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A COMPARATIVE ANALYSIS OF THE PERFORMANCE OF URBAN PUBLIC TRANSPORT SYSTEMS IN EUROPE

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Abstract

Regulatory reform in EU transport policy has forced urban public transport authorities to operate increasingly under a market regime. The EU policy favours in particular a system of limited competition through the granting of concessions to public transport operators. This paper seeks to identify the success conditions for local public transport systems in a sample of 22 European cities. On the basis of extensive field research a systematic performance table of urban public transport systems in these cities is created with the aim to investigate the impact of four classes of critical success factors on the performance of these systems. In the empirical part both a qualitative interpretative analysis and a recently developed tool from artificial intelligence, viz. rough set analysis, is deployed in order to derive policy relevant conclusions.

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1. Setting the Scene

European integration is a fuzzy term comprising a wide variety of socio-politica1 elements, geographical settings and institutional-economie mechanisms. The European Union has originated from an uncoordinated patchwork of different driving forces, missing networks and self-centred regulatory regimes. The pace towards more coordinated policies, for instance, in the area of a common agricultural policy (CAP) or a common transport policy (CTP), has been long lasting and sometimes fi-ustrating. Nevertheless, Europe is gradually shaping its own politica1 face, a development that urgently needs to take place in the light of the foreseen entry of the accession countries (see also Commission of the European Communities 2001).

One of the policy areas in which the European Commission has been active is transportation policy. Policy development in this area is govemed by two genera1 principles laid down in the Treaty of Europe, viz. the subsidiarity principle and the proportionality principle. The first principle stipulates: *"In areas, which do not fall within its exclusive competence, the Community shall take action. (...), only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States and can therefore, by reason of the scale or effects of the proposed action, be better achieved by the Community "*, while the second principle has to be interpreted as follows: *"Any action by the Community shall not go beyond what is necessary to achieve the objective of this Treaty "*. Within this overall framework a common European policy for the transportation sector is being developed.

One of the foundation stones of the CTP is to introduce more market orientation in the transportation sector in order to increase the efficiency in this rather old-fashioned system. Various mechanisms based on policy devolution are at present envisaged, in particular decentralisation, deregulation and privatisation. Through a strong adherence to market principles the transport sector is expected to offer an effective contribution to an efficiency rise in the European unification process. Such a policy is not only needed for cross-border transportation (e.g., the railway sector, the aviation sector or intemational freight transport), but also for public transport at various geographical scales ranging from interregional to local transport. The European Commission is at present developing a comprehensive framework of appropriate regulations and financial incentives in order to favour the performance of public transport with the help of *market incentives*. From the three possible ideal-typical organization forms of public transport, viz. a public monopoly with closed markets, a system of limited competition and a system of entirely deregulated markets, the Commission supports a framework based on *limited competition.*

The present study aims to test whether the gradual transition towards a system of limited competition for urban public transport (or urban mass transit) has been successful in terms of a better achievement of the targets set by the public transport authorities. In addition, the study aims to identify the critical success factors for the achievement of the success (or the lack of success) of public

transport systems in various urban regions in Europe based on both a taxonomic interpretation and a meta-analytic comparison.

This paper is organized as follows. In Section 2 a concise introduction into European policy on (urban) public transport is offered; particular attention will be given to various policy objectives which serve as a frame of reference for judging the actual achievement of urban public transport systems. Next, we will offer an overview of various organizational forms of urban public transport systems in Section 3. As a step towards a practica1 policy analysis Section 4 will map out the various critical success factors for these achievements. In Section 5 the data base for our taxonomic analysis of various European urban public transport systems will be presented. A substantive interpretation of empirical findings and results of a more rigorous analytical method for handling smal1 sample qualitative data in comparative case study research, viz. rough set analysis, based on meta-analytical principles, are contained in Section 6; the resulting policy rules will be interpreted as well. And finally, the paper will be concluded with some policy perspectives.

