Faculteit der Economische Wetenschappen en Econometrie

SERIE RESEARCH MEMORANDA

Infrastructure, suprastructure and ecostructure: A portfolio of sustainable growth potentials

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Research Memorandum 1999-51

November 1999

vrije Universiteit amsterdam

INFRASTRUCTURE, SUPRASTRUCTURE AND ECOSTRUCTURE: A PORTFOLIO OF SUSTAINABLE GROWTH POTENTIALS

A Comparative Analysis

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Abstract

This paper aims to offer a new perspective on the productivity enhancing impact of public capital. In contrast to the majority of the literature which addresses mainly infrastructure effects on national or regional growth, the present contribution argues that a much broader analytical viewpoint is needed which encapsulates also knowledge and research capital (suprastructure) and environmental capital (ecostructure). After a discussion of the state of the art and a critical overview of various caveats in a traditional approach, a new evaluation framework is presented. A qualitative test on the validity of the new approach is conducted by means of a comparative case study analysis.

1. Productivity and Public Capital

The scene of public policy has drastically changed in recent years. Policies of a directly controlling nature have largely been replaced by indirect policies which serve to facilitate the operation of the market by means of flanking measures or market-based (dis-)incentives. The devolution movement has had far reaching implications for the functioning of our economies at the turn of the century.

This observation applies also to regional policy. Decentralization, deregulation and privatization have become trend-setting mechanisms to enhance efficiency in a regional system while leaving the responsibility for regional development as much as possible with the stakeholders involved. In this context a vivid debate has started on the range of competence and effectiveness of regional planning. The typical traditional view on regional planning as 'manna from heaven' has faded away and more modest ambitions on the role public policy can play have emerged.

Public policy – including regional and infrastructure policy – is nowadays increasingly viewed from the perspective of endogenous growth theory (see e.g., Romer 1986, Lucas 1988, Aghion and Howitt 1988, and Nijkamp and Poot 1999). The idea is that an extension of the range of traditional production factors (such as capital, land, labour) towards contemporaneous modem productivity-enhancing input factors (such as knowledge, R&D, education etc.) may offer a more appropriate explanation for additional returns on investment. By focussing on human capital and by incorporating the creation of such capital as an endogenous explanatory factor, the role of public policy is no longer external to the (regional-) economic system, but an intrinsic part of its operation. Clearly, some caution is warranted on the assumed positive impact of public capital on economic development (Andrews and Swanson 1995, Mas et al. 1996).

An important starting point for a thorough analysis of the impact of public capital on regional development was given more than forty years back by Hirschman (1958) who in his study on the strategy of economic development convincingly demonstrated that social overhead capital is a necessary but not sufficient condition for economic development. A major challenge of public policy is to address the balance between directly productive inputs and social overhead capital, where an optimal allocation of both types of factor inputs can be based on conventional cost-minimizing principles. Unbalanced growth may then be the result of a lack of fine tuning between directly productive capital and social overhead capital. In Hirschman's view social overhead capital has a rather broad meaning; it is usually public capital which is normally characterized by lumpiness and indivisibility and does not necessarily have an directly productive character (in contrast to labour or capital). It may be either material in nature (roads, railways, (air)ports, pipelines etc.) or immaterial (knowledge networks, communication, education, culture etc.), but its relevance is high. The first class is called here infrastructure, the second one suprastructure (see Nijkamp 1986, and Lakshmanan 1989).

An avalanche of studies has subsequently been conducted in this field. Rostow (1960) has argued that transport infrastructure is of decisive importance for economic development, witness the impact of railroads on economic growth in many US states. In regional development theory the main emphasis has been placed in the past decades on the physical (or material) components of public capital, i.e., on infrastructure. The focus has often been on the removal of bottlenecks in the development of a region in order to improve its accessibility (e.g., the construction of a bridge, tunnel or railway connection) (see e.g., Mera 1973, and Bruinsma et al. 1996). Later on, attention was also devoted to the instrumental role of infrastructure in

removing structural interregional inequality conditions (see e.g., Blum 1982, Nijkamp 1986, and Biehl 1995). And more recently, this equity argument has been extended towards a broader analysis of interregional competitiveness conditions, in particular with a view to the acquisition of foreign direct investments (see e.g., Conrad and Seitz 1997, Van Geenhuizen and Nijkamp 1998, and Nijkamp 1993). In recent years, also the relationship between infrastructure and suprastructure (in particular, innovativeness and knowledge use) has intensively been studied (see also Capello 1996). Suarez-Villa (1996) has argued that in the US some convergence can be found between the long-term upswings and downturns of both infrastructural investment and innovative capacity, while he was also able to reveal a remarkable association between educational infrastructure development and (both aggregate and corporate) innovative capacity. Apparently, the growth potential of an area is influenced by both infrastructure and suprastructure capital of a public nature.

Empirical evidence on the positive correlation between infrastructure and suprastructure supply and economic development is not always conclusive, although they seem to be rather convincing at a macro level (see World Bank 1994). Various surveys can be found in Rietveld (1989), Garcia-Mila and McGuire (1992), Munnell (1992), Johansson (1993), Nijkamp and Blaas (1995), Bergman and Daoshan Sun (1996), Binder and Smith (1996), Gillen (1996), and Talley (1996). An attempt at a systematic cross-sectional comparative study of such impacts based on meta-analysis is found in Button and Rietveld (1998), while a broad overview and various empirical case studies can be found in a recent study of Rietveld and Bruinsma (1998), who summarize various studies.

