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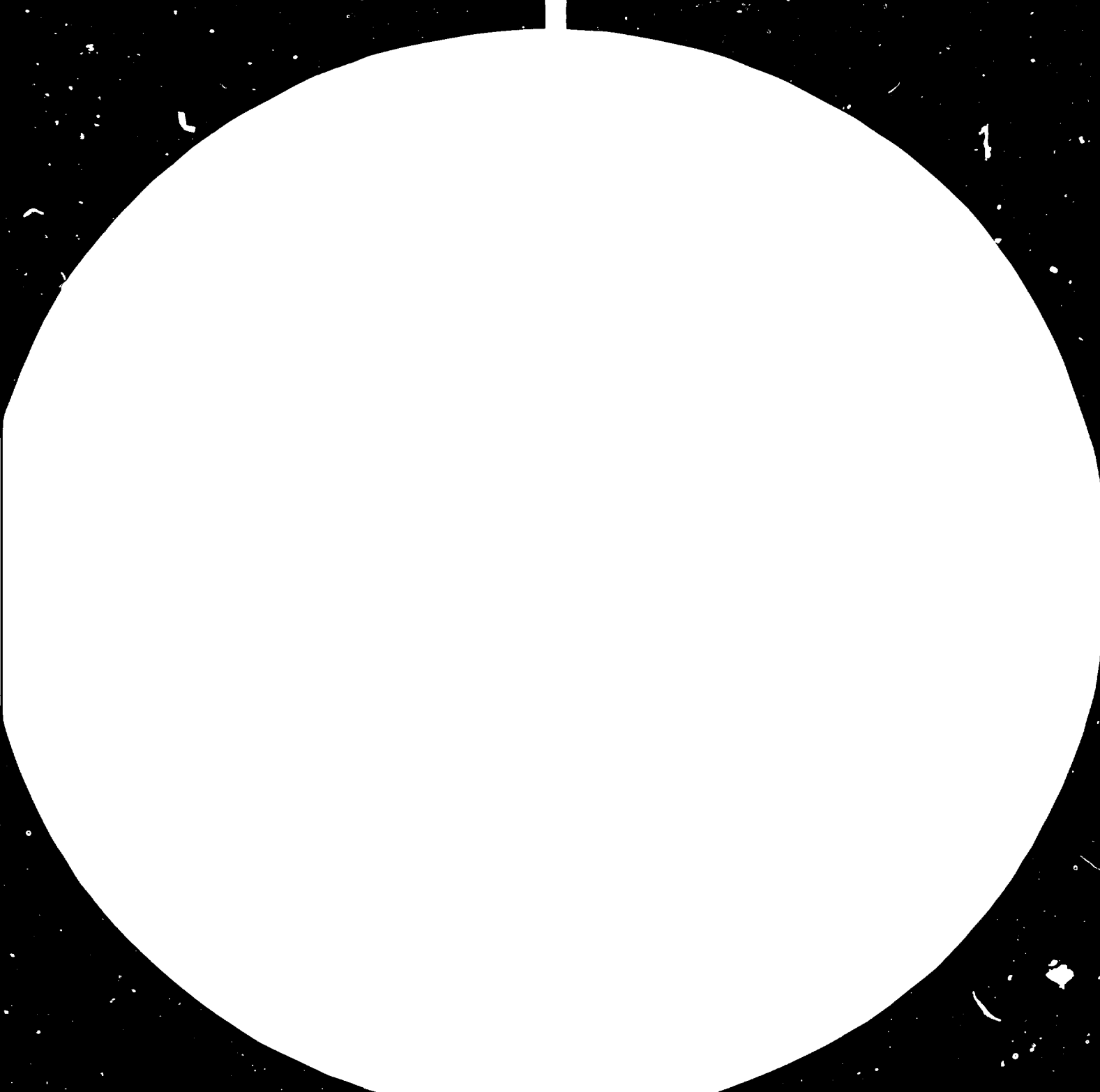

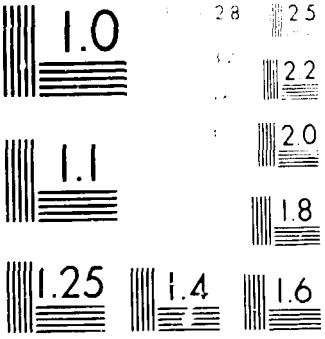
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TECHNOLOGY IN THE SERVICE OF DEVELOPMENT *

(This background document is related to issue II)

Prepared by the Secretariat of UNIDO

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CONTENTS

A NECESSARY DEMYSTIFICATION

1. It is essential for developing countries to produce a growing part of the capital goods which they need. That is an indispensable condition for restoring the equilibrium of the international division of labour and progressively achieving a new international economic order (see Issue No. 1).

This structural change encounters difficulties which should be clearly identified. A distinction should be made between the wrong questions and the real problems. The wrong question is to ask if capital goods are a kind of sanctuary of industry reserved to a small élite. The answer to that has been given by history. Various countries at one time under-developed or agricultural, such as the USSR or more recently China, but also countries as diverse as Italy, Spain, Portugal, Finland, Bulgaria, Romania, the Republic of Korea, Brazil and India, have successively either built a complete structure or made important "breakthroughs" in this sector. The following examples relate to some of the countries for which studies have been carried out within the framework of the preparation of the First Consultation on the Capital Goods Industry.

- In Spain, during the 13-year period from 1962 to 1975, the production of capital goods increased fourfold, with an annual growth rate of more than 11 per cent. 1/ In 1977, Spain had become the world's twelfth largest producer.

- In Bulgaria, during a 30-year period, the volume of production of capital goods multiplied by ninety, and the share of that activity in industrial production tripled to the current level of 25 per cent. 2/ In 1977, Bulgaria ranked twenty-sixth among world producers of capital goods.

- In China, during a 30-year period, production multiplied by more than thirty, with an annual growth rate exceeding 15 per cent. The capital goods industry currently provides 80 per cent of the machines and equipment for basic industries, 74 per cent for power-generating plants, and 94 per cent of metal-cutting machinery used in factories. 3/ China currently ranks seventh among world producers.

These three countries, one of them having a market economy and the other two centrally-planned economies, and which are very different in their levels of development, have therefore made remarkable progress. They had the common characteristic of being essentially rural countries where engineering industries had to start from almost nothing. 4/ They show that there are no insurmountable difficulties in entering and developing the capital goods industry. It is therefore, necessary to demystify the idea according to which the obstacles are such that developing countries should renounce such activities or that the current international division of labour should be maintained.

2. Developing countries face two dangers. The first is that of frequently underestimating the possibilities by misunderstanding the real conditions of manufacture of the different groups of capital goods. The second, for the same reason, is of drawing up unrealistic plans which cannot be applied since the barriers to be overcome in a given period of time have been poorly evaluated. A variant of this attitude is the transfer of manufacturing installations which are out of scale with the management capacity of the country, and which therefore fail immediately.

For the great majority of developing countries, the first danger is the main one: that is underestimating possibilities, the scarcity or the absence of projects. However, the second danger is just as real, and in certain countries may even be the main one. The denial of objective realities and the understandable impatience to make rapid progress have led to subjectivism and finally acted as a break on progress.

The politician and the planner must therefore avoid these two initial traps: fatalism which leads to resignation, and subjectivism which leads to failure. A task of demystification of unwarranted assumptions about the capital goods sector forms part of the combat against these two trends, especially against the underestimation of possibilities, which concerns most developing countries.

3. The true problems therefore remain to confront developing countries. They result from the heritage of history and are connected with the following factors: the intrinsic difficulties of the different degrees of technological complexity of the sector; the constraints resulting from the size of markets and geopolitical conditions; the degree of realism of the objectives set and the internal policies followed; and the encouragement or obstacles, from external sources with regard to the nature and importance of external integration and co-operation.

The real question, therefore, is not whether developing countries can manufacture capital goods, but what they can produce during the next 20 years, taking into account, on the one hand, the degrees of complexity within the universe of machines and, on the other hand, the specific characteristics of each developing country or group of developing countries, and of their existing production capacities or those which they can reinforce during the period considered. In other words, the real problems to be discussed are the following:

- How can the handful of large developing countries with a capital goods industry that has "taken off" gain full access to the "industrial club"?

- How can the 20 developing countries with an embryonic capital goods industry develop that industry? To what extent and for which products can they achieve national integration? What are the possibilities of sub-regional integration?

- How can the 60 developing countries which have virtually no capital goods industry acquire one? Would it be through agricultural machinery or through capital goods common to all branches? What can be done in the smallest countries? What would be the repercussions for the sector of a policy of final consumption for the benefit of the poor majority of the population?

4. The solutions to these problems are not simple. They raise a great number of complex questions which have been studied by the UNIDO secretariat. It has therefore been necessary to be highly selective in choosing topics for discussion during the First Consultation on Capital Goods.

With a view to guiding the discussion, the following topics are therefore proposed:

(a) Barriers to entry to the capital goods sector, particularly developing countries which do not produce capital goods.

(b) How can technology be placed in the service of development for the various groups of developing countries which are at different levels?

(c) How should the capital goods sector be planned in the developing countries?

BARRIERS TO ENTRY

5. There are two types of barrier, the first technological and the second social, blocking entry to the sector.

Technology does not only involve giving material form to the laws of nature, it also acts as a mediator between those laws and economic laws. 5/ The technical system is a physical and social whole. Its constraints are therefore also social constraints.

We have begun our analysis with the latter.

The factors liable to block entry to the capital goods sector or prevent its growth in the developing countries do not, generally speaking, seem to differ from those observed in industrial economies. 6/ The components of the barriers to entry are the cost advantages of established firms, product differentiation, economies of scale, capital needs, the control of technological transfers and the availability of capital goods. These components obviously play a part in the case of the capital goods sector.

In a situation of high price inflation, investment costs for creating new industries obviously increases and gives an advantage to established producers. 7/ Product differentiation and the share of the market held by well-known brands may inhibit the willingness to take initiatives elsewhere.

The economies of scale which have characterized industrial development during the past 30 years, may also have a dissuasive effect. Thus, some of the capital goods common to all branches are the result of large-scale mass production. 8/

If capital needs are relatively low in some of the capital goods industries, the need for human capital formation is, on the other hand, important. (See Issue 1).

The control of technological transfers varies with the product cycle. While it no longer exists for ordinary capital goods, it becomes increasingly rigorous, on the one hand, when the product is in the process of initiation and growth, and on the other hand, as soon as it rises in the scale of complexity.