2. Basic Elements of European Urban Public Transport Policy

Transport is one of the connecting principles of European integration policy (see Nijkamp et al. 1998). This applies to all geographical levels ranging from intemational to local. For example, at the intemational level, the policy on Trans European Networks (TENs) is of utmost importance. At the local level, the EU competence regarding the operation of local networks is limited by the above-mentioned principles of proportionality and subsidiarity, but the genera1 objective of favouring efficiency in European transport systems applies here as well, beside the fulfilment of socio-economie objectives (such as employment generation) and environmental objectives (e.g., reduction in CO_2 emissions in the transport sector).

Urban transport is generally seen as a public service of great importance. At the individual leve1 it is a service that meets the needs of mobile citizens, while at a societal leve1 it contributes to quality of life and sustainability. The EU directorate-genera1 on Transport has even positioned public transport as a crucial service for European citizens (see DG Transport 1996), witness the following statements: *"Needs of citizens are put at the centre of decisions about transport provisions"*, and: *"Ideally, public transport should be accessible, affordable and available to all citizens. Financial and technical considerations may constrain this, but the Commission believes that the goal is important and worth of debate... "*. The Commission's policy, therefore, is focussed on a higher use intensity of public transport.

Clearly, a major weak element in the provision of high quality urban and suburban public transport is the low transparancy in the organization of European public transport. The organizational models range from public enterprises (with a dominant role of public authorities in ownership, planning and operation) to private enterprises in deregulated markets. Public monopolies have become notoriously inefficiently operating firms due to lack of incentives in a protected market. Privately

organized firms in the public transport market are assumed to operate much more efficiently, but this efficiency rise may be offset by a loss in terms of integration of public transport systems (see also Van Ooststroom 1998). Consequently, the European Commission has formulated a blend of these two extreme forms that might offer a better compliance with the needs of both citizens and society at large. This organizational mix presupposes a light regulation, which may favour the achievement of production efficiency, cost efficiency, socio-economie objectives and client orientation.

The semi-market model advocated by the Commission is based on a system of concessions to be granted on a competitive basis by responsible public authorities to various public transport operators. The regulatory and operational framework of the services to be offered has to be specified by the public authority. This model has two major consequences. First, it leads to a shift in the mission of a public transport operator from a duty to deliver a service toward the establishment of a contract between two parties, viz. the public authority and the operator, so that the two roles cannot coincide anymore. Clearly, in the accompanying legal framework the rights and duties of both parties (e.g., geographical coverage of the transport service, frequency and tariff structure) have to be specified. In the second place, the concession model introduces clearly market incentives, as a concession has only a limited time span and a new concession is subject to a call for tender. The new regulatory framework of the EU in the area of public transport comprises the following genera1 objectives (see DG Transport 1996):

- *to encourage increases in use ofpublic transport;*
- *to encourage system integration and fulfilment ofpublic service requirements;*
- *to establish incentives for service providers and planning authorities to improve accessibility, efficiency, quality and user friendliness of public transport systems;*
- *to promote financial conditions required for making public transport services more attractive, both for public andprivate investors;*
- *to ensure minimum requirements in respect of the qualifications of staff, thus guaranteeing high levels of reliability, safety and security;*
- *to safeguard flexibility in relation to specific national, regional and local priorities and the particularities of national legal systems.*

These objectives would stimulate a strong public transport sector in Europe and eliminate existing barriers that induce inefficiencies. The operationalisation of the above principles at a local scale is mainly a responsibility of public authorities at a local or regional level.

Another possible govemment intervention in the public transport sector may be based on the provision of subsidies or loans, from either the European Regional Development Fund (ERDF) or the Cohesion Fund (CF). Financial means from the ERDF can be obtained in order to stimulate small- and medium-size enterprise activities, to favour generally productive investments, to improve weak infrastructures or to encourage local development. Support from the CF serves to favour socio-

economic integration in Europe, inter alia for the improvement of accessibility or connectivity to the TENs.

3. The Organization of Local Public Transport Systems

Local public transport (LPT) systems – in EU countries and world-wide – exhibit an enormous variety of appearances in terms of organization and relationships with stakeholders, as well as of planning and control systems. In the framework of our study we will deploy a practica1 classification of LPT systems on the basis of the *'right of initiutive'*, where the fundamental and legal decision on how to organize an LPT system rests either with a public authority or with the market. In the first case, the transport authority has a forma1 monopoly, whereas in the second case LPT initiatives originate from the – often anonymous – free market system (though restricted by legislation and regulatory measures). Figure 1 offers a systematic further distinction of the possible organizational structures of the above major classification.