The question is now whether a limitation of infrastructure concepts to physical objects offers a significantly broad framework for analyzing regional impacts of public investments, in particular as there is increasingly the need for regional sustainable development. This will be the subject of this paper. We will start with a critique of traditional impact assessment of conventional physical infrastructure capital.

2. Ambiguities in Impact Assessment of Public Capital

In a recent comprehensive survey paper of Nijkamp (1998) various caveats have been mentioned in the study of effects of infrastructure investments. They will concisely be summarized here as a list of causes for inconclusive statistical results in various empirical studies.

- **definition of public capital**

An applicable and unambiguous definition of infrastructure and suprastructure – interpreted as a possibly productive contributor to regional growth – is not easy. Both categories comprise a diverse portfolio of constituents ranging from roads to telecommunication systems or from sewage systems to business information centres. Dozens of indicators can be envisaged which may be assumed to play a role in enhancing the growth (potential) of an area, but their precise measurement – even in financial terms – turns out to be full of hurdles. An aggregate denominator is difficult to find, and even a financial analysis is problematic in the light of the long planning horizons of different types of infrastructure and suprastructure.

- **measurement of output**

Clearly, the assessment of the output or performance of public capital expenditures is not simple either. Several authors argue that GDP per capita is a proper output indicator, while others (see Aschauer 1989, and Mullen et al. 1996) argue that productivity growth is a good measuring rod. The productivity argument

claims that a cost-benefit approach may lead to overestimated national benefits, as the outcomes are strongly influenced by travel time savings of households, a phenomenon which does not have directly measurable economic implications for GDP. On the other hand, the generative effects are often underrepresented in a cost-benefit approach. And therefore, again others argue that the business response in terms of locational choice with a view to new investments or new jobs is the most suitable indicator. Which indicator is the most preferable one depends partly on the availability of data (which are in most cases inappropriate anyway) and on the goal of the policy study concerned (e.g., the removal of bottlenecks, the reduction in spatial welfare differences, or the enhancement of the competitiveness of the area).

- **geographical scale**

It is evident that the geographical scale of the impact analysis of social overhead capital is of critical importance. This scale appears to range from national to local studies in empirical research. Examples of macro studies are Kessides (1996) and World Bank (1994) while studies on local impacts can be found *inter alia* in Bruinsma et al. (1996) and Seitz (1995). In general, it is clear that the smaller the geographical scale, the higher the expected consequence of social overhead expenditures due to the absence of spatial substitution effects (e.g., as a result of business relocation in the same area). Thus, the identification of the relevant region is a difficult task, not only because of a frequent different spatial coverage of input and output indicators, but also because of different administrative subdivisions (e.g., in terms of infrastructure construction and labour markets).

- **time horizon**

Next, the time horizon of the impact assessment of infrastructure or suprastructure expenditures is another important source of concern. Surprisingly, most impact studies are static in nature, and hence suppose that the economic effects materialize in the same period as the investments are made. This approach very much contrasts empirical facts, where often a long time horizon is needed before public expenditures lead to measurable achievements in a region or city. In an assessment study on regional impacts of expenditures of the European Regional Development Fund by Nijkamp (1995), it was shown by means of a time-varying sensitivity analysis that the estimated order of magnitude of the impact parameters – and even their statistical significance – was highly dependent on the lag structure in the impact model.

- **typology of effects**

The estimated success of public investments is largely determined by the various effects under consideration (Rietveld and Bruinsma 1998). In general, three major types of effects on the regional or urban economy can be distinguished:

- **direct construction and building** effects associated with the public expenditures at hand; these effects are usually of a short-term nature and accrue mainly to the building and construction sector, either inside the region or outside (dependent on the location of the building firms).
- **indirect economic efficiency effects** (redistributive effects) associated with the relative price advantages of firms located in a region where the social overhead capital is realized (e.g., as a result of a better geographical accessibility or an improved access to educational or research facilities). Such price effects lead to an enhancement of the competitive position of regional firms through the gains of trade. The basic argument is that the improvement of accessibility leads to a reduction in transportation costs for firms and households. This may give rise to substantial redistribution effects among economic groups and also among regions.

- **generative effects** associated with the birth or relocation of new firms attracted to the region at hand because of its improved competitive position. These firms may locate in the region as intermediate actors serving the stock of existing firms (through forward and backward linkages) or as new opportunity seekers in a successful business environment (the Silicon Valley phenomenon) (see also Martin and Roberts 1995).

- **network structure**

The importance and output of social overhead investments are co-determined by the network configuration in which the region or the capital good at hand is involved. The allocational efficiency and the distributive gains of interregional trade are dependent on the connectivity structure (and thus on the degree of openness) of the network concerned (see also Capineri and Rietveld 1997). This applies to both material and immaterial networks (see also Beckmann et al. 1998). In addition, the provision of an extensive network may make industries more footloose. Open access networks may be favourable for regions with a strong economic performance, so that an improvement of the connectivity patterns of these regions may reinforce their competitive position. On the other hand, improvement of almost missing links with isolated regions may suddenly expose such regions to uncommon competitive forces from abroad and even deteriorate their weak economy.

