Chapter 1
History of transport pricing

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1. Introduction

To understand why transport pricing is in any way different from pricing more generally in economics requires consideration of the specific characteristics of transport as a good or service. Transport as an activity cannot be stored and is directly consumed as it is produced. Hence the price of a transport service has both a spatial and a temporal dimension; it relates to the interaction of demand and supply at a specific location and at a specific point in time.

The production of a transport service typically requires the use of infrastructure such as a road or rail network or a port or airport and the provision of vehicles to use this infrastructure. The infrastructure is large and can typically provide a service to many competing users. The size of the infrastructure can lead to a natural monopoly and in some cases, especially rail, this has led to vertical integration of infrastructure and service. Unbundling this vertical integration has often been seen as necessary to remove the inefficiencies from hidden transaction costs.

The existence of scale economies in the provision of transport services on a given infrastructure is less obvious, but there may be economies of scope and network economies. Direct competition between different operators is possible as long as there is some transparent mechanism for the allocation of rights (slots) to use the relevant network.

It is these specific characteristics of transport that fascinated some of the founders of modern economics as a discipline and has continued to provoke interest in successive generations of economists. It requires the definition of marginal costs for a fixed infrastructure and a variable service; and whether the short- or long-run marginal cost is the more relevant. It requires an analysis of the potential for monopoly and appropriate balance between potential scale and scope economies and the risks of monopolistic exploitation. It requires an assessment of the need for regulation against the possible benefits of allowing free competition. It also increasingly requires a consideration of the external costs of transport as a major contributor to greenhouse gases, atmospheric pollution and the damage from noise and vibration as well as the costs of accidents and risk to life.

In this chapter we highlight some of the major themes that have run through the works of successive generations of economists as they have sought to reconcile the theoretical first-best solution with the practicalities of fixing prices that are both efficient and acceptable, not least in the context of the politics of transport policy. The chapter does not set out to provide a comprehensive bibliography of the subject, nor to give a detailed review of the implementation of pricing by transport operators or public authorities, but rather to provide

a framework to understanding both the historical and analytical developments which are covered in detail in subsequent chapters. We start with a brief timeline of historical developments in Section 2. Section 3 deals with the development of pricing in practice. Section 4 looks specifically at the core question of paying for roads and congestion pricing. Section 5 examines the role of the public sector in meeting public service obligations and in regulation. Section 6 explores issues in implementing ideal prices before Section 7 offers some concluding thoughts.

2. A timeline of historical developments

2.1 Nineteenth century origins

Many would now regard the earliest formal statement of the basic issue of pricing in transport to be that of Jules Dupuit (1844; 1849). Dupuit, however, acknowledged the contributions of Say and Ricardo in the development of his thinking as he saw the pricing issue as deriving from an understanding of utility and thus placed the issue firmly in what has become known as welfare economics (see, for example, the review in Ekelund and Hébert, 2002). Dupuit, however, rejected the basic classical assumption in Say that assumed that through perfect markets the price of a good would reflect exactly its value and hence utility to each consumer. He saw that each individual would have a maximum price that they would be prepared to pay, and this defined an implicit marginal utility curve. Utility was not therefore something that could be uniquely determined by a market price. As Rothengatter (2018) has suggested this was later to cause confusion with the neoclassical analysis of marginal utility in Marshall (1920).

Dupuit's contribution was also not an abstract piece of theorising, his concern was the eminently practical one of how to define and measure the public utility (utilité publique) of public works as defined in an administrative law of 1841 (see Bonnafous and Crozet, 2018). The main thrust of this was to identify the sum of the utility derived by users. There are two main points to take from Dupuit's arguments. First, is the best-known observation that the optimal tariff to be charged for the use of an uncongested bridge would be zero. This was put forward in his 1844 paper but, following some criticism based on a misunderstanding of the argument, was reiterated in his 1849 paper which had the more focused title of "On the influence of tolls on the utility of means of transport". The second, and often overlooked, point is that Dupuit focused on the effect on the delivered price of goods from an improvement in transport (in the example it is a new canal). In this way he can be distinguished from the later focus of Marshall and Pigou as he is essentially dealing with a general equilibrium solution rather than the partial equilibrium of "the marginalists" (as identified by Rothengatter, 2018). The price of transport *per se* is of less interest than the effect on the prices of goods.

