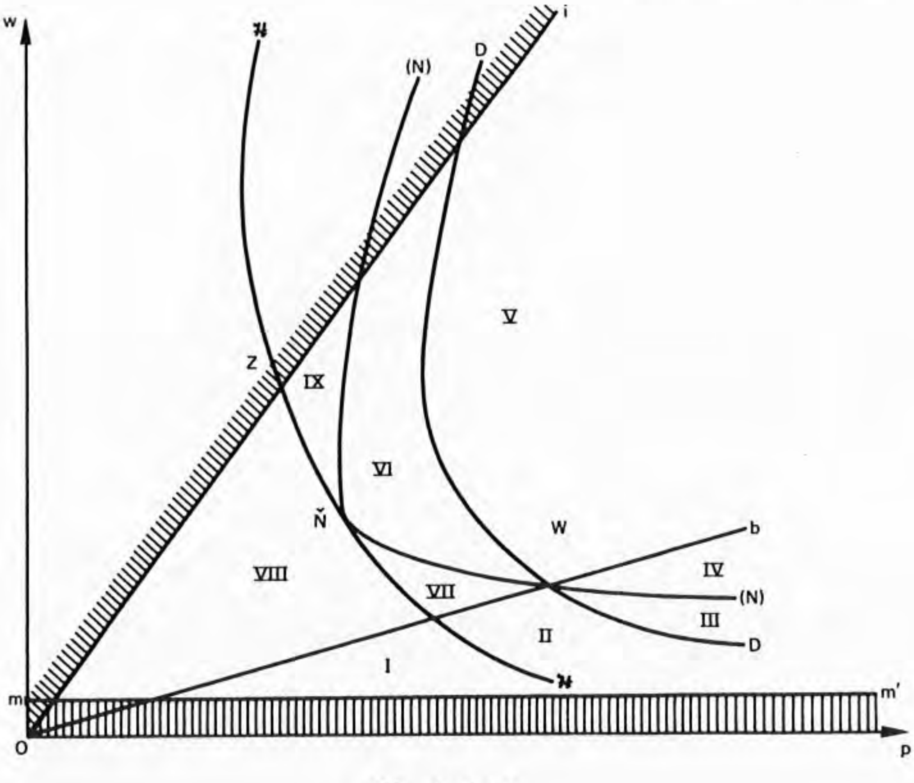


Fig. 8.A11

8.A11 without any regard for the relevance of the points (p, w). Before proceeding to its analysis, several points need to be established.

First, let us recall that E_w, corresponding to the Walrasian equilibrium prices, satisfies (62) and that $\check{E}$, corresponding to the tangency point of (N) and $\mathcal{H}$, satisfies (71), in which N has been substituted for H. From the two equations it follows that $\check{E} < E_w$, which means that $\mathcal{H}$ intersects 0b below W, at c.

Second, let $H_1 < H_2$ be the two intersections of Q_1 and Q_2 – i.e. of (68) and (69) – when they exist. From

$$3pEf(H_1) = 2w(H_1E + 2A),\ 3pEf(H_2) = 2w(H_2E + 2A), \tag{88}$$

it follows, by subtraction and the mean theorem, that

$$3p\,[f(H_2) - f(H_1 0]/(N_1 - N_2) = 3pf'(\theta) = 2w, \tag{89}$$

for some unique θ such that $H_1 < \theta < H_2$. And since $pf'(D_L) = w$, we obtain the important result that[1]

$$D_L < \theta < H_2. \tag{90}$$

[1] Relation (90) is the crux of the fact that the relation between price constellations and disequilibrium types is never ambiguous.

Third, D belongs to the domain east of $\mathcal{H}$. Indeed the two curves could not intersect, because there is no point $\check{H}$ such that $\check{H} = D_L$. The slope of AB is E/6p and that of the tangent to 0Q*at H is Ef′(H)/4w. If these slopes were equal,

$$f'(H) = 2w/3p; \tag{91}$$

hence, $\check{H} \neq D_L$.

Fourth, from (62) and (87) it follows that D passes through W (an expected result), where it intersects (N) from above and from the west. For the Walrasian equilibrium prices, (p_0, w_0), the straight line AB intersects 0Q* at the point corresponding to $N = D_L$ and at a second point, N_2, which by (90) is such that $N_2 > N = D_L$. Let now $0 < w/p - w_W/p_W < \epsilon$, where ϵ is sufficiently small. To w/p, there corresponds $D'_L = N - \Delta N$. Because of the continuity of f′(H), from (89) it follows that the corresponding line AB that passes through the point corresponding to D'_L intersects 0Q* the second time in N'_2 such that $N < N'_2 < N_2$. D passes, therefore, through the intersection of $(N - \Delta N)$ and (N'_2). From what we know about the relative positions of the curves (H) with respect to $\mathcal{H}$, that intersection is above (N).

However, D cannot intersect (N) at a *relevant* point different from W, for that would mean that $D_L = N$ for two different ratios w/p (which is impossible).

Fifth, we will find that in some cases $H_1 < D_L < H_2 < N$. This situation raises a crucial question. Since both H_1 and H_2 are possible *analytical* disequilibrium solutions, is the solution indeterminate? The answer is that the *economically relevant* solution is completely determinate, with employment at H_1.

Let Π_1 and Π_2 be the profits corresponding to H_1 and H_2, respectively. From

$$\Pi_2 = pLf(H_2) - wLH_2, \Pi_1 = pLf(H_1) - wLH_1, \tag{92}$$

it follows that

$$\begin{aligned}(\Pi_2 - \Pi_1)/L &= p[f(H_2) - f(H_1)] - w[H_2 - H_1] \\ &= [pf'(\theta) - w][H_2 - H_1].\end{aligned}$$

From (90), it follows that $\Pi_1 > \Pi_2$. Hence, in order to maximise profit under constraint, the production units must necessarily employ H_1.

Bearing in mind the findings of the preceding section concerning the relative positions of any pair of curves (H_1) and (H_2), as well as that of any (H), $\mathcal{H}$ and D, we arrive at the following description of each of the domains into which, (N), $\mathcal{H}$, D, and 0b may divide the constellations (p, w), as shown in Figure 8.A11.[1] There may be either eight or nine domains according to

[1] The constraint represented by (64) will be taken into account later.

whether N is greater or smaller than H_Z, that is, according to whether the point of tangency of (N) and $\mathcal{H}$ is higher or lower than Z.

I. $Q_1 = Q_2$ has no solution. Moreover $D_L > N$, as is always the case below Ob. According to rule III of Section 10, the production units should choose the scale that is nearest to D_L. Hence, the disequilibrium solution is full employment with a uniform rationing of the commodity for all.[1] The case is known as repressed inflation (on the thought that rationing may be eliminated by increasing the production capacity of the physical plants).

II. $N < H_1 < H_2$ and $D_L > N$. Since $\Sigma(D_L) < 0$, the order is $N < D_L < H_1$. The pattern is again repressed inflation.