- **initial position and future perspective**

The effects of public capital expenditures are decisively contingent on two critical conditions, viz. the initial situation and the future contextual factors.

The initial situation refers to two factors, viz. (i) the overall economic condition in the region: an area with a feeble and backward economic structure will face greater difficulties in reaping the fruits of public expenditures than an area with an already flourishing economy, and (ii) the overall infrastructural and suprastructural condition: an area with severe structural bottlenecks for a promising economic growth will find it much easier to accelerate its growth pace after proper overhead capital investments than an area with a properly functioning infrastructure and suprastructure (the phenomenon of decreasing marginal productivity).

The future contextual factors refer to the embeddedness of social overhead investments in the future economic situation which is characterized by intrinsic long-range uncertainties. In this framework, the use of scenario analysis has become very popular in the assessment of possible development paths of a region in association with the provision of infrastructure and suprastructure (see for an extensive analysis and case study also Nijkamp et al. 1998).

- **the user perspective**

In recent years – especially in the European context – the restructuring potential of infrastructure (networks) has become an increasingly important issue, both analytically and politically. Industrial restructuring and spatial dynamics are contingent on spatial networks in a mobile society. Spatial-economic connectivity and changes in industrial organization have far reaching consequences for the competitive profile and position of all regions in a network economy. In particular, geographically isolated regions have expressed a concern that they may find themselves positioned outside current mainstream industrial developments. The industrial-economic systems of our world are indeed rapidly changing, at all geographical levels. It is at the end the user of networks who will decide on the socio-economic benefits of such network. And the industry plays a major role there. The traditional large-scale production plant is gradually losing its relevance. In a post-fordist economy we observe much more emphasis on flexible entrepreneurial behaviour based on lean production. Modem

industrial production is characterized by both specialization and globalization, in which the modern component industry and industrial assembly play an important role. Flexible production in a globalizing economy means that the national identity of products as 'national flagships' is disappearing. Global alliances and partnerships generate some sort of a 'glocalization' feature of home-based production.

- **private-public partnerships**

The ownership conditions, the governance competence and the exploitation conditions of various types of social overhead capital have recently gained much attention. We have seen privatization trends in the public utility sector (e.g., electricity), the public transport sector (e.g., buses, railways) or the cultural sector (e.g., museums), while also for new types of infrastructure entirely privately financed network links have been designed and built (e.g., the Channel Tunnel). Much debate has centered around the question of the economic-financial desirability and feasibility of private financing or – more appropriately – of private-public cooperation in the supply of public goods. Since the beginning of this century network supply has often been a public government responsibility, but in recent years – after the recognition of market failures and government failures – we observe an increasingly commercial attitude towards network supply. This means that the organization of the supply side of networks will likely change drastically with more emphasis on commercial exploitation. This means once more that physically isolated areas (e.g., islands) which have relatively higher costs for their volumes of transport may face more problems in the future. Networks are at the same time vehicles through which nations (or regions) can influence (part of) the international (or interregional) competition. Monopolistic and oligopolistic structures in space are the result. The socio-economic benefits of coordination and harmonization are, however, often neglected in favour of emphasis on narrow nationalistic or regionalistic interests. Clearly, the fundamental position of the government as an initiator, facilitator or risk-bearing entrepreneur is at stake here, even though the arguments are more instigated by public deficit conditions (including for many EU countries even nowadays the entry conditions for the EMU). Less attention has been given to the regional financing conditions of infrastructure, especially in a federal structure where fiscal federalism also assigns an important position to the regions.

- **a complex portfolio**

Public capital is a complex portfolio of various public goods which may show up in different mixes in different regions. The overall effect of this portfolio depends on the synergy within this package of public service provisions. Any improvement in one component of this portfolio has of course a potentially beneficial impact on the region, but its real long-lasting effect depends also on the emergence of a sequential bottleneck in the development process of regions. Thus, it is necessary to identify the order of importance of the successive growth barriers, as is advocated in the potentiality factor approach. As a result, an improvement in public capital may in an absolute sense be favourable for a region, but perhaps in terms of market share (in a relative sense) be disadvantageous. Especially in a competitive multiregional setting this is an important caveat.

3. A New Perspective

In recent years the discussion on the feasibility and desirability of infrastructure policy has received in many countries a new focus. There is a growing awareness that physical infrastructure is by far not a sufficient condition for a competitive edge of regions. The productivity gains of public capital may be significantly enhanced if

there is a proper balance with suprastructure. But even the combination of infrastructure and suprastructure is still far from a sufficient condition for economic development. We observe increasingly that prosperous regions place more and more emphasis on their quality of life as a major attraction force for advanced business activities and high-skilled labour (the so-called ecostructure). The proper blend of infrastructure, suprastructure and ecostructure then serves to offer an appropriate contribution to regional efficiency objectives, employment objectives and environmental considerations. This would also position public capital provision in the center of the sustainability debate.