The LPT system is usually operating in a complex force field with several key players. In our taxonomic approach we make the following distinction:

- consumers/users (C)
- local voters (K)
- local authorities (A)
- public transport firms or operators (0)

This list of stakeholders can be used as the basis for an integrated typology of the two above-mentioned initiatives in relation to entry conditions to the LPT market.

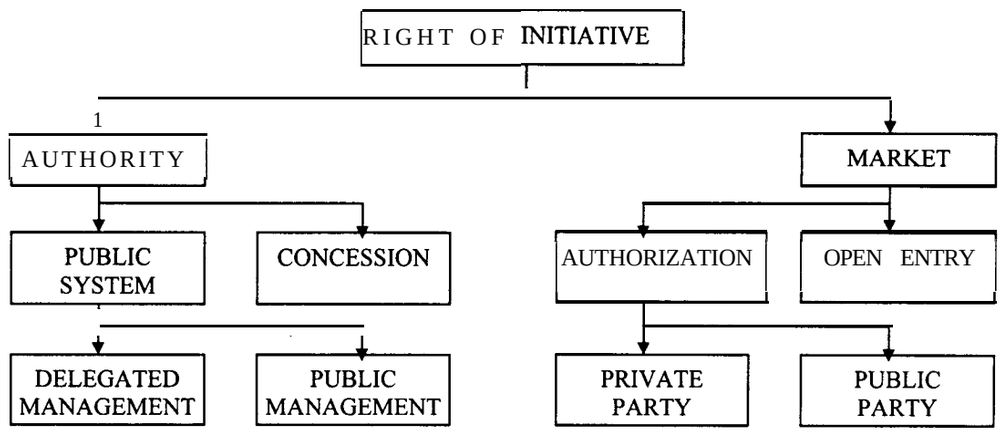

Figure 1. Taxonomy of LPT initiatives

The parties involved with LPT systems (i.e., A, C, K, 0) execute different roles and functions on the market for collective passenger transport. In particular, the following activities and tasks can be distinguished:

- supply (delivery) of LPT services to clients (D)

- payment for LPT service provision (P)
- democratic (voting) impact on quality and quantity of LPT services or systems (V)
- public regulation of supply and/or demand of LPT services (R).

The execution of these tasks and roles brings the four above-mentioned parties together, as these items make up the linking pins between the parties concemed. The linkage structure between these four classes of stakeholders can now schematically be mapped out using a connectivity matrix (see Figure 2).

Linkage to / from	A	C	K	O
A				
C				
K				
O				

Figure 2. A connectivity matrix between the four stakeholders in LPT systems

The nature of the linkage between A, C, K and 0 in a given LPT constellation can be denoted by filling the entries of the matrix with the corresponding relevant items D, P, V or R. In this way, a systematic way of depicting (almost) all relevant LPT constellations is achieved. Of course, there are many organizational forms of stylised linkage pattems. By way of illustration we will present here one arbitrary possible LPT constellation, namely one based on a LPT initiative from the market accompanied by a system of public authorisation. The corresponding connectivity matrix is in this case the following (see Figure 3).

Linkage to / from	A	C	K	O
A		R		R
C				P
K	V			
O		D		

Figure 3. Connectivity structure of a market-based LPT constellation govemed by a system of public authorisation

In an ideal-typical form this constellation can also be represented as follows (see Figure 4).

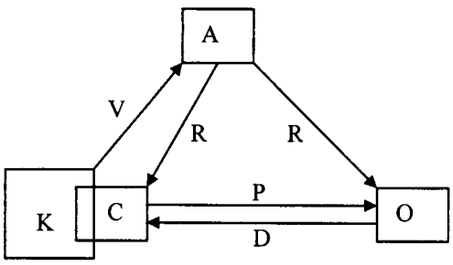

Figure 4. Illustrative organization of an LPT market system under a regime of a public authority

Needless to say, there are numerous types of LPT constellations that can be depicted by the connectivity matrix in Figure 2 (see for a review also Van Egmond 2001). Systems of public monopoly, subsidised LPT systems, competitive tender procedures, selective concessions, delegated management, or public ownership can all systematically be handled in this way. This approach can be extended by including as driving forces, besides extemal environmental factors, also different levels of planning competence in LPT systems, notably strategic, tactical and operational planning. This will be further discussed in the next section.

