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# DEVELOPMENT POLICY: MAIN CHARACTERISTICS OF TECHNOLOGICAL DEPENDENCE AND DOMINANCE AND THEIR CONSEQUENCES FOR NATIONAL POLICIES DESIGNED TO STRENGTHEN TECHNOLOGICAL CAPACITIES*

by

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## Reform Concepts at Crossroads: the Need for a New Approach

Attempts to reform the "International Scientific and Technological Order" are clearly at crossroads. The overall balance to be drawn today with regard to the effects of prevailing reform concepts is a rather bleak one, to say the least. None of the real issues of underdevelopment and domination have been touched by any of the prevailing reform concepts. This applies specifically to the limitations imposed by the way in which science and technology are inserted into an increasingly hierarchical world order. Three reform issues have received clearance for international negotiations: The UNCTAD Code of Conduct for the Transfer of Technology, the Reform of the International Patent System, and Technical Cooperation among Developing Countries (TCDC). Whatever well-meaning intentions may have been behind these prevailing reform moves - at the level of implementation results are either deadlocked or tend to become counterproductive [1].

This is not to deny that the "reformist front" has seen some advances, that some of these moves have been translated into institutional set-ups and funds and that new legitimization possibilities have been made available for using these very institutions and funds in a somewhat different way than before. Nor is it to deny that as part of these reformist moves an enormous amount of new informations has been digged up concerning mechanisms and effects of the present international scientific and technological order and that bureaucrats and politicians from the Third World engaged in the international reform process could considerably improve their bargaining techniques.

But these are minor points compared to the real issues

at stake:

- First, the tremendous and accelerating increase of underdevelopment, misery and exploitation pertaining to a majority of the world population urgently necessitates a concerted effort to apply science and technology effectively to development. Development must be understood as a process of radical economic, social and political transformation which would make possible significant improvements of the material and social welfare of the underprivileged. If solutions cannot be found rapidly, global conflict potentials might get out of control.

- Second, reform through international conferences might not necessarily be the appropriate method of action. In fact, evidence abounds that there has been a tacit consensus of power elites from North and South to use the international conference technique as a devise for coopting, diluting, diverting and ultimately denying movements for change. This is so, because international megaconferences, however "progressive" their agenda might be, still leave ultimate decision power in the hands of governments which, in most cases, are unlikely to give priority to the interests of the underprivileged. Furthermore, such meetings tend to exclude many of the people who could best identify problems and have the richest experience in confronting them.

- Third, the logic underlying the NIEO-programme has to be thoroughly reviewed. Obviously its effectiveness as a bargaining instrument has significantly declined, inter alia as a result of the increased crisis of the world economic system. Furthermore, the NIEO concept turned out to be insufficient to secure a minimum

amount of "Third World Solidarity" vis-á-vis the North. In fact, power elites in the Third World are increasingly becoming aware of this growing "dysfunctionality" of the NIEO-programme. The recent intensification of Third World countries' competition for privileged access to bilateral "industrial cooperation"with the US, the EEC and Japan is a case in point.

But more fundamentally, it must be asked whether the NIEO has ever been conceived as an instrument to change in any substantial way the present international economic and political power relations. In fact, as some insiders to the NIEO bargaining process would argue, it might very well be counter-productive in that it seeks to straightjacket potential liberating forces [2].

- Fourth, the strengthening of scientific and technological self-reliance in developing countries and the effective application of science and technology for development require major socioeconomic and political transformations in the Third World. Furthermore, substantive changes are required in the structure of international power relations.

  This argument which is obviously true, but has been mostly neglected in prevailing reform discussions, should not, on the other hand, be taken as an alibi for political apathy. Historical experience shows that what was perceived as unlikely or even utopian at one point of time, sometimes only after an extremely short period turned out to be everyday routine. This implies that any attempt to devise an analytical framework for reformist policy action in the field of science and technology should not exclude "concrete utopia", such as, for instance, substantial changes in the inter-

national power structure. (Take, as an extreme case, the recent events in Iran and their tremendous effects on international geopolitics and economic circuits!)

To conclude, it is obvious that Third World countries do not have much choice left but to formulate and effectively implement national policies to strengthen scientific and technological capacities. But such policies should be based on much sounder analytical grounds. There is an urgent need for a fresh approach towards the conceptualization of such an analytical framework.

This implies, inter alia:

- defining a basic matrix of goals and instruments for self-reliant development;
- a review of branch- and product-specific patterns of technological dependence and dominance, confronting developing countries;
- redefining the criteria of success for industrialization strategies;
- operationalizing the concept of "technological self-reliance", especially with regard to identifying priority sectors for selective technological delinking;
- identifying realistic options for collective self-reliance among developing countries; and most importantly
- identifying institutions and social and political coalitions which are necessary to push through these new concepts.

In this paper, I will focus on some major characteristics of technological dependence and dominance and their consequences for national policies to strengthen technological capacities.

In part 2 I will focus on some basic issues relating technological dependence and underdevelopment. Part 3

will spell out some consequences for national science and technology policies. It is specifically pointed out that self-reliance requires selective technological de-linking and that key development objectives and priority areas for science and technology should be closely inter-linked. Finally, a tentative catalogue of research pro-posals and issues for debate will be presented.

## 2. Main Characteristics of Technological Dependence and Dominance

There is obviously an urgent need for a fresh approach to the conceptualization of technological dependence and its dynamic relationship with underdevelopment and poverty. If we want to define realistic conditions of success for the effective application of "science and technology for development", we need to know much more about the motive forces behind technological dependence and about its effects on development, accumulation and innovative capacities in the Third World.

### 2.1. The Concept of Technology

Technology, as a product of science, fulfils a twofold function: It is a force of production, and it is an instrument of social control. In fact, technologies are in a sense the crystallization of specific historical modes to organize social relations. In short, I would define technology as the specific way in which labour and means of production are combined, to use knowledge for the appropriation and change of one's material and social environment. In a class society, for instance, technology will be used to perpetuate power and privileges. That is, the ruling elite, besides controlling and appropriating the economic surplus, cannot but exercise the strictest control over science-based technology.

Three levels of the application of technologies should be distinguished:

a. the process of production in a narrow sense, including all manufacturing activities inbetween the exploitation of raw materials and the production of final consumption goods;

b. the process of production in a broad sense, including all phases from r&d, via the procurement of essential inputs and infrastructural preconditions for production, to marketing, finance and management decision-making;
c. all those social activities, which secure the enlarged reproduction of a given society, i.e. all kinds of political, economic and military measures, including, for instance, preventive counterinsurgency.

Most contributions to the discussion on transfer of technology and technological dependence are restricted to a., though some might take up some aspects of b.. Yet for really understanding the dynamics of technological dependence and its social effects, it is essential to take into account all of these three levels of the application of technologies.

Basically, a technology is determined by the material conditions of the object which has to be processed, of the final product, and of the process of production which makes possible this metabolism. But this is only one aspect. Equally important are the non-technical determinants of technology, i.e. its economic and social determinants:

- the strategy and organizational structure of the production entity, for instance of capitalist firms;
- the economic determinants of the social process of production, for instance profit-oriented production;
- the requirements of the protection and development of a social system, for instance the preservation of unequal access to economic surplus.

Surely technological progress means first and foremost: improvement of the means to control one's material environment. Through this, technological progress allows for the growth of productivity of the society's productive forces. This is the one and very important side of the coin. But there is still a second function of technological progress. The history of sciences shows that, the well-meaning intentions of inventors and scientists notwithstanding, technological development has been mostly used to establish new and more efficient forms of dominance, the safeguarding of hierarchical structures and the deployment of more intensive forms of social control. This begins in the very process of production itself by segregating the labour force from the productive means and by the parallel separation of manual and mental labour. One does not have to quote Frederick Taylor to comprehend this aspect of technological development, any reading of "Business International" will show the same. Technological development strives to increase labour productivity and labour intensity and to improve the possibilities of "scientific management". This aspect of technological development is even further stressed by modern management techniques. Indeed one of the main preconditions for the worldwide commercialization of goods, means of production and technologies has been the fact that through this kind of technological development new methods and organizational techniques have been developed in the highly developed capitalist states, which enables them to control the surplus resulting from these worldwide transfers.

The development of technologies doesn't take place in a vacuum. It is the result of a specific historical mode of accumulation. In other words, each historical mode of accumulation requires a specific mode

to produce and supply technologies, its dominant technology system. A technology system will be dominant, if it fits more or less closely to some basic material characteristics of the mode of accumulation and to the class structure and patterns of state intervention underlying it. On the other hand, those technology systems which happen to be dysfunctional or even counter-productive to the enlarged reproduction of a historical mode of accumulation, will be displaced and suppressed. This is exactly what is happening today in developing countries with regard to the socalled "traditional" or "pre-capitalistic" technologies.

The dominant technology systems of today are the result of a specific historical mode of accumulation, as it has developed after 1945, first in the U.S., then, during the sixties, in Western Europe and Japan.
Basically, this mode of accumulation displays four major "material" characteristics:

a) The growing importance of the "Petroeconomy", defined in a broad sense, with regard to the overall productive activities.
b) The progressive separation of manual and mental labour in the very process of production itself. This separation of manual and mental labour had very significant effects on the way in which science and technology are produced and used for accumulation and social development. In fact it has two highly interrelated effects. On the one hand it leads to a progressive deskilling of a great part of the labour force. On the other hand it facilitates a growing centralization of control over knowledge ("software") by "think tanks", engineering firms, and central management headquarters.
c) A progressive computerization and automation, not

only of manufacturing techniques (the proliferation of continuous production processes), but including distribution, services, r&d, and "social engineering technologies".

d) Excessive consumption of energy and highly capital-intensive and centralized modes of energy provision.

Simultaneously, this mode of accumulation is based on a certain way of organizing social relations, which essentially boils down to the fact that the economic surplus is controlled and appropriated by a small minority. Furthermore, it presupposes a certain class structure and certain ways of operationalizing state functions.

Thus, "modern" science-based technologies, like any other technology, are the product of a social process of production. At the same time they are a product of the social relations within which they are developed and utilized. These limitations should be taken into account by governments and planning institutions of developing countries when they are talking about access to "modern" technologies. Some of the far-reaching expectations concerning the import of Western technology may turn out to be just a new variety of a "development myth". Technologies, which, in the context of Western industrialized countries, might be rightfully termed "modern" or "key" technologies, may not inevitably be the optimal choice for a developing country's policy to optimize national accumulative potential and the fulfilment of basic needs. Worse still, evidence abounds that the import of Western "modern" technologies can have extremely retrogressive effects for both aims.[1)]

To sum up, technology is more than the sum of techniques,

which are applied in the process of production. Technology is obviously a strategic factor on all levels of economic and social development. Especially today, technology has become a major instrument of domination. This applies both to power relations within a society and to international relations, especially with regard to the North-South context. [2)]

## 2.2. The Dynamics of Technological Dependence

Technological dependence (TD) today, in a majority of developing countries, constitutes a major element of their deformed economic and social development. The key to understanding TD is to analyse it as part of the overall dependency characterizing Third World societies. There is a certain ambivalence in using concepts like technological dependence or technological dominance. It should be clear that this does not imply that other levels of the dependence/dominance relationship do not exist. On the contrary! The decline of some classical instruments of domination notwithstanding, there is no doubt that a great and increasingly multifarious variety of very efficient instruments for global and regional domination does exist, especially vis-à-vis developing countries. This applies, inter alia, to finance, marketing and control of prices, production logistics, strategy and organizational structure and consumption patterns - let alone certain social techniques and institutions dedicated to the legitimization and reproduction of political systems and class structure, including preventive counterinsurgency, political destabilization and, if need be, modern-style "gunboat diplomacy".

What it does imply is that there might be some sense in singling out that specific variety of the dependence/dominance relationship, i.e. technological dependence/

technological dominance, if only because, of late, technology has gained considerable ground as an instrument of control and domination, in relation, for instance, to trade and monetary pressures or military intervention. In this sense, TD may rightfully be termed a crucial determinant of the room of manoeuvre for development strategies.