This can be illustrated by a recent Dutch policy trend. An important discussion in the Netherlands aims to answer the question how the scarce space can be structured in such a way that a good economic competitive position can be maintained and developed. Because of the gradually decreasing importance and influence of classical economic instruments to maintain or to strengthen the competitive position of the Netherlands in an international context (like foreign exchange, budget and monetary policies); infrastructure is one of the few remaining policy fields to influence the nation's position in a competitive environment. However, economic targets are not the only aspects to which policy-makers pay attention in recent years. This observation, fed by various developments in the wide social and economic context, leads to the recognition that infrastructure is not a static term, but responds to new conditions for proper economic growth (recently often expressed as sustainable development). This paper will describe the role and meaning of infrastructure nowadays and in relation to sustainable development. First, the term infrastructure will be given a new meaning based on current trends and literature research. Next the contribution of various (Dutch) investments to a sustainable development is shown. This all leads to a contemporary and operational description of the term infrastructure. We will demonstrate in our analysis that an infrastructure portfolio is a suitable tool for the analysis to fulfil sustainable policy objectives.

Various economic and technologic developments have resulted in an increasing emphasis in our economy on the production and supply of high-valued products and services. Growth in the size of the economy and growing competition, which inter alia becomes clear from the shift of a large part of our production to low-wage countries, form partly the cause of this tendency. This also appears from the way in which companies organise and co-operate. More often, networks of different companies arise to respond to rapid changes outside the company. Another cause is related to rapid technological developments, like those in the ICT, mobile phoning and the digital network. This shift towards high-quality services and products has led to the increasing importance of knowledge in our economic process. Clearly, R&D plays a pivotal role in competitiveness. The result of this is that infrastructure should have to be developed or maintained in order to facilitate and stimulate these developments. At the same time this is of importance in maintaining and/or creating a well-developed climate for domestic and foreign companies to settle. By the way, a good climate to locate means not only the supply of proper infrastructure, but also the availability of other relevant aspects, like existing knowledge and, more recently, quality of the environment. So infrastructure has a multidimensional effect. It serves in a macro-economic way to facilitate a productive ratio of production factors (see Aschauer, 1989). Next to this it serves spatial economic objectives by stimulating the attractiveness of regions and cities (see for an overview, Nijkamp, 2000), in which also ecological and social factors play a role.

The importance of a good climate for business location – together with infrastructure – is most obvious in the development of large cities. At present, a lot of companies move to the ring of the city, because city-centres (as engines behind economic activities) lost a great deal of their attractiveness. Causes related to this development are, for example, weak accessibility and lack of acceptable housing. Because of this, and the increasing distance between weak groups and the rest of the society, more and more social frictions in large cities will arise. Two tasks seem to show up here for the government. First, making the inner cities again attractive for companies to settle in order to create employment and production, and second coping with social difficulties, for example, by stimulating initiatives of local entrepeneurship to create also employment for the less skilled people.

Another, more recent, development is the concern that the growth of economic activities puts a lot of pressure on the environment. This environmental pressure can assume different forms. Especially in larger cities, there is a great pressure on the availability of space, which limits a healthy economic development. Another observation to be made is the relatively large annoyance of noise and smell in cities. This again affects the attractiveness (as working and living area) of cities in a negative way. There are of course also other negative environmental developments in many countries, like increasing soil contamination, which led to the growing attention for the policy aim to reach an "absolute decoupling" of economic growth and environmental pressure. The **various** key forces of economic, social and environmental nature are mapped out in Figure 1.

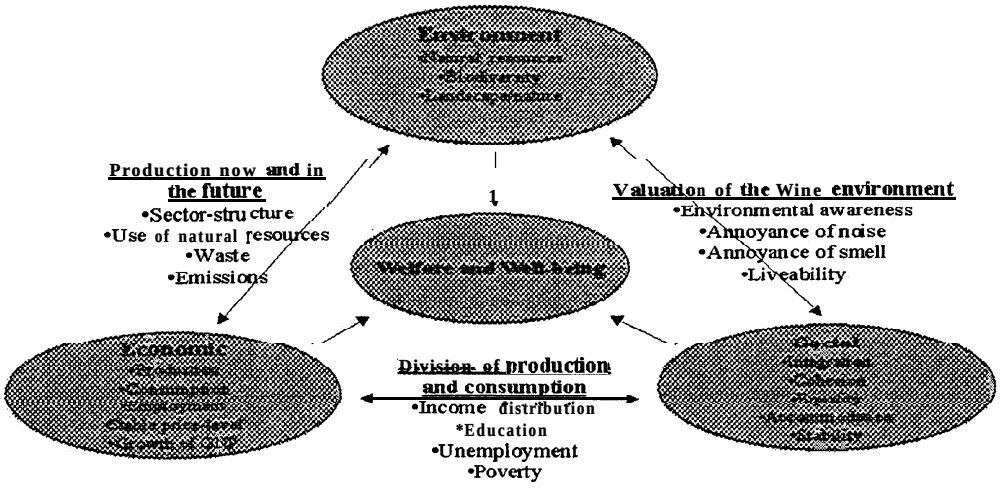

Figure 1: The general overview of three systems and their indicators

The combination of these economic, technological, social and ecological trends, and the problems and possibilities of these, have gradually caused a shift of thinking towards a sustainable development of our society. The question, which arises here, is how infrastructure can contribute to this aim. After a conceptual approach of infrastructure, the various results of an empirical study to the effects and impacts of infrastructure projects will be outlined. Furthermore, some lessons will be drawn with regard to future infrastructure policy. We will start an analysis with a clear description

of the concept of infrastructure. Various developments have indeed resulted in the fact that the conventional ideas about infrastructure are not anymore in accordance with recent economic and social phenomena. An enlargement of the meaning of the term infrastructure is thus clearly necessary. In addition to this, the term sustainable development will be described with regard to current policies and the role of infrastructure.

