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Chapter 36

THE PERFORMANCE OF BUS-TRANSIT OPERATORS

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1. Introduction

The transit industry is a fairly heterogeneous mixture of companies with different ownership status that provide passenger services in a highly regulated environment, and making use of a diversity of vehicles (bus, tramway, metro, light rail, etc.). In almost all countries, urban and interurban bus transit is an important component of this industry. The purpose of this chapter is to review what is known about the economic performance of bus-transit operators. Although other criteria for evaluating performance may be suggested (effectiveness, financial indicators, etc.), we mainly focus on issues of productivity and efficiency. Based on the recent literature, we summarize the main trends in productivity growth and efficiency in the industry. More importantly, we review the most relevant technological, environmental, and regulatory determinants of productivity growth and of differences in efficiency levels between operators. The available evidence is interpreted relative to a number of recent policy discussions on regulatory reform of the sector. These discussions concern, among others, the role of subsidies and contractual arrangements, and the effects of recent changes in competition policy, such as the introduction of competitive tendering in the industry.

Knowledge about the determinants of the performance of bus operations is especially relevant in view of the recent history of the industry. In most western economies, the demand for bus transit has been declining for several decades due to suburbanization tendencies and modal shifts towards private-car transport. Massive operating deficits showed up from the 1970s onwards, partly under the influence of public-sector regulation of transit fares as well as output levels and network structures. This widespread public intervention in the transit industry has traditionally been legitimized both by efficiency arguments (e.g., economies of scale, service coordination to form coherent networks) and

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equity considerations (e.g., the ability to cross-subsidize peak travelers by off-peak users). In the last two decades, however, concerns about regulatory failures have led to a reassessment of transport policy (Glaister et al., 1990; Berechman, 1993). The suggestion that transit markets could meet the conditions for contestability resulted in substantial deregulation as well as greater reliance on private operators in many countries, including the U.K. and the USA.

The highly regulated economic environment within which transit firms operate makes a decent understanding of the factors affecting productivity and efficiency crucial. For example, it contributes to the discussion on the relative merits of private versus public provision, it adds useful insights on the desirability of regulatory reforms, and it provides information on how to limit cost and subsidy levels. Moreover, it allows policy-makers to assess to what extent recent policy changes are likely to foster the performance of bus operators. Since many of the regulatory problems readily transfer to other network industries in general, much of our understanding of the performance in this industry will be equally relevant for other transport modes as well.

To set the stage, Section 2 very briefly reviews the basic concepts of efficiency and productivity as used in the literature, and reviews the discussion on the specification of appropriate inputs and outputs in the transit sector for use in performance studies. In Section 3, the existing empirical literature on urban transit performance is summarized and its determinants are critically assessed. Finally, Section 4 concludes.

2. Performance measurement in bus transit

As previously indicated, we mainly focus on issues of productivity and efficiency as indicators of performance. To avoid ambiguities, we start out by briefly reviewing these basic notions, and indicate the difference with measures of effectiveness. We then review the difficulties in specifying proper inputs and outputs for performance measurement in the bus-transit industry. Note that more details on the available methodologies to evaluate productivity can be found in Chapter 19 of this handbook. Other excellent sources for economic performance measurement in transportation are, among others, Berechman (1993) and Oum et al. (1992).

2.1. Performance concepts: productivity, efficiency, and effectiveness

Productivity is a concept that somehow evaluates the outputs of an organization relative to the inputs used in the production process. The concept derives its economic meaning only from comparisons over time or across different organizations. For example, an increase in productivity over time would simply indicate that, relative to the inputs used, bus operators have succeeded in producing more output. An alternative way of conveying the same information is to say that, at given input prices, operators have been able to realize given output at lower costs. In the one-output case, productivity growth therefore implies lower average costs.

Roughly speaking, productivity growth over time can be due to a combination of technical progress and improvements in efficiency. Technical progress, for example, may be due to technological innovations or learning by doing. Technically, this shifts the production (cost) frontier upward (downward) over time, allowing bus operators to provide more services with given inputs. Efficiency changes, on the other hand, are related to either changes in the company's position relative to the production and cost frontiers or the exact position on the frontier. First, technical efficiency focuses on the degree to which bus operators are capable of attaining the maximal possible output levels that can be realized with given inputs. In economic terms, a technically efficient bus company operates on its production frontier. A company is technically inefficient if production occurs in the interior of its production possibility set. Second, scale efficiency and allocative efficiency reflect the exact position of the firm on the production frontier. Scale efficiency specifically relates to a possible divergence between the actual and the long-run optimal production scale under competitive conditions. An operator is scale efficient if its choice of inputs and outputs corresponds to that resulting from a long-run zero profit competitive equilibrium; it is scale inefficient otherwise. Allocative efficiency requires the specification of a behavioral goal and is defined by a point on the boundary of the production possibility set that satisfies this objective given certain constraints on prices and quantities. In other words, whereas operating on the production frontier is sufficient to be technically efficient, allocative efficiency is related to the exact position on the production frontier, where the most desirable position depends on the specific goals being pursued. In many applications it is assumed that an acceptable goal for the bus companies under scrutiny is to minimize costs at given input prices. In that case, a technically efficient producer is allocatively inefficient when it produces with the "wrong" input mix. This results in a deviation from its cost frontier, yielding higher than minimal costs at given input prices.