Let us now have a closer look into some specific characteristics of TD. A country, or more generally, any economic entity (be it a region, commune or an industrial plant) may be called technologically dependent under three conditions:

- it needs to import technology;
- it needs to import the capacity to utilize and apply the imported technology, and, finally,
- it is incapable to adapt, reproduce and improve the technologies received in an autonomous way.

Yet it is important not to rely exclusively on descriptive definitions of TD, but to uncover some of the roots underlying this phenomenon. In fact, TD means that there exists a structural gap between the social technology needs and the technology supply. Social technology needs are to be derived from the requirements of a development strategy which aims at the optimization of three goals: utmost fulfilment of needs for a majority of the population; utmost use of local resources and long-term increase of accumulation potential.

But this is only one aspect of the problem. What has to be explained, is: Why does a country not mobilize without delay all its resources and social energies to overcome this very gap, and why would it not be able to count on really helpful external assistance?

When obvious things are not done, there most be some basic reason, or, in other words, some structural constraints. I would propose to look at three of them.

First, developing countries are in fact confronted with a situation, which could only be adequately described as one of an overwhelming technological dominance. That is, the knowledge which is needed to overcome the aforementioned gap, to develop new technologies to disseminate them and to make productive use of them - this strategic knowledge is concentrated within a few private and public r&d-centers, which are predominantly located in major OECD-countries. Thus, any serious attempt of a developing country to increase "national technological capacities" will, nearly invariably, be confronted with significant external constraints.

Second, TD reflects some basic structural deformations pertaining to a developing country's forces of production. This applies specifically to its scientific, innovative and learning capacities and to their integration into the overall process of the country's social and economic development. That is, the key elements of a developing country's capacity to get off ground an increasingly endogenous industrial sector, such as r&d-capacities, engineering activities, educational systems and its capacity to produce capital goods, are undergoing a process of progressive disintegration. Developing countries are in fact what Sagasti has aptly called societies with an exogenous scientific and technological base [3], i.e. societies in which knowledge-generating activity is not related in any significant way to productive activities. This basic structural deficiency of developing countries' productive forces has by now received extensive empi-

rical documentation [4].

Too, some progress has been recently made with regard to an operationalization of these concepts [5]. For instance, we know now that we have to specify the criterion of "structural incapacity to produce capital goods" and that we should pay specific attention to three product groups: capital goods for the production of capital goods, especially machine tools; machinery for producing agricultural implements and textile machinery; and capital goods used in the production of basic materials and intermediates.

Or we know now that, with regard to linking local r&d-potential to productive use, the existence of esoteric scientific and research communities is definitely of marginal value if not completely counter-productive. Of real importance would be, for instance:

- Well integrated and experienced laboratory teams;
- scientific and technical management cadres devoted to social cost-benefit criteria;
- an "appropriately" qualified labour force, i.e. workers which would neither be overskilled in the sense of being highly specialized watchdogs of "automated factories" nor deskilled in the sense of having been deprived of certain general-purpose skills, such as, for instance, welding;
- clear priorities with regard to the allocation of scarce skills (priority candidates would be the aforementioned capital goods branches);
- and, finally, the selective recovery and upgrading of "traditional" innovative capacities, if these have not already been destructed by foreign technology penetration.

Third, TD is an outcome of certain basic deformations

of class structure and the political systems prevailing in developing countries. This applies not only in the sense of a description of a historical relationship. It applies too in the sense that social and political constraints internal to developing countries have very significant obstructive effects on present policies to overcome technological dependence. It is this internal constraint which has been given the least attention in attempts to analyse the dynamics of technological dependence.

So we have four essential elements of a <u>definition</u> of technological dependence:
gap between social technology needs and technological supply; external constraints for policies to overcome technological dependence; basic structural deformations of productive forces and innovative capacities, and internal social and political constraints. In what follows, I shall focus mainly on the second point.

But before, let me add three essential requirements for any attempt to identify in an operational manner a developing country's TD:

a) It is not insufficient scientific-technological capacity <u>per se</u> which is the real problem, but the near complete lack of autonomy even with regard to very basic decisions concerning technologies which are employed as part of a "national" development plan. This applies both to decisions on what kind of technologies will be needed for social reproduction, and to decisions on what sources of supply should be tapped to fulfil these technology requirements.

b) It is <u>within</u> a society that the technological

needs for social reproduction have to be defined, both with regard to the optimal use of local resources and the utmost fulfilment of basic needs. The identification of a society's manifold manifestations of technological dependence has to take place as a social learning process, giving adequate participation of those directly affected by technological dependence. Only then, effective control of technological dependence might become a realistic aim.

This engenders some very harsh decisions, with regard to priorities chosen and with regard to establishing the institutions and political instruments to fight for that long and painful internal social transformation, which is the only reliable basis for achieving technological self-reliance. The concept of "Technological Self-Reliance" should cover two aspects:

- the ability to generate, adapt and use technological systems relevant for meeting social technology needs, defined in the aforementioned way;
- the ability to choose and control the areas of partial technological dependence, which, in any country, will remain unavoidable for many years to come.

c) Attempts to diagnose and policies to overcome TD should be based on a systematic review of branch- and product-specific patterns of TD, especially with regard to priority sectors. Forms, mechanisms, and growth patterns of TD should be differentiated accordingly. This may help somewhat to neutralize a major decision dilemma for technology policies in developing countries: Whether to opt for maximum growth of industrial output, nearly invariably accompanied by large-scale imports of foreign tech-

nology and "upgrading" of local means of production and class structure to the "needs" of these foreign technologies; or whether to focus on decision autonomy in the sense defined above, which, as long as applied indiscriminately to all/most sectors of the economy, would be bound to fail anyway. Thus, the differentiation of branch- and product-specific criteria for TD enables a developing country to identify the priority sectors for selective technological delinking from the world market, which, under given conditions, may be the only realistic approach to overcome TD. 6)

## 2.3. The Dialectics of Technological Dependence and Technological Dominance

Technological Dependence in developing countries is the result of the very asymmetric distribution of control over both inputs into and outputs of research, development & engineering activities on a global scale. Developing countries are in fact confronted with a situation which can only be adequately described as overwhelming technological dominance. That is, the major elements necessary to generate, distribute and make productive use of technologies are highly concentrated within a few private and governmental r&d-centres, located predominantly in the major OECD-countries. This relates, inter alia, to:

- Basic research and innovative capacities. Especially in this field, public "think tanks", like, for instance, the Rand Corporation, the MIT, the Stanford Research Institute, the Denver Research Institute, the Battelle Institute, or the Fraunhofergesellschaft, are playing a major role. In this context, the term "public" is rather misleading.

One should talk of institutions, which are financed out of tax funds, but whose results are available only to certain specific segments of the "public".

- The avantgarde technologies. It is noteworthy that especially in this field there is a clear predominance of firms which have gained their technological lead mostly out of militarily orientated r&d, for instance: the Lockheed Missiles and Space Co. in Sunnyvale/Calif., a daughter of the Lockheed Corporation, in the field of new technologies for seabed mining, especially with regard to manganese nodules; or the Industrial Products Division of the Hughes Aircraft Co. with regard to developing laser-directed industrial automation systems; or, finally, the MBB Ottobrunn of the Federal Republic of Germany for new technologies of public transports.

- The socalled "technological building blocks", especially the semiconductor-technology. Although, with regard to value and weight, such technological building blocks are usually only a minor part of the technology systems, into to which tney are integrated, they are the real decisive elements. Consequently, there will be no effective control of process and product technologies, as long as one does not control these technological building blocks.

- The information systems for worldwide screening and tapping of scientific-technological developments and for feedbacksconcerning production experience. Besides the relevant information systems of Multinational Corporations, Banks, and Engineering Consultancy Firms (see, for in-

stance, Control Data Worldtech Inc., a, what is termed, "technology exchange service" of the Control Data Corporation), it is again public information systems and data banks, which play an important role. A case in point would be: the U.S. Air Force Systems Command, which, according to its own statements, maintains probably the most complete information system on innovations and innovative potentials in the field of electronics. Compared, for instance, with the contents of such an information system, it is hard to see how the Industrial Information System, presently prepared within UNIDO's Industrial Documentation Unit, will be able to play more than only a marginal role.

- Basic engineering activities, especially process engineering and equipment design. The rapidly expanding world markets for these activities are increasingly under the tight control of a handful of private firms. US-firms are dominant, such as, for instance, A.D. Little J. Diebold Assoc., Fluor Co., Stone and Webster, Bechtel, Austin, Kaiser, to name but the most important ones.

- Finally, the manifold techniques to solve problems of worldwide logistics, maintenance, and marketing.

Research and development expenditures

To give some very rough illustrations of this overall pattern of technological dominance, let me

start with the global distribution of r&d expenditures. Recent figures (socialist countries excluded) indicate that a certain multipolarization of technological dominance has taken place since the middle of the sixties. Yet this relates nearly exclusively to some redistributional effects between capitalist industrialized countries. The developing countries' share of world r&d-spending, which was 2 % in 1963/64, has only insignificantly increased to 2.8 %. It is thus safe to say that, for developing countries as a whole, the very asymmetric distribution of innovative capacities has not significantly changed during the last 10 years. 7)

In fact these statistical indicators may significantly overestimate the innovative capacities available to governments of developing countries. Figures relating to the distribution of r&d-spending, as impressive they may be, give only a partial picture of the prevailing pattern of overall technological dominance. Thus, one should ask: What are the functions of those local r&d-activities being financed out of the 2.8 %-share of overall r&d-expenditures? And, if there is in fact some socially valuable output of r&d-expenditures, under what conditions could one talk of innovative capacities, "accessible" to governments of developing countries?

**In this context, one should take care of three points:**

- **A great part of developing countries' r&d takes place without any significant link to productive activities located there. That is, a great part of what, according to statistics, are r&d-expenditures, are in fact consumptive expenditures.**
- **Those of the developing countries' r&d-activities,**

which are in one way or another related to productive purposes, have been, in most cases, effectively screened and absorbed by the "worldwide networks for tracking profitable innovations" mentioned above.

- In many developing countries up to 50 % of officially documented r&d-expenditures are related to military and police purposes, i.e., to a very high degree are nothing but marketing subsidies for some Western armaments firms.

Any meaningful interpretation of the distribution of r&d-spending should be combined with an analysis of the significant and growing perverse transfer of financial means from developing to capitalist industrialized countries, embodied into growing debt payments and worsening terms of trade. These growing payments are closely linked to the developing countries' increased imports of technology. Thus, not only do developing countries have but an extremely limited access to overall innovative capacities, but in fact they are actively funding metropolitan r&d-activities, thus strengthening their technological dominance.

Capital goods production [8]

In 1970, around 61 % of the world production of capital goods accrued to capitalist industrialized countries, around 36 % to the socialist countries of Eastern Europe. In the same year, developing countries produced 3.18 %, i.e. roughly the same part of world production as in 1963 (2.89 %). The

bulk of this very low volume of developing countries' capital goods production is concentrated in a small number of countries: India, Brazil, Argentina, Mexico, South Korea - Algeria and Iran are examples of recent newcomers to this group. In 1970, only 3 countries (India, Brazil and Argentina) were more than 80 % self-sufficient with regard to engineering products.[9] With regard to machine tools, a key element of any capital goods production, only 4 countries (Argentina, Brazil, India and Mexico) have significant levels of production. The world market for machine tools is dominated by West German and US firms. The growing submarket for NC machine tools, or, more generally, for 'automated factories' is first and foremost controlled by US firms, followed by Japanese and West German firms.[10]

The growing automatization of industrial production has one "tendon of Achilles", i.e. the production of electronic components, and, more specifically, the semi-conductor-technology. In 1976, US firms controlled around 75 % of the market for integrated circuits, whereas some 10 years ago their part was only around 55 %. Thus, one might even discern a tendency towards increased technological dominance of US firms, at least in technologically strategic sectors. The US-trade balance on technology-intensive products may be another point in case. Since 1956, it was never negative. The lowest surplus was 6.6. bio $; in 1973 the surplus was 10.7 bio $, 1974 19.2 bio $ and, finally, in 1975 it reached 24 bio $.