4. A New Description of Infrastructure

An applicable and modern infrastructure concept will not only have to take into account the just mentioned developments, it also has to correspond to existing policy ideas of infrastructure. Next to, of course, the traditional transport infrastructure, the MC Graw-Hill Dictionary of Modern Economics definition of infrastructure mentions elements like energy supply, communication systems and an aggregated level of education and knowledge (The MC Graw-Hill Dictionary of Modem Economics, 1983). It appears that also more immaterial and other forms of infrastructure belong to this term.

Clearly, many of the above mentioned elements of infrastructure have to be confronted with essential characteristics of infrastructure, which have been used in definitions and descriptions in the literature. Biehl uses in a fundamental study a production function in which, next to labour and capital, also infrastructure is seen as a production factor (Biehl, 1985). This fact shows the productive character of infrastructure. In order not to extend the meaning of infrastructure too wide (thus becoming without any meaning and content), it is sensible to qualify infrastructure as directly productive. Indirect productive elements as, for example, education are in this way excluded from the definition. Their productivity will only be influenced in the long term via the factor labour. In addition to this the description of the Dutch Social Economic Council (SER) can be mentioned which emphasises the real estate part of infrastructure (SER, 1987). This means that infrastructure is not only directly productive, but it also is a capital good or has an immovable nature. So, infrastructure has not only a productive character but also the characteristic of a stock.

Features of infrastructure	New developments
Essential features:	
1. Facilitating: increasing the efficiency of production factors	Environment as production factor is of more importance
2. Capital good: stock magnitude	Increasing importance of capital
3. Public or semi-public: no rivalry and excludability of users	More and more private and public-private partnerships in financing Excludability measures more and more implemented, like road pricing
Optional features	
1. Network: composed of interconnected parts which are less meaningful on their own	Transition towards a network economy
2. Non –substitutability: high costs to substitute infrastructure with a private production factor	R&D-efforts are also made in private companies
3. Tied to the location: infrastructure is hard to move	Knowledge is not tied to the location
4. Polvvalence: input for a large number of production processes	Infrastructure is more and more a portfolio of offered services

Table 1: Essential and optional features of infrastructure with related developments

Furthermore, infrastructure is provided in a (semi) public way because of the large investment costs, non-divisibility and non-excludability. These three characteristics

return in almost every description or definition of infrastructure and are thus essential on the development of a new interpretation. Indeed, other characteristics are mentioned as well in literature, but these are more category-dependent and thus to qualify as optional characteristics (see Table 1). This analysis of characteristics and new developments based on Table 1, has finally led us to formulate a new and modem description of infrastructure:

Infrastructure encloses those real estate provisions, which increases the efficiency of the use of production factors and meet the following requirements: infrastructure is directly productive, is characterised by stock features (capital good) and it has the character of a (semi-) public good.

When we test the many mentioned elements on the three essential features of infrastructure, it appears that three categories of infrastructure can be distinguished (see also Figure 2). The first category is the physical network infrastructure, which encloses elements like transport infrastructure and public utilities, water management and industrial sites. Second, the immaterial knowledge infrastructure can be distinguished, which encloses elements like research at universities, R&D and ICT. The last category is the nature and environmental infrastructure, which is of increasing importance as a factor for companies to settle somewhere (for example, the Dutch province of Utrecht). This new definition corresponds in a better way to present social and economic discussions.