Several approaches exist to estimate productivity growth and efficiency on the basis of observed transit data. We limit ourselves to a brief overview; for more details, see Lovell (1993) and Chapters 19 and 20 in this handbook. First, to measure overall productivity, index number approaches have been developed that rely on aggregation procedures to define aggregate input and output quantity or value indices. Total factor productivity is then obtained as a simple ratio of aggregate output per unit of aggregate input (or cost per aggregate output). Unfortunately, the link with the economic notion of a technology is often not guaranteed under this approach. Second, both productivity and efficiency can be estimated based on parametric and non-parametric methods to determine production or cost frontiers. In both cases, productivity is calculated by considering shifts in the frontier over time, whereas technical efficiency is determined by considering individual transit operators' deviations from the frontier. On the one hand, the parametric frontiers require the specification of a functional form: flexible functional forms such as the translog have been quite popular in empirical applications. Non-parametric methods, on the other hand, determine the frontier without postulating a functional form. They envelop the data on transit inputs and outputs by piecewise linear hyperplanes, using mathematical programming methods. The most popular models are data envelopment analysis (DEA) and the free disposal hull (FDH).

Apart from productivity, efficiency, and technical progress, one is often interested in the effectiveness of firms. The latter concept relates realizations to the goals put forward. These may be purely related to the supply side (e.g., realize a 5% increase in vehicle-kilometers) or they may be demand-related (e.g., increase the number of passengers by 6%). Effectiveness then measures the extent to which the specified goals have been achieved. It is often argued that effectiveness as such is not an overall acceptable performance concept from an economic point of view, mainly because it is perfectly compatible with large inefficiencies. Indeed, one can realize the objectives and be highly effective, but do so in a very inefficient and costly way. Alternatively, differences in measured inefficiencies across transit firms may simply derive from unobservable differences in objectives. This emphasizes the need for a proper understanding and careful specification of transit firm objectives, an issue to which we return below. It is clear that, if objectives are correctly specified, both efficiency and effectiveness are relevant and useful concepts focusing on different dimensions of performance.

2.2. *Specification of inputs and outputs for performance measurement in the bus industry*

Independent of the precise methodology used, performance measurement in the bus industry requires the definition of inputs (or input prices in the case of determining cost frontiers) and outputs. Such definitions are not straightforward and give rise to some controversy.

First, consider the input side. The traditional inputs in transport are capital, labor, and energy. None of these aggregate inputs, however, is homogenous. In all cases, differences between operators may exist in terms of quality or composition. With respect to labor, for example, the basic distinction could be made between driving and non-driving labor. Moreover, the definition of "effective" labor time may be quite difficult for drivers due to interrupted shifts, waiting times, etc.

As to capital, a large fraction of bus companies' capital stocks reflects rolling stock (i.e., the bus fleet), which typically consists of many different vintages. At the same time buses of any given vintage may be used at different intensity, leading to very diverse economic depreciation patterns. Finally, due to recent technological advances and rising environmental concerns, bus companies no longer solely rely on gasoline as fuel for their vehicles.

More difficulties arise on the output side. In the early literature, either "pure" supply indicators (vehicle-kilometers or seat-kilometers) or demand-related output measures (passenger-kilometers or the number of passengers) have been used. Several authors have argued that, if in empirical cost and productivity studies a choice has to be made between supply- and demand-related indicators, the former may be superior. One of the main arguments is that inputs do not necessarily vary systematically with demand-related output measures, and therefore do not allow a reliable description of the underlying technology (Berechman and Giuliano, 1985). However, it is now widely believed that the complexity of transit firms' objectives and the heterogeneity of transport output imply that both demand and supply characteristics are relevant. Moreover, recent methodological advances imply that multidimensional output measures that avoid the explicit choice between demand and supply related indicators can easily be specified. Finally, recent research has devoted quite a bit of attention to the implications of treating transport explicitly as a network industry. Substantial progress has been made in understanding the consequences of aggregating outputs on individual links of the network into meaningful aggregate output measures.

To elaborate on these issues, first note that the specification of appropriate output measures depends on the assumed objectives of the transit firm. Clearly, there is no overall consensus on the proper goals of transit firms in the literature. Although early empirical models assumed cost minimization as the behavioral assumption, both normative and positive models have challenged this approach and have suggested a wide variety of potential objective functions for transit firms in a regulated environment. Normative models (Bös, 1986) have put forward the traditional public enterprise objectives that follow from welfare maximization. In addition to standard efficiency goals, they allowed for distributive objectives in determining fares, deficit finance in the case of natural monopolies and macro-economic objectives; e.g., reducing unemployment by relatively "overhiring" labor. Positive models, on the other hand, have stressed that actual objectives are the result of the interaction between operator or managerial preferences, the political and regulatory environment, and the activities of possible pressure groups. Therefore, models have been specified that include bureaucratic objectives (e.g., maximize output subject to an allowable deficit) or take account of possible political targets or institutional restrictions on managerial flexibility (Berechman, 1993).

It is clear that the proper objective function of the transit firm is intimately related to the social, political, and regulatory environment in which it operates. Moreover, the objectives of the firm are crucial for the proper specification of transit output and for the *ex post* interpretation of performance measures. For example, if the firm operates in a regulatory environment that implicitly stimulates the excessive use of labor, it follows that assuming cost minimization at observed input prices is inappropriate. In addition, evaluating performance based on this assumption leads to highly misleading results.