2.2 The Marshallian approach

Marshall was writing some 50 years after Dupuit and was clearly aware of Dupuit's work, albeit in a couple of footnotes (Marshall, 1920 pp. 85, 394). Marshall focused on the importance of the idea of "increments of utility" and clearly drew parallels between his graphical representation of marginal utility and the diagrams used by Dupuit. It is from this that the common belief that Dupuit and Marshall were talking about exactly the same

concept arose, or that Marshall simply took Dupuit's idea, renamed it as consumers' surplus and conveniently published it in English. In Marshall's view the marginal unit of a good would be sold at a price which exactly reflected the marginal utility to the consumer, but intra-marginal units would generate an implicit surplus as the consumer would have been prepared to pay a higher price. Marshall's influence on the development of economics through the use of the partial equilibrium analysis could be argued to have created a barrier to a wider understanding of the problem initially posed by Dupuit.

2.3 The contribution of Pigou

This dichotomy was reinforced by the work of Pigou (1920, 1932), Marshall's chosen successor as Professor of Political Economy at Cambridge. Pigou is often regarded as the one who set out the basic economics of transport pricing as an element in the foundations of welfare economics. Whilst Marshall focused on the way that variations in competition in the market would affect the price and hence the consumers' surplus, Pigou's principal focus was on the deviations between private and social net product. This divergence was another way of looking at the impact of various forms of competition, but it went further in that it also applied to differences in ownership of resources and hence to situations where one person's production or consumption of a good or resource had consequences, which could be positive or negative, for another's consumption or production. Pigou's concern was how to modify the behaviour of an individual or firm, which by pursuing its interest in maximising private net product, would be unconcerned with the social net product, which would maximise social welfare. This led to the suggestion of imposing a tax, which became known as a Pigouvian tax, on the difference between the implicit marginal private cost and the relevant marginal social cost. This would make those imposing what became known as externalities on others recognise the true costs of their production or consumption and hence modify their behaviour towards achieving a social optimum. The Pigouvian tax has become the mainstay of work on optimal transport pricing although Pigou was more concerned, as was Marshall, with the implications for controlling monopoly and subsequently understanding the issue of imperfect or monopolistic competition which had become a major topic in the 1930s and is picked up in an Appendix to a later reprint of the 1932 Fourth edition (Pigou, 1952).

Interestingly Pigou only makes passing reference to the question of charging for roads (1920, p.193) in the context of charging fuel duty and vehicle licence tax as an example of payment for the imposition of costs. He remarked in a footnote that such funds were in the UK at that time only supposed to be devoted to the construction of new roads and not, as he argued they should be, to the maintenance and repair of roads damaged by the use by vehicles. In the first edition of the book (Pigou, 1920, p.194) he proceeded to follow this discussion with an example of two roads where applying a differential tax could reallocate traffic more efficiently. This is often taken to represent the first statement of a theory of congestion pricing. Pigou's example was challenged by Knight (1924) and Pigou dropped the model from subsequent editions (e.g. Pigou. 1932). McDonald (2013) shows that Pigou was mistaken in trying to use the two-road model to illustrate the case for a tax on the output of industries subject to decreasing returns, but that the basic principle in justifying congestion pricing was picked up by later writers such as Walters (1954) and Beckmann et al. (1956).

Pigou's larger transport example was that of ''the special problem of railway rates", to which he devoted a whole chapter (Pigou, 1932, Chapter XVIII). In this Pigou focused on the debate over using a "cost of service principle" or a "value of service principle" to set railway rates. This hinges on the basic characteristic of transport referred to above, that it is consumed as it is produced with no possibility of storage or resale. Relying on a cost-of-service principle raises the problem of discrimination between those for whom a service can be provided at low cost and those, because of either the difficulties of construction or the low density of population, where it can only be provided at a high cost. Defining cost of service involves the double problem of allocating fixed (sunk) costs and dealing with joint costs. A value of service principle implied price discrimination on the basis of willingness to pay, in extreme perfect price discrimination as would be charged by a discriminating monopoly (Pigou, 1932, p.290), thus expropriating all the consumers' surplus. Both of these issues are found in many common current issues in pricing such as peak load pricing and yield management pricing used by airlines and rail operators to vary seat prices in real time (see Chapter 3 for a deeper coverage of the theory of profit-oriented pricing techniques).