The control of these'technological building blocks' enables those firms to force upon developing countries

restrictions which are embodied in the transferred technologies themselves and which prevent the technology-receiver from reproducing, let alone further developing these technologies by means of 'prototype copying', 'reverse engineering' and 'selective technical upgrading'.

Technology-embodied restrictions

Four categories of these technology-embodied restrictions can be distinguished:

a) adaptation to Multinational Corporations' global industrial standards restrict adaptation possibilities to local conditions;

b) planned diversification and obsolescence of all products transferred, including turnkey plants, subsystems, machinery, intermediates and spare parts;

c) maintenance and repair techniques that make an overhaul of the imported machinery impossible or at least extremely costly without using the company's maintenance & repair manuals or computerized maintenance information systems; and

d) planned technological indivisibility as a result of the transfer of technologies within a package.

This last point is of increasing importance. Packages consist of main components (e.g., to take the example of the Green Revolution,

miracle grains) and of complementary inputs (for instance, fertilizers, insecticides, pesticides, irrigation systems, pumps, etc.). Without these inputs, the package cannot function. A package consists of a combination of mutually dependent innovations and improvements that are, for all practical purposes, indivisible or could be divided only at a very high cost. Thus, sellers of a package are in a very favorable position to make themselves irreplaceable for a long time.

Control of technology life cycles

Another essential element of technological dominance is the near complete control, by a handful of private firms, of the life cycles of most of the technologically relevant industrial products and processes. This control is used by these firms as a major instrument of oligopolistic competition, i.e. by skillfully devising optimal time patterns for obsolescence. This, of necessity, will make any attempt of a developing country to reach technological autonomy by importing such oligopolistically controlled technology a truly Herculean task. For the developing country may try its best to acquire operational capacity, than to proceed to reproductive capacity, and, finally, to reach improvement capacity. Once it will try to enter the world market with its "own new technology", it will immediately find out that it has been already surpassed by the original technology-exporter's new technology.

Control over basic engineering

Finally, technological dominance is decisively determined by the strict control of process engineering and equipment design, access to information systems and control of technical standards. Again US firms and public institutions dominate these fields. For instance, even the french firm Technicatome, during the formulation of a feasibility study on the commercial export of nuclear power stations, preferred with good reasons to call for the assistance of the US engineering firm Bechtel.
Concerning avantgarde technologies (nuclear energy and alternative energy resources; exploitation of low grade ores; oceanography; public transport etc.) it seems as if the die is already cast for an even further intensification of technological dominance. The same applies to one field of avantgarde technologies which is in fact a taboo to most of the discussions on science and technology for development: the military technologies.

Thus, the technological dependence of developing countries corresponds to the technological dominance of a handful of highly developed market economies. Technological dependence and technological dominance are in fact closely interrelated processes. Any meaningful analysis of technological dependence of developing countries and especially with regard to strategies to overcome technological dependence presupposes a thorough analysis of the causes, effects and protective mechanisms of technological dominance.

## 4.4. Identifying New Forms of Technological Dependence and Dominance

New forms of the internationalization of capital, such as offshore sourcing or worldmarket-subcontracting in components, certain basic industries and even engineering consultancy and equipment production have led to new forms of technological dependence and new forms of technological dominance. Both do have considerable negative consequences for the room of manoeuvre for strategies to overcome technological dependence in developing countries.

To take but one example: the progressive computerization and automation of, let us say, the machine tools industry, which applies not only to the manufacturing techniques in a narrow sense, but also to r&d-activities, engineering, maintenance and marketing-activities. This progressive computerization and automation has already produced significant changes, inter alia, on the following three levels:

- The contents of the technical coefficients of intra-industry-linkages is considerably changing, i.e. industries or subgroups of industries, which up till now might have been of a strategic nature for progressive industrialization, are now loosing this specific quality.
- The preconditions for and elements of effective control over technology are considerably changing. For instance, in an increasing number of cases, control of the socalled "technological building blocks",

i.e. some tiny electronic devices, will secure effective control over the overall technology system, both with regard to process and product technology. This opens up new possibilities for worldwide schemes of "planned obsolescence" as the most subtle instruments of effective control over innovation and accumulation capacities.

- The forms and contents of the working process, not only in manufacturing itself, but also in laboratories, engineering departments and marketing divisions, are already undergoing significant changes. This applies, for instance, to the division and contents of tasks and job specifications, and specifically to skill requirements.

Or take the growing importance of maintenance for establishing new patterns of the technological dominance/technological dependence relationship. According to one expert in this field [11], maintenance services related to package transfers (for instance, turnkey- or product-in-hand-plants) are rapidly becoming the key element for devising new patterns of planned obsolescence. To be more precise: We are not talking primarily of repair of accidential breakdowns nor of preventive maintenance, required at regular intervals of an equipment's life cycle. The real issue is corrective maintenance. Corrective maintenance is defined to include all measures to counteract abrasion and wear out of components. Abrasion is a normal part of a component's life cycle, the extent of which depends on its age and the way it is used. During the first years the variations are minor, but increase later on. The wear of a single component usually has little influence on the proper functioning of the equipment, but if a number of components showing wear are combined, they may cause technical changes in the plant as a whole, resulting, inter alia, in:

- variations in the product quality;
- increased consumption of energy or raw materials;
- increased refuse;
- reduced security of the working place.

Corrective maintenance is a highly complicated matter and demands perfect knowledge of the process used. For instance, it may be necessary to reprogram a process computer, or work out new rules for the regulation of cycle. Now, as Bennaceur and others [12] have shown, maintenance contracts concluded with suppliers of turnkey plants usually cover only one or two years of operation. When the training and maintenance personnel is provided, contracts invariably exclude corrective maintenance. Another aspect of this same phenomenon is that a growing number of TNCs has now at their disposal globally mobile "trouble shooting" flying squads which can be called to any industrial site around the globe at extremely short notice [13].

Developments such as the aforementioned ones have already produced new and qualitatively intensified forms of technological dependence. Yet there is still a near complete lack of perception of these new forms of technological dependence and their very negative economic and social consequences, especially for the majority of the developing countries' population.

The ever growing proliferation of technologies into the Third World during the last 20 odd years has in fact led to a <u>qualitative intensification of the gap between social technological requirements and technological supply</u>. Still worse, the local capacity to control or reduce this gap may have even significantly declined.

Let us take an example of complex mechanical engineering, i.e. the development and production of aircraft. Even once a country will be able to produce locally 70 and more percent of the overall value added, the decisive bottleneck with regard to technological self-reliance would still exist: the inability to produce (develop/test/repair & maintain) the main parts of the system, i.e. engines, high quality steel and alloys and avionics, to name only the most extreme examples. So even such a country which may be able to produce all of the frame (which in itself requires a lot of precise metal working and machinery building skills) may still find itself being completely dependent on external decisions with regard to the concrete forms and conditions of production and sale of the aircraft. It is this kind of technological dependence which I would call technological dependence on a qualitatively higher level. It is qualitatively higher, because first to build up the facilities for airframe production and related complementary production facilities (including, for instance, aluminium smelting and milling facilities) and infrastructure did cost the country a lot in terms of scarce resources being absorbed into it. And second, because this establishing of technologically highly complex production facilities did not produce the previously expected widening of the room of manoeuvre for economic decision-making. On the contrary, one even can detect a significantly higher vulnerability with regard to external decisions. Any interruption of imports of some strategic components would lay idle the existing production capacities and would further dramatically add to the waste of scarce resources. Let us even assume that after some years the country might be able to run

this production line on its own. Still this country will definitely be unable to maintain, let alone reproduce this plant without 'external aid'. Cum grano salis, the results won't be different for other branches of mechanical engineering.

The most obvious manifestation of this qualitative intensification of technological dependence is the increasing perfection of the "system character" of technology exports. All major technology elements necessary for the realization of a given project, are increasingly tied up into one package deal, i.e. from the pre-investment study to the final acceptance of the production unit, including in many cases long term-contracts with regard to maintenance and repair, supply of essential inputs and "technological building blocks", and marketing. The main effect for the technology-importing country is, that the network of technology dependence-relationships, induced by these package imports, gets more and more complex and obscure. In many cases the foreign main contractor deliberately strives to keep a monopoly with regard to understanding and controlling the complicated agreements between the various firms involved and the complex channels and mechanisms of their realization. Recently, new types of contracts for the procurement of ready made-production units - from "turnkey-production units" to "product in hand" - or to "turnkey market"-contracts - have in fact further increased this non-transparence of the technological dependence-relations induced by the technology package transfer. A very good example has been, for instance, Abtellatif Benachenhou's case study on turnkey- and product in hand-contracts in Algeria.[14)]

Worldwide sourcing and the concomitant tendency towards increased global intrafirm transfers not only make possible but simultaneously make necessary an ever increasing intensity of control. This close relation between the internationalization of capital and the growing need for MNCs and some national and international public institutions mainly controlled by OECD-countries to conceive ever more far-reaching global control mechanisms, especially with regard to strategic sectors, such as innovative capacities, etc. is in fact one of the salient aspects of the presently evolving new international division of labour.

Strategies to overcome technological dependence in developing countries should explicitly take into account these new forms of technological dependence and technological dominance roughly described above. Unfortunately, most of the concepts presently available with regard to strategies to overcome technological dependence fail to do exactly this. Thus, they may produce just another form of partial strategy with all the inherent dangers of rising misery, frustration and conflict potential.

## 2.5. Technological Dependence and Capacity to Accumulate

Technological dependence has significant negative effects, at least during a certain period of transition, on policies to increase the long-term accumulation potential and to improve social equity. Not only has it very negative consequences for the capacity to accumulate. Still worse, it may turn out to be a major obstacle for strategies to fulfil basic needs. I will focus here only on the accumulation issue and will deal with the social equity issue in chapter 3. However let

me first add one differentiation and that is: TD p e r s e is clearly not the essential impediment for such policies. But definitely it opens up new inroads for an increase of overall dependency, thus considerably decreasing the room of manoeuvre for autonomous development strategies.

TD has very negative consequences for the capacity to accumulate of developing countries. Obviously, as long as a country has to import most of the means to produce goods, including whole plants, this means that any attempt to substitute imports, especially with regard to capital goods and intermediates, will, of necessity, lead to large-scale follow-on imports, i.e. negative import substitution. But that is only the tip of the iceberg. There are more fundamental, yet 'low-profile' built-in mechanisms for draining off scarce foreign exchange, such as, for instance:

(1) The nearly complete dependence on basic engineering activities, especially with regard to design-engineering and equipment design. To give but one example, which is on Algeria, a country, which, at least according to its own pretensions, has been following a consequent policy to strengthen national technological capacities. There, in the period 1970-73, it were only 4 % of all industrial projects where engineering activities have been carried out on a significant scale by Algerian firms. [15] With the accelerated rate of plant procurement since 1974, it is safe to assume that this 4 % mark might have further fallen.

(2) The far-reaching dependence with regard to the maintenance and repair of imported machinery and "turnkey" plants. This applies especially to "corrective maintenance" and "trouble shooting", i.e. the capacity to react quickly and at lowest cost to unforeseen dis-

turbances in the production process.

(3) The nearly complete dependence concerning access to information systems storing the bulk of new technological knowledge and feedbacks on production experience.

Add to this the rich opportunities, available to suppliers of technology, for transfer pricing, which, for the receiver country, is identical with a significant overpricing of technologies supplied. Thus, TD may not only be instrumental in reducing import capacity and in worsening the receiver country's terms of trade, but, in addition, may cause high monetary instability and depreciation of local resources, as a result of the price inflation embodied into imported technology inputs. There is an obvious circularity here: to expand technology imports (which are deemed essential for "upgrading" the economy towards world market conditions), developing countries must increase their exports; to expand their exports, developing countries must further increase their technology imports, and so on ... .