A second observation is that in the literature there now is a general recognition of the heterogeneity of transport output in terms of temporal, spatial, and quality characteristics. For example, companies may operate a highly dense or a sparse network, they may differ in terms of peak-to-base ratios, and their services may differ in quality (as reflected in, e.g., speed, punctuality, frequencies, travel linkages, cleanliness of vehicles, drivers' attitudes). Therefore, models aiming at a realistic description of bus-transit operations must account for various relevant service and network characteristics and must include variables describing the regulatory environment. Important variables may include commercial speed, frequency, variables providing details on the nature of regulations (e.g., specification of a minimum aggregate output level), various demand factors such as prices of other modes, peak-to-base ratios, and variables reflecting the structure of the network and the urban area. Over the past decade, many empirical models have incorporated at least some of these characteristics (Filippini et al., 1992; Hensher, 1992; Kerstens, 1996). If output and network characteristics are appropriately included it follows that the early distinction between demand vs. supply-related indicators becomes largely irrelevant.

In principle, including a series of output and network characteristics in a technology specification is straightforward. In practice, however, problems do arise, both for parametric and nonparametric approaches. If, in addition to inputs and generic outputs, a large number of additional attributes are thought to be relevant, the nature of the non-parametric approach implies that a very large number of observations will tend to be situated on the frontier due to the well-known curse of dimensionality. This undermines the discriminatory power of the analysis, and using this frontier to determine efficiency of individual operators may become difficult.

For parametric methods, problems of a slightly different nature occur. Applying such approaches to multiple output technologies may easily lead to an excessively large number of parameters to be estimated, especially when flexible functional forms are utilized. At least two approaches have been suggested to circumvent this problem. First, the seminal work of Spady and Friedlaender (1978) has led to the specification of hedonic output composites that correct the generic output (such as vehicle-kilometers) for variations in spatial, temporal, and quality characteristics. The importance of the individual characteristics in defining the output aggregate is estimated jointly with the structure of the technology. A second approach is to explicitly exploit the network nature of transport services. The idea, developed by Jara Diaz and his collaborators (Jara-Díaz, 1982; 1988; Jara-Diaz and Cortes, 1996; Basso and Jara-Diaz, 2005) is to start from a very disaggregated definition of transport output, viz., individual origin–destination flows per period, and to exploit the relation between the output for which data are available and the underlying origin-destination flows. Notice that empirical applications in bus transit are still scarce.

Finally, several recent papers have considered the specific role of service characteristics in the analysis of cost efficiency and performance. In a highly relevant contribution, Prioni and Hensher (2000) emphasize that some service-quality indicators can be interpreted at the same time as a supply characteristic and as a direct determinant of transit demand; e.g., timetable frequency maps into waiting time. The distinction is important because the former directly affects the firm's production costs, whereas the latter affects the user cost for the passenger but is only indirectly passed on to the bus operator. Indeed, the impact of the user cost on demand translates into output changes only to the extent that the firm's output is affected by final demand. The authors propose a methodology to incorporate such quality indicators in studies of transit cost efficiency and effectiveness in a way that nicely distinguishes between the direct cost impact of the characteristic and the indirect effect via final demand. The method is based on joint estimation of the cost and the demand sides of the transit market. Hensher and Prioni (2002) further elaborate on the need to specify a service quality index that adequately captures service effectiveness when designing performance-based contracts.

We should add a critical note regarding the implicit assumption in these studies that quality improvements always contribute to increased customer satisfaction. Friman (2004) reports a converse relationship for Swedish operators investing in information systems, vehicle standards, increased frequency, and construction of travel centers. Quality improvements in fact decreased consumer satisfaction, since the frequency of perceived critical incidents increased. This is probably due, among others, to the long implementation periods with inevitable service disruptions and the increase in passengers' expectations following information on the ongoing service improvements.

Finally, the above discussion on transit firms' objectives and the specification of appropriate output indicators can be summarized as follows. First, there is no universal agreement on the objectives of transit firms, and explicit or implicit goals that guide decisions may widely differ across firms. Second, there does seem to be general agreement that empirical models should include output characteristics that capture both demand and supply attributes. If this is appropriately done the discussion with respect to the choice of demand vs. supply-related indicators is no longer crucial. Third, the network structure and the relation between output aggregates and underlying origin-destination flows may provide a fruitful avenue for cost and productivity measurement in the transport sector. Finally, to the extent that service quality indicators map into both supply and demand characteristics it seems desirable to analyze their impact on cost and performance within the framework of a joint demand–supply equation system.

3. Performance of bus operators

Many studies are available on the productivity and efficiency of bus operators, using a variety of methods. This section aims to summarize the main conclusions from this research. Attention is limited to those findings for which a reasonable degree of consensus seems to exist. We proceed in two consecutive steps. We first review what appear to be the main conclusions with respect to the characteristics of the technology and with respect to productivity growth and efficiency in the bus industry. Next, we summarize in more detail what is known about the determinants of differences in performance.

3.1. Bus technology and performance: some facts

In this section, we consecutively review some general characteristics of the technology of bus service suppliers, such as substitutability of inputs in production, price sensitivities of input demands, degree of returns to scale, and presence of economies of scope. Then we summarize productivity and efficiency results.

3.1.1. Production technology, returns to scale, and economies of scope

Although some variability exists due to differences in local circumstances and regulatory environment, there are some fairly robust conclusions with respect to transport technology (Berechman, 1993). First, it is fair to say that the production of bus kilometers implies very limited substitution possibilities between capital and labor. At least some substitution between capital and fuel and between capital and maintenance does seem to exist. Technically superior buses, or rolling stock capital of more recent vintages, typically implies better fuel efficiency and reduced maintenance costs. The actual exploitation of possible input substitution is to some extent induced by direct capital subsidies. For example, government subsidies for rolling stock allow for improved fuel efficiency and a rapid turnover to offset maintenance costs.