4. Success Factors of LPT Systems

To increase the use and efficiency in LPT systems it is necessary to gain more insight into the driving forces or determinants of the performance of such systems. Base on the various EU directives referred to above, a subdivision may be made into two classes of objectives. First, there are socio-economic performance criteria, in particular, the increase in the use of LPT systems, an improvement in environmental quality conditions or a contribution to employment. In this framework, one may also mention accessibility, quality, availability and affordability of LPT services. In the second place, there are financial-economic performance criteria, in particular intemal tost-efficiency and customer-oriented effectiveness. This complex set of interlinked objectives/criteria for the functioning of LPT systems is depicted in Figure 5. Clearly, the actual fulfilment of such policy goals would have to be 'explained' from a set of generic and site-specific background factors. The main indicator for policy success is the usage of local mass transit systems, which is a composite indicator of many underlying policy-relevant criteria as described in Figure 5.

The performance of LPT systems is thus critically contingent upon a set of major driving forces (critical success conditions, abbreviated as CSCs). These are:

- extemal factors
- strategic factors
- tactical factors
- operational factors.

We will concisely describe these 4 CSCs.

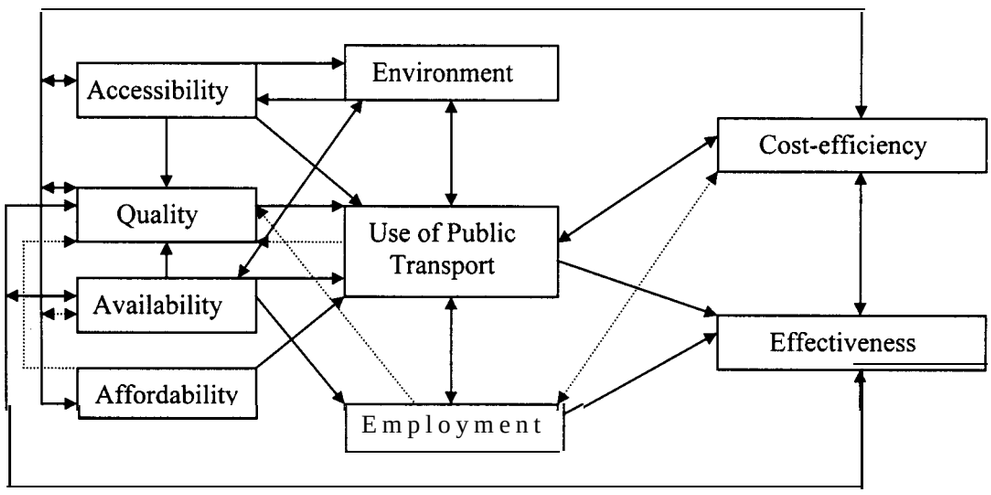

Figure 5. Interaction scheme of LPT objectives/criteria

A. *External CSCs*

These factors cannot be controlled by the LPT agency concemed. We will distinguish here 3 major extemal CSCs:

Al. *population.* This factor refers to the potential demand for LPT services and represents also an efficiency indicator in relation to the critical mass of LPT users (including also the population from adjacent areas as well as tourists).

A2. *population density.* This factor is a proxy for the economies of geographical density and influences the type of LPT systems offered.

A3. *population distribution.* This factor refers in particular to the degree of uniformity or heterogeneity in the geographical dispersion of people (e.g., a poly-nuclear structure versus an urban-rural dichotomy).

A4. *incidental large urban manifestations.* Large urban manifestations such as exhibitions, sports events or cultural events exert a significant but ad hoc impact on the performance of LPT systems.

