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What is infrastructure?

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Abstract: After having pointed out the diverse uses of the term "infrastructure" in the literature on the market-economy, the different categories of infrastructure will be described. The argument in this context is that the classification of infrastructure suggested by Jochimsen has proved useful: institutional, personal, and material infrastructure. On this basis a concept for the definition of infrastructure will be developed. The hitherto taken approach to understanding infrastructure, especially material infrastructure, mainly referring to the attributes of infrastructure, will be rejected. Rather it will be attempted to characterize infrastructure by its essential functions. We then may discuss the development-theoretic implications of infrastructure. Finally, infrastructure policy will be introduced in relation to institutional, material and personal infrastructure.

JEL-classification: J10, H54, O12, P10

Keywords: Institutional infrastructure, personal infrastructure, material infrastructure, functions of infrastructure, development theory, infrastructure policy

Zusammenfassung: Nachdem die uneinheitliche Verwendung des Begriffs der Infrastruktur in der Literatur zur Marktwirtschaft aufgezeigt worden ist, werden die verschiedenen Kategorien der Infrastruktur beschrieben. Dabei wird argumentiert, dass sich die Einteilung von Jochimsen als zweckmäßig erwiesen hat: institutionelle, personelle und materielle Infrastruktur. Auf dieser Grundlage wird ein Konzept für die Definition der Infrastruktur entwickelt. Der bisher beschrittene Weg zum Verständnis der Infrastruktur, insbesondere der materiellen Infrastruktur, über die Eigenschaften der Infrastruktur wird abgelehnt. Vielmehr wird versucht, die Infrastruktur mit Hilfe ihrer wesentlichen Funktionen zu erfassen. Dann lassen sich die entwicklungstheoretischen Implikationen der Infrastruktur diskutieren. Schließlich wird die Infrastrukturpolitik auf die institutionelle, materielle und personelle Infrastruktur bezogen.

* I dedicate this paper to Reimut Jochimsen (†) who is one of the first scholars to understand the importance and the scope of the term "infrastructure" in the field of economics.

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1. Present use of the term "infrastructure"

In the field of economics Tinbergen (1962: 133) introduces the distinction between infrastructure (for example, roads and education) and superstructure (comprising manufacturing, agricultural and mining activities). However, in this context, we neither find precise definitions nor any theoretic references of these terms. Nowadays, Nijkamp (2000: 88) speaks about infrastructure as material public capital (roads, railways, (air)ports, pipelines etc.) and suprastructure meaning immaterial public capital (knowledge networks, communication, education, culture etc.), again without specifying the proposed terms in sufficient detail.

The first systematic approach for the market-economy we owe to Jochimsen. For him "infrastructure is defined as the sum of material, institutional and personal facilities and data which are available to the economic agents and which contribute to realizing the equalization of the remuneration of comparable inputs in the case of a suitable allocation of resources, that is complete integration and maximum level of economic activities" (Jochimsen 1966: 100). This definition distinguishing between material, institutional and personal infrastructure Jochimsen (1966: 31-39) bases on his comprehensive critique of Eucken's theory on the data of an economy (Eucken 1965: 127-162, Eucken 1955: 377-378). However, Jochimsen's definition has the disadvantage of not making factor price equalization concrete which, by the way, theoretically cannot be maintained under realistic assumptions (cf. Christiaans 1997). Moreover, we must critically point out that Jochimsen (1966: 103) understands material infrastructure to be an enumeration of essentially public facilities characterized by specific attributes.

Until today we cannot dispose of a well-founded and useful definition of infrastructure ("infra" stems from the Latin language, meaning below, thus "infrastructure" can be taken to express "foundation"). Numerous formulations have been put to the test, leading to a substantial diversity and complexity of suggestions and problems which shall not be described here in detail (cf., for example, Jochimsen/Gustafsson 1970a, 1970b, Frey 1972, 1978, Biehl 1986, Nijkamp 1986, Lakshmanan 1989, Aberle 1995, Rietveld/Bruinsma 1998, Haughwout 2000b, Nijkamp 2000). All of these formulations have in common that infrastructure, essentially material infrastructure, is to be supplied by the state. Also, in the public discussion, the term made a successful terminological career, rising to a formula of political technocracy. Traditionally, "infrastructure" has been applied to permanent installations required for military purposes. Modern general usage of the term

concerns the necessary economic and organizational foundation of a highly developed economy (transport network, labor force etc.) (Drosdowski/Scholze-Stubenrecht/Wermke 1997: 359).

The reason for this unsatisfactory situation is that the simultaneous realization of three analytic objectives difficult to grasp and not necessarily compatible with each other has been aimed at. These objectives are

- the formulation of a concept for the term "infrastructure",
- the incorporation of theoretic approaches (for example, the theory of public goods), and
- the description of the reality of infrastructure provision.