III. This case differs from II in that $\Sigma(D_L) > 0$; hence, $N < H_1 < D_L < H_2$, which also represents repressed inflation.[2]

IV. In this sector, just as in all sectors above (N), $H_1 < N < H_2$. Since here $N < D_L$, the producers would like to hire all workers (in order to obtain the maximum possible profit). However, at full employment production exceeds demand, because $\Sigma(N) > 0$. According to the characteristic tenet of disequilibrium theory, this contradiction can be eliminated if and only if the producers hire H_1 workers, in which case production (not to be confused with supply) is equal to the demand under constraint.[3] The unemployment is caused by a lack of demand at full employment. The pattern is that of Keynesian disequilibrium.

V. The only difference between this sector and IV is that now $D_L < N$. Now $\Sigma(D_L) > 0$, hence, $H_1 < D_L < H_2$. The producers cannot therefore sell all their optimal supply, $Lf(D_L)$. The solution is again represented by H_1, i.e. by a Keynesian disequilibrium.

VI. Since this sector is below (N), we have, as in some previous cases, $N < N_1 < N_2$, with $D_L < N$, and $\Sigma(D_L) < 0$. In this case, the producers can choose to work with their optimal scale. There is unemployment, $N - D_L$, with production falling short of demand. Consumers have to be rationed. The situation is known as classical disequilibrium.

VII and VIII. In both these sectors, $D_L < N$, and also $D_L < H_1$, since $\Sigma(D_L) < 0$. The pattern is again classical.

IX. This domain exists only if $N < \check{H}_z$. It differs from VI only in that $N < H_1 < H_2$. But since still $D_L < N$, the pattern is again classical.

[1] On this point, more in Section 13.

[2] It is clear that in this case, as in some others, the *disequilibrium* solution is the same in all three domains, I, II and III. Only the initial patterns may differ in II. However, there is no ambiguity in either classification. We want to overemphasise this point because during the meeting we stated that repressed inflation may overlap with Keynesian unemployment. *The statement was wrong*. Our error was caused by not realising that not all *analytical* solutions of $Q_1 = Q_2$ are economically *relevant* and that the classification of the disequilibrium does not always coincide with that of the initial conditions (Section 9).

[3] On this point, more in Section 13.

It may be well to note that cd, defined by (56), cuts D from above. This observation allows us to see that classical disequilibria develop from initial conditions that are classical disequilibria (Figure 8.A6a). However, some classical initial conditions may lead to Keynesian disequilibria. Initial Keynesian disequilibria always lead to Keynesian unemployment. But Keynesian patterns may also develop from some anti-classical initial conditions. These last conditions may end up as repressed inflation disequilibria, but not all initial repressed inflation situations change their pattern. Knowing these changes should help economic policy (if it is based on disequilibrium theory), because any economic policy must act on the initial causes, not on their outcomes.

To determine the loci of constant unemployment we must eliminate those elements of our map that, for one reason or other, have no relevance to this problem. To begin with we must eliminate the curves (H) for any $H > N$. These curves are tangent to $\mathcal{H}$ below $\check{N}$. But even the remaining curves must be amputated, as it were. The branch above their point of tangency $\check{H}$ must be eliminated. The reason is that through each point of such a branch there passes another curve, (H), that corresponds to a lower value of H. As we have seen, if $H_1 < H_2$, disequilibrium cannot be at H_2. The relevant loci of Keynesian unemployment, for $H^m < H_1 < N$, are the lower branches of the curves (H_1). For the curve (H^m), however, whose point of tangency with $\mathcal{H}$ is at $E = \infty$, there is no branch to be eliminated. The same applies to the curves (H) such that $H < H^m$. These, as we have seen, do not intersect each other, but follow in successive order above (H^m).

But there is still more. No production unit can employ H workers if the price constellation is such that

$$wH > pf(H). \tag{94}$$

This means that the branch of (H) above the intersection, j_H, of (H) with the straight line $0b_H$ represented by $wH = pf(H)$, must also be eliminated if j_H happens to be on the branch of (H) that has not been already eliminated by the previous operation (Figure 8.A12). For j_H we have

$$E(j_H) = 4A/H. \tag{95}$$

From this relation and from the result, mentioned earlier, that D intersects 0i at a point for which $E = 4A/H_m$, it follows that (H^m) and D intersect on 0i at j_{H^m}.

The locus, j, of j_H is obtained by substituting H from relation (95) into (79), which yields

$$pEf(4A/E) = 4wA. \tag{96}$$

For the shape of this curve, we must note that, because of the continuity properties assumed about $f'''(H)$,

$$3Bwf'(0) = 3Bp[f'(o)]^2 + 2Af''(0) \tag{97}$$

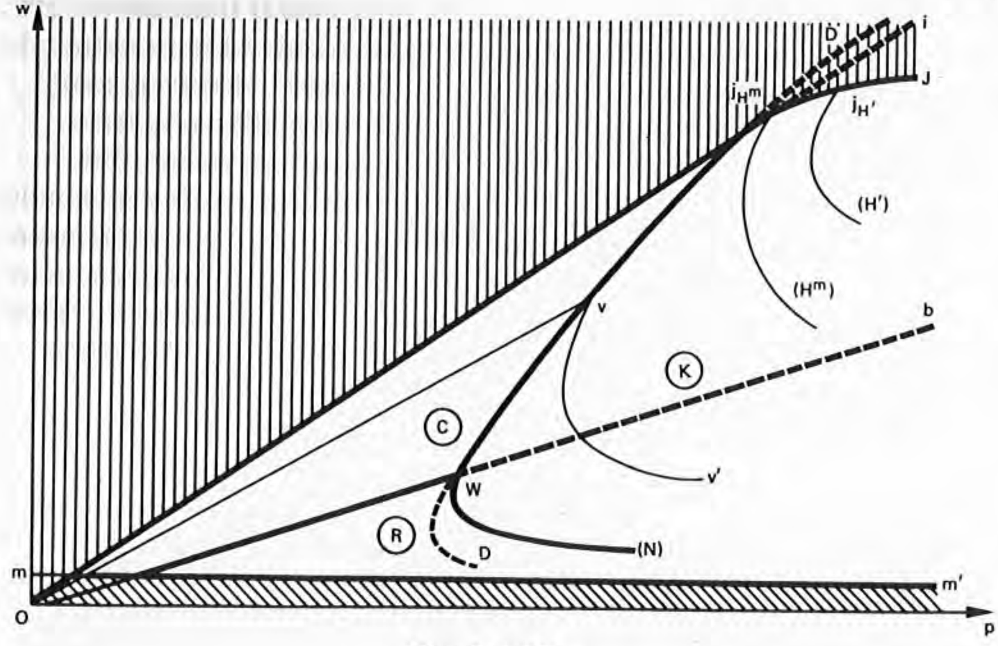


Fig. 8.A12

is an asymptote of J, provided $f'(0) \neq 0$. If $f'(0) = 0$, the upper branch of J has a parabolic shape. E = 0 also is an asymptote of J, but the lower branch of J presents no relevant interest. In fact, only the branch above $j_H m$ is economically relevant. Indeed J is tangent to Oi at $j_H m$. Any straight line $w = kp$, $f'(0) < k < f'(H^m)$, intersects J in two points, as is proved by the shape of the curve representing $f(H)/H$. Only if $k = f'(H^m)$ do these two points coincide, namely, with $j_H m$. But D is intersected only at one point by any straight line $w = f'(H)p$, $H^m < H < N$. Hence, the constellations that are not eliminated by (94) are represented by the lower branches of the curves (H), for which $H < H^m$.