B. *Strategic CSCs*

The goals of LPT systems are also influenced by strategic factors determined by the various stakeholders, in particular national, regional and local authorities. The strategic factors distinguished here are:

B 1. *politica1 interest.* In both publicly organized and market-oriented LPT systems public authorities have a significant impact on the functioning of LPT systems through both regulating and facilitating interventions.

B2. *specific LPT regulutions.* Within the EU context of subsidiarity and proportionality many initiatives have been developed which aim to improve the efficiency in the LPT sector. Regulatory uncertainty may have a negative impact on the LPT performance.

B3. *integrated LPT and urban development.* Urban and suburban development plans need to be supported by sufficient availability of LPT systems. Such an integration needs to be realized on both a structural and a project basis in order to attract sufficient demand.

B4. *coordination between LPT sector and public authorities.* In this framework various tasks play a role, such as granting concessions, evaluation of licences by a responsible public authority, provision of subsidies etc.

C. Tactical CSCs

The tactical leve1 addresses the question how genera1 objectives can be converted into an actual implementation of LPT services. The following categories can be distinguished:

Cl. *orgunizational frumework.* The organizational constellation refers in particular to the right of initiative as spelt out in Figure 1.

C2. financial framework. The financial ramification is concemed with financial aspects of various LPT tasks including the contractual aspects (e.g., management contract, gross cost contract, net cost contract).

C3. subsidies. These forms of financial support comprise both structural and non-structural subsidies. The latter category concerns financial assistance for ad hoc projects. Structural subsidies can be subdivided into direct and indirect subsidies. Direct subsidies mean a transfer to the LPT operator, while indirect subsidies mean a financial support via the user. Also cross-subsidisation between various public services or LPT services is possible.

C4. private-public partnership. This type of co-operation between the public sector and the private sector may relate to both the operational execution of LPT services and the operation of LPT infrastructure projects. The motives for this co-operative mode are inter alia: benefits from synergy, multifunctional development, blend of regulatory and business culture, better coverage of market risks etc.

C5. symbiosis between LPT and other transport modes, A better integration may generate win-win situations, e.g., in case of multi-modal passenger terminals.

D. *Operational CSCs*

At the operational leve1 we address the actual supply and execution of LPT services, in particular production and sales activities. The following factors can be distinguished here:

Dl. *variety in supply of LPT services.* Relevant categories are inter alia: bus, tram, metro, train, people mover etc.

D2. *privilegedposition of LPT compared to other traffic.* Priority rules for LPT may offer this system a more competitive position.

D3. *density of LPT.* Density may refer to both the service (e.g., frequency and intensity) and the infrastructure.

D4. *integration of LPT.* The various LPT systems may have a higher degree of cohesion through the integration of fares, logistics, routing etc.

D5. *LPT marketing and information.* This factor refers to the need for market and client orientation of a modern LPT sector.

These CSCs will now be used as a test framework for a comparative analysis of LPT systems in various European cities.

5. Creation of the Data Base on LPT Systems in European Cities

The classification of the CSCs discussed in the previous section needs a further operationalisation by indicating to which extent the various LPT objectives and CSCs are realised in each of the European cities investigated in our study. The European case cities selected in our study cover a wide range of urban size categories and of organizational/regulatory frameworks and offer a representative cross-section of different urban public transport constellations. This will allow a comparison of both urban regions of similar sizes but functioning under different arrangements and of urban regions of various sizes but functioning under similar arrangements (cf. also Yin 1994). The following cities were ultimately chosen (see Table 1).

1. Athens	9. Dresden	17.Mannheim/Heidelberg/ Ludwigshafen
2. Barcelona	10. Dublin	18. Oslo
3. Berlin	11. Hagelanden	19. Paris
4. Bern	12. Hanover	20. Rome
5. Bordeaux	13. London	21. Stockholm
6. Brussels	14. Leeds	22. Vienna
7. Budapest	15. Lisbon	
8. Copenhagen	16.Malmö/Lund/ Helsingborg	

Table 1. List of selected European case cities

For each city in this list the set of performance (success) indicators included in Figure 5 has been assessed in a qualitative (categorical) form by using local expert information (see for details Van Egmond 2001). These scores are based on the degree of fulfilment of objectives included in Figure 5. The centra1 objective is usage of urban mass transit systems, as a result of the various background

factors included in this figure. An expert summation of all these individual performance criteria may then lead to a comprehensive score for the LPT success according to the following trichotomic classification of the performance of a given LPT system in any of these cities: successful (score 1); moderately successful (score 2); unsuccessful (score 3); unknown success receives a code 4. The actual performance assessments based on reports, articles, yearbooks, research, intemet and casual interviews can be found in the first row (P) of Table 3.

