LONG-WAVE RESEARCH: THE STATE OF THE ART, ANNO 1983

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FOREWORD

This Collaborative Paper is very deserving of the name because it results from a conference held in Italy in October 1983 and from the collaboration that has continued since that meeting. Dr. Delbeke has done a magnificent job in placing individual theories in the wide spectrum of views on the long wave on the basis of the results of the latest research, and in identifying the relationships among the different theories. What is more, he has managed to describe the character of these relationships (as either complementary or contradictory), so creating a complete picture of the most recent thinking on the subject.

We are making this overview available before the proceedings of the conference appear, and particularly to provide background material for the next long-waves conference, which will be held on 10–15 June 1985 in Weimar in the German Democratic Republic.

Tibor Vasko
Leader
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PREFACE

This review of current research into long waves is primarily based on the papers and discussions at the Conference on "Long Waves, Depression, and Innovation: Implications for National and Regional Economic Policy", organized by IIASA (Austria) and IRPET (Italy) and held in Siena and Florence from 26 to 29 October 1983. This meeting, the most recent of its kind, was intended to bring together all the leading researchers in the field. Although the organizers almost succeeded in reaching this goal (E. Mandel, W.W. Rostow, and I. Wallerstein could not attend), it was to be regretted that a representation of economic historians was not invited. Their absence will therefore inevitably be felt in this paper, because the reconstruction and reliability of historical times series were not treated at the Conference. In our view, however, the participants were representative of the main schools of inductive and deductive research.

The organizers planned five topics upon which the discussions should concentrate. These topics were:

(1) Theories of the Long Wave
(2) Identification of Long Waves
(3) Theory Testing and Integration
(4) Possibilities for Influencing Long-Wave Behavior
(5) National and Regional Aspects.

However, the scheme was not followed very strictly in the composition of most papers, partly because the various long-wave studies do not yet form a coherent body of research; this is still in its early phases of scientific development, though it is evolving fast. Different approaches of interpretation are competing on an equal level, and it seems that many of them might be profitably integrated.

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ABSTRACT

In this paper a classification and a survey of recent long-wave theories are presented. According to the basic variable of each approach, real-economic, monetary–financial, and social structure theories can be discerned.

The inductive research is concentrated round the generalization of logistic growth paths borrowed from natural science, and the traditional but perhaps more preferable descriptive statistical methods for treating historical time series.

The more deductive research is the most expansive field, and four directions can be found in it. The historical–institutional approach of Freeman and his SPRU group considers essentially the diffusion of the microelectronics technology complex as the most important challenge for the world economy. The growth-theoretical approach, starting with Mensch's publications, deals more with the analysis of unstable growth paths originating from technological basic innovations. The system dynamics model simulation of Forrester and his MIT group accentuates the rational behavior of microeconomic agents resulting in macroeconomic instability, caused by a self-ordering mechanism. In this context, monetary and financial variables seem to be important amplifiers of that instability. Finally, the influence of extraeconomic variables is an important debating theme. Indeed, fundamental technological change leads to institutional innovations on a national but most of all on an international level, and this leaves ample room for economic policy.

1. INTRODUCTION

Given the current state of long-wave research, it is difficult to present a comprehensive summary of all the papers and discussions at the Conference. Therefore, this paper presents only one of the possible interpretations of the state of the art. Nevertheless, we are convinced that this disadvantage represents at the same time a merit of the paper. Indeed, it is in the early stages of research, when the confusion is considerable, that insights are essential. This is why the paper will not adhere to the five planned topics, but will review the most important issues.

In the next section, we sketch the theories that have been revived or developed recently and classify them according to which variables are considered crucial in the different explanations. The rest of the paper deals with relatively new methods and models. After a short review of the inductive investigations, the fourth and most extensive section concentrates on theory building. Four main classes of explanations can be discerned: the historical–institutional, the growth-theoretical, and the macroeconomic approaches, completed with theories based on the influence of noneconomic variables. The final discussion is dedicated to policy issues and the probable directions of further research.

2. A CLASSIFICATION OF RECENT THEORIES

In a general sense, we may state that long-wave research deals with structural changes in the economy. Nevertheless, there are many different approaches, and several authors have developed schemes of the most important ones. In our view, three main categories of theory can be discerned: the real, the monetary, and the institutional. At the time of writing, the real theories clearly are the most attractive, and this was made evident at the Conference.

Delbeke (1981) classifies the real theories according to the production factor that is supposed to be crucial and shows the complementary character of the different approaches. The role of entrepreneurship is considered to provide the most important approach (*Bruckmann*)*. Schumpeterian innovation

* Authors' names are italicized where references are to Conference papers (see list of References at end of paper).

theories are certainly the most widely debated since *Das Technologische Patt* (Mensch 1975). Freeman stresses the impact of innovation on labor demand, and he and his Science Policy Research Unit (SPRU) at the University of Sussex are becoming increasingly involved in a fundamental discussion with Mensch (Freeman *et al.* 1982). The capital theories of Forrester (1977) (excess capacity) and Mandel (1980) (the Marxist law of the falling rate of profit) are taking up and modifying the original ideas of Kondratiev. Rostow (1978) stresses the availability of raw materials and is, to a certain extent, generalizing from the oil scarcity of the 1970s.

This classification scheme can be broadened to incorporate relative prices, which many authors treat either implicitly or explicitly. In our scheme, we observe that the production factors gradually become scarce during the upswing and abundant during the downswing, but to varying degrees. This is, in principle, reflected in the relative factor prices. However, this redistribution of factor income, which is an essential feature of the long wave, can be hindered by inertia. Some institutional theories consider this disturbance explicitly, and interpret the time lags as necessary to produce the long-wave depression. Some authors take the Marxist approach to be a different class of real theory. However, Marxists are opposed to this, in our view rightly, because the declining and rising rate of profit, i.e. the rate of capital accumulation, is also inherent in any other approach. In fact, they take the distribution of factor income, and the concomitant social struggle, as the most important element of their theory.

Theories based on the relative prices of goods can also be included in our classification scheme sketched out above. For example, the rapid growth of leading sectors is caused by declining relative prices of their products, made possible by improvement innovations in the products and in the production processes. Similarly, on an international scale, Rostow's theory deals explicitly with the terms of trade of primary versus industrial goods.

The monetary theories can be treated as a second category. Interest in the monetary aspects of the long wave has been remarkably low in recent research. During the interwar period it was quite the reverse, when most researchers stressed that the price level most clearly reflected the long wave, being the link between the real and the monetary sector (Dupriez 1947, 1959). Of late, few researchers have been attracted to this type of analysis because of the constant rise in prices since the 1930s. Therefore, when prices were

analyzed, interest shifted more to relative prices. Moreover, most researchers are troubled by the stress laid by Kondratiev and Cassel on gold discoveries, which have, of course, been important to the gold standard but much less so to the fiduciary standards since the interwar period.