Since such a research project turns out to be much too complicated and ambitious, we shall concentrate on the more modest approach of solely analyzing the first objective, the formulation of a concept for the definition of infrastructure relevant for the dynamic theory of economic development. The preliminary working topic is as follows: What are the essential preconditions for the privately organized division of labor, that is, for market-relevant private production and capital formation? Or: what are the prerequisites in a comprehensive, total view to economic growth? Observe that these questions are not related to any economic objective, following the tradition of neoliberal thinking.

These questions form the gist of the term "infrastructure" whose introduction can only be justified by the complementarities of material, institutional and personal infrastructure in relation to economic development. The identification of the term "infrastructure" with the term "material infrastructure" as it can often be found in the literature is an unnecessary and misleading contraction of the term, nothing but a misunderstanding of the problems to be discussed.

The regional or spatial reference of infrastructure is not controversial. However, here the hitherto pursued approach to understanding infrastructure mainly with respect to its attributes (cf. Youngson 1967) will be rejected. Rather we shall strive to characterize infrastructure by its essential functions. They are called "essential" since they initiate changes of economic variables, e.g. changes of costs of the firms or changes of household utilities. In this manner of advance, the human being, the economic agent, is taken to be an individual and, at the same time, a member of

the community which is not identical to the state (as the overall term for all public bodies and institutions). The state is here understood as one possible, but not the only form of organizing the community to solve problems of the society (cf. also Etzioni 1995). The harmonization of individual interests and their adjustment to and the creation of public welfare are considered as an important problem that shall not be discussed here. Lack of public concern on the side of individuals or individuals' behavior detrimental to public welfare (or even perverse behavior of individuals) are excluded from analysis as problems to be attended by an adequate policy of the economic order (Ordnungspolitik). An example of such undesirable behavior is free-riding.

The categorization of infrastructure according to Jochimsen (1966: 100) will be accepted here; however, the sequence of categories given by him will be changed, following the neoliberal view of economic growth processes.

The provision of institutional infrastructure is considered to be a task of the state. However, private agents or organizations, in principle, are taken to be responsible for supplying personal infrastructure and material infrastructure. Government activities are not excluded. "Research now supports the proposition that privately owned firms are more efficient and more profitable than otherwise-comparably state-owned firms" (Megginson/Netter 2001:380). For an example deviating from the traditional notion of higher efficiency of private activities in comparison to public action cf. de Fraja (1993). In general, we join the position of Tinbergen (1962: 132-133) that the decision on the public or private provision of personal and material infrastructure should be subject to cost-benefit analysis (cf. also, for instance, Edwards 1992).

Although still in contrast to reality in many aspects, the assumption of mainly private production of personal and material infrastructure fits well into the concept of infrastructure proposed in this paper which is influenced by neoliberal economic thinking. There is no solid argument for permanent and comprehensive state activities in these two fields of infrastructure. Besides, the reorganization of public production to private provision of infrastructure is an important topic of the present policy debate, at least in most industrialized countries, a first step being deregulation (cf., for example, Crandall 1997, Rothengatter 1997, Willms 1998, Peltzman/Winston 2000; observe also that the problem of an insufficient supply of

public capital services as pointed out by Galbraith (1971: 221-238) does not exist ex definitione, for a discussion cf. Böckels/Scharf/Widmaier 1976).

From a systematic point of view it is advisable to distinguish between the effects and the determinants of infrastructure, specifying each approach by the category of infrastructure under investigation (cf. Buhr 1977). The effects of an infrastructure category, for instance material infrastructure, refer to its impacts on demographic and economic variables. Their influences determining infrastructure demand, are summarized under the heading of the determinants of infrastructure. Within this framework it would lead too far to discuss in detail the effects and the determinants of institutional, personal and material infrastructure so that this line of thought must be interrupted here.

2. Categories of infrastructure

2.1 Institutional infrastructure

This category of infrastructure comprises all customary and established rules of the community as well as the facilities and procedures for guaranteeing and implementing these rules by the state.

Codified rules are represented by the legal order which is based on the legal constitution of a nation (the Grundgesetz in the Federal Republic of Germany (FRG)). From these fundamental principles the economic constitution (Wirtschaftsverfassung) of the country emerges as the legally determined main issues of the economic order (Wirtschaftsordnung) which is also constituted by commonly used practices (cf. the competitive order of Eucken, Eucken 1955: 241-324).

A nation's legal constitution includes regulations on the types of government tasks and on the distribution of these obligations to different institutions of the state. Government tasks lead to government expenditures which must be covered by government revenues. These tasks are attended by specific bodies politic (for instance, the parliament, administrative authorities, courts). They give good examples for the concerted effects of the different categories of infrastructure.

The legal constitution also embodies regulations on the relationship of the citizen to the state and on the organization and management of the public sector. Here the creation of concrete procedures is required (for example, organized barter for negotiating budget estimates, for distributing tasks between administrations and for burden sharing among administrative unions) which are determined by political processes and administrative practices.