To map out in a categorical form the CSCs for each city a codified qualitative information table has to be deployed (see Table 2.). Next, empirical estimates of all 18 factors determining the CSCs have been made for all 22 European case cities, again based on various local information sources on LPT. With the help of extensive comparative fieldwork the codification included in Table 2 has been assessed for each individual city. The empirically estimated information is contained in Table 3 under the headings A through D. The information in the latter table will now be treated in two steps. First, we will offer a qualitative interpretation of the results, based on an analysis of frequencies of CSCs in this matrix. Next, we will deploy a new multivariate classification method for nomina1 measurement scales, coined rough set analysis.

6. Empirical Results

A qualitative inspection of the coded data matrix (Table 3) offers already quite some interesting insights. The performance scores in Table 3 demonstrate that from our sample of 22 European cities at least 5 cities are regarded as having an unsuccessful operation of their LPT systems. A moderate success is claimed by 9 cities, while a good performance can apparently be found in 7 cities. For one city the performance of its LPT systems could not be unambiguously defined. So the genera1 finding is that the present conditions of a European policy of limited competition has led to rather successful outcomes, since a total of 16 cities out of 22 cases has moderately to high successful LPT systems (measured in terms of an increase in the use of LPT).

From the set of 22 cities a total of 16 may be considered as cases of limited competition, the dominant organizational form of EU LPT systems. From these 16 cases, a total of 10 may be interpreted as based on initiative by the public authority, while the remaining ones represent an initiative by the market (or an ambiguous case). In general, these cases appear to yield rather promising results. Thus, one may conclude that the adoption of a specific organizational-institutional form of LPT based on limited competition provides the conditions for a balance between the socio-politica1 objectives of sound socio-economie and financial-economic development of LPT systems.

If we make a distinction into extemal, strategic, tactical and operational background conditions for the performance of LPT systems, then we arrive at the following genera1 conclusion on their impact on the LPT performance.

		Codification of CSCs					
		1	2	3	4	5	6
CSCs	**External**						
A1	Size	>3 mln	3 mln>x> 1 mln	1mln>x> 500.000	<500.000		
A2	Nr. of people/ km2	>2000	2000>x> 1000	<1000			
A3	Distribution	Yes	Not significant				
A4	Incidental large manifestations	Yes	No				
	Strategic						
B1	Policy interest	Large	Average	Not significant			
B2	Specific LPT legislation	General legislation	Specific legislation	Not significant	Unknown		
B3	Integration LPT and urban development	Systematic	Project - based	Not significant			
B4	Match between LPT and authorities	Yes	No				
	Tactical						
C1	Organizational framework	Regulated	Limited competition; initiative of authorities	Limited competition; initiative of market	Limited competition; initiative of market/ authorities	Deregulated market	Combina-tion of main types
C2	Financial framework	Net cost contract	Gross cost contract	Manage-ment contract	Unknown		
C3	Subsidies (% operational costs)	<25%	25%-50%	>50%	Unknown		
C4	Public-private partnership	Infrastruc-ture related	LPT service related	Infrastruc-ture and LPT service related	No partnership	Unknown	
C5	Integration of LPT with alternative modes of transport	Yes	Not significant	Unknown			
	Operational						
D1	Variety in LPT services	Bus/tram/ (sub-)urban heavy rail	Bus/metro/ (sub-) urban heavy rail	Bus/(sub-) urban light rail/ (sub)-urban heavy rail	Bus/(sub-) urban heavy rail	Bus/tram and/or metro and/or light rail/ /(sub-) urban heavy rail	Other important combina-tions
~~D2~~	~~Priorities of LPT~~ with respect to other traffic	~~Yes~~	~~No~~	~~Unknown~~			
D3	Density of LPT	High	Average	Low	Unknown		
D4	Integration of LPT	High	Average	Low	Unknown		
D5	LPT marketing and information	High	Average	Low	Unknown		