Some Conference participants mentioned, however, that the price level, calculated as the wholesale price relative to gold, showed the clearest long wave (*Craig and Watt, Goodwin*). Others stated that a study of long-term fluctuations in price formation, credit, and money circulation is absolutely essential (*Menshikov and Klimenko*). The group from the Massachusetts Institute of Technology emphasizes the role of these variables in the downswing, particularly for economic policy. Two papers were presented to stimulate long-wave analysis of the monetary sector. *Senge* analyzed the interplay of nominal interest rates and inflation, i.e. the real interest rate, while *Delbeke and Schokkaert* studied the interaction of investment and debt, indicating the possibility of endogenous money creation during the long wave.

Theories that emphasize social and institutional structures can be considered as the third main category of long-wave theory. A very appealing approach of this kind was presented by *Perez-Perez* of the SPRU. She calls for a global view instead of a too narrow economic analysis: to explain long waves the total system must be studied, i.e. the interactions of the technological, social, and institutional components with the economic subsystem. (The work of Gordon *et al.* (1982), stressing the social structure of capital accumulation, should also be mentioned here.) For example, the distortion of market signals as a result of the counterproductive behavior of institutions, which prolongs the depression, can be interpreted as a specific case of institutional factors at work (*Glismann*).

This classification of real and monetary economic theories and of theories referring to social structure allows us to make some useful observations. All three types of approach agree, implicitly or explicitly, that the long wave is inherently based on capital accumulation and is therefore most noticeable in the industrial economies, especially the market-oriented economies. Moreover, it seems that a fruitful integration of long-wave theories is not possible if these three main categories are not included. The monetary and financial sector seems to be particularly neglected in research, because it has to be considered as more than a mere reflection of the real sector. Finally, it should be noted that any classification is only possible with some degree of simplification. In

fact, many long-wave theories belong to more than one of our categories, because the present classification uses the basic variable as its sole criterion. This classification is therefore first and foremost a logical scheme developed for the confused observer who wants some insight into a rapidly expanding field of research.

3. THE INDUCTIVE RESEARCH

The identification of the long wave is the crucial first phase of research for several reasons. *Mensch* (Paper B) calls it "exploratory research [which] usually means descriptive, historiographic, empirico-inductive (data-driven) work directed at formulations of tentative hypotheses and tentative assumptions." We think this is an unavoidable phase, since there is no firm body of deductive reasoning available. Hence, the different long-wave theories had to start from diverse empirical indications, and this has led to different conclusions – at first sight, at least.

Secondly, and related to the first reason, mainstream economists feel quite skeptical about the long-wave concept. Statisticians see the long wave as a "result" of wrong statistical procedures, especially of detrending with moving averages, with filters in spectral analysis, or with the choice of the basic movement (Slutzky effect; see Slutzky 1937, Adelman 1965). Others argue that there are very different statistical procedures that empirically show the existence of the long wave (*Glismann*). Indeed, we may at least accept that there are some recurrent unstable movements over the long term. Another criticism is that the statistical procedures are applied to series that are found to be too short, given a length of about 50 years for one long wave. Thus, the whole idea of the long wave could have started erroneously, from overinterpretation (*Entov*). Forrester and his MIT group try to avoid this problem by rejecting correlation analysis in favor of the methods of system dynamics. In their view, a model that generates data comparable to the historical data forms a good statistical test, while what remains unexplained by the model consists of historical peculiarities.

We are convinced that a reconstruction of economic time series for the whole industrial period is a crucial task, of which the largest part still has to be done. Freeman even remarks that this task should be seen as an art (*Freeman and Soete*). Moreover, when reconstructed data, especially national accounting data, are available, historical criticism remains essential to show where the weaknesses are situated, in order to avoid drawing empirical conclusions from *a priori* reasoning. We consider this art of data reconstruction as one of the most important and promising forms of research, which must be continued despite the rapid development of the more deductive approaches.

However, empirical analyses were of minor importance at the Conference, and we attribute this to the absence of economic historians. Nevertheless, a good sample of inductive long-wave research was presented. Firstly, there was the approach of Craig and Marchetti, who collected, selected, and analyzed several groups of long-term data. They concluded that a certain long-wave pattern was observable, and made extrapolations for the future, the former cautiously, the latter self-confidently.

Craig found some, but not abundant, evidence to support the idea of the long wave as a metaphor for change. His long waves were strongly correlated with war, and therefore the extrapolation suggests an extremely dangerous period early in the 21st century.

Marchetti can be considered as the leading advocate of the inevitability of logistic growth caused by innovation processes (*Craig and Watt*). Craig sees the saturation problem as very difficult for this type of analysis. Indeed, the fit of logistic equations assumes that one knows in advance what the saturation level is, while at the point where saturation is reached there seems to be ample reason to believe in further growth, e.g. in the automobile sector (*Craig and Watt*). In contrast, *Marchetti* uses the logistic curve as the best method to describe physical phenomena and concludes that "the signals... are crystal clear" when one is "getting out of the quicksands of money indications". In his view, long waves go beyond economics, and therefore he prefers to define them as "long-term pulsations in social behavior". He concludes that "A pulsation of about 50 years seems to pervade all sorts of human activity", and that this takes place without much decision making. For example, "car populations grow exactly like animal populations", while nuclear fusion can be expected for 2025, "*Alles im Schritt*". What Craig mentioned as possible is strongly advocated by Marchetti, i.e. that strict biological rules are at work in the economy, and in human

society.

This kind of research raises a lot of interesting questions. The use of logistic curve analysis, showing saturation levels, is taken up by several authors, implicitly or explicitly (e.g. *van Duijn* and *Vacca*). However, one has to realize that saturation in economics is never absolute but relative. But most of all it is crucial to know whether economic behavior follows the deterministic rules of a biological system. If the answer is positive, the search for policy measures has no sense at all. This suggestion will be taken up in Section 4 when we deal with the self-organization paradigm. However, at this moment it is good to keep in mind the warning of Schumpeter (1942), quoted by *Islam*: "Analysis, whether economic or other, never yields more than a statement about the tendencies present in an observable pattern. And these never tell us what *will* happen to the pattern but only what *would* happen if they continued to act as they have been acting in the time interval covered by our observation and if no other factor intruded."

The inductivist approach, borrowed from natural science, was not followed by *Bieshaar and Kleinknecht*. They analyzed GNP and production data for the world and for seven individual countries. Their aim was to supply some practical evidence as a basis for further development of long-wave theory. Their most interesting conclusion is that the evidence for the existence of long waves before 1890 is ambiguous, except for Belgium, Italy, and Sweden, but that there is a fairly significant pattern after that date. The pre-1890 ambiguity can be explained in three ways: by underestimated data, by movements with stronger impacts than the long wave (e.g. the hegemonic life cycle of Great Britain), or by the hypothesis that long waves become primarily important for the era of *Hoch- und Spätkapitalismus*. A complementary explanation could be the remark of *van Duijn* that, during and after its economic take-off, a country is less affected by the next long-wave downswing. This claim is confirmed by Bianchi's empirical regional analysis for Italy (*Bianchi et al.*). Indeed, since 1890 all countries analyzed by Bieshaar and Kleinknecht have become mature economies.

In our view, the latter way of empirical analysis is helpful and must be pursued further, not only for production data but also for more qualitative and social information. In this way new insights can be brought to the fast-growing deductive research. However, it would be more successful if this theoretical development could help define important areas for further empirical

investigation.