A second related point concerns the price and cross-price elasticities of the demand for inputs. Given limited substitutability, a high degree of unionization

typically found in the bus industry and the regulatory restrictions of personnel policies, the demand for labor is almost always estimated to be very inelastic. This might also partially explain the often substantial wage cuts observed after the introduction of competitive tendering procedures, especially in developing countries (Hensher, 2003). Own price elasticities for energy and capital services are generally estimated to be quite inelastic as well, although typically larger than labor demand elasticities. Small but non-zero cross-price effects are in many studies estimated between rolling stock and fuel.

Third, research dealing with economies of density and economies of scale in bus operations has made it very clear that the early contentions that bus mass transit is a declining average cost industry requires substantial qualification. In the very short run, holding both network structure and fleet size constant there appear to be large economies of capital stock utilization. These are again partially due to capital subsidies that imply that the bus industry experiences massive excess capacities, with actual fleet sizes largely exceeding optimal levels. In addition, most studies find that bus technology is characterized by economies of traffic density so that more intensive use of a given network reduces the cost per vehicle-kilometer. This appears not only to be true in the short run because of the aforementioned capital stock utilization economies, but also in the medium run when fleet size can be adjusted. Finally, results with respect to economies of scale, allowing for adjustment of all inputs, including fleet size and network size, are mixed. Although there are some exceptions, the overall picture is one of a U-shaped relation between average cost per vehicle-kilometer and output expressed in vehicle-kilometers, with very broad ranges of constant returns to scale. Surveys of the literature up to the early 1990s are consistent with this picture (Berechman, 1993). It is argued that small firms (<100 busses) typically experience increasing returns to scale; that medium-sized companies (<300–400 busses) face limited increasing or constant scale returns; and that the large systems (>300–400 busses) are subject to decreasing returns to scale. Various recent analyses confirm this view. For Europe, Filippini et al. (1992) find important economies of scale and density for Swiss operators. The Fazioli et al. (1993) and Thiry and Tulkens (1992) studies confirm this finding for Italian and Belgian companies, respectively. The Swiss and Italian studies recommend selective merger policies based on the estimated production structure. Finally, for the USA. Viton (1997) reports the U-shaped average cost functions with increasing returns to scale for the smaller operators, then constant and, finally, decreasing returns to scale for big companies.

Fourth, there is some evidence that economies of scope exist in the bus industry and that at least some mergers may be economically beneficial, although it must be admitted that relatively little is known about the potential cost reductions that can be realized by such operations. Viton (1992, 1993) are the only detailed studies we are aware of offering an answer to the question of whether consolidation in the bus industry could lead to cost savings and which mergers exactly should be envisioned. For the seven companies in the San Francisco Bay area, the answer depends to some extent on the modes being offered by the potentially merging companies and by the number of companies being merged. In general, benefits fall with the number of companies involved, while caution should be made for the possible perverse effects of mergers on the wage structure and on market structure within and across contracting areas (also see Hensher, 2003). Fraquelli et al. (2004) find economies of scope associated with urban-intercity diversification. They interpret this as evidence that the merging of neighbouring companies could create better integrated local networks.

Finally, it must be mentioned that recent advances in estimating cost models on the basis of aggregates defined on the individual origin-destination flows (Jara-Diaz and Cortes, 1996; Basso and Jara-Diaz, 2005) may offer opportunities to reconsider some of the evidence derived from the available literature reported above. These authors show that earlier measures of returns to scale may have been inappropriate. They suggest calculating returns to scale from cost elasticities with respect to the vector of output aggregates, weighted by their local degree of homogeneity with respect to the original underlying flows. Moreover, they argue for new ways to identify the precise role of network expansion on costs. They show that returns to scale with variable network size cannot be used to study the effects of network expansions, because the previously used methods implicitly assume that traffic density remains constant. Instead, to evaluate the economies associated with network expansion, they propose a new concept of economies of spatial scope and show how to calculate it on the basis of cost functions specified in terms of aggregate output data.

3.1.2. *Efficiency and productivity: general trends*

The survey of Berechman (1993) noted a cost escalation in transit systems in many countries, and either declining or mildly positive productivity trends. Cost inflation is to some extent related to the nature of the regulatory process (fare and service regulation in terms of social and accessibility goals) and to transit firms' weak budget constraints due to subsidies. Limited productivity growth is partially to be expected given the nature of the bus technology and its operating environment. First, driving busses is a rather established technology, whereby improvements in fuel efficiencies have to a substantial degree been exploited and potential further improvements in labor efficiency have become unlikely since one-man, one-bus operation has become the general rule. Second, increasing congestion levels, especially in urban areas, are a major external factor impeding improved performance. These tend to lead to decreasing commercial speeds, even though a number of counteracting measures have been taken (e.g., exclusive lanes, automatic traffic signaling guaranteeing priority to busses). Moreover,

some studies seem to suggest that in cases where positive productivity growth has been observed, it is largely due to a catching-up effect (i.e., an improvement in technical efficiency over time) and not so much due to technological advances (Viton, 1998). The literature also suggests that recent regulatory changes in a number of countries have somewhat spurred productivity growth (see below).

Much recent work has focused on technical efficiency patterns (De Borger et al., 2002) and the ensuing meta-analysis of Brons et al. (2005). Three general conclusions stand out from this literature. First, the existence of substantial remaining technical inefficiencies among urban transit operators in different countries is undeniable, although it is unclear how these performance results compare to other sectors in the economy. Second, comparative work of transit operators in different countries reveals a huge variability in technical inefficiency, both across and within countries. For example, U.S. operators compare favorable compared to their European counterparts. Within Europe, operators in the U.K. appear to be doing very well, which may be the consequence of recent regulatory changes. This observed variation points to differences in managerial quality, regulatory practices, operating environment, etc. Third, the available efficiency studies emphasize the relative nature of the best-practice comparisons and the importance of underlying assumptions.