Of much greater importance are those deformations of a developing country's accumulative potential, resulting from TD, which may in fact prevail for a very long time. To be sure, countries with sufficient 'political stability' and 'resource endowment' (including natural resources, infrastructure, and humanware) may nowadays experience an oversupply of technologies. To some extent this may even include technologies of a very high complexity, which, superficially, may be conceived as an indicator that the country is having access to key technologies. Too, in a growing number of developing countries there are first signs of expanding 'localized' r&d-capacities, i.e. test-, standardi-

zation- and engineering-activities transferred over from MNCs' central or regional headquarters. Yet, one crucial problem remains: the control of the strategic elements of the overall economic circuit and especially of the industrial sector, the socalled technical coefficients of interindustrial relations. Dependence on imports of, inter alia, machine tools, machinery to produce agricultural implements, equipment for the basic goods industry and central engineering-activities means that decisions with regard to investment allocation and the organization of the production processes will be subordinated to external control. That is, even the most basic precondition for national control of capital accumulation will be absent as a result of TD. To give but one example: Suppliers of machine tools have been following for some time now a policy of worldwide proliferation of computerized manufacturing techniques, which from their point of view, i.e. with regard to the optimization of their product life cycles, might be called functional. Yet with regard to the already extremely alarming levels of unemployment and 'marginalization' prevailing in developing countries, this policy might indeed have disastrous consequences. But how should a country which nearly completely depends on machine tool imports and which sticks to the predominant world market orientation of its productive activities, be able to resist such a policy? True, there exists an option to bring in 'outsider' firms, thus trying to diversify dependence. Candidates for such alternative procurement sources could be found in socialist countries or even some developing countries, like, for example, India. Predominantly these firms produce non-computerized

machine tools and have a significant surplus available for export. It might be safe to assume that at least a certain number of such firms have not already been integrated into worldwide sourcing and cooperation schemes of TNCs. Nevertheless, developing countries only marginally made use of this option, inter alia, probably out of fear to loose potential benefits in terms of worldmarket competitiveness, expected from the use of NC-machine tools. Under such conditions, the room of manoeuvre for attempts to reform technology policies will, of necessity, be reduced to the mere adaptation of local productive forces and class structure to the requirements of imported technology. Thus, developing countries may have chosen in fact the worst of all worlds: growing misery and exploitation of their population without any significant chances to improve accumulative capacities.

## 3. Consequences for National Policies to Strengthen Technological Capacities

Let us draw together now the different threads of an alternative research and policy approach to the issue of science and technology for development. We have seen that international transfer of technology, left to the laws of oligopolistic competition, has led, on a global scale, to a further increase of the already very asymmetric distribution of control over both inputs into and outputs of research, development and engineering activities. It has thus been instrumental in perpetuating the hierarchization of North-South, but also of South-South-relations, with all the inherent implications for underdevelopment, misery and global conflict potential. Technological dependence is a dynamic process which has recently gained increasing weight as an obstacle to strategies of transition towards self-reliance. In other words, without a comprehensive and coherent national science and technology policy, designed as an integral part of the national plan, there will be no self-reliant development. Obviously, research and policy activities related to the identification of priorities for the application of science and technology to development are of utmost importance. But what kind of development is meant and how to identify socially relevant scientific and technological priority areas? [1]

### 3.1. No Self-Reliance without Selective Technological Delinking

Before talking about priorities we should keep in mind one basic precondition for the application of science and technology to development, i.e. the effective control of developing countries' governments or other public institutions over science

and technology, especially with regard to identifying and pushing through urgently needed "alternative technology systems". As a result of centuries of externally-geared underdevelopment, most developing countries today need technology imports if they want to increase output, productivity and their long-term development potential. The crucial problem is how to avoid that such a process of importing foreign technology on a significant scale will lead to a qualitative intensification of dependence. This clearly implies the necessity to internalize the technology issue as part of an autonomous decision-making process by means of selective technological delinking and by defining priority areas for technological self-reliance. [2)]

In addition to what has been said before, five points need to be specifically stressed:

a) Instead of asking for an indiscriminate proliferation of Western technology imports, emphasis should be placed on highly selective acquisition of strategic technologies with significant multiplier effects for increasing the developing countries' self-reliance. This is in fact the essence of what I would call "selective technological delinking". One way of doing this consists in focussing on technologies for capital goods production related to the fulfilment of basic needs. This implies a priority for technologies needed for capital goods producing basic needs products and for capital goods needed in down-stream activities on local resources. In fact, selective acquisition of technologies needed for an increasing integration of national resource

use and the fulfilment of basic needs constitutes an essential element of policies to strengthen national technological self-reliance. Take for instance a developing country which is well endowed with natural gas and iron ore but does not have coking coal. In such a country, a policy to base the development of its steel industry on the technology system: "Automatic classic blast furnace, based on coke" might rightfully be called an extreme form of resource waste. Instead, the optimal approach would be to combine the technique of "direct reduction" with an overall "miniaturization" of plant size. The negative consequences of an indiscriminate proliferation of Western technology imports for self-reliance and development are most obvious with regard to recent attempts of a growing number of developing countries, to give nuclear power an increasing share in their future energy systems - an approach which has been rightfully termed the "nuclear trap".

Strengthening technological self-reliance implies furthermore the necessity to develop basic needs-oriented national engineering capacities and Fundamental Research. Without them, the local production of basic-needs-oriented capital goods will easily be coopted and reintegrated into worldwide sourcing strategies of international capital.

b) For a policy to strengthen technological self-reliance, the focus on technologies for basic needs-related capital goods production is a necessary, but not a sufficient condition. It is a necessary condition, because it implies decision autonomy with regard to what products are needed for the fulfilment of basic needs and how and under what conditions for the producers they are

produced. It may thus be called a necessary first step towards an effective participation of those directly involved, i.e. the majority of the developing countries' populations. Yet, this is only one side of the coin, and if one does not want to evoke a new set of "development illusions", one should hasten to add the other side. That is, policies to strengthen technological self-reliance need to identify those industries and their optimal modes of interlinkages, which, under given geographic, historical, social and economic conditions, will increase the long-run national accumulation potential.

c) Identifying conditions of success should not be perceived in a narrow sense. Definitely, questions like: What institutions and what social and political coalitions are necessary to realize these new approaches? - will play a prominent role.

d) Delinking is definitely not an "easy" solution. Without "social transformation", i.e. without political and economic revolutions, delinking is not only unfeasible but a chimera. Delinking might have significant chances of success only in periods which do not leave much choice anyway with regard to economic, political and military self-protection. But these "worst cases" are in fact "very normal cases" for a great many developing countries! Thus, it will not only be very difficult to realize delinking and keep it going for a certain time. Invariably, delinking will be accompanied by very high social costs, it will have to be of a partial nature and will be full of contradictions. Yet still in many cases <u>selective technological delinking</u> might be the <u>only viable approach to improve the developing countries' potential for technological self-reliance.</u>

e) Strategies to increase technological self-reliance are bound to be long-term strategies. Consequently the path towards the realization of higher degrees of technological self-reliance will be full of contradictions and set backs. Any attempt of a developing country's government to identify successfully the prevailing forms and mechanisms of technological dependence/technological dominance and to implement efficient countervailing policies will for a long time to come, be confronted with new forms and mechanisms of technological dependence/technological dominance, and so on ... . That is why delinking strategies have to be both selective and flexibly handled.

## 3.2. Interlinking Key Development Objectives and Priority Areas for Science and Development

For any strategy of self-reliance, it is essential to identify and push through a complex set of alternative technology systems which would allow for the maximum mobilization of domestic resources and the extension of national development capacities. The solution is not to make "one across-the-board dogmatic technology choice" [3]. A variety of technology levels may coexist at a given moment according to sectors, subsectors, products or even individual plants, ranging from advanced and sophisticated technologies to socalled traditional ones. The choice of a social optimum for such a technology mix presupposes the systematic identification of sector- and product-specific alternative technology production routes and their main preconditions of success. This is in fact one of the most urgent research requirements for development research.

If we want to identify such priority areas for science and technology, we have to have a clear con-

ception of the key development objectives to which these science and technology priorities should be subordinated. I would propose to focus on five key development objectives [4]:

- Effective control of key sectors;
- Converging needs with effective demand;
- Support of agriculture, especially to achieve self-sufficiency in food;
- Social optimization of using and processing natural resources;
- Identifying and strengthening of "industrializing industries".

Effective control of key sectors

Today, in a majority of developing countries, key sectors of the economy are controlled by private capital, mostly originating from the OECD-region. This means that, by and large, the development of these sectors has been subordinated to the requirements of worldwide sourcing strategies of international capital.

Without effective public control of key sectors of the economy there will be no control over accumulation let alone development. This is a basic precondition for the establishment of dynamic inter-industry linkages and for the realization of strategies of transition towards an alternative development pattern. Nationalization per se is just one first step. By no means should it be confused with effective control. The latter must include: control of the market, of the essential inputs, of forward and

backward linkages and, last, but most importantly, control over relevant basic research and technologies.

Converging needs with effective demand

In most developing countries, the gap between the needs of society, or more specifically, the needs of its underprivileged majority, and the effective demand, i.e. the demand which can enter monetary exchange relations, is dramatically increasing. Decreasing fulfilment of basic needs and overconsumption in some urban growth poles are the familiar symptoms of this trend. No doubt, a deliberate and comprehensive policy to converge needs with effective demand is of utmost importance. This would imply three interrelated priority activities:

a) Identifying social needs

Doing this as a technocratic exercise would be useless and it must and can be done as a social learning process [5]. It is in this context that some of the national and regional papers prepared for UNCSTD have collected valuable informations [6] which could be used as a starting point for in-depth participative field research.

b) Defining criteria for the adjustment of effective demand to social needs

In this area, detailed research has been nearly completely lacking. On a very general level some criteria are rather obvious, such as:

- utmost fulfilment of basic needs of the underprivileged;
- utmost productive integration of the labour force;
- utmost use of local natural resources;

- utmost integration with local scientific and technological capabilities and (upgraded) traditional skills;
- traditional consumption and living habits will be preserved, at least insofar as they won't lead to discrimination or exploitation. (see the recent debate on women's rights in postrevolutionary Iran).

What we do need is a rich body of field research and case studies on a much more disaggregated level which could then help developing countries' governments to orient policies to establish a genuine new consumption model.

c) Restructuring the supply side

Much lip service has been paid to this. But without knowing social needs and without having converged them with effective demand, the most well-intentioned policies to "restructure the supply of goods and services for national development" will lead to nowhere. It is this kind of "choice of product"-problem which still needs a lot of case studies and questioning of those directly involved, i.e. especially the agricultural poor.

d) Implications for choice of product and technology: a hypothetical example

Let us take as an example a country that has undergone a political revolution. The new government, we assume, tries to initiate a process of economic and social transformation, which would lead to a development pattern based on self-reliance and the needs of the underprivileged. Such a self-reliant strategy would have clear implications with regard to choice of product and technology.