4. THE MORE DEDUCTIVE RESEARCH

In recent years, most energy has been dedicated to the interpretation of the long wave, and to the search for underlying causal mechanisms. In fact, several people implicitly assume that further efforts to demonstrate empirically the possible existence of long waves may be subject to rapidly declining marginal returns (e.g. *Delbeke and Schokkaert*). Several researchers even doubt whether a definite statistical proof can be produced in the near future (*Freeman and Soete, Bieshaar and Kleinknecht, Tinbergen*), while for van Duijn using the long-wave concept is an act of faith (van Duijn, oral comment). *Mensch* (Paper B) goes a big step further, claiming that we are leaving the inductive phase and entering the deductive one. Indeed, waiting for the next hundred years has no sense at all, while we can take the prediction by several authors (e.g. Mandel) of the present downswing as an indication that "something" is happening over a very long term. *Menshikov and Klimenko* offer some consolation with the remark that we have neither strong empirical evidence for the existence, nor convincing theoretical arguments for the impossibility of the long wave. Given that any science needs a framework of thought for its development, we are convinced that enhanced deductive reasoning becomes essential.

Critical observers often state that the long-wave concept can only attain credibility if scholars develop theoretically convincing endogenous models for it (*Bieshaar and Kleinknecht*). While most Conference participants fully agreed about this need, it remained dubious within which boundaries the fundamental forces are supposed to be at work: within the economic system or within the whole society. *Goodwin* made a remarkable intervention, doubting the possibility of an endogenous economic explanation of the long wave. In particular, he thought the determination of the lower turning point extremely difficult. In our view, Goodwin's remark goes to the heart of the present research. The assertion that the long wave is intimately connected with the whole of society, i.e. with economic, social, and political variables, gained support from many researchers. This argument can also be found in the older theories, which state, for example, that wars accelerate existing processes and are responsible for the change in their direction (Dupriez 1947, Akerman 1957). However,

within such a broad framework, some made a deterministic interpretation, e.g. Marchetti, while many others made a nondeterministic one, e.g. Goodwin, Freeman, and Tinbergen. According to Tinbergen, only conditional predictions can be made because of the important role of exogenous variables. Therefore, we may state that the economic–holistic and deterministic–nondeterministic dualities in long-wave analysis will have strong implications for the design of economic policy.

Freeman pointed out that a meaningful division of the various long-wave theories might be between the neo-technological theories and the rest (*Freeman and Soete*). Indeed, most interest in the recent past was given to Schumpeter's thesis about innovation as a process of creative destruction. In 1975, in his work *Das Technologische Patt*, Mensch reopened the debate by claiming that a long-wave depression can only be overcome by a cluster of basic innovations. This cluster breaks through because entrepreneurs are forced to innovate, given the saturation of existing markets and the urgent need to create new ones. The following upswing is carried by rapidly expanding leading sectors, in which the basic innovations are improved. Mensch's interpretation of Schumpeter's work has been named the "depression-trigger" hypothesis, because in the middle of the downswing, the "technological stalemate", numerous radical innovations are the only way out of it.

This hypothesis has been criticized by Freeman and his SPRU group. They question the supposed clustering of basic innovations in the depression. According to them, recovery is based upon the rapid diffusion of applications of new technologies that had emerged as basic innovations before the depression. Moreover, counting basic innovations can be misleading, as it is not primarily the individual innovations but rather the systems of interrelated product and process, technical and managerial innovations that seem to be of most importance. According to the SPRU, then, the main policy objective is not so much to stimulate new basic innovations as to develop policy measures aimed at fostering the diffusion of the new, and existing, technological complex in such a way as to minimize social costs worldwide and to reap the maximum social benefits. Freeman's stress on the diffusion of the new technology complex is also indicated in the literature as the "demand-pull" hypothesis.

This technology debate opened a wide and fruitful discussion on the basis of Schumpeter's work and forced both groups of researchers to deepen their analyses and arguments. In this way two very different methodologies

developed. Mensch refined his hypothesis on a more mathematical basis, and together with his collaborators he tried to integrate his innovation hypothesis into formal growth theory using nonlinear dynamic models. Freeman and his SPRU group followed a completely different way of research. They stressed the need to analyze the unique features of microelectronics and related technologies. In their view, a rapid diffusion of the new technologies is hindered because there is an urgent need for accompanying institutional innovations, on both the national and the international level. Using an historically oriented and institutional approach, they are able to develop clear, operational directions for economic policy.

To these two important technological theories must be added two other approaches, namely the more macro-oriented research and the analysis of noneconomic variables. However, we have the impression that these might possibly be integrated into the two methodologies described above. The system dynamics methodology of Forrester and his MIT group emphasizes the growing excess capacity in the upswing, which must be brought back to "normal" levels during the downswing. Technological innovation is essentially playing a passive role, although it can be activated. The basis of their analysis is the microstructure of self-ordering in the capital goods sector, although numerous amplifying variables can also be integrated. Menshikov and Klimenko utilize the Marxist law about the tendency of the falling rate of profit. In a small model they illustrate the interplay of labor and capital productivity and the effect on profits and industrial change. Delbeke and Schokkaert demonstrate that long-wave instability may also follow from financial and monetary variables and that even a simple linear dynamic model can generate long waves. They describe some important macroeconomic barriers to rapid diffusion of innovations. Finally, Millendorfer and Screpanti model the important influence of noneconomic variables. Following these principal lines of thought, we will review the different contributions to the building of theories of the long wave.

4.1. The Historical–Institutional Approach

Freeman and the SPRU group can be considered as the main representatives of what we can call "the historical–institutional approach". Indeed, they reject any deterministic conclusions from history, and look for concrete policy measures, particularly of an institutional character, in order to cope with the enormous problems accompanying the diffusion of the present technological complex.

Following Freeman, we can learn a lot about the historical relationship between innovation diffusion and economic growth. However, mechanistic predictions have no sense at all, because the actual technology complex and its effects must be placed in the broader framework of human society. Each long wave must be studied as an historical epoch, containing constant and variable relationships, both having considerable importance. For example, it is essential to take into account that Great Britain was overtaken as a technological and world leader in the third Kondratiev cycle. Analogously, researchers must be very careful with historical statistics, because their classification is closely connected with past historical circumstances.

Partly for that reason, the counting of innovations and the division between basic and improvement innovations, the basis of Mensch's work, seem to be problematic. We must urgently study the diffusion of the present interrelated group of fundamental innovations, i.e. the microelectronics sector. Not only economic but also institutional and social factors are determining whether this potential carrier of new growth will have a positive impact on society. In particular, an accompanying policy will determine the demand for, and thus the speed and the effects of diffusion of the new technology complex. We must realize that technological and institutional innovations are two sides of the same coin, but that very different combinations of both are possible.