Frontier methods have also been used to study some other efficiency notions. From the scarce available literature it appears that scale inefficiencies are no major source of poor performance (Kerstens, 1996). Moreover, the few studies considering allocative inefficiencies suggest that the nature of these inefficiencies strongly depends on the regulatory environment. On the one hand, the existence of capital subsidies encourages capital-intensive production methods; on the other hand, union influence and managerial preferences may induce excessive labor input in the production of bus services.

The empirical literature also nicely shows the importance of clearly specifying firm objectives and the relevant output of bus companies when analyzing performance. Indeed, several studies have noted that there is almost no correlation between technical efficiency and effectiveness among bus operators, and that conclusions regarding performance are highly conditional on output specification. This observation may to some extent simply illustrate the fact that transit services may be offered that do not match the needs of potential customers.

3.2. *Determinants of bus transit productivity and efficiency*

In this section, we turn to an overview of some of the most important potential determinants of productivity and efficiency in the bus-transit sector. Knowing that overall productivity increases are limited, what are the determinants of variations in productivity growth and in efficiency between operators? We consecutively focus on ownership and size of operators, on the role of network characteristics and environmental factors outside the control of bus operators, on subsidies and contractual arrangements, and, on competition policy and regulation. Importantly, note that reported results may in some cases be derived on the basis of specific implicit assumptions about transit companies' objectives that need not enjoy universal approval.

3.2.1. Ownership

It is often informally argued that productivity and efficiency is higher in the private than in the public sector. For the transit sector, surveys by Perry et al. (1988) and Berechman (1993) on the effect of ownership and management systems on performance do not strongly support this view, however. Their results indicate that variations in ownership and management as such have few predictable associations with operating efficiency. In addition, the use of outside expertise under the form of contract management is no guarantee of improved performance. What does turn out to be the case is that both the level and the structure of supply are different between public and private provision. As the organization of transit supply in some countries serves social goals (accessibility, income redistribution, etc.), it is generally found that service levels are higher under public ownership. Moreover, public operators typically also offer a larger fraction of total vehicle-kilometers during peak hours, implying higher peak-to-base ratios. The latter findings again illustrate the importance of underlying objectives and the incorporation of relevant supply and demand characteristics.

In more recent studies, private ownership does seem to perform better in terms of productivity and technical efficiency. For example, Chang and Kao (1992) and Kerstens (1996) detect a better performance of private bus operators in Taiwan and France, respectively. However, despite the evidence produced by the recent literature, there are several reasons why it is not at all clear that public bus operators produce bus services less efficiently and are less productive than private companies. First, as suggested above, public operators offer more services and are characterized by higher peak-to-base ratios. If the distinction between peak and off-peak supply is not explicitly taken into account, this deteriorates their perceived relative performance. Not only are peak transport costs higher per vehicle-kilometer than off-peak costs, due to differences in operating speed, but in addition fleet sizes are almost exclusively determined by peak-period supply. This implies larger average fleet sizes for public companies for any given total supply of vehicle-kilometers, yielding lower perceived efficiency levels. Second, results on the relative performance of private vs. public operators may be biased due to a selection problem. To the extent that unprofitable private suppliers have become publicly owned or, more generally, that nationalization to a large

effect affected units in which private operators were not interested (high-cost operations, services in less-developed regions, etc.), relatively poor performance may have been a logical consequence. Third, it should be stressed that almost all the available studies were unable to control for the degree of competition and the nature of government regulation in the sector. Indeed, one could *a priori* argue that ownership is of little relevance on its own. In markets with strong regulation and characterized by an absence of effective competition for private operators, very little relation between ownership and productivity or efficiency may exist. Italian evidence by Fazioli et al. (1993) seems to confirm this statement. They found no relation between technical efficiency and ownership among urban transit firms precisely because of the absence of effective competition for both public and private operators and strong regulation. Therefore, it seems safe to conclude that ownership is not the most crucial factor in determining the efficiency and productivity of bus operators. Much more important seem to be the degree of market competition and the nature of regulation.

Some evidence suggests that size is important in determining performance. The issue of scale economies was alluded to before. Moreover, both US and European evidence is available that indicates a negative relation between technical efficiency and operator size. This has been interpreted as bureaucratic inefficiency.

3.2.2. Network characteristics and environmental variables

One of the basic problems remains to account for the network structure and characteristics when determining the performance of transit operators. The problem is twofold. First, data on many potentially relevant attributes are unavailable. Second, and more importantly, many of the relevant characteristics are largely outside the control of the operators, but are imposed by the regulatory environment (network size, number of routes, frequencies) or partly determined by demand (number of stops). It is therefore unclear whether such network attributes should be considered as part of the description of technology or as a determinant of performance.

Not surprisingly, studies that do treat network characteristics as determinants of performance find that they are quite relevant. For example, there is evidence that the number of stops affects performance negatively, and that the average distance between stops reduces operational efficiency. Urban operators seem to perform better than rural transit providers. Many studies find that network length itself has an impact on performance, although the sign remains a matter of some controversy. Furthermore, average speed is typically found to have a positive effect on efficiency and lowers costs, confirming the popular conjecture that increasing traffic congestion levels do hinder public transport in urban areas. Finally, capital–vintage effects (e.g., measured by average fleet age) seem to slightly deteriorate performance.