The unavailability or insufficient stock of capital goods for producing other capital goods is also an element of barriers to entry. Hence the importance for countries lacking them to carry out a sort of basic primitive accumulation.

These components of barriers must be, as previously stated, related to the cycle of the different products, and also to the characteristics of demand, existing structures (monopoly, oligopoly, dispersed competition), behaviour (strategy with regard to prices, sales control and research) and results (profits). 9/

6. The UNIDO Secretariat has assembled considerable information on various aspects of these problems (see bibliography). But because of the multiplicity of the groups of capital goods and their structural heterogeneity (see Issue 1), it has not been possible so far to establish the corresponding basis of the industrial economy of capital goods. 10/

It is therefore risky to propose at this stage conclusions based on the existence of barriers other than those of technology, which prevent developing countries from penetrating the different levels of the capital goods sector. Nevertheless, a few dominant characteristics may be described.

Thus, oligopolistic power is exercised by transnational corporations in the sub-sectors of heavy electrical equipment, 11/ more advanced machinery for agriculture, 12/ and the food industry, sophisticated equipment for the petroleum and petrochemical industries, 13/ large boilers, and centrifugal tubes, such as those for monitoring and control. Certain specialized vertical turning mills are produced by only a few firms. In reality, like industry in general, the capital goods sector is not a galaxy but a hierarchical whole. 14/ Within the European Economic Community, in particular, the growing number of transnational agreements on specialization, subcontracting, large-scale supply, marketing and technological co-operation tend to create a new industrial structure, and thus to bring about a new international division of labour within the Community. To the extent that these agreements and this new international division of labour take place within a context of highly dense structures and oligopolistic domination, it has been considered that they will necessarily cause some obstacles and distortions to traditional types of competition.

7. In default of an in-depth analysis, the participants in the First Consultation on Capital Goods are invited to consider the question of barriers to entry for developing countries. Do real barriers exist? If so, for which groups of product? Is there an alteration of international competition in developed market economy countries which spreads by braking or stagnating effects to developing countries? Is there, on the contrary, a dominant opposite trend characterized by the redeployment of certain capital goods industries to developing countries, and if so, in what form - "shared production" (see Issue 1, note 30), integrated production (with what national integration rate and what real added value?) with subsidiaries or independent firms?

In this connection, the question arises as in other sectors, as to the extent to which the existence of high tariff protection in certain developing countries might incite large companies to practise "tariff jumping" and to establish their own subsidiaries, which might after all be what the host country was looking for.

If therefore, the representatives of the countries participating in the First Consultation on the Capital Goods Industry establish the existence of barriers to entry arising from international relations, the possibility of negotiations to eliminate or reduce them should be considered.

8. Barriers to entry are not unilateral and solely due to international relations. They may be created by internal relations within developing countries themselves. Thus local monopolistic powers, even limited, may block developments within or outside the sector. 16/ The lack of entrepreneurs in developing market economy countries may be a serious sociological barrier. The scarcity of qualified human resources, without being an insurmountable obstacle, may initially influence the type of growth of the sector and impose the choice of vertical integration of activities.

It would therefore be important for developing countries at the First Consultation to provide information on the effects, past and present, of these obstacles, on the possible blockages, and since a number of developing or formerly underdeveloped countries have finally been able to penetrate the sector, on how the internal obstacles were overcome.

9. If it appears necessary after the discussion, it is proposed that the UNIDO secretariat, in co-operation with other organizations such as UNCTAD, continue the work undertaken in this field.

* * *

HOW CAN TECHNOLOGY BE PLACED IN THE SERVICE OF DEVELOPMENT?

10. Technological constraints constitute a major obstacle. In view of this fact the UNIDO secretariat has undertaken an examination with the following aims:

(a) To understand the nature of this constraint in the context of the present technological system, that is, to attempt to identify the technological requirements for the manufacture of capital goods and to evaluate their complexity;

(b) To identify the main long-term trends in the technological development of the sector;

(c) To establish a simpler normative technological model in most developing countries.

The results of this study are summarized below.

11. With a view to understanding the capital goods technological system, the UNIDO secretariat has pioneered a new method: that of the analysis of technological complexity. 17/ A summary of this analysis and its main results is annexed.

This analysis reveals an enormous variation in the complexity of machinery and the increasing number of factors involved in this complexity, together with discontinuities in technological complexity, the existence of different levels and the conditions required for these levels to be attained.

Within the technical system therefore, technological levels represent barriers which developing countries may or may not be able to overcome within a given time.

12. The analysis suggests routes for entering the sector and ways of increasing capital goods, taking account of the state of the technological capacity already existing in the various groups of developing countries (see the next chapter on the planning of the sector). It demonstrates that the most difficult stage is the beginning, the creation of the base of the capital goods industry at the lowest levels of technological complexity (1 and 2 according to the system of classification employed). At the present moment 60 countries, that is most of the developing countries, are in this situation. The international community's attention should consequently be drawn to this matter.

This accumulation required more than one century for industrialized market economy countries. Today it is no longer possible for such accumulation to take place in the same conditions. Technology at that time was simpler and could, therefore, be assimilated by ordinary craftsmen. This is no longer the case. 18/ Accumulation changes in nature according to historical conditions. 19/

It is clear that within the framework of co-operation among socialist countries of Europe, the provision of this basis to the least developed among them made it possible to reduce these time spans by several decades. It is also probable that the assistance initially provided to China also contributed to its rapid progress.

Certain developing countries, in the course of time, could equip themselves with the basis for a capital goods industry specifically adapted to their own needs. But this implies a series of conditions: the existence of a societal consensus and of a mobilization of efforts based on a less unequal distribution of revenue, an adequate balance with the production of consumer goods, and an effective co-ordination with the educational system. In fact, some developing countries have taken this course. The policy of counting mainly on ones own forces is not inconsistent with the stimulation of external aid. Such aid, provided it takes into account past and present experience, may help to gain decades. Such periods are crucial for meeting the challenges of growth, employment and hunger in developing countries.

The problem is not therefore posed in narrow terms: are industrialized countries prepared to undertake a common, organized and predictable development effort, and not merely to provide financial assistance? 20/ (This question is also raised in Issue 3).

It is clear that, for most of these countries, the capital goods which they could produce would be intended principally for their domestic market. They would not present any competitive threat to the developed countries. At the very most they might replace some imports. In reality, it would be a question of opening new markets associated with the accumulation of the fixed capital required for industrialization. The type of aid extended regarding this last process would be in terms of solidarity, rather than competition.

13. We will see what the situation is for other developing countries capable of producing more complex capital goods. For various reasons, these countries come up against contradictions resulting from the present state of the art:

- The simple semi-finished production, or those at the bottom of the capital goods range, which are common to all branches of activities, are often products with a lengthy cycle of innovation, which are widely used, and where production is carried out in long production runs at competitive prices.

- The capital goods sector is a major employer of labour. This is a favourable circumstance because of the problems of employment in many developing countries. This labour can be comparatively unskilled for the final part of the manufacturing process but needs to be highly skilled in the previous stages of production. The size of the companies is relatively large, and in all cases the threshold which has to be passed may seem high in many developing countries where the concept of the small and medium-sized enterprise does not correspond with the definitions which are used in the industrialized countries.

The contradictions resulting from the prospects for technological development in the sector and the modes of industrialization arising therefrom seem much more important.

14. The UNIDO secretariat has endeavoured to identify the main long-term trends in the technological development of the sector.

It has collected data on the sector's technological development prospects, as they are taking shape in the industrial countries. 21/ 22/

Opinions generally converge on the following points:

- The new developments in iron and steel will have an influence on the capital goods industry.

The machine will evolve more and more into a system, that is a coherent assembly of mechanical, electric and electronic components. Development will require design technicians dominating these disciplines and their interfaces. Progress will no longer be based on increasingly sophisticated engineering but on the association of engineering with electricity and electronics supported by physics and chemistry, in particular optics, pneumatics and hydraulics.

- Design and manufacture, hitherto independent activities, will evolve towards an integration made possible by the use of computers.

- Instead of radical changes in manufacturing processes such as smelting, there is expected to be an evolution towards the more economic use of matter and energy, improvement in working conditions and automation of the production process.

- The chains of transfer suitable for mass production have the disadvantage of their rigidity. The future seems likely to bring flexible production systems uniting the productivity of chains of transfer to the flexibility of numerical command. They are capable of simultaneously machining parts of different forms in relatively short runs. The grouping in cells of machines rather than in specialized sections is another type of flexible production system likely to bring great changes to shop organization.

- Automation, the activities of which were previously limited, will see an extension in its field of application. Micro-electronics will have a revolutionary effect on industrial evolution in the years ahead. Whereas process computers were heavy and costly systems suitable for use only in large establishments, the technological advent of micro-processors makes possible decentralized solutions and multiple small applications. When the complexity of the functions require it, a specific microprocessor may play the role of a general microprocessor. In this context, numerical command machine tools, which have been made possible by the fusion of engineering, electronics and computer technologies, play a major role in the productivity of the engineering industry.

- Industrial robots, that is reprogrammable multifunctional manipulators, will become more widespread in countries with growing manpower costs and for heavy, unhealthy or dangerous work, in particular reducing manpower needs in assembly activities. In short, the machines of the future will incorporate a more advanced technology, and save energy, materials and human labour. The analyses converge on these points. 23/

The described trends lead to forecasts, the accuracy of which is no doubt an illusion, but which have the interest of indicating a direction and the time required for the new developments in industrialized countries.

- Around 1985: assembly tasks will be integrated with other computer-based production routines.

- Around 1987: approximately 15 per cent of the total production of machine tools should consist of components of blocks of flexible production systems.

- Around 1995: more than 50 per cent of direct automobile assembly work should be carried out by robots, thanks to progress in the development of sensors and programmable automation.

15. Technological development prospects raise two basic questions that are closely interrelated: one concerns the future employment situation in the industrialized countries, the other the technological courses to be followed by the developing countries.

16. The repercussions of technological development on the employment situation are arousing concern among trade union leaders. 24/

The social impact of micro-electronics, for example, appears to be negative with regard to the future employment situation in many branches of industry and services. It is based on process innovation, and some time will pass before it leads to product innovation likely to generate employment. Hence there is a historic difference from the situation which existed between 1950 and 1960, when automation shifted employment but did not reduce the total amount.