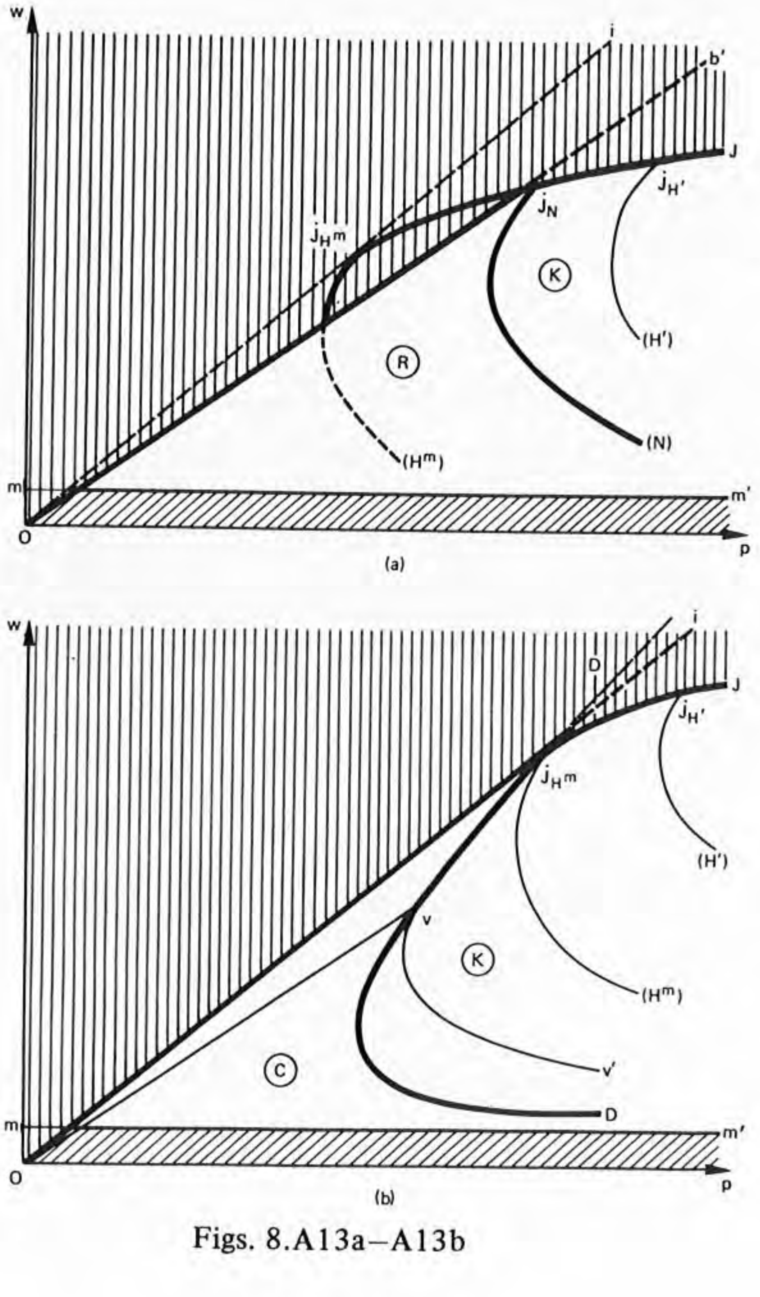
On the basis of the foregoing observations, the relevant map of static disequilibria for the case under consideration, (A), is represented in Figure 8.A12. The shaded areas represent price constellations for which the system cannot possibly work. The relevant domain, delimited by 0i, D, and 0b, corresponds to classical unemployment. The domain delimited by D, J, and (N) corresponds to Keynesian unemployment. Finally, the domain delimited by mm′, 0b, and (N) corresponds to repressed inflation.[1]

But the most salient result (about which more later) is this. The locus of a given employment level N_1 such that $H^m \leqslant N_1 \leqslant N$, is a kinked line 0vv′ (the segment below mm′ being, of course, excluded). On 0v, the equation of which is $w = f'(N_1)p$, the pattern is classical. At v the pattern becomes

[1] The patterns corresponding to points on any one of the boundaries are not ambiguous, although they may reflect mixed features, as this is most obvious in the case of D.

Keynesian and the locus is vv′, the relevant branch of (N_1). For $N_1' < H^m$ the locus is only the branch of (N_1') below $j_{N_1'}$, and the pattern is Keynesian throughout.

B: $N < H^m$. Since no price constellation can now satisfy both $w = f'(N)p$ and $wN \leqslant pf(N)$, the analytical 0b lies above 0i. *There is, therefore, no Walrasian equilibrium*. Price constellations above the line $wN = pf(N)$, represented by 0b′ (Figure 8.A13a), are unavailing. The domain between the branch of (N) below j_N and J corresponds to the Keynesian pattern. The branch of the curve (N_1), $N_1 < N$, is the locus of Keynesian employment N_1. The domain between $0j_N$, (N), and mm′ corresponds, as before, to repressed inflation.



Figs. 8.A13a–A13b

Because not all plants can be manned at their optimal capacity, H^m, the situation just considered reflects a deficit of population. There is thus underpopulation or, equivalently, overcapitalisation. In this case, the most we can hope to achieve is full employment, not Walrasian equilibrium.

C: $H > H^*$. In this case again no Walrasian equilibrium exists. The corresponding map is represented by Figure 8.A13b. There are only two patterns: Keynesian above D, and classical below D. The employment isoquants for $N_1 \geqslant H^m$ have the same kinked shape, Ovv′, as in Figure 8.A12. And for $N_1' < H^m$, they again are the branches of (N_1') below J.