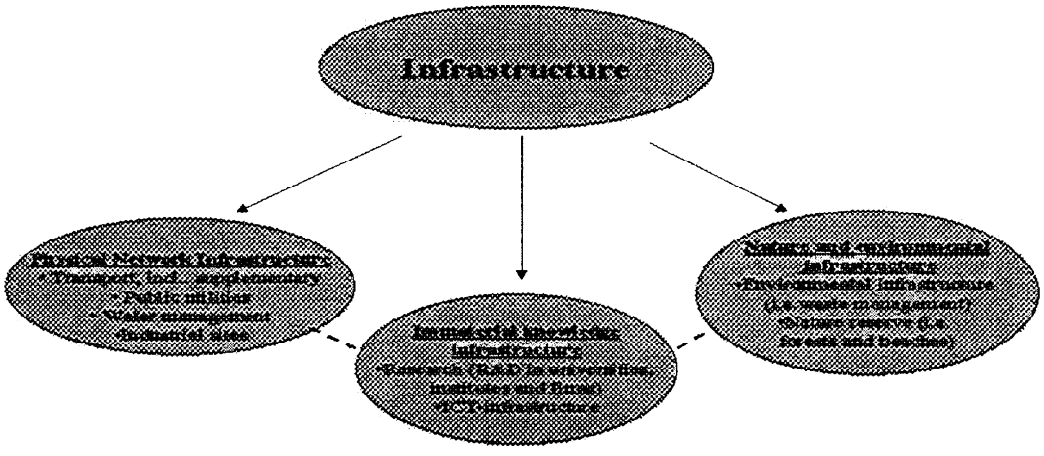

Figure 2: The three categories of infrastructure

5. Sustainable Development as a Policy Challenge

The above-presented trends show that the development of economic potential only is not desirable. Developments and problems in other areas than in economics have gradually led to the notion that a broader basis has to be used in making policy decisions. The term sustainable development forms the heart of these thoughts. In our attempt to give this term some substantive contents, the Brundtland report is helpful (World Commission on Environment and Development, 1987). From this report it becomes clear that attention should be paid to future generations and the possibilities to fulfil their needs. However, this description is very abstract and not very practical and applicable. A more detailed study into the term is necessary to give us more conclusive evidence about this aspect. As well as in policy documents as in the literature three different systems are mentioned which form the heart of the term

sustainable development. These three are the economic system, the social system and the ecological system (see for example CPB (1998) and Serageldin and Steer (1994)). The remark has to be made that a positive contribution to all those three systems is necessary to speak about a sustainable development. The measurement of the development of these systems can be done on the basis of relevant, measurable indicators. These can be selected for each system in order to study the effects in more detail. In this way a clear vision of the level of sustainability is obtained.

These three systems form not only important aspects for sustainable development. These components can also be recognised as potential inputs for proper economic growth. Factors like quality of life and the environment are recently often mentioned to be potential inputs for production (see Kowalski and Schaffer, 1999).

Different standards can be used to qualify such a development. First, we mention the already earlier named term of absolute decoupling, which means the aim to obtain a growing economy while the environmental pressure is being reduced (see Table 2). Strong sustainability, by which all the three systems show a positive development with regard to sustainability, is a second standard. In making a more dynamic approach possible, one can use other standards which take a less positive development into account (relative decoupling, decoupling and weak sustainability) (Opschoor, 1987). Relative decoupling may mean an increase in environmental pressure, which is less than proportional to economic growth. Weak sustainability stands for a negative development within one of the three systems, but which is more than compensated by positive developments within the other two systems.

	Economic growth	Change in environmental pressure (AEP)
Coupling	1%	$\Delta EP \geq 1\%$
Absolute decoupling	1%	$\Delta EP < 0$
Relative decoupling	1%	$0 < \Delta EP < 1$

Table 2: Absolute and relative decoupling, illustrated, based on I % economic growth

Now that we have standards which can be used to qualify a sustainable development, something has to be said about the final judgement of various cases. For each system various indicators can be identified, as can be seen in Figure 1.

	Development		
System indicator	Construction	first order	second order
Economic system			
• Growth GNP	+	+	+
• Income per capita		+	
• Employment			
• Etc.			
Total		+	
Social system			
• Income distribution	-	+	
• Labour participation	-	-	
• Liveability		-	+
• Etc.			
Total		-	
Ecological system			
• Emissions		++	
• Use of space		+	+
• Landscape/nature		-	+
• Etc.			
Total		+	

Table 3: Example of the judgement of a case

Important is to keep in mind that these indicators can be different depending on cases, although also an approach of a standard package of indicators is possible. Here we used the former approach in using indicators depending on the cases. Furthermore, we made a distinction between different effects. Three kind of aspects arc distinguished; effects caused by construction, first order and second order effects. First order effects are most of the time direct effects, while second order effects have an indirect character. Because of the temporary character of construction effects, these are neglected in our evaluation. Other aspects, which have to be taken into account with this judgement, are spatial scale, size of the project and the approach (static or dynamic). Table 3 gives an example of the judgement of a case. Applying our standards here, one can speak of weak sustainability and absolute decoupling.

The foregoing can be clustered into one system, the so-called expert system (see Figure 3). This system can be used as a decision support plan concerning investments in infrastructure and their contribution to a sustainable development. It can be seen as an overview of different steps to make a clear judgement of concrete case studies possible. The expert system will help local and regional governments in deciding whether infrastructure projects are to be carried out or not.