'able 2. The codified table for the CSCs of LPT systems

	EUROPEAN CASE CITIES																				
CSCs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
P	3	2	2	1	3	2	2		12	13		2		14	1	2	3	2	12		2	1
A1	1	1	1	4	3	2	2	2	3	2	3	3		12	3	2	3	2	12		2	2
A2	2		11	3	3	1	1	1	2	2		111		2	2	3	2	2	2		13	1
A3	12	12	2	2	1	2	2	2	2	2	1	1	2	2	1	1	1	2	2	2	2	2
A4	2	2		12	2	2		11	2		12	12		2		12	11	2		2		11
B1	2	1	1	1	3	2		2	12		2	11	11	2		2	2	1	1	1	1	1
B2	2	2		12	11	4		2	12		11		2	12		2	12	2	1	2		3
B3	2	1	1	1	2	12		12	2		12		2	12		2	2	11		2		13
B4	2		12		12		12		11		12		11	12	12		11		1	1		2
C1	12	2	11		3	2	2	2	3	3		2	2	6	6	2	2	2	4	12		3
c2	12	2	3	3		11	2	2	3	2		2	2	12	12		12		2	2		2
c3	2	2	3	2	3	3	3	2	3	1	3	2	4	4	2	3	2	2	3	3	3	3
c4	11	3	4	4		13	4	4	4	5		3	4	3	4	5	4	4	4	12		4
c5	13	11		2	11	1	2	2		2	3		3	1	2	3	2	1	1	1	1	1
D1	2	5	5	5	4		5	5	4	14	13		5	4	5	4	5	5	5	5	5	5
D2	12	13		13	2	3		3	3	3	3		3	2	13		12		3	11		3
D3	2	2	12		3	2	2		11	2	2		12	4	2	14		11	2	2		2
D4	3	11		2		3	11	11	2		12		2	3	3	2	1	1	1	2	1	1
D5	2	12	3		3	4	3		2	12	4		13	2	3	2		4	14	14		2

Table 3. The coded data base on performance (P) and CSCs (A, B, C, D) of European LPT systems

The *external* factors do not appear to exert an unambiguous impact on the success scores of LPT. Although these are some clear links with some of the constituents of the external factors, the overall result is inconclusive.

For the *strategic* factors we observe a more straightforward influence on the success score of LPT. In particular, the quality of govemance and management appears to be a decisive positive factor (e.g., for Bern and Paris). On the other hand, overorganization of the LPT Systems leads most likely to a failure.

At the *tactical* level we also observe interesting findings. In particular, cities with an LPT system govemed by regulated or limited competition appear to yield a good performance. This should also be reflected in a sound division of financial responsibilities of all stakeholders, especially in the context of a gross cost contract or a clear management contract. Furthermore, it appears that high subsidies for LPT systems lead to an unsatisfactory financial and socio-economie performance, while moderate subsidies appear to yield in genera1 good results. Clearly, marked incentives do stimulate the performance of LPT systems.

And finally, at the *operational* level we find that the presence of an integrated LPT system with different modalities tend to offer a better performance.

We may conclude that there is not a single, preponderant and unambiguous performance cause for LPT systems. Our cases demonstrate clearly that the success (or failure) has a multidimensional causality structure. This means that we have to investigate also the simultaneous occurrence of combinations of the four above mentioned critical success conditions. This will be done in the next stage of our analysis.

In the second place, we will now use a recently developed qualitative classification method, viz. *rough set analysis*, to extract new insights from the nomina1 data in Table 3. We have a data base of 22 cases (i.e., cities) each characterised by a performance indicator (or nomina1 value of a success indicator). Furthermore, the discriminatory score of this performance indicator is 'explained' by the nomina1 values of the CSCs in our codified table, subdivided into four main categories (extemal, strategic, tactical and operational). Each of these categories is subdivided into subcategories, so that altogether we have 18 explanatory factors. Thus, we have to explain the nomina1 expression for a success factor regarding the performance of LPT systems fi-om an underlying set of nomina1 expressions for CSCs. It is clear that, even apart from the smal1 sample of 22 cities, this is statistically an impossible task due to the low level of measurement (i.e., nomina1 data).