13. Rationing rules

As we have seen, in various situations of disequilibrium there is a need for some rationing in order to assure that the economic disequilibrium can exist in all situations, as the new theory wants it. One such specific rule for rationing the consumers in the case of classical unemployment has been suggested by Malinvaud (Section 10). Let r, $r = x - u$, $u > 0$, be the rationed amount of the commodity the employed worker is allowed to purchase. Knowing (by some still unexplained procedure) this restriction, such a worker will adjust his supply of labour time, L', accordingly. If the ophelimity function has the form (5), we have

$$L' = L - pu/2w = (Bw - m_0 + pr)/2w. \qquad (98)$$

The production must now satisfy the constraint demand of the employed workers as well as the demand of the unemployed workers and of the government:

$$3pr[f(D_L) - 2D_L f'(D_L)] = 2(A - 2D_L m_0)f'(D_L) - 3(Bw - m_0). \qquad (99)$$

The rub is that this equation may fail to determine r, if

$$f(D_L)/2D_L = f'(D_L). \qquad (100)$$

Indeed, as the ordinary graph of the average and marginal productivity of labour would immediately show, this equation always has at least one solution, $D_L > H^m$. That is not all: (100) is a differential equation, whose integral is $f(H) = \alpha\sqrt{H}$. For this function, (99) is completely indeterminate, a snag that cannot be set aside as long as the production function satisfies the standard assumption (16). However, the snag persists in a somewhat smaller form even for an S-shaped production function. True, such a production function cannot be represented by $\alpha\sqrt{H}$ over the closed interval $[H^m, H^*]$, which is pertinent to the model defined by (A). Yet the production function can be represented by $\alpha\sqrt{H}$ over any closed interval $[H', H'']$ such that $H^m < H', H'' < H^*$. Then, (99) fails to determine r for any value of D_L belonging to that interval. The point is highly important, because it proves that rationing rules for classical unemployment may break down for other ophelimity functions as well.

For the case of repressed inflation, the same rule leads to

$$\Sigma_X^0 = Lf(N) - Nx\text{-}G/p = u\,[pf(N)\text{-}2Nw]\,/2w. \tag{101}$$

Because for repressed inflation $\Sigma_X^0 > 0$, u cannot be positive unless $pf(N) > 2wN$, which means that the receipts of the firms must be greater than twice the wage bill. If prices do not allow this to happen, the rule, simple and transparent though it appears *prima facie*, becomes inoperative. Other rationing rules may have the same fate.

Disequilibrium theory counts on possible rationing only for the commodity and labour power, but not for labour time (probably because the latter co-ordinate is absent from the standard framework). However, Keynesian unemployment (which, according to the same theory, is the more relevant in actuality), could be eliminated by rationing labour time.

The idea is not far-fetched. To recall, in 1933 the United States Congress passed a law reducing the work week to thirty hours for the sole purpose of reducing the massive unemployment of that time. (The law was never put into effect.) Charles Roos (1933), who immediately set out to analyse the implications of such a measure, also remarked that 'Theorists have generally very glibly referred to the supply of labor without specifying the length of the work week, whereas obviously, if all workers were employed on a forty-hour average work week, some would be unemployed if the work week could be suddenly increased to fifty hours'. In retrospect, one can only wonder why economic theorists still continue to ignore the labour time in the analysis of production and unemployment.

If L^0 is the exogenously determined labour time, the corresponding demand for the commodity of an employed worker is

$$x^0 = 2(wL^0 + m_0)/3p. \tag{102}$$

The proper L^0 for the elimination of Keynesian unemployment is given by

$$L^0\,[3pf(N) - 2wN] = A. \tag{103}$$

This equation always has a solution, L^0, for any relevant price constellation.

In the case of a classical pattern, however, rationing the number of working hours would make matters worse since it would diminish an already insufficient production. Classical unemployment, so it seems, is a harder nut to crack.

14. Concluding remarks

Two additional observations should be made in closing. The first concerns a specific feature of the ordinary disequilibrium model. Any model must, of course, be consistent within itself. But a model intended to represent a process that presumably goes on without any distinction between one day and the next must also be consistent as an *algorithm*. This means that its final outcome must satisfy the same assumptions as those imposed on the initial conditions. For example, a model requiring that all initial co-ordinates be positive must ensure that all final co-ordinates also be positive. The model cannot represent what happens on Tuesday if the conditions inherited from Monday do not belong to the same axiomatic set as those of Monday morning.[1]

Malinvaud's assumption about the initial conditions (which is representative of the usual disequilibrium models) is a case in point. All individuals start with the same amount of money, m_0; the government has a fund G. The business sector has no initial money balance. By the end of the day, that sector is in possession of the profit

$$\Pi = pLf(N_1) - wLN_1 = G + 2(N - N_1)m_0/3 + N_1(3m_0 - Bw)/4, \qquad (104)$$

which is always non-negative if $E \leqslant 4A/N_1$ (as we have seen). This profit consists of the government expenditure G, the expenditure by the unemployed, in all $2(N - N_1)m_0/3$, and the net change in the balances of the employed, $N_1\Delta m = N_1(3m_0 - Bw)/4$.

The process by which disequilibrium is reached thus fundamentally changes the distribution of money between the various participants. For the model to represent the next-day process as well, some additional rules must be introduced for re-establishing the initial distribution. Naturally, one would think of taxing away the whole profit, which would restore the initial position of the business sector, and using the proceeds for doing the same for individuals and the government itself. Alternatively, one may propose distributing Π among the households 'according to a predetermined distribution pattern' (Barro and Grossman, 1971, p. 84). Unfortunately, things are not so easy even for the very simple model under consideration. That recipe obviously fails if $\Pi = 0$. In this case, the employed absorb all the money in the community. The only way to restore the initial distribution is for the government to tax away the entire savings of the employed and use the proceeds for subsidising the unemployed by a negative tax and endowing itself again with G. But even if $\Pi > 0$, the distribution of profit among the investors (assumed to include the government) would not do as a general rule. Δm may still be negative, since $N_1E < 2A$ requires only

$$3N_1\Delta m + 2m_0(N - N_1) + 3G > 0. \qquad (105)$$

The intervention of the government is then necessary for siphoning the savings of the employed either for subsidising the unemployed, or financing itself, or doing both. The simplest rule is therefore for the government to tax all savings and profits and to practise negative tax (which might include the employed as well).

The idea of a business sector that operates constantly without profit after

[1] We should note that the Walrasian model is consistent in this sense.

taxes and a government that may have to practise negative taxation is so remote from the prevailing system that our model is utterly inadequate to serve as a guide for policy.

The second observation is a reminder: no process of a dialectical nature can be adequately represented by an arithmomorphic blueprint. Only mechanical processes ('mechanical' being understood in its extensive sense used in epistemology) can be so represented. For dialectical processes we can, at most, resort to an analytical simile (Georgescu-Roegen, 1966; 1971). Being the product of a heroic mental jump between the two irreducible modes of cognition, a simile can nonetheless be useful in some particular way. Ordinarily, it can make us aware of some unsuspected difficulties or of latent errors in some of our conventional notions. That is, if a simile cannot tell us what to do, it may tell us what not to do or not to believe.