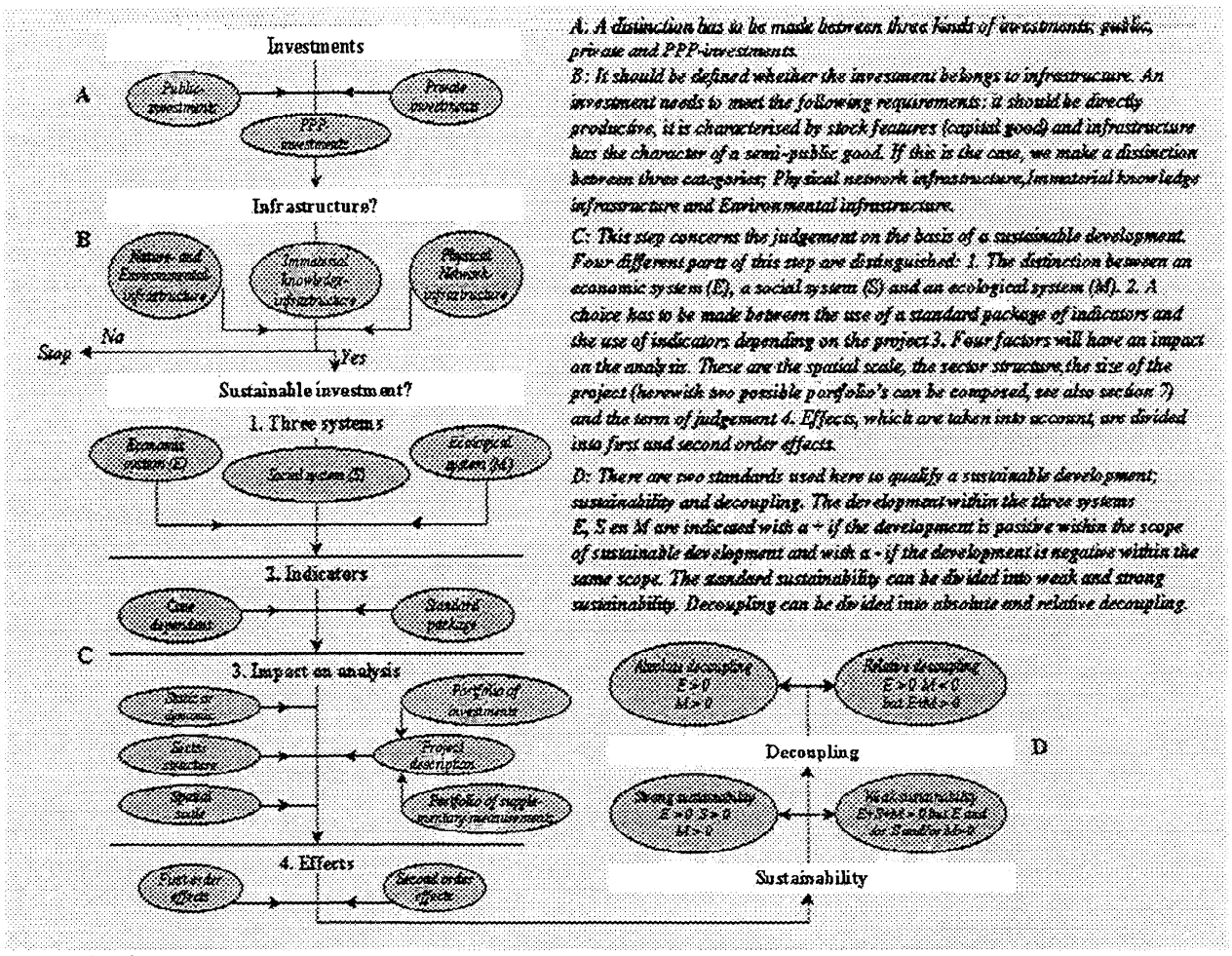

Figure 3: The expert system

6. Empirical Results

It is interesting to test the above-mentioned framework on its empirical merits. For this purpose, next to (social)economic aspects also ecological aspects have to be taken into consideration. A comparative case-study approach is chosen. Various

Dutch cases of different sizes and with various policy goals are considered in more detail.

The aim of this empirical study was two-sided; on the one hand to show which investments contribute to a sustainable development and on the other hand to test the applicability of the new description of infrastructure. The purpose was to include as many different projects as possible (so-called contrast projects) to make the framework for testing as wide as possible. Not only the size of the projects was important, also the nature of the cases, in the light of the earlier used description.

The case-studies were investigated by means of an analysis of background reports and interviews with stakeholders. The results are presented in a summarised way in Table 4. This table shows that only one project does not belong to our description of infrastructure. Our description is indeed stretched out, but not in a way that it contains every investment. This appears to be sufficiently discriminating. For most of the cases one can speak about weak sustainability and relative decoupling. Only five cases show a positive development seen from the perspective of sustainability (strong sustainability and absolute decoupling). Two of those four are knowledge infrastructure projects, which can be explained because of the minimal use of space and limited impact on the environment. Another conclusion, which becomes not directly clear from the table, is the fact that a lot of the projects mentioned here is based on a public-private partnership (PPP) construction. This construction can apparently often contribute to a sustainable development. These kind of projects are often from, an economic perspective, interesting for private firms; the government can then pay more attention to social and ecological goals.

		Development				
Case	**Infrastructure?**	**Economic**	**Social**	**Ecologic**	**Sustainability**	**Decoupling**
Ecodrome Zwolle	No	+	+	+/-	Weak	Relative
Amsterdam Zuidas	Physical network Infrastructure	+	+	-	Weak	Relative
SKB (Stichting Kennisontwikkeling en kennisoverdracht Bodem)	Knowledge infrastructure	+	+	+	Strong	Absolute
Truckpark Waalhaven	Physical network Infrastructure	+	+	+	Strong	Absolute
KLICT (Ketennetwerken, Clusters en ICT)	Knowledge Infrastructure	+	+	+	Strong	Absolute
Spoorzone Delft	Physical network Infrastructure	+	+	+	Strong	Absolute
Bedrijvenstad Fortuna (Sittard)	Physical network Infrastructure	+	+	-	Weak	Relative
A 73-zuid	Physical network Infrastructure	+	+	-	Weak	Relative
CSG (Centraal Stads Gebied) Amersfoort	Physical network Infrastructure	+	+	+	Strong	Absolute

Table 4: Results of the empirical study of infrastructure projects

This analysis produces some interesting recommendations for investment policies regarding infrastructure and spatial planning, which are not necessarily limited to the Netherlands. Investments in knowledge infrastructure and stimulation of PPS-constructions could become important local points in future policy aiming at achieving a sustainable development.