The diffusion of the microelectronics sector has been analyzed in detail by Soete and Dosi. Their most interesting conclusion is the enormous rise of capital productivity, and hence the capital-saving potential that could ease the shortage of this production factor to a considerable extent. At the same time, however, the labor displacement effects are significant and therefore handling the combined consequences, including the inevitable resistance from workers, will require skillful and imaginative policies. As regards the diffusion issue, Soete points out that the conditions for successful entry into the area of

microelectronics technology are different from those of the more traditional industries. Instead of requiring production experience ("learning by doing"), as in mechanical engineering, or overall plant experience ("learning by investing"), as in the chemical and other process industries, these technologies, at least in the present phase, can be based on direct application of scientific and engineering knowledge. Since, in addition, the particular features of the technology make it difficult to protect, technological competition on a world scale could increase in importance. For these reasons, the international diffusion of microelectronic applications to the newly industrializing countries might be more rapid than generally expected. In Soete's view, a period of recession and depression is not only a period of dramatic national structural "shake-ups"; it is also a period of shake-up in the relative ranking of countries according to both growth and technological performance.

Perez-Perez has worked further on the social and institutional innovations by adding an attractive dimension to the long-wave debate. She claims that, while the economic subsystem can largely be treated as self-contained, this cannot explain long waves. The depression in the long wave must be conceived as the symptom of a serious mismatch between the technoeconomic subsystem and the socioinstitutional framework, while the upswing is a positive interaction between these two spheres: "depression is a 'shouting' need for full-scale reaccommodation of social behavior and institutions in order to suit the requirements of a major shift that has already taken place, to a considerable extent, in the technoeconomic sphere." The depression is thus a process of "creative destruction" not only in the productive sphere but also in the social and institutional spheres. The mismatch is occurring because the two subsystems have very different rates of change: the economic sector, spurred by profit and growth motives, is rather flexible in comparison with institutions, which suffer from a high degree of inertia.

Perez-Perez' main contention is that technological evolution is neither continuous nor haphazard, but that it occurs in successive distinct waves related to the dynamics of the relative cost structure of all possible inputs to production. She suggests that, in a very broad sense, each technological wave would be built around the intensive use of a particular input or set of inputs – which she calls the "key factor" – with certain basic characteristics: (a) low (and descending!) relative cost, (b) apparently unlimited availability, (c) potential all-pervasiveness, and (d) a capacity to reduce the unit costs of

capital, labor, and products and to change them qualitatively.

Perez-Perez proposes that, around the peak of a Kondratiev cycle, the technological wave, or "technoeconomic paradigm", based on the prevailing "key factor", exhausts its capacity to increase productivity and profits further. During this period, through a trial-and-error process, a new group of technologies emerges, based on a new low-cost input, involving not only strictly technical innovations but also new managerial and organizational principles. This new set of technologies allows a quantum jump in potential productivity, which is why it gradually turns engineering and managerial "common sense" toward intensive use of the new "key factor" and toward the now higher "best-practice frontier".

Thus, she suggests that the oil-based "mass production" paradigm, which lay behind postwar growth, is being substituted by an information-intensive, microelectronics-based, "flexible production" paradigm, which increasingly determines the new "how", "what", and "where" of profitable production, transforming the pattern of investment and influencing the behavior of most markets. But the social and institutional framework that was appropriate for the deployment of the energy- and material-intensive industries does not suit the requirements of the new technological wave, and even constitutes an obstacle to its diffusion. This increasing "mismatch" between the socioinstitutional framework and the technoeconomic sphere is, according to Perez-Perez, responsible for the continuation of the downswing. And it is only through appropriate social and institutional innovations, which take into account the specific characteristics of the new paradigm, that the next upswing can be unleashed.

This broad analysis stresses the need for a qualitative dimension in the long-wave debate, and offers clear insight that the social–institutional barrier is hindering further diffusion of technological innovations in the downswing. Moreover, it is attractive because it is consistent not only with the approach of Freeman but, as Perez-Perez stresses, also with that of Forrester, Mensch, and van Duijn. However, her call for more interdisciplinary research was most actively answered by proponents of Marxist analysis, perhaps because, paradoxically, her theory about how capitalism goes through, and overcomes, long-wave crises has a similar structure to the original thesis of Marx about how the collapse of the capitalist system would come about. Indeed, the depression can be interpreted as a manifestation of the tension between the productive forces and

the social relations of production. *Entov* describes the depression as "the crisis of the entire structure of established socioeconomic relations". *Menshikov and Klimenko* deal explicitly with "the major role of changes in the production relations of capitalism, which do not neatly coincide with long waves in material production". These changes have to be associated with consecutive stages in the evolution of capitalism, which are clearly accelerated by the long wave.

Goodwin comes very near to the hypotheses of the SPRU group. In his view, "long swings are the result of the slow perfection and adaptation of major technological innovations, which persisted over a number of shorter fluctuations". Gradually, the whole production structure becomes transformed as a result of a great number of successive small improvements and adaptations of the new technology. However, this constant flow of technological change is converted by the economy into fluctuating growth, because accelerator and multiplier mechanisms accompany investment. Once the potential of the new technology is exhausted, weak booms and prolonged depressions occur until a new set of innovations becomes feasible. In this process, the role of extraeconomic variables is considered to be essential in the long run of the economy, e.g. the role of state activity such as wars, social services, and control efforts. Goodwin therefore concludes: "How long the present depression will last and how vigorous will be the recovery will surely depend on such extraeconomic factors and not on systematic, economic relations".

4.2. The Growth-Theoretical Approach

Starting from inductive insights, Marchetti and Craig took up the idea of the economy or society behaving as an ecological or sociobiological system. "Our view is that the same laws of nature that gave rise to all other living systems are also controlling for man" (*Craig and Watt*). They suggest that the long-term instability, of which the long wave is a major expression, be analyzed along such lines. Indeed, if we define the long wave as the succession of recovery, growth, recession, and depression, there is only a small difference from the statement of Prigogine (1980), quoted by *Islam*: "All self-organization systems operate in the cycle of becoming, growing, changing, and decaying." But also economists have already launched this idea, as indicated by *Silverberg*: "That socioeconomic development can be considered an ecological history of human

artefacts and populations is the theme of Boulding (1978, 1981)".

The attractiveness of this view of economic life stems from the inability of current economic theory to analyze the processes of transition, which is in fact the essence of industrial development. Especially the deeper insights of Schumpeter on the "creative destruction" nature of innovation have largely failed to find entrance into the main stream of analytical economics (*Silverberg*). Therefore, more and more economists are treating the technological innovation embodied in investment as the core of growth theory. They use non-linear dynamic models to study the emergence of new configurations from structural instability. Two variations can be distinguished: that of Mensch–Haag–Wold and Nijkamp on the one hand, and that of Silverberg on the other. While the former concentrate on models in which stable and unstable periods alternate, the latter stresses more the existence of an essentially unstable historical trend. They all prefer the use of the term "structural instability" instead of "long waves", but they do not exactly indicate the difference between the two.

Mensch starts from a metamorphosis model of long-term industrial innovation. Its four phases can be discerned from the existing mix of innovation types, distinguishable by their basic/improvement, radical/moderate, or product/process character. Innovative investment causes intensifying (R) and extensifying (E), or contractional and expansionary, effects, but to a different degree in each phase. This double aspect of technical progress has to be interpreted as the origin of structural instability in economic life: "Progress just is not 'well-behaved' but ambiguous" (*Mensch*, Paper A).