Take the current notion that to reduce unemployment one should either increase the wage rate or decrease prices (which is tantamount to increasing the purchasing power of wages). From Figure 8.A12 it is immediately obvious that in the case of classical unemployment the contrary is true: one must either increase prices or decrease wages (up to a certain level).[1] The same map shows that, contrary to Malinvaud's assertion (1977, p. 66), even in the case of a Keynesian disequilibrium increasing wages may increase unemployment, if the disequilibrium corresponds to a point on (H) above the turning point, which corresponds to (81).

To justify the map of Figure 8.A12, let us first note that from (81) and (95) it follows that

$$E_m(H) < E_j(H). \tag{106}$$

Hence for $H < H^m$, H is always backward-bending below J. (See also Figure 8.A13). For $H^m \leqslant H \leqslant N$, let a_H be the intersection of (H) and the straight line $w = f'(H)p$. For a_H we have

$$E_a(H) = 4Af'(H)/[3f(H) - 2Hf'(H)]. \tag{107}$$

For the equality $E_m(H) = E_a(H)$ to be satisfied over some non-zero interval, f must be a solution of the differential equation

$$[3f - 2Hf'(H)]\sqrt{2AM_0} = 4Af'(H)\sqrt{H}. \tag{108}$$

This yields

$$f = c(2A + \sqrt{2AM_0H})^3. \tag{109}$$

For this function, which can be valid only for a true subinterval of $[H^m, H^*]$, the turning point of (H) is on D. Functions therefore exist for which the turning points may be on either side of D.

An example of a function with a continuous derivative that fits the map of

[1] That this also is a simple consequence of (52) is a familiar point.

Figure 8.A12 is

$$f(H) = 3\sqrt{3}H^2/16 \quad \text{for } 0 \leqslant H \leqslant 4/3,$$
$$f(H) = \sqrt{H-1} \quad \text{for } 4/3 \leqslant H \leqslant 10, \qquad (110)$$
$$F(H) = (-3H^2 + 62H - 311)/3 \quad \text{for } 10 \leqslant H \leqslant 11/3,$$

for which $H^i = 4/3$, $H^m = 2$, $H^* = 11/3$. N may have any value such that $H^m < N < 10$.

The extremely simple formula (7), assumed for utility, is responsible for the fact that in the model under consideration, a decrease in prices always reduces Keynesian unemployment. But if the ophelimity function is assumed to have only the generally accepted properties, no definite sign can be attributed to $\delta N_1/\delta P$ on the basis of relation (65) which defines Keynesian disequilibrium. The conclusion that the disequilibrium theory offers us no guide on how to remedy Keynesian unemployment is not without value. On the contrary, it is worth remembering.

Discussion of the paper by Professors Fitoussi and Georgescu-Roegen

Professor Modigliani began by saying that this paper had a broad sweep, considering philosophical issues, and with Schumpeter very much in evidence. A major purpose was to explain why there had been such a sharp change in the pattern of unemployment before and after the Second World War. It was certainly true that since 1945 there had been less cyclic variation in unemployment but it was not clear to him whether the authors were saying that the average level had been higher or lower in the second period. Nevertheless, they wanted a model to explain what had happened. They began by rejecting disequilibrium theories like those of Professor Malinvaud. They castigated him for understandable reasons, criticising him for talking of disequilibrium without looking for a mechanism to put it right. Malinvaud assumed a given level of prices which was there for ever. If there was disequilibrium at these prices there was no reason why disequilibrium should ever end. Malinvaud did not search for an equilibrating process like that of Marshall's long run. Of course, there was no such thing as long-run equilibrium in the sense of a state reached but only a direction in which the system moved.

The authors explored unemployment along Schumpeterian lines as a reaction to the innovation process. Innovation disturbed equilibrium. The economic system then sought to re-establish it, so that there was a continuous move towards re-establishment of equilibrium. As we all knew, Schumpeter believed that innovation went in waves, though Professor Modigliani had always found it hard to see why. According to the authors, Schumpeter seemed to be correct until the Second World War, with unemployment a cyclical phenomenon. Since the Second World War however, there had been the Schumpeterian innovation to transform all Schumpeterian innovations. This was R & D expenditure which made innovation an induced process. Innovation still disturbed the system and led to unemployment and its reabsorption, but the flow was now steadier. Unemployment was not cyclical but permanent. The authors gave a number of factors which they thought caused unemployment today to represent a steady state situation. They thought there was persistent excess capacity with geographical dispersion. However, they gave no hard evidence on the existence of excess capacity. The authors further mentioned two reasons for the way unemployment responded. First, there was wage and price rigidity. Prices did change, but slowly, so that the adjustment process was also slow. Second, there was a supposed asymmetry in the response of modern managers to changes in demand. They responded to increased demand by increasing output less than they reduced it when demand fell. He was not quite clear whether the authors were talking about the speed or the extent of this response because the paper seemed contradictory. The reason why the modern manager behaved this way was that he was risk-averse. The paper went through various transformations to show that dispersion of demand led to unemployment. What he was not clear about was whether if there was zero excess demand output would be stable or whether it would then fall. The appendix to the paper was devoted to a formal and severe criticism of Professor Malinvaud and pointed to some shortcomings which led to some questionable results.

Professor Modigliani said he had two main criticisms of the paper. First, there was the asymmetric response he had already noted to increases and decreases in demand. In the paper, output responded less to increases than to decreases but he imagined that one could credibly support the reverse case. One could say that it was easy to increase output with existing capacity; only when new capacity was needed was there risk. When demand increased, business did not want their competitors to get a big share of the increase, hence they would respond fully. On the other hand, one could argue that workers disliked falling output because it led to unemployment, so that business would try not to fire workers but to reduce prices, accumulate inventories etc. In general, he was wary of asymmetries, including the one in the paper. He acknowledged, however, that American experience might be different from that in Europe. In Europe, employers seemed to be reluctant to hire workers because it was difficult to fire them later. One implication was that if demand increased this might not lead to a rise in output, or at least in employment. But then a fall in demand might also not lead to a fall in employment. In any event, this mechanism was not mentioned in the paper.

Second, in his view, the bearing of this source of unemployment was not too serious. The main thesis was that unemployment resulted from innovation. He was sympathetic to this view, but one ought to distinguish between whether unemployment had changed in nature, and whether or not it had increased on the average. He himself had reservations about a presumed increase in average unemployment after the Second World War, at least up to the seventies. There had certainly been smaller and fewer cycles since the Second World War, but he thought that was due to the application of Keynesian economics. The reason we had no more 1929s was that economists were smarter. Why was this not a possible explanation? Of course, since 1970, as a result of stagflation economists had become increasingly doubtful about their ability to manage exogenous inflation or to end the momentum of inflation, but he thought we had learned a great deal about the management of aggregate demand.