In his discussion of railway rates Pigou was clear that perfect use of either cost of service or value of service, by setting rates that exactly reflected the costs of provision or the utility derived, would pose problems. However, he also considered that, using parallels with the electronic metering used in electricity distribution, it may be possible to get closer to a solution to this problem. This anticipates both yield management pricing and the use of electronic road pricing.

2.3 An alternative tradition

Whereas much of subsequent theories of transport pricing are grounded firmly in this marginalist tradition of Marshall and Pigou, it must not be forgotten that there were other approaches to the fundamental questions of economics. The Austrian tradition, as outlined in the works of Böhm-Bawerk (1891) and Wicksell (1901), focussed on the process of production through time and the need to recover the cost of capital incurred. Hicks (1973, p12) referred to this as "the typical businessman's viewpoint, nowadays the accountant's viewpoint, in old days the merchant's viewpoint". This underlies a focus on the pricing of transport to cover the cost of the capital employed and hence a cost recovery approach to pricing.

3. Pricing in Practice

3.1 Marginal cost pricing

Identifying the marginal cost of providing a specific transport service and its further division into private and social elements became, following Pigou, the dominant theme of contributions to the debate. Initially this was how to relate price to marginal cost in such a way as to maximise social welfare in the presence of a balanced budget constraint. The problem arises because transport, and particularly transport infrastructure, may display falling long-run average costs due to scale economies such that marginal cost will be below average cost and setting price equal to marginal cost will result in a deficit (Chapter 9 shows that this principle governs much of the literature of pricing in public transport, for instance). The problem of setting taxes on different goods in such a situation was first examined by

Ramsey (1927), a problem that Ramsey indicates was suggested by Pigou. However, the general presumption of decreasing costs (increasing returns) and the existence of externalities was challenged by Knight (1924). Although Ramsey does refer again to the question of motor taxes (p.59), the more direct application to transport was further developed by Boiteux (1956). So-called Ramsey-Boiteux pricing adjusts the price-cost margin by the relevant price elasticity of demand, and this has become a key result for price setting in public transport. The problem identified by Boiteux (1956) and implicit in the earlier discussions was formalised by Baumol and Bradford (1970). This raises the question of how to implement such pricing when the public authority faces a budget constraint.

The issue of transport pricing in practice was examined further by Hotelling (1938), formalised by Beckmann et al. (1956) and that of road user charges in particular by Walters (1968) and Newbery (1988a, b). The formal development of the theory of marginal-cost pricing applied to transport, following the seminal work of Beckmann et al (1956), occurred in the 1960s as the pressure for dealing with the growing problem of congestion and the need to value transport investments in developing economies became stronger. Walters (1961) gave the first presentation of the main concept of pricing according to increasing short-run social marginal costs, reinforced by Mohring and Harwitz (1962), and Vickrey (1963) extended the analysis to a more general analysis of urban transportation.

The question is then whether the relevant reference for pricing is short-run or long-run marginal cost and hence whether the primary goal is short-run allocation or long-run provision of optimal capacity (see, for example, Vickrey, 1948). This leads into a debate about the extent to which any optimal pricing system can recover the costs of providing transport without resorting to the need for subsidy (see section 5 below). A cost recovery approach contrasts with the optimal pricing approach and owes more, as we have seen above, to the Austrian tradition than to the marginalist tradition rooted in utility.

Following the contributions of Beckmann et al. and Walters the theory of congestion pricing has dominated much transport research over subsequent decades. This has looked to build beyond the essentially static model of identifying the first-best social optimum implied in the Pigouvian tax to models of dynamic congestion and the search for second-best solutions. Arnott et al. (1990, 1998) discuss the idea of bottleneck congestion in networks and Verhoef (2001, 2003) explores the concept of hypercongestion in which there is no self-adjustment to a stable equilibrium. Verhoef et al (1995) and Verhoef (2002) develop second-best solutions. These theoretical foundations are well summarised in Small and Verhoef (2007, pp. 120-148) and Chapters 2 (Peer and Czerny) and 3 (Verhoef) of the present *Handbook*.

3.2 External costs, pricing, and optimal transport systems

Whilst much of the early work had focused on the principle of pricing under conditions of limited capacity and the particular problems of paying for roads and dealing with the natural monopoly problem of railways, attention began to be devoted to how to use pricing to achieve a better balance of mode use. The theory is essentially simple, one of equating (social) marginal costs, but application of this depended on knowing what those marginal costs were. Considerable effort was therefore expended on identifying the components of such costs. This needed to cover the private costs in situations involving increasing returns

to scale and network economies as well as economies of scope where, for example, joint and common costs had to be shared across separable markets such as those for freight and passengers on a rail network. Moves towards privatisation of transport operators often hinged on questions of the existence and extent of potential sources of increasing returns from large operators. At the same time the implementation of pricing to achieve a socially more efficient transport system depended on identifying the external costs of each mode.