These fears do not seem to be simply a new version of those felt throughout the history of progress in machinery.

The current economic recession and the prospect of structural reduction in employment resulting from technological evolution provoke new contradictions within developed market economy countries and questions by the workers with regard to assistance to the Third World.

Therefore these questions must be considered as essential and clear anwers must be given. The First Consultation on Capital Goods should make it possible to clarify ideas on this subject.

It will be recalled that the effects of aid are not only unilateral. It has been demonstrated [25/] that the delivery of factories and equipment from the industrial countries in exchange for purchasing some of the products manufactured with that equipment is generally reflected in a largely positive balance in terms of direct and especially indirect employment in the developed countries. Any elimination of direct employment is related rather to somewhat unskilled work, whereas the creation of employment is related to skilled posts. The two mechanisms are out of phase in time: it will be eight or ten years before any negative effects on employment in the industrialized countries stemming from the new industrial installations of the developing countries will make themselves felt. The industrialization of the Third World therefore seems to be a way out of the employment problems in the market economy developed countries, to the advantage of skilled workers.

As has been said already (see Issue 1) the enormous scale of the needs leaves room for large scale imports of capital goods and for local manufacture. Therefore the net creation of employment should be stimulated both in the industrial and the developing countries, [26/] and a new equilibrium should be struck that reconciles three factors: the technological development of the "centre", the industrialization of the "periphery", and a new international division of labour, as part of the New International Economic Order. [27/]

The achievement of the Lima objectives in general and the gigantic industrial transfer which would result therefrom, cannot be accomplished without a transfer of resources. And the latter cannot be provided by western countries without the support of public opinion.
The dimension of a planetary new deal does not only imply solidarities in terms of capital, but also in terms of the labour forces. It is therefore essential that long-term prospects with regard to the development of capital goods industries in developing countries and of their social consequences, both domestic and international, should be made clear.

It is therefore suggested that after the First Consultation on Capital Goods the UNIDO secretariat should continue to explore the technological prospects of the sector and their social implications for the international division of labour, associating themselves in their work with the representatives of the national authorities, the enterprises and the workers' organizations.

17. To the developing countries, the way in which the technological model of the industrialized countries develops is not an academic question. The development of the "centre" cannot fail to have profound repercussions, if only because of the need to import large quantities of equipment in which the technology is embodied.

That raises a second question (see paragraph 15): the choice of the appropriate technological model for the developing countries.

18. The choice of the technological model comprises several ingredients: the present state of the technological system, its future development, the capacity for technological innovation and the degree of liberty in composite trade 28/.

- Analysis of technological complexity shows the heterogeneity of the capital goods sector. Some capital goods have remained remarkably static technically for 20 or even 50 years, and others are rapidly replaced in five or even two years. Within the present technological model, therefore, several technological generations exist side by side.

- Technological development displays growing complexity. This movement is an integral part of the course of history, scaling-up innovation, rapid obsolescence rates, which have marked the last 30 years.

Technological progress is perceived differently in different industrial countries. With optimism in the socialist countries, where it is considered that the scientific and technical revolution provides new possibilities for society. 29/ With growing reservations in the OECD countries, in which it is the subject of a discussion on which conflicting points of view are held. Disenchantment is manifested as well as critical reflection on technical choices in view of the needs of society. 30/

It is considered that the mass consumption society leads to wastage through the design of objects that are overloaded with inessential features. 31/ Out of this current of ideas comes a flood of publications combining ecological criticism with criticism of economic and political systems. 32/

In short, throughout the criticism of the technological model the point at issue is the growth model followed, and what emerges is the scenario of a "new growth" of national income that is slower, has a different content and is the result of rapid changes in values. 33/ Without neglecting these important trends, the UNIDO Secretariat considers that in the Western countries that orient the world technological model, the design of machines will in the next 20 years be much more directly influenced by the attempt to achieve savings in energy, raw materials and manpower, 34/ and that decision-makers in the developing countries must adopt their positions accordingly. Supply from the industrial countries will probably develop towards more complex, more "intelligent", more efficient and more economical machines.

In view of this prospect, which dramatizes the employment problems in the developing countries, what are the possible choices open to them?

Essentially - a priori - there are two: to select imports of capital goods and local manufactures for the purpose of stabilizing a technological model that will make it possible to employ a large labour force with a low level of skills, or to develop local research and development in order to adapt or innovate appropriate technologies geared to factors of production and the objectives pursued.

- The possibility for a genuine choice of the technological model implies degrees of liberty in composite trade. The power relations within the hierarchy of industry may be reflected for example by imposing the supply of capital goods linked with the financing of industrial arrangements. The opening of the "technological package", the selection of technologies and capital goods by the recipient imply a capacity for analysis and powers of negotiation. They also make necessary organized national machinery for the transfer of technology.

- In the long term, the degree of liberty of choice depends mainly on high R and D capacity in the developing countries. It is necessary to bear in mind the time taken by R and D to produce results[35]. It takes time. That is one reason why the programmes launched by UNIDO in this field should be vigorously activated[36].

- Without underestimating UNIDO programmes' impact in the future, it is reasonable to consider that most of the industrial transfers to be carried out in order to achieve the Lima target will be made in the same way, that is to say, by transfer of the technologies of the dominant economies. There may be by no means negligible differences between these various technologies with regard to their transfer to markets of different sizes and degree of sophistication, but these alternatives are within the category of capital intensive technologies. Hence it is advisable to organize systematic information on the technological alternatives available in the industrialized countries and also regarding those generated in certain developing countries; a relevant activity is now being organized in UNIDO with the Industrial and Technological Information Bank (INTIB).

- Consequently, in order to extend the degree of liberty of choice of the developing countries, it is necessary in the first place to reduce the effects of domination in the negotiations for industrial arrangements and the transfer of technology, secondly, to increase the volume of operational information on technological alternatives which is available to national decision-makers, thirdly, to promote local R and D programmes vigorously and, fourthly, to establish organized national machinery for the transfer of technology and technological innovation.

19. The choice of the technological model in the developing countries that already have an industrial base is the central topic in a debate in which there are two lines of thought:

- The first considers that investment based on capital-intensive technology is incapable of resolving the problems of underdevelopment, in particular those of unemployment. It has given rise to many publications on the subject of intermediate, soft, adapted, appropriate, less expensive, etc., technologies.[37] This current of thought and

action has found its inspiration in the achievements of both China in the 1960s (the image of China walking on "two legs" popularized the recourse to intermediate technologies) and India. This is in line with the current of criticism in the West that aims at a "new style of growth".

Initial results have been obtained elsewhere, but this policy seems to have encountered a major contradiction in developing market economy countries. Private entrepreneurs seem little inclined to favour labour-intensive investments. The labour-force economy seems to remain a constant at the level of the enterprise, even in developing countries.

- The second considers that developing countries, and above all newly industrialized countries, cannot remain aloof from the technological progress of industrial countries and must make selective transfers.

In fact, national decision-makers in relatively advanced developing countries now find themselves, and will increasingly find themselves, confronted with the following dilemma: whether to accept in future a widening of the technological gap with the industrialized countries, or to try to limit it as much as possible. The example of machine tools revolutionized by electronics is especially illustrative. 38/ Should this new equipment, essential to the productivity of the engineering and capital goods industries, be imported? Is this new labour-saving equipment likely to reduce the bottleneck represented by the training of qualified personnel in the capital goods industry (see Issue 1)? How does the problem shift in terms of the necessary software and the degrees of dependence? Should one now prepare for the future manufacture of at least a part of these sophisticated machines by developing countries having an industrial base?

It does seem - and the First Consultation Meeting will confirm or invalidate this statement - that for these countries the dilemma is generally solved by plunging ahead and ignoring the consequences, by accumulation on the basis of intensive technology.

In the capital goods sector only a few large recently industrialized countries are able to conceive of the future in terms of catching up. This is not possible for the other developing countries. Hence the question arises: "What technology for what growth?"

20. The feasibility of simpler technological models was raised during the preparatory meeting in Warsaw [39/] as a fundamental question that should be explored. The problem was raised of constructing a capital goods industry in many developing countries not in order to reduce the technological gap but to meet the needs of the population in the various countries.

There are two complementary approaches to this problem: one of them is technico-economic in nature and the other socio-political.

From the technico-economic point of view, research along two lines is necessary:

1. With reference to the present technological model, it would be necessary:

(a) To identify capital goods involving simple technology (levels 1 and 2) or of intermediate complexity (level 3);

(b) To ascertain whether these capital goods are static in nature and whether technical progress is not likely to make manufacturing processes more complex in the future;

(c) To ascertain whether the production scale for these capital goods is compatible with the markets of small and medium-sized developing countries and, if not, whether there are technological alternatives for the manufacture of capital goods in shorter production runs;

(d) To ascertain whether these capital goods meet the needs of the countries in question. In this approach, it is therefore necessary to select the simplest capital goods out of the existing stock.

The UNIDO Secretariat has compiled an initial amount of information on the above points and has taken this as its inspiration to propose a strategy for the sixty developing countries that have not yet a capital goods industry to enable them to enter the sector (see below: Planning of the sector).

2. In order to abandon the present technological model and move towards greater simplicity, it would be necessary to clarify the following questions:

(a) Is it possible to reverse the historical movements of economies of scale, of scaling-up innovation, by designing production installations of a smaller size and moving towards "scaling-down" innovation?

(b) Is there an unnecessary load of technological complexity in machines, in the excess of components, the degrees of accuracy and excessive tolerances, when compared with the real use of these machines in developing countries?

(c) Would it not be of value to hold back the very rapid rate of obsolescence and to move towards the production of machines, perhaps of slightly lower performance, in longer and more stabilized production runs?

(d) Would it not be of interest to manufacture products which are more durable and to organize, systematically, the recovery of the durable if not imperishable parts of such items of equipment?

(e) Would it not be of value and possible to redesign machines to a simpler design without their necessarily being copies of old and obsolete models?

These questions are wide open and doubtless clear-cut answers are not yet called for. Nevertheless, the following remarks may be advanced:

- In certain sectors the reversal of the economies-of-scale approach has begun (for example, iron and steel and fertilizers). That may give the medium-sized developing countries a new chance to "turn the corner" in good time and to develop capacity for the design and manufacture of the new equipment necessary.