As for the average level of unemployment, the authors seemed to recognise only one source, that resulting from the loss of jobs through the disequilibrium generated and maintained by the process of innovation. This view of unemployment was consistent with models like that of Holt which showed that a steady flow of job losers could give rise to a stable pool of unemployed even though the losers would eventually find new jobs, because of the time required to find a job. But the authors neglected the many other sources of flow into the pool of unemployed – people fired because of shifts in private and public demand between products and regions, or because of fluctuations in aggregate demand, job quitters, new entrants and re-entry into the labour force.

All of these flows were important if one wanted to understand why there was an equilibrium rate of unemployment (the so-called full-employment unemployment) and why that rate was, say, around 5 per cent in the USA, but much lower in the Scandinavian countries or in the Federal Republic of Germany. For very open economies, and in the presence of multinational corporations, this diversity could not be so readily explained by the innovation model. The higher level for the USA seemed rather to be explained by the much larger flows of labour relative to the labour force, and perhaps longer job-search time, arising from such factors as the size of the country, the heterogeneity of the population and the greater freedom of firing which in turn generated a larger flow of job openings and greater readiness to quit. A small homogeneous country with appreciable restrictions on firing would be characterised by smaller flows.

In Professor Modigliani's view, the rise in the average rate of unemployment in the last few years must be seen as the intended result of aggregate demand management policies designed to bring inflation under control.

In conclusion, it seemed to him that the paper brought attention to an important phenomenon. There was a combination of the fact that dynamic innovation in society was good, but perhaps while it was good the conclusion was that one should not allow it to move too quickly because that led to unemployment. Nevertheless, he thought the authors took too partial a view, and in a broader perspective what they had to say could be more valuable.

Professor Georgescu-Roegen could not see how Professor Modigliani had reached the conclusion that he wanted 'to give hell' to Professor Malinvaud. He had taken the Malinvaud model as the basis for his criticism because that model was the most specific and precise of the set of such models, and was also the latest presentation of disequilibrium theory. All that he had done was to deal with the problems raised by the theory just as any scholar would.

Professor Georgescu-Roegen was prepared to accept most of what Professor Modigliani had said in addition. The paper he had presented together with Professor Fitoussi had not attempted to 'finish' dealing with the problem of unemployment. The authors simply wanted to point to what they believed to be its true cause. An analogy might be supplied by a river which sometimes flooded. One obviously needed more bridges, dams, etc. but this did not mean that the flooding was caused by the bridges and dams. The paper sought to show how the late capitalist society paid for its extravagant growth, often by developing a wrong technology. In the USA people spoke of 'another Edsel', because the Edsel was a car which had been carefully researched and advertised, but which in the end proved to be a total failure. Other worrying developments had been due to Madison Avenue advertising technology. Salesmen kept coming along and saying, 'What we sold you last year was rotten; now try this *new* gadget'. Why did we have to worry about Keynesian teaching if there were no innovations? And Walras and Marshall were perfectly right in saying that, with no disturbances, the economic system would move towards an equilibrium. Professor Georgescu's criticism of disequilibrium theory concerned the point that, given prices and real wages, this led to a static (determined) disequilibrium. He did not think that represented the factual truth.

Mr Kaser wanted to take up Professor Modigliani's introductory observation that the appendix to the paper was substantially focused on Professor Malinvaud's recent work, including his paper for this conference. The authors used three models, listed in the appendix. These were the Keynesian, classical, and repressed inflation models. These had been considered in the discussion of Professor Malinvaud's paper, and indeed had also been explored in some respects by Professor Hines.

Mr Kaser wanted to deal with the statement in the appendix that 'individuals seek to maximise their utility and firms seek to maximise their profits'. He suggested that in the real world individuals, in their role as trade unionists, were in fact willing to share work, and that multiplant businesses were prepared to share profits. Any of either that were not inclined to share in such a way could be compelled to do so by even the most libertarian governments through the conventional taxation system. Of course, in appealing to the real world an economist was often only urging his hearers to accept his own model, but he would like to quote a few empirical cases which, perhaps surprisingly, no-one had yet mentioned in the conference.

Two of Professor Malinvaud's macroeconomic models of involuntary unemployment required the profitable employment of capacity $\bar{y}$ in all its sectoral uses, namely, the Keynesian and classical situations. The early discussion had not considered the repressed inflation model whose conditions ruled, as Lord Kaldor had earlier noted, in the West immediately after the Second World War. Mr Kaser wanted to add that the model was relevant to eastern Europe today where sectoral production was clearly determined by the availability of employment, and not by profitability. Examples could be found in the coal mines of Wales in 1947 and today in Poland, but it was part of Mr Kaser's argument that it was not only in the repressed inflation model that the profit margin constraint could be relaxed. The instrument was the transfer of income, particularly between enterprises and through the aegis of the government. The role of government was also relevant to the distribution of personal income, which Professor Malinvaud assumed stable. Intersectoral financial transfer reduced Professor Malinvaud's equilibrating function for labour mobility. Shop stewards notoriously preferred labour mobility, though they could occasionally be overruled by their trade unions or government. Professor Timofeev had implicitly invoked the role of social transfers in his criticism of the authors' approach, and this could similarly modify the starting assumption of Professor Hines's paper, namely 'the simple fact that in a market economy production is undertaken for profit'.

One could rather say that in some western European countries there was pressure for production to be undertaken for employment reasons. Individual instances readily came to mind in the UK and in France (Lip). Japanese corporations were well known for their policy of employment maintenance. All such cases suggested a voluntary reduction of wage rates, or sometimes of hours worked. However, Mr Kaser's principal contention was that enterprises might well be motivated to produce up to or even beyond the break-even point provided that subsidies were paid if profits became negative. To avoid inflation, such subsidies must be financed from current profits or household income. But there were two vehicles for such transfers. First, households could be taxed. Second, multiplant firms could indulge in cross-subsidisation or be taxed. Marris's theory of managerial capitalism supported the idea of employment maintenance by pointing to various motivations. The important one here was the desire of these managers of a large firm to maintain its turnover to resist takeover by another. Professor Giersch had similarly mentioned the satisficing principle.

Professor Modigliani had already noted that transfers that were capital-deepening would be frustrated, either because savings were too small, or because an open economy could not maintain a low enough interest rate. Mr Kaser's own proposition should be followed through, partly by taking account of different propensities to consume between households and enterprises, as mentioned by Professor Kolm, or through raising the multiplier by distributing expenditure for the employed to the unemployed, as had been mentioned by Professor Henin.

Sir Austin Robinson said that, when confronted by a mathematical model, he always asked himself whether that model was covering all the relevant and important issues. He had no doubt that structural employment was important, but wondered whether the authors were looking at what mattered most. Unemployment in the1970s was perhaps more largely a consequence of the growth of the economies of Japan, Hong Kong, Singapore and other developing countries. Again, he thought of the oil crisis, of Britain's entry into the EEC and of the problem within the EEC of finding where the member countries' comparative advantages lay. There were also changes in income distribution, in tastes and in technology. These helped to cause structural unemployment.