Nevertheless, our codified information table may represent a latent structure through which the value of a performance indicator may yet be explained by means of combinatorial logic. In this context, the use of techniques from artificial intelligence, in particular rough set analysis, may be helpful. Rough set methods are multivariate classification methods that aim to detect pattems in a data base, even in the case of low measurement scales (including nomina1 scales). They are not based on

conventional statistics, but on the identification of deterministic rules (or statements) that are supported by the data base at hand.

Such rules often take the form of *'if...then'* statements and reveal under which conditions (i.e., combinations of values of the explanatory variables in the data base) a certain score on the dependent variable is valid. Thus, the result of a rough set analysis is a series of deterministic statements ('decision rules') of an 'if.. . then' nature. If a certain variable shows up in all conditional statements, it offers apparently an explanatory contribution in all cases. Such a variable is called a 'core'. In this deterministic way relevant critical success factors can be identified.

We will now present the conditional statements which emerge from the application of a rough set analysis to the above data base (using the ROSE software programme). This application of rough set methods leads to the following 7 decision rules, i.e. conditional statements which explain under which conditions (values of CSCs) a certain performance score is realized.

(i). (B2 =2) & (C4=4) & (C5=3) → P=l
(ii). (C4=4) & (D3=2) → P=l
(iii). (A3=2) & (C1=2) & (D1=5) & (D4=1) → P=2
(iv). (D5=1) → P=2
(v). (A1=2) & (B1=2) & (C2=1) → P=2
(vi). (A3=1) & (B2=1) & (C5=2) → P=3
(vii). (C2=1) & (D4=3) → P=3

These results show that there is no core (i.e., a common factor in each of these decision rules), although the accuracy of the approximation in this set of rules appears to be high. Essentially there are many reducts that provide an optimal representation of this multivariate classification. Attributes with a relatively high frequency in these reducts appear to be A2, A3, B2, B4, Cl, D3 and D5, with the highest frequency for D5.

The various decision rules specified above can be interpreted in a straightforward way. Let US take as an example rule (vii), which states that a failure of a LPT system (i.e., P=3) may be the result of a combination of a financial framework based on a net cost contract (i.e., C2=1) and a very low leve1 of integration within the LPT system concemed (i.e., D4=3).

These decision rules look rather complex, but can in various cases be interpreted in a straightforward way. For example, rule (i) claims that a successful LPT system may emerge when there is a specific, customized and non-overloaded regulartory regime and when the privileged position of LPT systems is so strong, that no public-private partnership is necessary. Similarly, rule (ii) stipulates that, with a fair density of LPT systems, such that no complementary support mechanisms in the form of public-private partnership are needed, the LPT system concemed tends to be successful. Another

example concerns rule (iv) which states that a medium success of LPT systems may already be expected with an intensive effort regarding marketing and information. An example of a failing performance can be found in rule (vii) which claims that a combination of a financial constellation based on a net cost contract and a low integration leve1 of LPT systems tends to lead to a low success.

7. Concluding Remarks

The necessary rise in efficiency and service provision in LPT systems requires a drastic reform in the organsation of urban mass transit systems. Such a regulatory transformation needs a closer orientation towards market principles in which delivery of high quality service to paying customers forms a crucial objective. This regulatory reform should also respect the peculiarities of LPT systems, such as its public nature, the indivisibility of parts of the infrastructure and the high fixed costs. Consequently, a shift towards mainly limited forms of competition seems to be plausible.

In our study, the success conditions for LPT systems in 22 European cities have been investigated. It turns out that these critical success factors can be subdivided into four categories, viz. external, strategic, tactical and operational. From these classes of conditions, in particular the strategic, tactical and operational factors appear to exert a major influence.

In general, the regulatory reform of public transport has created new challenges and also new opportunities for a more successful functioning of these systems. Our comparative analysis has demonstrated that in the past years – despite variation – many European cities have managed to organize their LPT systems in a more efficient and satisfactory way.

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