Tab. 1: Implications of Self-Reliance Strategy: Choice of Product

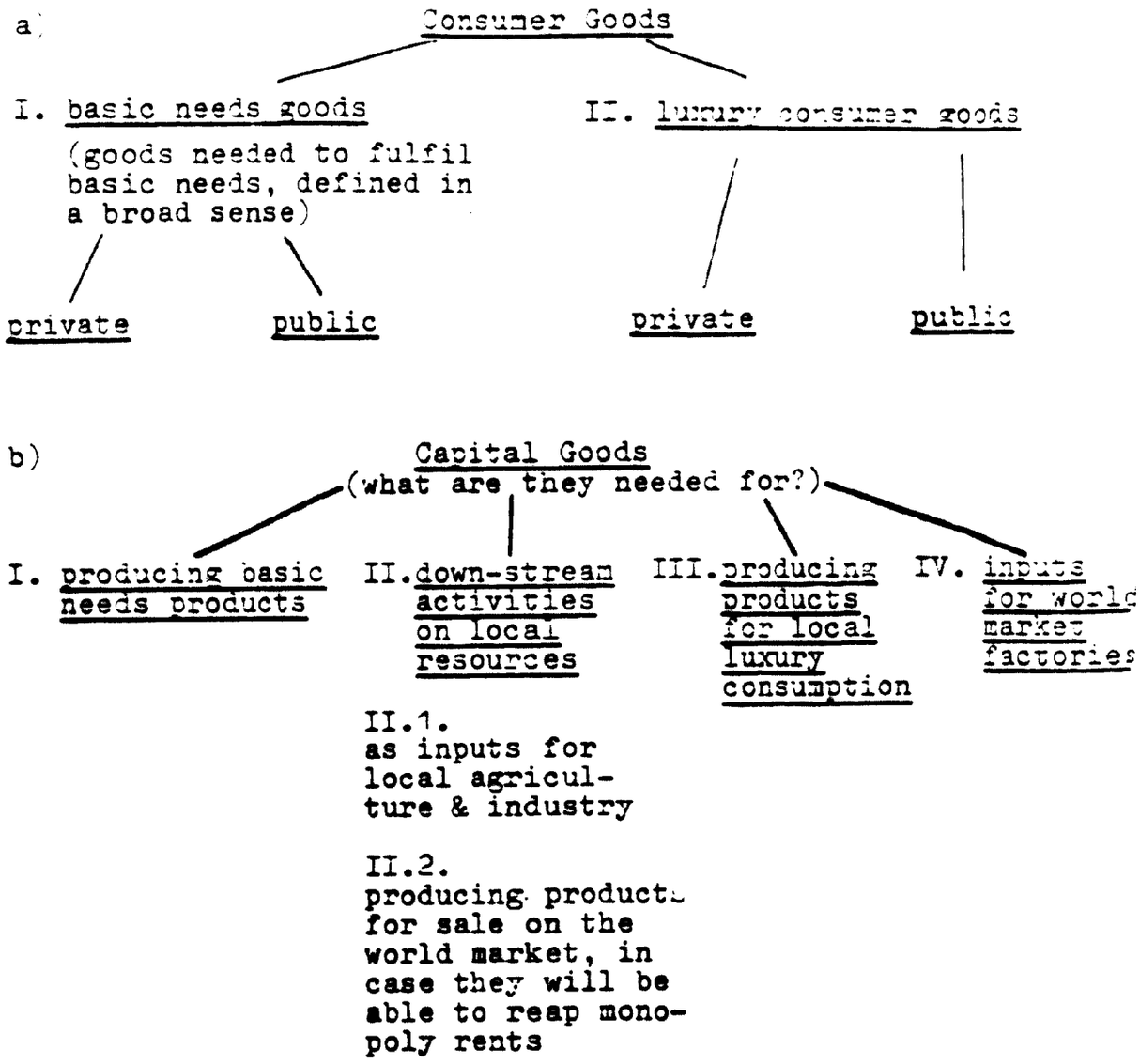


Table 1 might help to delineate priority candidates for choice of product.

With regard to consumer goods, product choice will have to rely nearly exclusively on basic needs goods, pre-

ferably on public ones. With regard to capital goods, product choice will have to be, ceteris paribus, restricted to I and II [7].

Now, let us assume that the economic, social and political constraints with regard to "appropriate" choice of product, as defined in Tab. 4, can be overcome. Indeed, these constraints would be formidable - nothing less than a complete reversal of the dominant mode of accumulation would be at stake. But even this would only be part of the story. Because now a second level of constraints has to be taken care of and that is exactly where the problem of technological dependence comes in. The issue at stake reads: How to acquire those basic research, development and engineering capacities which would enable the country to produce those priority basic needs goods and capital goods categories I and II?

But this again is not the whole story, because in fact these priority products can be produced with <u>different systems of technology</u>, and based on <u>different modes to organize the labour process</u>. In fact, the primary aim of those technology systems and modes of labour organization which are the dominant ones today on a worldwide scale, is to reduce the labour costs, i.e. the price of the labour force. There are two options available to realize this goal, i.e. to increase unemployment and/or to deskill a growing part of the labour force. This structural bias of dominant technology systems and modes of labour organization has as its logical corallory a significant decline of the living conditions for a majority of the world population.

To our country, in making its self-reliance strategy related technology choice, would have to take into

account two other criteria:

- Technology systems and organizational patterns of the labour process should be choosen in such a way that the country would be capable to reintegrate its active population into the process of social production. (In fact, developing countries have been experiencing a secular decline in their labour absorptive capacities which, as growing empirical evidence has shown, is essentially a result of the type of technology imported [8].) That is, choice of technology and labour process should enable our country to increase its absorptive capacity for socially useful labour.
- The gap between the nature of the means of production located within its geographical frontiers, and, more specifically, its dominant technology systems on the one hand, and the level of qualification of its labour force, on the other, should be significantly reduced. Criteria for qualification should not be exclusively identified with the mere capacity of the labour force to subordinate itself under the necessities of the production processes, but should include the capacities to comprehend, control and reproduce these very processes. The growing deskilling of the developing countries' labour force, as a result of the present international system of transfer of technology, may be in fact the most essential element of developing countries' technological dependence - systematic research on this topic is nearly completely non-existent.

Support of agriculture, especially to achieve self-sufficiency in food

Today, most developing countries, even those with an abundant potential for agricultural production, are becoming increasingly dependent on food imports. The achievement of self-sufficiency in food is a major objective of a self-reliant strategy [9]. Consequently, support of an agriculture, which would guarantee self-sufficiency in food, is one of the main priorities for development strategies and especially for industrialization strategies. This applies to sectors producing agricultural inputs (implements, fertilizers, pesticides, irrigation equipment etc.), to sectors serving transport and distribution requirements and to those processing agricultural goods. Possibilities for the application of science and technology to increased agricultural productivity, to improve post-harvest technology, to introduce innovations into plantation industries, fisheries and forestries abound.

It should be noted that agro-allied industries are sectors where international capital (the socalled "agribusiness", especially originating from the United States) has recently gained a particularly strong position. In other words, any policy which wants to use agriculture and agro-allied industries as an instrument to achieve self-sufficiency in food must surround these sectors by effective protective mechanisms against penetration and denationalization. This is a necessary precondition for the effective utilization of some of the very useful knowledge recently accumulated in some international and national institutions, such as the United Nations Research Institute for Social Development (UNRISD), the Food and Agriculture Organization of the United Nations (FAO), the International Rice Research

Institute (IRRI) at Manila, Philippines, and the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) at Hyderabad, India.

Social optimization of using and processing natural resources, including energy resources

Mineral, water, agriculture, fisheries, forests, wildlife and renewable and non-renewable energy resources are among the basic elements for national industrialization and development. National control over the prospecting, exploitation, production and marketing of these natural resources is thus an essential precondition for self-reliant development.

Yet, most of these resources, at least if they have a significant profit potential, have been systematically screened and tapped by international capital, which takes great care to preserve this monopoly of knowledge. In fact, to carry out rapid and detailed surveys of geological, mineral, agricultural, forest, fishery and other resources in developing countries requires the use of highly sophisticated technologies such as remote sensing using satellite imagery, airborne surveys and aerial photography. These technologies are dominated by a few private and public firms mainly located in the US, and to a lesser degree in Japan, Great Britain, France and the Federal Republic of Germany. They are furthermore extremely costly [10]. The same applies, by and large, to technologies needed for the exploitation and processing of these natural resources.

In other words, most developing countries still have to develop the basic preconditions for effective control over the natural resources located within their

frontiers, i.e. national capacities to detect, exploit and process them. Thus, utmost importance should be given to research in this field. This should include a systematic search for areas in which cooperation between developing countries would be feasible.

On the other hand, availability of natural and energy resources should have a determining effect on the contents of the industrialization strategy as regards choice of sectors, choice of process and techniques. Here again, the state of knowledge concerning the kind of linkages which should prevail between resource endowment defined in the sense above and industrialization patterns, is still very deficient. Such knowledge would be urgently needed to guide industrialization to refrain from misuse of those natural resources which are scarce and non-renewable, to give priority to sectors linked with processing renewable ones and to develop the production of inputs and equipments for sectors exploiting local natural resources. In other words, developing countries need systematic research which would enable them to subordinate industrialization to the requirements of ecodevelopment, i.e. to the protection and development of the resources of the biosphere.

Identifying and strengthening of "industrializing industries"

Industrialization, potentially, is the centrepiece of socio-economic development. It has an enormous potential to accelerate the development of other sectors, such as agriculture, transport and communications, energy, drugs and pharmaceuticals, health and social services etc.. That is, industrialization can be the most effective instrument for a progressive integration of the key elements of the developing country's social and economic development.

Yet, in reality, industrialization in the Third World has nearly invariably meant the progressive disintegration of these economic and social circuits with all the inherent consequences for structural deformation, underdevelopment and misery.

A concerted effort is needed to redefine industrialization patterns conducive for development and to give an operational content to industrialization as an integral part of a strategy of transition towards self-reliant development.

Utmost priority should be given to the identification and promotion of the socalled "industrializing industries", i.e. industries which would allow for the optimal use of local natural resources, would guarantee the fulfilment of basic needs and would allow for the long-term optimization of accumulation and scientific-technological capacities. Such a strategy includes, inter alia, the development of the machine tool industry, the production of textile and agricultural machinery, and a reorientation of basic industries, processing locally available resources which would aim to increase the share of down-stream activities and to push ahead its integration both with regard to the country's industrial and agricultural production. This strategy would include attempts to strengthen local engineering capacities. especially with regard to pre-investment studies, chemical engineering and equipment design and attempts to control technological building blocks and technology life cycles.

The general principles of such a strategy have been established by now. What we do need is a whole series of concrete sector- and product-specific case studies which would help to clarify in detail the scientific and technological requirements of such a strategy.

## 3.3. Conditions of Success

Three basic conditions of success for national policies designed to strengthen national technological capacities can be discerned:

- a restructuring of the international context;
- a thorough change of the educational system;
- identifying carriers of the strategy and optimal timing.

### Restructuring the international context

To apply science and technology effectively to the aforementioned key development objectives, developing countries would obviously have to restructure considerably their present international economic, political and military relations. This would have to include concerted attempts to increase the potential for international cooperation, especially with regard to economic and technical cooperation among developing countries. [11)]

We still lack systematic research undertaken from a Third World perspective on how the crisis of the international economic and political relations is going to effect the positions of industrialized countries with regard to international cooperation, and especially with regard to new forms of national and collective self-reliance in the Third World.

Clearly, the prevailing trends point to much more rigid and uncompromising positions [12)]. But this is only a global picture and reality is much more complex. No doubt will there be differences with regard to countries and industrial sectors involved.

This will be even more so with regard to political groupings and social classes involved.
Take, for instance, the case of the OECD-region. The recent successfull moves to increase the homogeneity of OECD-countries' bargaining position vis-à-vis an increasingly fragmentated Third World notwithstanding, there is no doubt that the world economic crisis is permanently generating new conflicts and political frictions between different fractions within this region. The same would apply to the global scene, whether one talks of an increasing multipolarization or not.

It would be even more important to analyse these conflict dynamics on the level of specific industrial sectors and branches. From the viewpoint of OECD-countries this has been extensively analysed, for instance by the OECD's Interfutures project by the OECD Directorate for Science, Technology and Industry, and by the French think tank GRESI (Groupe de Reflexion pour les Strategies Industrielles) [13]. Finally, it is no secret that trade unions, by and large, do have somewhat different ideas than, say, employers' associations, on how to integrate developing countries into a restructured world economy.

Third World countries should be able to draw on research on such diverging positions and conflicts of interests among industrialized countries. Only then could areas of conflict and areas where conciliation of interests is possible, established in an operational manner, and only then could realistic options be identified for national and collective Third World strategies to diversify dependence.

## Another education system is needed

Furthermore, the education systems prevailing in developing countries have to be thoroughly changed. Presently, they are not only completely inadapted to development needs, but constitute in fact a major factor of dependence [14]. Education should instead be given the function of becoming a training place for self-reliance [15]. Only such an alternative education system could guarantee

- an "appropriately" qualified labour force, i.e. workers who would neither be overskilled in the sense of being highly specialized watchdogs of "automated factories" nor deskilled in the sense of having been deprived of certain general-purpose skills, such as, for instance, welding;
- scientific and technical management cadres devoted to social cost-benefit criteria, and
- that "traditional" innovative capacities will be selectively recovered and upgraded.