3.2.3. Subsidies and contractual arrangements

An important issue is whether subsidies to bus-transit operators are harmful to productivity growth and efficiency. A first observation is that there appears to be sufficient evidence to conclude that subsidies do increase operating costs. In fact, it has been argued (Pucher, 1988) that the main direction of causation runs from subsidies to cost increases, and not the reverse. In other words, subsidies do not tend to cover cost increases that have arisen due to some external reason, but rather tend to induce a cost escalation. A second and related finding is that operational subsidies tend to worsen the performance of urban public transport in a variety of different respects. It not only shows up in higher costs, but also in the number of revenue-passengers, in excessive wage increases (Berechman, 1993), and in technical inefficiency (Sakano and Obeng, 1995; Kerstens, 1996). Third, the effect of specific capital subsidies on excess capacity of rolling stock has already been alluded to. Moreover, although there is no strong theoretical argument as to why this should be the case, there is some evidence that they increase technical inefficiency. For example, Tulkens et al. (1988) related the bad performance of a Belgian operator to excess capacity resulting from redundant investment in busses, directly linked with investment subsidies. Fourth, it seems that the size of the effect of subsidies on performance depends on the political proximity of the regulator and on whether the regulator can or cannot control company information. With respect to the former, the evidence suggests that more central government levels seem to be less able to monitor the use of their funds than lower-level government bodies. This has been observed both in the USA (Anderson, 1983) and in Europe (Filippini et al., 1992).

Kerstens (1996) is one of the first to explicitly analyze the impact of contractual arrangements on transit firm performance (more specifically, on technical efficiency). He showed that contractual formulas that imply risk-sharing between government and operator enhance the efficiency of the bus-service supplier. Not surprisingly, introducing contracts that impose more risk on transit operators provide the necessary incentives to improve performance. Moreover, it turns out that the negative effect of subsidies on efficiency that was previously mentioned is independent of the precise risk-sharing arrangement between operators and public authorities. The length of the contract specified was also found to increase efficiency. Finally, a locally levied, ear-marked tax on the wage bill turns out to have a positive impact on performance. This is consistent with the observation that these tax rates affect the monitoring efforts of citizens and, indirectly, of regulators. The basic inciting effect of risk-sharing contracts for French operators is confirmed in the works of Gagnepain and Ivaldi (2002) and Roy and Yvrande-Billon (2007). The same result that high-powered incentive contracts, often including some form of yardstick competition, improve efficiency has been confirmed for the Norwegian (Dalen and Gómez-Lobo; 2003) and Italian (Piacenza, 2006) cases. Of course, these results assume that contract types offered are exogenous to efficiency results. If firm efficiency would affect the contract selected, then the above interpretations would be tenuous.

3.2.4. Regulation and competition policy

It was previously suggested that not ownership but the nature of regulation and the degree of competition in the industry might well be the most important determinants of performance. At the theoretical level, the economics literature offers strong arguments to support this view. First, fare and output regulation induce the firm not to pursue traditional goals such as profit maximization or maximizing the value of the firm. The consequence is that the implicit objective functions for transit firms are not well defined. In the literature, potential objective functions include, among others, maximization of passenger-miles, maximization of operator utility (which itself depends on contractual arrangements), and maximization of revenues. Pursuing these objectives may imply large inefficiencies. Second, in the case of public ownership or generous operating subsidies, and given strong union influence, there are no appropriate incentives for cost minimization either. This suggests some allocative as well as technical inefficiency. Third, regulation and the absence of direct competitors prevent transit firms from adjusting their output and network to declining demand, they imply little flexibility with respect to quality improvements, and do not stimulate even quite straightforward innovations; e.g., use of busses of different sizes.

Few economists disagree with the statement that the regulatory regimes that were in place in the past few decades indeed have contributed to higher costs, more subsidies, substantial inefficiencies, low productivity growth, and a lack of innovation in the industry. Some discussion does remain, however, on the extent to which deregulation can reverse the observed trends in all of the above undesirable industry characteristics. For example, one argument is that most of the estimated inefficiencies are not related to regulation but to environmental factors, such as low operating speeds due to congested urban areas. This is of course an empirical matter. To the extent that this is true, observed inefficiencies will not disappear after deregulation. In addition, some economists have argued that welfare maximization does require at least some regulation, including some subsidies and the possibility of cross-subsidies between services, to guarantee service availability, to allow exploitation of network economies by the provision of integrated services, and to guarantee the reduction of external congestion costs. Although the validity of this argument cannot be fully assessed without additional empirical research, an important question is whether current regulatory policy is the best alternative for achieving these goals. For example, desirable services that would disappear after deregulation can be stimulated through direct subsidies.

Important as the above arguments may be, by far the most serious concern about deregulation is the uncertainty with respect to its effect on competition.

The argument is simply that monopolistic market structures remain intact due to a lack of entry by new firms, especially in established networks in urban areas. It is argued that the characteristics of bus transit systems (economies of density, economies of scope at the level of individual routes, excess capacity) are likely to lead to monopolistic or oligopolistic market structures, even after deregulation. Consequently, desirable effects on performance and on service levels are unlikely outcomes. Of course, a critical issue in evaluating this argument is whether bus transit markets are contestable (Banister et al., 1992). If they are, incumbent operators (even if they operate in a monopolistic environment) must continuously anticipate the threat of new competitors, so that competitive outcomes in terms of service provision, fares, and operating practices are to be expected.