The law of the economic constitution includes all constitutional rules forming the public-legal foundation of the legal order for the economic sphere (cf. Hall/Soskice 2001 as a recent approach). Since the Grundgesetz does not explicitly indicate a decision for a specific economic system, the problem of the economic constitution lies in the determination of basic rules relevant for the economic constitution. Today there is no longer a controversy on the validity of the essential constitutional principles governing the Grundgesetz (in particular, rule of law, rule of social principles, and postulate of democracy) and the basic rights of the citizen (for example, guarantee of a person's free development and of the freedom of economic activity (above all, freedom of concluding treaties)) for the economic order. In addition, the Grundgesetz points out important special regulations determining economic activities which refer to the mobility of economic agents, the free practice of a profession, the freedom of coalition, and the guarantee of property and inheritance rights.

The supplies of the following public goods indisputably belong to the tasks of the government: legislation and judicature; administration of the community, in particular internal national security; safeguarding fundamental research; maintenance of the value of money in a paper money system; and outward defense, also production of military goods. It is not necessary that the state itself renders these services, the state must only guarantee their provision.

A comprehensive economic assessment of the institutions of the state and their productive activities is nowadays given by the new institutional economics (cf. Richter/Furubotn 1999: 453-476, Erlei/Leschke/Sauerland 1999, Kasper/Streit 1999, Ménard 2000, Williamson 2000) which also concentrates on applying the methods of this field of economics to the analysis of state bureaucracies (cf. Moe 1990). Government administration essentially means public decision-making ranging from problem identification to the formulation of objectives, to the selection of solution alternatives, finally to the concrete decision. Thus the management of

public institutions under the rules of communication and subject to legal restrictions is the main object of administration economics and law (cf. Eichhorn/Friedrich 1976, Schuppert 2000, Fehling 2001).

A cardinal place in the framework of economic policy is occupied by the policy of the economic order (Ordnungspolitik) that sets forth the economic constitution (for example, the environmentally oriented development of the economic order of the social market-economy) (cf. Cassel/Ramb/Thieme 1988). The functioning of the market-economy requires the government to take a strong position in the protection of competition that unrestrictedly pursues and maintains all necessary controlling measures, particularly here in reference to the private provision of material infrastructure. Regularly, the criticisms opposing the concept of the market-economy are nothing else than criticisms of the government's policy of the economic order. A weak or absent order policy is a failure of government activity! On the contribution of institutional economics to the theory of the economic order cf. Feldmann 1999.

2.2 Personal infrastructure (human capital)

It comprehends the number and the relevant properties of the working population (for example, general and special education, qualification in different functions). That is, we have to deal with population as a stock variable and the labor participation rate that are changed by the birth rate, death rate and migration (quantitative aspect of personal infrastructure) as well as with the characteristics of the working population (qualitative aspect of personal infrastructure).

Personal infrastructure or human capital has marked references to institutional and material infrastructure (for example, consider the implementation of the policy of the economic order or the supply of qualified labor for the production of material infrastructure goods).

The central position of personal infrastructure in economic life results from its basic relationships to the causes of economic growth (Casson/Godley 2000, Woll 2000 : 430). Concentrating solely here on the qualitative aspect of human capital we must indicate: motivations of the working population (willingness to work, to save, and to progress) determining labor intensity and efficiency, quality of innovations and extent of learning by doing; social status and professional image; reaction to the

given degree of freedom of economic activity. All of these factors are related to the level of education of economic agents which is considered to be a reliable welfare indicator (cf. Sen 1999).

There are many references of personal infrastructure to the field of economics: population theory (for example, raising children today presupposes the existence of a sufficient maternal infrastructure); labor economics (cf. problems of labor organization and of fulfilling management functions); economics of education (cf. problems of schooling or adjustment of education to labor demand); and growth theory (cf. traditional theory on human capital and on unskilled and educated labor (Barro/Sala-i-Martin 1995), endogenous theory (van Schaik 1995, Klenow/Rodriguez-Clare 1997, Aghion/Howitt 1998).

From our point of view, government activities should generally be excluded from the sphere of education whose organization and development are to be left to private initiatives (cf. also Straubhaar 1995). The main reason for this position is simple: the public officials' obvious lack of understanding the vital role of education in economic growth being a long-term process (cf. Krueger/Lindahl 2001, Karlsson/Zhang 2001). This comprehension of economic growth should not be endangered by short-term influences such as the possible change of education policy due to the (for example, four-year) substitution of the ruling party or parties in a democratic election cycle. In addition, the sufficient creation of education capital is an obligation of the older towards the younger generation (cf. De la Croix 2001). This inter-generations-problem, at the outset, should be solved without any concern for distributive issues according to the laws of demand for and supply of education (on the present general problems of German university education and their solution by the principles of competition cf. Woll 1973, Woll 2001). This means that the supply of education must follow the structure of education demand under the rules of profit-oriented production, thus describing in brief the solution of the problem of the determinants of education infrastructure.