What was it that limited the capacity of a country to adapt to the new situation? He thought there had been far too little work by economists on the practicable rate of adjustment by an economy with only price incentives. In wartime there could be rapid change because of controls. There was nothing of this in the paper. Perhaps one needed more work on these practical problems of how fast an economy could adjust. He thought that prices could handle such changes satisfactorily if they were no greater than, say, 2½ per cent of change per annum. In Europe today he was not surprised that there was structural unemployment. Countries could not adjust as rapidly as was needed at the moment.

Professor Malinvaud limited his discussion to four types of consideration.

First, concerning the scientific approach to the study of unemployment, he would easily accept the role of dialectics, especially in order to impose a complete grasp on the phenomenon. But then modelling had still a complementary role to play for the consolidation of dialectical discoveries and for the study of their consequences.

There was also agreement on the fact that explanations of unemployment should bring in time in an essential way (the unemployment of the 1970s could not be fully understood without reference to the events of the 1960s). Irreversibility and asymmetry were then important, as always when time was involved. Static models were not necessarily useless, but they were certainly partial.

Second, since unemployment was a disequilibrium phenomenon, rapid innovations could in some circumstances make unemployment worse. He was *a priori* ready to give credit to the main argument of the paper, namely that the present unemployment was structural and caused by technological innovations.

However, as a dialectician, he would find it hard to accept this as the whole explanation. He thought the authors were too pessimistic about our ability to absorb unemployment. He could point to periods in history when innovation was high and unemployment low, and did not think one could fully explain recent unemployment in these terms.

Third, Professor Malinvaud thought there was also agreement on the role of uncertainty in the behaviour of the firm. This might explain the increase in unemployment first in 1971 and then in 1973. He was quite happy to accept what the authors said about asymmetry, but was perplexed at the claim that a fundamental reason for present unemployment was the 'growth mania' of the new managerial class. One could not argue simultaneously that managers were too much growth-oriented and that, because of uncertainties, they did not build the productive capacity that was needed.

Fourth, as for the Appendix, Professor Malinvaud was ready to accept most of it and to recognise that the theory of general equilibrium under fixed prices and quantity rationing raised still more problems than he had dealt with in his own writings. In particular he agreed that a precise analysis of unemployment ought not to deal only with the labour input but to distinguish between number of employees and hours of work.

He did, however, have considerable difficulty with the last sentence of the Appendix. 'Models that aim only at simply describing possible disequilibriums, even when they are not affected by short-comings of the kind pointed to in this Appendix, cannot shed much light on the cause of unemployment and on its impact on the adaptation of markets.' He thought the Appendix showed how difficult it was to create such models. But since unemployment was a disequilibrium, there was no alternative when one wanted to supplement dialectics by more analytical reasoning.

Professor Bergmann wanted to look at a narrow point, namely the contribution of the increase in frictional unemployment to current unemployment problems. She agreed that attention to job turnover and to the role of search in the labour market process was valuable, but this theoretical emphasis had led to airy statements on its large importance. In an extreme case, one could say that all unemployment resulted from turnover, so it was necessary to do some measurement. Her own work had measured the extent of frictional employment and the extent to which an increase in turnover had led to increase in unemployment with demand constant. Figure 12.2 in her own paper showed that white males had a 2½ per cent probability per month of being hired. 1 per cent of the 6½ per cent unemployment rate could be attributed to frictional unemployment. We could take it that frictional unemployment showed up in vacancies. If frictional unemployment resulted from search, then only an ability to find a job vacancy was confirmed.

If innovation led to unemployment, we could talk of demand shortage. So if one really were interested in frictional unemployment, one was interested in the match between job creation and job destruction. If when anyone left a job it was immediately refilled, there was no frictional unemployment. However, we had not even begun to explain the increase in unemployment which had occurred.

Professor Henin turned to the main theme of the paper, which was that a major cause of unemployment was change. Maybe most economists wanted to say rather that the main cause was uncertainty about the way in which change occurred in the economy. But Professor Henin thought that a more essential and more operative answer was to note that such a change occurred in a decentralised economy, where, unlike the models by Walras and Pareto, there was no perfect mechanism for the *a priori* co-ordination of plans. This was the very message of disequilibrium theory. There might be a wide variety of models saying that. But the important point was that – to be relevant – they had to speak about an economy with imperfect co-ordination.

Professor dos Santos Ferreira referred to the appendix to the paper. He did not share the authors' interpretation of the general equilibrium model with quantity rationing, but wanted to stress that the distinction which they introduced between the amount of employed manpower and the length of the working day seemed to him a potentially important innovation. However, he did not think that this distinction was introduced in the most fruitful way, nor that it considerably modified the working of the Malinvaud model. The authors considered exclusively the influence of consumer behaviour and institutional factors on the length of the working day. In fact, working time was the result of (constrained) optimisation by the firm, taking account of the increase in the average hourly wage rate resulting from overtime. It would be interesting to consider the effects upon the different equilibrium regimes of the variability of working time as a consequence of firms' rather than of workers' behaviour.

Professor Frey referred to structural change on the side of labour supply. There was a big change in work force participation, and participants knew that he looked for a change in participation by the aged in future.

He wondered whether it would be better to renounce bad technological progress or to find better technological progress than in the last decade. He referred to a 1965 report on technology in the USA which had pointed to a drastic reduction in hours of work per week.

Dr Gordon was surprised to read in the paper that most unemployment was frictional unemployment caused by frequent structural change resulting from innovation. That, to her, was structural unemployment. To her, an increase in frictional unemployment resulted from the fact that people left jobs or were fired, even though there was no change in output. This might be very difficult in practice to distinguish from cyclical unemployment.

Professor Modigliani had said that he did not see why innovation should come in waves. What Schumpeter had actually said was that innovations were implemented in waves. This was important here because there was no reason why that was less true now than it used to be. It was true that there was now more research and development, but there was still the same phenomenon of the wave-like implementation of innovation.

Professor Hines agreed that one should discuss the different shocks to which an economy was subject, and that the method of adaptation to these was unimportant. The framework which he and Professor Malinvaud both used could be made to encompass them.

The appendix to this paper looked at the disequilibrium method which could be used where prices did not adjust. Most economists now seemed to agree that a quantity response was perhaps the most immediate reaction to a shock. There was not a Walrasian market-clearing vector of prices, but some prices adjusted faster than others. For example, as in the paper, capital markets cleared more quickly. Adjustment might be more rapid for product markets as compared with labour markets, though these did adjust and it was recognised that quantity adjustment might operate rather than price adjustment. If there was no adjustment of prices in the goods market, one could have an increase in imports. Whether foreign exchange was then available had implications for the adjustment of goods prices.