The answer to the contestability issue is not obvious and has not fully been settled. What is clear is that not all bus-transit markets are likely to be contestable. Crucial in the discussion is: first, whether there are important sunk costs; and, second, whether there are entry-deterring strategies by incumbent firms that are likely to be successful. Although it has been argued that the separation of ownership and use of rolling stock implies the absence of sunk costs, this argument is not convincing in the presence of large excess capacities of rolling stock. In practice, the latter imply that the rolling-stock capital of entering firms has indeed the characteristics of a sunk cost, suggesting the market may not be contestable. Moreover, to the extent that prices and schedules are flexible after deregulation price cuts and schedule adjustments can potentially be used to deter entry. Most importantly, theoretical spatial research suggests that incumbent firms can relatively easily set up entry-deterring strategies when two conditions are satisfied (Berechman, 1993). First, if it has the fixed facilities (e.g., a central bus station) available that are crucial to exploit network economies (interconnections between different lines); and, second, when the demand structure is characterized by complementarities between lines. The conclusion from this theoretical research seems to be that in the intra-urban transit market, where these conditions are typically satisfied, it will be relatively easy for incumbents to deter entry, so that monopolistic market structures are indeed likely to persist. Since these same factors play little role in interurban markets, deregulation of these markets is likely to generate more competitive outcomes. Empirical evidence is still scarce.

Empirical information on the impact of more competitive environments and the nature of regulatory measures on performance can only be obtained when some variability in these phenomena can be observed, either over time, or between operators in different cities or even countries. While international comparative research is still almost entirely absent, the best evidence is probably derived from empirical studies on recent deregulation efforts in a number of countries. In addition to ideological and financial motives, these efforts were often specifically aimed at improving the performance of public transit systems.

Thus, although empirical evidence is still limited in terms of geographical coverage, a brief overview of it provides a few stylized facts that yield interesting information.

First, the evidence suggests that costs have indeed been drastically reduced, both in the USA and the UK. In both countries, the number of employees substantially declined. In the case of the UK, two reasons for cost reductions were identified. One was that deregulation introduced productivity-enhancing working practices and led to reduced wage rates. With respect to the latter, Glaister (1997) stresses that competitive input markets, especially for labor, are at least as important as competition in the output market. The other cost-reducing factor was the requirement that the remaining subsidized (social) bus services should be subjected to competitive tendering (CT), i.e., a bidding process for the monopoly right to supply a predefined service at a particular spatial level during a particular period. This is believed to have lowered subsidies by about 20%. Preliminary estimates of the overall welfare effects of tendering procedures suggest substantial welfare gains, net of administrative and tendering costs (Glaister, 1997).

Several recent papers have specifically devoted attention to the role of CT as a subsidy reduction mechanism. For example, Hensher and Wallis (2005) survey the available evidence derived from 10 developed countries (covering more than 20 cities) and suggest very substantial cost savings from initial round tenders – ranging from 20-30% for Scandinavian countries to almost 40% in some Australian cities. They also, however, find that cost savings vary widely and depend on pre-tendering conditions, such as the initial cost efficiency of operators, the ownership structure, etc. Moreover, the evidence suggests that cost savings may largely be a one-shot phenomenon in the sense that further rounds of tendering may actually lead to new cost increases. There are several reasons for this finding: better informed bidders in later rounds, firms reacting to excessively low initial bid's (the "winner's curse"), a reduction in competition in later rounds due to a smaller number of participants, etc. Comparing performance-based negotiated contracts with CT, the authors find that in the former case, benchmarking and yardstick competition may lead to collusion over the benchmarks. In the case of CT, however, collusion may equally well occur under the form of agreements about who bids for what contract. Inadequate contract design can result under both regulatory designs to empty buses, split routes, etc. Moreover, all contracts leave substantial budgetary uncertainty for the government.

The analysis of CT in France seems consistent with some of these findings (Yvrande-Billon, 2006). This study reveals that over time fewer bidders compete and the proportion of CT procedures with only one bid increases. Against the background of increasing costs and decreasing number of journeys per inhabitant, Yvrande-Billon relates these problems to a variety of defects in the French attribution process: inadequate service specification, effective collusion by the leading operators in the CT process, and poor ex-post control on contract execution. This example serves to illustrate the importance of a coherent legal and institutional framework for CT to obtain the desired benefits.

Finally, Hensher (2003) studies the implications of the contract area in competitive tendering procedures. On the one hand, one can expect efficiency losses from larger area sizes (due to a reduction in competition and higher monopoly power). On the other hand, benefits due to network economies and scale economies can potentially be realized. The evidence presented suggests that little scale economies seem feasible for companies with more than 100 busses, but that there are indeed mild network economies. It is unclear whether these are sufficiently large to justify raising the size of contract areas.

Second, the effect of deregulation on service provision and quality is unclear. Both in the USA and the UK, overall more service was offered (in terms of vehicle-kilometers), but in the latter case both quantity and quality of services were reduced for smaller and rural communities. Moreover, there was some concern over the lack of service stability, a feature highly valued by passengers, even when the deregulated regime has been in place for quite some time. The lack of service stability seems to result in a drop in consumer confidence. From the consumer's viewpoint reduced coordination of schedules and routes seems to outweigh the overall increased service volume. This reopens the question on a potential role of the public sector in service coordination. For example, Hensher (2003) reviews the available evidence on the benefits of interconnectivity and fare integration, and concludes that no clear effects on patronage can be found. Part of the reason is that what matters for users may not be so much fare integration, but a reduction of time losses associated with transfers. If this is the case, it might be better to reduce cross-regional transfer times by alliances between companies responsible for different contract areas, or by agreements for cross-border service provision by one operator.