If necessary – and now the policy of the economic order in the framework of the institutional infrastructure comes into the picture – the government may initiate the creation of laws guaranteeing, for instance, equal access to and opportunities of schooling or demanding the general obligation of school attendance according to minimum standards. Elementary education should be supplied by the state to guarantee the development of the fundamental capabilities of communication

among the members of society (cf. Woll 1988). Also the state may exert the supervision of the application of necessary basic legal and administrative rules in the field of education. However, all of these exceptions of government interference do not change the general view of the singularity of education and thus education infrastructure to be privately supported to create and maintain qualitative personal infrastructure.

2.3 Material infrastructure

This type of infrastructure is understood to represent capital goods in the form of transportation, education, and health facilities, equipment of energy and water provision, facilities for sewage, garbage disposal, and air purification, building and housing stock, facilities for administrative purposes and for the conservation of natural resources (for subdivisions cf. Biehl 1986: 100-111). Due to its public provision often given in reality, in the literature material infrastructure is also referred to as social overhead capital, social amenities, or public facilities.

Generally accepted are

- (1) the distinction between capital equipment and capital services, on the one hand, and operation of a facility or production of output, on the other hand,
- (2) the spatial representation of material infrastructure (cf. Buhr 1975: 22-25):
In a horizontal approach we may distinguish point systems (for example, airports, hospitals), point-network systems (for example, telephone services, electricity supply), and network systems (for example, roads)(cf., e.g., Steyer 2001). From a vertical viewpoint we may refer to the continent, the nation, the area, the region, the county, the lot (for example, international highways, interstate highways, expressways, motorways and country roads, through roads and main streets, local streets).

Especially noteworthy is the dynamic interdependence of the effects of material infrastructure (Buhr 1975: 30-38, Rietveld 1989, Vickerman 2000) and the determinants of material infrastructure (cf. Buhr 1975: 168-227), particularly in a regional context. On the interplay in time cf. Buhr 1973, 1975, 1981.

Here the position is taken that output creation of material infrastructure is to follow the general principles of profit-orientation of production, in cases of exception under distribution restrictions.

The rejection of the characterization of material infrastructure by its properties is essential for this paper. The following attributes, some of them connected, have been assigned to the capital goods of material infrastructure (cf. Stohler 1965, Buhr 1975, Frey 1979, Biehl 1986).

a) Technical properties: These attributes are provision in large units (cf. Lakshmanan 1989: 243), limited divisibility, high capital intensity and capital coefficient, long duration of life (slow movement), little substitutability, reduced spatial mobility, restricted possibilities of import, outputs as generally used inputs, relatively long time of investment installation.

The properties of the capital stocks are not unambiguously related to material infrastructure, since the same qualities in general belong to the production equipment of the chemical industry or of automobile production (cf. Scazzieri 1993). Thus, these traits cannot sufficiently characterize material infrastructure.

b) Economic properties: The following three points have been presented in the literature on material infrastructure.

(1) Properties of production and cost: Material infrastructure capacities are generally typified by a high proportion of fixed cost, cost digression due to fixed costs and/or increasing returns to scale in large-scale operation (cf. Diewert 1986, Duncombe/Yinger 1993), substantial step-costs, and a high risk of investment.

All of these facts finally result from the technical properties of material infrastructure that have been discussed above and rejected as insufficient characteristics.

(2) Character of public goods: The main point in this context stressed repeatedly is market failure, that is the deviation from the market results of perfect competition or the violation of the conditions of a Pareto optimum. This failure is explained, with reference to the supply side, by the invalidity of the exclusion principle and, with reference to the demand side, by the unknown number of privileged demanders undetermined because of utility diffusion and the absence of rivalry of users because of unlimited capacity within certain limits of output production.

By definition, the notion of market failure lacks any solid relationship to reality so that the public goods character of material infrastructure cannot be of concern basically (cf. Woll 1987: 450-454).

In addition, most models of public goods aiming at the solution of price formation problems are limited in their extent and contribute little to the theory of public production (cf. Eichhorn/Friedrich 1976, Schuppert 2000, Fehling 2001).

The characteristics of public goods may be given for material infrastructure goods under very specific conditions, for example, road usage at times of free flow traffic (cf., for instance, Biehl 1986, Crandall 1997: 167). However, up to date the public goods problems are solely of theoretical concern (a typical discussion still is Musgrave 1971) and have no importance yet in applied infrastructure economics and planning. A reasonable example for this point is transportation planning (especially cf., for example, Bell/lida 1997, in general cf. Button 1996).

The strict identification of material infrastructure with public goods (cf. Andersson 1993, Haughwout 1996, 2000a, Colombier 2001) is certainly an exaggeration that lies beyond any serious discussion.

The arguments in favor of merit goods which the state must supply or the consumption of which the state must reduce because of "wrong" household preferences run counter to the principle of consumer sovereignty.