One also had to look at the implications for profit. The authors did say that, in a market economy, one must start from some rate of profit. Whether this would lead to growing unemployment would depend on wages, prices and the rate of interest. If one by-passed this system, what was the alternative mechanism? Perhaps one could not talk in terms of the general level of profitability and of cross-subsidisation. One would then have to find a new way of generating a level of activity. However, it was necessary to develop our models for doing that.

Professor Holt did not think one could link frictional unemployment to the number of unemployed. The idea was not sound. There were severe difficulties in identifying voluntary and involuntary unemployment. It was necessary to study the costs and benefits of unemployment, and these concepts were then not very useful, even though Professor Bergmann's measure was a very ingenious one.

Lord Kaldor said the issues raised in the Georgescu-Roegen–Fittousi paper had been discussed as far back as the 1920s at the Kiel Institute. The unemployment then being experienced in Germany was put down to technical change. He agreed with Professor Malinvaud that there was no evidence that technical change was now so much faster than a few years ago or that that particular feature explained the radical difference in the rate of unemployment and the gravity of the situation in western countries today. In the 1960s, OECD countries took it as a matter of course that aggregate output would grow by 5 per cent per annum and argued that stability was unimportant. Some countries grew more rapidly than others. In the UK with much unemployment in the previous decades and a good deal of emigration, there had been twenty years during which unemployment had been less than 2 per cent.

All that had now changed, and he thought it was important to ask why the capitalist world had grown so quickly for so long. There had been harmonious development. Even though there were intersectoral pressures, all went well, and consumption and production moved in step. There was no rapid increase in prices, but no collapse either. He thought the latter had been prevented by the readiness of governments to build up stocks, while technical progress in land-saving inventions had helped the output of raw materials and fuel to increase rapidly. This harmony had now vanished, and things had gone haywire. However, he did not think one should conclude that we were entering on a new age where we could not sustain the working population in employment. In ten years' time, he suspected that we should find that many of the fears in this discussion were premature.

Professor Fitoussi replied to the discussion. The paper intended to say that unemployment was affected not only by variations in aggregate demand, but also and sometimes more importantly by the way in which they took place. A general reduction of income, for example, had discriminatory effects. The first impact would be on some markets rather than others. Therefore macroeconomic reasoning should not be abandoned. But one had also to look at structural effects. In some situations the structural effect was far more important than the global effect.

He agreed with Professor Henin that we need a theory of imperfect co-ordination of markets, but he disagreed on the fact that the theory of general equilibrium with rationing provided such a framework. This theory worked in terms of co-ordination through quantities rather than prices, so one had trial and error models with full co-ordination through quantities.

A productive way of working on a theory of imperfect co-ordination was to look at the asymmetries which characterised the economy. There was general agreement among the economists about the existence of such an asymmetry in variations of prices. Thus price movements had an upward bias. But this was only part of the story. As a corollary there was an asymmetry in quantity variations; *an inverse asymmetry*. So quantity movements had a *downward* bias. Macroeconomic equilibrium was by nature stochastic, since such an equilibrium was the resultant of a plurality of disequilibria. It was the null average of a series of excess demands of contrary sign. A structural disequilibrium was therefore associated with macroeconomic equilibrium. One had partial markets in imbalance, with structural disequilibrium leading to positive effects on prices and negative effects on quantities. Hence to the Phillips curve, which was an inverse conjunctural relation, we had to add a direct structural relation between inflation and unemployment. The important point was to understand that the two relations were complementary.

To Sir Austin Robinson, Professor Fitoussi replied that the factors the former emphasised produced a structural imbalance. He himself had not only been concerned with innovation in the technical sense. 'Novelty' was multidimensional. It could be expressed by innovation – a change of taste, technique, the expansion of markets – or by institutional evolution – alteration of tax rules, unemployment compensation, the length of the working day. It could be brought about by the transformation of a country's international relations, as in the case of economic developments affecting bargaining power. In short, it could be manifested in many areas, and could, by its nature, be constrained by a taxonomy. So the shocks of innovation led to some unemployment through the worsening of structural disequilibrium. For Professor Robinson this meant that this effect was most important for structural unemployment, but it also had an impact on aggregate demand and production. One of the models in the paper showed that structural disequilibrium led to a fall in the production or in its rate of growth.

To Professor Malinvaud, Professor Fitoussi pointed out that the paper did not argue that dialectical reasoning was the only possibility. However, one needed to combine it with analytical reasoning, otherwise one would not see the mistakes in the dialectical process. This was an essential basis for the progress of economic science.

At the conference, the distinction had been discussed between frictional unemployment, structural unemployment, and unemployment resulting from deficient demand. He did not believe that one could distinguish in this way between structural and involuntary unemployment. He thought that structural change led to unemployment and that, for most economists, involuntary unemployment was the most significant and relevant type. Changes in real demand and in structures led to involuntary unemployment. So even if we had a situation where excess demand was zero, we might have unemployment. He had tried to show that even if there was good macroeconomic demand management, this would not solve all the problems of involuntary unemployment.

Professor Georgescu-Roegen also replied to the discussion. He pointed to the extensive recent literature on modern innovations. This phenomenon was well-known and had been recognised by many writers, for example, Galbraith. There had been studies of the rhythm of innovations over the past 150 years. However he thought there was a difference of several orders of magnitude between different decades. After 1945, innovation had become much more frequent, especially in electronics and chemicals. It was not possible to deny that this increase had led to more frequent exogenous shocks to the economic system. Since prices (in this case) adapted more rapidly than quantities, any innovation led to difficulties. He did not want to get into the semantics of the various types of unemployment, but simply wanted to show that innovation necessarily led to 'frictional' unemployment.

Professor Fitoussi and he had referred to the difference between dialectical and analytical models, and to the legitimate importance of the former. Professor Malinvaud's contribution had been concerned with specific functions rather than with a general model. In doing what he had done, Professor Georgescu-Roegen had only pointed to some of the inconsistencies of that specific presentation. If one represented prices and wages in a plane, one had an area of Keynesian unemployment, another for classical unemployment, and other kinds. The unsatisfactory point of this theory was that it led to different types of equilibrium in some cases, depending on the position of prices. There was therefore ambiguity. By modelling unemployment situations, one could solve such an analysis mathematically to show what actually was happening. For Keynesian equilibrium, one had one description of the situation, just as one might identify a square among all quadrilaterals. But the system did not explain the actual reason for unemployment. It did not address itself to the real-world problems.

Professor Bergmann mentioned the lengthening of the period of unemployment. This was a point made in general. In a more precise analysis, it bore on the impact of innovations.

Professor Holt had said it was not clear that all problems were looked at from one point of view. He thought that opinion was justified. Causes were hopelessly multiple.

On the criticism of the paper by Professor Robinson, Professor Georgescu-Roegen said it would be foolhardy to try in a relatively short paper to set out the policy measures required to solve the complex problem of unemployment. He and his colleague had not tried to do this, but to show how continuous shocks, caused by innovations of all sorts, were responsible for chronic unemployment.