Third, the evidence on the effect of deregulation for market structure seems to be reasonably consistent with the predictions of the theoretical spatial models referred to above. In the UK, it is observed that market structure after deregulation is clearly non-competitive, and most likely non-contestable, in major urban areas. One of the consequences of the non-competitive character of the industry was a quite substantial fare increase. The interurban bus-transit market, on the other hand, appears to be contestable, although relatively little new entry actually did occur. Fare increases in this market remained very limited. The historical evolution in the USA, where prior to deregulation the interurban market was dominated by two large transit firms, suggests that the market is contestable as well. A large number of small operators entered the market, reducing market concentration considerably. Most of the entrants offered a single specialized service, rendering doubt on the existence of strong economies of scope in interurban transit.

Fourth, the effect of deregulation on patronage is ambiguous. For instance, in the UK the combination of service adjustments and fare increases actually reduced the load factor. This phenomenon is partly attributed to non-zero price elasticities, and partly to a lack of marketing effort by the bus industry (Glaister, 1997). The study of Morris et al. (2005) shows that U.K. local authorities employ little coherent marketing strategies for promoting city buses. This finding raises questions on the marketing of public transport services in general, a seemingly neglected research topic. Deregulation did lead to the introduction of new busses of different size, implying smaller bus types in intra-urban transit.

It is too early to make any definite statement about the impact of deregulation on productivity and efficiency. However, two conclusions seem warranted. First, the above evidence does suggest some likely positive effects on efficiency. For example, the strong effects on labor practices and on costs and subsidies, the use of competitive tendering techniques for subsidized transport, and the innovative policies of operators in terms of bus types may all contribute to higher efficiency. Any improvement in efficiency has to be evaluated against potential welfare losses due to regulation, e.g., due to reductions in specific rural services. Second, although the performance of the urban transit sector may benefit from increased competition, many questions remain as to the optimal design of these policies. For example, the exact role of the public sector after deregulation, potentially necessary to guarantee the development of integrated network structures and to encourage information provision, is still unclear. Moreover, although tendering procedures may stimulate competition, it is well known that this strongly depends on the characteristics of the procedures used; the optimal tendering procedure has yet to be determined.

4. Conclusion

In this chapter we have summarized some important results of the recent economic literature on the performance of bus-transit operators, where the emphasis was mainly on the determinants of productivity growth and efficiency in the industry. A number of conclusions emerge from the analysis.

First, there is strong evidence that recent productivity growth is either negative or at best mildly positive. Second, substantial inefficiencies remain among bus operators, although huge differences exist over time and across countries. Third, contrary to a common argument there is substantial evidence that it is not so much public versus private ownership that is crucial in explaining differences in efficiency between operators. The degree of competition and the nature of regulatory measures that affect operators are much more relevant. The risk-sharing properties of the contracts between operator and public authority, and both the level and the nature of subsidies are important characteristics of the regulatory environment that influence the performance of the transit operators. Fourth, the impact of environmental variables and characteristics of the network on performance is clearly highlighted in a number of studies. It is important to stress that some characteristics affecting efficiency levels are to some extent either under the control of the companies or can be directly manipulated by the public authorities (number of stops, network length, and length of lines). Others, however, are largely exogenous to the operator (e.g., average operational speed) and mainly determined by the available fixed transport infrastructure, congestion levels, etc.

Finally, although many uncertainties remain, deregulation is likely to improve performance in a number of different respects. The available evidence does suggest that any improvement in efficiency has to be evaluated against potential welfare losses due to deregulation (reductions in specific rural services, decline is service quality, etc.). For example, competitive tendering may improve performance, although recent research indicates that cost savings may be a one-shot phenomenon, in the sense that further rounds of tendering yield new cost increases. Moreover, a coherent legal and institutional framework is a prerequisite for successful deregulation policies. Furthermore, it seems clear that deregulation will be more successful in promoting competition in the inter-urban market than in the intra-urban market. In the latter case the existence of large fixed facilities, network economies, and demand complementarities suggest that the market is not contestable so that monopolistic forces tend to remain.

The above conclusions have obvious implications in terms of the regulation of public transport markets. For example, the destructive impact of subsidies may call for making them conditional on performance. In general, introducing more competitive elements into the industry (e.g., through tendering systems) is likely to improve performance, provided the institutional environment is appropriately designed. In order to increase the technical efficiency in the industry, it may be wise to revise the contractual arrangements between operators and public authorities so as to allow operators more organizational freedom. Complementary to this, public authorities can influence the efficiency of transport operations by improvements in the transport network that reduce, for instance, the levels of congestion.

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Chapter 37

MODELS OF AIRPORT PERFORMANCE†

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1. Introduction

Modellers have concentrated their attention on two main aspects of airport performance. In the early years of economic analysis of airports, attention was focused on congestion processes and costs, and the merits of different options, such as pricing, administrative controls, and investments as means of reducing these costs. There was limited interest in this type of model for some time, though lately there has been a resurgence of interest. Currently, much effort is being directed towards developing models of productive efficiency measurement. Airports have been a surprisingly late area for application of such techniques as total factor productivity, data envelopment analysis, and cost or production frontiers, which have been common in other transport and utility industries for some years (see Chapter 20). There is a small, though rapidly growing, and literature in this aspect of modelling.

Here, attention is focused mainly on these two types of modelling effort. Most of the models discussed have some numerical component, either in the form of econometric estimation, simulation of results based on assumed parameter values, or calculation of productivity or efficiency. Most of these models also have intended relevance for policy. The earlier, demand–congestion–pricing models are considered first, after which performance-measurement models are considered. In addition, a brief discussion is provided of two other areas of modelling – modelling of airport choice, and computable general equilibrium modelling of impacts of airport operation.

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