Moreover, in reality, economic agents are generally willing to pay a positive price for most material infrastructure goods (for example, electricity). And specifically, users of locationally bound material infrastructure may be understood to form a club. Regarding club goods, prices can be determined (cf. Buchanan 1965, Starrett 1988, Guengant/Josselin/Rocaboy 2002) as it is done in practice. A plausible example is given by a regional public passenger transport system organized as a user club (cf. Meyer 2002).

The result is that the possible public goods traits of material infrastructure play a subordinate role in the provision of material infrastructure, even more so, if the supply is privately produced. In the improbable case that problems arise, then it is the turn of the policy of the economic order (for example, prohibition of any behavior detrimental to public welfare).

- (3) Creation of external effects (cf. Lakshmanan 1989, Crandall 1997): Pecuniary external effects do not represent a problem in a market economy, particularly not in the case of the private provision of material infrastructure via markets. Regarding technological external effects such as network effects (cf. Liebowitz/Margolis 1994, Swann 2002) we may refer to the price solution of the Pigou model (Pigou 1946) or to the determination of well defined property rights for the derivation of market results in the sense of Coase (1960). For an introduction into the problem of property rights and external effects cf. Schumann/Meyer/Ströbele 1999: 490-500. Whatever the concrete form of internalization of the external effects (cf. Mishan 1971) will be, external effects are not exclusively constituent properties of material infrastructure (cf., for example, environmental problems) and do not justify public provision of material infrastructure.

c) Institutional properties: Here essentially two contributions are made in the literature on material infrastructure.

- (1) Public provision of material infrastructure: The main reasons indicated, on the one hand, are historically given administrative practices and decision-making by political mechanisms. Such justifications are generally not convincing and are excluded here. Even very large projects such as the Channel Tunnel between Great Britain and the European mainland have been financed and constructed by private investors (cf. Vickerman 1989, Hayashi 1993).

On the other hand, it has been argued that state planning is necessary because of the absence of market prices (cf. also Rietveld 1989: 256). This point is also without substance in view of price formation by trial and error, derivation of shadow prices or cost apportionment.

- (2) Private production under public control: The typical case is that of the natural monopoly (for example, public utilities) (cf. Schumann/Meyer/Ströbele 1999: 290-296). The justification of public control refers to the protection of the consumers against exploitation as a distributive issue and to the necessary limitation of deficit firm operation to avoid the necessity of public financial support (cf. Button 1996).

The arguments against this stand taken on the issue are as follows. Monopoly control is a case of regulation policy which, in the first place, belongs to the field of the policy of the economic order and thus to the realm of institutional infrastructure. Whether the change of market results in the framework of regulation policy, now understood as a process policy, is necessary, is a matter of the given facts. In a dynamic view, monopoly as a form of market organization is subject to technical progress and free market entry. Therefore it is advisable to keep back recommendations on monopoly control that are based on static equilibrium models (Woll 1987: 457, Spulber 1989, Bobzin 2002).

In addition, market power can be restricted by introducing competition on the level of firm operation as separated from the usage of the capital stock (for instance, rail network management and competition for transport service provision (cf. Bassanini/Nastasi 2001)). Private capital stock use must then regularly be submitted to monopoly control in whatever form.

Moreover, natural monopoly is not the only market form on the supply side of material infrastructure provision (cf. Gramlich 1994, Crandall 1997). Rather the whole range of market types is present in reality, in the extreme nearly perfect competition in housing construction.

In consequence of the above given arguments the term "material infrastructure" shall not be defined with reference to the properties of material infrastructure, but shall be drawn closer by indicating its functions. This finding generally also applies to institutional and personal infrastructure.

3. Functional approach to infrastructure

The economic agents contribute – individually and in interaction with each other – to the creation of the social product which is attributed to the national community. These productive contributions are based on the provision of infrastructure. Let us concentrate here on material infrastructure, since the influences of this category can most easily be understood. The generalization of our considerations to include also institutional and personal infrastructure does not create any additional problems of substance.

Material infrastructure has the function of rendering possible the opening and development of the economic agents' activities. It puts into action the potentialities of economic units for the benefit of society. This is a dynamic view that goes beyond the realization of precautions for the human beings' existence in the sense of Jaspers' Daseinsfürsorge (cf. Jaspers 1931) or Forsthoff's Daseinsvorsorge (cf. Forsthoff 1973, see also Cox 2000).

Thus, the creation and maintenance of material infrastructure are obligations of the community towards the individual productive economic agents. Material infrastructure takes the forms of household-oriented infrastructure, enterprise-oriented infrastructure, and market-oriented infrastructure, all types having their specific positive or negative effects on demographic and economic variables by which the functions of infrastructure become materialized.

The community's material infrastructure obligations correspond to the demand for infrastructure from the economic agents. As already indicated, the factors determining this demand are referred to as the determinants of material infrastructure. Satisfaction of infrastructural demand draws attention to the complementarities of material infrastructure facilities and of elements of different infrastructure categories. A town hall (that is, administrative work done by specifically trained employees located in a particular building) is an illustrative example (cf. also, for instance, Stephan 2001).