## Carriers of the strategy and timing

In order to make self-reliance a viable strategy one has to know not only what it should aim at, and why. One also has to know who shall do it, i.e. the carriers of this strategy, and how they are going to do it. This obviously presupposes a critical inventory of the prevailing world order, especially with regard to factors and mechanisms underlying international economic, scientific, technological and political relations. Only then could one hope to identify in an operational manner the socially and politically relevant forces

attached to or opposing self-reliance, the areas of conflict and the areas where conciliation of interests is possible, the necessary institutional set-ups, and, finally, the social and political coalitions necessary to realize this strategy.

Identifying carriers of self-reliance and their conflicting interests is a highly complex and multi-dimensional task. Yet we still lack systematic research on this essential issue.

Another crucial problem is the question of timing. Galtung has recently pointed out that it has two dimensions: the principle of ripe time, and the principle of correct time order [16]. If developing countries would base their strategies and tactiques on a careful scrutinizing of the timing question, they would not anymore simply have to react towards the dominant activities of the North. Rather, they might be for the first time able to use the inherent imbalances and contradictions of the world economic crisis as a driving force to increase their room of manoeuvre for national and collective self-reliance. Yet, the time factor has been nearly completely ignored in discussions on how to proceed with self-reliance.

To conclude, without thorough going political and economic change, that is without a complete restructuring, for the benefits of the underprivileged, of the prevailing class structure and state functions, the application of science and technology to self-reliant development will not only be unfeasible but a myth.

Such change must occur as much in the Industrialized Countries as in the Third World. Otherwise, misuse of science and technology will not end.

## 3.4. A Tentative Catalogue of Research Proposals and Issues for Debate

This paper in no way could claim to present more than piecemeal answers to the question on how national policies to strengthen technological capacities should be designed and implemented. This reflects the present state of research in this field. Yet, a beginning has to be made.

The following tentative catalogue of research proposals and issues for debate will hopefully stimulate some further thoughts and systematic research in this field.

### 1. Focus on the operationalization of new approaches

Research should focus on the operationalization of new approaches which might be useful for the formulation of some basic guidelines for self-reliance strategies, both with regard to the specific field of science and technology, and with regard to overall social development.

This implies, inter alia:

- A review of branch- and product-specific patterns of technological dominance/technological dependence, confronting developing countries, especially with regard to identifying priority sectors for selective technological delinking;
- an evaluation of major types of science and technology policy, prevailing in or proposed to developing countries;
- an identification of the economic, social and political changes needed to achieve more technological self-reliance in developing countries

2. Alternative approaches with regard to energy and resource-oriented industries [17]

(1) More attention should be given to research in the energy and resource-oriented sectors:

a) Of a country-case study nature, looking at the successes and failures of individual countries with respect to making autonomous technological decisions;

b) on ownership and control over particular processes or technologies and on their diffusion [8];

c) on the feasibility of technical cooperation among developing countries, including sharing of know-how and experience, joint procurement of critical equipment, materials and components and joint production;

d) on technology transactions involving particular supplying firms, utilizing data from both technology supplying and receiving countries, with particular attention to pricing of technology, materials and equipment flows;

e) on technology transactions, comparing terms and conditions among different recipient countries;

f) on forward and backward linkages resulting from the application of technology in the energy and resource-based sectors, including long-term economic and social effects;

g) on the developing countries' experience concerning joint ventures with COMECON countries.

(2) Developing countries need to carry out their own well-conceived r&d programs on energy technologies utilizing renewable resources. Furthermore, research is also desirable on technology options with regard to energy consumption.

(3) With respect to both energy and resource-based industries, there is a need to search for, upgrade and diffuse existing indigenous technologies.

(4) In gaining the maximum advantage from their natural resource endowments and in controlling the technology for their exploitation, developing countries must strengthen and develop their own independent capacity in the fields of surveying, exploration and prospecting.

(5) With regard to the aforementioned case studies, the influence of class structure and the political system on the achievement of greater technological self-reliance should be specifically taken care of. More attention needs to be paid to the nature of social, political and economic measures required for creating and strengthening the capacity to perceive, adapt and apply appropriate technological innovations as well as the capacity to make one's own innovations.

(6) Selective technological delinking, though it may be uneconomic in static comparative advantage terms, obviously <u>can</u> have significant long-term benefits with regard to increasing the country's development potential. This may specifically apply to some sectors of the energy and resource-based industries (for instance, agro-allied industries catered to food production). To be able to identify conditions of success and strategic and tactical guidelines, a lot of very

detailed branch- and product-specific case studies concerning "selective technological delinking"-potential is needed. It is in this context that much of the recent discussions, especially within UNIDO, on appropriate industrial technologies and, more specifically, on appropriate plant size may be of some help to formulate a catalogue of detailed research priorities [19].

3. Strengthening the self-reliance of national capital goods production and engineering capacities and preconditions for identifying and pushing through alternative "technology production routes" [20]

(1) Research is urgently needed which would identify, both on an aggregate and on a sector-and product-specific level, the role of capital goods industries and engineering consultancy for the process of accumulation.

(2) Research is urgently needed which would identify those segments of the capital goods industries and engineering consultancy which have been recently transferred on a significant scale to developing countries or are candidates for such a transfer. We need specifically detailed research on the involvement of specific firms, on the strategic functions and tactical procedures underlying these new forms of industrial deployment, i.e. what are the determinants of these new varieties of worldwide sourcing strategies? In-depth surveys of the types of agreements and joint ventures prevailing in this field are needed. Research done at the International Centre on Industrial Studies of UNIDO , the International Development Research Centre and the OECD Development Centre[21] has already produced some valuable informations. On this basis, a catalogue of

detailed research projects should be formulated now which should be pursued with high priority.

(3) Research is needed on the scope left to technology-importing developing countries for adapting the organization of the labour process in the case of a given production technique. This requires a lot of (comparative) sector and firm specific case studies. Also comparative studies should be undertaken of similar production units in the OECD region, in the COMECON region, and in developing countries, in terms of the contents of particular jobs, job specifications, hierarchization of the labour process and other social effects of technology.

(4) Research is very urgently needed on the role and consequences of automation. The increasing computerization of production, development, maintenance and distribution activities is significantly changing the overall structure of the capital goods industry and its role in the process of accumulation. This applies especially to the international context [22]. What are, for instance, the effects on the developing countries' room of manoeuvre to build up and strengthen national capital goods industries and local engineering capacities? Will automation not lead to a significant increase of dependence, for instance in terms of imports of automated equipment, technological building blocks, which are so complex that autonomous reproduction (for instance, via reverse engineering etc.) in developing countries may be precluded for a long time to come? Will increasing reliance on automation not reduce the possibilities to build up integrated national engineering (particularly basic engineering) capacities? And, finally, will automation not lead

to a decrease in the scope for adapting the organization of the labour process?
The state of knowledge is nearly zero concerning the kind of technology options, which are availabe to developing countries with regard to increased automation and concerning their scope for adaptation! That is, we need systematic research which would help us to establish the room of manoeuvre for countervailing technology policies on automation to be pursued by developing countries.

(5) We need comparative research on the level of complexity of equipment goods delivered to developing countries by OECD countries, COMECON countries, and Third World suppliers like Brazil and India. This would help to clarify the room of manoeuvre for strategies to diversify sources of supply and to identify areas for economic and technical cooperation among developing countries.

(6) With regard to identifying alternative technology production routes, historical case studies should be undertaken on "alternative" or "minority" technology systems of equipment goods production (see, for instance, the case of the Soviet Union during the interwar period).

(7) Research is needed on what will be the effects of automation on the kind of "small-scale industrial technologies" availabe on worldmarkets. Given the fact that most of these commercialized scaled-down industrial technologies are highly automatized (automatic mini-steel mills; automatic mini-cement plants), will this not lead to a qualitative intensification of technological dependence?

(8) The maintenance function is clearly emerging as a key factor of technological dominance in the field

of equipment goods[23]. Research on this subject is urgently needed. This applies especially to "corrective maintenance". Establishing "maintenance poles" and programmes for increasing "corrective maintenance capabilities" should be high priority areas. Research and policy actions concerning maintenance should also be priority candidates for [illegible].

4. How to operationalize the concept of "appropriate technology"?[24]

(1) It has recently become fashionable, within ILO, UNIDO, and some national development agencies, to see the solution of social, political and economic problems in the development of new, socalled appropriate technologies. In particular, there is a tendency to assume that problems of unemployment in developing countries might be solved by labour-intensive technologies, without accompanying social and political changes.

(2) Used in this way, the concept of appropriate technology can serve to breed new myths about the omnipotent role of technology. It can also lead to new forms of technological dominance, by which appropriate technologies are researched, and developed in some major OECD countries, produced and marketed by multinational corporations and international organizations, in what can only be seen an "unholy alliance".

(3) choice of technology can only be a subsidiary aspect in the formation of "sound" or "suitable" development strategies. A technology can only be considered appropriate in relation to political goals. For a certain period of time, developing countries,

trying to dissociate themselves from the prevailing international division of labour, will have to make use of certain technologies that are, in many ways, inappropriate.

(4) Since, however, technologies emanating from the industrialized countries carry with them the hierarchical division of labour characteristic for capitalist production, the development of alternative technologies will be essential in the long term, if developing countries are to proceed along an alternative development path. Technologies will have to be developed that encourage a broader participation and mobilization of the majority of the population. New methods for evaluating technology, that take into account the social and environmental costs and benefits, will have to be devised.

(5) The development of alternative technologies will thus be important also for today's industrialized countries. In these countries the only long-term solution to problems of structural unemployment and deskilling of labour involve new political strategies including the struggle for new forms of work organization and new participatory technologies.

(6) There is a need for research linking the development of self-reliant political strategies with the development of appropriate technologies. In what political context is a technology to be defined as appropriate? And by which social group is an appropriate technology to be developed? Who are the potential social bearers of appropriate technologies? These are the questions that are usually avoided in the international discussions of appropriate technology but are the questions that are most in need of answers.

(7) Specifically, studies on the embodiment of social relations in specific technologies should be undertaken.

This would help to collect material and informations on technologies, both material and social, including techniques and procedures of transferring technologies, and on the effects of their embodied and/or generated social relations. On this basis, questions like the following ones might be more thoroughly researched:

- What technologies embody undesired or appropriate social relations?

- Which characteristics of specific technologies are responsible for the desired/undesired social relations? Would depackaging help correct negative effects?

- What links exist between the material and social environment into which a given technology (embodying e.g. inappropriate social relations) is transferred and the resultant social relations?

- Does the transfer method and procedure affect the transmittal of social relations?

- What criteria can be used to assess if a given technology should not be/should be transferred, given the transfer mechanism, the social and material environment in the donor and recipient social systems?

- What criteria exist to decide if a given technology, or the technology for a given sector should be transferred, even if it incorporates undesirable social relations, if it is needed to meet urgent needs? What would possible countervailing measures have to look like?

(8) The technological situation of today has to be analyzed in a historical perspective. For instance, we need systematic research on why certain technology systems became predominant and why others, some of them with

an equal productivity potential, have been displaced and disappeared. That is, a critical history of the historical dialectics of "technological progress" is urgently needed. One focus should be a critical history of the penetration of Third World societies by Western dominant technology systems. Another approach might be to reconstruct the history of resistance against "modern" or "new" technology. Understanding the historical reasons for the dominance of certain technology systems might help to get a clearer view of their main characteristics and thus paves the way for identifying and pushing through alternative technology systems.

5. Science and technology policies, social structure and the state: identifying the room of manoeuvre for strategies of transition towards self-reliant development [25]

(1) The application of science and technology for development implies the establishment of coherent internal socio-economic structures in developing countries compatible with meeting basic needs and the principals of sound ecodevelopment. Only then will science and technology policy lead to self-reliant development. The capacity for autonomous decision-making requires the building up of a complex of institutions, laws, educational systems and research facilities and, in general, an integrated scientific and technological infrastructure capable of making appropriate decisions regarding the importation of foreign technology, choice of alternative technology systems and adaptation and development of technologies. There is no recipe for science and technology policy or technological development applicable across the board to all developing countries. Each country must devise its own principles of technology assessment, its own ways to integrate science and technology into development planning according to its own unique conditions and development

objectives.