- The overloading of products with inessential items is not so evident in capital goods as it is with durable and non-durable consumer goods. It has nevertheless been recognized by some engineers in the industrialized countries. 40/ This realization is no doubt made difficult by intrinsic endogenous development and the semi-autonomous nature of technological development. 41/

- The struggle against wastage in society leads us to consider the design of products in new terms in order to make possible, inter alia, their disassembly. 42/ The countries that succeed in making a breakthrough

in this field and that take over leadership will probably be able to obtain important advantages for the future. That does not necessarily imply the most complex solutions. It may be a chance for the developing countries, and the same applies to the manufacture of more durable goods (which, it is true, refers mainly to consumer goods).

- The redesign of machines that are simpler, sturdy, easier to repair and have sufficiently high performance, is not out of the reach of the developing countries. 43/ It would doubtless demand co-operative association between those that have sufficient capacity and possibly the assistance of the industrial countries.

From the socio-political point of view, that raises the problem of the compatibility of a simple technological model - one that deviates from the path of development of the dominant technological pattern - with the type of growth projected.

- Certain developing countries, and perhaps the majority of these countries, think of their growth by analogy with the consensus observed in developed countries concerning dominant values in the post-war period, by which economic growth in the traditional sense of the term was assigned a privileged position. 44/

The experience of the last 30 years shows that there is little chance that this type of development will reduce social inequality and make a significant contribution towards raising the living standards of the masses of the poor. Technology has two aspects: it is a dose of knowledge and qualifications that is embodied in the functions of production and in the structure of functions of consumption. 45/ Final consumption "pulls" the capital goods sector, when it exists in many developing countries. When the decision-making power belongs to a small privileged élite, that may lead to the marginalization of the needs of the rural masses. 46/ Industry is "pulled" towards the manufacture of durable consumer goods bought by only part of the population, or towards the production of capital goods for their manufacture. As mass production implies very specialized and sophisticated equipment, their local manufacture is usually out of the question. Activities are usually reduced to assembly work. External technological dependence is therefore reinforced. The "pattern" of final

consumption leads neither to the production of capital goods intended for final consumption by the vast majority of the population nor to the reproduction of the production apparatus itself. 47/

In conclusion, the logic of a model based on final consumption derived from the industrialized countries' model is associated with that of the dominant technological model. The possibilities for defining and applying a simplified technological model seem to be lower in that context.

- In a smaller number of other developing countries, the ideas which lead to a recognition of the need for a New International Economic Order call for reflection on the ends and means of a new development strategy different from that gradually elaborated and adopted during the First and Second Development Decades.

For these countries the question of the new economic order is not raised in terms of catching up but of "new growth". The underlying values of such growth consist of various combinations of the following, according to the national situations: priority for the needs of the rural masses, a less unequal distribution of income, policies of sectoral self-sufficiency, policies of self-reliance, progressive technological apprenticeship, mastery of industrial installations commensurate with the management potential of the country, the establishment of an industrial fabric that is integrated and specifically suited to national realities. A priori these countries seem to be more likely to define and implement a simpler technological model, because they have the appropriate socio-economic forces. The limiting factor then seems to be the national scientific and technological infrastructure.

Considering the exchange of views during the First Consultation Meeting it is suggested that the UNIDO Secretariat should continue its work to explore the possibilities for the dissemination of simpler technological models of interest to a large number of developing countries.

21. It is not impossible that the tendency towards complication of the technological model and the converse, namely, the tendency for its simplification should exist side by side.

The first is a development that no force seems able to halt, because it is a response to the technical possibilities and problems of our age. The second can only be a normative policy related to other problems.

In fact the technological choices open to the developing countries will probably not arise in the future in the form of an option between two technological development models - one of which is to be promoted - but will arise for each country, at the level of each sector, according to dimensional factors, markets and human capacity. The most probable solution - and no doubt the most appropriate concept - is that of technological pluralism. 48/ That implies a judicious choice of more advanced technologies that are likely to have linkage effects with simpler technologies, in sectoral and intersectoral combinations. The options regarding capital goods constitute the foundation stone for the management of technological pluralism.

22. It must therefore be realized that, as the result of a constraint or a balanced choice, during the next 20 years and beyond, the developing countries - and especially those that have an advanced industrial base - will not escape the effects of the complication of the present technological model, particularly, innovation by "invasion of the sector", represented, for example, by electronics. This probability, if not this certainty, leads us to deduce two important operational implications for the developing countries which seem to be common to various growth strategies for the sector:

- Technicians and other workers capable of maintaining and repairing the machines of today and tomorrow, in which the rate of the components will steadily increase, should be trained.

- The organization of material in university curricula for engineers should be reconsidered. The machine as a system implies an integration of knowledge and disciplines and a teaching programme which is truly polytechnical and not narrowly compartmentalized. 49/ Such a revision concerns both industrialized and developing countries. It may provide the latter with an opportunity to undertake as quickly and as thoroughly as possible the preparation of the qualified human resources of the twenty-first century.

It is a field in which co-operation can already be initiated.

It is suggested that the UNIDO Secretariat, in co-operation with ILO and UNESCO, should continue the studies undertaken for the training of machine repair mechanics and reorientation of the training of engineers from the developing countries.

* * *

PLANNING OF THE CAPITAL GOODS SECTOR

23. The past experiences of different countries and the challenges which the developing countries have to cope with - under widely varying conditions - all lead to the same conclusion: The long-term development of the capital goods sector must be planned. The primary reasons for this have been indicated (see Issue 1).

In the light of these experiences and challenges, we are led to select from among many questions four main problems to which planning should give a reply in the specific context of every individual country:

(a) The selection of paths of entry to industry;

(b) The establishment and growth in complexity of the industrial fabric;

(c) The coupling of levels of complexity of technology;

(d) The mastery of factors of international interdependences.

These problems are briefly reviewed below. In the light of them, we shall then suggest a few guidelines for planning of the sector.

24. Since the options selected will involve a long-term commitment, the choice of paths of entry and of growth is of decisive importance, for it is through these choices that the texture of the industrial fabric is determined.

If it is true that transport material has a high technological complexity, the question arises as to whether developing countries having decided to establish a capital goods industry in such materials have chosen a path likely to permit the development of that industry. In most cases in fact, the activities seem confined to assembly work without leading to real industrial apprenticeship in the sector. The question is complex and deserves discussion. Were other choices possible in view of the lack of qualified manpower? Did that contribute substantially to the growth of employment? Are there cases where that has made it possible, by a policy of stimulation, to develop a real apprenticeship in local upstream subcontracting enterprises? Does this type of industrial transfer represent the future for developing countries? 50/ Is this future not already threatened by technological progress, in particular the introduction of microprocessors into machinery, which will permit great flexibility in automation, reduce production costs in industrial countries, and may compromise the relative advantages of developing countries based on lower manpower costs?

It is therefore useful to make an objective evaluation of past experiences, whether successes or failures, in order to prevent countries preparing to enter the sector from taking the wrong paths.

Where can the 60 developing countries [51] which have no capital goods industry begin, and where is it in their interest to begin?

- Analysis suggests that the group of simple agricultural machinery has the lowest technological complexity. Furthermore all those countries are essentially agricultural. Consequently, there is perhaps a path which could be more systematically followed. The basic technological line concerns forging, plating, machining and welding. It opens up the possibility of manufacturing simple products for rural life. Sociologically, it can rely on village craftsmen, in which case the latter should be assisted in the acquisition of other capacities (for example mechanical welding). [52] Within the framework of such a policy, emphasis is placed on the decentralization of activities and on the authentic practical school of repair and maintenance shops for training a more qualified manpower.

Downwards from agriculture the production of simple capital goods for the food industry is a possible complementary policy. This equipment intended for reduced scales of production may have the advantage of being well-adapted to the needs of local markets. [53] In general, this equipment is more complex than simple agricultural machinery, but its manufacture does not seem to be beyond the reach of most of the 60 countries considered.

- Entry by means of capital goods common to all branches is, a priori, an interesting idea, because such goods represent 40 per cent of the value of capital goods, and their mean complexity is less than the mean of all capital goods. But the dispersion of complexity is considerable and only a small part seems suitable for production by countries which currently lack capital goods industries. Moreover, the simplest capital goods are common and sometimes technologically stable for decades. But they are most often mass-produced. The barrier is therefore not technological but is one of respective production costs and the scale of the market. This path of entry therefore implies a severe selection of products.

- One of the criteria of choice is the option of technological lines which make it possible to diversify production, to carry the apprenticeship function as far as possible, and to find out paths which do not block the process and which prepare for the crossing of technological barriers.

The discontinuity of the technological complexity of capital goods implies qualitative changes. The technological horizon of the blacksmith, of the village craftsman, may be broadened, but it has its limits. Entry into the manufacture of other types of machines, even simple ones, implies a new production. It is to the new structure that about 20 developing countries have acceded.

25. The second problem of planning is the establishment and growth in complexity of the industrial fabric. This concerns mainly the 20 or so developing countries which have an industrial base for capital goods.

In general, those countries have been able to dominate other technological lines including sheet-metal working (cutting, forming, etc.), welding, forging (for tool-making), ironworks and engineering of medium complexity.

In a number of countries in this group, projects exist for manufacturing machine tools (lathes, millers, cutting machines, borers, etc.) intended mainly for repair and maintenance shops. Projects also exist for incorporating national components into large basic industrial projects such as energy production, iron- and steelworks, petrochemicals and cement, which require in particular boilerwork activities.

In certain cases, these projects give rise to a regional programming and division of labour (Andean Pact in Latin America, for example). For the oil-producing countries, in particular the Arab countries, studies are being actively carried out to establish integrated development projects in the sector.

These countries have therefore entered into a process of growing complexity of their industrial fabric. The latter generally consists of components of types 1 and 2 with elements of type 3 under the adopted classification. 54/ Some of the countries are at the crossroads so far as concerns their basic policy directions.

The UNIDO Secretariat has found that most of these countries are now asking themselves two basic questions:

1. In what direction and to what extent should the infrastructure for the capital goods industry (i.e., semi-finished goods and technical services) be developed? 55/

2. In what direction, i.e., vertically or horizontally, should the elements in the capital goods industry be integrated?

- It is clear that without a minimum of semi-finished products and technical services infrastructure, the manufacture of equipment goods is reduced to assembly activities, that is a pseudo-industry for capital goods.

This infrastructure must therefore be established, and to do so is of decisive importance up to the level of intermediate technological complexity (level 3 on the scale adopted). That is the price to be paid for economic and technological accumulation. Without this national infrastructure, it is impossible for the industry to achieve self-sustained progress.