The external costs of transport have assumed a much larger role in recent years. The issues that dominated in the late nineteenth century and early years of the twentieth have been replaced to a large extent by the contribution that transport makes to environmental degradation though its carbon footprint and emissions. Increasingly this has been about more than just the direct impacts of individual journeys but also the external cost of constructing infrastructure to take increasing volumes of traffic and the sustainability of current and expected levels of mobility. Pricing clearly has a major role to play in this debate, both in terms of reflecting the true cost of mobility by each mode and in attempting to influence behaviour in terms of both levels of trip generation and mode choice.

Valuing these external costs of transport is not just a simple matter of identifying the source of these externalities and applying a market price. Whilst there are well developed methods for obtaining estimates (see for example Rizzi and Ortúzar, 2015), getting consensus on the external costs of transport has not proved simple. Political considerations weigh heavily on this according to the impacts that any increases in the price of transport might have on voters and on other sectors of the economy such as the automobile or aircraft production industries or in those countries with significant oil production. Some of the differences between the United States and Europe can be seen in Delucchi and McCubbin (2011)[1] and Friedrich and Quinet (2011), whilst the latter demonstrates the compromises necessary to achieve a consensus view in European discussions. These reflect the differing preferences and perceptions of consumers plus the differences in the spatial organisation of the economy and the consequent pattern of demand for transport. Andersson, Cerruti and Huse cover the most recent features of this literature in Chapter 4 while Nash and Link (Chapter 21) document the evolution of related policies in the European Union.

3.3 Price discrimination

The nature of the demand and supply of transport services makes it a potentially important area for the use of price discrimination (for a useful review see Anderson and Renault, 2011). This was recognised from an early stage and features strongly in Dupuit's (1849) original analysis where he seeks to build up the demand curve from the maximum amount users are prepared to pay. Pigou (1932) also addressed the issue from the perspective of the impact on consumers' welfare. Whilst cases of pure first-degree price discrimination[2], where each individual user is made to pay a price equal to their own willingness to pay, are rare, the use of yield maximising booking systems on planes and trains starts to get close to this. Here prices vary in real time according to demand and available capacity. Potential users with larger price elasticities of demand who are prepared to book either well in advance, or take a chance on a last-minute booking, can get lower prices albeit often with

[1] See also Berechman et al. (2011)

[2] The basic definitions and a formal analysis are given in Quinet and Vickerman (2004) pp.276-283

zero flexibility. Those with low price elasticities of demand, typically business users or others with limited flexibility in the time of travel, have to pay higher fares. This means that users on any particular flight or train may have paid significantly different fares for what is essentially the same journey, although one for which the implied utility and willingness to pay is very different. This arises because the service paid for cannot be transferred either between different users or different times by the same user.

More common is third-degree price discrimination where it is not possible to distinguish between individuals except through their response to a specific characteristic. The most common form in use in transport is time of day pricing which allows price discrimination between peak and off-peak or weekday and weekend. Whilst this reflects the cost of providing capacity in the peak, it also exploits the different price elasticities of demand between different groups of users but averaged across the groups. A variant of this is the use of discounts for specific groups, for example by age, so that older users or students are given discounts, or in some cases free travel, albeit with restrictions on for example time of day when they can be used. More generally many operators use the idea of discounts for regular users such as season tickets, railcards, frequent flyer clubs, or "carnets" which provide for cheaper travel on the individual journey but may require an upfront payment. This is not dissimilar to the two-part tariff idea often used in energy pricing in which users pay a fixed fee for connection and then a cheaper price per unit used. These give greater ease of use for the individual user and a greater certainty of revenue for the operator, but also carry implications for equity (covered in more depth by Heyndrickx and Mayeres in Chapter 7) and may work against the general principle of charging higher prices in peak hours leading to crowding issues (see, for example, the discussions in Carbajo, 1988; Jara-Diaz et al. 2016; Hörcher et al. 2018).