(2) The internationalization of capital and its forms of insertion into the dependent economies of the Third World have been determined by and have multiple effects on socio-political structures, both in home and host countries of multinational corporations and on the relationship between them. This reality poses various theoretical, empirical and methodological questions, and confirms the need to approach these problems within the framework of a truly multidisciplinary analysis.

(3) Research is urgently needed on the various forms in which the internationalization of capital and the concomitant "transfer" of technology has effected the political behavior of the classes or class-fractions traditionally linked to international capital; that of those which control nationally-owned (or mainly national) enterprises; and the behaviour of the working classes, particularly labour organizations (including rural ones). For instance, it will be of utmost importance to have highly disaggregated empirical research on the role of public enterprises and para-statals within the framework of national science and technology policies. Can they be used as a major instrument for national science and technology policies or are they rather playing the game of a "Trojan Horse" for the progressive denationalization of productive forces and of options for development strategies? Research is furthermore urgently needed on questions like: What are the linkages of the dependent state with its hegemonic centre? What are the effects of the increased penetration by international capital on the organization and behavior of state bureaucracies and the bargaining capacity of dependent countries?

(4) On the other hand, research is urgently needed on the state in transition pursuing alternative development strategies. We need research, for instance, on what have been the reactions of international capital in specific cases of structural transformations attempted by dependent states, so as to be able to define the areas of confrontation as well as those where conciliation of interests is possible.

(5) On a more technical level, research is urgently needed on the following topics:

a) Contradictions between the explicit and implicit science and technology policy and their relationship to the logic of social and economic agents. (Sectorial approach).

b) State Enterprises' purchasing policies and their effect on r&d of their suppliers and connected industries.

c) Possible State action to develop and use new knowledge for solving society's problems. (Sectorial approach).

d) Possible State action to strengthen the technical and scientific capacity of the educational system and of the technical and scientific system and to establish links with the productive system.

e) State intervention to develop knowledge for problems for which there are no solutions available in the present industrialized countries' stock of knowledge, especially where the market forces do not lead to this solution (e.g. tropical diseases).

f) Appraisal of the state as a regulatory agency of

imports of technology.

g) State support to Trade Union's involvement in the educational system.

(6) There is an urgent need for research to evaluate recent attempts, especially prevailing in some so-called key countries of the Third World, to "upgrade" and strengthen national scientific and technological capabilities via the establishment of local arms industries.

Major research questions would include, inter alia:

a) How to evaluate intersectoral spin-offs and complementary forward and backward linkages, especially with regard to the socalled "industrializing industries"?

b) How to evaluate effects on the degree of technological self-reliance? That is, how to evaluate the effects on the capacity to choose and control patterns of technological demand and supply and on the capacity to devise systems of technology diffusion and adaption?

Of critical importance would be some methodological guidelines for empirical case studies, especially with regard to critical sectors, such as, for instance, electronics and telecommunications, optronics and laser technology, the aluminium industry; high quality alloys and refined steel, down-stream activities with regard to strategic raw materials, and high precision machinery.

6. Establishing new forms of international cooperation, especially among developing countries [26]

(1) We need detailed research on the implications of the NIEO programme [27]. According to the regional paper for Latin America, prepared by the secretariat of the UN-Economic Commission on Latin America for UNCSTD [28], the NIEO programme "... entails the restructuring of international relations in order to bring about changes in the present division of labour and in the relations existing in the present international order so as to transform its most outstanding characteristic, its assymetrical nature, into one of negotiated symmetry by means of greater participation of the developing countries in world industrial activities; the achievement of their self-reliance in the production of food; an increased share in the external trade through an appreciable increase in exports; the strengthening of their local scientific and technological capacity; and greater access of these countries to the stock of financing and scientific technological know-how available in the world."

According to the same source, this would, in the international sphere, require the following principle structural changes:

"... a) Redistribution of the world's productive potential;

b) Access of the developing countries to the sources of international financing and of generation of scientific and technological knowledge;

and c) The development of new forms of international co-operation that will tend to strengthen internal efforts to achieve development processes defined within the countries themselves."

How to proceed? The present state of knowledge on the options available to Third World countries is nearly

zero. We still need a lot of detailed case studies.

(2) This urgent need to bridge existing research deficits applies even more with regard to options for collective self-reliance, and, more specifically, with regard to options available for TCDC[29].

(3) There is an urgent need for case studies identifying the "reformist potential" for scientific and technological cooperation between North and South. Areas of conflict and areas where conciliation of interests is possible have yet to be established on a much broader scale. The same applies for research on "success stories"and failures of such cooperation between groups of developing countries and OECD or COMECON countries.

(4) We still lack in-depth case studies on the effects of major technological break-throughs realized in the OECD region on the economic and social development and particularly on the scientific and technological self-reliance of developing countries.

This would apply especially to the following areas:

a) Development of synthetics and other forms of substitutive research induced by price increases of raw materials. This preventive synthetization of raw materials is in fact a very powerful countervailing instrument available to OECD countries against further OPECization attempts by Third World raw material producers. Test cases would be, inter alia: cobalt; chromite; sugar and sweetener produced on the basis of corn derivates; guayule as a new source of natural rubber; chocolate produced on the basis of soja.

b) Technological innovations concerning seabed mining, offshore drilling, offshore prospecting etc..

c) New military technologies and their potential "civilian spin-offs", for instance: laser technology; optronics; weather modifications; bioweapons.

d) New technologies concerning material testing and production in the space.

e) New technologies concerning the miniaturization and decentralization of automation systems.

f) Technologies to increase the worldwide mobility of capital, for instance: factories on board of ships; low cost or zero cost maintenance and repair; mobile building techniques.

g) The tremendous technological potential of genetic engineering and bio industries.

h) New technologies for the increased computerization of society.

i) New technologies available for the (partial) humanization of the labour process.

7. Establishing informal networks of multidisciplinary and multilateral research cooperation

The very tight compartmentalization of different approaches to the dynamics of technology and society, prevailing up till now, must definitely be overcome. New multidisciplinary research approaches must be devised, and truly multilateral channels for research cooperation between concerned research groups in developing countries and developed countries should be

established. Multidisciplinarity here implies not only permanent exchange of information and research cooperation between social scientists, development practitioners, engineers and natural scientists. It implies also a planned and well conceived policy to promote research contacts and interlinkages between "research specialities" within one profession. For instance, during the Bonn workshop on "Technological Dependence - a Major Hindrance for Autonomous Development" [30], it turned out to be of considerable value that research individuals and groups had been brought together, who, seemingly, work on rather different research subjects, such as, for instance, development planning, North-South-relations; problems of production and transfer of civilian and military technologies within the OECD-region, East-West-cooperation etc.. Multilaterality implies first and foremost that the choice of research programmes takes into account social interests which up till now have been clearly marginalized. It implies further that control mechanisms and criteria of success for joint research will be established on a mutually agreed basis.

For obvious reasons, most of the established institutional arrangements in this field will only to a limited extent be able to fulfil these functions. Thus, alternative institutional channels for research cooperation have to be established. For instance, one immediate solution might be to broaden the impact of already existing informal networks of self-reliance information centers. A pragmatic approach would be to use the recently updated UNDP Directory of Institutions for TCDC in Developing Countries, UNIDO's preliminary compilation of "Technologies from Developing Countries", and the forthcoming OECD-Development Centre Directory

of Development Research Institutes in Developing Countries. This might be supplemented by different already existing information networks, such as, for instance, those established by the African Regional Centre of Technology, the Third World Forum, the Association of Third World Economists, the International Foundation for Development Alternatives, the International Peace Research Association and the Research Policy Institute in Lund.

## Notes

### Chapter 1

(1) For a comprehensive treatment of these issues see Dieter Ernst (editor) - "The New International Division of Labour, Technology and Underdevelopment - Consequences for the Third World", Campus Verlag Frankfurt/New York (forthcoming), especially chapters I, II and IV. Concerning the UNCTAD code of conduct see, for instance, Miguel S. Wionczek - "Prospects for the UNCTAD Code of Conduct for the Transfer of Technology", Mazingira (Oxford), No. 8, 1979, and Dieter Ernst - "A Code of Conduct for the Transfer of Technology: Establishing New Rules or Codifying the Status Quo?", in: Karl P. Sauvant and Hajo Hasenpflug (eds.) - "The New International Economic Order. Confrontation or Cooperation between North and South?", Westview Press, Boulder/Colorado, 1977

(2) See, for instance, Karl P. Sauvant - "The NIEO-Programme: a Framework for Restructuring the World Economy?" in: "The New International Division of Labour, Technology and Underdevelopment ...", op. cit.

### Chapter 2

(1) See, for instance, "The Perversion of Science and Technology. An Indictment", The World Order Model Project, July 1978, Poona/India and UNCTAD - "Transfer of Technology. Its Implications for Development and Environment.", New York, 1978. For more details see Dieter Ernst - "International Transfer of Technology: An Inventory", in: "The New International Division of Labour, Technology and Underdevelopment ...", op. cit., chapter I

(2) With regard to the increasing importance of technology for North-North-conflicts, see, inter alia, the reports of OECD-Interfutures

(3) Francisco R. Sagasti - "Towards Endogenous Science and Technology for Another Development", in "The New International Division of Labour, Technology and Underdevelopment ...", op. cit.

(4) See, for instance, Amulya Kumar N. Reddy - "The Transfer, Transformation and Generation of Technology", in: Labour and Society, 1977; and Amilcar Herrera - "Research and Development Systems in Rural Settings:

Background of the Project, Mimeo, Facultad Latinoamericana de Ciencias Sociales, Mexico, 1978

(5) See, inter alia, A. K. Malhotra - "Consulting and Engineering Design Capability in Developing Countries. A Report prepared for the Science and Technology Policy Instruments (STPI) Project", Sussex, July, 1976 (unpubl. manuscript), and Amulya Kumar N. Reddy - "An Alternative Pattern of Indian Industrialization", in: Human Futures, Vol. 1 (1978)

(6) For more details see chapter 3

(7) For further details see Jan Annerstedt - "Technological Dependence: A Permanent Phenomenon of World Inequality? Some Implications of the Present Distribution of Global R&D Resources", in "The New International Division of Labour, Technology and Underdevelopment ...", op. cit.

(8) For a more comprehensive treatment see the contributions of Seif Bennaçeur, François Gèze, Daniel Malkin and Rafael Tiberghien in "The New International Division of Labour, Technology and Underdevelopment ...", op. cit.

(9) Selfsufficiency being defined as consumption/output plus imports minus exports

(10) Within the next few years, Japanese firms, subcontracting an increasing part of their NC machine tools production into Southeast Asian production sites (for instance South Korea), might in fact overtake US firms.

(11) S. Bennaçeur - "Role and Importance of Maintenance for Economic Independence", Paris, 1978 (unpubl. manuscript)

(12) S. Bennaçeur ibid. and a whole serious of UNIDO-publications, for instance: - "Operation, Maintenance, Design and Manufacturing of Chemical Plants and Equipment in Developing Countries: Report of UNIDO Seminar", New York, 1970, UNIDO (ID/WG.60/15)

(13) Jack N. Behrman and Harvey W. Wallender - "Transfers of Manufacturing Technology within Multinational Enterprises", Cambridge, Massachusetts, 1976

(14) Abtellatif Benachenhou - "Foreign Firms and the Transfer of Technology to the Algerian Economy", ILO-working paper, WEP 2-28/WP10, October 1976

(15) op. cit. Note that the definition of engineering activities applied here is a very loose one so that it

is not possible to specify the kind of engineering activities undertaken by the Algerian firms. And note secondly that in nearly all of these contracts, apparently controlled by Algerian engineering firms, there is still one kind or another of "assistance" by foreign consultant firms.