The growing complexity of the industrial fabric as a result of the progress of the technological infrastructure is a decisive turning-point. It is the permissive condition for full access to complexity level 3, where it is possible to produce 40 per cent of the equipment goods. This level makes it possible to produce, in particular, most of the semi-finished products, part of the goods common to all branches, and, among the specific machines for the sectors of final demand, part of agricultural machinery, equipment for the food industries and equipment for the chemical and petrochemical industries.

At level 4, 75 per cent of the products could be manufactured.

One must not pretend that reaching level 3 for developing countries of medium size, which already have a certain base, will not require time: the 20 years between now and the end of the century seem in many cases a minimum. However, whether the horizon is slightly more distant or slightly nearer, as a function of the initial bases, resources, policies and international co-operation, this general objective does not seem to be beyond the scope of many developing countries.

The goal suggested by the UNIDO Secretariat is obviously of a very general nature. It should be possible subsequently to define it more precisely on the basis of national projects and a better knowledge of alternative strategies applied by different countries.

- There is no inevitable response to the suggested developments. The future will be built partly on the basis of the paths chosen during the development process in favour of vertical or horizontal types of integration.

Historically, those countries which are today industrialized have given different answers to the spatial arrangement of the sub-groups of the capital goods industry. Constraints which, initially, could not be eliminated have resulted in a type of vertical integration of activities. In other countries, market forces and the existence from the sociological point of view of a class of entrepreneurs have divided up these activities and have led to horizontal forms of integration.

In many developing countries, and for different reasons, there have been no possible choices other than recourse to vertical integration. First of all, the technical infrastructure was almost non-existent. Secondly, the size of the market was often too small to justify the existence of specialized firms. Thirdly, the establishment of foreign subsidiaries often created a vertical structure. However, the rapid increase in complexity from level 3 onwards leads to a difficult management problem. If the central production unit integrates all or part of the components of the technical infrastructure, the total complexity exceeds that of the variety of management. At worst, the system risks running out of control. At best, it leads to an underutilization of installed capacities.

In the case of horizontal integration, the technical infrastructure production factors are divided into distinct enterprises. The total complexity is thus divided up and is more easily managed. The difficulty shifts, in this case, towards the mastery of the linkages between the assemblies and subassemblies, and hence to the intersectoral and inter-company links.

The national comparisons made by the Secretariat suggest that, without blocking the system itself, [56/] it is necessary that, because of its development, and as a condition of its continuation, it should restructure and modify its own links. As soon as circumstances permit, branching off towards horizontal integration becomes necessary, [57/]

together with the cleaning-up of activities within the vertical enterprises, leading to more effective specialization and distribution of these in relation to other enterprises. In this way the structure has to evolve.

To state these principles is easy, to apply them is not. That is why it would be of the highest interest for both developing and former underdeveloped countries experiencing a change in their industrial structure to agree to explain their position on this point.

26. The third problem of planning of the sector is reduction of the gap between the complexity of technology transferred from abroad and local technological capacities.

The transfer of turnkey factories linked to large investment projects introduces manufacturing units of high and sometimes very high levels of technological complexity. The weaker the technological level of the local environment, the less likely it is that the introduction of such elements will produce effects of encouragement on the existing technological variables. The distance between the latter and the variables introduced seems too great to permit their coupling. It is the coupling which should "pull" the existing capacities upwards and facilitate the apprenticeship function. In other words, the created poles of industrial growth have not produced the expected effects. 58/ The observation does not seem to concern only developing countries of small and average size, but the largest, in particular China. 59/ Isolated islands of complexity have been created.

There are certainly exceptions, and the First Consultation provides an opportunity to verify this assertion and, where this obstacle has been overcome, to determine how the coupling was achieved between local technological capacities and the technological complexity introduced, and how the latter was removed from its island and diffused.

27. The fourth problem of planning is mastery of the factors of international interdependence inherent in the very nature of capital goods.

An apparently paradoxical phenomenon should be stressed: the more a country progresses in the manufacture of capital goods, the greater the international interdependence.

Components play a growing role in total complexity. At level 4 they take over the majority influence.

The international division of labour is highly developed for components. As a general rule, the number of nationalizations of the means of production in developing countries will therefore tend to increase and then to decrease. Trade and international co-operation are therefore an intrinsic constraint, and not even the most developed countries can live in a state of autarky in respect of equipment goods.

A question that risks being stated in the wrong terms is that of self-sufficiency. It may be global if by that is meant an equilibrium of commercial exchanges. It cannot be total if it is understood to mean the autonomous production of the means of production, infrastructure and components. At the lower levels of complexity (1 and 2), the weight of the components is weak. But most of the time they are too complicated to be manufactured locally and must be imported.

Interdependence is therefore a fact, the true problem being that of its conditions, either strong or weak. 60/ A country that manufactures increasingly complex equipment without a parallel development of its capacity of technological innovation is clearly creating for itself a situation of structural dependence. 61/ The example of Spain suggests that rapid industrial success does not exclude these dangers. 62/

One of the essential problems of sectoral planning is therefore the problem of defining an evolving policy regarding importation and local manufacture of components.

As the industry becomes more complex, national constraints change.

Thus, for developing countries with an industrial base, the priority is the strengthening of design and engineering capacities. For the largest countries (India, for example), in certain sectors the problem now seems to be that of mastering the most advanced technological production routes: precision engineering, high-quality metals and electronics, the integration of which would fully open the doors to international competitiveness 63/.

The phenomenon of interdependence linked to increasing complexity has important implications for the planning of the sector:

- It makes it necessary to establish in the developing countries, as soon as possible, a design and ultimately an engineering capability; to provide training in the repair of numerous and increasingly important components, training which is generally not available in most developing countries; to ensure the gradual adaptation of the training programmes [64]/ in recognition of the fact that the increasing complexity of manufacturing processes entails a shifting of functions within the same enterprise, [65]/ a seriously underestimated phenomenon. Planning must therefore co-ordinate the evolution of the system of education and training, programming accordingly transfers of technology and technical assistance from abroad.

- A consequence, then, of this interdependence is that international co-operation becomes imperative (see Issue 3). In order that this co-operation not be imposed as some sort of binding obligation perpetuating relationships of dependence, but, on the contrary, that it help to correct imbalances, it is necessary that, during international negotiations, a time-table be drawn up indicating how the requirements of the capital goods industry in terms of means of production, human resources, infrastructure, and components are expected to evolve, and that this time-table and its scheduling be the subject of negotiations. This would also appear to be a condition for the success of regional co-operation among developing countries.

28. The problems associated with the growth of the capital goods industries in the various groups of developing countries suggests a number of fresh approaches to the planning of this sector.

It must be recognized that, apart from some notable exceptions, in the majority of the developing countries the establishment and growth of this sector has been virtually unplanned. Under the pressure of necessity and opportunities, the introduction of capital goods industries has proceeded by fits and starts. In most cases, in any event, the countries lacked even the minimum means of planning. The result has most often been an unco-ordinated, or poorly co-ordinated, industrial fabric lacking essential links and suffering from structural weaknesses difficult to overcome at a later stage.

The demand for capital goods can today be determined as a function of the demand of the consumer sectors and the Government's policy objective.

UNIDO has acquired valuable experience in this area through its planning of this sector in a number of large countries, such as Mexico. By correlating the analysis of this demand with the study of existing capacity, it has been possible to arrive at the requirements for the expansion of facilities and for the establishment of new enterprises. It has been possible to prepare a capital goods development programme containing a breakdown of the various technical assistance activities. 66/

On the basis of UNIDO's experience, certain complementary factors in the planning of the sector can today be identified. These concern three essential aspects:

(a) The combination of the "pull" and "push" approaches;

(b) The design of projects for the vertical integration of iron and steel industry projects with engineering industry projects in selected developing countries;

(c) The design of integrated projects relying on multipurpose production apparatus for diversification in manufacturing.

These aspects will be briefly discussed below.

29. It is proposed to rely on a practical combination of the "pull" and "push" approaches in the planning of the capital goods sector.

As the reader will be aware, technological innovation is generally regarded as the result of an induction, either of the market or of the technique itself. 67/ In the first case, this phenomenon is designated as the "pull" approach, in the second as the "push" approach. This theoretical classification may be useful to characterize the strategic options to be taken by developing countries in order to create or develop their capital goods industries. In most cases, demand from the utilizing sectors has pulled and directed the manufacture of local capital goods. Import substitution policies are a variant within this general classification.

In fact, planning methods in the sector necessarily, and often exclusively, start from the demand approach. They less often consider the technical possibilities of the production apparatus to push the development of the sector.

In the first policy, the capital goods sector is pulled from outside by downwards-located sectors. The market mechanisms are the dominant forces, links are established from downwards (the utilizing sectors) to upwards (capital goods), with the downwards sectors playing the role of the dynamic pole of development.

In the second, it progresses as a result of its own dynamism and intrinsic forces. The capital goods sector itself becomes the driving force. Voluntarist policies of fixed capital accumulation are then the dominant forces. The mastery of increasingly complex technological lines itself becomes an explicit objective.

It seemed interesting to reinterpret various policies from this point of view through case studies available to the Secretariat. Thus, the case of Spain is a model of the pull approach, by which the general economic development of the country, with its accelerated process of industrialization, created growing demand for equipment and machines. In most developing countries, demand for equipment goods is also pulled by the utilizing sectors. Often, however, the guiding force is not mass production of consumer goods for the enjoyment of the great majority of the population. The production of capital goods is intended for a final market limited essentially to the demand of the affluent strata of the population, a demand which itself reproduces the dominant patterns of consumption. 68/ There is also a pull effect, but it is distorted by the structure of final demand. It should be noted that the same production apparatus could, in many cases, without major technical difficulties, produce capital goods intended for the essential needs of the population and the reproduction of the production apparatus itself. The choices to be made are therefore secondarily technical and principally social and political.