4. Paying for roads

The paying for roads question has been a major theme in the political economy of transport pricing. On the one hand it is the relatively simple recognition that congestion causes marginal social cost to rise faster than private costs and that this situation will continue unless there is some form of intervention. On the other hand, the more radical approach is the idea of effectively privatising the road network such that the problem becomes internalised (Roth, 1996, 2006). A Pigouvian tax is the obvious analytical solution to the first approach, but the practical problem of estimating an optimal rate of tax and charging it and the political problems in implementing it have largely prevented large scale introduction of time varying or traffic volume dependent tolls. This is further complicated by the recognition of the dynamic nature of congestion and the need to resort to second-best solutions as noted in section 3.1. The focus of this section remains on practical implementations of road pricing; the underlying theoretical problems are covered by Mun and Fukuda in Chapter 8.

Toll roads have existed since the early days of road transport, largely as a means of covering the costs of maintaining the road in the light of the damage caused by vehicles passing along it. Some countries have seen a proliferation of tolled highways more recently, usually roads which provide a better standard of service than existing roads, but which largely run parallel to existing routes, so users have a choice of a faster road at a higher cost or a slower

route at a lower cost. This includes the use of high-occupancy toll lanes reserved for vehicles with more than a just a driver in some parts of the United States, as Chapter 19 describes.

The development of more sophisticated electronic toll collection systems based either on automatic number plate recognition or by using on-board receivers have made tolling both more feasible in high-density urban areas and more able to differentiate by vehicle type, time of day and traffic levels. But drivers have been very resistant to such universal charging, even if the net result would be lower costs of a journey due to lower levels of congestion saving both time and fuel (for a comprehensive discussion of the issues see Jensen-Butler et al. 2008; Santos and Verhoef, 2011; Lehe, 2019).

The largest scale implementations of urban road pricing have been the electronic system in Singapore (Santos, 2005) and the area-based systems in London and Stockholm. These required either the courage of a political leader as in the case of London, or in the case of Stockholm a well-managed trial that demonstrated the potential benefits to drivers before a referendum on implementation (Eliasson, 2008). The London experience has been that traffic and congestion did decrease significantly on implementation, in fact to the extent that predicted revenues were below the target (Peirson and Vickerman, 2008; Santos, 2008). Most estimates of the impact of price changes on the demand for transport are based on revealed preference studies which observe the impact of marginal changes in price (usually increases) on demand. It has been difficult therefore to predict accurately the effect of a step-change in both the level and the relative price to other modes. This suggests that it will be difficult to predict the outcome of any attempts to reset prices on a large scale.

The London system earmarked revenues for improved bus services and thus went some way towards an integrated system for urban traffic although an area-based system allows free movement once inside the zone and there are exemptions and discounts for residents and certain types of vehicle such as electric cars. This tends to distort the system and it has become complicated by the introduction of an ultra-low emission zone aimed at reducing pollution. A flat fee loses the direct link between congestion and charging. Since the charge is an addition to all other taxes on the use of vehicles it is often perceived as inequitable with negative impacts on businesses inside the zone. Increases to the charge and attempts to extend the zone have been part of the rescue package for Transport for London following the collapse of public transport revenues post-pandemic (Department for Transport, 2020). This is a long way from having an integrated system for charging for urban transport.

5. Public provision, the public service obligation and regulation

5.1 Public provision and public service

The question of whether pricing is a means of covering the costs of providing a transport good or service with the elements of a public good or a means of ensuring an optimal allocation between different types of transport with different cost structures has dominated more recent debates. This has coincided with the move to deregulate and privatise the provision of transport. If transport can be seen as a competitive good, then the problem of regulating prices recedes, and normal anti-trust legislation can be used to avoid the abuse

of a monopoly position. This does, however, leave the problem of what happens when operators withdraw from a market that is seen as unprofitable, the public service obligation. Franchising or competitive tendering removes competition from within the market and replaces it by competition for the market. In this case the public sector will again become responsible for setting price levels. The public sector regulator may wish to use the level of prices (or any permitted increases) to squeeze profit levels and secure greater efficiency, but this is typically driven by a need to reduce public sector budgets rather than evidence of any gross inefficiencies.