7. Concluding Remarks

From the foregoing it becomes clear that infrastructure is a comprehensive and dynamic term. Recent ideas and various trends showed that the traditional concept of infrastructure is subject to change. This made a rethinking of the meaning of infrastructure necessary. The new description, as presented above, was supposed to take these new circumstances into account and to fit within present-day policy. Another requirement was the correspondence with recent discussions in the Netherlands, in which the strengthening of economic structure is important. These aspects are all taken into account with the development of a new description of infrastructure through which finally a contemporary and applicable description has arisen.

At the same time, this description forms an excellent starting point to approach investments in infrastructure as portfolios. A portfolio is here a collection of different investment options, which are mutually integrated and contribute to different policy-goals by their positive synergy. This portfolio-approach is based on different parts, which form together the whole project. An advantage of this approach is the flexibility within the investment portfolios (Geerlings et al., 1998). Because not every separate part has to contribute to the same extent to the previously formulated objectives, there are possibilities for compensation. Criteria and risk are examples of these possibilities to compensate within the portfolio-approach. Criteria compensation means, for example, that one part of an investment which may improve economic performance, while it neglects environmental objectives, is compensated by another part, which reduces the negative impact on the ecological system. In the end it is important that the whole project contributes to the specified policy objectives (for example, sustainable development). This approach can also lead to synergy, clustering and cohesion. These advantages appeared also from the empirical analysis.

Finally, a distinction can also be made between a portfolio of investments and a portfolio of supplementary measures. The difference between both is that in the first case each project can consist of more investments in infrastructure, while in the latter case only one investment in infrastructure is undertaken. This one investment can be extended by a package of supplementary measures to decrease negative effects of the investment and generate positive effects within the three systems (concerning sustainability). From many projects it appears that there are possibilities to carry out more than one investment in infrastructure within one project. A big advantage of such an approach arises in judging whether projects are to be carried out or not. When we evaluate projects on the basis of sustainable development, which is an important theme in current Dutch policy, it becomes clear that a portfolio approach is more able to easily realise an integrated sustainable development. This also becomes clear from Figure 4. This figure shows possibilities to adjust investments in infrastructure to obtain a sustainable development.

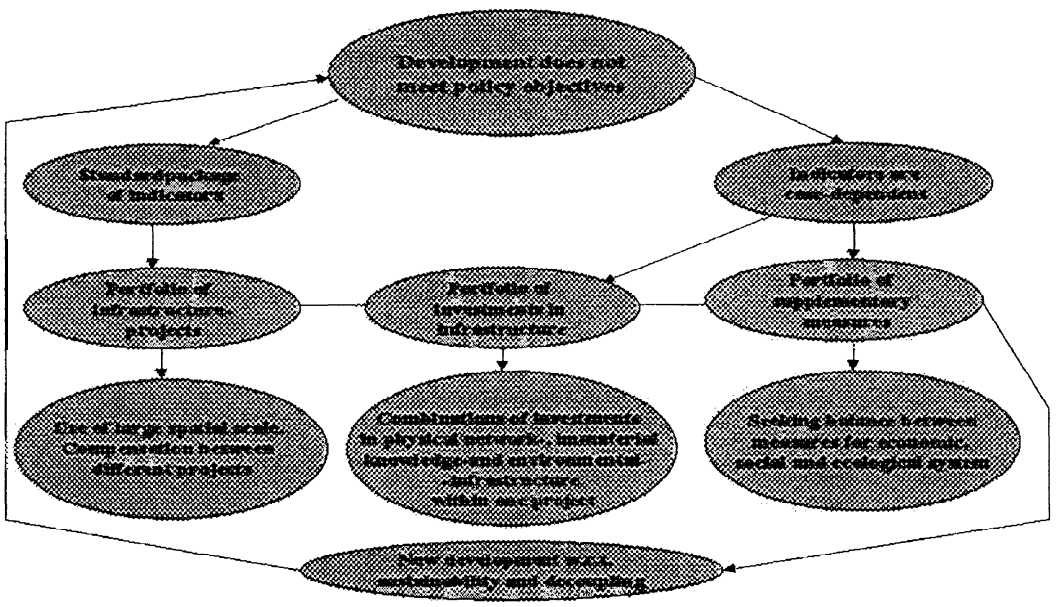

Figure 4: Adjustment possibilities policy with regard to investments in infrastructure

So, investments in infrastructure have to be considered as a portfolio, certainly from the viewpoint of a judgement on the basis of various (social)economic and ecological objectives, where not only economic criteria are important. It will be obvious that, in the light of the proposed portfolio-approach, the wider description of infrastructure offers improved possibilities to reach a sustainable development compared to the conventional ideas. PPS-projects and investments in the knowledge infrastructure, as good examples of the case studies, can play a positive role here. This provides a more integrated approach, which can play an important role in the decision-making process about infrastructure projects. So there are many possibilities for local and regional governments to contribute to a sustainable society and to an absolute decoupling between economic growth and environmental pressure with the help of investments in infrastructure.

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