These social and political choices have led China to emphasize heavy industry, which appears to have played a driving role regarded today as excessive. The Chinese policy is a typical example of the "push" approach, centred on the gradual mastery of technical infrastructure, amidst the tumultuous conditions which have marked the history of that country in recent decades. 69/

In India, the abundance of natural resources made possible the establishment of an iron and steel industry, which 30 years ago was the first priority. The second priority in time was the establishment of a capital goods industry. But however important was the logic of steel-making, it has been overtaken by the manufacture of the equipment required for steel production. Emphasis has been placed on the radical change of structures and not on gradual evolution. 70/

In Brazil, technological mastery was an explicit objective, and a selective policy of introducing and developing the manufacture of capital goods was implemented, together with a mechanism for filtering imported technologies and stimulating national innovation. 71/

It may be noted that only the large developing countries seem to be in a position to implement a policy directed towards the strengthening of their technical production infrastructure. India and Brazil have, a priori, the potential market, but while the policies applied have not ignored market considerations, demand has not exercised such a tyrannical influence, and industrial policy has been boldly seen from the point of view of supply.

In other countries of medium size which do not have such a large market potential, such as Algeria, long-term development plans make it possible to conclude that for a long time demand will exceed supply, and that therefore the main problem is to increase the possibilities of the production apparatus and to master technological developments.

The pull and push approaches have their advantages and their disadvantages and can be risky 72/. The main risk of the exclusively demand-oriented approach is that, through an incoherent policy, an unintegrated industrial fabric will be built and it will not be possible to create the conditions for technological mastery. The main risk of an exclusively push approach is that it may result in a capital goods production apparatus unlinked, or insufficiently linked, to the downward sectors, which would lead to unutilized excess production capacities.

It therefore seems necessary to search for the most adequate combination of these two basic approaches in the specific conditions of each country.

This is why the UNIDO Secretariat has sought to devise supplementary tools as a means of providing additional help to planning officials in developing countries who lack the analytical instruments with which to incorporate the technological variable in an explicit way. The so-called technological complexity analysis is intended for this purpose; it is the instrument which corresponds to the "push" approach. As recommended at the Warsaw Preparatory Meeting, the method has been tested for the purpose of making it into an operational instrument available to the developing countries.

It is therefore proposed that the first world Consultation should recommend that UNIDO give high priority to its efforts to assist in the planning of the capital goods sector, and that it contribute to the development of new and effective instruments for use by planners and to their training.

30. It appears that interesting possibilities may be opened up through the planning of the integration of iron and steel projects and the engineering industries, including the capital goods sector.

Some countries seem to have closely linked the capital goods industry with intermediary industries such as iron and steel. On the basis of input-output tables, this strategy may be described as "descending". The link between the development of the iron and steel industry and that of capital goods is particularly strong in China. 70/

Today, a number of iron and steel projects exist in developing countries. A UNIDO study 73/ has estimated that a total of 108 will exist by 1990. Of this number, 40 projects accounting for nearly one half of the capacity of the projects studied are based on direct reduction processes and are generally small-scale; 41 countries, which have limited experience in iron and steel, propose to create or develop an iron and steel industry. 74/

Considering that the importance of iron and steel comes as much from what it promotes as from what it produces, 75/ as in India and China, the iron and steel projects, even those of small size, could be used as a pole of encouragement of a basic metal-processing sector and of a rudimentary capital goods industry if none exists.

Moreover, the financing of iron and steel investments, their low profitability, and the orientation towards high-performance steels pose awesome problems for the young iron and steelworks of developing countries, and in fact obliges them to establish links with the engineering industry. These links raise the question of which iron and steelworks go with which engineering industry. If planning of the iron and steel sector is integrated with that of the capital goods industry in those countries, "descending" strategies (iron and steel towards capital goods), "rising" strategies (demand for capital goods orienting iron and steel supply) and the push approach (domination of the respective technological lines) seem suitable for combination.

Since the intermediate industries projects (iron and steel and petrochemicals, for example) require repair and maintenance shops, the latter could serve as focal points, as a kind of training school for mechanics, for the upwards creation of a core of capital goods industries. 76/

Other combined strategies are possible. The downward poles of development may also be utilized within the framework of a voluntarist policy that may be described as "rising". It starts from the consumer sectors, rises through the technological lines and comes finally to the production of capital goods. 77/ The example of the Republic of Korea seems to illustrate this strategy for limited types of capital goods.

The challenges of underdevelopment require the exercise of creative imagination and not just the reproduction of past experiences which are usually specific to different countries. In this connection, it would be interesting to understand how a country like Cuba, under the constraint of a heritage characterized by monoculture, was able, on the basis of the sugar industry, to implement a "pivotal" strategy making possible the production of increasingly complex capital goods for that industry, and then to diversify production. 78/

It is therefore suggested that, following the First Consultation, UNIDO should continue its country studies and undertake a comparison of these experiences and an analysis of their relevance to the development policies for this sector in the developing countries.

It is further suggested that particular attention should be given to the joint planning of the iron and steel and capital goods industries of 40 developing countries, mainly in Africa, and that concrete projects should be initiated.

31. The planning of the integration of capital goods industries "upstream" and "downstream" of agriculture similarly appears to offer another possibility.

Thus, for the 60 countries which have no capital goods industries, agriculture could, in most cases, constitute a focal point around which to establish such industries - farm machinery ("upstream") and food industries ("downstream"). This policy could be combined with the policy of optimizing the versatility of the production system so as to provide a wide range of manufactured goods (e.g., for the construction sector).

At the micro-economic level, this policy should make it possible to begin small production runs which, unless there is product diversification, would be difficult to justify because of the limited nature of the market.

Accordingly, consideration should be given not only to projects for the manufacture of simple agricultural machinery, but also, in keeping with the "push" approach, to projects which, while based on this industry, exploit the production system to manufacture other products as well, in most cases for use in rural areas.

It is suggested that UNIDO should study the feasibility of projects integrated around agricultural mechanization and that, on the basis of work now in progress, [79] it should launch suitable pilot projects.

In conclusion, sectoral planning in the developing countries can be approached from three fresh angles, which, in ascending order of complexity, are the following:

- The integration of simple machine-building "upstream" and "downstream" of agriculture, an approach of interest principally to the 60 least industrialized countries;

- Vertical strategies integrated between the iron and steel and the capital goods sectors, with apparent advantages for 40 countries;

- Strategies which combine the "pull" and "push" approaches and which, a priori, are applicable in varying degrees to all the countries, but the need for which appears particularly urgent for the 20 developing countries with capital goods industries currently facing a choice as to their path of future development.

32. The rebalancing of the capital goods sector and its growth in the developing countries is an essential condition for the establishment of the new international economic order. It is obviously a task of great scope and long duration.

It is also a task that cannot succeed without a rigorous methodology of concerted action at the international level. It is for the purpose of defining this methodology that the UNIDO Secretariat has decided to convene the First Consultation. Its main outline is already evident:

- The international community must recognize the need for producing increasing quantities of capital goods in the developing countries.

- The introduction of the developing countries into this sector and the build-up of their production must be a matter of long-term planning, and UNIDO must assist them in this task.

- A clear, long-term view of the development outlook is an essential condition for strengthening the negotiating position of the developing countries. The results and adjustment of this planning could provide a flexible framework for a kind of indicative sectoral planning.

- Greater transparency in projects would both trigger and flow from international co-operation. This transparency must be built into the planning process.

- The corollary of long-term planning is long-term international co-operation.

- On the basis of these principles, it is possible to define gradually the modalities of the operations to be undertaken, along with a programme of action for UNIDO.

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NOTES ON ISSUE 2

1/ "Estudio sobre el desarrollo y evolucion de la industria de bienes de equipo en Espana" - METRA/SEIS - UNIDO - 1980.

2/ "Development of the Capital Goods Industry in Bulgaria - Summary and Conclusions", prepared by the Institute of Economics, Bulgarian Academy of Sciences - UNIDO - ID/WG.324/8 of 15 September 1980.

3/ Li Yong Xin, Associate Chief Engineer - Techno-Scientific Information Research Institute - The First Ministry of Machine Building P.R.C.: "Development of Capital Goods Industry in China", a study in co-operation with UNIDO - March 1981 - Beijing.

4/ To these examples may be added the equally typical case of Belorussia. Sixty years ago the per capita production of its engineering industries was 8 per cent of average Russian production, the level of which was itself low. Today, in this Republic, the equipment goods sector accounts for 70 per cent of the value of industrial production. As a result of specialization, it ranks third in the USSR for the manufacture of machine tools, second for lorries, third for tractors and first for harvesters and silo fillers.

See: O.I. Prikhodtchenko - Belorussian SSR "Développement industriel de la RSS de Bielorussie (expérience de la République en 60 ans)" - UNIDO - Seminar on Strategies and Instruments to Promote the Development of Capital Goods Industries in Developing Countries - Algiers - 7-11 December 1979.

5/ A. Zvorikine: "Ideas of technology - Technology and the laws of its development" in The Technological Order - Proceedings of the Encyclopaedia Britannica Conference edited by Carl F. Stover with a foreword by William Benton, Detroit, 1963 - Wayne State University Press.

6/ See the classic work by J.S. Bain entitled "Barriers to New Competition" - Harvard University Press, Cambridge, 1956, and, more recently, Roger Sherman, University of Virginia: "The Economics of Industry" - Little Brown and Co., Boston, 1974. Alexis Jacquemin: "Economie industrielle Européene. Structures de marché et stratégies d'entreprises" - Dunod, 1975.

7/ The situation of iron and steel projects illustrates the growing cost of investments. See: "Propositions de scénarios" - UNIDO/IS.213/Add.1 of 23 February 1981.

8/ "Capital Goods common to all branches of industry, excluding machine tools and electric power generation and distribution equipment" - ICME Business Consultants, Zürich, Switzerland - April 1979.

9/ Jean-Marie Chevalier: "L'économie industrielle en question" - Calmann-Lévey, 1977.

10/ The interested reader will find an example of a matrix for industrial economy in the petrochemical sector in "First World-wide Study on the Petrochemical Industry: 1975-2000" - Chapter: "The barriers to the entrance of the new producers" - UNIDO/ICIS.83 - 12 December 1978.

11/ "Les stratégies d'entrée dans la production de biens de capital pour l'énergie électrique" - IREP, Grenoble/UNIDO - May 1980.

12/ "World-wide Study on the Agricultural Machinery Industry (first study)" - UNIDO/ICIS.119 of 29 June 1979.

13/ "Biens d'équipements pour la pétrochimie et les engrais dans les pays en voie de développement" - IREP, Grenoble/UNIDO - November 1979.

14/ If any doubt existed on the subject, it would suffice to consider the absolute scale of production magnitude of the engineering and electrical industries (value added in 1977).