Chapter 3

(1) Unfortunately, most of the documents prepared for the forthcoming United Nations Conference on Science and Technology (UNCSTD) do not deal with these crucial issues. See, for instance, "Preliminary Draft Programme of Action. Note by the Secretary-General of the Conference, presented to the Preparatory Committee for UNCSTD, Fourth Session", (A/CONF.81/PC.28, 9 March 1979, pages 8 and 9.

(2) This argument has been developed in Dieter Ernst (editor) - "The New International Division of Labour, Technology and Underdevelopment - Consequences for the Third World", Campus Verlag Frankfurt/New York (forthcoming), especially in chapters I and V.

(3) François Le Guay - "Industrialization as Part of a Self-Reliance Strategy", in: IFDA Dossier 2, November 1978, Nyon

(4) The following arguments owe much to: François Le Guay - "Industrialization as Part of a Self-Reliance Strategy", op. cit.; Jacques Perrin - "Repercussions Sociales des Transferts de Technologie. Conditions de Travail et Transfert de Technologie", Grenoble, IREP-Université des Sciences Sociales de Grenoble, Juillet 1977.

(5) See, for instance, the illuminating and pioneering concepts of Amilcar Cabral in "Unité et Lutte", Paris, François Maspéro, 1975, or in "Return to the Source: Selected Speeches by Amilcar Cabral", New York and London, Monthly Review Press, 1973. That such a concept can be realized has been documented in Denis Goulet's recent case study "Looking at Guinea-Bissau: A New Nation's Development Strategy", Overseas Development Council Occasional Papers No. 9, March 1978, Washington D.C.

(6) See especially the regional paper prepared by the UN-Economic Commission on Latin America. For a systematic evaluation see Volker Rittberger - "The New International Order and United Nations Conference Politics: Science and Technology as an Issue Area", UNITAR - Science and Technology Working Papers Series no. 1, New York, 1978, and Jürg Mahner - "A Preliminary

Assessment of National Papers as a Basis for UNCSTD Conference Programming", UNITAR-Science and Technology Working Papers Series no. 3, 1979

(7) We are leaving aside some crucial problems related to II.2. See, for instance, Hveem's case study on Algeria in "The New International Division of Labour, Technology and Underdevelopment ...", op. cit. and Pierre Judet -"L'économie algérienne et la logique de l'indépendence', in: Le Monde Diplomatique, February 1979

(8) A. S. Bhalla (ed.) - "Technology and Employment in Industry", ILO, Geneva, 1975

(9) See "Regional Paper for Latin America. Science and Technology in Latin America: Regional Diagnosis and Action Programme" (A/CONF. 81/PC.16/Add.1), 29 January 1979, p. 56 and Susan George - "How the Other Half Dies. The Real Reasons for World Hunger.", Pelican Books, Harmondsworth, 1978/3

(10) For satellite crop identification by commercial US teledetection firms, see, for instance, A. B. Park (Vice President of the Earth Satellite Corp. Inc.) - "Inventorier la Planète", CERES (FAO), January - February 1975. For recent developments with regard to Lacie (= Large Area Crop Inventory Experiment) which will allow for an integrated worldwide system to control and regulate food production, see: Computer, 1979, Vol. 12/No. 1

(11) See, for example, Dieter Ernst - "Technical Cooperation among Developing Countries (TCDC): a Viable Instrument of Collective Self-Reliance?", paper prepared for ACAST Symposium on Science and Technology in Development Planning , Mexico City, May 28 - June 1, 1979

(12) See, for instance, the article "New World Economic Order", in: Business Week, July 24, 1978. With regard to Western Eruope see: Constantine Vaitsos - "From a Colonial Past to Asymmetrical Interdependence. The Role of Europe in North-South-Relations", paper presented at the General Conference of EADI (= European Association of Development Research and Training Institutes), Milan, September 1978

(13) Most of these OECD Interfutures and OECD-DSTI studies have only restricted distribution. For GRESI see: "L'evolution á long terme de la division internationale du travail" (Document de Travail), Paris, November 1975. See also: Yves Berthelot and Gérard Tardy - "Le défi economique du tiers monde", Paris, La Documentation Française, 1978, and Proceedings of the Hea-

ring on "North-South-Interdependence" at the German Parliament, Bonn/FRG, Deutscher Bundestag, 1979 (forthcoming)

(14) See Paulo Freire's writings, for instance, his "Education for Critical Consciousness", New York, The Seabury Press, Inc., 1973. See also, for the case of the Philippines, Renato Constantino - "Neocolonial Identity and Counterconsciousness. Essays on Cultural Decolonisation", London, Merlin Press, 1978

(15) This term is Le Guay's, see, op. cit., p. 7

(16) Johan Galtung - "What is a Strategy?", IFDA Dossier 6, April 1979, pp. 4 and 5

(17) The following arguments are based on the report by the Working Group on "Energy- and Resource-oriented Industries", established at the Bonn Workshop on "Technological Dependence - a Major Hindrance for Autonomous Development", Bonn/FRG, 2-5 November 1978. For more details, see note (30).

(18) See, for instance, Pierre Judet's case study on the process of "direct reduction" in: The New International Division of Labour, Technology and Underdevelopment ...", op. cit.

(19) See, for instance, UNIDO - "Conceptual and Policy Framework for Appropriate Industrial Technology in Developing Countries. Discussion Paper prepared by the secretariat of UNIDO" (ID/WG.282/112), New Delhi /Anand, India, 19 October 1978

(20) The arguments in this section are based on the reports of the Working Group on "Capital Goods Production and Engineering Consultancy", established at the Bonn Workshop.

(21) For UNIDO-ICIS-activities, see, for instance, UNIDO - "Capital Goods Industries", Preliminary Study, April 1978. For IDRC-research activities in this field see Francisco Sagasti - "Science and Technology for Development. Main Comparative Report of the STPI Project", IDRC, Ottawa 1978. For OECD-Development Research Centre see the report on the meeting on "Strengthening National Engineering Capacities" (October 1978, Paris), to be edited by M. L. Perichitch.

(22) See the case studies of Seif Bennaçeur, François Gèze and Daniel Malkin, see note (8) of chapter 2

(23) See note (11) of chapter 2

(24) The following arguments are heavily drawing on the Report of the Working Group on "How to Operationalize the Concept of 'Appropriate Technology'?" established at the Bonn Workshop.

(25) The following arguments are based on the Report of the Working Group on "Science and Technology for Development: The Role of the Public Sector and the State", established at the Bonn Workshop, and the reports of two pioneering research undertakings:
- The studies on Transnational Enterprises, social classes and the state, undertaken at the Instituto Latinoamericano de Estudios Transnacionales (ILET), Mexico City (see: "Research Programme of the Division of Economic Studies", ILET, Mexico City, April 1978. Research Director: Raúl Trajtenberg).
- The STPI project, directed by Francisco Sagasti (see his: Comparative Report on the STPI Project, op. cit).

(26) Some of the arguments in this section are based on the report of the Working Group on "The Reform of the International System of Transfer of Technology and UNCSTD-Interests Involved and Main Trends", established at the Bonn Workshop, and discussions with Jon Sigurdson and Staffan Jacobson of the Research Policy Institute in Lund.

(27) A beginning has been made - see, for instance, the CEESTM-UNITAR Meeting on "Progress in the Establishment of a New International Economic Order: Obstacles and Opportunities", Mexico City, 8-13 January 1979 (see the forthcoming Pergamon Press reader entitled "Strategies for the NIEO", edited by Laszlo and Lozoya).

(28) "Regional Paper for Latin America. Science and Technology in Latin America: Regional Diagnosis and Action Programme" (A/CONF. 81/PC.16/Add. 1), 29 January 1979. The following quotations are from pages 56 and 57.

(29) For more details, see note (11)

(30) This workshop was part of the NGO activities in preparation for the United Nations Conference on Science and Technology for Development (UNCSTD). It was funded by the German Society for Peace and Conflict Research (DGFK) as part of its programme to promote research on the international transfer of technology and the application of science and technology to development, specifically with regard to newly arising North-South conflict potentials. For details see Dieter Ernst - "International Workshop on 'Technological Dependence - a Major Hindrance for Autonomous Development'. Final Report", Hamburg, 6 November 1978.

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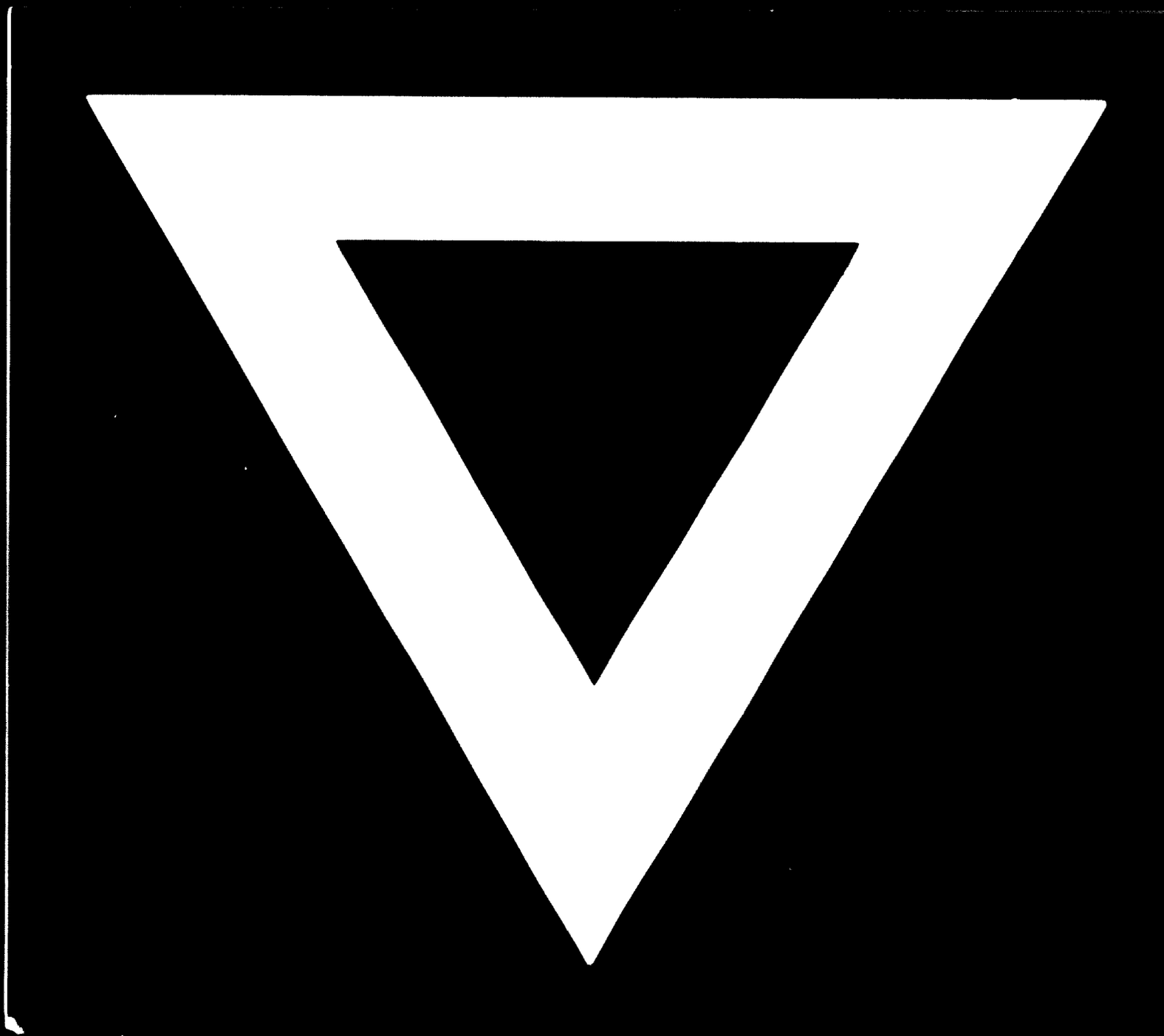

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