To integrate this view into growth theory, the equilibrium tendency restriction of the neoclassical and neo-Keynesian models has to vanish. In this way, the ambivalence of economic growth can be made explicit, while at the same time a potential for regime change is introduced. Then, a bifurcation model is constructed with, in Mensch's words, "neoclassical and post-Schumpeterian features".

A bifurcation model allows for a critical domain, where either small unpredictable fluctuations or facts will decide which of the alternative paths – potentialities – will be chosen. More concretely, Mensch uses a production potential function, explicitly allowing for E and R effects. The neoclassical specification indicates that the capital factor is heterogeneous over time and that a biequilibrium property is incorporated, i.e. that two maxima are

separated by a minimum while only one maximum can exist at a specific time. The post-Schumpeterian feature reflects the ambivalence of innovation by the hysteresis property, i.e. inertia causes a discontinuous pattern between periods of high growth and E/R figures and periods of low growth and E/R figures (*Mensch*, Paper A).

Mensch is refining his theoretical and empirical research in collaboration with Haag, Weidlich, and Wold. The latter proposes his Partial Least Squares (PLS) method for the estimation of Path Models with Latent Variables (PMLV). This technique has the advantage of modeling and estimating directly and indirectly observed variables, or manifest and latent ones. Starting from the theoretical basis he developed with Weidlich, *Haag* elucidates some crucial points of Mensch's model by empirical investigation (Weidlich and Haag 1983). From economic data, he develops a macroeconomic potential, i.e. a nonlinear relationship that can assign to one set of input variables more than one set of output variables, in times of structural change. At a critical point, closely related with the business cycle, the economy changes from a stable to a less stable structure, or undergoes a phase transition from a monostable to a bistable potential. Haag is able to calculate from the empirical data the parameters of this potential that show the combination of E and R effects chosen by the economy. Moreover, he claims that it is possible to link the potential parameters with an appropriate set of input variables with the help of an optimization procedure (Haag *et al.* 1984). In this way, Haag's analysis allows for prediction and analysis of possible human influence for realigning the economy toward a monostable path. At the same time, many relevant structural macroeconomic variables can be formulated explicitly, while the parameters and their significance can be determined from the set of known data.

Nijkamp developed a nonlinear dynamic model including the element of space as both a driving and a constraining factor for economic dynamics. He gives particular attention to a specific kind of Lotka–Volterra equation used for modeling in population biology. Such a model has the advantage of incorporating some key factors (innovation, public overhead investments) that act as driving forces for a spatial system. It is possible to insert technological progress in the "depression-trigger" as well as in the "demand-pull" hypothesis. Moreover, the model is able to generate a wide variety of dynamic growth patterns, of which the long wave is only a particular case. Nijkamp's conclusion is that long waves are not a necessary phenomenon, but may emerge under

specific economic and technological conditions in a spatial economic system.

While the former models concentrate on the dichotomous alternation of stable and unstable growth periods, *Silverberg* refers more to historical instabilities in the underlying trend. Starting from Goodwin's 1967 growth cycle model, he developed a pair of equations formally equivalent to the Lotka–Volterra model. Then he incorporated innovations embodied in new capital goods and analyzed the consequences in terms of nonlinear dynamic interaction between wages, profits, sectoral and aggregate employment, and productivity. In this way, the dynamics of technological progress are fundamentally integrated because of the feedback from the level and composition of investment to the growth of productivity and effective demand. He emphasizes that this way of analysis is far more than a capital-stock adjustment model (Silverberg, oral comment).

Silverberg argues that within his model the rather new "self-organization paradigm" can be used for a thorough analysis of structural instability. This theory, derived from natural science, is in fact built on the dialectic of whole and part, on the one hand, and on chance and necessity, on the other. Physical, biological, and chemical systems normally show a tendency to equilibrium, because their various components compensate each other's behavior. However, at certain moments the disequilibrium forces are more powerful and they drive the whole system to a new state. This theory was originally formulated by H. Haken (Stuttgart) under the name "synergetics", and by Prigogine (Brussels), who named it "dissipative systems". This notion of negative and positive feedbacks is also used by Toffler (1980) to explain the transition from an industrial toward a "Third Wave" society.

According to Silverberg, the transition processes of the industrial system, or the whole of industrial history, can be interpreted along these lines. The dynamic interaction between the macrosystem and its component subsystems can be analyzed using nonlinear dynamic models (e.g. bifurcation), while the outcome of innovations can be treated as stochastic fluctuations. This would allow for the simultaneous existence of a diversity of expectations, techniques, and rates of profit, a feature that has been neglected by economic theorists. The interaction between the system's components and external constraints will create a structure characterized by a certain stability and historical instabilities, driving the system toward new basic technological conditions and institutions. Once the dominant trend can be observed, it will be possible to describe

its further evolution, i.e. the final outcome from instability or the beginning of a new equilibrium period. This prediction is based on the dynamic interaction of the system's heterogeneous components, such as labor, various capital and consumer goods, and energy.

As a conclusion, we can state that the integration of the long wave into growth theory is a promising field of research. The essential feature is that, owing to the embodiment of technology, instability pressures are crucial. Thus, long-wave research is only one sign of the recent evolution in economic analysis, where the attention paid to nonlinearity, microeconomic heterogeneity, and macroeconomic disequilibrium is growing fast. There are some questions left, however. For example, the precise difference between long waves and structural instability was not made clear. In particular, there seems to be no agreement whether the former is a specific or a general form of the latter. Moreover, all models presented were treated in real terms while monetary and financial variables were completely neglected. It can also be argued that socioeconomic systems are characterized by intentions and expectations, and that social research cannot be controlled in the same way as laboratory investigations. In neoclassical models, one assumes that the market is working perfectly, and that the entrepreneur has a perfect knowledge of the future, while in reality he is speculating on a favorable outcome. In other words, the basic lesson from Keynes' work seems to have been forgotten, while economic policy is implicitly considered as ineffective or of minor importance.

Silverberg is nevertheless convinced that human aspects can be modeled within an ecological–evolutionary framework, because this approach is not marred by a deterministic starting point. He agrees that endogenizing everything into a closed dynamic model creates a straitjacket on thinking. Yet, an open dynamic system is critically dependent on the interaction of stochastic and deterministic elements, and this means far more than imposing noise on a closed deterministic system. "In an interdependent nonlinear system, fluctuations, innovations, or changes in external constraints can play a decisive role in triggering bifurcations and changes in regime, and thus serve as the driving force in an evolutionary process" (Silverberg, oral comment). In this way, theory can be opened to history and irreducible diversity. In other words, this fundamental point is very close to that of the SPRU group, and in particular of Freeman, who stresses the role of unique historical factors, despite the very different methodology used.

4.3. The Macroeconomic Approach

Various authors constructed macroeconomic models that do not strictly belong to the growth-theoretical approach described above. We think the study of the long wave along these lines is important, in particular when an economic policy has to be designed, and when financial and monetary variables have to be included. The system dynamics method of Forrester and his co-workers is in this regard very interesting. Menshikov and Klimenko model the Marxist law of the falling rate of profit, and indicate useful leads and lags. Lastly, Delbeke and Schokkaert show that even a traditional linear model, based on financial variables, can offer useful insights for theory and policy.