Despite many studies estimating the price elasticity of different modes of transport, real evidence of the effects of using price as a means of changing transport users' choice is limited as discussed above in the context of congestion charging. Building on an analysis of Mohring (1972) into scale economies in urban bus transport, Turvey and Mohring (1975) extended this to derive the basis for optimal, first-best, bus fares including passengers' time costs. Glaister and Lewis (1978) explored the potential for a fares policy for London which explicitly took into account the price elasticities of demand for all modes including private car transport, assuming that the first-best conditions were not available for the alternative mode. Cervero (1990) used estimates of fare elasticities to examine the case for eliminating fares on public transport. There have been studies of the impact of making public transport free in individual cities (e.g. De Witte et al. 2006; Cats et al 2014, 2017; Hess, 2017), but relatively few of these have become permanent as political pressure on budgets dominated. An experiment to hold down prices in South Yorkshire in the late 1970s and early 1980s (Goodwin et al. 1983) was successful in maintaining public transport ridership at higher levels than in comparable areas but was ended by pressure from central government over the impact on local finances. As with the imposition of congestion charging the effect of step-changes in prices proved difficult to predict.

A detailed discussion of the issues in the provision of public transport is in Chapter 9 (Jara-Diaz et al) and the political and governance issues in chapter 6 (Russo and De Borger).

5.2 Regulation

The twin issues of monopoly on the one hand and destructive competition on the other dominated much of the discussion of transport pricing in the first half of the twentieth century. This led in turn to the regulation of transport operators to try and curb the potential for destructive competition through low barriers to entry in the growing road transport sector and fear of exploitation from natural monopolies in sectors such as rail which required large investments in infrastructure. In many cases this led ultimately to public ownership. Regulation focussed largely on entry and unfair competition through licensing of both operators and their services and in ensuring a minimum level of provision through a public service obligation placed on operators (Ponti, 2011). In such a regime prices were typically based on average costs across all operations rather than marginal costs, allowing for cross-subsidy. The decline in demand for public transport alongside the rise in private car ownership in the second half of the twentieth century posed problems for this regime. More services became marginal threatening the viability of the public service obligation and in turn more expensive to maintain as pressure mounted on public sector budgets. At the same time the growth of demand for air travel made the traditional highly regulated and often exclusive mode of delivery increasingly outdated.

The simultaneous desire for economies and liberation from regulation led to a push for deregulation and privatisation across the whole sector. The belief that competition would reduce the cost of providing expensive public service obligation services whilst allowing innovation and the development of new services fuelled this move. It was recognised that complete deregulation leading to a free for all could be destructive, so some residual regulation remained. This was first of all to maintain safety through entry regulation but secondly became the introduction in many markets of competition for the market rather than in the market through some form of franchising or competitive concessions. As in the privatisation of other utility markets the public sector usually retained some overall control of prices. This could be either in the form of retaining the right to set prices with operators competing for services on a gross cost basis or, in effect, a control on profits typically by setting the allowed annual change in prices related to an overall price index. In some cases this ensured that prices should rise by less than the price index to try and force increases in efficiency.

Some of the biggest changes occurred in local public transport and railways. In the former there was a move from direct public sector provision in many countries towards a regime of competitive tendering (Gagnepain et al. 2011; van de Velde, 2015). Changes in rail involved a number of dimensions but in Europe there was a general move towards the vertical separation of infrastructure and rail services and an increase in the use of competitive tendering at least for some regional services (Nash, 2011, 2015). Price setting in these regimes has two basic dimensions.

The first is essentially a political and policy decision on to what extent the individual user should cover the cost of any journey. In some jurisdictions, the United Kingdom being an obvious example, the individual user is expected to bear a larger share of the cost, so fares are high in both nominal terms and real terms relative to, for example, wage levels. This leads to high farebox ratios and a greater revenue risk to the operator in the event of a downturn in traffic levels, such as experienced during the Covid-19 pandemic (Vickerman, 2021a).

The second is the way prices are set in any franchising or competitive tendering process. Under a gross cost approach, the regulator or public sector commissioning body sets the fare level and the services and receives all the revenue whilst the operator takes only the supply side risks of costs. Under a net cost approach, the operator takes on both revenue and cost risks, subject to any overall control over price levels. In UK rail franchising, for example, basic fares including season ticket prices are regulated with annual fare changes determined by the Department for Transport, but operators are free to set other fares. The bidding for franchises thus depends on operators' ability to forecast potential growth in the market to secure the revenues that will enable the operator to pay the government for the franchise. On several occasions operators have failed to meet the contractual terms of the franchise and have had to hand the franchise back (Vickerman, 2021b).

It is clear from this discussion that the prices of public transport services are increasingly unrelated to the cost of providing that service or a conventional relationship between

supply and demand. They have become largely a matter of political choice and what public sentiment or voters' opinions will bear.