Two superpowers have an added value for the sector exceeding $100 billion, 10 countries have an added value of approximately $10 billion, 23 countries have an added value of a few billion dollars, 18 countries of about $100 million, 17 countries of tens of millions of dollars, 10 countries of about $1 million, and the other countries have less.

15/ Remo Linda, adviser to the Direction générale de la Concurrence, Commission of the European Communities: "The division of labour within the European Community and the new endogenous competition" - special issue: Towards a new international division of labour - Revue d'économie industrielle - fourth semester 1980.

16/ G. Misas: "Una contribución al estudio del grade de concentración de la industria colombiana" - Edición tiempo presente - Bogotá - 1975

17/ The reader interested in a more detailed analysis may refer to the document "Technology in the service of development", Global Preparatory Meeting for the First Consultation on the Capital Goods Industry, Wawsaw, Poland, 24-28 November 1980, UNIDO, ID/WG.324/4, 19 September 1980, and to the "Condensé des études sur les biens d'équipement".

18/ See Paul Bairoch: "Industrial revolution and underdevelopment" - SEDE - 1964.

19/ A distinction is made by Soviet economists between extensive and intensive modes of growth. See the work of W. Andreff: "Structure de l'accumulation du capital et technologie en URSS" - Revue d'études comparatives Est-Ouest - Vol. IX, No. 1, March 1978.

20/ See Claude Cheysson, member of the European Commission: "Pour la croissance d'un 'new deal' planétaire" - Le Monde, 30 April 1981.

21/ In particular the following:

- "Les biens d'équipement automatisés: les acteurs, leur impact sur les conditions de production" - IREP, Grenoble/UNIDO - February 1980.
- L. Demol: "L'industrie des biens d'équipement dans les pays développés à économie de marché" Report for UNIDO - Brussels, April 1981.

22/ S.M. Patil: "Technological perspectives in machine tool industry and their implications for developing countries - Summary" - UNIDO/IS.226 - 5 May 1981.

23/ See also Guy Denielou, President of the University of Compiègne: "Science et Société" - Le progrès technique No. 17 - 1980, and Robert U. Ayres: "Uncertain Futures - Challenges for Decision-makers" - John Wiley & Sons - 1979.

24/ See Günter Friedrichs, Head of the Automation and Technology Department of the German metallurgical trade union IG-Metall: "La micro-électronique: impacts socio-économiques" - Revue Futuribles 2000 - September 1980.

25/ UNIDO - André Tiano: "Buy-back financing of international sales of factories" - UNIDO/EX.99 - 9 November 1979.

26/ This approach requires new methodological tools, which are currently being created; for example, the use of inter-industry matrices in work equivalent. See Nicole Dubrulle, Patrick Ranchon: "Demande finale et emploi - approche par la méthode de l'equivalent-travail d'une production" - Cahiers du Centre d'études de l'emploi - P.U.F., 1977.

The accounting of international trade in work equivalent could add a new socio-political dimension to negotiations on the international division of labour.

27/ The work factor is not fully taken into account in the international specialization theory, which regards it as being homogeneous. The different evaluations of work must be considered. See François Vellas: "Le rôle des qualifications du travail dans la théorie du commerce international et la spécialisation des pays intermédaires" - Revue d'économie industrielle - 4th quarter 1980.

28/ Composite exchange, as opposed to pure exchange, is defined as "a combination of free, reciprocal transfers of utilities and relationships of power". It expresses in logical fashion the economic relationship which is essentially one of conflict/co-operation. F. Perroux: "Pouvoir et économie" - Bordas, 1973.

29/ See N. Driakhlov, S. Chovkhardine, S. Nikichov, Y. Pletnikov: "La révolution scientifique et technique et la société" - Editions du Progrès - Moscow, 1973. French translation, 1979.

30/ Ten years ago the OECD report "Science, Growth and Society - a New Perspective" ("Brooks report") - 1971, raised the fundamental problem of the reorientation of technology.

31/ See in particular, J. Baudrillard: "Les systèmes des objets - La consommation des signes" - Denoël-Gauthier - 1968.

32/ See in particular, among the numerous publications, Orio Giarini and Henri Loubergé: "La civilisation technicienne à la dérive - Les rendements décroissants de la technologie" - Editions Dunod, Paris - 1979.

33/ "Interfutures" - "Facing the Future" - OECD, 1979.

OECD did not consider this the most likely scenario.

34/ Guy Denielou: op. cit.

35/ S. Elekoev, in the study presented at the Warsaw Global Preparatory Meeting: "Economic aspects and social consequences of the development of the capital goods industries in developing countries", points out that in Colombia the development of a windmill at the Genótas appropriate technology centre represented six years of research, the testing of 24 prototypes and a cost of $100,000.

36/ UNIDO, "The technology group": "National approaches to the acquisition of technology" - ID/187 - study published in May 1977 - last published: July 1979; and "The technological self-reliance of developing countries: towards operational strategies - A preliminary view" prepared by the UNIDO Secretariat - UNIDO/ICIS.133 - 15 November 1979.

37/ See in particular:

- E.F. Schumacher: "Small is beautiful"

- "Appropriate Technology. Problems and Promises" - OECD Development Centre - 1976.

- UNIDO: "Development and Transfer of Technology Series".

On the problems of appropriate technology, its selection and negotiation, see the basic work of José Giral y Sergio Gonzalez: "Tecnologia apropriada" - Technology Development Group - Faculty of Chemistry - National Autonomous University of Mexico - Alhambra Mexicana, May 1980.

38/ S.M. Patil: op cit.

39/ "Report, UNIDO" - ID/WG/324/14/Rev.1 - 9 December 1980.

40/ These words of a retired Western Union electronics engineer reflects this awareness:
"Before my retirement, I made the observation that American engineers seemed to have lost the ability to do anything in a simple fashion. One cardinal principle which I applied in my work was this: if your device has a defect, don't try to cure it by adding more complexity; rather, go back into the original design and find the cause. Look under the hood of any modern car and you will see the death of that concept."

- Frank T. Turner: "Modern Science and Technology on Parson's Position"

- Technology and Society - I.E.E.E. - Vol. 7, No. 25 - March 1979.

41/ See the work of G. Simondon: "Du mode d'existence des objets techniques" - Aubier-Montaigne - 1969.

42/ Research in this field is being carried out by institutes such as M.I.T. See Robert L. Lund and W. Michael Denney: "Extending Product Life: Time to Remanufacture?" - Center for Policy Alternatives - Massachusetts Institute of Technology - 1978 - AMACOM.

43/ An illustrative example is that of the simple tractors which are the subject of UNIDO programmes.

44/ See "Interfutures" scenarios, op.cit.

45/ P. Aydalot: "Dynamique spatiale et développement inégal" - Economica, 1976.

46/ "In dualist societies virtually all the decision-making authority is in the hands of élites, who are, accordingly, responsible for the filtering process whereby requirements become demands (transmitted to the institutions of education, science, and technology) and necessities (which are regarded as having only minor importance). In most cases, this filtering process on the part of the élites operates in such a way that: (a) the requirements of the élites are almost without exception addressed in the form of demands calling for technological responses; (b) the requirements of the rural communities are, on the whole, disregarded, even though they in fact mirror fundamental and urgent necessities."
Amulya Kumar N. Reddy: "Le transfert, la transformation et la mise au point de technologies pour le développement" - Travail et Société - Vol. 2 - April 1977.

47/ Christian Gillen: "Estrategia para el desarrollo de la industria de bienes de capital para los países del tercer mundo de desarrollo intermedio" - UNIDO - February 1980.

48/ Ignacy Sachs, Daniel Théry et Chrystina Vinader: "Technologies appropriées pour le Tiers Monde, vers une gestion du pluralisme technologique" - OECD - June 1974.

49/ See R. M. Avakov: "The future of Education and the Educatior of the Future" - International Institute for Educational Planning - UNESCO - February 1980, and Pierre F. Gonod: "Pour une planification conjointe de l'éducation et de la technologie" - International Institute for Educational Planning - UNESCO - 1978.

50/ See Issue 1 - note 29.

51/ It will be recalled that they have 400 million inhabitants, that 11 of them are large, that the majority have less than 10 million inhabitants, that 28 have less than 1 million, that they are preponderantly agricultural, that 50-70 per cent of the population is rural, that 30-70 per cent of exports are agricultural, and that the consumption of capital goods is very low, averaging approximately $20 per capita, or one seventh to one eighth that of developing countries having an industrial base.

52/ "Industrialization and Rural Development" - UNIDO - ID/215 - 1978.

53/ Frank Long: "Capital Goods Production in a Small Developing Economy. The Generation of Intermediate Technology in Food Processing: a Case Study of Guyana" - 1981 (to be published).

54/ For the definition of levels 1, 2 and 3, see the document "Technology in the Service of Development", op. cit.

55/ See, in reference document "Condensé des études sur les biens de capital", diagram No. 1 - page 114.

56/ The blockage of the system may take different forms. For example, the vertically integrated enterprise that produces its own inputs necessarily has weaknesses. It has difficulty specializing. The inertia with regard to the introduction of electronics, in particular, is reinforced.

57/ These circumstances are, in particular, the increasing density of the industrial fabric, the strengthened national technical capacities, and the existence of a rudimentary engineering capability.

58/ See F. Perroux: "Note sur la notion de 'pôle de croissance'" - Economie appliquée No. 8, 1953; "L'effet d'entraînement: de l'analyse au repérage quantitatif" - Economie appliquée, 1973; and Albert O. Hirschman: "The Strategy of Economic Development" - Yale University Press, 1966.

59/ Li Yong Xin, op. cit.

60/ F. Perroux: "Pouvoir et économie" - Bordas, 1973.

61/ Political science now makes a distinction between "bargaining power" and "structural power". See James A. Caporaso: "Dependence, Dependency and Power in the Global System: A Structural and Behavioural Analysis in International Organization", sponsored by the World Peace Foundation and the University of Wisconsin Press - winter 1978 - volume 32, No. 1.

62/ METRA/SEIS - op. cit.

63/ "Les biens de capital pour la sidérurgie dans les pays en développement" - IREP, Grenoble/UNIDO - November 1979.

64/ Its absence is felt in many training programmes, with adverse effects on technological transfers. See, in the 1990 Scenarios for the Iron and Steel Industry - Part one - The Dossiers, Dossier VI: "The Design and Implementation of Projects and Commissioning of New Plants" - UNIDO/IS.213 of 23 February 1981.