The analysis of the interdependence of the effects and the determinants of material infrastructure in time makes complicated research necessary (cf. Buhr 1981). Thus, we have an explanation for the fact that partial investigations dominate analyses in a total view of material infrastructure.

Material infrastructure implies the functions of safeguarded opening and development of the activities of

- each individual household

here: household-oriented material infrastructure, that is, all capital goods

- guaranteeing birth and respectable death, especially reproduction (cf. Bökemann 1990),
- securing the existence of human beings (maintaining health and personal safety, cf. Bhargava et al. 2001),
- guaranteeing the capability of work, the opportunity to earn and to spend an income,
- enabling the acquisition and sale of property in the form of capital and/or land (cf. Bökemann 1982; on the fundamental role of property rights cf. Erlei/Leschke/Sauerland 1999, Richter/Furubotn 1999, de Soto 2000, Weede 2000).

- each individual enterprise

here: enterprise-oriented material infrastructure, that is, all capital goods

- making possible the disposition of property in the form of capital and/or land,
- securing the organization of the factor combinations,
- securing the production of output(s),
- securing the sale of product(s);

at this place, we may subsume state institutions taken as enterprises (cf. Richter/Furubotn 1999 : 453);

- each single market (factor markets, goods markets)

here: market-oriented material infrastructure, that is, all capital goods serving the coordination and interaction of economic units to realize their economic plans.

Observe strictly that household-oriented material infrastructure directly refers to quantitative personal infrastructure. And even more important: Qualitative personal infrastructure and institutional infrastructure fulfill the given functions without creating any basic problems.

Thus, the decisive content of the general term "infrastructure" is the activation or mobilization of the economic agents' potentialities. The creation and maintenance of infrastructure is an obligation of the community towards each individual economic agent.

The following examples will help to support and clarify the preceding argumentation. With respect to roads as a category of material infrastructure we may give two briefly formulated instances. In the first place, basic to the determination of the economic impacts of road infrastructure is the term "accessibility" (cf. Karl 1997, Reggiani 1998, Rietveld/Bruinsma 1998, Vickerman/Spiekermann/Wegener 1999). Roads are capital goods which make possible the mobility of persons and goods in space in an intended way or, in other words, which make certain locations accessible for economic agents (cf. above the functions of the different types of infrastructure). In the second place, we may refer to the illustrative case of a snowfall on a road network. The classic question is how to direct the existing number of snow-ploughs in the network to attain a maximum of traffic flow as soon as possible.

An industrial park supplying a bundle of material infrastructure facilities is composed of a number of lots for industry location (cf. also Feller 1997). These well-equipped lots exert location incentives, however, they do not necessarily create the desired locational demand for industrial real estate. For the importance of all types of infrastructure as location factors cf. Vanhove (1999).

Concerning institutional infrastructure we may indicate that present tax legislation of FRG, to a substantial extent, runs counter to the definition and sense of institutional infrastructure. An important point of evidence is the given extent of illicit work in the shadow economy due to the disincentive effects of taxation in this country.

The World Population Report for the year 2000 (United Nations Population Fund 2000) describes the miserable situation of women in many parts of the world. Measures protecting, helping and encouraging handicapped women are measures of the three categories of infrastructure.

We may now turn to the formulation of the definitions of infrastructure.

Infrastructure of an area is the sum of all relevant economic data such as rules, stocks and measures with the function of mobilizing the economic potentialities of economic agents.

Thus we also know:

Institutional infrastructure to be provided by the state comprises the rules as well as facilities and procedures guaranteeing and implementing the rules with the function of activating the economic potentialities of economic agents.

Personal infrastructure is represented by the number (quantitative personal infrastructure) and the properties (qualitative personal infrastructure) of the working population that influence the economic potentialities of the economic agents. The realized potentialities determine again the properties of the economic agents (learning by doing in a wide sense).

Material infrastructure refers to the capital stocks that serve the function of mobilizing the economic potentialities of economic agents.

The fundamental relevance of the term "infrastructure" in modern societies results from the far-reaching absence of its underlying idea of encouragement of human beings, of creating incentives for economic agents in a dynamic sense.

It seems to be advisable to stress that the definitions of infrastructure, the categories of institutional, personal and material infrastructure, have been developed from "below", starting from a brief description of their functions. Therefore it would be totally unacceptable to concentrate solely on these definitions, criticize their verbal contents without any reference to what was said about the categories of infrastructure before. It seems also to be a matter of course that it may be necessary to specify these definitions further in order to correspond to particular research objectives.

4. Development-theoretic implications of infrastructure

Subsequently, we shall depict the development-theoretic importance of the term "infrastructure". For this purpose we shall concentrate on material infrastructure, assuming the complementarity of institutional and personal infrastructure (cf., for example, Hanushek/Kimko 2000).