Since 1975, the System Dynamics National Model (SDNM) has been the vehicle for the development of an endogenous structural theory of the long wave at MIT. There, the System Dynamics Group is basically modeling the behavior of microeconomic agents, and the macro-result is a self-sustaining long-term cycle which, once set in motion, grows in amplitude up to a limit. Several important channels contribute to the generation of the long wave, such as self-ordering, debt/price dynamics, technology and innovation, and political and social values. However, *Sterman* emphasizes that self-ordering is the basic mechanism at work, because it is sufficient to generate the long wave. The other factors have a more amplifying character. The self-ordering of capital reflects the dependence of the capital-producing sectors of the economy, in the aggregate, on their own output. In fact, self-ordering amplifies the disequilibrium pressures created by the interaction of locally rational decision rules (bounded rationality) and the lags involved in capital acquisition within a firm. As a result, "irrational behavior" is produced on a macro-level. Therefore, Forrester states that the accelerator mechanism of self-ordering "creates the 50-year cycle of what would otherwise be a 20-year medium cycle in capital acquisition" (Forrester 1977, p.534).

Sterman stresses that this self-ordering principle does not exclude other approaches. On the other hand, he calls for a demonstration of the sufficiency of other mechanisms for the generation of long waves. In particular, the role of technological innovation, essentially treated as passive in the SDNM, seems to be more the result instead of the origin of self-ordering (Graham and Senge 1980). This view has considerable implications for policies directed at stimulating innovation, because they may be insufficient to mitigate the effects of the

current downswing. Therefore, economic policy has to be directed more toward the solution of excess capacity in the capital goods sector, which is caused by the self-ordering accelerator. Indeed, during the upswing, this mechanism creates a serious excess of capital stock, and the downswing has the function of bringing the economy back to internal equilibrium.

Senge expanded the SDNM by developing a theory of the real interest rate behavior in a long-wave perspective. In his view, real interest rates tend to rise as the inflationary pressures of the upswing give way to deflationary ones during the downswing. Once they start to rise, they reduce demand, reinforce the deflationary pressure, and keep increasing. A crucial assumption concerns the relative sluggishness of nominal interest rates in adjusting to changes in inflation. Nominal rates rise until credit shortages are eliminated, i.e. at the end of the upswing. Prices tend to move in parallel with nominal interest rates, and increase until the excess demand of the expansion is absorbed. However, inflation, being the rate of change in prices, starts to decline considerably before nominal interest rates reach a peak, and hence the rise in real interest rates. Senge shows that the simulated data are consistent with historical observations and with Fisher's empirical analysis. A major implication of his theory is that it questions the "crowding out" effect of government deficits and tight monetary policy as being responsible for the recently high real interest rates.

The system dynamics analysis develops a causal theory, offering an endogenous structural explanation of the long wave. It rejects the direct use of historical data, but compares them with the data generated by the model. It allows for historical particularities and for a qualitative dimension, being a powerful complement to the formal analysis of model behavior. In other words, the System Dynamics Group looks for a mechanism, not for a determinism (Senge, oral comment). The major advantages of the system dynamics method are, however, not clear to us. In our opinion, macroeconometric models can also be powerful tools of analysis. They offer the opportunity for interdependent theoretical and empirical analysis, while historical data can be used directly. Following the remarks of Freeman and of Perez-Perez, the basic microstructures used can change fundamentally over a long period (cf. pure and monopolistic competition during, respectively, the industrial revolution and late capitalism). In any case, the Conference produced a fruitful confrontation between the different views on this matter, and the opportunity for

publication of some parts of the model, which had unfortunately remained largely a "black box" until then.

Menshikov and Klimenko utilize the law of Marx about the tendency of the rate of profit to fall. Firstly, they empirically investigate indicators of labor productivity, capital intensity, the output–capital ratio, the rate of profit, and the profit per man-hour. They conclude that long waves clearly exist and that a new recovery in growth rates can occur only after a recovery in the output–capital ratio. They then construct an economic model in which the relationship between the growth rates of the capital–labor ratio and the rate of profit is considered as the driving force behind the long wave and as crucial for explaining the turning points. In the simulated figures, the leading and lagging variables are analyzed. The turning point of the growth rate of the profit rate (p) precedes the change of the growth rate of the capital–labor ratio (k) in the opposite direction by 7 years, while the turn in the growth rate of labor productivity (y) comes 6 years later. It takes another 13 years for p to reach its peak or trough.

Delbeke and Schokkaert presented a macroeconomic model for the financial sphere. They emphasize the role of small partial models, which are as simple as possible, deepening our understanding of the basic mechanisms at work. In particular, the interaction of investment and debts, being a simple stock–flow mechanism, is able to generate endogenously a long wave for empirically reasonable values of the parameters. In the upswing both investment and debts are increasing, until the debt position, and hence the cost of credit, become too high. At that moment, investment starts to decline until a normal debt level is reached again. The recurrence of the long-wave phenomenon can only be produced by the introduction of exogenous shocks, such as innovations. However, when prices are inserted in the debt inflation and deflation model, the cycles become permanent. This suggests that the integration of a monetary sector may be a promising track. In particular, the money supply seems to be endogenously determined along the long-wave path. This simple model shows the necessity of studying the macroeconomic conditions that dominate the diffusion of innovation. Further exploration in this direction seems worth while, especially for the analysis of the downswing and for the design of economic policy. Of course, this form of partial analysis is extremely useful for integration into other approaches.

4.4. The Importance of Noneconomic Variables

Most authors stress the role of noneconomic variables in the long wave, as was the case in the interwar period. Perez-Perez of the SPRU was the most active proponent of this approach at the Conference. However, two other papers explicitly dealt with sociopsychological factors, within a model framework, namely those of Millendorfer and of Screpanti.

Millendorfer presented some remarkable insights from the Austrian STUDIA model, investigating long-term mechanisms of societal development. He claims, and proves empirically, that we must try to understand the economy by looking beyond the economy to a comprehensive holistic approach. Therefore, STUDIA uses a huge quantity of empirical data, not only on economic and technological variables, but also on "soft" variables like measures of motivation, sociopsychological variables, indicators of the quality of family life, etc. To analyze the observed growth-reducing factors every five to six decades, a new formal method of multivariate analysis, named Main Plain Analysis, was developed. This method facilitates theory building on a large empirical base, and in particular the relationships between hard and soft variables can be made clearer. Then, with the help of sociopsychological mechanisms, STUDIA tries to explain why the innovative push occurs in cycles of 50-60 years, a question unanswered by Schumpeter. The length of the cycle in the feedback system is determined by something similar to anthropological constants, regulating the dynamics of the relationships between generations. In addition, the oscillations of creativity and achievement motivation in the sociopsychological cycle are used to help understand the oscillations of inventions and innovations. Indeed, intensive growth rates, i.e. those mainly caused by innovations, are positively correlated with constructed Freudian sublimation indicators. Thus, creativity and innovation have strong roots in the living area, described by soft variables and their mechanisms.