65/ L. Demol: op. cit.

66/ Sergio Zampetti: "UNIDO's programme for the development of capital goods industries" - UNIDO/IOD - 1980.

67/ See, in particular, William H. Gruber and Donald G. Marquis: "Factors in the transfer of technology" - M.I.T. - 1969, and E. Jantsch: "La prévision technologique" - OECD - 1969.

68/ Christian Gillen: op. cit.

69/ Li Yong Xin: op. cit.

70/ K.R. Parameswar, Executive Director, Bharat Heavy Electricals Ltd., New Delhi; "Development of the capital goods sector in India" - document prepared for the Global Preparatory Meeting for the First Consultation on the Capital Goods Industry" - Warsaw, Poland, 24-28 November 1980.

71/ Presidency of the Republic: "Basic Plan for Scientific and Technological Development 1973-1974" - June 1973.

72/ See the tables summarizing the risks in the reference document: Abstract of studies on the capital goods industry - UNIDO - June 1980.

73/ "1990 Scenarios for the Iron and Steel Industry" - UNIDO/IS.213 - 23 February 1981.

74/ The 41 countries are: Ecuador, Central American countries (6), Paraguay, Uruguay, Trinidad, Morocco, Libyan Arab Jamahiriya, Syria, Iraq, Jordan, Lebanon, Saudi Arabia, Qatar, Bahrain, Abu Dhabi, Oman, Mauritania, Senegal, Togo, Ghana, Ivory Coast, Nigeria, Cameroon, Zaire, Angola, Zambia, Mozambique, Tanzania, Kenya, Uganda, Afghanistan, Pakistan, Sri Lanka, Burma, Bangladesh.

75/ Communication from Mr. Liassine, former General Manager of the Algerian National Iron and Steel Company, at the Congress of Arab Economists - October 1970.

76/ L. Demol: op. cit.

77/ Pierre Judet: "Ce rôle de l'état dans la croissance économique de la République de Corée du Sud" - Revue d'économie industrielle - 4th semester 1980.

78/ According to information communicated by the representative of Cuba at the Global Preparatory Meeting in Warsaw.

79/ In particular the projects for simple tractors.

ANNEX

NOTE ON THE ANALYSIS OF TECHNOLOGICAL COMPLEXITY

1. The methodology of the analysis of technological complexity has been dealt with in publications of the UNIDO Secretariat.[1/] It will not be discussed in this document. Its principles will only be mentioned in order to facilitate the work of the First Consultation.

An attempt was first made to reduce to a representative sample, the enormous variety of machines and equipment, which includes millions of products. This led to the selection of 318 groups of machines belonging to group 38 of the ISIC international nomenclature. The following question was then asked: what must be done to manufacture them. That led to the selection of 80 variables, or necessary inputs.

Each of the variables includes different levels of complexity. The technologies belong to different generations which are historically dated, and concrete definitions are given for the six levels considered for each variable.[2/]

In the absence of criteria for quantifying the weight of the variables considered, a conventional grading scale based on empirical experience in the sector was used.[3/]

On the basis of the sample, a system of information on technological complexity has been constructed, the combinatory possibilities of which are very high. With 318 groups of products, 80 variables and six levels of complexity, the system has a recording capacity of 152,640 items of data. As compared with this theoretical capacity, the analysis of the 318 groups of machines has effectively mobilized about 35,000 items of data. The magnitude of this figure has justified the processing of the information by computer.

Finally, the 80 variables have been classified into "subassemblies" in the structure of production of capital goods and many be divided into three "blocks":

A. The central production unit

B. The production infrastructure

C. The components incorporated in the capital goods

The central production unit is the block which supplies the completely assembled product to the customer. It necessarily includes both men and the means of production. It can therefore be divided into two sub-assemblies; the first A1, is centred on the management of the enterprise. Sub-assembly A2 consists of the means of production, that is to say the machinery which is essential for the functions of the central production unit.

The infrastructure B consists of the semi-products and technical services sub-assemblies. The subassembly B1, "semi-finished products", covers the principal activities of the "first converting of metals" activity, that is to say foundry work, forging and stamping. Sub-assembly B2, "technical services", includes all the normal sub-contracting work in the engineering industries (annealing, heat treatment, metalization), the supply of manufacturing equipment (tools, dies and moulds, gears, etc.) and also the manufacturing processes characteristic of metal fabrication and engineering construction (boilerwork, machining and stamping).

The components C are an assembly that belongs to the simple or complex engineering industry (ball-bearings for example) or the electrical or electronic industries, or specialities such as hydraulics, pneumatics, measuring instruments etc. The model is schematized in an annex.

Thus the analysis of technological complexity was centred on the production function and the identification of inputs. The result was the measurement of the technological complexity of the machines. 4/

2. This analysis has led to the formulation, with the caution necessarily required by a novel undertaking of this kind, certain "laws" of complexity and change in the sector. The analysis suggests that within the enormous variety and complexity characterizing equipment goods there exists relationships of order and a non-arbitrary arrangement in the world of machines. These relationships have been presented in an essay in the form of "propositions" to show the non-dogmatic character of the conclusions and to facilitate discussion.

In total, eight principal propositions and 19 subsidiary propositions have been put forward concerning the "laws" of composition, with seven principal and 10 subsidiary propositions for the "laws" of

change. At the risk of simplifying the observed results, they will be reduced to the following principle propositions which are likely, a priori, to have an impact on the work of the First Consultation.

Proposition A

Capital goods are characterized by the considerable heterogeneity of their technological contents and, consequently, by their complexity.
Complexity due to components increases with total complexity.
The dispersion of production complexity for capital goods without components is smaller, although it still remains large.

Proposition B

Considered as products (international classification), the machines show great inequality of complexity. The mean complexities are arranged in the following order: simple metal products, electrical machines, measurement and monitoring instruments, non-electrial machines, transport equipment.
This mean order of complexity with components does not vary when calculated without components. However, the dispersions vary.

As a function of the final demand in the sectors for which they are intended, the order of complexity of specific capital goods is as follows: agricultural machinery, agro-food industries, chemicals and petrochemicals, building and building materials industry, engineering construction, extraction of minerals, agro-industries, tobacco, leather, textiles, heavy metallurgy, iron and steel, forging, foundry, road transport equipment, rail transport equipment, air transport equipment.

Without components, the order of complexity becomes: agricultural machinery, food industries, mechanical engineering, building materials industry, chemicals and petrochemicals, extraction of minerals, agro-industries, heavy metallurgy, road, rail and air transport equipment.

Proposition C

The mean complexity of goods common to all branches, which represent 40% of the value of capital goods, is less than that of the mean of all capital goods. The weight of the

components is less, but the dispersion of complexity is considerable. There is a technological gap between the products of low complexity and the others.

Proposition D

The great majority of capital goods are concentrated at levels 3 and 4 of total complexity.

Proposition E

The production apparatus manufacturing capital goods is integrated by cumulative complexity levels which represent various technological generations. Enlargement of the range of products necessitates recourse to production factors of higher degrees of complexity. In order to produce capital goods it is not only the presence of production factors which are necessary, but also that the latter should have a specific index of complexity, and, as a consequence, that different generations are mobilized within the technological stock.

3. The above analysis concerns the kinds of rules which appear to exist in the static arrangement of the capital goods system. It is necessary to supplement this with the dynamism of the evolution which is suggested by the existence of different levels of complexity. These levels are observed today, but they have a history, and time was necessary for them to be established. This leads to the formulation of the main propositions concerning the "laws" of change.

Proposition A

The rise in the total complexity is accompanied by changes in the industrial fabric constituted by assemblies A (central production unit), B (technical infrastructure) and C (components). At levels 1, 2 and 3, A dominates, at level 4, B and C become equally important, while at levels 5 and 6 the influence of components in the total complexity becomes preponderant.

At level 1 the influence of means of production (subassembly) (A2 of the central unit) on the total complexity is dominant.

Then comes the influence of the subassembly A1, which is centred on the management of the central production unit. The technical infrastructure and components have a smaller influence.

At level 2 the influence of means of production in the total complexity remains high, as does also that of management. The influence of the technical infrastructure and of components increases.

At level 3 the influence of the subassemblies is equalized, the factors of production and management are balanced, and their influence remains slightly higher than that of the infrastructure and the components.

At level 4 components take over the majority influence, infrastructure is balanced with management in the total complexity, while the influence of the production apparatus is relatively reduced.

At level 5 the trends shown at level 4 are amplified: components, and to a lesser extent the infrastructure, increase in importance, that of management is stabilized, while that of the means of production falls.

At level 6 components increase markedly in importance, while the relative influence of the technical infrastructure on complexity is reduced. That of management increases appreciably, while that of the means of production falls considerably.

Proposition B

Among the production factors more than 50% are necessary at level 1 of the total technological complexity of machines. In order to advance to level 2, the presence of 80% of these factors is necessary; at level 3, practically 100% are necessary. (These propositions are independent of the level of complexity of the factors).

Proposition C

The basis of the industrial fabric is constructed at levels 1 and 2. It is the first accumulation at these levels which allows a considerable "gain" in the number of machines produced, and in complexity, at level 3. From this level onwards the increasing complexity of the variable makes possible the increase in the number of the more complicated machines, according to a non-linear process.

NOTES

1/ "Technology in the Service of Development" - Global Preparatory Meeting for the First Consultation on Capital Goods - Warsaw, Poland, 24-28 November 1980 - UNIDO - ID/WG.324/4 - 19 September 1980.

2/ For a definition, see pp. 5 and 6 of the above-mentioned document "Technology in the Service of Development".

3/ This analysis is based on the work of Mr. Franco Vidossich: "Busqueda de una teoria para producir beines de capital en los paises en via de desarrollo" - January 1980 - Report for UNIDO/ICIS.

4/ For a study of the problems of measuring technological complexity, see: "Note on measuring the complexity of machines and equipment" in annex 2 of the document "Technology in the Service of Development" - ID/WG.324/4/Add.2 of 19 September 1980.

It will be noted that the measurement of the complexity of machines and equipment has been done on the basis of their production function. Another approach would consist in measuring on the basis of output, which would lead to the addition of different criteria, in particular the functions performed by the machine. It is interesting to note the work done in this respect in Poland, which also uses a conventional grading scale.

Tadeusz Florczak - TEKOMA - Poland: "Technical Level of Production Goods as an Important Element of Industry Development Strategy" - Warsaw, March 1981.