Regulation is discussed in the context of European approaches to pricing in chapter 21 (Nash and Link) and in how it is applied to questions of public-private partnerships in chapter 16 (Fischer et al) as well as the wider discussion of public transport in chapter 9 (Jara-Diaz et al.).

6. Implementing ideal prices

Whilst theoretically ideal prices could be defined for most transport services their adoption has been hindered by the lack of an appropriate means of implementing them in practice. On-line booking for airfares and many long-distance rail journeys has meant that operators could get closer to individuals' willingness to pay for a specific journey. This is in part because these are likely to be larger expenditures which occur infrequently. Payments for everyday journeys have remained until recently largely dependent on cash payments except where season tickets or some form of regular user card were available. New ways of charging for journeys can make pricing more sensitive both to the user and to the circumstances of the journey such as time of day. The move in many large cities to integrated fare cards have allowed for a single means of payment to cover journeys by different modes or allowing for multiple interchanges thus simplifying the journey for the user with a greater degree of transparency. This includes the potential for giving discounts for the regular traveller by imposing a maximum daily fare. However, it also moves us away from the first-best optimal pricing by blurring the transparency of the fare paid for each trip. Transferring this technology to the use of contactless bank cards simplifies the situation for the occasional traveller.

Similarly, the ability to charge private motorists directly for their journeys by means of on-board transponders that interact with roadside stations has increased the potential for more sensitive road pricing than that provided by cordon-based systems. In both private and public transport the ability to transfer this technology to mobile phones provides the opportunity to integrate all transport pricing in a way that makes the relative cost of journeys by different modes transparent and hence aids optimal decision making. Thus, integrating the journey planning technology used by many with the relevant charging systems may bring us closer to the theoretical solutions of the textbooks once the privacy concerns raised by such a situation have been resolved.

The next stage of development is to bring both public and private modes of transport into an integrated system. This "Mobility as a Service (MaaS)" idea identifies that the basic demand is for mobility rather than particular modes of transport. Different operators, including taxis, ride-hailing services and active transport (such as cycling and walking) can provide services but these are sold through "integrators" who can offer a subscription service for mobility (Hensher, 2017; Matyas and Kamargianni, 2019; Mulley et al. 2018). Whether this really represents a further step towards being able to achieve optimal pricing in practice has been questioned in more recent attempts to model the effects of the supposed business models (Hörcher and Graham, 2020; van den Berg et al. 2022).

7. Concluding thoughts

The main message of this chapter is that a consistent theoretical model of pricing has been developed over the past two centuries. The model recognises the specific characteristics of transport both in the charging for the use of transport infrastructure and for transport services. What has proved less straightforward has been the implementation of theoretically correct first-best prices in practice. This has been both for technical and logistical reasons on the one hand and for political reasons on the other. It has been simpler on both grounds to opt for second-best solutions. Hence there has been a reluctance to move away from solutions which subsidise public transport as means of approximating the right relative prices of public and private transport. It is possible that the technical and logistical constraints are now much less with modern digital technologies that will allow for prices closer to the first-best for each user. However, if this implies increases in the prices for public transport there will be pressure on equity grounds to find ways of limiting the increases for certain classes of user.

The political will to move transport prices such that they reflect the full cost, including all external effects, will differ according to the regimes currently in place. Regulated prices and subsidies can be used to manipulate both levels of mobility and the choice of mode; changing the paradigm can be difficult and can produce unexpected consequences. For example, to encourage cleaner transport electric cars are often subsidised and exempted from congestion charges. The growth of electric car numbers then reduces the tax revenues governments receive from the sale of fossil fuels and there is no incentive to reduce car movements in congestion charge zones. Unless and until there is a consistent approach to pricing mobility there will continue to be problems of this type (see discussion in Poon and Vickerman, 2020).

The Covid-19 pandemic has caused problems for transport operators across the world. Reduced ridership has led to large falls in revenue that have required government bailouts. It seems likely that the recovery, certainly in Europe and the Americas, will take several years. It is not yet clear whether ridership in large cities will ever return to the levels seen before the pandemic as working from home, at least for part of the week, becomes part of the normal pattern of work. In many cities car usage has returned more strongly than public transport usage. Does this provide a major opportunity for a rethink of how to price public transport and reset the relative prices of the various modes (Vickerman, 2021a)?

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