The analysis by Millendorfer has a rather deterministic character. This is shown, in particular, when he concludes that "the length of the cycle is determined by something like an anthropological constant. It means that we have no instrumental variables, no political tool to change the length of [it]." Nevertheless, Millendorfer suggests some policy advice that is close to the proposals of the SPRU. "What we can do is to minimize the amount of the downswing by anticipation of the coming upswing". In more concrete terms, he

proposes four principles: (1) the human-economic principle: more emphasis on the importance of man instead of things in economic life; (2) the priority of nonmaterial over material factors: more creativity, initiative, qualification of labor, and a reduction in the exploitation of material factors; (3) finely structured formations rather than "gigantomania": rejection of the overemphasis of the large scale; (4) context and totality: a maximum of autonomy and freedom of decision making for small units, which acknowledges their rightful place in the wider context.

Screpanti analyzed a set of social variables in addition to economic variables and constructed a model with the use of catastrophe theory and the notion of transition phases. In the years 1808–20, 1866–77, 1911–22, and 1967–73, being the upper turning points of the Kondratievs, major proletarian insurgencies broke out. These periods must be considered as transition phases, with more than "normal" unrest. The upswing brings improvement in workers' achievements, but at the same time their frustration rises at an increasing rate. Social tension accumulates until the effects of frustration overcome those of achievements. At that moment, workers express in a few years the tension suppressed over a long time. As a consequence, capitalists' "high spirits" collapse and investment declines. The downswing begins and has a worsening effect on workers' achievements. Only after some time does frustration adapt to the decreasing achievements, when the workers realize their defeat. According to Screpanti, "In a sense it could be said that the entire B-phase of the long cycle serves to bring workers back to reason." The declining militant behavior then paves the way for a new upswing. The whole process is further strengthened by the coming of new generations of young workers, because major wars occur during the critical transition phases of the long cycle. In fact, the generational cycle of Screpanti is closely analogous to the anthropological constant of Millendorfer. In our view, these methods of analysis are good illustrations of the promising field of interdisciplinary research in the long-wave perspective.

5. IMPLICATIONS FOR ECONOMIC POLICY AND FURTHER RESEARCH

There is considerable agreement that the long wave cannot be considered as a monocausal phenomenon, and that future lines of research have to integrate the several theories. The System Dynamics Group at MIT is calling for "a grand unification theory" (*Forrester et al.*), while Mensch perceives a regrouping of the existing theories under only two umbrellas, namely a neoclassical and a neo-Marxian theory (*Mensch*, Paper B). In the previous section we tried to sketch some major directions along which further integration of research could proceed. However, the main question, as posed by Mensch, is "Who integrates whom?" As far as we can see, there is no agreement on this matter.

According to the MIT group, further integrative research has to contain the following characteristics: a formal dynamic model, for which all assumptions are made explicit, endogenously generating long waves, and built on a structural–causal and not a correlative or econometric approach. For the MIT group it is essential that microstructures create the macroeconomic outcome. Small models have to be developed showing sufficient or necessary conditions for the long wave, or the amplifying role of some characteristics. Moreover, tests have to prove the adequacy and the robustness of the model structure, while generated data have to be compared with historical data (*Forrester et al.*). In other words, the starting point is the SDNM methodology, in which an active innovation process can be inserted.

From a phenomenological point of view, Mensch is near to agreement with the Forrester proposals, emphasizing that a post-Schumpeterian theory has to start from micro-foundations to show the macrodynamics. Indeed, these micro–macro models can remove the vague and impressionistic ways of research of Schumpeter and Marx, which caused a lot of skepticism as expressed by W. Baumol (*Mensch*, Paper B). However, Mensch is also convinced that his model is a good starting point for cooperation. Moreover, he observes the research frontier moving from data- to model-driven, and is already expecting the next phase transition, i.e. to instrumental research, prescribing economic activity in scenarios, and forecasting. He states that the long wave is the core area of the much larger field of disequilibrium dynamics, while he sees "much of our special theories already embedded in mainstream economics" (*Mensch*, Paper B).

However, in our opinion, to situate current long-wave research in this way is to exaggerate its present role. For van Duijn the aim of it becoming a part of standard economics is not so important. Schumpeter never has been regarded as a mainstream economist, while many scholars have read and used his interesting ideas. In van Duijn's view, all that counts is to do good research, and to avoid becoming a sect. Moreover, at this moment, we think that long-wave research is neither a full part of present economic research, nor the core of it, and it will require a long time to consider it as a new paradigm. Lastly, the methodologies of Forrester and Mensch are so different that it is likely that the former wants to integrate the depression-trigger hypothesis more than the consequences of the Schumpeter Clock approach. Consequently, the path to integration will be long and difficult, without clear "umbrellas" for the near future. Nevertheless, long-wave research inevitably has to follow that path, in order to deepen our understanding. In our view, conferences such as this one automatically widen the scope for further integrated research. The broad interest in the institutional aspects can only be proof of that.

A concrete example of integration of various approaches, and therefore one that is difficult to place in the scheme developed here, is the research carried out by *Piatier*. Starting from the study of innovations and renovations, he integrates some ideas of Marchetti and Mensch. Being a business cycle analyst, he stresses the importance of the way in which the long cycle determines the Juglar, which he considers very useful for the analysis of turning points. However, he also has similar insights to the Sussex group and does not neglect the role of noneconomic variables. Indeed, he emphasizes the role of demand, the diffusion of microelectronics, and the economic, social, and political problems concomitant with this process. Not only is the whole production system forced to change, but also its environment: the managers, the educational system, the infrastructure, etc. In the short term, the effect on labor demand will be disastrous. While Piatier expects the next upswing at the end of our century, he believes that an adequate economic policy can shorten this period by a decade. However, this can only happen on one condition, namely that the financial problems postponing the recovery are solved, and not, it is hoped, with a *Krach*, as happened in 1929. Such integrative approaches seem to be essential for our future research, but it is clear that at present only the first qualitative steps have been made in this direction.

A second major field of research has to be the design of an adequate economic policy. Following *Tinbergen* in his video message, it seems at least just as worth while to think about policy measures, given the insurmountable difficulties and the long time it will require to have a definite proof of the existence of the long wave. Also Freeman sees a gigantic task in this field in order to ease the enormously bad and possibly dangerous consequences for mankind. He quotes Keynes (1923) in this context, as follows: "Economists set themselves too easy a task if in tempestuous seasons they can only tell us that when the storm is long past the ocean is flat again" (*Freeman and Soete*).

However, only a minority of the Conference papers dealt explicitly with the matter of economic policy, while the proposals made cover a broad range, from pure liberalism (Glismann) to international interventionism (Tinbergen). The growth-theoretical approach is rather silent on this matter. However, Silverberg (oral comment), following Forrester and Sinibaldi, raises the fundamental question: Have we to concentrate our energy to start the next long wave as quickly as possible, or to reach some kind of stationary state, i.e. to enjoy the fruits of economic development without instability pressures and unemployment threats? The former option seems inevitably to be implied by industrial capitalism, or, stated the other way round, the latter requires a radical reorganization of social and economic structures. Given the powerful economic and political pressures, it seems that the combination of permanent change and social cost will be chosen. Following this logic, then, Craig states that a primary goal of policy should be to minimize the disruptions associated with the transitions of social systems from one mode of stabilization to another (*Craig and Watt*). This suggestion is not worked out in more concrete terms, however.