Emphasis will be laid upon the following development processes.

(1) Growth at low-level (national, regional) product

Typical for this situation are economic units (households, enterprises) that are engaged in specific and unspecific activities. For example, production of a defined output is a specific activity of an enterprise, whereas unspecific activities of this firm are its own electricity generation, maintenance of own facilities for water supply, use of its own sewage system as examples of self-sufficient infrastructure provision.

In the process of economic growth the unspecific activities of infrastructure supply become separated from the specific activities of the economic units. New firms and agencies in the field of material infrastructure production will emerge so that non-infrastructure and infrastructure capital stocks will develop at different growth rates in time.

(2) Different Cases of Capital Growth

a) Case of "harmonious" structure of non-infrastructure and infrastructure capital stocks

Two analytical problems deserve to be pointed out here: on the one hand, the stability of the structure of the different capital stocks (cf.

Domingo/Tonella 2000, Wang 2002) and, on the other hand, the facilitation of the transformation from a goods producing economy towards a dominant service economy by infrastructure, especially communications infrastructure (cf. Lakshmanan 1989, Creti 2001, Röller/Waverman 2001).

Particularly under the assumption of full employment this case supplies a convincing basis for productivity analysis, especially of material infrastructure, concerning the economy as a whole (cf. Aschauer 1989, Batten/Karlsson 1996: 17-72) or the relative position of infrastructure

production to non-infrastructure production (regarding the contribution of Baumol cf. Krueger 2001: 216-218).

Main theoretic approaches to be pursued in this field are the solution procedures of sequencing problems of production as they come up, for example, in shipbuilding and machine scheduling (Shephard et al. 1977, Shephard 1983, Teich 1998), applied theory of dynamic programming (Gluss 1972, Neumann 1977), and network analysis (cf. Noltemeier 1976, Jungnickel 1994, Economides 1996).

Evaluating this case we come to the conclusion that it is a theoretically interesting borderline-case well-suited to discuss the given definitions of infrastructure.

- b) Case of material infrastructure as growth incentive (especially excess supply of infrastructure)

As main problems we may point out estimating the efficacy of the effects of infrastructure, especially in typical cases of economic development (cf. Buhr 1981, Feltenstein/Ha 1999, Rioja 1999), analyzing, in a modified context, infrastructure productivity to solve the infrastructure productivity paradox (cf. Haughwout 2000b), and determining the key sectors with strong backward linkage effects, forward linkage effects, and in addition agglomeration effects in an input-output context (cf. Rao/Harmston 1979, Kogelschatz 1988, Braun 1993).

This case is the important case of economic development to which the above given definitions of infrastructure are to the point. Good examples are modern country programs of infrastructure investments (cf., e.g., that of Turkey).

- c) Case of externally induced "fast" growth of infrastructure capital stock ("bathtub" case: trust in substantial economic growth unrelated to infrastructure investments)

Let us give two examples. The first example concerns the notion of West German politicians on the reconstruction of the five new German states after reunification. The quick revitalization of especially material infrastructure (telecommunication, road network, sewage disposal, energy supply) in

these states unrelated to the development of economic indicators— so their opinion - will generate growth and thus create "blooming landscapes". This is a convincing example on the prevalent misunderstanding of the process of economic growth and of the effectiveness of the functions of infrastructure, as reality indicates.

The second example refers to the economic development of a part of the American west. Due to technical progress (particularly, invention of the transistor at Stanford University, Palo Alto/Calif.), the availability of land and capital, and to the west migration of the American labor force, Santa Clara County located south of the San Francisco Bay, California, experienced considerable economic growth in the post-war period that was embedded in a more than generously provided system of material infrastructure (cf. Buhr 1975).

The relevance of this case c) depends on the concrete circumstances. Infrastructure considered alone has an incentive function that must not be related to other growth factors such as technical progress and availability of qualified labor. Initially, there may be no effects of infrastructure whose stock magnitudes are exogenously determined. Only in the process of accelerating growth the efficacy of the effects of infrastructure comes into existence more and more. Thus, in particular, the given second example as a borderline case to case b) still complies with the definition of infrastructure.

- d) Case of infrastructure capital stock as growth barrier (especially excess demand for infrastructure)

We are here confronted with the problems of the determinants of infrastructure, especially problems of investment evaluation (price formation, relevant profit level, benefit-cost difference, cost-effectiveness, minimum provision standards, compatibility with the environment). A possible access point of discussion may be the connection between cost-benefit analysis and cost-effectiveness analysis (cf. Dolan/Edlin 2002). Among the general problems is the absence of entrepreneurial supply functions (for example, long-lasting neglect of reinvestment problems as enterprise planning failure) of outstanding importance.

Provision or bottleneck problems of material infrastructure (cf. Rietveld 1989: 262-264) have no reference to the definition of infrastructure that concentrates on the stimulating contribution of infrastructure to economic development. In the present case, the given level of infrastructure provision constitutes a main hindrance to growth. The decline of infrastructure has analogous consequences.