Most researchers dealing with policy issues agree that the long wave is an international phenomenon, originating from unstable investment in the developed capitalist countries. The industrial planned economies would also show the same behavior but to a lesser extent, and this can be attributed to their own saturation of markets and to the linkage of international trade. Therefore, *van Duijn* concludes that it is first and foremost in the OECD countries that the problems are situated, and it is there that they have to be solved. Moreover, historically, innovations diffuse from the core to the periphery. Hence a massive transfer of funds from North to South is not the best solution. In contrast, capital shortage will be aggravated in the industrialized countries, and a recovery will be postponed further. According to van Duijn, this is not an

argument for egoism, but the result of long-wave analysis that only the growth-center economies are able to be a locomotive for the peripheral economies. Moreover, the problems for the new industrialized countries (NICs) are not so enormous because historical research shows that after a country has taken off it is less affected by the next long-wave downswing. At the same time, a new upswing will create chances for new take-offs, transforming once again some less developed countries into NICs.

Other researchers cannot agree with van Duijn's policy advice. The MIT System Dynamics Group also situates the cause of the long wave in the industrial world because of the dominant role of self-ordering: the more capital there is engaged, the more serious the long wave. The disequilibrium effects are distributed over the whole world, but with different time lags. The downswing has an important function, namely the elimination of overbuilt capital, the latter being the result of the upswing. This excess capital, instead of van Duijn's shortage, can be removed in a slow or a catastrophic way. The latter solution has to be avoided, but the key to it lies not in the real, physical sector of the economy, but instead in the financial, attitudinal, and institutional aspects (*Forrester et al.*).

According to the MIT group, there are very few high-leverage policies available and, moreover, they can be pushed in the wrong direction or are subject to a tendency to overreact. Some policies can ease the impact of dislocations or reduce the severity of the downturn. However, it has absolutely no sense to look for a guilty person or group, as Glismann is doing for bureaucracy, because the instability was created by the interplay of all forces in society. What has to be found is a combination of fiscal, monetary, and banking policies that can sustain public purchasing power and prices without allowing further debt accumulation or inflationary money creation for speculative investments (*Forrester et al.*). In other words, this advice is a kind of Keynesian policy without inflation, and without investment incentives, given the massive excess capacity.

The MIT advice is basically built on a "passive" technological innovation, because Forrester is convinced that its role is overemphasized in the long-wave debate. In contrast, the Sussex group stresses the importance of the new technological paradigm at length, adding a post-Schumpeterian dimension to the rather Keynesian policy of the System Dynamics Group (*Forrester et al.*). Freeman is "going back to basics", i.e. to the original work of Keynes and

Schumpeter. The latter was very hostile to government intervention, which he tolerated reluctantly. The basic lesson of Keynes, i.e. "the socialization of investment without public ownership" (*Freeman and Soete*), made him the architect of the new match between the prevailing technological paradigm and the social institutions. For Keynes, aggregate demand had an important role, while Schumpeter was more sectorally oriented because of the role of technology. Nowadays, we have to look for a new theory because none of the dominant theoretical paradigms (neoclassical, Keynesian, Marxist) can offer an answer to the question how to solve the growing mismatch between technology and the institutional environment.

From a neo-Schumpeterian point of view, Freeman is in favor of government policies encouraging a new wave of public and private investment, and offering incentives for the adaptation of social institutions (*Freeman and Soete*). The main goal is to achieve the maximum gain from the new technological complex with the minimum social costs. If private investment is too timid, public investment has to fill the gap. Anyhow, specific demand pressures and institutional changes have to be created to stimulate the diffusion of microelectronics. *Tinbergen* also calls for social changes and refers to the Japanese worker being very productive because of the high satisfaction gained from work, owing to more consultations involving workers and a less unequal income distribution than, for example, in the USA. Generally, the SPRU group is calling for more optimism and realism, and for avoidance of the creation of a "lost generation" (Freeman, oral comment). We only have to remind ourselves of the collective frustration of the 1930s and its concomitant social and political instability. Today, we can again observe growing tendencies of law and order, conservatism, and militarism (*Menshikov and Klimenko*). Tinbergen (in a written comment to the author) treats the intensive competition in armaments as the most urgent problem to be solved. One must be aware that these new tendencies are again trying to cope with the wrong problem.

Freeman and Soete further emphasize the crucial role of the technological–institutional match in an international framework. In fact, Soete in his research has shown that the new technology is more international in scope and requirements than anything that has preceded it. For newcomers it is easier to create new social institutions than to adapt old ones, as in the mature economies, while the capital-saving nature of microelectronics and the potential for small-scale applications are particularly favorable for the NICs.

Moreover, it must be noted that the balance of economic and political power is changing in favor of the developing world. Thus, a very rapid international diffusion of the new technology is very likely, and therefore the need for a "matching" new international framework becomes very urgent. However, this new match is probably the most difficult challenge confronting the world economy. Indeed, as Freeman and Soete observe, "the national boundaries of decision making, the intensified international competition, the growth of protectionism, the re-emergence of Cold War attitudes and politics, and the persistent failure of North–South dialogues all serve to emphasize the great difficulties of re-establishing a new and more favorable international economic and political framework for expansion".

At this time, international solutions seem to be taking the place of the national ones of the 1930s, and are likely to become dominant in he next "match". However, at that time, nobody could propose with certainty the right policy that was needed. Goodwin (oral comment) reminded us of the policy of the Roosevelt administration, which tried a lot of valuable proposals until one proved to be successful. Indeed, we may state that the major merit of Hoover, the predecessor of Roosevelt, was that he showed at length that the classical deflationary solution, or the restoration of 19th century rules, was no longer possible. The dominant economic thinking of the time no longer had consistent solutions available, and this opened the way for positive policy experimentation. We have the feeling that we have arrived at the same situation again. *Tinbergen* claims that a good policy does not necessarily require knowledge of the right explanation. Consequently, he suggests spending far more energy in searching for good policy advice, instead of hoping to build the good theory first and then derive the right policy from it. It can work the other way round, as is illustrated by the development of Keynesian theory. At present, the most concrete and valuable policy proposals are those of the Brandt Report (Brandt 1980), and Tinbergen and the SPRU group are urgently asking for their implementation, in order to solve the acute social, political, economic, and financial problems on a world scale (*Freeman and Soete, Tinbergen*).

As a general conclusion, then, we may state that this Conference was an important step toward a better understanding of what is happening and what should happen in our world today. It was shown that the long-wave idea is very useful for this understanding, not least because it has to be seen as a multidimensional phenomenon. It has important economic features, while the

social, political, and even cultural aspects cannot possibly be neglected. The notion that technological innovation creates structural instability, which forces institutional innovation, was one of the most interesting themes dealt with at length at the Conference. Because the long-wave idea is able to throw new light on neglected or even forgotten aspects of our industrial development, we are convinced that it deserves further research on empirical, theoretical, and policy levels.

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