The preceding classification of development processes may be reconsidered from the viewpoint of infrastructure model building. However, we should observe that the number of infrastructure models is substantial and that these models generally do not fit together. Each model has its own approach and structure and aims at its specific objective of explanation. Therefore a satisfying overview of existing infrastructure modeling is beyond the scope of this paper. Some examples must do here.

All of the mentioned development situations may be discussed within the framework of a model given by Frey (1969). In contrast, a growth model formulated by Siebert (1971) solely concentrates on the effects of material infrastructure (above mentioned case 2b), again restricting his analysis to production effects and mobility effects of the infrastructure capital stock.

A dynamic model constructed by Buhr (2001) deals with the macroeconomic supply-demand determination of regional equilibrium incomes in regional goods markets as a framework for discussing the implications of competition among regions. The author separates demanded and supplied infrastructure capital of two regions embedded in the nation, thus being able to discuss at least the above mentioned cases 2a), 2b), and 2d) at the level of each region. The supply side of the model is represented by different regional production functions which include the supplied regional capital stock of infrastructure, leaving aside the stock of human capital and the private capital stock. The production functions generate regional factor demand, here specifically the regional demand for infrastructure capital. The corresponding regional supply of infrastructure capital is mainly varied by regional public investment; capital depreciation does not occur. Public investment is residually determined on the basis of the assumption that there are balanced budgets for the public sectors of the regions and the nation.

With respect to the residual determination of public investment this approach leaves a blank spot that may be closed by a political model of economic growth as suggested by Frey (1968). He discriminates the application of this model according to the excess supply of or excess demand for infrastructure, stressing the inseparable interplay of economic and political forces in reality. As valuable as such contributions are, they have unfortunately the disadvantage of not being formalized.

The general result of the development-theoretic considerations is that the above given definitions of infrastructure are useful in the context of economic development.

5. Infrastructure policy

As before we assume that the state is responsible for creating and maintaining the institutional infrastructure of a nation that forms the main reference of infrastructure policy. From an economic point of view, the government guarantees and protects the economic order that is changed by the pertaining policy. The economic order sets rules for state activities and private economic operations, that is, also for the existence and production of personal and material infrastructure, here assumed to be supplied by private initiatives (government activities in these fields are understood to be temporary exceptions). Thus, the policy of the economic order, apart from other objectives, concentrates on the variations of personal infrastructure (changing the rules of, for example, population policy, labor market policy, and education policy) and of material infrastructure (changing, for example, the rules of capital policy). In other words: private producers of personal and material infrastructure must strictly be controlled by institutional infrastructure. In this context, the policy of the economic order may be supported by utility-related or (private or social) profit-related policy measures such as tax incentives. The main point is the integration and activation of different policies in the sense of the given economic order and the proposed definitions of infrastructure.

Possible policy results are

- change of structure of infrastructure capital stocks,
- substitution between material and personal infrastructure (for example, introduction of modern telecommunication services),
- reduction of activity-independent costs of economic units' consumption or production (cf., for example, Conrad/Seitz 1992, 1994).

Infrastructure policy at the national level refers to institutional infrastructure (cf. also Momberg 2000: 284-288) and thus, within this framework, also to personal and material infrastructure. Its main general objective is to mobilize the relevant potentialities of economic agents.

While we stressed the dominance of institutional infrastructure at the level of the entire economy, we may also concentrate on the dominance of material infrastructure, particularly looking at individual categories of material infrastructure that are supported by pertaining types of personal and institutional infrastructure. Let us consider the following two examples.

(1) Medical care:

material infrastructure	e.g. hospitals, i.e. buildings for specific medical services and housing of patients,
complementary personal infrastructure	e.g. doctors with different qualifications, specifically trained nurses, administrative personnel,
complementary institutional infrastructure	organization of hospital work, medical regulations, remuneration schedules, financial schemes of patient insurance and support etc.

(2) Information systems:

material infrastructure	e.g. buildings and hardware equipment in different fields (telephone services, telecommunication, computer services etc.)
complementary personal infrastructure	e.g. knowledgeable personnel of information technology in diverse categories
complementary institutional infrastructure	e.g. laws and norms concerning security of information systems and data protection, international procedures of standardization etc.

Finally, we point out the approach of stressing the dominance of personal infrastructure supplemented by typical functions of institutional and material

infrastructure. The main access point here certainly is the human being's capability of learning, of acquiring economically relevant qualifications. The complementary institutional and material infrastructure is so obvious that it must not be described in detail here.

Whatever category of infrastructure is considered to be dominant, an essential task of infrastructure policy will be to maintain and improve the complementarities, the integration and cooperation, of institutional, personal and material infrastructure. In this sense the realization of the notion of infrastructure is relevant for progress in economic development, particularly in times that lack satisfactory concepts of economic policy.

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